

Special Instruction

i04694729

Autonomous Stop (A-Stop) System for Autonomous Hauling

SMCS Code:

Off-Highway Truck/Tractor
793D (S/N: FDB1-Up)
793F (S/N: SSP1-Up; RBT1-Up)
797F (S/N: LAJ1-Up)

Table of Contents

Introduction	1
Overview	1
A-Stop Operation	3
Stopping	4
Clearing an A-Stop	5
Resuming Autonomous Operation	5
Testing the A-Stop System	5
Electrical Input Components	5
Autonomous Stop Receivers	5
Electrical Output Components	6
A-Stop Transmitter	6

Introduction

This document contains operational information about the A-Stop System.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

Note: Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC rules.

Overview

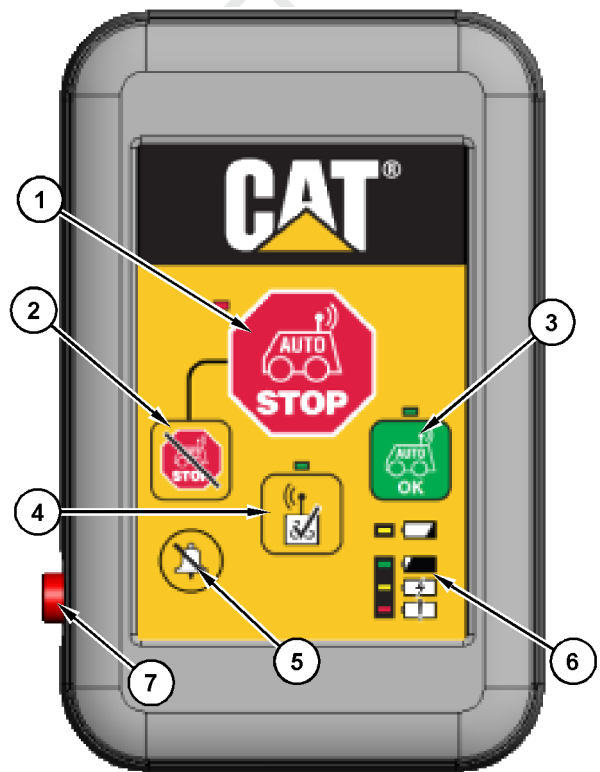


Illustration 1

g02799169

Table 1

Callout	Button	Description
1	A-Stop Button	Used to transmit an A-Stop Signal received by all autonomous machines within range. The A-Stop signal will continue to transmit until the A-Stop Reset (2) is pressed. ⁽¹⁾

(continued)

(Table 1, contd)

Callout	Button	Description
2	A-Stop Reset Button	Used to stop transmitting the A-Stop signal. The A-Stop Reset button (2) will only stop the transmission of the A-Stop signal, this button will not clear an effected machine to resume operation.
3	Clear Button	Used to signal all machines in the area that those machines can resume autonomous operation. Each transmitter that has signaled an A-stop must be pressed before the effect machine can resume operation. ⁽²⁾
4	Test Button	Used to initiate an A-Stop system test between the transmitter and all autonomous machines in range of the transmitter. The test button (4) is a momentary switch
5	Alarm Silence	Used to silence the audible alarm during an A-Stop event.
6	Battery Charge Indicators	Used to show status of the transmitter battery.
7	Charging Port	Used to charge the transmitter.

(1) Only the transmitter that sent the A-Stop signal can cancel the A-Stop command.

(2) Pressing the clear button (3) does not allow the truck to resume the task it was assigned before the A-Stop was initiated. The clear button (3) only allows the truck to receive another assignment. MineStar must be used to assign an autonomous ready truck after an A-Stop event.

The autonomous stop (A-Stop) system is used to stop the autonomous trucks in the area in case of emergency or unplanned need. The system sends a radio signal to all the trucks within the operating range of the handheld transmitter. The communications of the A-Stop system operate independently from the normal autonomy system and can be used even if MineStar cannot communicate with the truck.

Each person working in the area of autonomous operation shall be issued an A-Stop transmitter and is required to carry the transmitter at all times.



Illustration 2
Receiver

g02799149

Each autonomous haul truck has two receivers which operate on different data links. The receivers are powered by the machine and send out a heartbeat message to the truck under normal operation.

A-Stop Operation

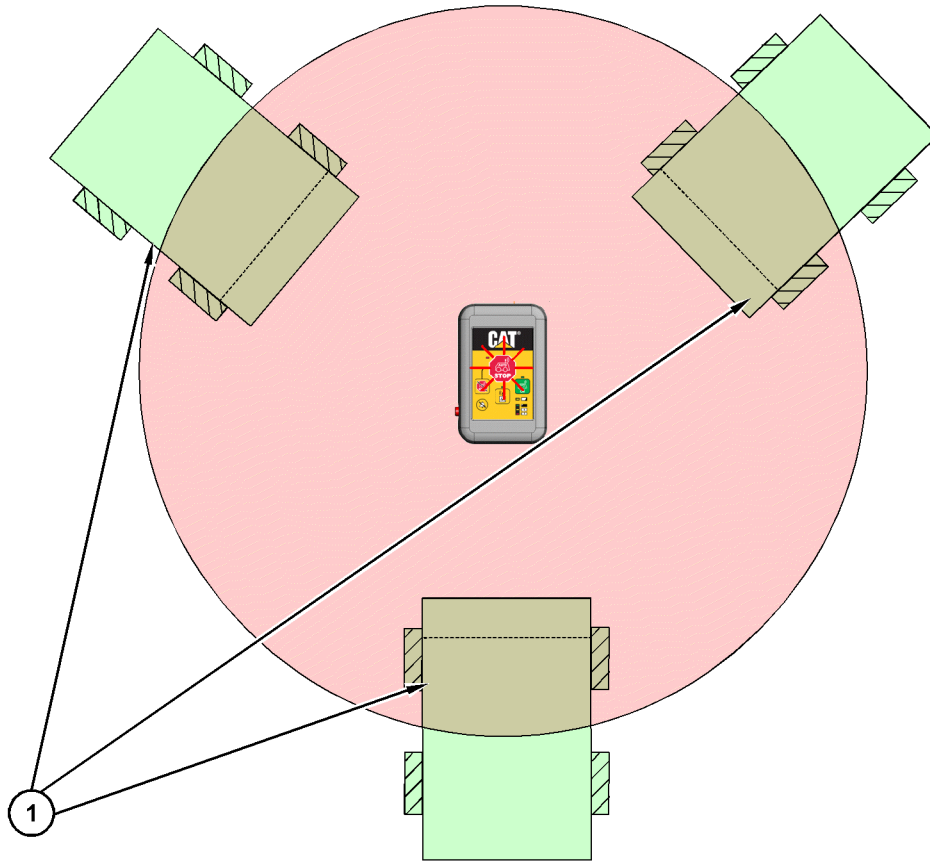


Illustration 3

g02728442

Single transmitter in operation

(1) Autonomous machines with on-board
A-Stop receiver

Illustration 3 shows three Autonomous machines with on-board A-Stop receivers. The flashing light on the A-Stop remote indicates that an A-Stop has been activated. The large circle in the illustration is the range of the A-Stop remote. In the illustration, the three Autonomous machines that are in range of the A-Stop remote are stopped due to the A-Stop button that was pressed.

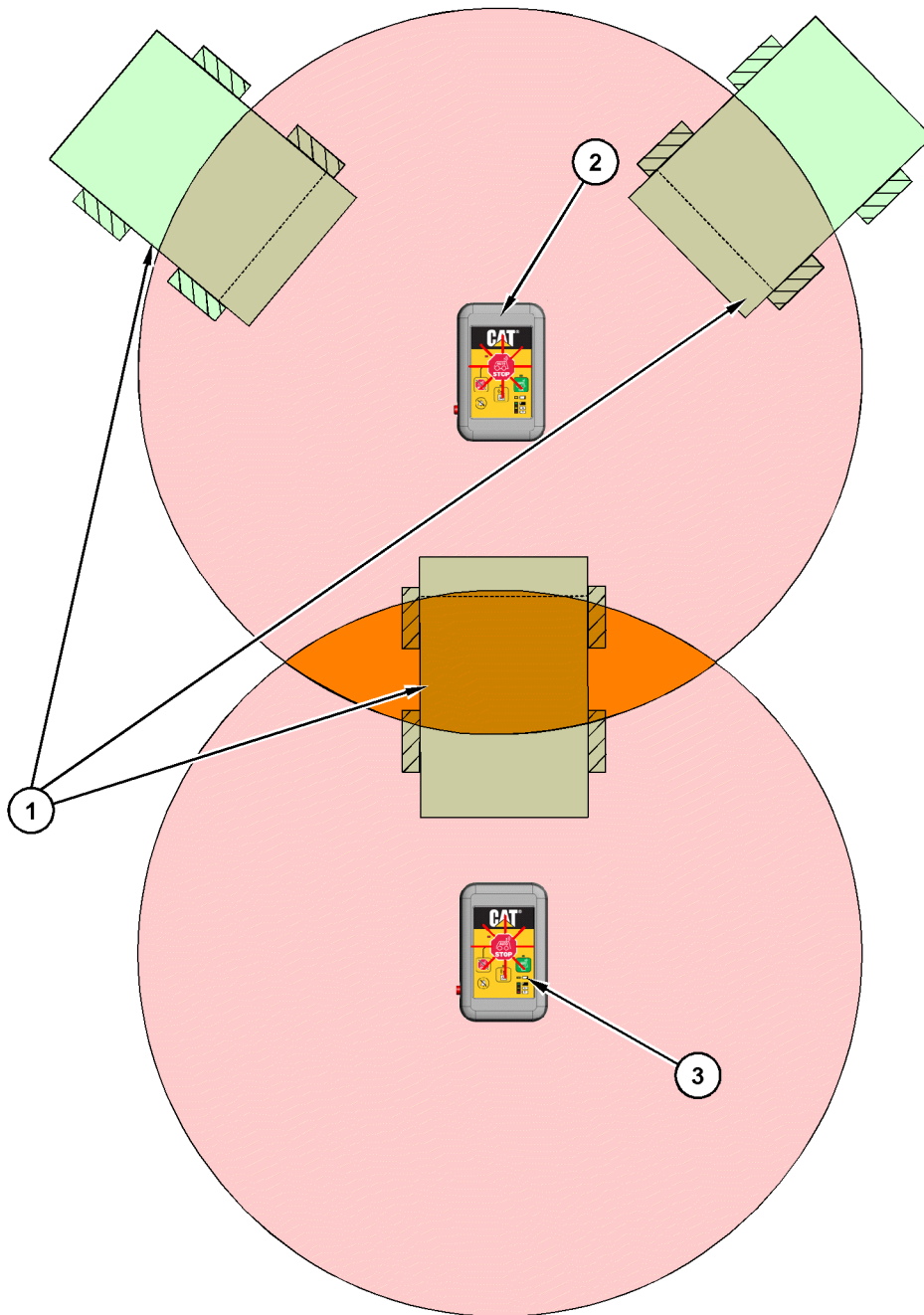


Illustration 4

g02727922

Multiple transmitters in operation

(1) Autonomous machines with on-board A-Stop receiver

Once an A-Stop event has occurred, any machines in the range of the remote transmitter will be stopped for as long as the remote is transmitting. A "Clear" signal will need to be sent before any of the machines affected will be able to resume normal operation. When more than one remote is activated at once, all remotes that sent an A-Stop command will need to send a "Clear" signal. Refer to Illustration 4 for an example of multiple transmitters in operation at once.

Stopping



Illustration 5

g02742797

When a truck receives an A-Stop stop signal, the truck immediately initiates a controlled stop. While the truck is in autonomous mode with A-Stop active, the autonomous mode and A-Stop lights will be flashing. Refer to Illustration 5 for an example.

Clearing an A-Stop



Illustration 6

g02742856

The truck identifies and records which transmitter or transmitters have initiated the A-Stop. The truck can only resume autonomous operation when an A-Stop clear message is received from all the transmitters that the truck received a stop message from. Once the truck has received a clear message from every transmitter that the truck received a stop message from, the truck will deactivate the A-Stop and the A-Stop light with stop flashing. Refer to Illustration 6 for an example.

Resuming Autonomous Operation

When the truck has received all the necessary clear messages, the truck is ready for a new assignment. The truck will not automatically resume the task that was assigned prior to the A-Stop. The truck requires the MineStar operator to assign the truck a task.

Testing the A-Stop System

An A-Stop transmitter can test the transmitter and truck system by using the test button (4). Press and hold the test button for 2 or more seconds while in range of one or more autonomous trucks. The trucks that receive the test message will acknowledge the test by honking the truck horn.

The A-Stop system also has a self-test function. The self-test is different from a test using an A-Stop transmitter. Periodically, the truck will send out A-Stop self-test signals that can detect a system failure all the way down to the antenna. The truck will notify the MineStar operator if a failure is detected in a self-test.

Electrical Input Components

Autonomous Stop Receivers

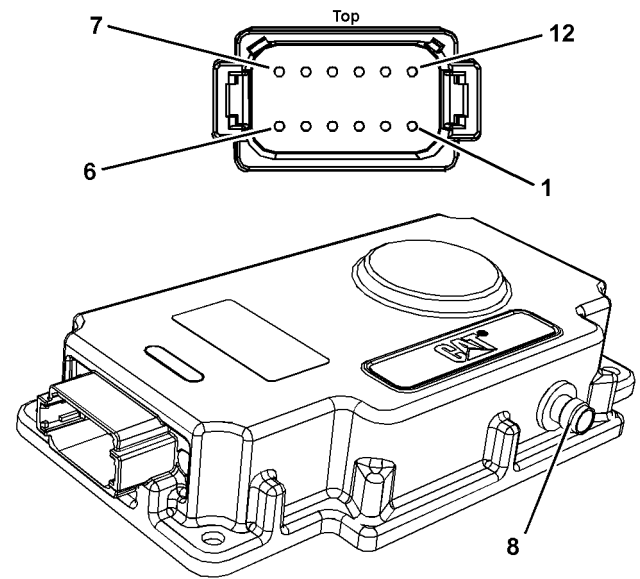


Illustration 7

g02799818

A-Stop Receiver

(8) antenna connector

Table 2

A-Stop Connector	
Pin Location	Signal Identification
1	+ Battery
2	- Battery
3	NC
4	NC
5	NC
6	NC
7	NC
8	CAN Hi
9	CAN Lo
10	CAN Shield
11	NC
12	NC

There are two A-Stop receivers per autonomous truck. The receivers are powered from the machine 24V supply. The receivers send and transmit at 919 MHz through the antenna which connects with a cable to the antenna connector (8) located on the side of the receiver. Each receiver communicates with the autonomous machine using a CAN bus. For redundancy, one receiver communicates over the machine CAN circuit and one receiver communicates over the autonomous CAN circuit. Under normal operation, the receivers transmit a periodic heartbeat message until an Autonomous Stop (A-Stop) command from an A-Stop Transmitter is received. The receivers also transmit to each other for redundancy.

The A-Stop transmitter is a hand held unit that can be carried by each individual within the area of autonomous operation. It runs off a rechargeable, 1.2 V NiMH battery which is charged using the port on the side of the transmitter. The transmitter sends signals at a 919 MHz fixed frequency to the A-Stop receivers within the transmitter operating range. The transmitter can stop every autonomous truck within approximately 300 m. The transmitter also has LED indicator lights for Stop, Clear, Test, Low Battery, Battery Charging, and Battery Fault functions. The transmitter will enter a power-saving sleep mode after 24 hours of inactivity or can be triggered manually.

Electrical Output Components

A-Stop Transmitter

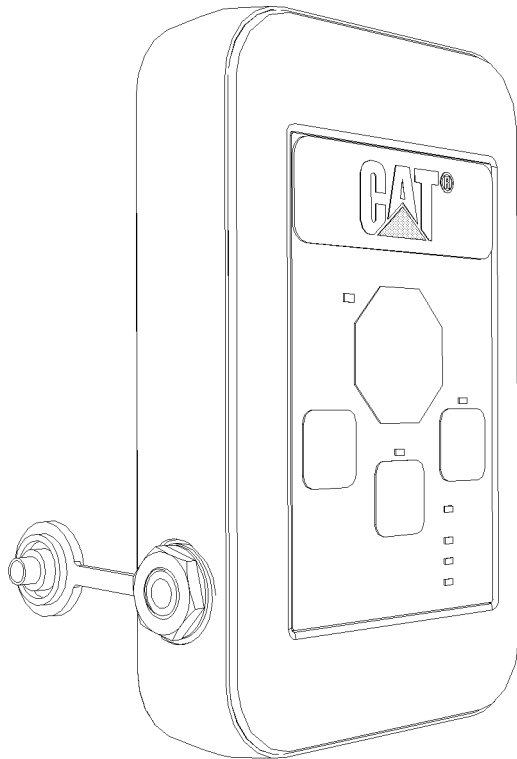


Illustration 8

g02799960

A-Stop Transmitter

PROOF

PROOF

©2012 Caterpillar
All Rights Reserved

Cat, Caterpillar, their respective logos, "Caterpillar Yellow" and the Power edge trade dress, as well as corporate and product identity used herein, are trademarks of Caterpillar and may not be used without permission.