

## The Technical Side - Automatic Levels

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The *Automatic Level* is a commonly used instrument in the survey and construction industries today. In this discussion we will explain how auto levels work and how to check and adjust them in the field.

The part of the automatic level that makes it "automatic" is the compensator. This is usually a prism or mirror suspended from several metal or mylar ribbons in the light path of the level's telescope. When the instrument is level, the prism or mirror hangs free and corrects the line of sight - even if the instrument is not perfectly level. If the instrument is taken too far out of level, the compensator swings up against stops that keep it within a reasonable range of movement. There are also dampeners that slow compensator movement to reduce vibration problems. Some of these are the air dampened type, which use a cup assembly to slow the compensator. Other compensators use magnets that slow the compensator assembly.

The unique design of the compensator introduces some possibilities for error that are not found in other types of levels. The compensator assembly is affected slightly by the earth's magnetic field. This is important in situations where extreme accuracy is necessary - such as first order levelling work. Vibration, from wind or from heavy machinery on a construction site, can affect the sighting accuracy. The dampening system in a compensator is designed to eliminate this, but heavy vibration can still be a problem. The compensator must correct the line of sight linearly for small variations in levelling. If the instrument is dropped or jarred more problems are introduced. The reticle might move and the instrument will not shoot level. The shock might stretch or even break the mylar or metal suspension members. If these break there is little to be done but replace the compensator. If they are stretched the linearity of the compen-

sator will be affected. This can sometimes be corrected by changing the weight bias of the compensator. There are also errors common to all instruments. The reticle of the level must be in good focus or parallax errors can occur. Correspondingly, the target must also be in good focus.

The automatic level can be easily checked and adjusted at an instrument facility. The instrument operator has a problem when the level is being used far from any repair shop and the accuracy and proper operation is in question. Fortunately, the level can be checked in the field quickly and easily. Before setting the instrument up, look back through the objective lens at the internal optics. The lenses should be clean and bright, and any condensation or dirt can be easily seen. If there is moisture on the internal optics, or if the instrument has been left out in the rain, the instrument must not be shut up in its case. Leave the level out or leave the case open to let it dry.

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To check the instrument, set it up on a tripod. The tripod must be in good working order - tight and with no play. Visually inspect the instrument for "raspberries" - any sign that the instrument has taken a fall (dents or scratches in the paint). Check the tangent and level screws for any indication that they are bent. While levelling the instrument, take note of how the level screws feel. They should be smooth and provide some resistance to turning, without being excessively tight. Position either end of the telescope over one of the level screw and turn that screw while looking through the eyepiece. If

the image wanders from side to side, the level screw is probably bent and should be replaced. Repeat this process with the other two level screws. If any are bent it is an indication the instrument has been knocked over. Level the instrument with the vial and then turn the instrument 180 degrees. The bubble should stay at the center. If not, adjust the vial halfway back to center with its adjustment screws and move it the rest of the way with the level screws. Repeat the process until the vial remains centered when the instrument is rotated 180 degrees. Look through the telescope and adjust the eyepiece focus so the reticle is sharp and there is no parallax. Parallax can be checked by viewing the target and moving the eye up and down. If the position of the target against the reticle changes slightly the eyepiece focus may have to change. The eyepiece focus, also known as the diopter adjustment, is adjustable to allow for changes in eyesight during the day or between different operators. Check the main focus by turning it through its entire range. You should be able to focus on some far object (such as the mountains) and then be able to focus slightly past that. You should also be able to focus to within several feet of the objective lens. Both the eyepiece focus and the main focus should turn smoothly, with no grinding or jumps. If the level has been dropped, the main focus rack may have jumped or have lost a tooth. This would show as a loss of focus range or the focus knob just turning without changing the focus. Check the tangent to see that it turns smoothly. There should be no play in it if the tangent is turned back and forth.

We have checked everything but the compensator and the adjustment of the level. After making the above inspection the compensator should be checked for proper operation. Make sure the instrument is level and position either end of the telescope over one of the level

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screws. While looking at the target, turn the level screw slightly. The view should move and then return to the exact same spot on the rod. If not, the compensator is not linear and needs to be repaired or replaced. Continue turning the level screw until the compensator comes up against its stop and no longer corrects the line of sight. At this point the edge of the bubble should be outside the circle on the vial. Gently turn the level screw back so the compensator comes back within its range. The compensator should start correcting the line of sight at the same point it contacted the stop. If the line of sight comes back to level and goes past this point while gently turning the level screw, the compensator is sticking to one of its stops. If it is sticking, tap the level and observe the line of sight. If the compensator is stuck the tap should break it away from the stop and restore the line of sight. Repeat the process going in the other direction to check the other compensator stop and the range. The range away from the center of the vial should be equal in both directions. If the compensator sticks to either stop, it is a good indication the stop is dirty

and needs to be cleaned or that there are other problems with the compensator. The compensator could be touching one of the dampening cups. The line of sight should always be at the same spot, especially when the bubble is inside the circle on the vial. If not, the level will not repeat readings.

Checking the adjustment of the level is a slightly more involved process. Set up two rods several hundred feet apart and set the level up exactly in the center between the two. You can check the centering by focusing on one rod and turning to the other. If the level is set up an equal distance between the two rods the second rod will be in focus. Note the difference in height between the two rods. Even if the level is out of adjustment the difference between the rods will be correct because the error will be the same at both rods. Now set the instrument up several feet away from one of the rods. If the instrument is in adjustment readings taken from the rods will have the same difference noted before. If not, adjust the instrument reticle to show the same difference recorded above. If there are any problems or questions in adjusting the

instrument take it to a qualified service facility.

The level screws, tangent, center, and focusing mechanisms of an automatic level are all lubricated for smooth operation. Unfortunately, the dust and dirt that the instrument is exposed to in everyday use accumulates on the instrument. This causes extra wear on the moving parts that will eventually affect the operation of the instrument. In (Nevada's) dry climate the lubricants dry out faster than normal and this also causes extra wear. In both cases the instrument should be disassembled, cleaned, relubricated, checked, and adjusted by a qualified service technician. The amount of time an instrument can go between cleanings depends on the amount of use and abuse that it gets. Generally, once a year is a good idea and the instrument should not go more than three years without an overhaul.

In general the automatic level is a dependable instrument that requires a minimum of care. With the information in this article you have the knowledge to ensure your automatic level is in good working order.



## ?? Technical Questions ??

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We'll do our best to track down the information for you.