Product: EXCAVATOR
Model: 313F LGC EXCAVATOR HDK
Configuration: 313F LGC Excavator HDK00001-UP (MACHINE) POWERED BY C3.4B Engine

Operation and Maintenance Manual
Cat Grade Control for 2D and 3D Excavators
Media Number -M0077726-01 **Publication Date -01/12/2017** **Date Updated -19/12/2017**

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Foreword

SMCS - 7008; 7600-ZM

Literature Information

This manual should be stored in the literature holder.

This manual contains safety information, operation instructions, and maintenance recommendations.

Some photographs or illustrations in this publication show details or attachments that can be different from your product.

Continuing improvement and advancement of product design might have caused changes to your product which are not included in this publication. Read, study and keep this manual with the product.

Whenever a question arises regarding your product, or this publication, please consult your Cat dealer for the latest available information.

Safety

The safety section lists basic safety precautions. In addition, this section identifies the text and locations of warning signs and labels used on the product.

Operation

The operation section is a reference for the new operator and a refresher for the experienced operator. This section includes a discussion of gauges, switches, product controls, attachment controls, and programming information.

Photographs and illustrations guide the operator through correct procedures of checking, starting, operating and stopping the product.

Operating techniques outlined in this publication are basic. Skill and techniques develop as the operator gains knowledge of the product and its capabilities.

Maintenance

The maintenance section is a guide to equipment care.

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Safety Messages

SMCS - 7405

WARNING

Do not operate or work on this machine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in injury or death. Contact your Cat dealer for replacement manuals. Proper care is your responsibility.

WARNING

Failure to use an approved access system during installation and removal of components could result in slipping and falling which could result in personal injury or death. To prevent injury or death, use an approved access system to reach the appropriate mounting locations of the components. Do not climb on the machine. Maintain three-points of contact and/or use a safety harness.

WARNING

Unexpected blade movement may occur when the blade control system is in automatic mode. Unexpected blade movements that occur while mounting or dismounting the machine may result in injury or death.

Before dismounting the machine, always place the automatic blade control system into manual mode and follow the machine parking procedures specified in the machine Operation Manual.

Crushing Prevention and Cutting Prevention

Support the equipment properly when you work beneath the equipment. Do not depend on the hydraulic cylinders to hold up the equipment. An attachment can fall if a control is moved, or if a hydraulic line breaks.

Unless you are instructed otherwise, never attempt adjustments while the machine is moving. Also, never attempt adjustments while the engine is running.

Whenever there are attachment control linkages, the clearance in the linkage area will increase or the clearance in the linkage area will decrease with movement of the attachment. Stay clear of all rotating and moving parts.

Keep objects away from moving fan blades. The fan blade will throw objects or cut objects. Do not use a kinked wire cable or a frayed wire cable.

Wear gloves when you handle wire cable. When you strike a retainer pin with force, the retainer pin can fly out. The loose retainer pin can injure personnel. Make sure that the area is clear of people when you strike a retainer pin.

In order to avoid injury to your eyes, Wear protective glasses when you strike a retainer pin.

Chips or other debris can fly off objects when you strike the objects. Make sure that no one can be injured by flying debris before striking any object.

Operation

Clear all personnel from the machine and from the area.

Clear all obstacles from the path of the machine. Beware of hazards (wires, ditches, and so on).

Be sure that all windows are clean.

Secure the doors and the windows in the open position or in the shut position.

Adjust the rear mirrors (if equipped) for the best visibility close to the machine.

Make sure that the horn, the travel alarm (if equipped), and all other warning devices are working properly.

Fasten the seat belt securely.

Warm up the engine and the hydraulic oil before operating the machine.

Only operate the machine while you are in a seat. The seat belt must be fastened while you operate the machine. Only operate the controls while the engine is running.

While you operate the machine slowly in an open area, check for proper operation of all controls and all protective devices. Before you move the machine, make sure that no one will be endangered.

Do not allow riders on the machine unless the machine has the following equipment:

- Additional seat
- Additional seat belt
- Rollover Protective Structure (ROPS)

Note any needed repairs during machine operation. Report any needed repairs.

Avoid any conditions that can lead to tipping the machine. The machine can tip when you work on hills, on banks and on slopes. Also, the machine can tip when you cross ditches, ridges, or other unexpected obstructions.

Avoid operating the machine across the slope. When possible, operate the machine up the slopes and down the slopes.

Maintain control of the machine.

Do not overload the machine beyond the machine capacity.

Be sure that the hitches and the towing devices are adequate.

Never straddle a wire cable. Never allow other personnel to straddle a wire cable.

Before you maneuver the machine, make sure that no personnel are between the machine and the trailing equipment.

Always keep the Rollover Protective Structure (ROPS) installed during machine operation.

Monitor the location of components that are mounted to the blade. Ensure that the components do not come into contact with other parts of the machine during operation.

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General Information

SMCS - 7220

The Global Navigation Satellite System (GNSS)

There are two fully operational Global Navigation Satellite Systems. The first is the NAVSTAR Global Positioning System (GPS). GPS was put in place and is maintained by the United States. The second GNSS is GLObal Navigation Satellite System (GLONASS). GLONASS was put in place and is maintained by Russia.

In addition to GPS and GLONSS there are two GNSS currently under development. The European Union is developing the Galileo GNSS system. It is estimated to be complete by 2020. The Chinese government is developing the BeiDou Navigation Satellite System GNSS (BDS). At this time it is operating as a Regional Satellite Navigation System. GNSS functionality is estimated to begin by 2020.

In addition to the regional functionality of the BDS, India also has an operational Regional Satellite Navigation System. It is known as the Indian Regional Navigation Satellite System or IRNSS with the operational name of NAVIC (NAVigation with Indian Constellation).

The newer GNSS receivers used in Caterpillar tractors can access both GPS and GLONASS satellite systems for the best possible world-wide coverage.

In general terms, a GNSS receiver computes a position that is based on radio signals that are received from several different satellites in a GNSS system. The satellites have highly accurate and reliable clocks making the timing of these satellite signals accurate. The GNSS receiver calculates the relative distance to each of the satellites. This calculation is based on the travel time of the signal and the speed of light (speed of the signal). The receiver then uses these distances to calculate the location of the receiver on earth.

As a broadcast only radio system, GNSS supports an unlimited number of users. The frequencies that are broadcast penetrate clouds, rain, and snow. GNSS can also accurately guide operations in fog or dust, and at night.

Note: Caterpillar is not responsible for the operation of any satellite-based positioning system or the availability of positioning signals.

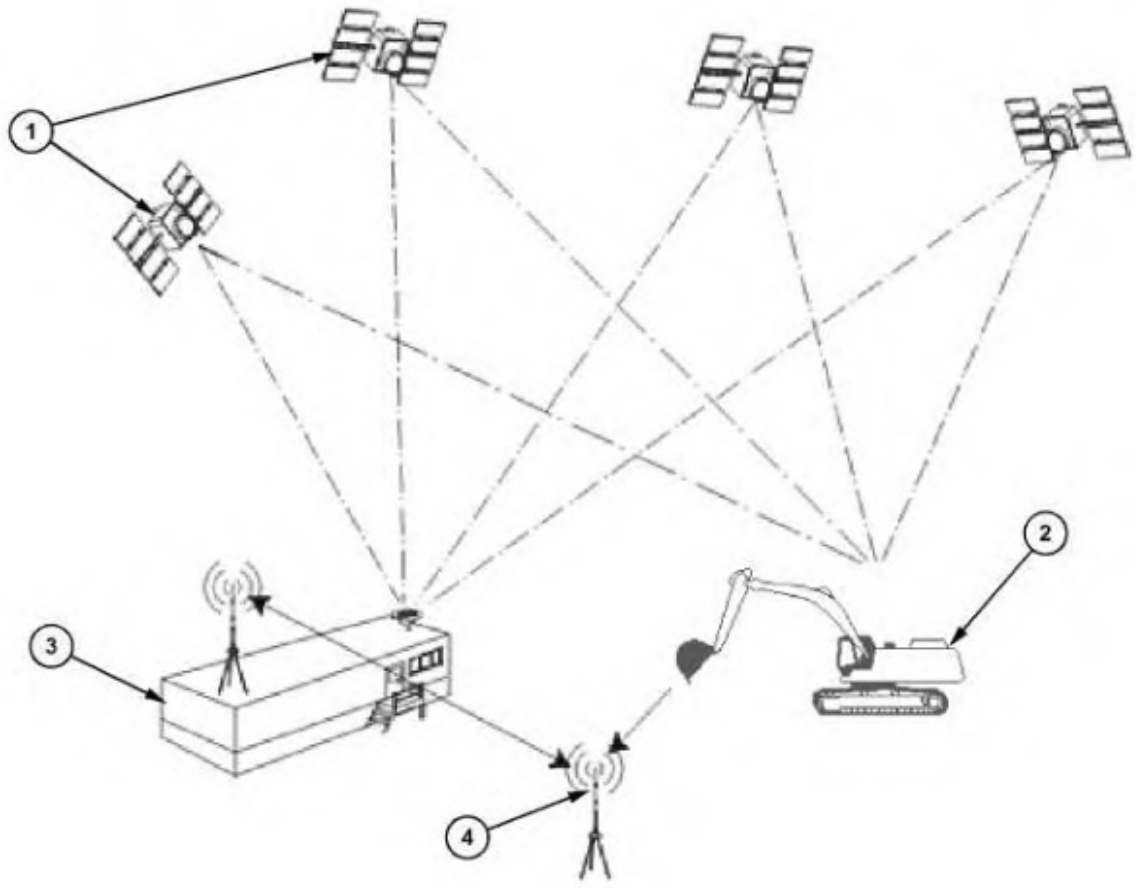

Illustration 1 g06151189

GPS and the Cat® Grade Control System
(1) GPS Satellites
(2) Machine equipped with the Cat® Grade Control System
(3) GPS Base Station and Data Radio
(4) Repeater radio (optional)

The method that is used for machine grade control in construction is the same used by surveyors for stakeout in construction. The method is called Real-Time Kinematic (RTK), GPS. Two GPS receivers are required to produce RTK positions. One GPS receiver is known as the GPS base station. The GPS base station has a fixed position. The other GPS receiver is known as the rover. This receiver is mounted on the machine.

The base station communicates to the rover through a wireless data link using a data radio. Illustration 1 shows this setup.

Both GNSS receivers make observations (measurements) of the GNSS signals at the same time. The base station broadcasts the observed information together with the location and other information across the data radio link to the rover. The rover then combines the data from the base station together with the machine data to compute an accurate position relative to the base station.

Note: Poor placement of the reference station can adversely affect the position accuracy of the rover.

A single base station can support an unlimited number of rovers, provided the rovers are within about 20 km (12.4 mi) of the base station. Normally, the range of the data radio link is the more limiting factor. The operator can use radio repeaters to extend the radio coverage.

Low accuracy corrected GPS (SBAS)

If low accuracy GNSS positions are adequate for the required site work, the operator can use Satellite -Based Augmentation System (SBAS) error corrections. SBAS corrected systems do not require additional site infrastructure.

A Satellite-Based Augmentation System (SBAS) supports wide-area or regional augmentation by using additional satellite-broadcast messages. Such systems are commonly composed of multiple ground stations that take measurements of one or more of the GNSS satellites, the satellite signals, or environmental factors that may impact the signal received by users. These measurements are used to send information messages to one or more satellites for broadcast to the end users to augment and improve accuracy, reliability, and availability of GNSS positional information.

The following SBAS networks are currently available:

Table 1

WAAS	Wide Area Augmentation System (United States)
EGNOS	European Geostationary Navigation Overlay Service (Europe)
MSAS	Multi-Functional Satellite Augmentation System (Japan)

GNSS receivers use a GNSS receiver configuration file (.cfg) to convert from WGS84 coordinates to the site coordinate system. High accuracy (RTK) GNSS systems use a configuration file generated from the site calibration. If the position of the base station entered for site calibration is not accurate, the site coordinate systems will shift away from the local coordinate system. When this faulty receiver configuration file is used by a GNSS RTK receiver, the shift will not be obvious. The site relative positions points will still be accurate and the accuracy of RTK positioning is unaffected. However, if the same receiver configuration file is used by a GNSS receiver that uses SBAS corrections, the shift will become obvious which will result in additional position errors.

To avoid additional errors, do one of the following:

- Make sure the base station antenna position used for the RTK site calibration is accurate to within about 1 m (3.3 ft). To achieve this level of accuracy use traditional surveying methods or long-term autonomous GNSS occupation data. Contact your site surveyor for more information.
- Use a configuration file generated by the Cat Grade Control software using the local circuit coordinate system, instead of the configuration file produced by the site calibration.

GNSS Site Calibration

Note: A poor quality GNSS site calibration will result in low-quality guidance information from the Cat Grade Control system.

GNSS site calibration is a mathematical relationship between a grid coordinate system (northing, easting, and elevation) of a project site and the GNSS coordinate system (latitude, longitude, and ellipsoidal height, also known as WGS84 coordinates). This relationship is determined by using GNSS to measure points with known grid coordinates, and then calculating the calibration parameters.

A surveying or civil engineering company should be used to establish the control points around a site. Make sure the operator locates the control points to prevent destroying the points during construction.

Five or more control points located at, or near, the corners and center of the project site will normally give good results.

Note: If a GNSS surveyor is employed to create the GNSS site calibration, make sure that the requirements are clearly specified for that surveyor. Caterpillar recommends a copy of this section of the manual is given to the surveyor.

Some survey software can do both a full site calibration and a single point calibration.

A single point calibration cannot provide any guarantee of accuracy as the parameters that define a site calibration will be default values. These default values may have no resemblance to the real values obtained through a full calibration. A single point calibration should only be employed on small sites with no existing control. Caterpillar recommends that you carry out a full site calibration to guarantee the required accuracy all over the site.

When doing a site calibration, pay attention to the following points:

- A minimum of five 3D local grid coordinates (north, east, and elevation) and five observed GNSS coordinates (latitude, longitude, height) should be used to provide enough redundancy.
- Independently obtain a set of GNSS coordinates from the grid coordinates.
- The selected calibration points should be around the perimeter of the site. Do not work outside of the area enclosed by the calibration points. The calibrations are not valid beyond this perimeter.
- When defining the acceptable accuracy limits, the calibration tolerances should not be larger than the accuracy tolerance for the site.
- When measuring points, use a bipod on a staff or a tripod to maintain stability.
- Check the accuracy of the calibration by visiting other control points that were not used in the calibration.

Converting The Site Calibration To A GPS Configuration File

When the site calibration is complete, the site surveyor uses a surveying software package to convert the site calibration data to a calibration file (for example: Site.dc).

Once the site calibration file is generated, there are several ways to convert the calibration to a GNSS Configuration File. Trimble Business Center, Site Controller Software (SCS900), or Trimble Configuration Toolbox can be used to merge the Site Calibration into the GNSS Configuration File. Refer to the applicable help documentation with each tool for complete details.

The site calibration files are stored in the display rather than the GNSS receiver. For this reason, each time the site is changed, make sure the site calibration files are updated.

To ensure that the correct files for each design are in use, do one of the following:

- Make sure that a valid configuration (".cfg") file for the design is in each design folder. When the design is loaded, the associated configuration file is sent to the receiver.
- Use the "GNSS receiver configuration" in the setup menu to send the site calibration to the GNSS receiver and update the parameters that are held in the display.

When a GNSS receiver configuration (".cfg") file is sent to a GNSS receiver, the system resets the receiver to factory defaults before applying new settings.

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System Components

SMCS - 7220

Machine Display

The Machine display mounted on the right-hand side of the cab provides useful machine information to assist the operator in operation of the machine. The Machine Display provides a user interface for both machine operation and for Grade system usage.

Illustration 1 g06181314

(1) LCD Display
(2) Beeper
(3) USB port
(4) Softkey buttons

(5) Main connector
(6) Arrow buttons

The Machine Display shows and manages basic two dimensional (2D) Grade information when the Grade Display is powered off and a properly configured work tool is selected. The Grade Display can also show 2D Grade information when the Grade Display is powered.

Note: The 2D Grade information in the footer of the Machine Display main screen will disappear from view when the Grade Display is powered on. The 2D Grade information will not reappear in the footer of the Machine Display main screen until the machine has been powered off for long enough that the electronic control modules shutdown completely .

Body Tilt Sensor

The Body Tilt sensor provides Grade system with the necessary information regarding the slope orientation of the machine. This sensor allows the Grade system to compensate guidance as the machine works over sloped and undulating terrain. The Grade system will not function without receiving the necessary data from this sensor.

Rotary Position Sensor

Illustration 2 g06181317

Illustration 3 g06181319

The Grade system depends on the sensors attached along the axis of the pins to provide angular information for the Boom Linkage and the Stick Linkage. These high-speed sensor track the motion of the linkage throughout the range of travel to provide real-time information regarding the linkage position.

Bucket Position Sensing Cylinder

Illustration 4 g06181321

The Grade system depends on the Bucket Position Sensing Cylinder which contains a protected sensor that provides real-time information regarding the cylinder extension. This high-speed sensor is protected inside the cylinder and provides high accuracy information to be used in the guidance calculations.

Laser Catcher

Illustration 5 g06181323

The Laser Catcher (also called the Laser Receiver) senses when the device is centered directly in a red wavelength rotating laser plane allowing the Grade system to work directly from a red wavelength rotating laser plane. This enables the Grade system to transfer the elevation target when working in 2D mode and moving or re-orienting the machine.

The Laser Catcher may be physically removed. The Grade system will still function as long as the system settings are configured to disable the Laser Catcher.

Note: The Laser Catcher will only function with rotating laser planes in the red wavelength spectrum. The Laser Catcher will not function rotating laser planes in the green wavelength spectrum. Rotation speed for laser transmitters should be set to 600 RPM or 900 RPM. High quality rotating laser transmitters are recommended for use with the Grade system for best accuracy and ease of referencing from the laser plane. Spectra Precision GL622, GL720, GL722 Grade Lasers are known to function well with the Grade system.

Remote Switches on the Joysticks

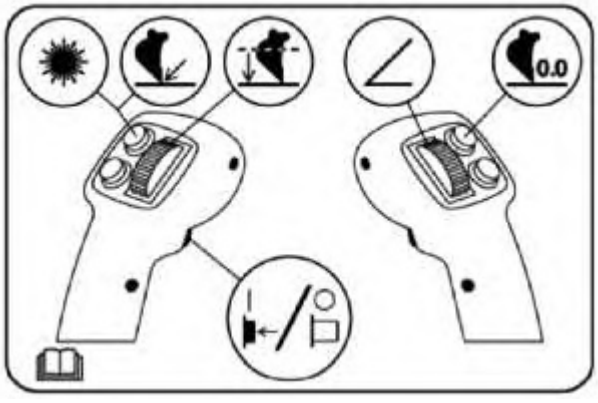

Illustration 6 g06181326

The joystick Remote Switches provide convenience of performing certain functions without taking hands off the joysticks to press a button on the Machine Monitor. Some frequent Grade operation tasks normally completed on the Machine Monitor or the Grade display may also be completed by the Remote Switches on the joysticks. The accessibility of these Grade functions on the joystick Remote Switches can improve machine and Grade system operation.

Note: The functions supported by the joystick Remote Switches can always be completed on the Machine Monitor user interface.

The switches on the joystick can be configuredto be utilizedby other machine systems depending on the button and switch combination. The Grade related functions are activated by pulling the left joystick trigger prior to activating the second remote switch.

TD520 Grade Display

Illustration 7 g06151218

(7) Suspend/resume (power) button
(8) Volume rocker
(9) Main connector port
(10) LCD display
(11) USB port
(12) Speaker

The main component of the Cat® Grade Control for Excavators is an on-board touch screen display designed specifically for grade control operation. The touch screen display is a computer that runs software for the Cat Grade Control System. It displays guidance information and other information for the operator of the machine. The touch screen display is an interactive platform for adjusting operation parameters for the Excavator.

In addition to the display, there are several sensors that are used with the system. The display and sensors are connected by a system harness that allows the components to send data and commands between each other.

Note: The USB port is a full-size standard A type. The USB port is protected by a sliding door. The sliding door must be moved aside to insert a USB plug or a USB drive. When a USB drive or plug is plugged into the USB port, the drive or plug will stick straight out from the port at a 90 degree angle from the screen surface.

Note: The mounting hub has mounting points for RAM Ball mounting bracket and a D6:CX mount. There are additional mounting points near the corners of the display for a CB460 mount.

GNSS Receiver/Antenna

Illustration 8 g06144476

Digital Acceleration/Gazelle/3D AccuGrade from the factory will use the MS972 combined antenna/receiver with no shock mounting.

The Cat Grade Control System uses a GNSS receiver and separate antenna (shown in Illustration 8) to determine the location of the machine in three-dimensional space.

The receiver can calculate drum location by using information that is broadcast from GPS and GLONASS satellites. The receiver will also use information broadcast from the GNSS satellites if a GNSS base station is used.

Data Radio

A data radio is used to receive data from one of the following types of base stations:

- GPS
- GNSS

The data radio is required to be working before the system can be used. The GPS data radio can also be used to send and receive files and other types of data from the office.

Currently, Caterpillar does not support radios. A radio from Trimble is recommended.

Base Station

When using an RTK mapping system, one of the following types of base station is required for the Cat Grade Control System to function correctly:

- GPS
- GNSS

Currently, Caterpillar does not support GPS base stations. A base station from Trimble is recommended.

A base station consists of the following components:

- GPS Receiver or GNSS Receiver
- GPS Antenna or GNSS Antenna
- Radio
- Cables
- Power Supply

There may also be a tripod or a mast for the antenna and the radio. For construction sites when work can continue for a long time, use a semi-permanent location such as the roof of the site office. A reliable power supply is needed.

Make sure that the base antenna is clear of obstructions, reflected signals, and sources of electromagnetic interference such as power lines. The data radio for the base station must be elevated several meters off the ground to provide optimum coverage.

The base station requires a starting location. For best results set up the receiver for the base station on a surveyed point. To establish this survey point, use site calibration or a professional surveyor experienced with this type of equipment.

Correctly set the antenna type at your base station. The position is degraded if the incorrect type of antenna is selected.

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Display Description

SMCS - 7490

Machine Display

Introduction

The Machine display is mounted on the right-hand side of the cab. The Machine display provides useful machine information to assist the operator in operation of the machine. The Machine Display also provides a user interface for both machine operation and for 2D Grade system usage. For 3D Grade system usage, refer to Section "TD520 Grade Display" .

Working with the Display

Illustration 1 g06181314

(1) LCD display
(2) Beeper
(3) USB port
(4) Softkey buttons
(5) Main connector
(6) Arrow buttons

Table 1

Item	Feature	Function
1	LCD display	The LCD display (1) shows the information from the machine and 2D Grade system needed by the operator.
2	Beeper	The Beeper (2) allows the display to provide audible indication of certain functions by the system and the display.
3	USB port	The USB port (3) can be used to offload a limited amount of data from the display such as the work tool list.
4	Softkey buttons	The Softkey buttons (4) allow the operator to select the function indicated by the icon in the space directly above the button.
5	Main connector	The Main connector port (5) connects the display to the machine and provides power to the display.
6	Arrow buttons	The Arrow buttons (6) allow the operator to navigate menus, scroll settings, and adjust numerical values.

Navigation and Selection

Illustration 2 g06181328

The Machine Monitor provides the user interface for the operation and configuration of the system. To operate and configure the Grade system, navigating the Machine Monitor menus and screens as well as selecting and configuring settings is essential.

Operations can be activated or set using the softkeys (4) shown at the bottom of the LCD display (1). The softkey button operation is indicated by the icon directly above the button.

To navigate the system, the Arrow buttons (6) may be used to adjust values and settings or to move the highlighted selection through the menu structure. Once menu items or values are highlighted using the Arrow buttons (6), the highlighted item may be confirmed with the "OK" softkey button.

Grade Information on the Machine Display

The Grade information on the Machine Monitor is shown in the footer of the main screen.

Illustration 3 g06181332

The Grade information on the Machine Monitor shows critical Grade information such as the Depth to Grade, Bucket Slope Angle, Bench Mode, Linkage Elevation Monitor System limits, and Bucket Focus. There are multiple patterns of softkey buttons that can be changed by using the Pattern Change softkey on this main screen. Refer to The Operation for Machine Monitor section for more details.

TD520 Grade Display

Introduction

The Grade Display is a computer that is used to interface with the Cat® Grade Control system. This section describes the operation of the display.

Working with the Display

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