Product: EXCAVATOR
Model: 320 EXCAVATOR YBP
Configuration: 320 Excavator YBP00001-UP (MACHINE) POWERED BY C7.1 Engine

Operation and Maintenance Manual
Cat® 2D and 3D GRADE System for Next Gen Hydraulic Excavators
Media Number -M0082987-03 **Publication Date -01/09/2018** **Date Updated -27/09/2018**

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Foreword

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 GNSSs currently under development. The European Union is developing the Galileo GNSS system. The Galileo GNSS system is estimated to be completed by 2020. The Chinese government is developing the BeiDou Navigation Satellite System GNSS (BDS). Now 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.

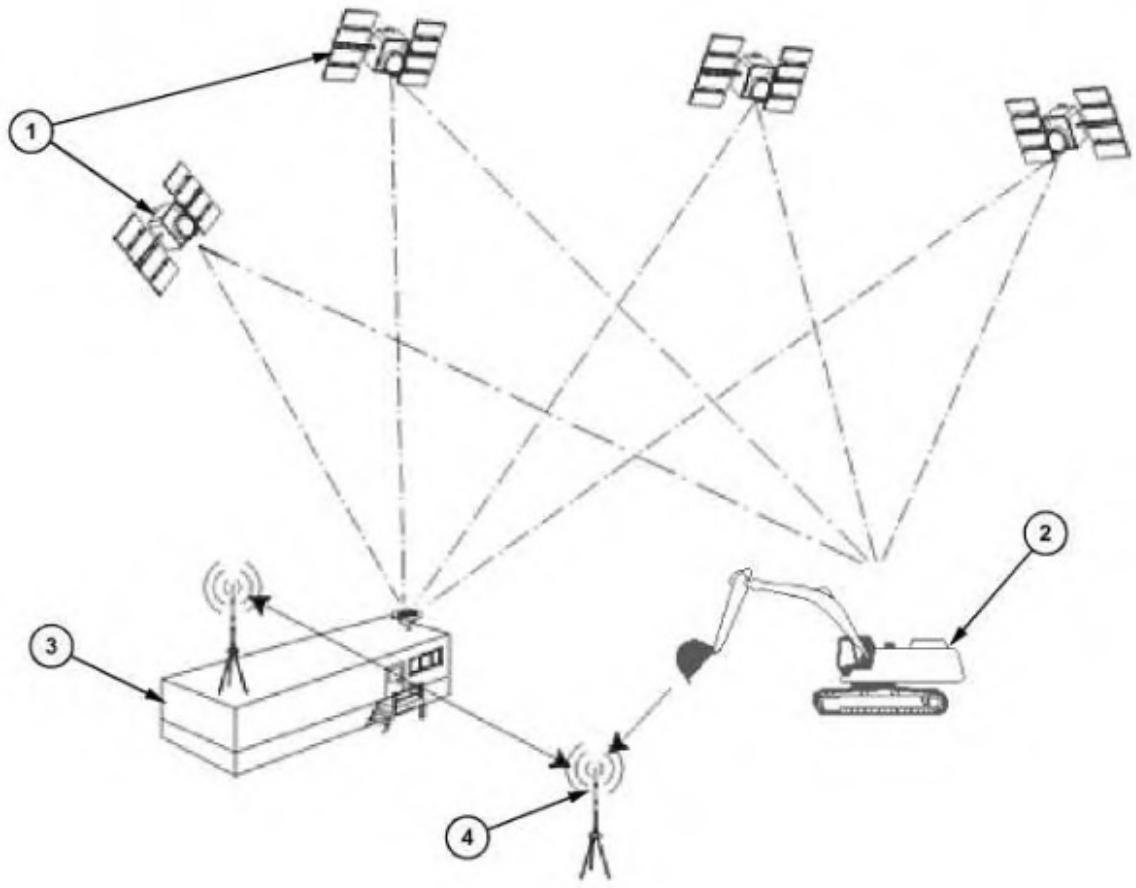

Illustration 1 g06151189

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 that 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 can be employed only 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.

Cat GRADE Folder Structure

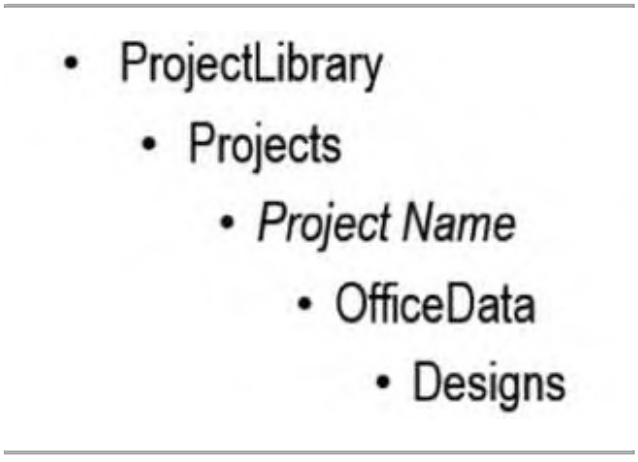

Illustration 2 g06243230

The file structure must be structured as shown in the Illustration 2 in order for the 3D Cat GRADE system to utilize it and be functional. Exporting the file from Business Center v3.80 and newer or using FileFlipper App that is installed on the TD520 Display will create a proper file structure and place the.cal and .dsz files in the proper place (folder).

A .dsz deign file is required and it will be located in the Designs folder. The .cal file is also required and is located in the OfficeData folder.

The .cal file sets all the coordinate system and the site calibrations information that will be needed by the GNSS Receivers. The .cal file will be loaded when a project is loaded to the machine 3D Cat GRADE system as it could be used for the whole project and with the multiple designs in a project.

Note: The .dsz and .cal files are different files format from AccuGrade. An AccuGrade .svd file can be converted to the Cat GRADE .dsz and .cal format using the FileFilpper application loaded on the TD520 display. An AccuGrade .svd file can also be converted to the Cat GRADE .dsz and .cal format, if exported from Business V.3.80 or newer.

Note: Performing a sync to the USB will also create this basic file structure. If manually created on a USB ensure that the file structure on the USB to be the exact capitalization and no spaces (ProjectLibrary and OfficeData). Refer to Illustration 2.

Loading a Project

- The project can be loaded using a USB through the operator interface on the TD520 display. Refer to Operation Section - System Settings Screen - File Transfer on this document.
- The project can also be synced from TCC if machine has internet connection and TCC account.

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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 g06234136

(1) Touch screen
(2) Beeper
(3) Main connector
(4) Main menu (Grid) option
(5) Side menu option

The machine display shows and manages the basic two dimensional (2D) GRADE system information. The 2D GRADE display requires a work tool to be properly configured and selected. On machines equipped with factory installed Cat® 3D GRADE system, the 2D GRADE system will not display any 2D GRADE information while the 3D GRADE display is turned on.

The 2D GRADE information in the machine display main screen will disappear from view when the 3D GRADE display TD520 is powered on. The 2D GRADE information will not reappear in the machine display main screen until the machine has been powered off for long enough that the Electronic Control Modules (ECMs) shutdown completely.

Work tool configuration and measure up can be accomplished only on the Cat® 2D GRADE system. The 3D GRADE system will use the work tools information that was stored and selected on the 2D GRADE system. The operator can select any of the work tools that was measured and configured on the Cat 2D GRADE system using only the machine display.

Note: Underwater excavation is only supported when using a dedicated underwater solution. When excavating underwater, do not submerge the sensors deeper than 1 m (3.3 ft).

Body Inertial Measurement Unit (IMU)

Illustration 2 g06320320

The Body Inertial Measurement Unit (IMU) provides GRADE system with the necessary information regarding the slope and the main fall 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.

Boom Inertial Measurement Unit (IMU)

Illustration 3 g06320318

Stick Inertial Measurement Unit (IMU)

Illustration 4 g06320316

The GRADE system depends on the Inertial Measuring Unit (IMU) sensors attached along the left side of the Boom and the Stick axis of the pins to provide angular information of the Boom 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 AMR Sensor

Illustration 5 g06217171

The GRADE system depends on the Bucket AMR Sensor to provide real-time information regarding the bucket angle. The Bucket AMR Sensor is a high-speed sensor and is installed on the Left side of the Stick linkage around the idler link pin. The Bucket AMR Sensor provides high accuracy information to be used in the guidance calculations.

Laser Catcher

Optional

Illustration 6 g06300311

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 option will not be offered from the factory, to order this option contact your local Cat dealer.

Note: The Laser Catcher will only function with rotating laser planes in the red wavelength spectrum. The Laser Catcher will not function if the 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 7 g06234137

(6) Bottom view
(7) Top view

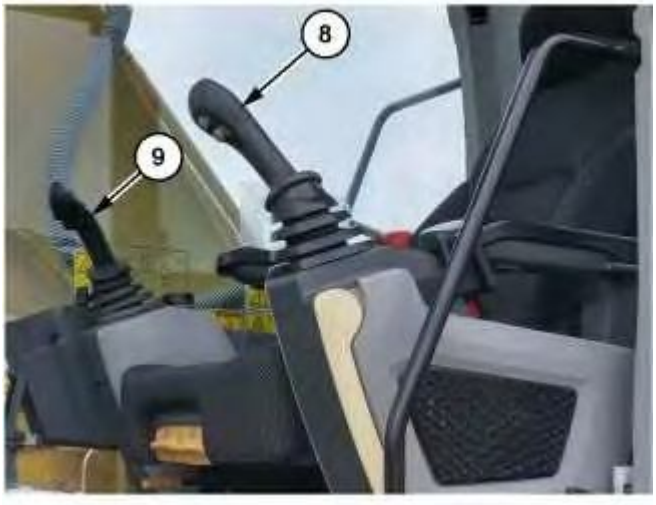

Illustration 8 g06234142

(8) LH Joystick
(9) RH Joystick

The joystick Remote Switches will provide the operator with a convenience of performing certain functions without taking their 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 3D 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.

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