GOVERNMENT OF THE PUNJAB
AGRICULTURE DEPARTMENT

MANUAL

LASER LAND LEVELLER

OPERATION & MAINTENANCE

Directorate General Agriculture (Water Management)
Punjab, Lahore

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May 2018

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PREFACE

This Manual is an effort to provide a guidance regarding operation and maintenance of LASER unit and proper management of Land leveling through LASER units. The Manual include all information and awareness regarding operation and maintenance of LASER units and detailed information about its parts.

Following are the main objectives for developing this manual:

- To provide Operation and Maintenance guidance to the LASER Operators and Service Providers.
- Awareness about the benefits and importance of precision land leveling.
- Capacity building of service providers, operators and farmers.

The information is based on technical specifications specified in respective documents for Punjab Irrigated-Agriculture Productivity Improvement Project. Maximum efforts have been made in developing the Manual for all levels of Supervisory Staff including Water Management Department Field staff, Trainers and Field Engineers of Consultants as well as Supply and Services Companies. Technical notes are provided at certain places to develop better understanding among field staff for effective use of the LASER units and supervision of LASER land leveling activity.

1. INTRODUCTION

1.1 PRECISION LAND LEVELING (PLL)

It is a mechanical process of grading and smoothing the land to a precise and uniform plane surface at grade or no grade (i.e. zero slopes) with variation of less than +/- 20mm (2cm). Generally, traditional method is used for PLL that involves earth movement with bucket type soil scrapers and tractor mounted rear blades which is very laborious and too expensive to finish the land surface to exact grade.

The LASER technology has proved to be a highly efficient tool for achieving a high degree of precision for carrying out PLL operation in much lesser time. The LASER controlled land leveling system consists of a LASER transmitter, a signal receiver, an electrical control panel and a solenoid hydraulic control valve assembly. The LASER transmitter transmits a LASER beam, which is intercepted by the signal receiver mounted on a leveling hydraulic scraper attached to the tractor. The control panel mounted on the tractor interprets the signal from the receiver and opens or closes the hydraulic control valve, which raises or lowers the leveling blade. Some LASER transmitters have the ability to level the field on single or dual graded slopes ranging from 0.01 to 15 percent.

Use of LASER technology in the precision land leveling was introduced in the Punjab during 1985 through On-Farm Water Management (OFWM) program. The same has been proved to be highly beneficial because it minimizes the cost of operation, ensures better accuracy in much lesser time, improves irrigation efficiencies, ascertains uniform seed germination, increases fertilizer use efficiency, and resultantly enhances crop yields. An impact assessment study was carried out by Planning and Evaluation Cell of Agriculture Department, Government of the Punjab during 2008 for its evaluation, which reveals following impacts at the farm level:

- Saving in irrigation time from 25.1 to 32.1 percent
- Increase in irrigation area by 34.5 to 42 percent
- Improvement in crop yields from 10.7 to 12.9 percent
- Reduction in farm culture able waste land by 2.1 percent

1.2 BENEFITS OF LASER TECHNOLOGY

LASER technology has the following benefits:

- Saves 50 percent irrigation water
- Increases crop yields up to 25 percent
- Enhances irrigated area up to 40 percent
- Improves cropping intensity from 35 to 40 percent
- Raises fertilizer use efficiency by 15-35 percent
- Decreases land under ditches and dikes by 60 percent and results increase in cropped area by 2.5 percent
- Reduces water logging and salinity up to 42 percent
- Ascertains uniform seed germination
- Makes farm machinery operation more efficient.

1.3 LIMITATIONS OF LASER TECHNOLOGY

- Costly equipment resulting in high initial investment
- Certain level of skill required for proper operation
- Less efficient in irregular and small sized fields

1.4 TYPES OF LASER LAND LEVELERS

1.4.1 Manual Leveling Lasers

Set-up of a laser leveling instrument requires the operator to manually level the unit by using the units' screws and bubble vials. These lasers rely on tubular bubbles for leveling. The user needs to level the laser in both the X-axis and Y-axis and rely on the bubbles for accuracy. These lasers can achieve a maximum accuracy of 1 cm at 100m.

1.4.2 Semi Self-Leveling Lasers

These lasers adjust themselves automatically within a range using a compensator. To get to a prescribed range, the laser is equipped either with a circular bubble with a bull's eye, or electronic lights that turn green when you reach the self-leveling range. These lasers are very accurate and have a shut-off feature if the laser is bumped or goes out of the self-leveling range. They can achieve accuracy of at least 1 cm at 100 m.

1.4.3 Fully Self-Leveling Lasers

These lasers automatically find and maintain level within a specified range. These lasers are equipped with an electronic level vial and servomotors. The servo motors level the instrument electronically and when leveled, the laser starts spinning. They are the easiest to use and can achieve accuracy of up to 2.5 mm at 100 m.

1.4.4 Split-Beam Lasers

These lasers emit simultaneous horizontal and vertical beams to establish both level and plumb reference lines.

1.5 WORKING MECHANISM OF LASER UNIT

The system includes a laser-transmitting unit that emits an infrared beam of light that can travel up to 700m in a perfectly straight line. The second part of the laser system is a receiver that senses the infrared beam of light and converts it to an electrical signal. The electrical signal is directed by a control box to activate an electric hydraulic valve. Several times a second, this hydraulic valve raises and lowers the blade of a grader to keep it following the infrared beam. Laser leveling of a field is accomplished with a dual slope laser that automatically controls the blade of the land leveler to precisely grade the surface to eliminate all undulations tending to hold water. Laser transmitters create a reference plane over the work area by rotating the laser beam 360 degrees. The receiving system detects the beam and automatically guides the machine to maintain proper grade. The laser can be level or sloped in two directions. This is all accomplished automatically without the operator touching the hydraulic controls.

2. LASER UNIT COMPONENTS

The major components include Laser Transmitter, Tripod Legs, Elevating Base, Telescopic Grade Rod, Level Eye Detector, Receiver, Three light Display, Mast, Control Box, Hydraulic Pump and Hoses, Hydraulic Oil Reservoir and Solenoid Control Valves, Shock Mount, Hydraulic Cylinder, Hydraulic Oil Filter, Battery and Electrical Connections

2.1 LASER TRANSMITTER

These are electronically self-leveling, rotating laser instruments that establish a reference plane of laser light above the work area. The laser beam is produced by an internal/external battery powered diode. The beam of light rotates at around 600 RPM. For a single/dual grade transmitter the reference plane of laser light can be tilted from 0-10 degree in single or dual axis. Transmitters are available in various designs i.e. zero grade (level) or no slope, single grade (generally in the range of 0-10% slope) and dual grade also 0-10% slope but providing in two directions. Features of the transmitter include

- Generally self-leveling instruments within +/-5 degree
- An early warning system shuts off the laser beam if the transmitter set up is disturbed and turns on again when it has been re-leveled.
- Some transmitters have built in batteries which may last up to 25-30 hours. These batteries are chargeable from 12V/220V source.
- Control and indicators are easily seen from the ground and allow constant monitoring of operations.
- Low voltage indication lamp flashes when battery falls below safe operating voltage.
- While the beam can be used for leveling up to 300 meters, experience in Pakistan indicates use to about 200 meters gives best results.

2.2 TRIPOD LEGS

The tripod legs support and position the laser transmitter at a desired height above the ground and are made of metal or sturdy hardwood with painted finish. Coarse height adjustment is achieved with the leg extensions and fine height adjustment with elevating base. Features include:

- Safety chains prevent the slippage of legs on hard surface
- Plumb bob hook is used to hang a plumb line to facilitate locating over a precise point.
- Large spurs provide solid foot pad to push the tripod firmly into the ground.
- Locking screw holds the inner leg extensions firmly in place when the desired beam height is reached.

2.3 ELEVATING BASE

The elevating base provides telescopic fine height adjustments and a locking-quick release mechanism for the laser transmitter. It is used in conjunction with the tripod legs for stable mounting of the laser plane transmitter. Features include:

- The telescopic column provides for the height adjustment of the laser transmitter.
- A quick release lever allows fast and easy transmitter set up.
- A locking ring enables the transmitter to be security fastened to the elevating tripod base.
- A simple crank or handle is used to raise or lower the base.

2.4 TELESCOPIC GRADE ROD

In a one man surveying system for topographic work the telescopic rod is used in conjunction with the level eye detector. The laser eye sensor is mounted on the top of the rod and by extending the rod. It can be positioned from 1300 mm to 4500 mm above the ground. If needed, a remote display is mounted at the foot level on a specially provided bracket to show readings surveys, grading and general construction work. Features include:

- The monitoring bracket holds the level eye detector.
- The rod can be locked at any intermediate position.
- A bubble level enables aligning the rod vertically for accurate readings.
- Scale is in centimeters and millimeters.

2.5 LEVEL EYE DETECTOR

A light weight electronic detector device reads the signal generated by the transmitter. The detector is indicated either visually with a liquid crystal display and/or additionally with audible beep tones. In conjunction with a telescoping grade rod it enables one man to survey an area.

Features include:

- Control switch/position control selects the operating mode to achieve accuracy between (+/-) 1/8” to (+/-) 1/16” as desired.
- Audio output emits fast beeping intermitted tone when high or low and a condition tone when the beam is centered.

2.6 RECEIVER

The receiver is a 360 degree Omni directional detector that picks up the laser signal and transmits it to the control box. It fits on the mast of the scraper and signals are sent via cables to the control panel. Power for the receiver also comes from the control panel. These signals are processed to indicate the relative position of the receiver to the laser reference plane.

2.7 THREE LIGHT DISPLAY

The three light display is designed to accept and process signals from the receiver, which indicates the relative position of the cutting edge to edge. It is used on machine control applications to provide a visual light display to machine operator. The grade lamp indicator shows the relative position of the cutting edge to the desired grade. The three light displays indicate five grade positions as follows:

i.	High	Solid amber
ii.	Near center high	Flashing amber
iii.	On grade	Flashing green
iv.	Near center low	Flashing amber
v.	Low	Solid amber

2.7.1 Mast

There are four types of masts:

- **Rigid Mast:** A rigid receiver mast with an increment/decrement tape, marked in centimeters, which allows the receiver to be mounted at known interval on the mast. The rigid mast is used in machine control applications where changes in BM are minimum and when manual adjustment of the receiver's height does not present a safety problem. A push/pull pin quick release provides easy removal of the mast from the mount.

- **Tape Mast:** The tape mast is driven by an electric motor. It provides a visual indication of elevation changes by a tape mounted on the telescoping inner mast tube. It is used in machine control applications that require remote adjustment of the receiver light and a visual indication of mast elevation changes.
- **Electric Mast:** It is also driven by an electric motor. It measures vertical movements electronically and sends the signals to the control box for processing. The receiver height is indicated on the LCD screen of the control box. It is used in machine control applications that remote adjustments of the receiver's height from the cab of the machine and when a numerical display of the mast movement is required on the control box.
- **Manual Mast:** The manual mast is a sturdy telescoping receiver mount that must be adjusted by hand to the correct elevation. An increment-decrement tape on the telescoping mast tube allows the receiver to be positioned at known intervals. It is used in machine control applications where changes in BM elevations are minimal and where manual adjustments of the receiver's height do not present a safety problem.

2.8 CONTROL MACHINE (BOX)

Control box accepts and processes signals from the receiver and displays these signals to indicate the blade's relative position to grade for either manual operation or automatic control when interfaced with the machine's hydraulic system. The control box also provides output for driving a solenoid type valve to control the hydraulic system of the scraper.

The control box is used with the electric mast where BM changes are frequent and adjustment of receiver's height from the cab is desired. Its display is by liquid crystal display (LCD) on the control box inside the operator's cabin. Grade indication lights indicate relative position of the cutting edge to grade as follows:

High	Solid amber light
High but close to grade	Flashing amber light
On grade	Flashing green light
Low but close to grade	Flashing amber
Low	Solid amber light

In automatic position, signals are sent to the hydraulic control valve for automatic control of the blade. In the manual position no signals are sent to hydraulic control valve.

The manual raise-lower switch overrides the automatic hydraulic control valve and allows the operator to raise or lower cutting edge manually as required by field conditions. The power lamp, when lit, indicates that system is on. The on/off switch controls power to control box system from the battery. A fuse protects the system from damage due to excessive electrical current.

2.9 HYDRAULIC PUMP AND HOSES

Initially, the hydraulic system of the laser operated scraper was independent of the tractor hydraulic system. A separated hydraulic pump was provided which was operated through the tractor power-take-off (PTO). Nowadays, the hydraulic system of scraper is directly coupled with tractor hydraulic system. Failure of the hydraulic system generally means a lack of proper vacuum in the suction line. Therefore, keep all connections tight and change oil and filter at regular intervals.

A lower output by the hydraulic pump also results in poor performance of the system. A speed of 540 RPM of the tractor PTO generally corresponds to an engine speed of around 1600 RPM. The hydraulic pump will only provide an optimum output when it operates at the proper RPM. The inlet hose to the pump is generally low pressure hose, while the delivery hose and hydraulic jack hoses are high pressure hoses.

2.10 HYDRAULIC OIL RESERVOIR AND SOLENOID CONTROL VALVES

The hydraulic oil reservoir provides shortage for the hydraulic oil. The reservoir apart from storage dissipates heat produced when the system is in operation.

The solenoid control valve controls the raised and lower position of cutting edge of the blade. It receives appropriate signals from the receiver through the control box. The system and speed of operations of the raise and lower functions can be monitored through the pressure control and unidirectional flow control valves in the system.

2.11 SHOCK MOUNT

Since the laser operated scraper on which the electrical/Tape Mast are mounted is subjected to heavy vibration during field operations, the mast is mounted on the shock mount to absorb these vibrating effects. The shock mount has rubber cushions to absorb the vibrations.

2.12 HYDRAULIC CYLINDER

The Hydraulic cylinder provides the power to raise and lower the scraper blade. Its movement is controlled by the solenoid hydraulic control valves.

2.13 HYDRAULIC OIL FILTER

The hydraulic oil filter absorbs dirt, dust, metal and other residues. Therefore, they must be changed periodically as recommended by the manufacturer. Clean oil is always important to keep the system in efficient condition.

2.14 BATTERY

The twelve volt (12 V) battery provides the power to the control box for operation.

2.15 ELECTRICAL CONNECTIONS

All cables and connectors conform to the US Military standards & specifications, or equivalent and are water proof.

3. OPERATION OF LASER UNIT

3.1 GENERAL

The laser operation includes properly connecting all the components of laser unit through cables, hydraulic assemblies and other fittings. It should be ensured that tractor, scraper, hydraulic components are in working order prior to start leveling operations. It should also be ensured that receiver is mounted on the scraper through electric mast at the desired height and all connections to the control panel on the tractor as well as hydraulic valves are tightly connected. The control box is powered on and all the buttons are in working conditions. Hydraulic system is also in working condition which may be checked by raising or lowering scarper through manual control of the control box. The air pressure in the tractor tyres as well as of scraper is as per the specifications. The most important component of the laser unit 'transmitter" is set thereafter.

3.2 POWERING THE LASER SYSTEM

3.2.1 Batteries

Laser is provided with either rechargeable nickel-cadmium or nickel/metal-hydride batteries depending upon the make/model of the laser system. It is always advisable to charge the batteries when the ambient temperature is in the range from 10^{o}C to 40^{o}C, charging at higher or lower temperatures may damage the batteries/increase the charge time resulting in loss of performance and reduced battery life. Alkaline batteries can be used as a backup; however, rechargeable batteries should be reinstalled in the laser as soon as possible.

Based on the specification of laser manufactures, when batteries are getting low, the status of LED flashes. Generally, if status LED flashes yellow, the laser has less than one hour of running time and when the status LED remains on solid yellow, the batteries have less than five minutes running time. Batteries should be recharged using standard charger available with the laser system; however, following care should be taken for charging the system:

- Be sure to charge the batteries before using it for the first time and after not using it for an extended length of time.
- Always charge the batteries with specified chargers, as per the manufactures' specifications.
- Never open the batteries.
- Never dispose of the batteries in fire to avoid damages/personal injury.

- Keep the batteries away from the reach of children.
- Carefully remove the screws from the battery housing and remove/install new/charged batteries and properly retighten the screws.
- When storing the instrument (or if the instrument is unused for a long time), it is recommended that the batteries are removed. This applies to dry cell batteries and rechargeable batteries alike.

3.2.2 External Cables

Some manufacturers provide laser systems (transmitters) with an external power cables which can be used to operate the laser in case the internal batteries discharged. This external power cable will provide power to the laser but will not recharge the batteries. Following precautions should be made before connecting the external power cables to the laser system:

- Turn off the laser before connecting/disconnecting the external power cables.
- Alligator clips should be connected to 12-V DC automotive of motorcycle battery ensuring correct connection i.e., red = positive, black=negative.
- To unplug the laser system, first remove the plug from the laser and then remove the alligator clips from the batteries.

3.3 TURNING ON/OFF THE LASER

After installing the laser on the tripod and placing at the desired location in the field, next step is to turn on the laser. Usually the laser unit suppliers provide operational guidelines for their specific product which should carefully be consulted before turning on/off the laser. Simply press the power button to turn on the laser. Generally, all the lasers are set to self-leveling mode on the power on. Most of the lasers have provisions for shutting down under certain conditions. When tripod stand disturbs the leveling of laser, the laser itself adjusts to auto level condition after some time. If laser is out of self-leveling range for more than ten minutes; it shuts down completely. To turn off the laser, the operator needs to press the power button for approximately three second.

Most of the lasers have provisions for selection of rotation speed i.e., 300, 600, 900 rpm. The rotation speed can be changed at any time by pressing the rotation control button (if provision exists in the laser) but for agricultural purposes, a rotation speed of 600 rpm is most suitable.

3.4 CHECKING/CALIBRATION OF A LASER TRANSMITTER

The laser transmitter should be periodically checked for accuracy. Most laser transmitters have two horizontal level adjustment screws that allow minor adjustments to be made along the two axes of the horizontal plane. The axes are usually labeled “X” and “Y”. All checking and calibration procedures are done at the zero slope reading.

3.4.1 Items Required to Check the Accuracy of the Transmitter

- A suitable tripod that allows you to rotate the transmitter in 90 degree increments.
- A minimum 65-meter range that is unobstructed and as close to flat as possible.

3.4.2 Checking/calibrating Procedure

- Mount the unit on a tripod at one end of the 60 m range and level it. Set ‘X’ and ‘Y’ axes grade counters at zero. With auto leveling transmitters, turn the transmitter control switch to the AUTO position and wait for the Auto Mode Indicator Lamp to stop flashing.
- Station a rodman with a receiver at the other end of the range 60 m away.
- Align the laser, using the sighting scope or groove, such that the ‘X’ is pointed directly at the rodman. Make sure the pent mirror is rotating and the Auto Mode Indicator Lamp has stopped flashing (if appropriate).
- Have the rodman take a precise reading to within 2 mm and mark the reading as X1.
- Rotate the transmitter 180 degrees and wait at least 2 minutes for it to re-level. In non-auto leveling transmitters, manually re-level the transmitter. Have the rodman take another accurate reading and mark it down as X2.

3.4.3 Outcomes

If the difference between X1 and X2 is less than 6 mm, no adjustment is necessary and the laser can be assumed to give the correct reading. If the difference is between 6 mm and 38 mm the transmitter, then needs to be calibrated and this can be done locally in the field. See calibration of the transmitter. If the difference is 38 mm or greater the unit must be re calibrated at an authorized service center. One cannot recalibrate it in the field without damage to the unit.

<u>If the difference is 38 mm or greater the unit must be re-calibrated at an authorized service center. One cannot recalibrate it in the field without damage to the unit.</u>

3.4.4 Calibrating the Transmitter Locally

If the difference in transmitter readings is between 6 mm and 38 mm then the transmitter can be calibrated locally by adopting the following procedures.

- From the two previous readings calculate the “X” average = (X1 + X2)/2 and have the rodman adjust the detector on the rod to the “X” average. (Center the detector between the two readings).
- Locate the “X” calibration screw and adjust it to align the beam to the “X” average at the detector. If gentle turning of the calibration screw cannot align the beam, return the unit to an authorized service center for calibration.
- After adjusting the beam, allow for the unit to stabilize before taking the next reading, then repeat the entire above procedure to check your work and do a fine readjust if necessary to get it just right.
- After adjusting the “X” axis, rotate the transmitter 90 degrees to the “Y” axis. Point the “Y” axis directly at the rodman, using the sighting scope or groove and repeat the above steps. Call the readings Y1 and Y2 and calculate the “Y” axis average as you did in step 1.

The same procedure may be employed by directing the beam onto a wall 60m away. Instead of having the rodman recording on the staff, make a mark on the wall at X1 and X2 and then draw a line in the center. The beam is then adjusted until it is recorded at the centerline. This system is useful if there is no rodman available or a measuring staff is not available.

3.5 LASER LAND LEVELING PROCEDURES

It is necessary to assure, prior to start the levelling process, that conditions are satisfactory for optimum operations. It will save power and expense to plough or chisel the areas to be cut. Tractor Operator must study the cut/fill map to fully understand cut and fill areas in the field so that the operator can move the soil in an optimum and efficient manner. The leveling process starts with formation of survey (cut/fill) map of the field to fully understand locations of cut and fill. The area from where soil is to be cut is chiseled or plowed to loosen the surface for easy

movement of soil. All the vegetation's and crop residues are also taken out from the field to remove hurdles during leveling operation.

It must be ensured that tractor, scraper, hydraulic, electrical components etc. are in proper working order before starting the leveling process. The receiver is mounted on the scraper and all connections to the control panel on the tractor as well as hydraulic valves are tightly connected. The LASER transmitter is set up properly to ensure that it is transmitting a horizontal plan of light over the entire operational area.

The transmitter is turned on and the correct field level is established by taking rod reading at the bench mark.

Two pieces of timber/brick are firmly set about one meter apart and are dug into the soil so that blade of scraper can rest on them in level position. Their top level is set equivalent of the designed field level ready from the mark and scraper is moved over these pieces and its blade is fully lowered onto them. The mast is then moved in upper or lower directions until the on-grade light is blinked on the control panel. Shift the switch from manual to auto position on control box. The Laser unit is now ready for the land leveling operation.

The tractor is then moved in the field towards cut area. If the receiver is above the LASER beam, the red light at the control panel turns "ON" and scraper starts cutting the soil. The operator moves the tractor towards the fill area where yellow light is turned "ON" and blade lifts itself up and starts dropping the collected soil. The tractor is again moved to the high (cut) area and shifts soil to low. The process is repeated time and again till entire field becomes at one level and the green light turns "ON" all over the area indicating that the field has now leveled.

The green light indicates achieving the desired field level. The Leveling operation is concluded by moving the scraper across the field to give it final finish.

3.6 OPERATING PROCEDURES

The scraper is designed to move moderate loads of earth but it is best to make shallow cuts over a long distance rather than to make deep cuts. Deep cuts require more power and cause slipping of the tractor wheels which often results in rough work. The tractor should be operated in the highest gear (usually 3rd or 4th gear) that it has power to slip its wheel without stalling.

Always complete a turn before starting to cut because the scraper will load more on one side if the cut is made while turning. The depth of cut that can be made will depend on the looseness of the soil, the scraper size and the power, as well as weight of the tractor. If the tractor wheels slip so much that forward motion stops, raise the blade with the override switch. As the depth of cut is reduced the tractor will move forward again without excessive slip. As the field becomes level this will not be a problem for the laser operated scraper.

Return to the cutting area should be made at safe speeds along a previously scraped strip which serves as a smooth roadway for the equipment.

3.7 SLOPE CALCULATIONS

Most of the land leveling requirements for Pakistan are for fields that are relatively level and therefore will be precision leveled at zero slopes. However, there may be times when there is a need for a field to have a slope in either one or two directions. In such cases, usually the slope in the direction of water flow is the primary slope and the slope at ninety degrees to this is the secondary or cross slope:

The need to develop a field with a slope is done for various reasons e.g. economic, type and depth of soils, quantity of irrigation water etc. But it has the following advantages:

a. In some cases, less soil has to be moved if a slope can be used.
b. Shallow top soil may need limited cuts for a level field.

On the other hand, it has also following disadvantage:

a. Water management requires a high level of skill, there is usually a requirement of managing runoff if water is not being wasted.

3.7.1 Determination of Average Elevation

If the field is fairly uniform throughout then taking elevations along each side of the field is sufficient to determine the primary and cross slopes. From these readings average reading can be determined as below:

Average reading (AE) = Total readings/Number of readings

As an example assume the following conditions and readings:

North	South	West	East
5.72	6.55	5.72	5.22
5.63	6.50	5.81	5.34
5.52	6.51	5.98	5.37
5.57	6.39	6.17	5.38
5.62	6.33	6.12	5.51
5.47	6.31	6.28	5.59
5.46	6.15	6.33	5.70
5.37	6.18	6.46	5.75
5.32	6.05	6.55	5.92
5.26	6.07		
5.23	6.03		
5.22	5.92		
AE= 65.39/12 =5.45	**AE=74.99/12 =6.25**	**AE=55.42/9 =6.16**	**AE=49.78/9 =5.53**

3.7.2 Determination of Field Slopes

Determine the average slope of the field in both the north-south and east-west directions.

Average Slope= Larger AE-Smaller AE

Average Slope (North-South) = South Average-North Average=**6.25-5.45=0.80**

Average Slope (West-East) = West Average –East Average= **6.16-5.53=0.63**

Then, primary and secondary (cross) slopes are:

Average slope= (Average slope X 100%)/Distance

Primary Slope	**Secondary Slope**
0.80 x 100 = 0.1%	**0.63 x 100 = 0.05%**
(1 meter/1000)	(0.5 meter/1000)

3.7.3 Setting the Transmitter

After determination of optimum slopes for the field, it is necessary to set the laser transmitter to these values. Laser transmitters have the capability of zero slope (level), single and dual slopes. A dual slope cannot be set with a “zero” or “one” slope transmitter. So use of the appropriate instrument is important.

To set a single (primary) slope of 0.1% (as in the above example) push the slope button control (or the primary control button for a dual slope instrument) until the reading in the counter is 0.100.

To set the cross slope of 0.05% (on a dual slope instrument) push the secondary slope control button until the reading in the counter is 0.050. The secondary slope will be perpendicular to the primary slope.

After setting of the laser transmitter to the proper slopes the land leveling operation can begin.

4. MAINTENANCE AND TROUBLESHOOTING

The mechanism of precautionary measure is established to protect the equipment/parts from any possible disorder/failure. Therefore, taking steps in advance is very essential to protect the equipment/parts from any possible danger and/or failure. Precautionary measures for proper operation and sustainability of the LASER unit involve proper handling, shifting and cleaning prior to use and after using.

Generally, all electronic components are enclosed in robust housings to safeguard them against any possible mechanical damage. Nevertheless, the devices as well as the junction and connection cables should be periodically checked for potential damages and soiling. Generally, all the lasers comply with OSHA Standards Act Section 1518.54 for use without eye protection devices. Consequently, protective eyewear is neither required nor recommended. As with any visible laser device, the following safety rules should be observed:

- Never look directly into a laser beam or point the beam into the eyes of others. Set the laser at a height that prevents the beam from shining directly into people's eyes.
- Do not remove any warning signs from the laser.
- Use of this product by people other than those trained on this product may result in exposure to hazardous laser light.
- If initial service is required, which results in the removal of the outer protective cover, removal must only be performed by factory-trained personnel.

LASER unit can be cleaned by an operator/farmer by observing certain measures. For devices such as transmitters, receivers and control panel; the surfaces must be cleaned by using standard cleaning agent on soft and line free cloth without applying any pressure. After cleaning, the cleaning agent should be removed completely with clean cloth from the device.

Do not clean the display with agents containing abrasive substances and never pack the equipment until it is fully dried.

To avoid poor contacts of the cables, the plug contacts and the connector threads have to be kept free of soil, grease, asphalt or other foreign material and to be protected from dampness. User should be cautious against the use of specific methods or procedures which can result in personal injury, damage to the equipment, or unsafe operating conditions. Remember, most accidents are caused by failure to observe basic safety precautions given as below:

a. Use extreme caution on the jobsite. Working around heavy equipment can be dangerous.
b. The scraper blade and rippers should be grounded before working on or around the machine.
c. Do not attach components while the engine is running.
d. Protect yourself at all times and wear protective clothing when working on or near hydraulic lines. Hydraulic lines can be under extreme pressure even when the machine is off.
e. Disconnect all electrical cables prior to any welding on the machine.
f. When operating in rainy weather or in wet conditions, the Control Box and cables must be thoroughly dried BEFORE placing them in the Carrying Case at the end of the day.
g. Also keep the Carrying Case dry at all times. DO NOT allow moisture to get inside the case. Moisture trapped in the case can adversely affect components.
h. DO NOT stare into the laser beam or view the beam directly with optical equipment.
i. Improper operation, lubrication, maintenance, or repair of this product can be dangerous and could result in fatal injury.
j. Relieve all pressure in the hydraulic lines before disconnecting or removing any lines, fittings or related components. If injury does occur, seek medical assistance immediately.
k. Do not weld near hydraulic lines or on any equipment when in operation.

Other precautionary measures for sustainable operation of the LASER unit are listed in Table 4.1.

Table 4.1 Precautionary Measures

S. No	Component/Item	Remarks
1	**Laser Transmitter**	• Always transport it in its original carrying case. • Keep the light house of transmitter clean. • Send the transmitter to the service center 2-3 times in a year. • Always switch off the system if not in use for long intervals. • Handle the transmitter like any other delicate electronic instrument and avoid dropping or handling roughly.
2	**Tripod Legs**	• Tripod legs should be properly secured during transportation
3	**Elevating Base**	• Avoid dropping and rough handling.
4	**Telescopic Grade Rod**	• Handle it with care as with an ordinary surveying rod.
5	**Level Eye Detector**	• Always switch off the battery when not in use. • Handle with care, i.e. do not drop or handle roughly.
6	**Receiver**	• Mount the receiver on the mast firmly. • Do not over tighten the mounting clamp. • Avoid use of hard materials for cleaning of glasses (photoelectric cell windows) to prevent scratches on the glasses.
7	**Three Light Display**	• Mount the instrument on the tractor/machine firmly to avoid excessive vibration.
8	**Mast**	• Keep all connections tightened.
9	**Control Box**	• Always switch off the main on/off button if not in use for long intervals. • Power cables should be secured firmly with clamps on the top battery terminals and should not be left loose in any case. • Prevent the survey/control box display window from becoming dirty. • Never connect the power cable directly to the tractor alternator.
10	**Shock Mount**	• Keep all nuts and bolts tight properly.
11	**Hydraulic Pump and Hoses**	• Avoid mechanical injury to these components. • Always operate the PTO pump at recommended RPMs (540).
12	**Hydraulic Cylinder**	• Assure that connecting pins are properly mounted and secured. • Check for and correct any leaks that may occur.
	Hydraulic Oil filter	• Use only the oil and type of filter recommended by manufacturer firm.
13	**Battery**	• Assure that a proper charge is maintained in the battery.
14	**Electrical Connections**	• Avoid mechanical injury to the cables. • Avoid over tighten and do not keep it loose.

4.1 MAINTENANCE

Taking care of equipment does not require any major effort but regular maintenance of it will ensure the efficiency, trouble free operation, lower repair/spares cost and longevity of the equipment/parts. Maintenance guidelines with regard to major components have been summarized in Table 4.2.

Table 4.2 Maintenance Guidelines

S. No	Component/Item	Remarks
1	**Laser Transmitter**	• Clean the light house of the transmitter regularly and may be sent to service providers if required.
2	**Tripod Legs**	• Check all fasteners regularly. • The hardwood legs should be cleaned and re-varnished when these start to show wear or deterioration due to use and/or exposure.
3	**Elevating Base**	• It should be kept clean and no oil as well as grease etc. is required.
4	**Telescopic Grade Rod**	• Handle it with care as with an ordinary surveying rod.
5	**Level Eye Detector**	• Replace battery if weak within two hours of low battery indication to avoid any possibility of inaccurate readings.
6	**Receiver**	• The photoelectric cell windows (glasses) should be cleaned of dust occasionally with cotton wool or other soft tissue, avoid use of hard material to prevent scratches on the glass.
7	**Three Light Display**	• Always use an electrical fuse of proper rating as recommended by the manufacturer. It will protect the system from high voltages.
8	**Mast**	• Keep all connection tightened. • Remove dirt.
9	**Control Box**	• Always use an electrical fuse of proper rating as recommended by the manufacturer. • Always use lens tissue or cotton ball for cleaning survey/control box display window. • Keep all connection tightened. • Electrical fuse should be replaced whenever required and only recommended product should be used.
10	**Shock Mount**	• Keep all nuts and bolts tight properly
11	**Hydraulic Pump and Hoses**	• Keep all connections tight properly.

12	**Hydraulic Cylinder**	• Regularly check for and damage and correct any leaks that may occur.
	Hydraulic Oil Filter	• Change oil and filter at recommended intervals but use only the recommended products (recommended by manufacturer firm).
13	**Battery**	• Check battery acid/fluid daily and keep filled to proper level.
14	**Electrical Connections**	• Avoid over tighten and do not keep loose.

4.2 TROUBLESHOOTING

Sometimes LASER unit stop working or does not perform leveling task properly due to some hardware/ technical issue which needs to be rectified for proper system operation. Most of the issues can be solved by the farmers/operators by themselves and if the problem does not solve by adopting the troubleshooting guidelines, then the service providers must be contacted for any repair or service of the unit. General problems likely to be faced during the operation of LASER units and their possible solutions are given in following Tables 4.3, 4.4 and 4.5.

Table 4.3 Laser Transmitter

Problem	Cause/Solution
Laser will not turn on	• Make sure the batteries have sufficient power and are installed correctly. • Make sure the batteries contacts are in proper working condition.
No signal is received at the receiver	• Make sure the receiver is turned on. • Make sure the batteries have sufficient power and are installed correctly. • Make sure the laser is sending out a beam. • Check for a laser signal with another receiver.
No laser beam	• Make sure the laser is on. • Make sure the batteries have sufficient power and are installed correctly. • Make sure that the laser (standard model) is within its self-leveling range (up to 25%). • Switch the laser into manual mode; the laser should come on.
The battery life is short	• Make sure high-quality batteries are being used. • When recharging the batteries, make sure the charger is plugged into an appropriate ac outlet. The batteries require a minimum charge time of six hours.
Laser beam not accurate	• Check and adjust calibration as needed. • Return the laser to an authorized service center for inspection.

LASER beam not propagating	• Battery not fully charged. • Out of auto level setting. • Adjust the controller to “Auto” to solve the problem.
Low Voltage Indicator blinking at the transmitter	• Weak batteries. • Loose battery terminal. • Replace batteries and/or tighten the battery terminals.
Auto Levelling System of transmitter not working	• Weak batteries. • Control witch is not at “Auto” position. • Replace batteries and/or press the “Auto” button.

Table 4.4 Laser Receiver

Problem	Cause/Solution
Receiver does not receive a laser signal	• Make sure the laser receiver is on. • Make sure the batteries have sufficient power and are installed correctly. • Make sure the batteries contacts are in proper working condition. • Make sure the receiver is within the operating range of the laser. • Try receiving the laser beam with another receiver.
Receiver occasionally beeps when it is not in the laser beam	• Make sure the receiver is not near radar or high-frequency radio stations. • Make sure the laser beam is not bouncing off a highly reflective surface.

Table 4.5 Miscellaneous

Problem	Cause/Solution
Bucket will not raise or lower	• Check the transmitter is working. • Check hydraulic connections. • Check electric connections on solenoid. • Check pressure relief valve setting on control valve. • Check for contamination in oil lines.
Bucket doesn't respond in certain parts	• Line of vision between transmitter and receiver blocked of field. • Receiver is at the same height as tractor cabin. • Laser beam above or below the receiver height.
Bucket will only move in one direction	• Check hydraulic connections. • Check electric connections on solenoid. • Check pressure relief valve setting on control valve. • Check for contamination in oil lines.
Bucket shudders when first started	• Oil cold or no load in bucket. • Check pressure relief valve setting.
Bucket raises and falls automatically	• Check line of vision. • Check electronic connections on solenoid. • Check oil level in tractor hydraulic system.
Field uneven	• Traveling too quickly. • Raise and fall speed too slow.
Field not level or slopes the wrong way	• Check the levelness/calibration of the transmitter. • Soil too compacted for bucket to cut.
Soil not flowing out of the bucket	• Soil too wet. • Too much foreign matter in soil.
Soil not flowing into the bucket	• Too much crop/weed residue on surface • Soil too compacted
Control Box not turn on	• Check the power switch. • Check the cable, terminals and connections with the battery. • Check battery voltage.
Power Bulb on control box does not blink	• Check the bulb. • Check the fuse. • Check the voltage of the battery. • Check for battery terminals and voltage.
Violent or "jumpy" hydraulic response	• Valve offsets may be set too high. • Offsets should always be set for minimum movements.
The switch box cable may be disconnected or damaged.	• Check that cables and connections are properly and securely connected. • Check that cables and connections are undamaged.
Scraper "oscillates" up and down	• The laser may be moving in the wind. • Ensure that the transmitter is securely anchored. • Work closer to the transmitter (or move the transmitter closer to the working area).

OFWM

LASER Land Leveling

Watercourse Improvement

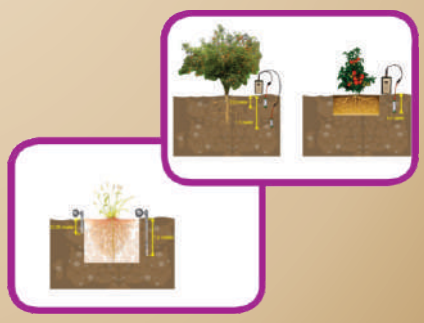
Sprinkler Irrigation

Drip Irrigation

Storage Pond

Solar Coupled HEIS

Training/Human Resource Development



Soil Moisture Meter

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