

5MP Lens Charts

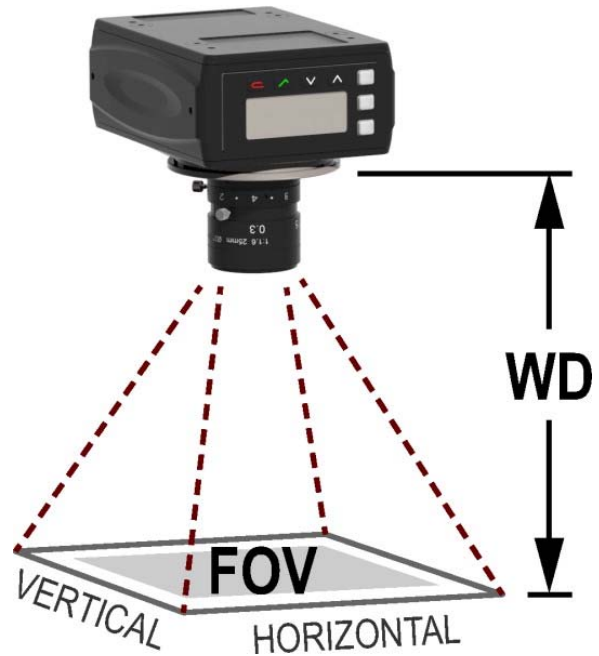
This paper offers information useful for selecting a C-mount lens for the VE Series 5MP vision sensor.

Working Distance and Field of View

The two main variables involved when discussing a camera's lens choice are the **Working Distance** and the **Field of View** size. The Working Distance, or WD, is the distance from the camera to the target object. In the case of this collection of lens charts, the Working Distance is measured from the front surface of the threaded lens cover mount. The distance is not measured from the end of the lens because different lenses from different manufacturers, even with the same focal length, can vary in length.

The Field of View, or FOV, is the real world size of the picture the camera takes. This can also be broken down into a horizontal FOV size and a vertical FOV size. Note that the picture taken by a VE Series vision sensor is not square. The imager used in the 5MP VE sensor is 2592 x 2048 pixels, making a rectangular image where the vertical FOV is 4/5 the size of the horizontal FOV.

The Working Distance and Field of View sizes are related by linear equations determined by the focal length of the lens. Choosing the correct lens for a given application might be a matter of selecting the desired size of the FOV, then seeing which of the options for focal length result in a good fit for camera Working Distance. The situation might also be reversed, where the desired mounting location of the camera is known (and thus the Working Distance is fixed) and the various focal length lenses give a range of FOV sizes to choose from. In all cases, only one of these two variables may be freely selected. The second variable then becomes a function of the first. This is the reason why we offer a broad range of lens focal lengths—to provide as many options as possible to suit different WD/FOV size requirements.



Multiple Manufacturers and Format Size

Banner does not manufacture any C-mount lenses used by our vision sensors. Any C-mount lens will technically work in a VE Series vision sensor, but some lenses are better suited than others. Banner recommends using at least 1-inch format lenses for the 5 MP VE camera. A lens of at least this format size ensures that the entire VE Series imager chip is used when taking pictures. These lenses are also better at resolving small features in the picture, allowing an inspection to make better use of the camera's resolution.

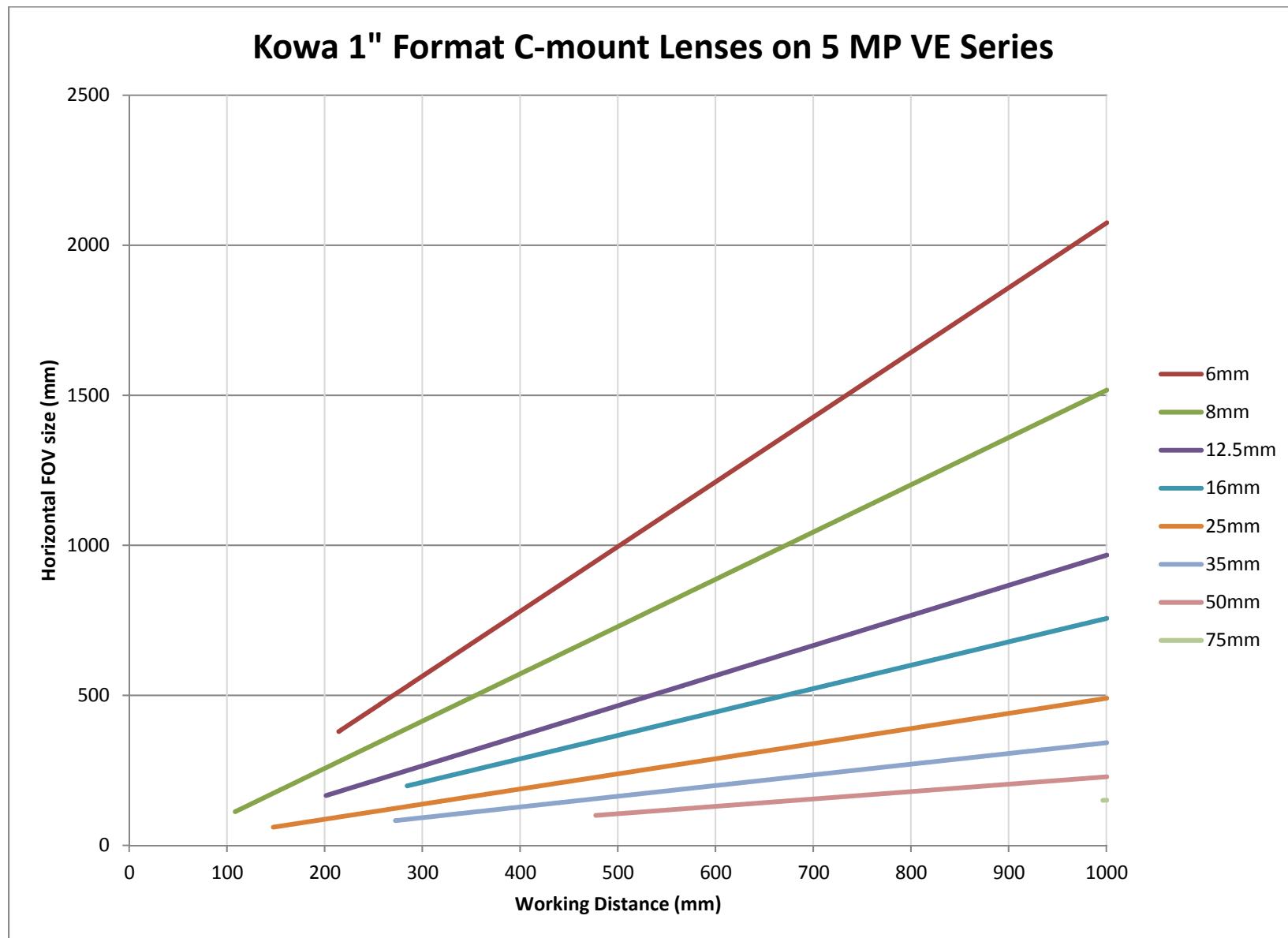
Imager Resolution: 2592 px (H) × 2048 px (W)
 Pixel Size: 4.8 μm × 4.8 μm
 Image Size: 12.4 mm (H) × 9.8 mm (W), 15.9 mm (diagonal)

Off the Charts

In the pages that follow, graphical views of the Working Distance versus Horizontal FOV relationships are shown, out to a maximum working distance of 1 meter. These graphs offer a quick and easy way to estimate the FOV size for a given Working Distance and lens focal length. Also provided are two tables with entries out to 1.5 meters. The first shows FOV size as a function of Working Distance and the second shows Working Distance as a function of FOV size. The mathematical equations that describe the relationship between these two variables are also provided, allowing for calculations beyond what the chart and tables offer.

Each lens has a natural minimum Working Distance. If a camera using this lens were to move closer to the target than this minimum distance, the image would be out of focus and the lens alone would not be able to fix it. This is where extension tubes and shims are used. Extension tubes allow a lens to come into focus at a Working Distance closer than the minimum. The relationship between Working Distance and FOV size remains in effect as extension tubes are added, and so extension tubes are usually used to generate very small FOVs. A microscope is basically a high focal length lens with a large amount of extension tubes applied.

Kowa 1-inch Format C-mount Lenses on 5 MP VE Series



Kowa 1-inch Format C-mount Lenses on 5 MP VE Series

WD (mm)	FOV (mm)							
	6mm	8mm	12.5mm	16mm	25mm	35mm	50mm	75mm
Minimum	380 x 300 @ 214mm	109 x 86 @ 108mm	165 x 130 @ 201mm	196 x 155 @ 284mm	59 x 47 @ 147mm	82 x 65 @ 272mm	100 x 79 @ 477mm	151 x 119 @ 996mm
20								
40								
60								
80								
100								
120		131 x 104						
140		163 x 129						
160		194 x 153			67 x 53			
180		226 x 178			77 x 61			
200		257 x 203			87 x 69			
220	392 x 310	289 x 228	185 x 146		97 x 77			
240	435 x 344	320 x 253	205 x 162		107 x 85			
260	479 x 378	352 x 278	225 x 178		117 x 93			
280	522 x 412	383 x 303	245 x 194		128 x 101	86 x 68		
300	565 x 446	415 x 328	265 x 210	211 x 166	138 x 109	93 x 74		
320	608 x 480	446 x 352	285 x 225	226 x 179	148 x 117	100 x 79		
340	651 x 514	478 x 377	305 x 241	242 x 191	158 x 125	107 x 85		
360	694 x 548	509 x 402	325 x 257	257 x 203	168 x 133	115 x 90		
380	737 x 583	541 x 427	346 x 273	273 x 216	178 x 141	122 x 96		
400	781 x 617	572 x 452	366 x 289	289 x 228	188 x 149	129 x 102		
420	824 x 651	604 x 477	386 x 305	304 x 240	198 x 157	136 x 107		
440	867 x 685	635 x 502	406 x 320	320 x 253	208 x 164	143 x 113		
460	910 x 719	667 x 527	426 x 336	335 x 265	218 x 172	150 x 119		
480	953 x 753	698 x 552	446 x 352	351 x 277	228 x 180	157 x 124	101 x 79	
500	996 x 787	730 x 576	466 x 368	367 x 290	238 x 188	164 x 130	105 x 83	
520	1039 x 821	761 x 601	486 x 384	382 x 302	249 x 196	172 x 136	110 x 87	
540	1083 x 855	793 x 626	506 x 400	398 x 314	259 x 204	179 x 141	115 x 91	
560	1126 x 889	824 x 651	526 x 416	413 x 327	269 x 212	186 x 147	120 x 95	
580	1169 x 923	856 x 676	546 x 431	429 x 339	279 x 220	193 x 152	125 x 99	
600	1212 x 958	887 x 701	566 x 447	445 x 351	289 x 228	200 x 158	130 x 103	
620	1255 x 992	919 x 726	586 x 463	460 x 364	299 x 236	207 x 164	135 x 107	
640	1298 x 1026	950 x 751	606 x 479	476 x 376	309 x 244	214 x 169	140 x 111	
660	1342 x 1060	982 x 776	626 x 495	491 x 388	319 x 252	222 x 175	145 x 114	
680	1385 x 1094	1013 x 800	646 x 511	507 x 401	329 x 260	229 x 181	150 x 118	
700	1428 x 1128	1045 x 825	666 x 526	523 x 413	339 x 268	236 x 186	155 x 122	
720	1471 x 1162	1076 x 850	687 x 542	538 x 425	349 x 276	243 x 192	160 x 126	
740	1514 x 1196	1108 x 875	707 x 558	554 x 437	359 x 284	250 x 198	165 x 130	
760	1557 x 1230	1139 x 900	727 x 574	569 x 450	369 x 292	257 x 203	169 x 134	
780	1600 x 1264	1171 x 925	747 x 590	585 x 462	380 x 300	264 x 209	174 x 138	
800	1644 x 1298	1202 x 950	767 x 606	601 x 474	390 x 308	271 x 214	179 x 142	
820	1687 x 1333	1234 x 975	787 x 622	616 x 487	400 x 316	279 x 220	184 x 146	
840	1730 x 1367	1265 x 1000	807 x 637	632 x 499	410 x 324	286 x 226	189 x 149	
860	1773 x 1401	1297 x 1024	827 x 653	647 x 511	420 x 332	293 x 231	194 x 153	
880	1816 x 1435	1328 x 1049	847 x 669	663 x 524	430 x 340	300 x 237	199 x 157	
900	1859 x 1469	1360 x 1074	867 x 685	679 x 536	440 x 348	307 x 243	204 x 161	
920	1902 x 1503	1391 x 1099	887 x 701	694 x 548	450 x 356	314 x 248	209 x 165	
940	1946 x 1537	1423 x 1124	907 x 717	710 x 561	460 x 364	321 x 254	214 x 169	
960	1989 x 1571	1454 x 1149	927 x 732	725 x 573	470 x 372	329 x 260	219 x 173	
980	2032 x 1605	1486 x 1174	947 x 748	741 x 585	480 x 379	336 x 265	224 x 177	
1000	2075 x 1639	1517 x 1199	967 x 764	757 x 598	490 x 387	343 x 271	229 x 181	151 x 119
1020	2118 x 1673	1549 x 1224	987 x 780	772 x 610	501 x 395	350 x 276	233 x 184	154 x 122
1040	2161 x 1707	1580 x 1248	1007 x 796	788 x 622	511 x 403	357 x 282	238 x 188	157 x 124
1060	2205 x 1742	1612 x 1273	1027 x 812	803 x 635	521 x 411	364 x 288	243 x 192	161 x 127
1080	2248 x 1776	1643 x 1298	1048 x 828	819 x 647	531 x 419	371 x 293	248 x 196	164 x 129
1100	2291 x 1810	1675 x 1323	1068 x 843	835 x 659	541 x 427	378 x 299	253 x 200	167 x 132
1120	2334 x 1844	1706 x 1348	1088 x 859	850 x 672	551 x 435	386 x 305	258 x 204	171 x 135
1140	2377 x 1878	1738 x 1373	1108 x 875	866 x 684	561 x 443	393 x 310	263 x 208	174 x 137
1160	2420 x 1912	1769 x 1398	1128 x 891	881 x 696	571 x 451	400 x 316	268 x 212	177 x 140
1180	2463 x 1946	1801 x 1423	1148 x 907	897 x 709	581 x 459	407 x 322	273 x 216	180 x 143
1200	2507 x 1980	1832 x 1448	1168 x 923	913 x 721	591 x 467	414 x 327	278 x 219	184 x 145
1220	2550 x 2014	1864 x 1472	1188 x 938	928 x 733	601 x 475	421 x 333	283 x 223	187 x 148
1240	2593 x 2048	1895 x 1497	1208 x 954	944 x 746	611 x 483	428 x 338	288 x 227	190 x 150
1260	2636 x 2082	1927 x 1522	1228 x 970	959 x 758	621 x 491	435 x 344	293 x 231	194 x 153
1280	2679 x 2117	1958 x 1547	1248 x 986	975 x 770	632 x 499	443 x 350	297 x 235	197 x 156
1300	2722 x 2151	1990 x 1572	1268 x 1002	991 x 783	642 x 507	450 x 355	302 x 239	200 x 158
1320	2765 x 2185	2021 x 1597	1288 x 1018	1006 x 795	652 x 515	457 x 361	307 x 243	204 x 161
1340	2809 x 2219	2053 x 1622	1308 x 1034	1022 x 807	662 x 523	464 x 367	312 x 247	207 x 163
1360	2852 x 2253	2084 x 1647	1328 x 1049	1037 x 819	672 x 531	471 x 372	317 x 251	210 x 166
1380	2895 x 2287	2116 x 1671	1348 x 1065	1053 x 832	682 x 539	478 x 378	322 x 254	213 x 169
1400	2938 x 2321	2147 x 1696	1368 x 1081	1069 x 844	692 x 547	485 x 383	327 x 258	217 x 171
1420	2981 x 2355	2179 x 1721	1389 x 1097	1084 x 856	702 x 555	493 x 389	332 x 262	220 x 174
1440	3024 x 2389	2210 x 1746	1409 x 1113	1100 x 869	712 x 563	500 x 395	337 x 266	223 x 176
1460	3068 x 2423	2242 x 1771	1429 x 1129	1115 x 881	722 x 571	507 x 400	342 x 270	227 x 179
1480	3111 x 2457	2273 x 1796	1449 x 1144	1131 x 893	732 x 579	514 x 406	347 x 274	230 x 182
1500	3154 x 2492	2305 x 1821	1469 x 1160	1147 x 906	742 x 587	521 x 412	352 x 278	233 x 184

Kowa 1-inch Format C-mount Lenses on 5 MP VE Series

FOV (mm)	WD (mm)								
	6mm	8mm	12.5mm	16mm	25mm	35mm	50mm	75mm	
Minimum	380 x 300 @ 214mm	109 x 86 @ 108mm	165 x 130 @ 201mm	196 x 155 @ 284mm	59 x 47 @ 147mm	82 x 65 @ 272mm	100 x 79 @ 477mm	151 x 119 @ 996mm	
20 x 16									
40 x 32									
60 x 47									
80 x 63						146			
100 x 79						186			
120 x 95						225	319	478	
140 x 111			113			265	375	559	
160 x 126			126			305	431	640	
180 x 142			138			344	487	722	1056
200 x 158			151	215		384	544	803	1178
220 x 174			164	235	286	424	600	884	1299
240 x 190			176	255	312	463	656	965	1420
260 x 205			189	275	338	503	712	1047	1541
280 x 221			202	295	363	543	768	1128	1662
300 x 237			214	315	389	582	824	1209	1784
320 x 253			227	335	415	622	880	1290	1905
340 x 269			240	355	440	662	936	1372	2026
360 x 284			253	374	466	702	992	1453	2147
380 x 300	214		265	394	492	741	1048	1534	2268
400 x 316	224		278	414	517	781	1104	1615	2390
420 x 332	233		291	434	543	821	1160	1697	2511
440 x 348	242		303	454	568	860	1217	1778	2632
460 x 363	251		316	474	594	900	1273	1859	2753
480 x 379	261		329	494	620	940	1329	1941	2875
500 x 395	270		341	514	645	979	1385	2022	2996
520 x 411	279		354	534	671	1019	1441	2103	3117
540 x 427	288		367	554	697	1059	1497	2184	3238
560 x 442	298		380	574	722	1098	1553	2266	3359
580 x 458	307		392	594	748	1138	1609	2347	3481
600 x 474	316		405	614	774	1178	1665	2428	3602
620 x 490	326		418	634	799	1217	1721	2509	3723
640 x 506	335		430	654	825	1257	1777	2591	3844
660 x 521	344		443	674	851	1297	1833	2672	3965
680 x 537	353		456	694	876	1336	1890	2753	4087
700 x 553	363		468	714	902	1376	1946	2834	4208
720 x 569	372		481	733	927	1416	2002	2916	4329
740 x 585	381		494	753	953	1455	2058	2997	4450
760 x 600	390		507	773	979	1495	2114	3078	4572
780 x 616	400		519	793	1004	1535	2170	3160	4693
800 x 632	409		532	813	1030	1575	2226	3241	4814
820 x 648	418		545	833	1056	1614	2282	3322	4935
840 x 664	428		557	853	1081	1654	2338	3403	5056
860 x 679	437		570	873	1107	1694	2394	3485	5178
880 x 695	446		583	893	1133	1733	2450	3566	5299
900 x 711	455		595	913	1158	1773	2507	3647	5420
920 x 727	465		608	933	1184	1813	2563	3728	5541
940 x 743	474		621	953	1210	1852	2619	3810	5662
960 x 758	483		634	973	1235	1892	2675	3891	5784
980 x 774	492		646	993	1261	1932	2731	3972	5905
1000 x 790	502		659	1013	1287	1971	2787	4054	6026
1020 x 806	511		672	1033	1312	2011	2843	4135	6147
1040 x 822	520		684	1053	1338	2051	2899	4216	6268
1060 x 837	530		697	1072	1363	2090	2955	4297	6390
1080 x 853	539		710	1092	1389	2130	3011	4379	6511
1100 x 869	548		722	1112	1415	2170	3067	4460	6632
1120 x 885	557		735	1132	1440	2209	3123	4541	6753
1140 x 901	567		748	1152	1466	2249	3180	4622	6875
1160 x 916	576		760	1172	1492	2289	3236	4704	6996
1180 x 932	585		773	1192	1517	2329	3292	4785	7117
1200 x 948	594		786	1212	1543	2368	3348	4866	7238
1220 x 964	604		799	1232	1569	2408	3404	4947	7359
1240 x 980	613		811	1252	1594	2448	3460	5029	7481
1260 x 995	622		824	1272	1620	2487	3516	5110	7602
1280 x 1011	631		837	1292	1646	2527	3572	5191	7723
1300 x 1027	641		849	1312	1671	2567	3628	5273	7844
1320 x 1043	650		862	1332	1697	2606	3684	5354	7965
1340 x 1059	659		875	1352	1722	2646	3740	5435	8087
1360 x 1074	669		887	1372	1748	2686	3796	5516	8208
1380 x 1090	678		900	1392	1774	2725	3853	5598	8329
1400 x 1106	687		913	1411	1799	2765	3909	5679	8450
1420 x 1122	696		926	1431	1825	2805	3965	5760	8572
1440 x 1138	706		938	1451	1851	2844	4021	5841	8693
1460 x 1153	715		951	1471	1876	2884	4077	5923	8814
1480 x 1169	724		964	1491	1902	2924	4133	6004	8935
1500 x 1185	733		976	1511	1928	2963	4189	6085	9056
			989	1531	1953	3003	4245	6166	9178

Kowa 1-inch Format Lens equations for 5 MP VE Series

H = horizontal FOV size, W = working distance



6 mm 1-inch format lens

Banner model: LCF06LK1F (p/n 803861)

Kowa model: LM6HC (1-inch format)

1-inch format, no compatible filter, minimum f/1.8

H(W), mm

$$H = 2.1575 \times W - 82.43 \text{ (minimum } W \sim 214 \text{ mm)}$$

W(H), mm

$$W = (H + 82.43)/2.1575 \text{ (minimum } H \sim 380 \text{ mm)}$$



8 mm 1-inch format lens

Banner model: LCF08LK1F (p/n 803862)

Kowa model: LM8HC (1-inch format)

1-inch format, 55 mm filter, minimum f/1.4

H(W), mm

$$H = 1.5751 \times W - 57.831 \text{ (minimum } W \sim 108 \text{ mm)}$$

W(H), mm

$$W = (H + 57.831)/1.5751 \text{ (minimum } H \sim 109 \text{ mm)}$$



12.5 mm 1-inch format lens

Banner model: LCF12LK1F (p/n 803863)

Kowa model: LM12HC (1-inch format)

1-inch format, 35.5 mm filter, minimum f/1.4

H(W), mm

$$H = 1.0029 \times W - 35.58 \text{ (minimum } W \sim 201 \text{ mm)}$$

W(H), mm

$$W = (H + 35.58)/1.0029 \text{ (minimum } H \sim 165 \text{ mm)}$$



16 mm 1-inch format lens

Banner model: LCF16LK1F (p/n 803864)

Kowa model: LM16HC (1-inch format)

1-inch format, 35.5 mm filter, minimum f/1.4

H(W), mm

$$H = 0.7799 \times W - 23.347 \text{ (minimum } W \sim 284 \text{ mm)}$$

W(H), mm

$$W = (H + 23.347)/0.7799 \text{ (minimum } H \sim 196 \text{ mm)}$$



25 mm 1-inch format lens

Banner model: LCF25LK1F (p/n 803865)

Kowa model: LM25HC (1-inch format)

1-inch format, 35.5 mm filter, minimum f/1.4

H(W), mm

$$H = 0.504 \times W - 13.571 \text{ (minimum } W \sim 147 \text{ mm)}$$

W(H), mm

$$W = (H + 13.571)/0.504 \text{ (minimum } H \sim 59 \text{ mm)}$$



35 mm 1-inch format lens

Banner model: LCF35LK1F (p/n 803866)

Kowa model: LM35HC (1-inch format)

1-inch format, 35.5 mm filter, minimum f/1.4

H(W), mm

$$H = 0.3566 \times W - 13.823 \text{ (minimum } W \sim 272 \text{ mm)}$$

W(H), mm

$$W = (H + 13.823)/0.3566 \text{ (minimum } H \sim 82 \text{ mm)}$$



50 mm 1-inch format lens

Banner model: LCF50LK1F (p/n 803867)

Kowa model: LM50HC (1-inch format)

1-inch format, 40.5 mm filter, minimum f/1.4

H(W), mm

$$H = 0.2461 \times W - 17.569 \text{ (minimum } W \sim 477 \text{ mm)}$$

W(H), mm

$$W = (H + 17.569)/0.2461 \text{ (minimum } H \sim 100 \text{ mm)}$$



75 mm 1-inch format lens

Banner model: LCF75LK1F (p/n 803868)

Kowa model: LM75HC (1-inch format)

1-inch format, 46 mm filter, minimum f/1.8

H(W), mm

$$H = 0.165 \times W - 14.299 \text{ (minimum } W \sim 996 \text{ mm)}$$

W(H), mm

$$W = (H + 14.299)/0.165 \text{ (minimum } H \sim 151 \text{ mm)}$$