

Annexes

Annexe 1 : Caractéristiques de l'huile synthétique Therminoil VP-1 et de l'eau surchauffée

Annexe 2 : Les conduites, les vannes, les coudes et les formes T choisis pour l'installation hydraulique dans le logiciel Pipedata Pro (La norme ASME).

Annexe 3 : Les courbes et les tableaux utilisés pour le dimensionnement de l'échangeur de chaleur (La norme TEMA).

Annexe 4 : Calcul des pertes de charges singulières.

Annexe 5 : Programme « Littéral Structuré » de l'API.

Annexe 6 : Contact de la société Siemens et du développeur des projets CSP Solarlite.

Annexe 1 :

Caractéristiques de l'huile synthétique Therminoil VP-1 et de l'eau
surchauffée

1. Caractéristiques de l'huile synthétique Therminoil VP-1

Temperature		Liquid Density			Liquid Heat Capacity		Liquid Enthalpy**	
°F	°C	lb/gal	lb/ft³	kg/m³	Btu/(lb·°F) (cal/(g·°C))	kJ/(kg·K)	Btu/lb	kJ/kg
54	12	8.93	66.8	1071	0.364	1.52	0.0	0.0
60	16	8.91	66.7	1068	0.366	1.53	2.3	5.4
80	27	8.84	66.1	1059	0.374	1.57	9.8	22.7
100	38	8.76	65.5	1050	0.382	1.60	17.3	40.2
120	49	8.69	65.0	1041	0.390	1.63	25.0	58.2
140	60	8.61	64.4	1032	0.397	1.66	32.9	76.4
160	71	8.53	63.8	1023	0.405	1.69	40.9	95.1
180	82	8.46	63.3	1014	0.412	1.73	49.1	114.1
200	93	8.38	62.7	1004	0.420	1.76	57.4	133.4
220	104	8.31	62.1	995	0.427	1.79	65.9	153.1
240	116	8.23	61.6	986	0.435	1.82	74.5	173.1
260	127	8.15	61.0	977	0.442	1.85	83.3	193.5
280	138	8.07	60.4	967	0.449	1.88	92.2	214.2
300	149	7.99	59.8	958	0.457	1.91	101.2	235.3
320	160	7.91	59.2	948	0.464	1.94	110.4	256.7
340	171	7.83	58.6	939	0.471	1.97	119.8	278.4
360	182	7.75	58.0	929	0.478	2.00	129.3	300.5
380	193	7.67	57.4	919	0.485	2.03	138.9	322.9
400	204	7.59	56.8	909	0.492	2.06	148.7	345.6
420	216	7.50	56.1	899	0.499	2.09	158.6	368.6
440	227	7.42	55.5	889	0.506	2.12	168.7	392.0
460	238	7.33	54.9	879	0.514	2.15	178.9	415.7
480	249	7.25	54.2	868	0.521	2.18	189.2	439.8
495	257	7.18	53.7	860	0.526	2.20	197.0	457.4
500	260	7.16	53.5	857	0.528	2.21	199.7	464.1
520	271	7.07	52.8	847	0.535	2.24	210.3	488.8
540	282	6.97	52.2	835	0.542	2.27	221.1	513.8
560	293	6.88	51.4	824	0.549	2.30	232.0	539.2
580	304	6.78	50.7	812	0.556	2.33	243.0	564.9
600	316	6.68	50.0	800	0.563	2.36	254.2	590.9
620	327	6.58	49.2	788	0.570	2.39	265.5	617.2
640	338	6.47	48.4	775	0.578	2.42	277.0	643.9
660	349	6.36	47.6	762	0.586	2.45	288.7	671.0
680	360	6.25	46.7	749	0.594	2.48	300.5	698.4
700	371	6.13	45.9	734	0.602	2.52	312.4	726.2
720	382	6.01	44.9	720	0.612	2.56	324.6	754.4
740	393	5.88	43.9	704	0.622	2.60	336.9	783.1
750	399	5.81	43.4	696	0.627	2.62	343.1	797.6
760	404	5.74	42.9	687	0.633	2.65	349.4	812.2
780	416	5.59	41.8	670	0.646	2.70	362.2	842.0
800	427	5.43	40.6	651	0.662	2.77	375.3	872.4

Liquid Thermal Conductivity			Liquid Viscosity			Vapor Pressure				Temperature	
Btu/ (ft·h·°F)	kcal/ (m·h·°C)	W/(m·K)	lb/(ft·h)	cSt (mm²/s)	cP (mPa·s)	psia	mm Hg	kgf/cm²	kPa	°F	°C
0.0792	0.1179	0.1370	13.26	5.12	5.48					54	12
0.0790	0.1176	0.1367	11.84	4.58	4.89					60	16
0.0784	0.1167	0.1357	8.64	3.37	3.57	0.0004	0.019	0.00003	0.0026	80	27
0.0778	0.1158	0.1346	6.60	2.60	2.73	0.0010	0.054	0.00007	0.0071	100	38
0.0772	0.1148	0.1334	5.23	2.08	2.16	0.0026	0.134	0.00018	0.0178	120	49
0.0765	0.1138	0.1323	4.26	1.707	1.761	0.0059	0.307	0.00042	0.0409	140	60
0.0758	0.1128	0.1310	3.55	1.434	1.467	0.0127	0.655	0.00087	0.0874	160	71
0.0750	0.1117	0.1298	3.01	1.228	1.244	0.0254	1.31	0.00179	0.175	180	82
0.0743	0.1106	0.1285	2.59	1.067	1.071	0.0483	2.50	0.00339	0.333	200	93
0.0735	0.1094	0.1271	2.26	0.938	0.934	0.0872	4.51	0.00613	0.602	220	104
0.0727	0.1082	0.1257	1.990	0.834	0.823	0.151	7.81	0.0106	1.04	240	116
0.0719	0.1070	0.1243	1.769	0.749	0.731	0.251	13.0	0.0177	1.73	260	127
0.0710	0.1057	0.1228	1.585	0.677	0.655	0.404	20.9	0.0284	2.78	280	138
0.0701	0.1044	0.1213	1.430	0.617	0.591	0.629	32.5	0.0442	4.33	300	149
0.0692	0.1030	0.1197	1.298	0.566	0.537	0.951	49.2	0.0669	6.56	320	160
0.0683	0.1017	0.1181	1.185	0.522	0.490	1.40	72.6	0.0986	9.67	340	171
0.0674	0.1002	0.1165	1.086	0.483	0.449	2.02	105	0.142	13.9	360	182
0.0664	0.0988	0.1148	1.001	0.450	0.414	2.85	147	0.200	19.6	380	193
0.0654	0.0973	0.1131	0.926	0.421	0.383	3.94	204	0.277	27.2	400	204
0.0644	0.0958	0.1113	0.859	0.395	0.355	5.35	277	0.376	36.9	420	216
0.0633	0.0942	0.1095	0.800	0.372	0.331	7.15	370	0.503	49.3	440	227
0.0622	0.0926	0.1076	0.748	0.352	0.309	9.41	487	0.661	64.9	460	238
0.0611	0.0910	0.1057	0.700	0.333	0.290	12.2	631	0.858	84.2	480	249
0.0603	0.0897	0.1043	0.668	0.321	0.276	14.7	760	1.03	101	495	257
0.0600	0.0893	0.1038	0.658	0.317	0.272	15.6	808	1.10	108	500	260
0.0588	0.0876	0.1018	0.620	0.303	0.256	19.8	1020	1.39	136	520	271
0.0577	0.0858	0.0998	0.585	0.289	0.242	24.8	1280	1.74	171	540	282
0.0565	0.0841	0.0977	0.553	0.278	0.229	30.7	1590	2.16	211	560	293
0.0552	0.0822	0.0956	0.524	0.267	0.217	37.6	1940	2.64	259	580	304
0.0540	0.0804	0.0934	0.498	0.257	0.206	45.7	2360	3.21	315	600	316
0.0527	0.0785	0.0912	0.474	0.248	0.1958	55.1	2850	3.87	380	620	327
0.0514	0.0765	0.0890	0.451	0.241	0.1866	65.8	3400	4.63	454	640	338
0.0501	0.0746	0.0867	0.431	0.234	0.1781	78.1	4040	5.49	539	660	349
0.0488	0.0726	0.0844	0.412	0.227	0.1703	92.1	4760	6.47	635	680	360
0.0474	0.0705	0.0820	0.394	0.222	0.1630	108	5580	7.58	743	700	371
0.0460	0.0685	0.0796	0.378	0.217	0.1562	125	6490	8.82	865	720	382
0.0446	0.0663	0.0771	0.363	0.213	0.1500	145	7510	10.2	1000	740	393
0.0439	0.0653	0.0759	0.356	0.211	0.1470	156	8060	11.0	1070	750	399
0.0431	0.0642	0.0746	0.349	0.210	0.1441	167	8640	11.7	1150	760	404
0.0417	0.0620	0.0721	0.335	0.207	0.1387	191	9890	13.4	1320	780	416
0.0402	0.0598	0.0695	0.323	0.205	0.1336	218	11300	15.3	1500	800	427

2. Caractéristiques de l'eau surchauffée entre 100°C et 232 °C

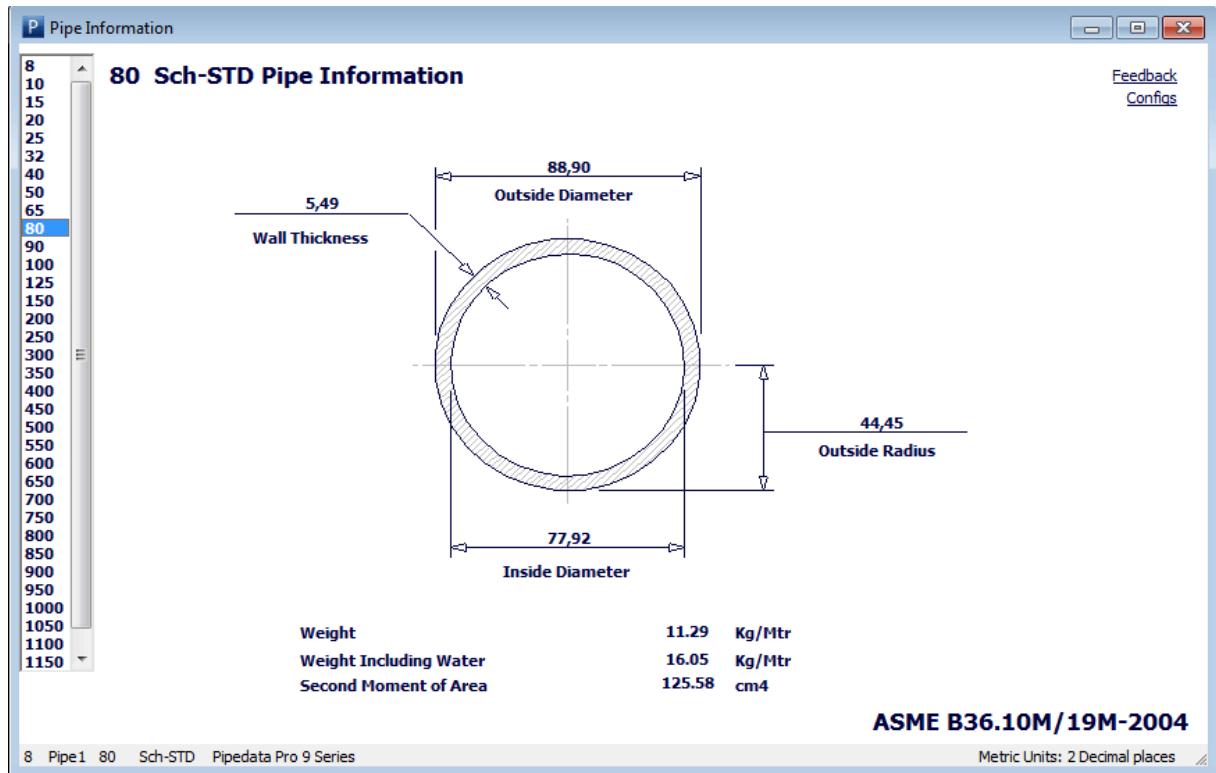
CARACTERISTIQUES PHYSIQUES DE L'EAU BOUILLANTE avant vaporisation												
Température	Pression	Masse	Chaleur sensible			Chaleur massique			Chaleur volumique			Viscosité
vaporisation		volumique	Enthalpie spécifique			Heat capacity			Heat capacity			dynamique
°C	Bar	Density	kJ/kg	W/kg	kcal/kg	kJ/kg	W/kg	kcal/kg	kJ/m3	W/m3	kcal/m3	kg/ms
http://www.thermexcel.com/french/index.htm												
100°C	1,013	958,05	419,06	266,13	100,09	4,194	1,171	1,007	4038,86	1121,90	964,665	0,000282
101°C	1,050	957,33	423,28	265,93	101,10	4,196	1,171	1,007	4036,95	1121,38	964,210	0,000279
102°C	1,088	956,60	427,50	265,72	102,11	4,196	1,172	1,007	4035,05	1120,85	963,755	0,000276
103°C	1,127	955,87	431,73	265,52	103,12	4,197	1,172	1,008	4033,15	1120,32	963,302	0,000273
104°C	1,167	955,13	435,95	265,31	104,12	4,198	1,172	1,008	4031,10	1119,75	962,813	0,000271
105°C	1,208	954,39	440,17	265,11	105,13	4,199	1,173	1,008	4029,37	1119,27	962,399	0,000268
106°C	1,250	953,65	444,40	264,90	106,14	4,200	1,173	1,009	4027,48	1118,75	961,948	0,000265
107°C	1,294	952,90	448,63	264,69	107,15	4,201	1,174	1,009	4025,61	1118,22	961,499	0,000263
108°C	1,339	952,14	452,85	264,48	108,16	4,202	1,174	1,009	4023,57	1117,66	961,014	0,000260
109°C	1,385	951,38	457,08	264,27	109,17	4,203	1,174	1,010	4021,86	1117,18	960,505	0,000257
110°C	1,433	950,62	461,32	264,06	110,18	4,204	1,175	1,010	4019,99	1116,67	960,159	0,000255
111°C	1,481	949,85	465,55	263,85	111,19	4,205	1,175	1,010	4018,13	1116,15	959,715	0,000252
112°C	1,532	949,08	469,78	263,63	112,21	4,206	1,175	1,011	4016,12	1115,59	959,235	0,000250
113°C	1,583	948,31	474,02	263,42	113,22	4,207	1,175	1,011	4014,43	1115,12	958,830	0,000248
114°C	1,636	947,53	478,26	263,20	114,23	4,208	1,176	1,011	4012,59	1114,61	958,390	0,000245
115°C	1,691	946,74	482,50	262,98	115,24	4,210	1,176	1,012	4010,75	1114,10	957,952	0,000243
116°C	1,746	945,95	486,74	262,77	116,26	4,211	1,177	1,012	4008,77	1113,55	957,477	0,000241
117°C	1,804	945,16	490,98	262,55	117,27	4,212	1,178	1,013	4007,10	1113,08	957,079	0,000239
118°C	1,863	944,37	495,23	262,32	118,28	4,214	1,178	1,013	4005,28	1112,58	956,644	0,000236
119°C	1,923	943,57	499,47	262,10	119,29	4,215	1,179	1,013	4003,47	1112,07	956,212	0,000234
120°C	1,985	942,76	503,72	261,88	120,30	4,216	1,179	1,014	4001,66	1111,57	955,780	0,000232
121°C	2,049	941,95	507,97	261,65	121,31	4,217	1,179	1,014	3999,71	1111,03	955,314	0,000230
122°C	2,114	941,14	512,22	261,43	122,32	4,219	1,180	1,015	3998,07	1110,58	954,923	0,000228
123°C	2,182	940,32	516,47	261,20	123,33	4,220	1,181	1,015	3996,29	1110,08	954,497	0,000226
124°C	2,250	939,50	520,73	260,97	124,34	4,222	1,181	1,016	3994,51	1109,59	954,072	0,000224
125°C	2,321	938,67	524,99	260,74	125,35	4,223	1,182	1,016	3992,58	1109,05	953,612	0,000222
126°C	2,393	937,84	529,25	260,51	126,36	4,225	1,182	1,016	3990,97	1108,60	953,228	0,000220
127°C	2,467	937,01	533,51	260,28	127,37	4,226	1,183	1,017	3989,22	1108,12	952,809	0,000218
128°C	2,543	936,17	537,77	259,05	128,38	4,228	1,183	1,017	3987,47	1107,63	952,391	0,000216
129°C	2,621	935,33	542,03	258,81	129,39	4,229	1,184	1,018	3985,57	1107,10	951,938	0,000214
130°C	2,701	934,48	546,31	258,58	130,40	4,231	1,184	1,018	3983,99	1106,66	951,561	0,000213
131°C	2,783	933,63	550,58	258,34	131,40	4,232	1,185	1,019	3982,27	1106,19	951,148	0,000211
132°C	2,867	932,78	554,85	258,11	132,41	4,234	1,185	1,019	3980,55	1105,71	950,738	0,000209
133°C	2,953	931,92	559,12	257,87	133,41	4,235	1,186	1,020	3978,68	1105,19	950,292	0,000207
134°C	3,041	931,06	563,40	257,63	134,42	4,237	1,187	1,020	3977,13	1104,76	949,923	0,000206
135°C	3,131	930,19	567,68	257,39	135,43	4,239	1,187	1,021	3975,44	1104,29	949,517	0,000204
136°C	3,223	929,32	571,96	257,14	136,44	4,240	1,188	1,021	3973,75	1103,82	949,114	0,000202
137°C	3,317	928,44	576,24	256,90	137,45	4,242	1,188	1,022	3972,07	1103,35	948,712	0,000201
138°C	3,414	927,56	580,53	256,66	138,46	4,244	1,189	1,022	3970,24	1102,85	948,276	0,000199
139°C	3,512	926,68	584,81	256,41	139,47	4,246	1,190	1,023	3968,73	1102,43	947,915	0,000198
140°C	3,614	925,79	589,10	256,16	140,48	4,247	1,190	1,023	3967,08	1101,97	947,520	0,000196
141°C	3,717	924,90	593,40	255,92	141,49	4,249	1,191	1,024	3965,43	1101,51	947,126	0,000195
142°C	3,823	924,01	597,69	255,67	142,50	4,251	1,192	1,025	3963,64	1101,01	946,698	0,000193
143°C	3,931	923,11	601,99	255,42	143,51	4,253	1,192	1,025	3962,16	1100,60	946,345	0,000192
144°C	4,042	922,20	606,29	255,17	144,52	4,255	1,193	1,026	3960,53	1100,15	945,957	0,000190
145°C	4,155	921,29	610,59	254,91	145,53	4,257	1,194	1,026	3958,92	1099,70	945,572	0,000189
146°C	4,271	920,38	614,90	254,66	146,54	4,258	1,194	1,027	3957,16	1099,21	945,152	0,000187
147°C	4,389	919,46	619,21	254,41	147,55	4,260	1,195	1,028	3955,72	1098,81	944,807	0,000186
148°C	4,510	918,54	623,52	254,15	148,56	4,262	1,196	1,028	3954,13	1098,37	944,427	0,000185
149°C	4,633	917,62	627,83	253,89	149,57	4,264	1,196	1,029	3952,55	1097,93	944,050	0,000183
150°C	4,760	916,69	632,15	253,64	150,58	4,266	1,197	1,029	3950,82	1097,45	943,638	0,000182
151°C	4,889	915,76	636,47	253,38	151,59	4,268	1,198	1,030	3949,42	1097,06	943,302	0,000181
152°C	5,021	914,82	640,79	253,12	152,60	4,270	1,199	1,031	3947,86	1096,63	942,931	0,000179
153°C	5,155	913,88	645,12	252,85	153,61	4,273	1,200	1,031	3946,32	1096,20	942,562	0,000178
154°C	5,293	912,93	649,44	252,59	154,62	4,275	1,200	1,032	3944,79	1095,77	942,196	0,000177
155°C	5,433	911,98	653,77	252,33	155,63	4,277	1,201	1,033	3943,11	1095,31	941,795	0,000175
156°C	5,576	911,03	658,11	252,06	156,64	4,279	1,202	1,033	3941,75	1094,93	941,470	0,000174
157°C	5,723	910,07	662,45	251,80	157,65	4,281	1,203	1,034	3940,24	1094,51	941,110	0,000173
158°C	5,872	909,10	666,79	251,53	158,66	4,283	1,203	1,035	3938,75	1094,10	940,753	0,000172
159°C	6,025	908,14	671,13	251,26	159,67	4,285	1,204	1,035	3937,11	1093,64	940,362	0,000171
160°C	6,180	907,16	675,47	250,99	160,68	4,288	1,205	1,036	3935,78	1093,27	940,046	0,000170
161°C	6,339	906,19	679,82	250,72	161,69	4,290	1,206	1,037	3934,32	1092,87	939,696	0,000168
162°C	6,501	905,21	684,18	250,45	162,70	4,292	1,207	1,038	3932,87	1092,46	939,349	0,000167
163°C	6,667	904,22	688,53	250,17	163,71	4,295	1,208	1,038	3931,27	1092,02	938,968	0,000166
164°C	6,835	903,24	692,89	249,90	164,72	4,297	1,209	1,039	3929,99	1091,66	938,662	0,000165

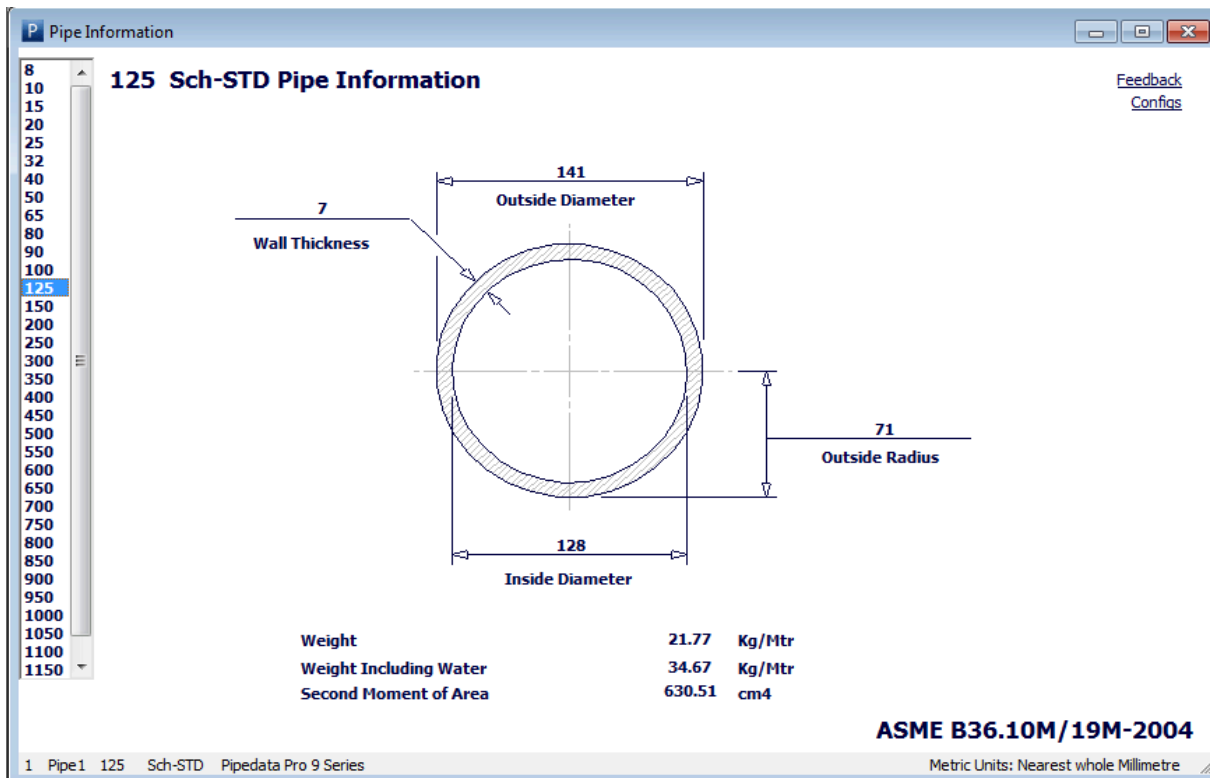
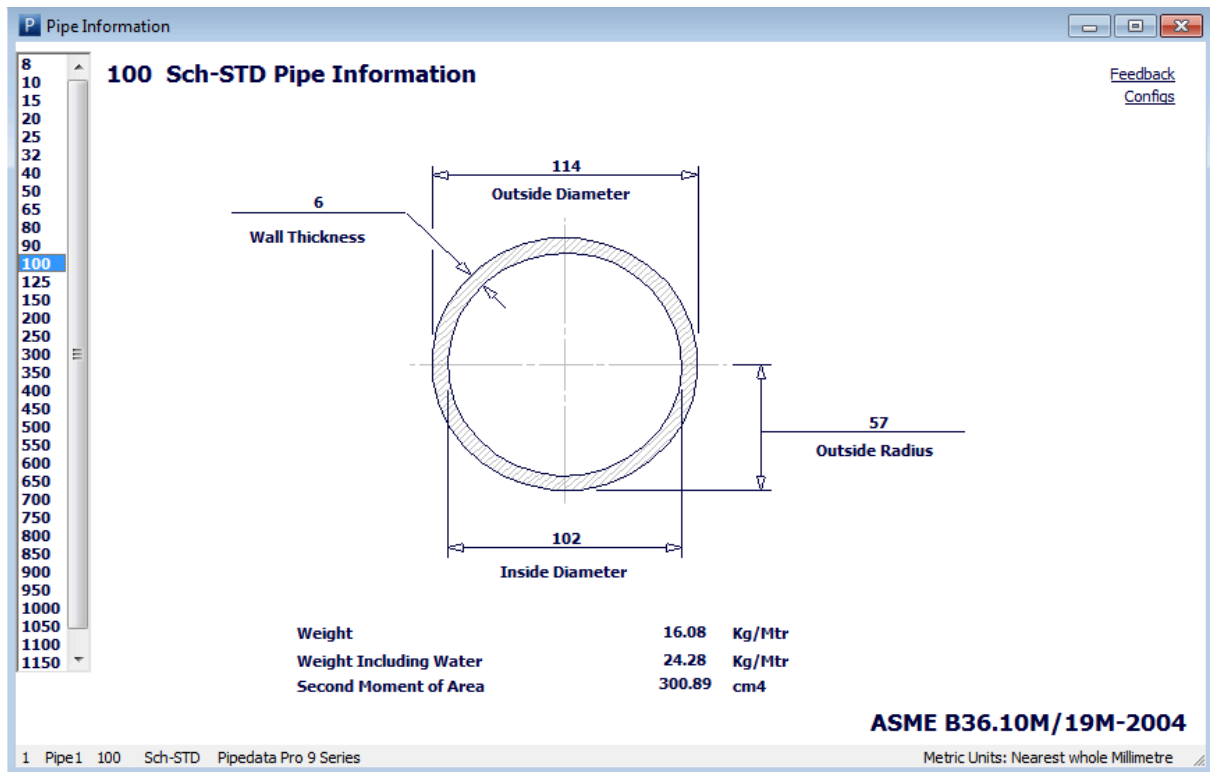
Température °C	Pression vaporisation Bar	Masse volumique Density kg/m3	Chaleur sensible Enthalpie spécifique			Chaleur massique Heat capacity			Chaleur volumique Heat capacity			Viscosité dynamique de l'eau kg/ms
			kJ/kg	W/kg	kcal/kg (4.1868J)	kJ/kg	w/kg	kcal/kg (4.1868J)	kJ/m3	W/m3	kcal/m3 (4.1868J)	
166°C	7,008	902,24	697,25	250,62	166,54	4,27	1,52	1,041	3928,57	1091,27	938,322	0,000164
168°C	7,183	901,24	701,62	250,35	167,58	4,32	1,216	1,041	3927,16	1090,88	937,985	0,000163
167°C	7,362	900,24	705,99	250,07	168,62	4,37	1,211	1,042	3925,60	1090,45	937,615	0,000162
168°C	7,544	899,24	710,36	249,79	169,67	4,42	1,212	1,042	3924,37	1090,10	937,319	0,000161
168°C	7,731	898,22	714,74	249,51	170,71	4,47	1,213	1,043	3922,99	1089,72	936,991	0,000160
170°C	7,920	897,21	719,12	249,22	171,75	4,52	1,214	1,044	3921,63	1089,34	936,665	0,000159
171°C	8,114	896,19	723,50	248,94	172,79	4,57	1,215	1,045	3920,28	1088,97	936,342	0,000158
172°C	8,311	895,17	727,89	248,66	173,83	4,62	1,216	1,046	3918,79	1088,55	935,986	0,000157
173°C	8,511	894,14	732,28	248,37	174,90	4,67	1,217	1,046	3917,61	1088,23	935,705	0,000156
174°C	8,716	893,10	736,67	248,09	175,95	4,72	1,218	1,047	3916,30	1087,86	935,391	0,000155
176°C	8,925	892,07	741,07	247,80	177,00	4,77	1,219	1,048	3915,00	1087,50	935,081	0,000154
178°C	9,137	891,02	745,47	247,51	178,05	4,82	1,220	1,049	3913,56	1087,10	934,737	0,000153
177°C	9,353	889,98	749,86	247,22	179,10	4,87	1,221	1,050	3912,44	1086,79	934,468	0,000152
178°C	9,574	888,92	754,29	246,93	180,16	4,93	1,222	1,051	3911,18	1086,44	934,169	0,000151
179°C	9,798	887,87	758,70	246,63	181,21	4,98	1,223	1,052	3909,93	1086,09	933,871	0,000150
180°C	10,027	886,81	763,14	246,34	182,27	5,03	1,224	1,053	3908,55	1085,71	933,542	0,000149
181°C	10,260	885,74	767,54	246,04	183,32	5,08	1,225	1,054	3907,49	1085,41	933,287	0,000148
182°C	10,497	884,67	771,96	245,74	184,38	5,13	1,227	1,055	3906,29	1085,08	933,001	0,000148
183°C	10,738	883,60	776,39	245,44	185,44	5,18	1,228	1,056	3905,10	1084,75	932,718	0,000147
184°C	10,984	882,52	780,83	245,14	186,50	5,23	1,229	1,057	3903,79	1084,38	932,403	0,000146
186°C	11,234	881,43	785,26	244,84	187,56	5,28	1,230	1,058	3902,78	1084,11	932,164	0,000145
188°C	11,488	880,34	789,71	244,54	188,62	5,33	1,231	1,059	3901,65	1083,79	931,893	0,000144
187°C	11,748	879,25	794,15	244,24	189,68	5,38	1,232	1,060	3900,53	1083,48	931,626	0,000143
188°C	12,011	878,15	798,60	243,93	190,74	5,43	1,233	1,061	3899,43	1083,18	931,363	0,000143
189°C	12,279	877,05	803,06	243,62	191,81	5,48	1,235	1,062	3898,20	1082,83	931,069	0,000142
190°C	12,552	875,94	807,52	243,32	192,87	5,53	1,236	1,063	3897,28	1082,58	930,850	0,000141
191°C	12,830	874,83	811,98	243,01	193,94	5,58	1,237	1,064	3896,24	1082,29	930,601	0,000140
192°C	13,112	873,71	816,45	242,70	195,01	5,63	1,238	1,065	3895,21	1082,00	930,355	0,000139
193°C	13,399	872,59	820,92	242,39	196,07	5,68	1,240	1,066	3894,05	1081,68	930,079	0,000139
194°C	13,692	871,46	825,40	242,07	197,14	5,73	1,241	1,067	3893,22	1081,45	929,879	0,000138
196°C	13,989	870,32	829,88	241,76	198,21	5,78	1,242	1,068	3892,25	1081,18	929,648	0,000137
198°C	14,291	869,19	834,37	241,44	199,29	5,83	1,244	1,069	3891,30	1080,92	929,422	0,000136
197°C	14,598	868,04	838,86	241,12	200,36	5,88	1,245	1,070	3890,23	1080,62	929,165	0,000136
198°C	14,910	866,89	843,36	240,80	201,43	5,93	1,246	1,072	3889,47	1080,41	928,985	0,000135
199°C	15,228	865,74	847,86	240,48	202,51	5,98	1,248	1,073	3888,59	1080,16	928,775	0,000134
200°C	15,551	864,58	852,37	240,16	203,59	6,03	1,249	1,074	3887,74	1079,93	928,570	0,000134
201°C	15,879	863,42	856,88	239,84	204,66	6,08	1,250	1,075	3886,75	1079,65	928,334	0,000133
202°C	16,212	862,25	861,40	239,51	205,74	6,13	1,252	1,076	3886,09	1079,47	928,178	0,000132
203°C	16,551	861,07	865,92	239,19	206,82	6,18	1,253	1,078	3885,30	1079,25	927,988	0,000132
204°C	16,895	859,89	870,45	238,86	207,90	6,23	1,255	1,079	3884,54	1079,04	927,806	0,000131
206°C	17,245	858,71	874,99	238,53	208,99	6,28	1,256	1,080	3883,80	1078,83	927,630	0,000130
208°C	17,601	857,52	879,52	238,20	210,07	6,33	1,258	1,082	3882,94	1078,60	927,425	0,000130
207°C	17,962	856,32	884,07	237,87	211,16	6,38	1,259	1,083	3882,41	1078,45	927,297	0,000129
208°C	18,329	855,12	888,62	237,53	212,24	6,43	1,261	1,084	3881,75	1078,26	927,140	0,000128
209°C	18,701	853,91	893,17	237,20	213,33	6,48	1,263	1,086	3881,12	1078,09	926,990	0,000128
210°C	19,080	852,70	897,73	236,86	214,42	6,53	1,264	1,087	3880,37	1077,88	926,810	0,000127
211°C	19,464	851,48	902,30	236,52	215,51	6,58	1,266	1,089	3879,95	1077,76	926,709	0,000126
212°C	19,855	850,26	906,87	236,18	216,60	6,63	1,267	1,090	3879,40	1077,61	926,580	0,000126
213°C	20,251	849,03	911,45	235,84	217,70	6,68	1,269	1,092	3878,89	1077,47	926,457	0,000125
214°C	20,654	847,79	916,04	235,50	218,79	6,73	1,271	1,093	3878,26	1077,29	926,307	0,000124
216°C	21,063	846,55	920,63	235,15	219,89	6,78	1,273	1,095	3877,96	1077,21	926,235	0,000124
218°C	21,478	845,30	925,22	234,81	220,99	6,83	1,275	1,097	3877,54	1077,10	926,135	0,000123
217°C	21,899	844,05	929,83	234,46	222,09	6,88	1,276	1,097	3877,16	1076,99	926,043	0,000123
218°C	22,327	842,79	934,44	234,11	223,19	6,93	1,278	1,099	3876,66	1076,85	925,924	0,000122
219°C	22,761	841,53	939,05	233,76	224,29	6,98	1,280	1,100	3876,49	1076,80	925,884	0,000122
220°C	23,201	840,26	943,67	233,40	225,39	7,03	1,281	1,102	3876,21	1076,72	925,817	0,000121
221°C	23,648	838,98	948,30	233,05	226,50	7,08	1,283	1,103	3875,96	1076,66	925,758	0,000120
222°C	24,102	837,70	952,94	232,69	227,61	7,13	1,285	1,105	3875,76	1076,60	925,708	0,000120
223°C	24,563	836,41	957,58	232,34	228,72	7,18	1,287	1,107	3875,43	1076,51	925,632	0,000119
224°C	25,030	835,11	962,23	231,98	229,82	7,23	1,289	1,108	3875,45	1076,51	925,636	0,000119
226°C	25,504	833,81	966,88	231,62	230,94	7,28	1,291	1,110	3875,36	1076,49	925,614	0,000118
228°C	25,985	832,50	971,55	231,26	232,07	7,33	1,293	1,112	3875,31	1076,47	925,601	0,000118
227°C	26,473	831,19	976,21	230,90	233,16	7,38	1,295	1,114	3875,14	1076,43	925,562	0,000117
228°C	26,968	829,87	980,88	230,54	234,28	7,43	1,297	1,115	3875,32	1076,48	925,605	0,000117
229°C	27,470	828,54	985,57	230,18	235,40	7,48	1,299	1,117	3875,40	1076,50	925,623	0,000116
230°C	27,979	827,21	990,27	229,82	236,52	7,53	1,301	1,119	3875,51	1076,53	925,651	0,000115
231°C	28,495	825,87	994,97	229,46	237,64	7,58	1,304	1,121	3875,53	1076,53	925,653	0,000115
232°C	29,019	824,52	999,67	229,09	238,77	7,63	1,306	1,123	3875,88	1076,63	925,739	0,000114

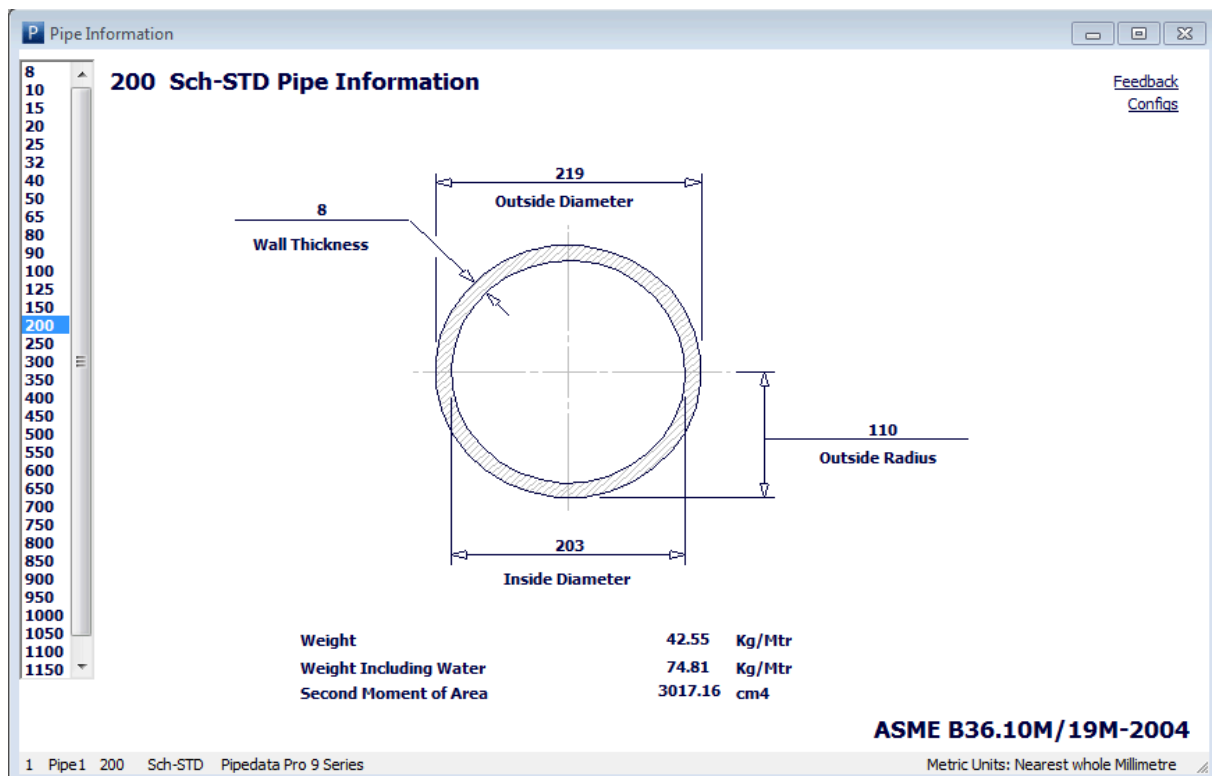
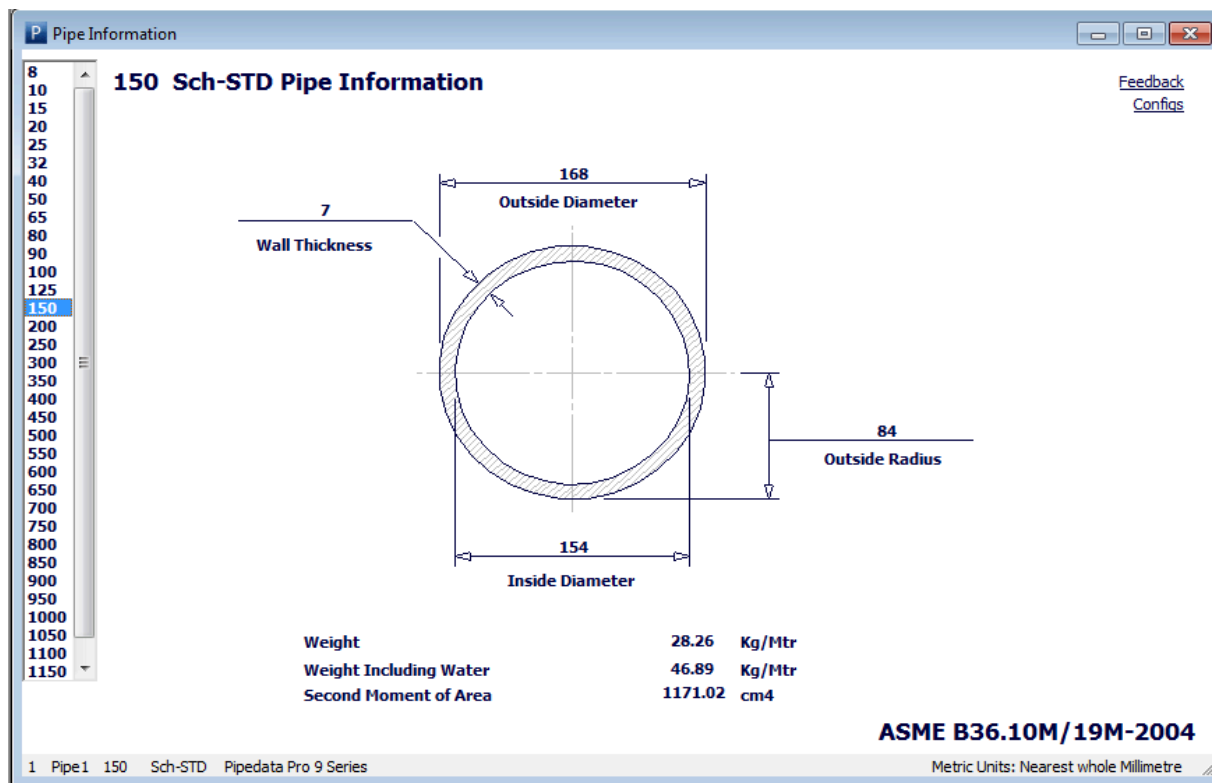
Annexe 2 :

Les conduites, les vannes, les coudes et les formes T choisis pour l'installation hydraulique dans le logiciel Pipedata Pro en respectant la norme ASME (American Society of Mechanical Engineers).

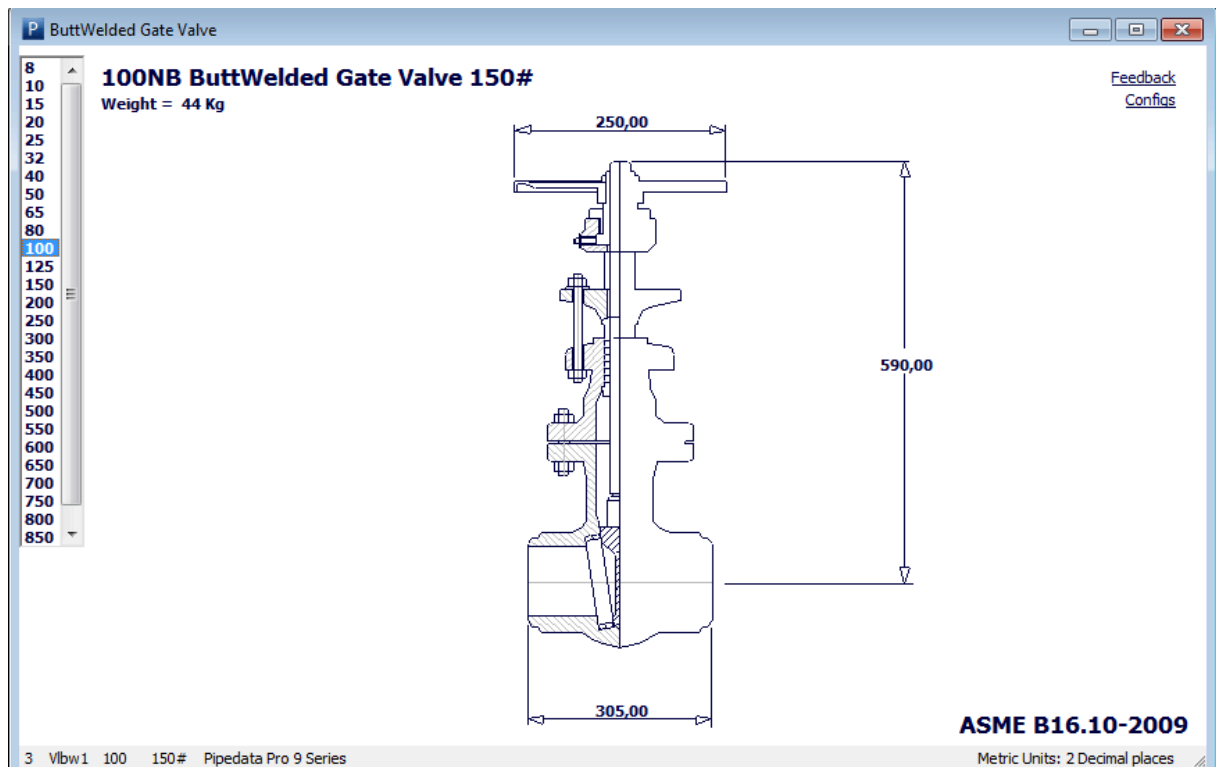
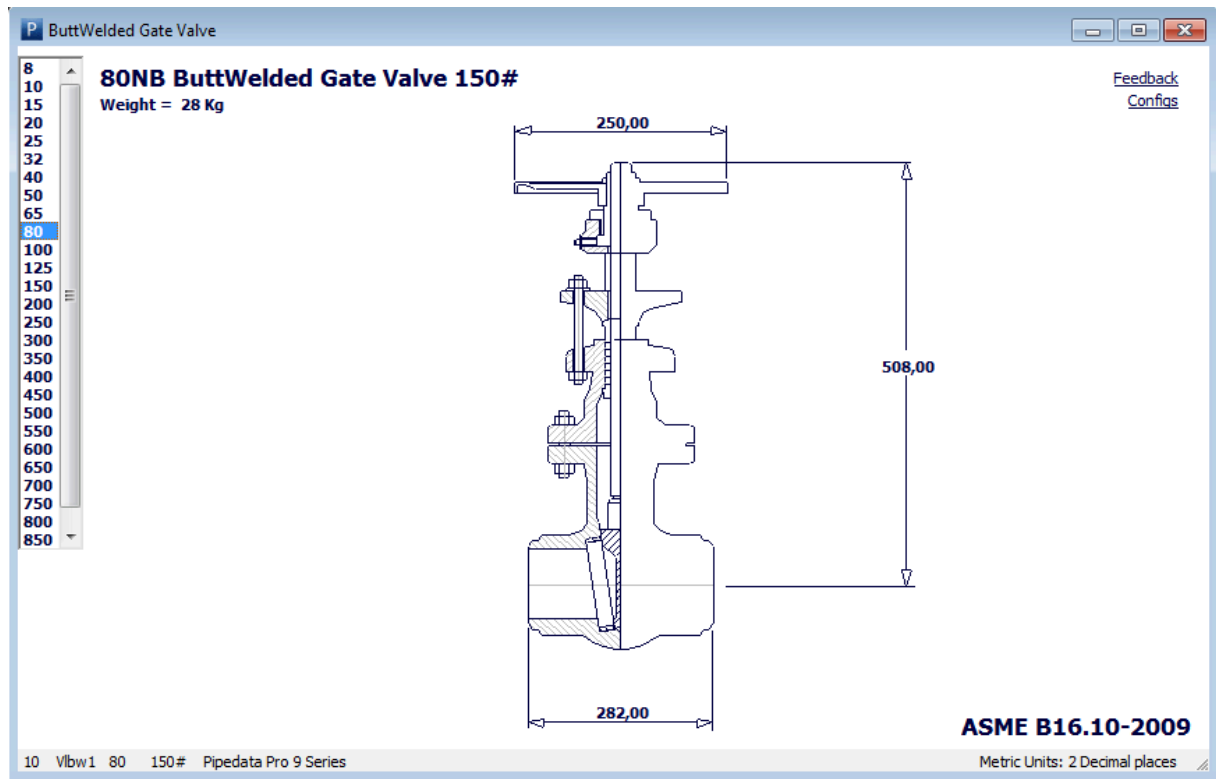
1. Les conduites

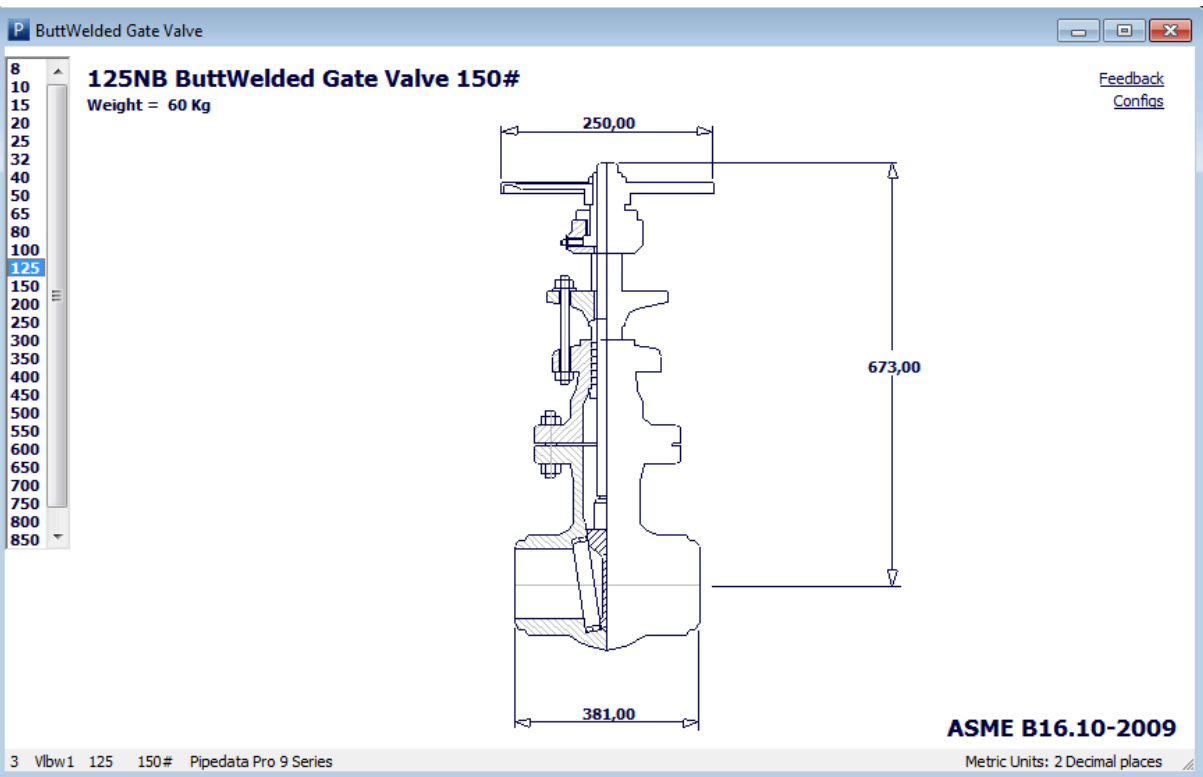


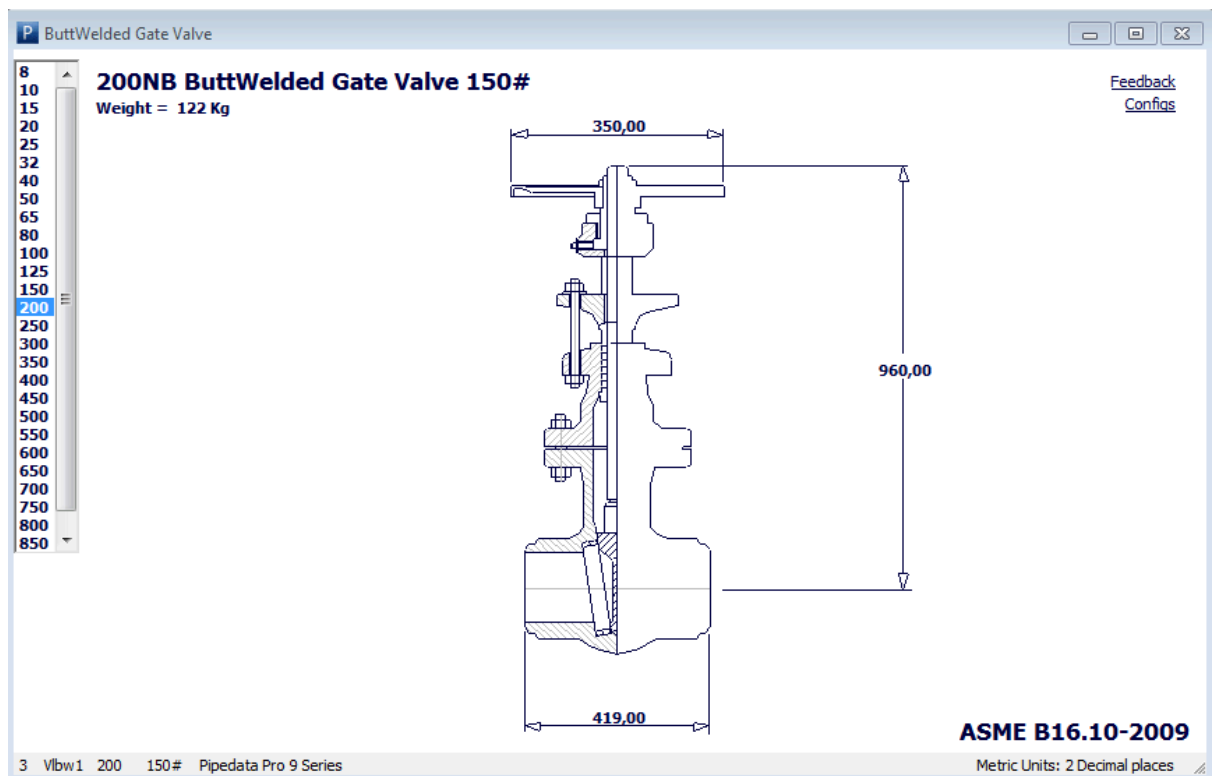
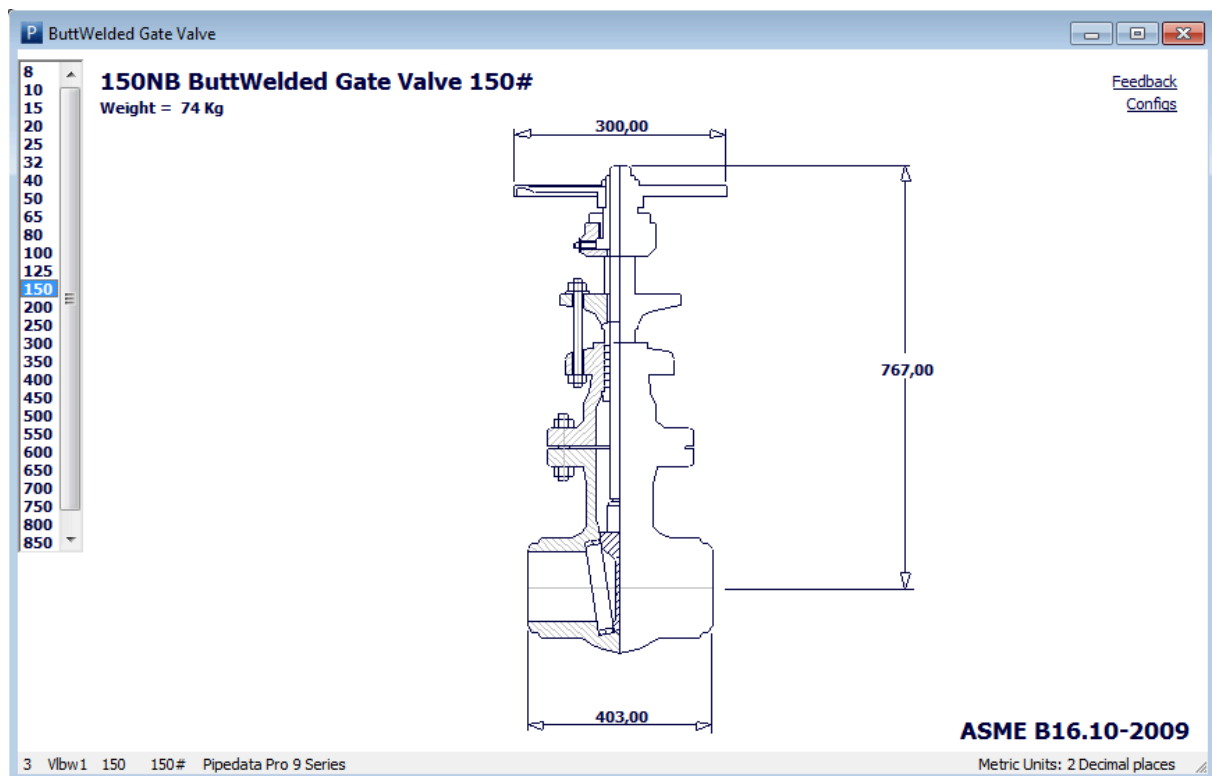




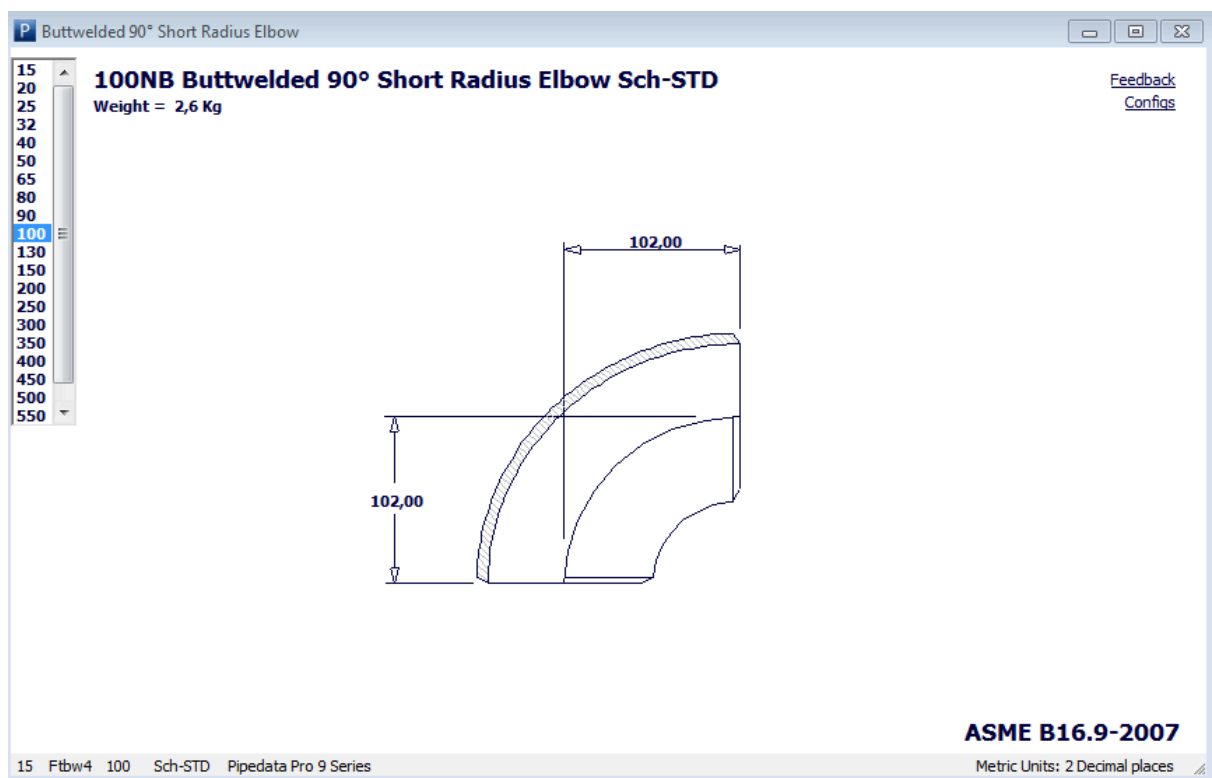
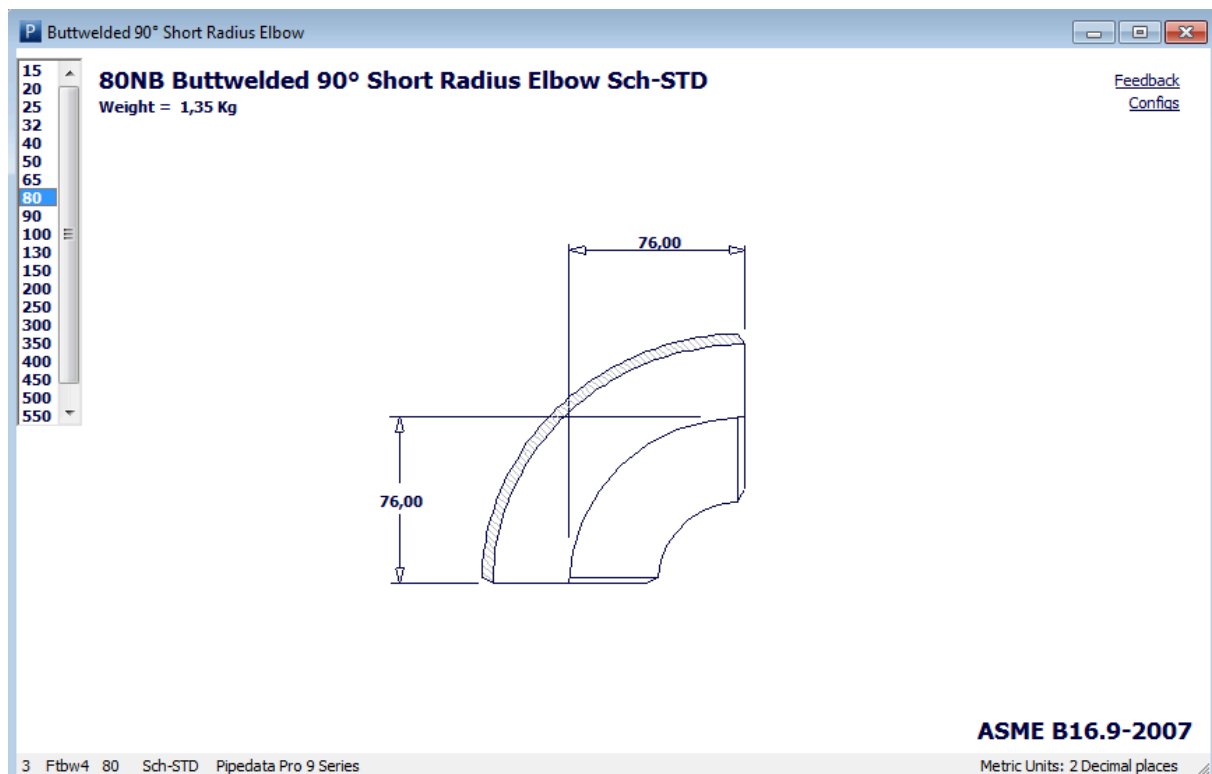
2. Les vannes

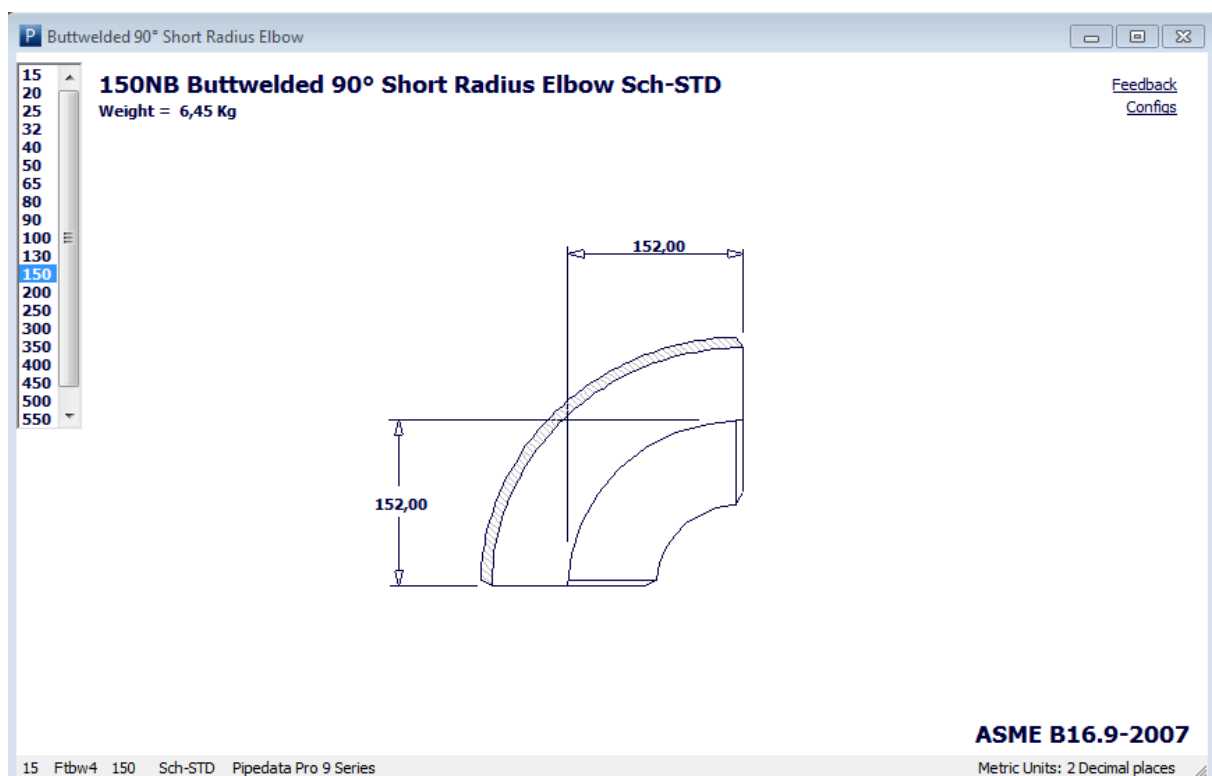
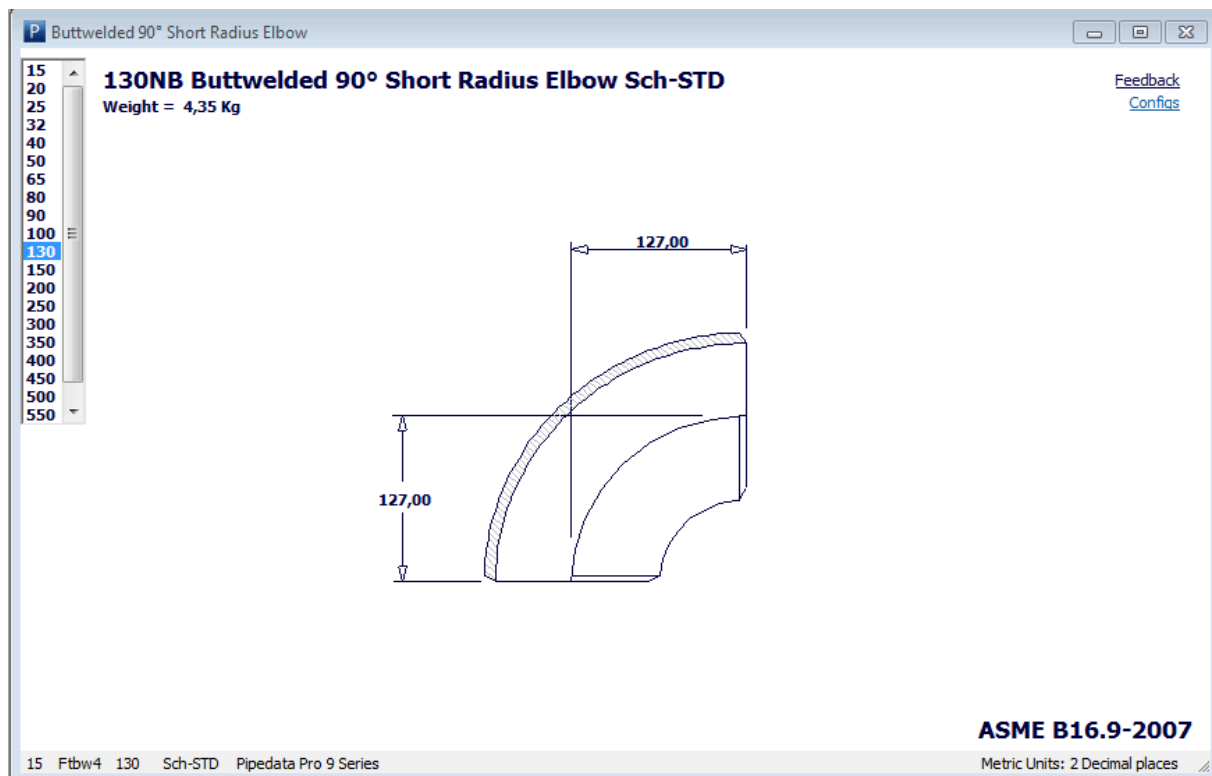


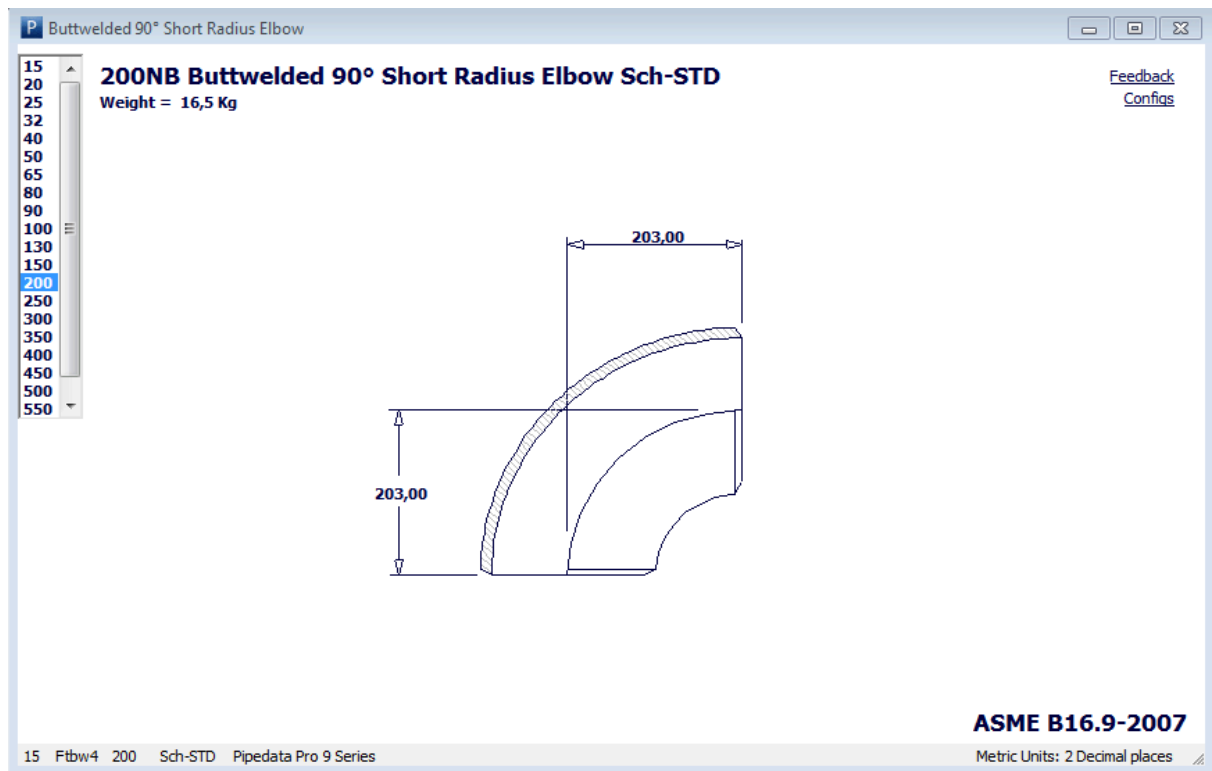




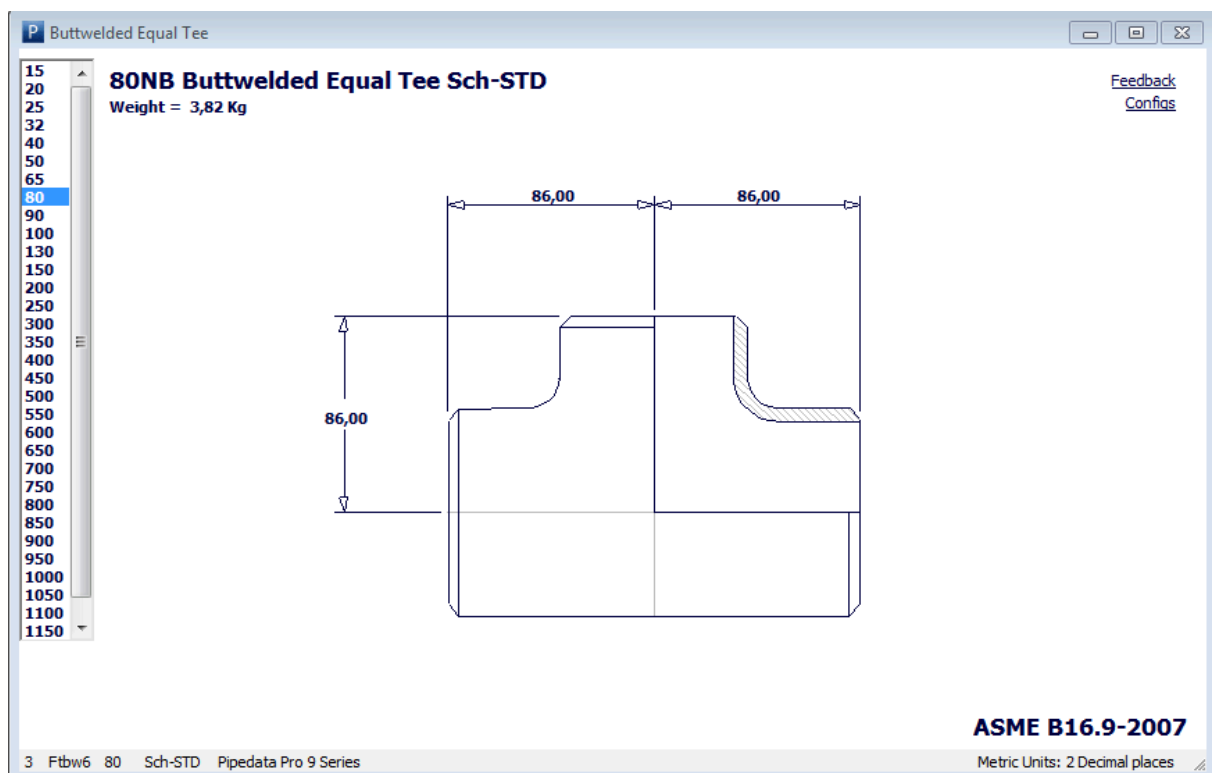
3. Les coudes

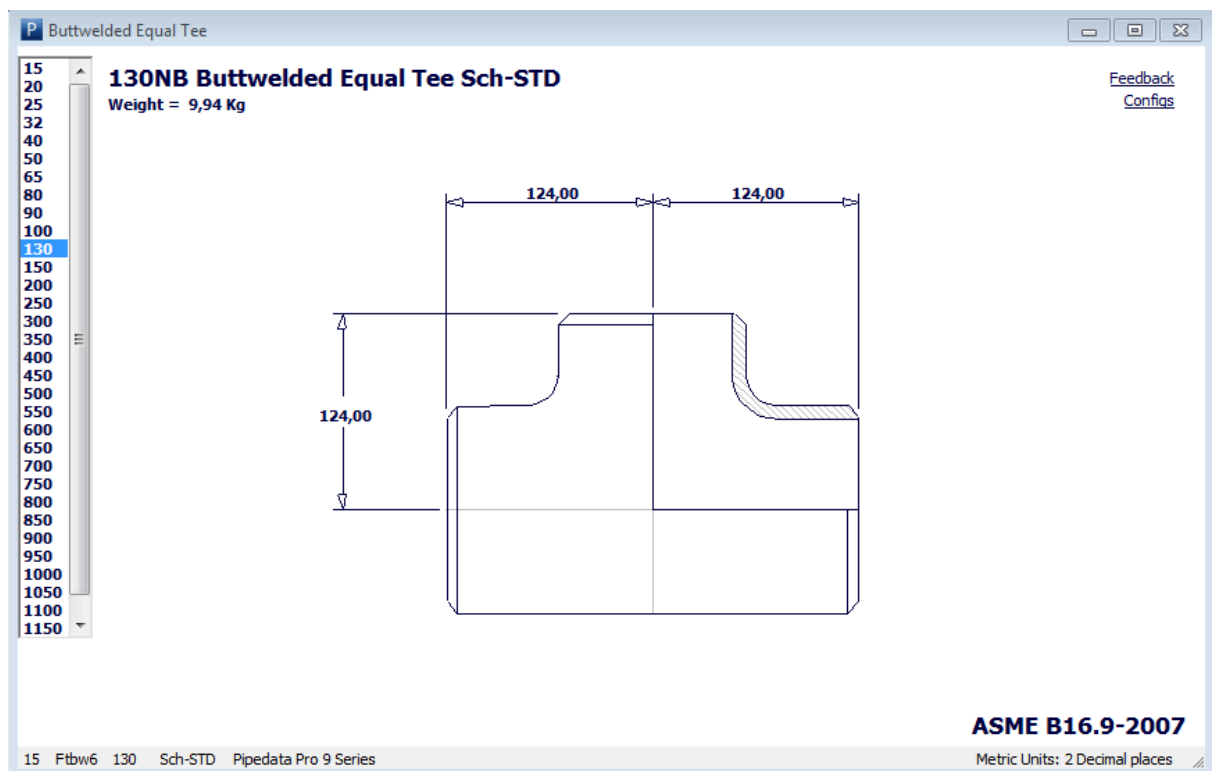
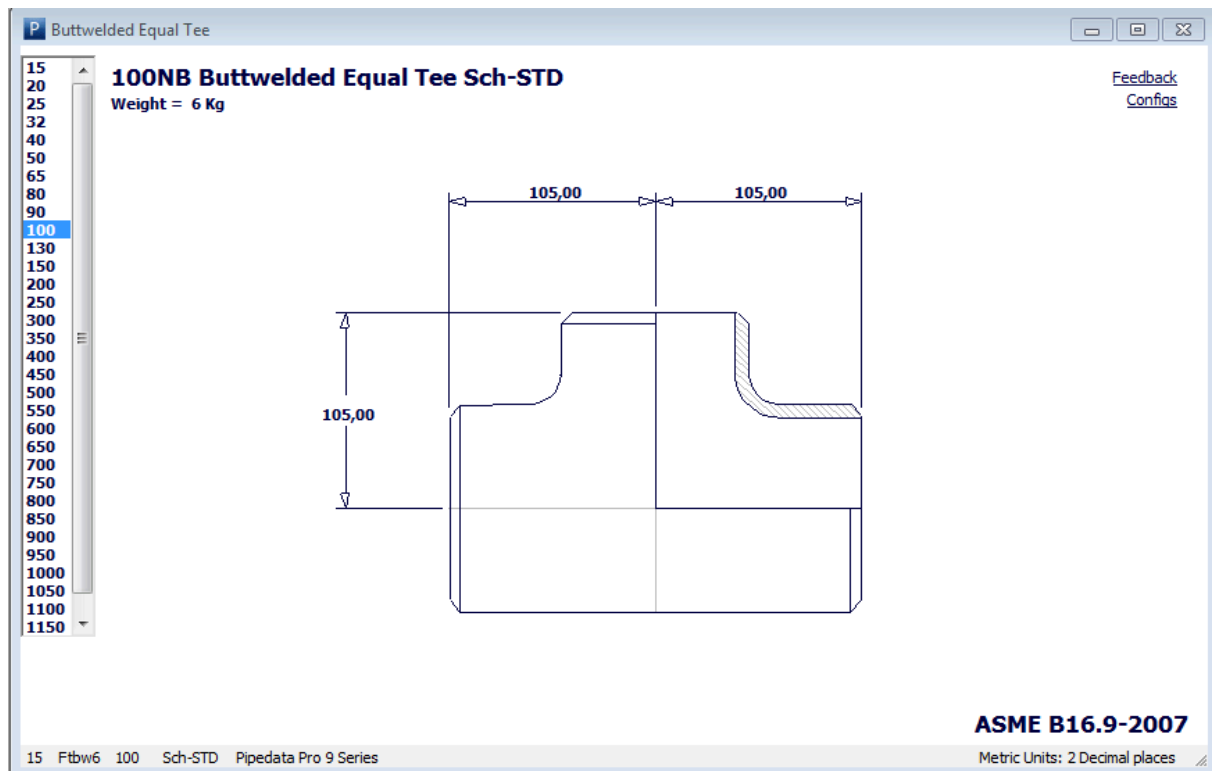


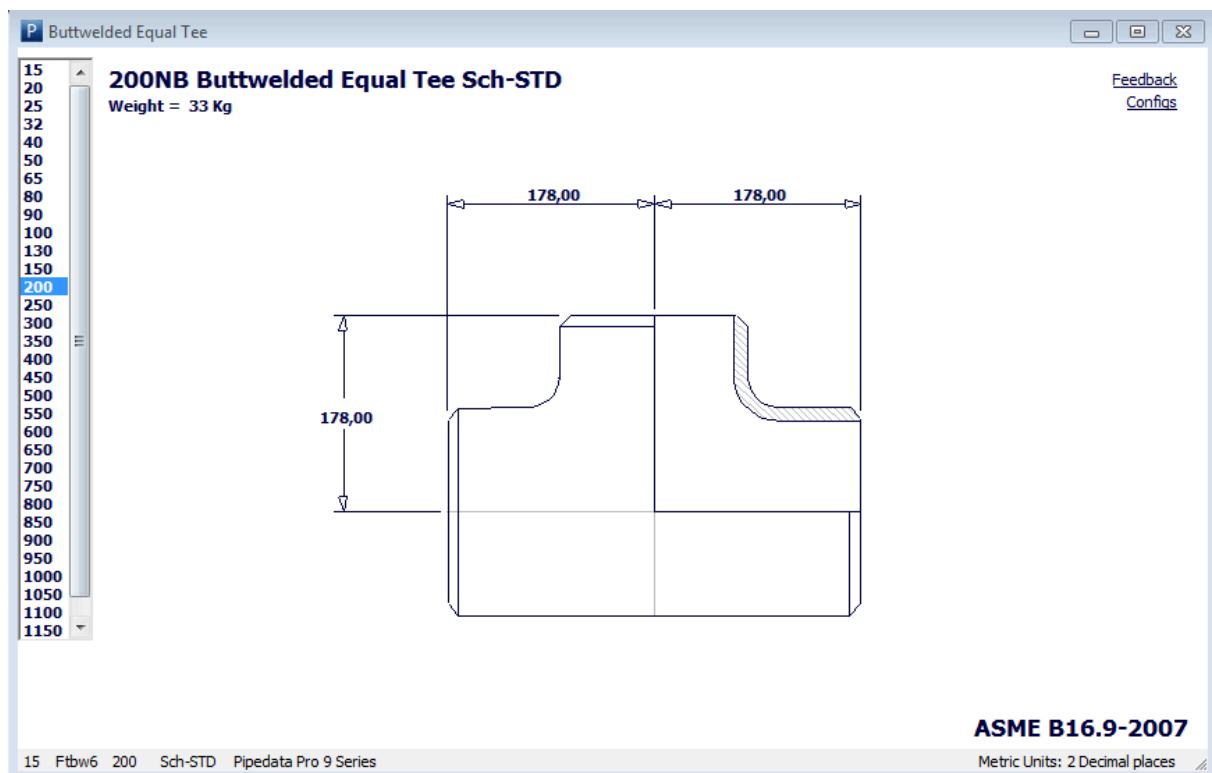
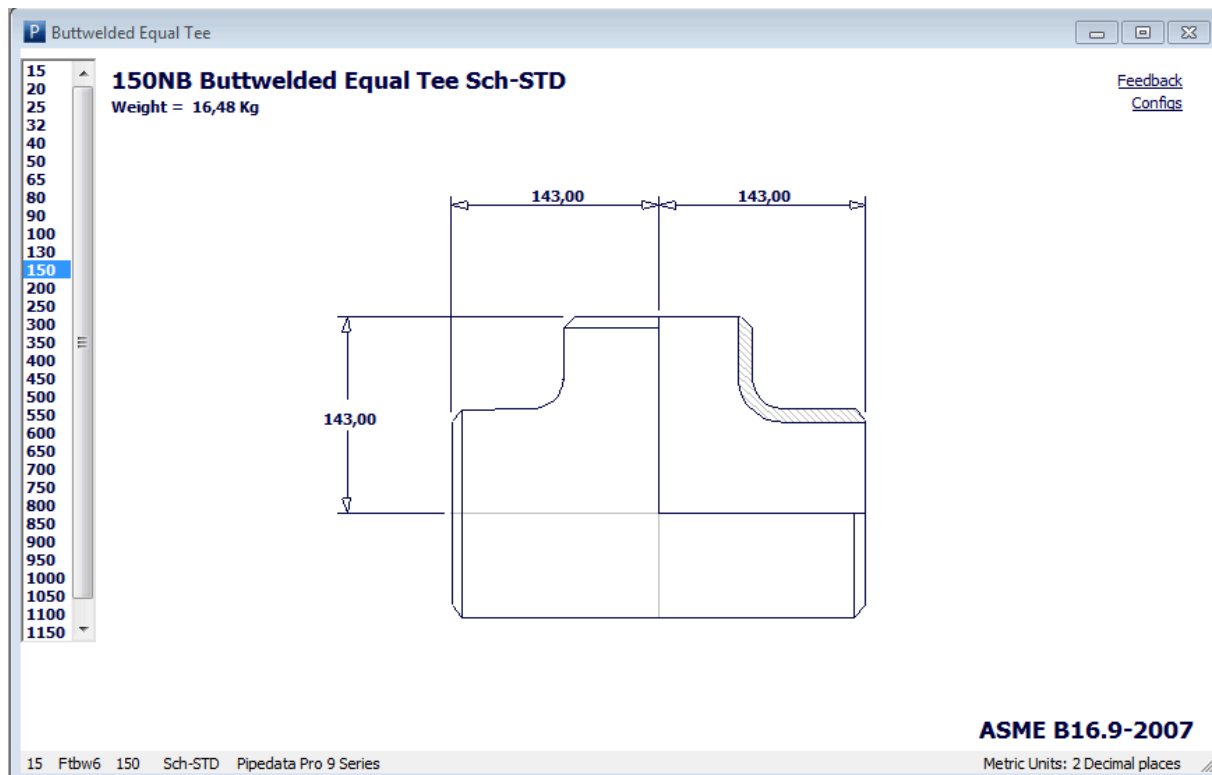




4. Les formes T







Annexe 3 :

Les courbes et les tableaux utilisés pour le dimensionnement de l'échangeur de chaleur conformément à la norme TEMA (Tubular Exchanger Manufacturers Association).

1. Tableau d'estimation du coefficient global U

TABLE 12.1. Typical overall coefficients

Shell and tube exchangers		
Hot fluid	Cold fluid	U (W/m ² °C)
Water	Water	800–1500
Light oils	Light oils	100–400
Heavy oils	Heavy oils	50–300
Gases	Gases	10–50
<i>Coolers</i>		
Organic solvents	Water	250–750
Light oils	Water	350–900
Heavy oils	Water	60–300
Gases	Water	20–300
Organic solvents	Brine	150–500
Water	Brine	600–1200
Gases	Brine	15–250
<i>Heaters</i>		
Steam	Water	1500–4000
Steam	Organic solvents	500–1000
Steam	Light oils	300–900
Steam	Heavy oils	60–450
Steam	Gases	30–300
Dowtherm	Heavy oils	50–300
Dowtherm	Gases	20–200
Flue gases	Steam	30–100
Flue	Hydrocarbon vapours	30–100
<i>Condensers</i>		
Aqueous vapours	Water	1000–1500
Organic vapours	Water	700–1000
Organics (some non-condensibles)	Water	500–700
Vacuum condensers	Water	200–500
<i>Vaporisers</i>		
Steam	Aqueous solutions	1000–1500
Steam	Light organics	900–1200
Steam	Heavy organics	600–900

2. Tableau caractéristiques des tubes d'échangeur

DIAMÈTRE EXTÉRIEUR (in et mm)	BWG	ÉPAISSEUR (mm)	DIAMÈTRE INTÉRIEUR (cm)	SECTION (cm ²)	SURFACE (m ² /m)		POIDS (kg/m)
					extérieure	intérieure	
1/2 in (12,7 mm)	14	2,10	0,848	0,565	0,0399	0,0266	0,600
	16	1,65	0,940	0,694		0,0295	0,490
	18	1,24	1,021	0,819		0,0321	0,384
3/4 in (19,05 mm)	10	3,40	1,224	1,177	0,0598	0,0384	1,436
	12	2,77	1,351	1,434		0,0424	1,216
	14	2,10	1,483	1,727		0,0466	0,963
	16	1,65	1,575	1,948		0,0495	0,774
	18	1,24	1,656	2,154		0,0520	0,597
1 in (25,4 mm)	10	3,40	1,859	2,714	0,0798	0,0584	2,024
	12	2,77	1,986	3,098		0,0624	1,696
	14	2,10	2,118	3,523		0,0665	1,324
	16	1,65	2,210	3,836		0,0694	1,057
	18	1,24	2,291	4,122		0,0720	0,811
1 1/4 in (31,75 mm)	10	3,40	2,494	4,885	0,0997	0,0783	2,604
	12	2,77	2,616	5,375		0,0822	2,158
	14	2,10	2,743	5,909		0,0862	1,682
	16	1,65	2,845	6,357		0,0894	1,340
	18	1,24	2,291	6,701		0,0918	1,024
1 1/2 in (38,1 mm)	10	3,40	3,124	7,665	0,1197	0,0981	3,185
	12	2,77	3,251	8,300		0,1021	2,634
	14	2,10	3,378	8,962		0,1061	2,039
	16	1,65	3,480	9,512		0,1093	1,622
	18	1,24	3,556	9,931		0,1171	1,237

BWG (Birmingham Wire Gauge) : Norme caractérisant l'épaisseur des tubes selon le diamètre et correspondant à une pression maximale d'utilisation.

3. Caractéristiques des faisceaux des tubes

CARACTÉRISTIQUES DES FAISCEAUX DE TUBES (NOMBRE DE TUBES PAR FAISCEAU)

a. Disposition des tubes en carré

DIAMÈTRE CALANDRE		TUBES 3/4" PAS = 1"				TUBES : 1" PAS = 1 1/4"				TUBES : 1 1/4" PAS = 1 9/16"			
		nombre de passes				nombre de passes				nombre de passes			
(in)	(cm)	2	4	6	8	2	4	6	8	2	4	6	8
8	20,3	26	20	20		16	14						
10	25,4	52	40	36		32	26	24		12	10		
12	30,5	76	68	68	60	45	40	38	36	24	22	16	16
13 1/4	33,7	90	82	76	70	56	52	48	44	30	30	22	22
15 1/4	38,7	124	116	108	108	76	68	68	64	40	37	35	31
17 1/4	43,9	166	158	150	142	112	96	90	82	53	51	48	44
19 1/4	48,9	220	204	192	188	132	128	122	116	73	71	64	56
21 1/4	54,0	270	246	240	234	166	158	152	148	90	86	82	78
23 1/4	59,1	324	308	302	292	208	192	184	184	112	106	102	96
25	63,5	394	370	358	346	252	238	226	222	135	127	123	115
27	68,6	460	432	420	408	288	278	268	260	160	151	146	140
29	73,7	526	480	468	456	326	300	294	286	188	178	174	166
31	78,8	640	600	580	560	398	380	368	358	220	209	202	193
33	83,8	718	688	676	648	460	432	420	414	252	244	238	226
35	88,9	824	780	766	748	518	488	484	472	287	275	268	258
37	94,0	914	886	866	838	574	562	544	532	322	311	304	293
39	99,0	1 024	982	968	948	644	624	612	600	362	348	342	336

4. Facteurs d'encrassement

TABLE 5.5 TEMA Design Fouling Resistances for Industrial Fluids		Liquids	
Industrial Fluids	m ² ·K/W		
Oils		Molten heat transfer salts	0.000088
Fuel oil no. 2	0.000352	Refrigerant liquids	0.000176
Fuel oil no. 6	0.000881	Hydraulic fluid	0.000176
Transformer oil	0.000176	Industrial organic heat transfer media	0.000352
Engine lube oil	0.000176	Ammonia liquid	0.000176
Quench oil	0.000705	Ammonia liquid (oil bearing)	0.000528
Gases and Vapors		Calcium chloride solutions	0.000528
Manufactured gas	0.001761	Sodium chloride solutions	0.000528
Engine exhaust gas	0.001761	CO ₂ liquid	0.000176
Steam (nonoil bearing)	0.000088	Chlorine liquid	0.000352
Exhaust stream (oil bearing)	0.000264–0.000352	Methanol solutions	0.000352
Refrigerant vapors (oil bearing)	0.000352	Ethanol solutions	0.000352
Compressed air	0.000176	Ethylene glycol solutions	0.000352
Ammonia vapor	0.000176		
CO ₂ vapor	0.000176		
Chlorine vapor	0.000352		
Coal flue gas	0.001761		
Natural gas flue gas	0.000881		

TABLE 5.11 Fouling Resistances for Water	
Temperature of Heating Medium Temperature of Water Water Velocity (m/s)	Up to 115°C 50°C
	0.9 and Less Over 0.9
Seawater	0.000088 0.000088
Brackish water	0.000352 0.000176
Cooling tower and artificial spray pond	
Treated make up	0.000176 0.000176
Untreated	0.000528 0.000528
City or well water	0.000176 0.000176
River water	
Minimum	0.000352 0.000176
Average	0.000528 0.000352
Muddy or silty	0.000528 0.000352
Hard (over 15 grains/gal)	0.000528 0.000528
Engine jacket	0.000176 0.000176
Distilled or closed cycle	
Condensate	0.000088 0.000088
Treated boiler feedwater	0.000176 0.000088
Boiler blowdown	0.000352 0.000352

115 to 205°C Over 50°C	
0.9 and Less Over 0.9	
0.000176 0.000176	
0.000528 0.000881	
0.000352 0.000352	
0.000528 0.000528	
0.000705 0.000705	
0.000881 0.000881	
0.000176 0.000176	
0.000088 0.000088	
0.000176 0.000176	
0.000352 0.000352	

Note: Rf = m²·K/W.
From Standards of the Tubular Exchanger Manufacturers Association (1988) 7th ed., Tubular Exchanger Manufacturers Association, New York. With permission.

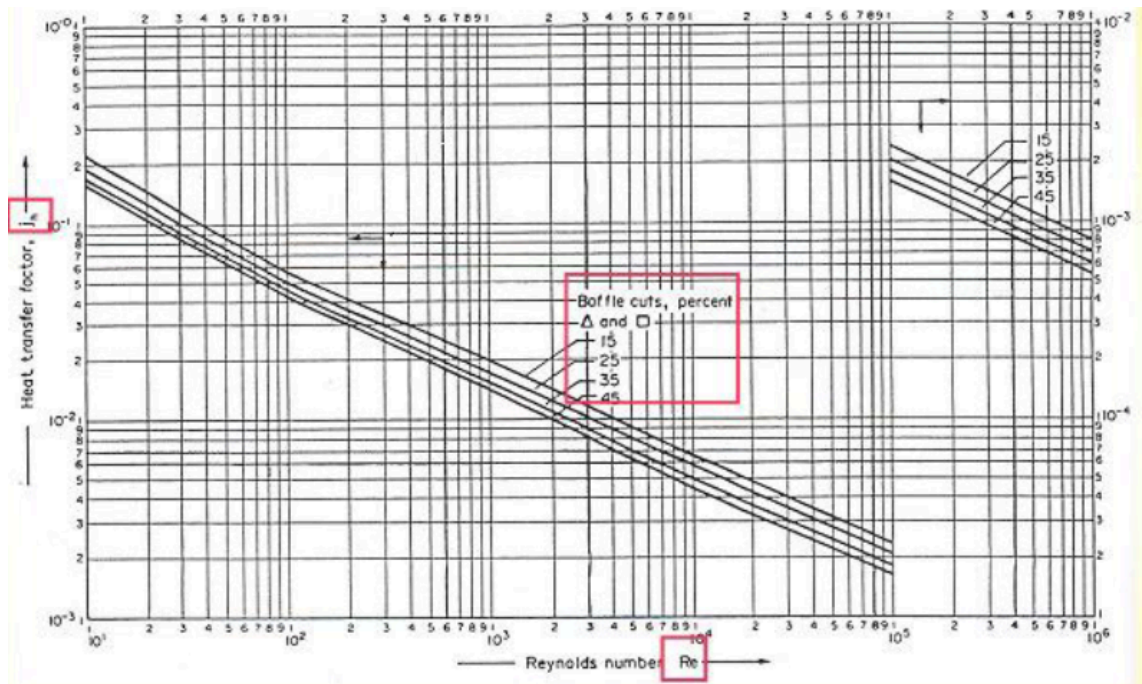
Résistances
d'encrassement
(W/m²·K)⁻¹

Liquides: 9.10⁻⁵ – 5. 10⁻⁴

5. Espacement des chicanes

D _c	I _B minimum
D _c ≤ 10"	2"
10" < D _c ≤ 30"	0,2 D _c
30" < D _c ≤ 60"	6"
D _c > 60"	0,1 D _c

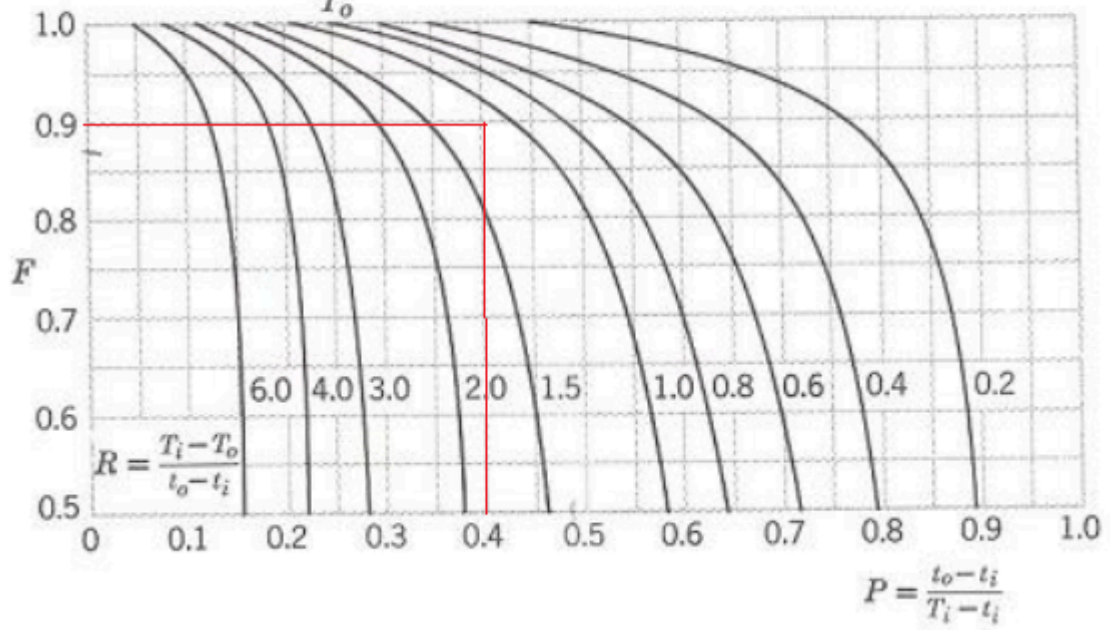
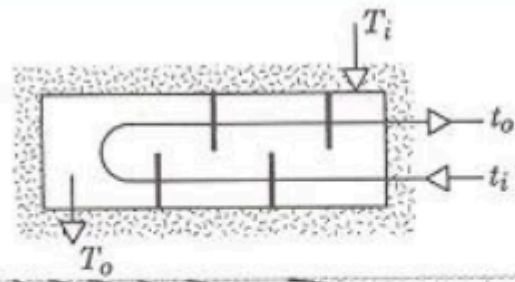
6. Diagramme du coefficient Jh



7. Epaisseur de la calandre

MINIMUM SHELL THICKNESS Dimensions in Inches (mm)				
Nominal Shell Diameter		Minimum Thickness		Alloy *
		Carbon Steel		
		Pipe	Plate	
6	11521	SCH. 40		1/8 (3.2)
30 - 36	(203-305)	SCH. 30	3/8 (9.5)	3/16 (4.8)
40 - 60	(1016-1524)		7/16 (11.1)	1/4 (6.4)
61 - 80	(1549-2032)		1/2 (12.7)	5/16 (7.9)
81 - 100	(2057-2540)		1/2 (12.7)	3/8 (9.5)

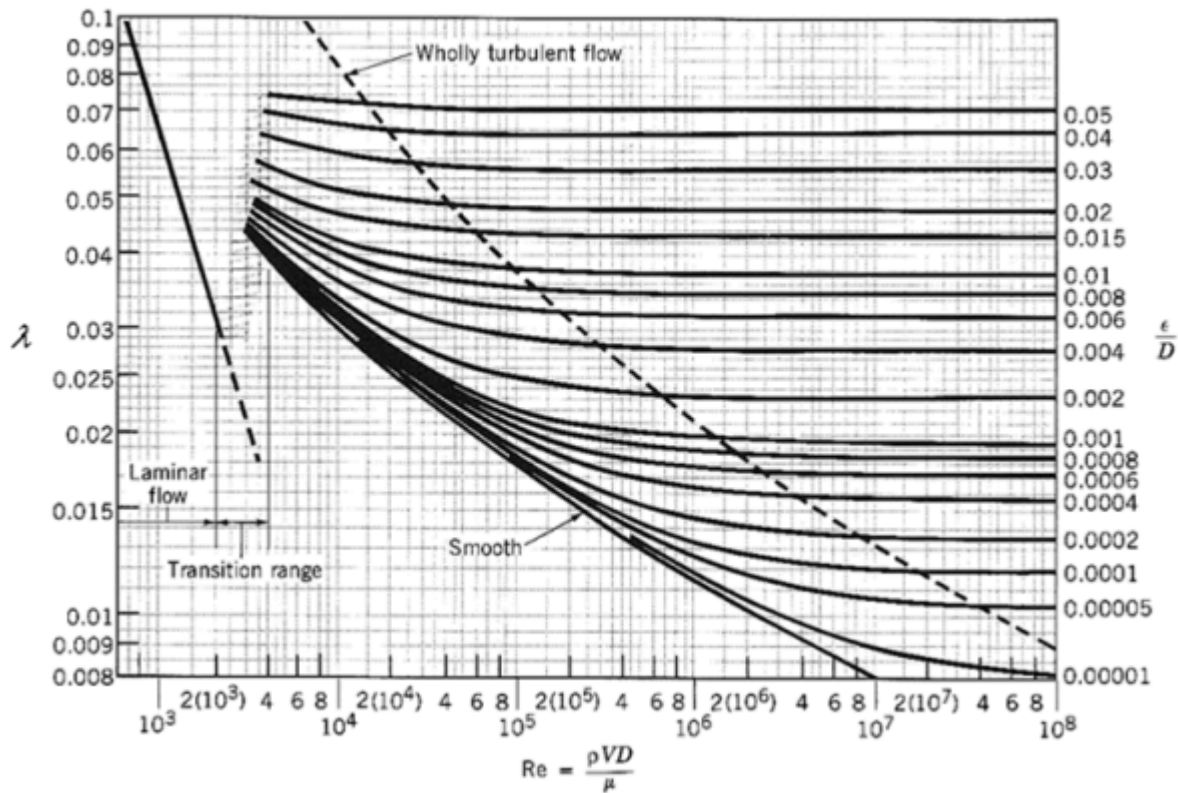
8. Le facteur de correction



Annexe 4 :

Calcul des pertes de charges singulières.

1. Diagramme de Moody pour la détermination du coefficient de pertes de charges λ



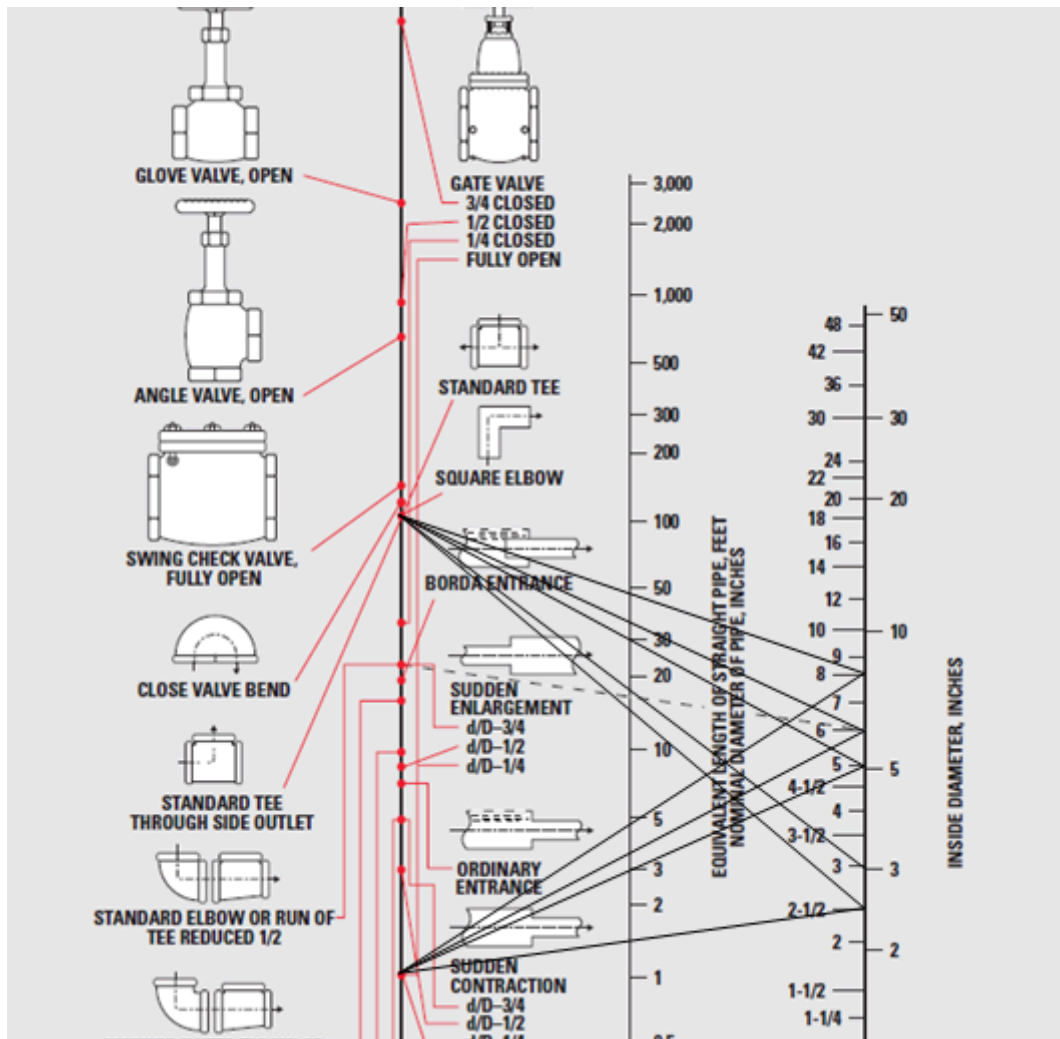
2. Les pertes de charges singulières au niveau des vannes et des coudes

Les pertes de charges singulières sont dues à la dissipation de l'énergie localisée dans les coudes et les vannes, elles sont caractérisées par un coefficient sans dimensions K déterminé expérimentalement tel que :

$$\Delta H_s = K \times \frac{U^2}{2g} = \lambda \times \frac{L_{eq}}{D} \times \frac{U^2}{2g}$$

Avec :

L_{eq} : La longueur équivalente ; c'est la longueur de canalisation qui fournirait la même perte de charge que la singularité. On utilise l'abaque suivant pour la déterminer :



Après avoir déterminé les longueurs équivalentes on procède de la même façon établie pour le calcul des pertes de charges régulières. Les feuilles de calcul Excel pour la détermination des pertes de charges singulières donnent les résultats suivants :

Circuit hydraulique huile synthétique													
Les coudes 90 °	Nombre	Leq (")	Leq (m)	D (m)	D (")	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
Cd1	1	45	13,716	0,203	7,992	2,614174	1129,2159	0,0001826	3281759,71	0,00009	0,00044335	0,017	0,40008329
Cd2	1	45	13,716	0,203	7,992	2,735354	1129,0868	0,0001826	3433492,36	0,00009	0,00044335	0,017	0,438034482
Cd3	2	35	10,668	0,154	6,063	3,093279	1128,7057	0,0001826	2944555,74	0,00009	0,00058442	0,018	1,216197325
Cd4	7	35	10,668	0,154	6,063	2,956243	1128,8516	0,0001826	2814472,36	0,00009	0,00058442	0,018	3,887892084
Cd8	3	30	9,144	0,128	5,039	2,295974	961,6	0,0001826	1547642,36	0,00009	0,00070313	0,018	1,036465669
Cd6	3	35	10,668	0,154	6,063	3,093279	919	0,0001826	2397477,77	0,00009	0,00058442	0,018	1,824295988
Cd tubes récepteurs	64	15	4,572	0,065	2,559	3,3	940,3	0,0001826	1104569,28	0,002	0,03076923	0,06	149,9177191
Les vannes	Nombre	Leq (")	Leq (m)	D (m)	D (")	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
V-1	1	4,5	1,3716	0,203	7,992	2,614174	1129,2159	0,0001826	3281759,71	0,00009	0,00044335	0,017	0,040008329
V-2	1	4,5	1,3716	0,203	7,992	2,735354	1129,0868	0,0001826	3433492,36	0,00009	0,00044335	0,017	0,043803448
V- tube récepteurs	16	1,5	0,4572	0,065	2,559	3,3	940,3	0,0001826	1104569,28	0,002	0,03076923	0,06	3,747942978
V-8	2	3	0,9144	0,128	5,039	2,295974	961,6	0,0001826	1547642,36	0,00009	0,00070313	0,018	0,069097711
V-4	4	3,5	1,0668	0,154	6,063	2,956243	1128,8516	0,0001826	2814472,36	0,00009	0,00058442	0,018	0,222165262
V-3	2	3,5	1,0668	0,154	6,063	3,093279	1128,7057	0,0001826	2944555,74	0,00009	0,00058442	0,018	0,121619733
V-6	2	3,5	1,0668	0,154	6,063	3,093279	919	0,0001826	2397477,77	0,00009	0,00058442	0,018	0,121619733
V-2-3-5	1	4,5	1,3716	0,203	7,992	2,735354	1129,0868	0,0001826	3433492,36	0,00009	0,00044335	0,017	0,043803448
V-7	1	3,5	1,0668	0,154	6,063	2,956243	961,6	0,0001826	2397477,77	0,00009	0,00058442	0,018	0,055541315
Régulateurs de débits	Nombre	Leq (")	Leq (m)	D (m)	D (")	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
R-8	1	3	0,9144	0,128	5,039	2,295974	961,6	0,0001826	1547642,36	0,00009	0,00070313	0,018	0,034548856
R-7	1	3,5	1,0668	0,154	6,063	2,956243	961,6	0,0001826	2397477,77	0,00009	0,00058442	0,018	0,055541315
R-6	1	3,5	1,0668	0,154	6,063	3,093279	919	0,0001826	2397477,77	0,00009	0,00058442	0,018	0,060809866
R-3	1	3,5	1,0668	0,154	6,063	3,093279	1128,7057	0,0001826	2944555,74	0,00009	0,00058442	0,018	0,060809866
R-5	1	3	0,9144	0,128	5,039	2,402403	919	0,0001826	60930679,9	0,00009	1,7859E-05	0,018	0,037826099

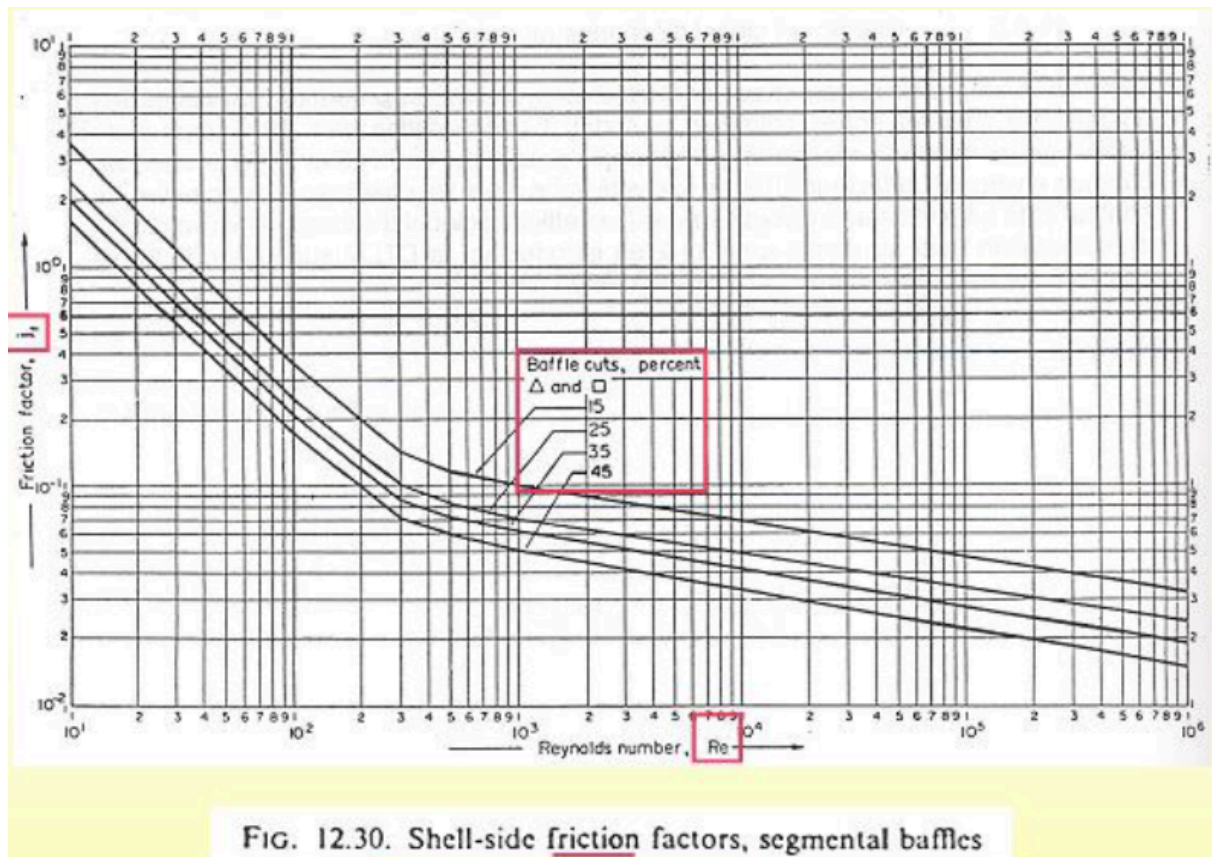
Circuit hydraulique Eau surchauffée													
Les coudes 90 °	Nombre	Leq (")	Leq (m)	D (")	D (m)	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
Cd-10	2	30	9,144	5,03936	0,128	2,80026051	906,19	0,000189	1718564,62	0,00009	0,00070313	0,018	1,027842608
Cd-9	4	30	9,144	5,03936	0,128	2,71548676	934,48	0,000189	1718564,62	0,00009	0,00070313	0,018	1,933103564
Cd-13	4	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	1,720300792
Cd16	4	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	1,617718299
Cd15	3	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	1,213288724
Cd12	3	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	1,290225594
Cd14	3	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	1,213288724
Cd11	3	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	1,290225594
Les vannes	Nombre	Leq (")	Leq (m)	D (")	D (m)	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
V-9	2	30	9,144	5,03936	0,128	2,71548676	934,48	0,000189	1718564,62	0,00009	0,00070313	0,018	0,966551782
V-11	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-11	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-14	1	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	0,404429575
V-12	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-12	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-15	1	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	0,404429575
Vanne V-13	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-13	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
Vanne 3 voie V-16	1	17	5,1816	3,0677104	0,07792	2,44257826	934,48	0,000189	941034,699	0,00009	0,00115503	0,02	0,404429575
Régulateur	Nombre	Leq (")	Leq (m)	D (")	D (m)	U (m/s)	p (Kg/m ³)	μ (Kg/m s)	Re	ε (m)	ε/D	λ	Pertes de charge (Pa)
R-11	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
R-12	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198
R-13	1	17	5,1816	3,0677104	0,07792	2,51883218	906,19	0,000189	941034,699	0,00009	0,00115503	0,02	0,430075198

3. Les pertes de charges au niveau de l'échangeur de chaleur

Les pertes de charges au niveau de l'échangeur de chaleur sont données par :

$$\Delta P = 8 \times Jf \times \frac{Dc}{de} \times \frac{Lt}{lb} \times \frac{\rho \times Vc^2}{2} \times \left(\frac{\mu}{\mu w} \right)^{-0.14}$$

Où J_f est le coefficient de friction , il est déterminé à partir du diagramme suivant :



AN :

Echangeur de chaleur Huile synthétique-Eau surchauffée									
Dc	de	Lt	lB	ρ	Vc	Rec	J_f	Pertes de charges Pa	
0,787	0,02715419	6,096	0,1524	940,3	0,00016208	383812,598	0,038	0,004352562	

Annexe 5 :

Programme « Littéral Structuré » de l'API

```

001 *=1 (Début de traitement)
002 LD %I2.1
003 AND%I1.1
004 AND%I1.3
005 ST%Q4.1
006 AND%Q5.1
007 AND%Q5.2
008 LD%I1.1
009 AND%I1.3
010     IF %I3.4 :=true OR %I3.1 :=true then
011         ST%Q5.6, %Q5.7, %Q5.8, %Q5.10, %Q5.11, %Q5.1, %Q5.3, %Q5.5,
012         %Q5.2, %Q5.12, %Q5.13, %Q5.14, %Q5.15, %Q5.16, %Q5.17, %Q5.18
013         %Q5.19, %Q5.20, %Q4.6, %Q4.9
014     %TEMP.s=142  END_IF
015 LD %I1.1
016 AND%I1.2
017 AND%I3.2
018 ST%Q5.6, %Q5.7, %Q5.9, %Q5.8, %Q5.13, %Q5.14, %Q5.15, %Q5.16,
019 %Q5.17, %Q5.18, %Q5.19, %Q5.20, %Q4.6, %Q4.9
020     IF %I1.3 :=false AND %I3.3 :=true AND %I3.5 :=true then
021         ST%Q5.21, %Q5.22, %Q5.23, %Q5.24, %Q5.25, %Q5.26
022         AND RETURN 021
023     ELSE
024         IF %I1.1 :=true AND %I1.2 :=true AND %I3.5:=true AND %I3.3 :=true
025         AND %I1.3 :=false then
026             ST%Q4.4, %Q4.2, %Q4.8, %Q5.1, %Q5.2, %Q5.3, %Q5.7, %Q5.4
027             %Q5.5, %Q5.6, %Q5.12, %Q5.13, %Q5.14, %Q5.15, %Q5.16,
028             %Q5.17, %Q5.18, %Q5.19, %Q5.20
029             IF %I3.3 :=true AND %I1.3 :=false then
030                 ST%Q5.21, %Q5.22, %Q5.23, %Q5.24, %Q5.25, %Q5.26
031                 IF %I2.1 :=true then
032                     ST%Q4.6, %Q4.9, %Q5.6, %Q5.7, %Q5.8, %Q5.12,
032                     %Q5.13, %Q5.14, %Q5.15, %Q5.16,
033                     %Q5.17, %Q5.18, %Q5.19, %Q5.20
034                 END_IF
035             END_IF, END_IF
036             IF %I3.3:=true AND %I1.3:=true then
038                 ST %Q4.4, %Q4.9, %Q5.3, %Q5.7, %Q5.10, %Q5.1, %Q5.2
039                 %Q5.12, %Q5.13, %Q5.14, %Q5.15, %Q5.16, %Q5.17,
040                 %Q5.18, %Q5.19, %Q5.20
041             END_IF
042             RETURN 021
043     END

```

Annexe 6 :

Contact de la société Siemens et du développeur des projets CSP
Allemand Solarlite.

1. Contact de la société Siemens

Nous avons contacté la société Siemens en Allemand pour obtenir des informations sur le collecteur Siemens SunField 6 et le tube récepteur Siemens UVAC 2010 et nous avons reçu le message suivant :

Siemens Infrastructure & Cities and Energy Customer Support Center Ticket Notification

Additional Recipients / Zusätzlich Benachrichtigte: (permanent) uwe.iestrich@siemens.com

Dear customer,

Siemens has modified its business strategy and organizational setup with respect to renewable energy. The company will focus its renewable energy activities on wind and hydro power. As part of this reorganization, the Solar business was discontinued in 2013. Siemens will continue to offer suitable products for solar thermal and photovoltaic power plants, such as steam turbines, generators, grid technology and control systems, which are produced outside of the Solar business.

Wishing you all the best with your endeavors.
Kind regards

Siemens AG

Infrastructure & Cities

IC & Energy Customer Support Center

Humboldtstr. 59

90459 Nuremberg, Germany

Tel.: +49 (180) 524 7000

Fax: +49 (180) 524 2471

Email: support.energy@siemens.com

Internet: www.siemens.com/energy-support/en

Intranet: <http://intranet.siemens.com/energy-support/en>

2. Contact du développeur de projets CSP (Solarlite)

Nous avons également contacté Solarlite (Leader mondial dans le développement de projets CSP) dans le but d'obtenir les devis et autres informations, ils nous ont demandé de remplir un formulaire pour savoir des renseignements généraux sur le projet et nous avons reçu le message suivant :

Thank you for your e-mail. We made a short and rough cost estimation to give you a first orientation. This cost estimation is based on the following assumptions and information:

- The demand is only for 3.3 hours a day whereas CSP plants operate for 7-10 hrs a day on average. So Solarlite propose a downsized system (7 MWth) which operate during sunshine hours and supply the thermal consumers. Whenever thermal energy is produced when no demand exist, then the hot water has to be stored in vessels for later use.
- Design criteria: 130 °C feed water, 160 °C pressurised sub-cooled water at 13 bara, 54.5 kg/s
- Solar field of 13,248 m² mirror area, land requirement: 40,000 m² on ground (not on roof-top) @ 400 m (N-S) x 100 m (E-W) with access roads around the collectors
- DNI: 2,170 kWh/m²/a
- Annual thermal yield: 14.3 GWhth which is equivalent to 2.62 full load hours operation every day; Solar will replace 80% of the fuel (assuming the annual thermal energy demand of the plant is 3.3 hrs/day* 365 days * 15 MWth @ 18 GWhth)
- Investment: 3.8 to 4.1 million € net price, local duties, taxes and customs not included

Scope of supply and services:

Inclusions: Solar collectors, receivers, ball joints, weather station, piping & instruments within the solar collectors, control system, installation, commissioning & training

Exclusions: Land cost, land grading and compacting, header piping and instruments from solar collectors to client, mechanical equipment i.e. pump, vessels etc..., hot water storage tank, infrastructure: road, lights, water, power etc...

We look forward to your reply and comments. Please feel free and contact us for further and more detailed information.

Kind Regards

Catrin Gaede

Assistant to the Management

Le tableau suivant compare notre étude avec celle faite par Solarlite :

	<i>Notre étude</i>	<i>Etude de Solarlite</i>
<i>Puissance à installer</i>	6.3 MWth	7 MWth
<i>Taux de remplacement de la chaudière</i>	87 %	80 %
<i>Surface des miroirs</i>	13080 m ²	13248 m ²
<i>Surface du terrain</i>	45780 m ²	40000 m ²
<i>Estimation du DNI annuel</i>	2129 Kwh/m ² /an	2170 Kwh/m ² /an
<i>Coût d'investissement (en excluant les coûts de Montage du champ solaire et préparation du site)</i>	39.5 millions MAD	De 41.8 à 45.1 millions MAD