

The machinist's level

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The machinist's level is an excellent tool to determine out-of-level components in a corrugating operation.

As corrugating plants age, the foundations begin to settle and the machinery starts to wear. On the corrugator, one may notice "baggy" edges or even warp. Machine components that are out of level or misaligned can cause both phenomena. This article addresses determination of levelness. Its primary concern is inspecting corrugator wet-end components. This is a practical first step to trouble shoot warp and twisting problems.

The machinist's level is a good instrument to inspect corrugators because the vial graduations allow taking accurate readings. The level also finds use on round surfaces such as idler rolls. It is inexpensive—usually less than US \$100 for the smaller levels.

Note that this article does not discuss the calibration procedure for the machinist's level. The calibration is nevertheless an important first step in its use.

GENERAL INFORMATION

The machinist's level—also called a mechanic's level—can be used to check the level of machinery, rolls and shafts, plates, etc. Levels are available in sizes of 6 in., 8 in., 12 in., 18 in., etc. Most boxplant maintenance departments seem to have the 12-in. size. Machinist's levels in the 6-18-in. range have graduations on the main vial that are approximately 0.005 in./ft. The level base normally has an involute or V-shaped groove running its length for proper seating on curved surfaces such as rolls. One end of the base has a small, laterally situated cross test level to

allow level detection simultaneously in two directions. This helps ensure accurate readings by preventing the level from canting or leaning to one side laterally. **Figure 1** shows a typical graduated main vial and a cross test vial.

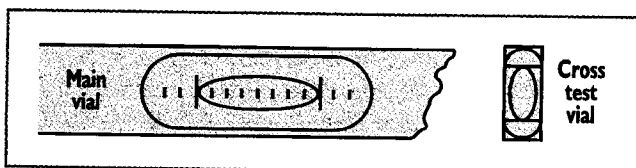
THE GRADUATED MAIN VIAL

Figure 2 shows a closeup view of the main vial for a 6-in. level. The level bubble rests between the two elongated graduations or long lines when placing the unit on a level surface. Each graduation represents 0.005 in./ft. There are eight graduations between the long lines or 0.040 in./ft on a 6-in. level. Ideally, the ends of the bubble will fit exactly between the long graduation lines. This gives the most accurate readings.

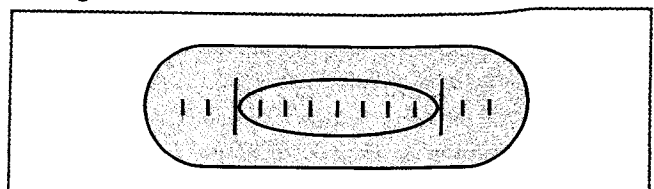
When purchasing a level, note that it does not have all the graduations between the two elongated lines. For example, the 6-in. level is missing three graduations in the center. The user can draw these on the vial with a regular ink pen and cover them with a small piece of transparent tape to prevent them from rubbing off. This is possible with a surprising degree of accuracy using a good eye and a steady hand.

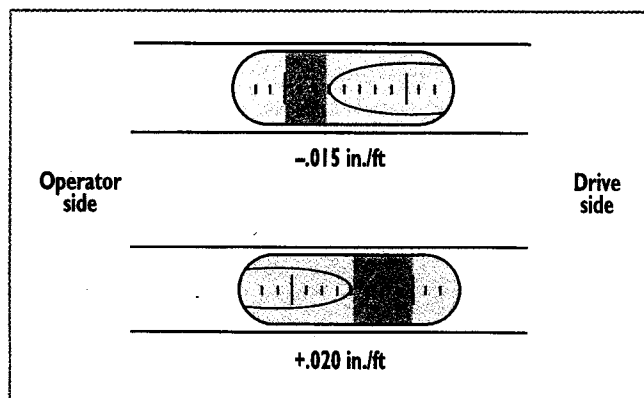
Be aware that the size of the bubble changes with temperature. Note that the bubble becomes smaller as the level becomes heated when checking the level of heated rolls and drums. The bubble becomes large in colder temperatures. The fluid in the vial is methanol. Normal operating range of the level is -60°F to 140°F for

1. Machinist's level



2. The graduated main vial





3. Level readings

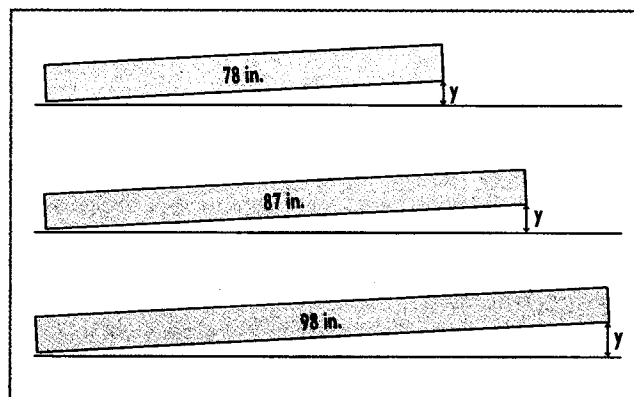
accurate readings. When checking the level of several heated vessels, allow the level to cool periodically for best accuracy. On heated vessels, work as quickly as possible without compromising safety. Do not place a level on a heated vessel too long because the vial will eventually burst!

READING THE LEVEL

Reading the number of 0.005-in. increments from the level is the first step to reading the level. Look at the distance in 0.005-in. increments as the edge of the bubble moves from the long increment line or from the level point. **Figure 3** shows two examples. The shaded area corresponds with the area on the level for the reading. In cases where the edge of the bubble falls between two lines, interpolate or estimate the reading.

Notice that each reading in Fig. 3 has a plus or a minus sign before it. This indicates the direction in which the item being measured slants. As with alignment checks, always assume the drive side of the equipment is "perfect." The plus or minus sign shows that the operator side is higher or lower than the drive side, respectively. The bubble always moves to the high side of the level. An easy way to decide if the slope is a plus or a minus on the machine is to lift the "operator side" of the level. If the bubble moves toward the center or corrects, then the operator side is lower than the drive side and the reading is a minus. If the bubble moves farther away from the level position or becomes worse, then the operator side is higher than the drive side and the reading is a plus.

The next step in obtaining the level reading is to determine how much higher or lower the operator side is relative to the drive side. In other words, how far out of level is the item? This will depend on the width of the machine as **Fig. 4** illustrates. The figure shows three similar rolls from different width corrugators. All have the same level reading or degree of slope. Notice that the amount of rise, Y , increases as the roll becomes longer.



4. For rolls with the same degree of slope, the amount of rise, Y , increases with the length of the roll

This is one reason tension problems and bearing problems are often not as noticeable when running narrow width paper. Problems may accentuate when using wider or full width paper. The length of the roll or the width of the corrugator is the run. One must know how many running feet of width the corrugator has. To determine this, simply divide the width of the corrugator in inches by 12. For an 87-in. corrugator, divide 87 by 12 to obtain 7.25 ft. (or round to 7.3 ft.).

To determine how far out-of-level the roll or machine is, take the level reading and multiply it by the number of running feet of machine width. A level reading of 0.015 in./ft would be approximately 0.110-in. out-of-level at the high end of the roll for an 87-in. corrugator: $0.015 \times 7.3 = 0.1095$. On the same machine, a roll with a level reading of 0.020 in./ft would be 0.146-in. out-of-level: $0.020 \times 7.3 = 0.146$ -in.

Knowing how to take level readings, it is possible to determine the running feet of width for a given corrugator and calculate how far out-of-level a roll or machine component is. To determine if a unit is within specification or tolerance, use a "general specification" of plus or minus 0.006 in. per running foot. Using the 87-in. corrugator as an example, multiply 0.006 in./ft by 7.3 running ft. This gives a maximum tolerance of ± 0.0438 in. that rounds to 0.044 in.

LEVEL EQUIVALENT TABLE

Checking the level of a hot corrugator especially during summer may seem like a long process when taking level readings and multiplying them to determine the amount out-of-level. This lengthy process led to the development of **Table I**. Some people call this the level cheat sheet. The table provides out-of-level amounts for corresponding level readings for three common corrugator widths: 78 in., 87 in., and 98 in. The heading for each width also shows the running foot multiplier: $\times 6.5$, $\times 7.25$, and $\times 8.17$ for 78-in., 87-in., and 98-in. corrugators, respectively.

78-in. corrugator (x 6.5) ± .039 in.			87-in. corrugator (x 7.25) ± .044 in.			98-in. corrugator (x 8.17) ± .049 in.		
Level reading	Amount o/o level	Approx. inches	Level reading	Amount o/o level	Approx. inches	Level reading	Amount o/o level	Approx. inches
.008	.052		.008	.058		.008	.066	
.010	.065	1/16	.010	.073	1/16	.010	.082	1/16
.012	.078		.012	.088		.012	.098	
.015	.090		.015	.110		.015	.123	1/8
.017	.110		.017	.124	1/8	.017	.139	
.018	.117		.018	.131		.018	.148	
.020	.130	1/8	.020	.146		.020	.164	
.025	.163		.025	.183	3/16	.025	.205	3/16
.030	.195	3/16	.030	.219		.030	.246	1/4
.035	.228		.035	.256	1/4	.035	.287	
.040	.260	1/4	.040	.292		.040	.328	5/16
.045	.293		.045	.329	5/16	.045	.369	3/8
.050	.325	5/16	.050	.365		.050	.410	
.055	.358		.055	.402	3/8	.055	.451	7/16
.060	.390	3/8	.060	.438	7/16	.060	.492	1/2
.065	.423	7/16	.065	.475		.065	.533	
.070	.455		.070	.511	1/2	.070	.574	9/16
.075	.488	1/2	.075	.548		.075	.615	5/8
.080	.520		.080	.584	9/16	.080	.656	
.085	.553	9/16	.085	.621	5/8	.085	.697	11/16
.090	.585		.090	.657		.090	.738	3/4
.100	.650	5/8	.100	.730	11/16	.100	.829	13/16
.105	.683	11/16	.105	.767	3/4"	.105	.861	7/8
.110	.715		.110	.803	13/16	.110	.902	

Tolerance = ± .006 in./running ft

Example: 78-in. corrugator is 6.5 running ft (78 in. = 6.5 ft)
 Multiply the level reading by 6.5 to determine the amount off
 Tolerance = .006 x 6.5 = ± .039 in.

I. Level equivalent table

Immediately above the three column headings is the tolerance for each corrugator.

To use the table, find the level reading and determine the amount out-of-level by looking at the number adjoining it in the adjoining column. For an 87-in. corrugator, for example, a level reading of 0.035 in. would be out-of-level 0.256 in. or approximately 1/4 in. as the shaded part of Table I indicates.

To save space, the table does not have every possible level reading. One can estimate the value by interpolating or reading between the lines. For example, a reading of 0.009 in./ft would be 0.065 in.—approximately half way between 0.058 in. and 0.073 in.

RECORDING THE LEVEL READINGS

When taking machine level readings, it is a good idea to organize the readings for later analysis. Level check forms can organize the data collected at single facers, glue machine, preheater stack, and bridge guides. Figure 5 is an example showing level checks on a line preheater.

LEVEL CONSIDERATIONS

The fact that a roll is out of level does not necessarily indicate what to fix. One may need other data such as the total indicated run out (TIR) and the bearing clearance. Rolls with very bad bearings and rolls or journals that are bent can result in out-of-specification level readings. Loose footing bolts, settling concrete foundations, and improper installations and leveling procedures can also cause problems.

One must be certain that the surface on which the level is set is very clean. Wipe a surface with a rag before positioning the level. Place the level at the roll or drum center rather than at an end. When checking the level of a machine component such as a single facer, do not use a roll mounted on pivot arms, i.e., the upper corrugator roll or pressure roll. Uneven loading of the rolls and roll crowns can give a false reading. For single facers, use the top small liner preheater or peanut roll. On glue machines, one usually uses a single faced web (SFW) preheater normally welded or bolted to the side frame.

THEORY

This section is only for readers who wish to relate level measurement to a mathematical equation. One might remember from high school mathematics that slope equals the rise over the run:

$$\text{Slope} = \text{rise/run} \quad (1)$$

In determining the out-of-level of an item, one is reading the slope from the machinist's level in in./ft of run as discussed above. Algebraically, the variable, m , often represents the slope.

The run is the length of the roll being measured in feet. This is the same as the corrugator width measured in inches converted into running feet of width above. The 87-in. corrugator above is 7.25 ft.

Let x be the variable to represent the run. Figure 4 illustrates the rise, Y . To calculate Y , rewrite Eq. 1 as follows:

$$m = Y/x \quad (2)$$

Solving for Y gives the following:

$$Y = mx \quad (3)$$

With a reading of 0.010 in./ft (slope) on an 87-in. corrugator that is 7.3-ft. (run) wide, $Y = 0.010 \text{ in./ft} \times 7.3 \text{ ft}$ or $= 0.073 \text{ in.}$

CONCLUSION

This article should inspire readers to dust off the machinist's level that has been locked in the maintenance storage cabinet for several years and use it. Out-of-level roll stand chucks, preheater wrap idler rolls, bridge guide idler rolls, and major machinery components are only a few common problem areas. Out-of-level wrap idler rolls often add to the mystique of a problem because the degree of uneven tension may change with the amount of wrap applied to the paper. The machinist's level can be a powerful troubleshooting tool. Keeping machine components level not only makes troubleshooting easier but also results in improved quality and productivity. **TJ**

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