



CAT[®] TROLLEY ASSIST SYSTEM

FOR ULTRA-CLASS ELECTRIC DRIVE MINING TRUCKS



CAT® TROLLEY ASSIST

**ELECTRIFYING
MINES
TO REDUCE
EMISSIONS.**

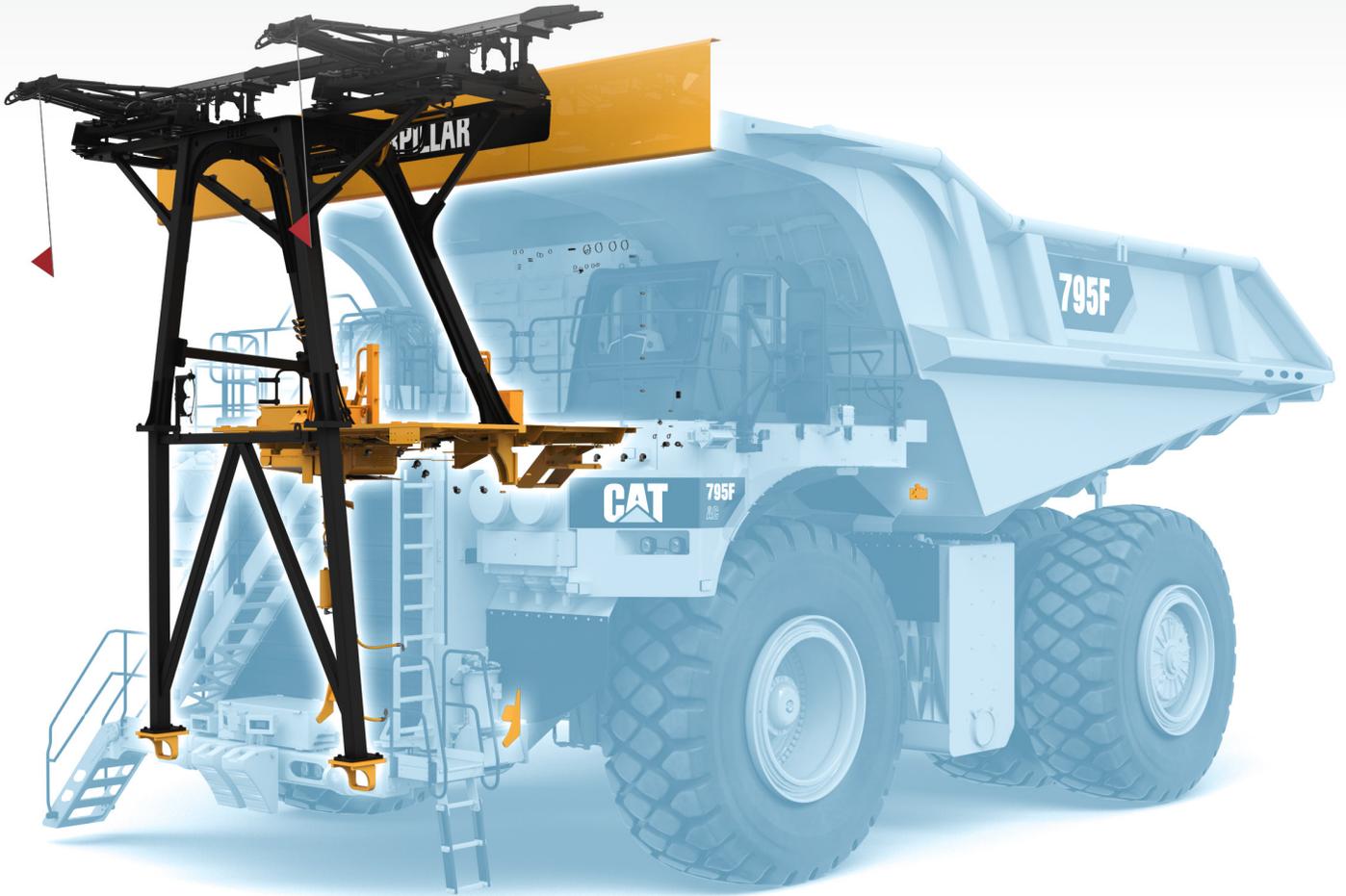
REDUCING GREENHOUSE GAS EMISSIONS

Trolley assist offers mines the ability to reduce engine emissions and increase mine electrification. The reduction in diesel fuel consumption lessens greenhouse gases, NOx, and PM emissions. It promotes a more sustainable mining operation.

- + More environmentally friendly mode of operation
- + Between 20% to 60% reduction in CO₂ emissions
- + Potential for carbon tax credits

COMPATIBILITY

The Cat trolley assist retrofit kit is currently available for the 795F AC truck. The trolley design is compatible with all other Cat ultra-class electric drive trucks (794 AC, 796 AC, 798 AC) – and will be available in the future.





INCREASED PRODUCTIVITY

While connected to the trolley line, the Cat 795F AC can nearly double its speed.
A recent study showed an increase of 100% speed-on-grade from 14 km/h (8.7 mph) to 28 km/h (17.4 mph).

Putting over 4500 kW to the ground, the 795F AC (connected to trolley) is the **Most Powerful Mining Truck in the World Today!**

- + Up to 100% speed-on-grade improvement vs. diesel mode
- + Higher Productivity
- + Faster Cycle Times

REDUCE FUEL BURN, INCREASE ENGINE LIFE

Diesel Fuel Burn Substitution

When connected to the trolley system, the truck's propulsion system becomes powered purely with electricity from the power grid, minimizing the use of the diesel engine and utilizing the full potential of the wheel motors.

Improved Engine Life

Thanks to the significant decrease in diesel fuel burn while on trolley, engines are exposed to less wear and tear — thus increasing the engine's life until overhaul.

- + 90%+ reduction in diesel fuel burn with trolley active
- + Savings of up to 40 liters of diesel per cycle per 1 km of trolley line
- + Increase machine engine life by up to 25%

100% CATERPILLAR DESIGNED AND INTEGRATED

The Cat trolley assist attachment is the only one in the industry fully designed, integrated, and built to Caterpillar specifications — leveraging the 100% Caterpillar-designed and integrated AC drive train.

The attachment includes:

- + A purpose-built, thoroughly-tested trolley structure
- + Pantographs
- + Support Systems
- + And the necessary components to fully integrate onto a Cat ultra-class electric drive mining truck.

The ruggedized pantographs are designed to Caterpillar specifications and work seamlessly with the rest of the attachment for optimal performance.

- + 100% Caterpillar-integrated drive train optimizes performance & serviceability
- + Reduced maintenance costs
- + Validated structures deliver more uptime and lower repair costs

CAT TROLLEY ASSIST SYSTEM SITE INFRASTRUCTURE REQUIREMENTS

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The Cat Trolley Assist System requires incremental truck iron and significant site infrastructure footprint to enable its operation. There are five key elements of the site infrastructure, they are: AC substation, DC substation(s), support poles, catenary lines, and the load height check. Site infrastructure for the trolley system must be provided by a third-party.



AC SUBSTATION

Site infrastructure starts with a large AC substation. The AC substation shapes AC power from the local power grid for use by the smaller DC substations along the trolley assist route. Typically, only one AC substation is needed for the entire trolley system.



DC SUBSTATION(S)

The DC substations are placed approximately every 1 km along the trolley route. Fed by the AC substation, these DC substations convert the AC power into 2,600 V DC power for the trolley lines. The total number of DC substations varies depending on the haul route length and the desired number of trucks targeted for simultaneous operation.

CATENARY LINES

Supported by the catenary routing poles, two catenary conductors are ran immediately overhead the haul road on the trolley assist segment. These two catenaries are DC conductors, and are directly connected to the DC substation(s). Carbon brushes on the pantograph directly contact the catenary lines for the duration of the trolley assist segment.



SUPPORT POLES

Support poles consist of a vertical base poles and catenary routing poles, and are placed approximately every 40 m along the haul road. Poles are placed as far apart as possible to maintain a suitable catenary arc. Vertical base poles, which typically need 3-4 m of a base to be installed, are placed immediately to the side of the haul road on the side of the direction of uphill travel. Catenary routing poles are cantilever mounted to the vertical base poles and extend approximately $\frac{1}{4}$ of the way over the haul road. Upfront design consideration is recommended If mine plan requires relocation of trolley lines.



LOAD HEIGHT CHECK

Before the first support pole and start of the trolley line, a system is used to detect the pile height of the truck and ensure that it is below the catenary height. The load height check system features two poles and a laser check to measure the truck pile height, and a red/green light immediately afterwards. The red/green light alerts the operator if the pile height is below the catenary height and it is okay to proceed (green), or if the pile height it at or above the catenary height, and the truck must process with non-trolley trucks (red).

REDUCE COSTS

THE CAT TROLLEY ASSIST ATTACHMENT OPERATES AT A HIGHER VOLTAGE THAN MOST COMPETITIVE TRUCKS.

The higher operating voltage significantly reduces electrical system losses in power transmission from the DC power lines to the wheel motors. This provides many benefits — such as lower infrastructure costs, reduced maintenance costs, and improved operational efficiency.

IMPORTANT ELECTRICAL VALUES AND DIMENSIONS

THE TABLE BELOW CONTAINS ELECTRICAL VALUES FOR A SINGLE TRUCK ON THE CAT TROLLEY ASSIST SYSTEM.

SINGLE TRUCK VALUES (referenced from the point the power is taken off the trolley line)

Maximum Trolley Power Draw	4,500 kW
Operating Voltage range	2,150 – 2,800 VDC
Full Power Voltage Range	2,450 – 2,800 VDC
Full Power Current Range	1,836 – 1,636 ADC
Reduced Power Voltage range	2,150 – 2,450 VDC

THE TABLE BELOW CONTAINS VARIOUS REQUIRED DISTANCES AND SPECIFICATIONS FOR TROLLEY OPERATION.

TROLLEY DIMENSIONS AND SPECS

Negative DC Trolley Line	Pantograph Directly Above the Operator Cab
Positive DC Trolley Line	Pantograph on the Right Side of the Truck
Distance between lines	3,985 mm
Pantograph Width of Carbon Brushes	2,445 mm

SUPPORT

The Cat trolley assist attachment comes with the full support of the Cat dealer network. 100% of the trolley components have a Cat part number and are supported by the Cat parts network.

A full set of operation, maintenance, and repair service publications are developed and published on the trolley attachment, and Cat dealers are trained and positioned to support the trolley system.



FREQUENTLY ASKED QUESTIONS (FAQ)

Q: When on Trolley, can the operator slow the truck to their desired speed and then accelerate if they need to?

A: The operator can modulate speed in trolley assist using the accelerator pedal in a similar fashion to a normal diesel propel mode. If the truck speed drops below 8 km/h (5 mph) while on trolley line, the trolley will disengage and switch back to diesel mode automatically for safety reasons. There are several additional safety measures built into Cat trolley assist.

Q: What is the line height variation amount and frequency?

A: The contact wire to road surface should be set to +/- 100 mm of the target height. During operation, the system is designed to accept a line height variation of up to +/- 500 mm at a frequency of 1 Hz. 500 mm reflects a combination of road surface and machine suspension / tire changes during operation.

Q: What are typical grade values that must be maintained to reduce the road tolerance rejection rate, and how much vertical and lateral movement is allowed on the truck before the pantograph disconnects?

A: Trolley requires dedicated road maintenance, the road must be in good shape. Potholes, ruts, and other deficiencies could cause a truck on trolley to disengage if it loses contact with the lines. The pantographs allow for +/- 1 m of lateral movement, and +/- 500 mm of vertical movement dynamically. The working range of the pantograph is 1.5 m.

Q: Is there a ground fault protection mechanism on the truck, or does that lie on the infrastructure side?

A: Truck components feature a ground fault protection; however, this is not a personal protection system. The sub station should also contain a ground fault protection.

Q: What mitigation should be taken to reduce arcing / sparks when contact with the line is interrupted due to uneven road surfaces? How does the truck behave under these circumstances?

A: To reduce arcing / sparking, the support poles should be placed 40 m apart, and the road should be regularly graded. The contact wires, when set with the hangers, should be parallel to the road +/- 100mm. The pantograph is designed to respond to vertical changes, but for sudden vertical changes the pantograph features a quick-drop system. Maintaining line tension is important, as drooping in the line will cause a sudden snapping of the line at the hangers, resulting in the pantograph arcing.

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