



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

Many of us would not have passed our childhood without visiting a circus, at least once. And, how happy we were laughing our heart out when the “joker team” made all sorts of pranks. Their colorful conical cap is one interesting part of their attire that gave them a distinct personality. Not to forget the big red cherry nose, of course. And no wonder that the cap became so popular that it was called “foolscap.” It was made short or long either from a 216 mm (8.5 inch) x 343 mm (13.5 inch) or 432 mm (17 inch) x 343 mm (13.5 inch) paper. And, many of grew up to become engineers, entrepreneurs, artists so on and so forth. Whatever the path of journey may be, it is impossible to stay away from one thing: PAPER. And, paper of different sizes have helped us accomplish many things. Writing, painting, typing, printing and scribbling something. How much ever can be the popularity of latest technologies, paper remains an indispensable part of our daily activities.

This week, let us explore the paper from its dimensional perspective. Whether you are using an envelope to post a letter or printing some report or photocopying a journal. International Organization for Standardization (ISO) have setup certain guidelines for different paper sizes. This will help in working with paper anywhere in the world easier and common.

Standard paper sizes like ISO A4 are widely used all over the world today. This text explains the ISO 216 paper size system and the science behind its design.

The ISO paper size concept

In the ISO paper size system, the height to width ratio of all pages is the square root of two ($\sqrt{2} = 1.4142:1$) called ASPECT RATIO. In other words, the width and height of a page relate to each other like the side and diagonal of a square. This aspect ratio is especially convenient for a paper size. If two “small” size pages are put next to each other, it will result in next “higher” size. For example, when two A4 sheets are placed next to each other matching “longer” side, it will result in A3 sheet.

The ISO paper sizes are based on metric system. Hence, square root of two will not permit the exact dimension. Therefore, there area of pages has been defined to have round metric values. As paper’s quality is essentially mentioned in GSM (grams per square meter) the metric value makes it simple for calculation of weight of the document if the format and number of pages are known.

ISO 216 defines the A series of paper sizes based on these simple principles:

The height divided by width of all formats will have a ratio equal to square root of two, 1.4142

Format A0 has an area of one square meter

Format A1 is A0 cut exactly into two pieces. This means the height of A1 is width of A0 and width of A1 is half the height of A0

Although inches are also used for measurement, generally the paper dimensions are defined in millimeters. Refer to table-1 (all numbers are in millimeters) for details. The inch dimensions are used in USA, Canada and few other countries. They are broadly categorized as “legal” or “letter” or “executive” types.



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

What is GEOMETRIC & ARITHMETIC MEAN?

In simple terms, Geometric mean of two (or more) numbers is the square root of product of these two numbers. Let us calculate the geometric mean of numbers 2, 4 and 8 to understand.

$$\sqrt{(2 \times 8)} = \sqrt{(16)} = 4 \quad \text{Similarly, for three numbers, } \sqrt{(2 \times 4 \times 8)} = \sqrt{64} = 8$$

Arithmetic mean of two (or more) numbers is the simple average of these numbers. For example the arithmetic mean of 2 and 8 will be = $(2 + 8) / 2 = 5$ and for 2, 4 and 8, it will be = $(2 + 4 + 8) / 3 = 14/3 = 4.666$

For applications where the ISO A series does not provide adequate format, the B series has been introduced to cover a wider range of paper sizes. The C series of formats has been defined for envelopes.

The width and height of a B format are the GEOMETRIC MEAN between those of a A size and its next HIGHER size. For instance, B1 is the geometric mean between A1 & A0, that means the same magnification factor that scales A1 to B1 also scales B1 to A0.

The Japanese JIS P 0138-61 standard defines the same A series as ISO 216, but slightly different B series of paper sizes, sometimes called as JIS B or JB series. JIS B0 has an area of 1.5 square meter such that the area of JIS B page is the arithmetic mean of the A series pages with the same and next higher number. The JIS B or JB paper standards are not very popular outside Japan since they do not conform to ISO standards.

All dimensions are in millimeters.

Table 1

A Series Formats		B Series Formats		C Series Formats	
4A0	1682 x 2378	-	-	-	-
2A0	1189 x 1682	-	-	-	-
A0	841 x 1189	B0	1000 x 1414	C0	917 x 1297
A1	594 x 841	B1	707 x 1000	C1	648 x 917
A2	420 x 594	B2	500 x 707	C2	458 x 648
A3	297 x 420	B3	353 x 500	C3	324 x 458
A4	210 x 297	B4	250 x 353	C4	229 x 324
A5	148 x 210	B5	176 x 250	C5	162 x 229
A6	105 x 148	B6	125 x 176	C6	114 x 162
A7	74 x 105	B7	88 x 125	C7	81 x 114
A8	52 x 74	B8	62 x 88	C8	57 x 81
A9	37 x 52	B9	44 x 62	C9	40 x 57
A10	26 x 37	B10	31 x 44	C10	28 x 40



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

The allowed tolerances are $\pm 1.5\text{mm}$ for dimensions up to 150mm, $\pm 2\text{mm}$ for dimensions between 151 and 600 mm, and $\pm 3\text{ mm}$ beyond 601mm. Some national equivalent of ISO 216 specify tighter tolerances. For instance, DIN 476 specifies $\pm 1\text{mm}$, $\pm 1.5\text{mm}$ and $\pm 2\text{mm}$ respectively.

The ISO standard paper covers a wide range of formats, but not all of them are widely used in practice. Among them, A4 is clearly the most important one for daily office use. Some main applications of the most popular formats are summarized in the following table-2.

Table 2

A0, A1	Engineering drawings, Posters
A1, A2	Flip Charts, Part drawings, Assembly procedures
A4	Letters, magazines, forms, catalogs, laser printer and copying machine output
A5	Note pads
A6	Post cards
B5, A5, B6, A6	Books
C4, C5, C6	Envelopes for A4 letter – Unfolded (C4), Folded Once (C5), Folded Twice (C6)
B4, A3	Newspapers, supported by most copying machines
B8, A8	Playing cards

The main advantage of ISO standard paper sizes becomes obvious for users of photo copying machines.

Example – 1

You are in a library and want to copy an article out of journal that has A4 format. In order to save paper, you want to copy two journal pages on two sheets of A4 paper. If you open the journal, the two A4 pages that you will now see together have A3 format. By setting the magnification factor on copying machine to 71% or by pressing A3 → A4 button that is usually available on most copying machines, both A4 pages of the journal article together will fit exactly the A4 produced by copying machine. One reproduced A4 page will now have A5 format. No wasted paper margins appear, no text has been cut off and no experiments for finding the appropriate magnification factor are necessary. The same principle works for books in B5 or A5 format.

Copying machines designed for ISO paper sizes usually provide following special short cut keys for easier magnification.

Table 3

71%	A3 → A4
84%	B4 → A4
119%	A4 → B4 (also B5 → A4)
141%	A4 → A3 (also A5 → A4)



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

The following table shows magnification factor for all A series ISO dimension papers. This will be helpful during photocopying or zooming a document for further applications.

Table 4

To → From ↓	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A0	100%	71%	50%	35%	25%	18%	12.5%	8.8%	6.2%	4.4%	3.1%
A1	141%	100%	71%	55%	35%	25%	18%	12.5%	8.8%	6.2%	4.4%
A2	200%	141%	100%	71%	50%	35%	25%	18%	12.5%	8.8%	6.2%
A3	283%	200%	141%	100%	71%	50%	35%	25%	18%	12.5%	8.8%
A4	400%	283%	200%	141%	100%	71%	50%	35%	25%	18%	12.5%
A6	566%	400%	283%	200%	141%	100%	71%	50%	35%	25%	18%
A6	800%	566%	400%	283%	200%	141%	100%	71%	50%	35%	25%
A7	1131%	800%	566%	400%	283%	200%	141%	100%	71%	50%	35%
A8	1600%	1131%	800%	566%	400%	283%	200%	141%	100%	71%	50%
A9	2263%	1600%	1131%	800%	566%	400%	283%	200%	141%	100%	71%
A10	3200%	2263%	1600%	1131%	800%	566%	400%	283%	200%	141%	100%

Not only the operation of copying machines in offices and libraries, but also photography, microfilming and printing are simplified by the aspect ratio (1: 1.4142) of the ISO standards.

Example – 2

If you are preparing a letter, you will have to know the weight of content in order to determine the postal fee. This can be conveniently calculated with the ISO A series paper sizes. Usual typewriter and laser printer paper weight 80 GSM (grams per square meter). An A0 sheet measures one square meter and next smaller measures half its area and so on. So an A4 sheet measures 1/16 of A0 weight, which is equal to 5 grams. So, if five A4 sheets are to be posted, it will measure 20 grams.

Calculation of weight of books, newspapers or packed paper is equally simple. You probably will not need such calculations often, but they nicely show the beauty of the concept of metric (ISO) paper sizes.

Using standard paper size saves money and make many applications simple. For example, if all scientific journals use only ISO formats, then libraries would have to buy only very few different sizes for the binders. Shelves can also be designed such that standard formats will fit exactly without too much wasted shelf volume.

ISO formats are widely used in applications other than paper. German citizen ID card uses A7 format and most of the passports are of B7 format. Interestingly, toilet paper in Germany are of A6 width size.



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

Sometimes, paper formats with a different aspect ratio are required for labels, tickets and other purposes. These should preferably be derived by cutting standard series sizes into 2, 3, 4 or 8 equal parts parallel with shorter side such that the ratio between longer and shorter side is greater than aspect ratio. Some example long formats are given in following table.

Table 5

(1/3) A4	99 x 210
(1/4) A4	74 x 210
(1/8) A4	37 x 210
(1/4) A3	105 x 297
(1/3) A5	70 x 148

Envelope formats

For postal purposes, ISO 269 and DIN 678 define the following envelope formats, although there could be few differences in some countries.

Table 6

Format	Size (mm)	Content Format
C6	114 x 162	A4 folded twice
DL	110 x 220	A4 folded twice
C6 / C5	114 x 229	A4 folded twice
C5	162 x 229	A4 folded once
C4	229 x 324	A4 unfolded
C3	324 x 458	A3 unfolded
B6	125 x 176	C6 envelope
B4	250 x 353	C5 envelope
E4	280 x 400	B4

Folding larger pages to A4 for filing

DIN 824 describes a method of folding A0, A1, A2 and A3 formats to A4 formats for filing. This folding technique ensures that there will be a 20 millimeter single-layer margin for filing holes and that the page can be folded / unfolded without removing from file. This will also ensure that the labels printed either in bottom-left or bottom-right corner of an engineering drawing will orient itself to the top for easy readability.

Filing Holes

ISO 838 specifies that, for filing purposes, two holes of 6 ± 0.5 mm diameter can be punched into sheet with a centre to centre distance of 80 ± 0.5 mm and offset by 12 ± 1 mm to the nearest edge. The holes must be located symmetrically in relation to the axis of the sheet or document. Any format that is at least as large as A7 can be filed using this system. If two more holes are to be punched, they will be 80mm above and below these holes giving it more stability inside a file.

If you like to improvise this article or contribute or comment please mail us at: feedback@maintenancecircle.com

This document contains information for reference only. We assume no responsibility for its implication.



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

Technical drawing pen sizes

Technical drawing pens follow the same size-ration principle. The standard sizes differ by a factor of square root of 2 (1.4142). The pen sizes will be 2, 1.4, 1, 0.7, 0.5, 0.35, 0.25, 0.18 and 0.13 mm. So after drawing with a 0.35mm pen on A3 paper and reducing it to A4, you can continue with the 0.25mm pen (ISO 9175-1)

Overhead projectors

When you prepare overhead projector slides for a conference, you might wonder, how large the picture are of the projector that you will have available is. ISO 7943-1 specifies two standard sizes of overhead projector picture areas. Type-A is 250 x 250 mm and Type B is 285 x 285 mm. Therefore if you use A4 transparencies, leave at least 30mm as top and bottom margins.

Most computer displays also have the same aspect ratio as TV sets. 4:3. 640 x 480 = 1024 x 768 = 1280 x 960. If you prepare presentation slides, the layout should be inside 280 x 210 mm. This will help in showing all parts of transparencies on all slides and easier printability.

One of the oldest written records regarding the two-square-root aspect ratio for paper sizes is a letter that the physics professor Georg Christoph Lichtenberg from University of Gottingen, Germany wrote to Johann Beckmann.

US and few other industrialized nations today uses non-ISO paper sizes like Letter (216 mm x 279 mm), Legal (216 mm x 356 mm), Executive (190 mm x 254 mm). Refer to the following table showing closer dimensions for ISO papers in inches.

Table 7

A Series Formats		B Series Formats		C Series Formats	
4A0	66.250 x 93.625	-	-	-	-
2A0	46.750 x 66.250	-	-	-	-
A0	33 x 46.750	B0	39.375 x 55.750	C0	36 x 51
A1	23.375 x 33	B1	27.750 x 39.375	C1	25.5 x 36
A2	16.5 x 23.375	B2	19.75 x 27.75	C2	18 x 25.5
A3	11.75 x 16.5	B3	13.875 x 19.75	C3	12.75 x 18
A4	8.25 x 11.75	B4	9.875 x 13.875	C4	9 x 12.75
A5	5.875 x 8.25	B5	7 x 9.875	C5	6.375 x 9
A6	4.125 x 5.875	B6	4.875 x 7	C6	4.5 x 6.375
A7	2.875 x 4.125	B7	3.5 x 4.875	C7	3.1875 x 4.5
A8	2 x 2.875	B8	2.5 x 3.5	C8	2.25 x 3.1875
A9	1.5 x 2	B9	1.75 x 2.5	C9	1.625 x 2.25
A10	1 x 1.5	B10	1.25 x 1.75	C10	1.125 x 1.625

The dominance of the "Letter" format instead of ISO A4 as the common paper format in North America causes a lot of problems in daily international document exchange with the USA and Canada. ISO A4 is 6mm less wide but 18 mm

If you like to improvise this article or contribute or comment please mail us at: feedback@maintenancecircle.com

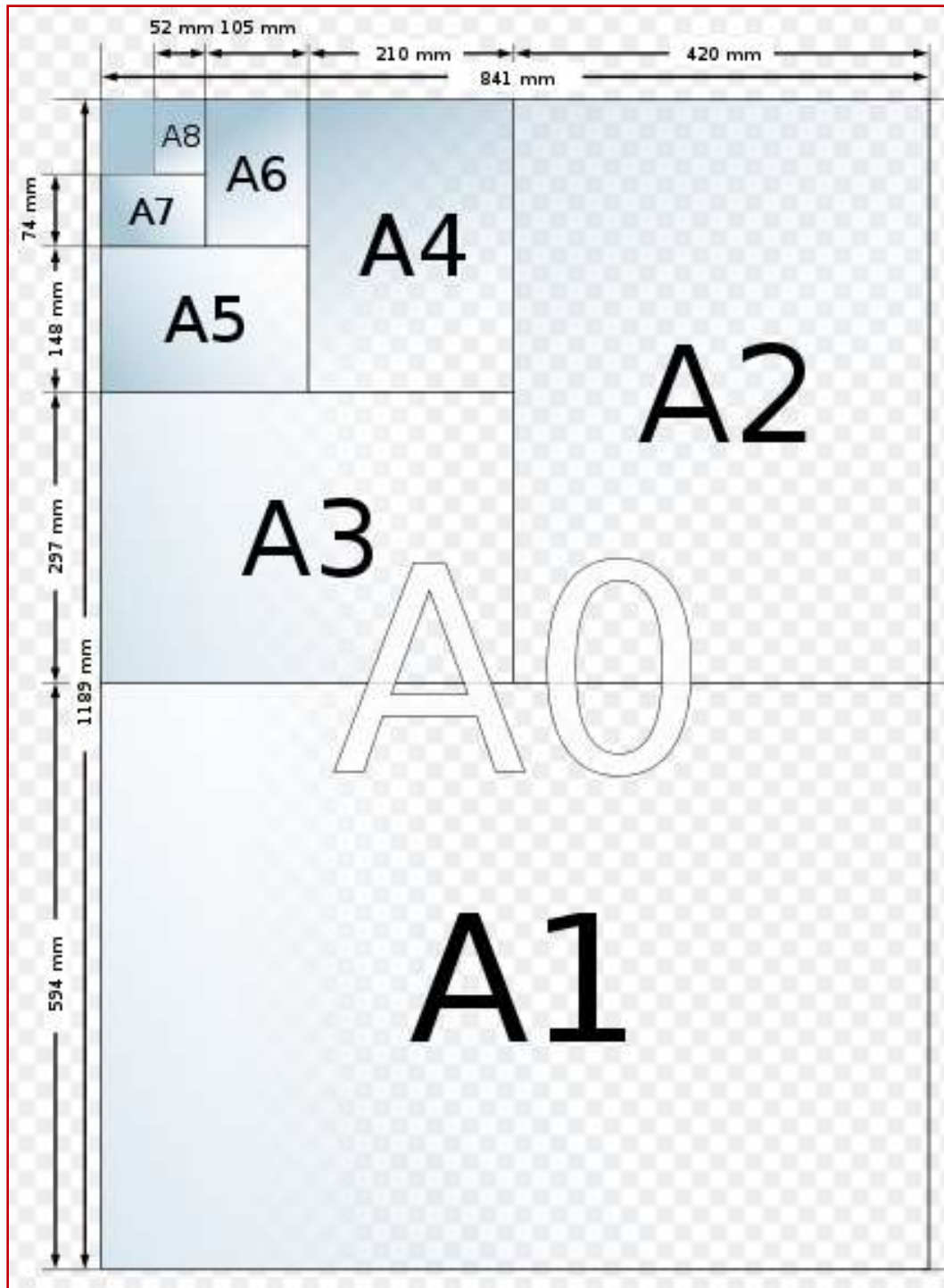
This document contains information for reference only. We assume no responsibility for its implication.



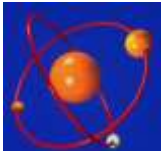
Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

higher than the "letter" format. Word processing documents with an A4 layout can often not be printed or modified without loss of information, loss of margins and all the styles applied, including page numbering. A4 documents must be printed with 94% magnification factor to fit into letter paper. Similar, letter documents have to be printed with 97% magnification to into 3% less wide A4 paper.

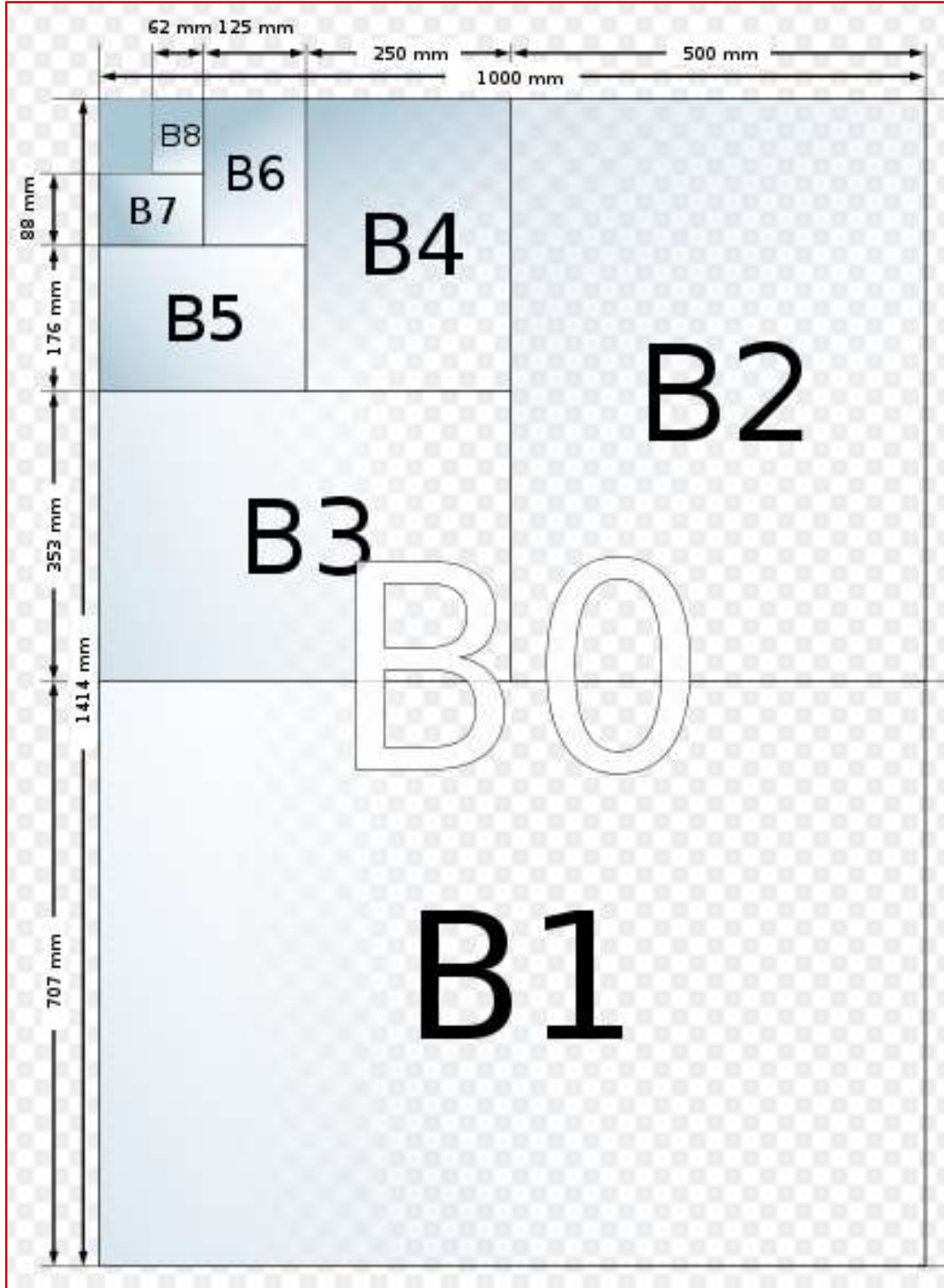


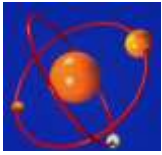
If you like to improvise this article or contribute or comment please mail us at: feedback@maintenancecircle.com
This document contains information for reference only. We assume no responsibility for its implication.



Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY





Maintenance Circle

NEWSLETTER FOR MANUFACTURING COMMUNITY

