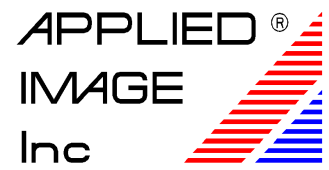


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Catalog Part No: (grouped by substrate material)

T-20-N-CG / T-20-P-CG / T-20-2-N-CG

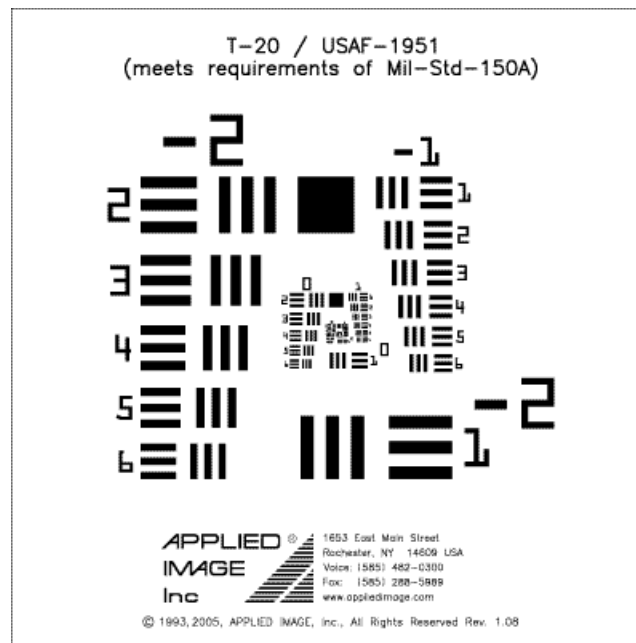
T-20-N-OP / T-20-P-OP / T-20-2-N-OP

T-20-N-TM / T-20-P-TM

T-20-N-RM / T-20-P-RM / T-20-M-P-RM / T-20-L-P-RM

Product Name: **USAF 1951 Chart** (Standard Layout)

Drawing / Photo of Part:



The above image is an approximate representation of the actual product.
Specifications are subject to change without notice.

Description: This test target meets requirements as specified in MIL-STD-150A for resolving power tests. The target consists of a series of *Elements* having two sets of lines at right angles. Each set of lines consists of three lines separated by spaces equal to the line width. Each bar has a length to width ratio of 5:1. (Line width is equal to one half of line pitch, which is the inverse of line frequency.) *Elements* are arranged in groups of six each and *Groups* are arranged in pairs. Even numbered *Groups* occupy the left side and bottom right corner and contain a square feature having an edge length equal to the line length of *Element 2* in that group. Odd numbered *Groups* occupy the top right corner and side. *Groups* and

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Elements are labeled and differentiated by numbering adjacent to their features. Frequencies in cycles/mm (c/mm) increase between each *Element* by the sixth root of two (approximately 12.25% per step). The general formula for the line frequency of any target *Element* can be expressed as $2^{\text{Group}+(\text{Element}-1)/6}$.

Note: Applied Image offers two improved versions of this test target as T-21 and T-22. These are labeled directly in c/mm to obsolete the frequency look-up chart as well as other indicator and layout improvements.

Substrate Size, Type, Image Forming Material, Polarity and Frequency Range:

<i>Part Number</i>	<i>Substrate Size (mm)</i>	<i>Substrate Type</i>	<i>Image Forming Material</i>	<i>Polarity</i>	<i>Frequencies (c/mm)</i>
T-20-N-CG	102 x 102	Soda-lime glass	Chrome	Negative	0.25 → 228
T-20-P-CG	102 x 102	Soda-lime glass	Chrome	Positive	0.25 → 228
T-20-N-OP	102 x 102	White opal glass	Chrome	Negative	0.25 → 228
T-20-P-OP	102 x 102	White opal glass	Chrome	Positive	0.25 → 228
T-20-2-N-CG	102 x 102	Soda-lime glass	Chrome	Negative	0.25 → 512
T-20-2-N-OP	102 x 102	White opal glass	Chrome	Negative	0.25 → 512
T-20-N-TM	102 x 102	Clear polyester	Photo-emulsion	Negative	0.25 → 181
T-20-P-TM	102 x 102	Clear polyester	Photo-emulsion	Positive	0.25 → 181
T-20-N-RM	102 x 102	Photo-paper	Photo-emulsion	Negative	0.25 → 22.6
T-20-P-RM	102 x 102	Photo-paper	Photo-emulsion	Positive	0.25 → 22.6
T-20-M-P-RM	305 x 305	Photo-paper	Photo-emulsion	Positive	0.0625 → 3.56
T-20-L-P-RM	1016 x 940	Photo-paper	Photo-emulsion	Positive	0.0156 → 3.56

Reading Direction: Right Read Chrome / Emulsion Up (RRCU / RREU).

Image Placement Accuracy: 0.001mm/100mm on glass. Polyester or paper expansion is the major source of change in photo-emulsion versions.

Feature Size Accuracy: Typical line width is 2 to 5 percent of aim.

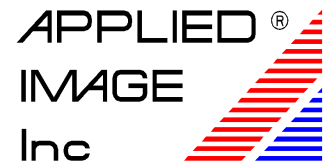
Image Contrast / Density: Chrome transmission density is 2.0 or higher; photo-emulsion transmission density 2.0 or higher (photo-emulsion on polyester); emulsion reflection density 1.3 or higher (photo-emulsion on paper).

History / typical use: Checking of optical resolving power for optical systems.

How to determine Group and Element size: With this version of the T-20 (original layout USAF-1951) chart, a look up table is needed. The chart is composed of

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GROUPs of six ELEMENTs (an element is 3 horizontal bars and 3 verticle bars of the same size). Groups are labeled with such numbers as; -6,-2,0,1,2,3. Elements are labeled 1 through 6. To tell what the resolution of an element is, note the number next to the bars (it will be 1 through 6). Then determine the group number by looking for the group number near element 1 of that group. The chart at the end of this document shows the resolution (at the chart) in cycles/mm and other

How To Use Resolution Test Charts: Multi-bar test charts are most often used to determine the overall resolution limit of an entire optical system. Each component of a system adds some degradation to image quality. Therefore, the comparison of a test chart in the object plane to the resulting image (image plane vs. film or image vs. electronic file) will produce the complete account of all components such as optics, image processing, vibration, color fringing, etc. Test charts may be used in optical systems that reduce, maintain (the same image size 1:1) or magnify the image size however; system magnification must be applied as a multiplier to determine the resolving power limit. **Example:** To evaluate a 35mm film-camera system, load the camera with the film of interest. Position the camera at a measured distance from the test chart and achieve good focus. (Commonly 25 focal lengths is the distance used from camera to the test chart.) Develop the image and measure the object and image sizes. (i.e. If the test chart card is 100mm wide in the object plane and 5.5mm on the film, the system reduction factor is 1:18.18 (0.055). Next, examine the film image using a microscope and determine the resolution limit. If the last distinct *Element* has a frequency of 5.04 c/mm, then the resolving power or the resolution of the film is calculated from that image frequency divided by the reduction (5.04/0.055 or 91.6 c/mm).

How to read a resolution bar test pattern: Resolution is defined as a threshold measurement. The resolution limit is the last group of bars that can be seen and correctly counted in both horizontal and vertical directions. Breaks within the bar pattern are acceptable, and do not cause failure of resolution as long as the bars are distinctly identified and accurately counted. A microscope with the necessary magnification is commonly used to view reduced images. The correct number of bars must be counted when determining the resolution limit in order to avoid an inflated measure. This problem can be seen while observing increasingly finer groups. Features will be beyond resolution and then appear again. One cause of

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this spurious resolution is poor focus of a lens, which causes the bars and spaces in the image to apparently flip polarity. Other causes are artifacts from digital scanning, or image processing algorithms.

Target Viewing Angle: Test charts may be placed at the center and outer edges of the field of view so that the comparisons can be made of resolving power between locations across the field of view. Commonly, a comparison is made between center and edge at 90-degree increments at the outer edge of the field of view. This is useful for detection of directional vibration influences and the common problem of uniformity of quality throughout the lens field of view. A more complete assessment would use charts at additional locations throughout the field for example, comparing resolving power at the center with the entire outside edge at 45-degree increments.

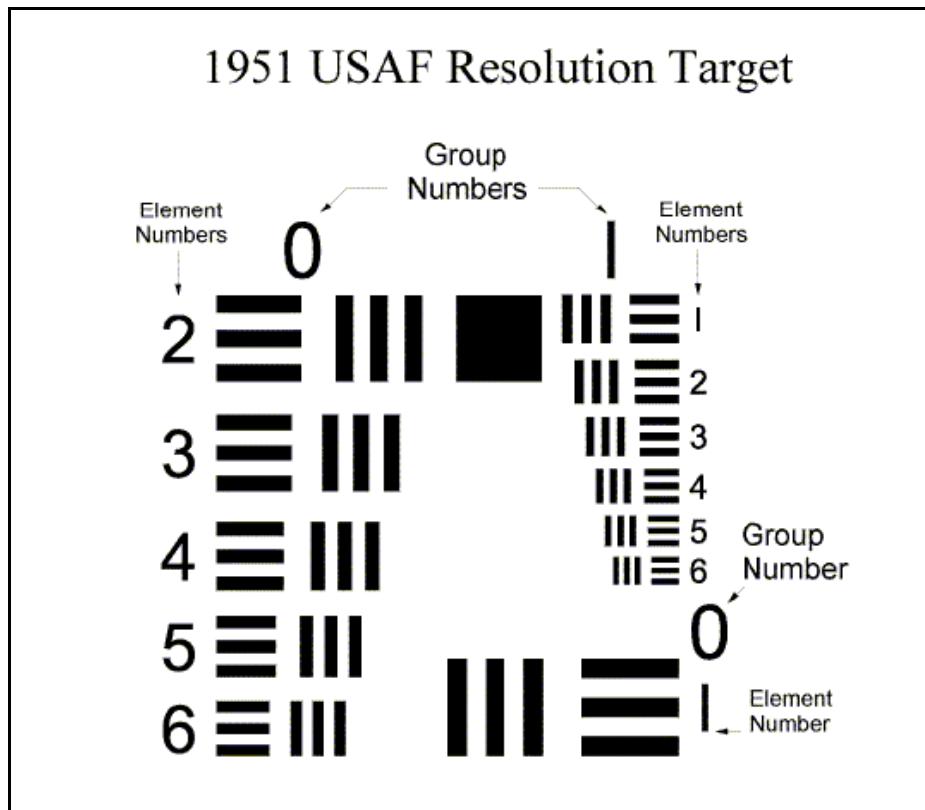
Terms: Line pairs per mm (LP/mm) or Lines per mm (lpmm) equals cycles per mm.

Related documents:

c-mm LPI DPI info.pdf,
T-21-spec.pdf,
T-22-spec.pdf

Related Parts: T-21, T-22, T-10

How to determine Group and Element size: With this version of the T-20 (original layout USAF-1951) chart, a look up table is needed. (all this look-up can be avoided by use of the T-21 or T-22 charts, which are labeled in cycles/mm) .The chart is composed of GROUPs of six ELEMENTs (an element is 3 horizontal bars and 3 verticle bars of the same size). Groups are labeled with such numbers as; -6,-2,0,1,2,3. Elements are labeled 1 through 6. To tell what the resolution of an element is, note the number next to the bars (it will be 1 through 6). Then determine the group number by looking for the group number near element 1 of that group. The chart at the end of this document shows the resolution (at the chart) in cycles/mm and other



1951 USAF Resolution Test Pattern - Group & Element Labels

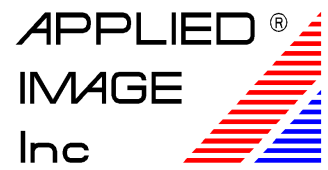
Resolution features of the 1951 USAF Resolution Target are arranged in elements and groups. Each Element is made up of equally spaced bars; three horizontal and three vertical. Groups consist of six elements labeled 1 through 6. Groups are labeled by number in order of increasing frequency.

The figure above shows the location of groups and elements. Note that Element 1 of even numbered Groups is placed in the lower right corner and diagonally opposite Element 2 of the same Group. With this exception, all Elements are arranged in ascending order from top bottom.

The resolution limit of a system is found by examining an image of the resolution test target to locate the Element of highest frequency where either horizontal or vertical lines are not indistinct. Note that the horizontal limit of resolution may indicate a different frequency than the limit of vertical resolution.

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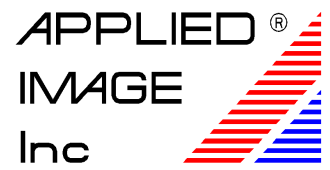


Group	Element	Frequency (cycles/mm)	Line or space width (micron)	Line or space width (inches)	DPI (Dots per inch)	PPI (Pixels per inch)	LPPI (line pairs per inch)	Dots per Cm	Lines pairs per Cm
-6	1	0.016	32000	1.259843		0.79	0.40	0.31	0.16
	2	0.018	28509	1.122392		0.89	0.45	0.35	0.18
	3	0.020	25398	0.999938		1.00	0.50	0.39	0.20
	4	0.022	22627	0.890843		1.12	0.56	0.44	0.22
	5	0.025	20159	0.793651		1.26	0.63	0.50	0.25
	6	0.028	17959	0.707063		1.41	0.71	0.56	0.28
-5	1	0.031	16000	0.629921		1.59	0.79	0.63	0.31
	2	0.035	14254	0.561196		1.78	0.89	0.70	0.35
	3	0.039	12699	0.499969		2.00	1.00	0.79	0.39
	4	0.044	11314	0.445422		2.25	1.12	0.88	0.44
	5	0.050	10079	0.396826		2.52	1.26	0.99	0.50
	6	0.056	8980	0.353531		2.83	1.41	1.11	0.56
-4	1	0.063	8000	0.314961		3.18	1.59	1.25	0.63
	2	0.070	7127	0.280598		3.56	1.78	1.40	0.70
	3	0.079	6350	0.249984		4.00	2.00	1.57	0.79
	4	0.088	5657	0.222711		4.49	2.25	1.77	0.88
	5	0.099	5040	0.198413		5.04	2.52	1.98	0.99
	6	0.111	4490	0.176766		5.66	2.83	2.23	1.11
-3	1	0.125	4000	0.157480		6.35	3.18	2.50	1.25
	2	0.140	3564	0.140299		7.13	3.56	2.81	1.40
	3	0.157	3175	0.124992		8.00	4.00	3.15	1.57
	4	0.177	2828	0.111355		8.98	4.49	3.54	1.77

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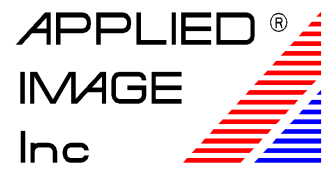


	5	0.198	2520	0.099206		10.08	5.04		3.97	1.98
	6	0.223	2245	0.088383		11.31	5.66		4.45	2.23
-2	1	0.250	2000	0.078740		12.70	6.35		5.00	2.50
	2	0.281	1782	0.070150		14.26	7.13		5.61	2.81
	3	0.315	1587	0.062496		16.00	8.00		6.30	3.15
	4	0.354	1414	0.055678		17.96	8.98		7.07	3.54
	5	0.397	1260	0.049603		20.16	10.08		7.94	3.97
	6	0.445	1122	0.044191		22.63	11.31		8.91	4.45
-1	1	0.500	1000.00	0.039370		25.40	12.70		10.00	5.00
	2	0.561	890.90	0.035075		28.51	14.26		11.22	5.61
	3	0.630	793.70	0.031248		32.00	16.00		12.60	6.30
	4	0.707	707.11	0.027839		35.92	17.96		14.14	7.07
	5	0.794	629.96	0.024802		40.32	20.16		15.87	7.94
	6	0.891	561.23	0.022096		45.26	22.63		17.82	8.91
0	1	1.000	500.00	0.019685		50.80	25.40		20.00	10.00
	2	1.122	445.45	0.017537		57.02	28.51		22.45	11.22
	3	1.260	396.85	0.015624		64.00	32.00		25.20	12.60
	4	1.414	353.55	0.013919		71.84	35.92		28.28	14.14
	5	1.587	314.98	0.012401		80.64	40.32		31.75	15.87
	6	1.782	280.62	0.011048		90.52	45.26		35.64	17.82
1	1	2.000	250.00	0.009843		101.60	50.80		40.00	20.00
	2	2.245	222.72	0.008769		114.04	57.02		44.90	22.45
	3	2.520	198.43	0.007812		128.01	64.00		50.40	25.20
	4	2.828	176.78	0.006960		143.68	71.84		56.57	28.28
	5	3.175	157.49	0.006200		161.28	80.64		63.50	31.75
	6	3.564	140.31	0.005524		181.03	90.52		71.27	35.64

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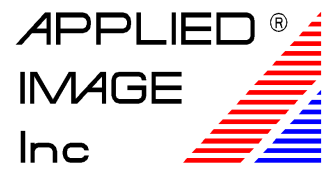


Group	Element	Frequency (cycles/mm)	Line or space width (micron)	Line or space width (inches)	DPI (Dots per inch)	PPI (Pixels per inch)	LPPI (line pairs per inch)	Dots per Cm	Lines pairs per Cm
2	1	4.00	125.00	0.004921	203.20	101.60		80.00	40.00
	2	4.49	111.36	0.004384	228.08	114.04		89.80	44.90
	3	5.04	99.21	0.003906	256.02	128.01		100.79	50.40
	4	5.66	88.39	0.003480	287.37	143.68		113.14	56.57
	5	6.35	78.75	0.003100	322.56	161.28		126.99	63.50
	6	7.13	70.15	0.002762	362.06	181.03		142.54	71.27
3	1	8.00	62.50	0.002461	406.40	203.20		160.00	80.00
	2	8.98	55.68	0.002192	456.17	228.08		179.59	89.80
	3	10.08	49.61	0.001953	512.03	256.02		201.59	100.79
	4	11.31	44.19	0.001740	574.74	287.37		226.27	113.14
	5	12.70	39.37	0.001550	645.12	322.56		253.98	126.99
	6	14.25	35.08	0.001381	724.12	362.06		285.09	142.54
4	1	16.00	31.25	0.001230	812.80	406.40		320.00	160.00
	2	17.96	27.84	0.001096	912.34	456.17		359.19	179.59
	3	20.16	24.80	0.000977	1024.06	512.03		403.17	201.59
	4	22.63	22.10	0.000870	1149.47	574.74		452.55	226.27
	5	25.40	19.69	0.000775	1290.24	645.12		507.97	253.98
	6	28.51	17.54	0.000690	1448.24	724.12		570.18	285.09
5	1	32.00	15.63	0.000615	1625.60	812.80		640.00	320.00
	2	35.92	13.92	0.000548	1824.67	912.34		718.38	359.19
	3	40.32	12.40	0.000488	2048.13	1024.06		806.35	403.17
	4	45.25	11.05	0.000435	2298.95	1149.47		905.10	452.55

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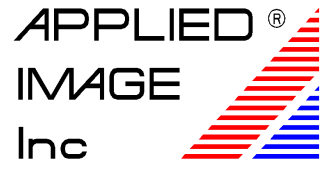


	5	50.80	9.84	0.000388		2580.48	1290.24		1015.94	507.97
	6	57.02	8.77	0.000345		2896.49	1448.24		1140.35	570.18
6	1	64.00	7.81	0.000308		3251.20	1625.60		1280.00	640.00
	2	71.84	6.96	0.000274		3649.35	1824.67		1436.75	718.38
	3	80.63	6.20	0.000244		4096.26	2048.13		1612.70	806.35
	4	90.51	5.52	0.000217		4597.89	2298.95		1810.19	905.10
	5	101.59	4.92	0.000194		5160.96	2580.48		2031.87	1015.94
	6	114.04	4.38	0.000173		5792.98	2896.49		2280.70	1140.35
7	1	128.00	3.91	0.000154		6502.40	3251.20		2560.00	1280.00
	2	143.68	3.48	0.000137		7298.70	3649.35		2873.50	1436.75
	3	161.27	3.10	0.000122		8192.51	4096.26		3225.40	1612.70
	4	181.02	2.76	0.000109		9195.78	4597.89		3620.39	1810.19
	5	203.19	2.46	0.000097		10321.92	5160.96		4063.75	2031.87
	6	228.07	2.19	0.000086		11585.96	5792.98		4561.40	2280.70
8	1	256.00	1.95	0.000077		13004.80	6502.40		5120.00	2560.00
	2	287.35	1.74	0.000069		14597.39	7298.70		5747.01	2873.50
	3	322.54	1.55	0.000061		16385.02	8192.51		6450.80	3225.40
	4	362.04	1.38	0.000054		18391.56	9195.78		7240.77	3620.39
	5	406.37	1.23	0.000048		20643.83	10321.92		8127.49	4063.75
	6	456.14	1.10	0.000043		23171.92	11585.96		9122.80	4561.40
9	1	512.00	0.98	0.000038		26009.60	13004.80		10240.00	5120.00
	2	574.70	0.87	0.000034		29194.79	14597.39		11494.01	5747.01
	3	645.08	0.78	0.000031		32770.04	16385.02		12901.59	6450.80
	4	724.08	0.69	0.000027		36783.13	18391.56		14481.55	7240.77
	5	812.75	0.62	0.000024		41287.67	20643.83		16254.99	8127.49
	6	912.28	0.55	0.000022		46343.84	23171.92		18245.61	9122.80

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Group	Element	Frequency (cycles/mm)	Line or space width (micron)	Line or space width (inches)	DPI (Dots per inch) PPI (Pixels per Inch)	LPPI (line pairs per inch)	Dots per Cm	Lines pairs per Cm
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