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NEW POWER, PRODUCTIVITY AND SAFETY


RTG RETROFITS

Version 3.0



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1. INTRODUCTION

This booklet gives a comprehensive overview of the retrofits that Konecranes provides for its Rubber Tired Gantry (RTG) cranes. It is organized so that you can quickly and easily find the retrofits that are available for your Konecranes RTGs.

Please start by finding your Konecranes RTGs by their G-number in the APPENDIX: RTG RETROFIT TABLE. Check the retrofits that are available for your RTGs. Then turn to the relevant sections in this booklet for a description of each retrofit and the benefits it provides.

Once you have decided on the retrofit(s) you want, contact your Konecranes representative for more information on what is involved and a customized quotation to suit your individual requirements.

NOTE: The retrofits described in this booklet are available for Konecranes RTGs only.

OUR RETROFIT MISSION

Our goal with every RTG retrofit is to make the handling, functionality and reliability of your existing Konecranes RTGs equivalent to the latest generation of Konecranes RTGs. In principle, we can and will retrofit any existing Konecranes RTG in the field.

At Konecranes, we constantly develop our crane technology to improve the efficiency, reliability and safety of our RTGs. As your Konecranes RTG starts to age, a retrofit will make the most of the strength and durability of its overall structure while incorporating new technology that did not exist when the RTG was originally delivered.

The new technology ensures that your RTG will continue to perform at the highest level, increasing safety and operational efficiency and maintaining spare part support. New components and parts reduce the need for repairs and unscheduled maintenance, and minimize downtime. Improved efficiency lowers the cost of running the crane. A retrofit also readies the crane for future technological developments, such as automation.

Most importantly, our retrofits keep the lifecycle value of your crane high and help to further reduce the total cost of ownership over its remaining years of service.

OUR RETROFIT PHILOSOPHY

Depending on the retrofit you choose, the new components and functionality installed on your Konecranes RTG will vary considerably.

Be that as it may, all of our retrofit projects are handled as turnkey projects by default from order to hand-over. We will:

- Inspect and assess the condition of the crane's relevant components before the retrofit to ensure everything is taken into account during the project
- Supply design and engineering for your specific case covering the mechanical, electrical, and/or software-related aspects
- Update and deliver a complete set of crane documentation
- Assemble and test the retrofit at our factory before packing, stowing, and shipping deliverables
- Ensure that the mechanical and electrical site installation work is supervised by one of our experienced site managers
- Test and commission your crane after the retrofit
- Train your staff (optional)

Your Konecranes RTG retrofit will be assigned to a dedicated Konecranes product manager who will take responsibility for it. Every Konecranes RTG retrofit type has a dedicated Konecranes product manager responsible for improving the processes related to it.

WHY CHOOSE KONECRANES AS YOUR RETROFIT PARTNER?

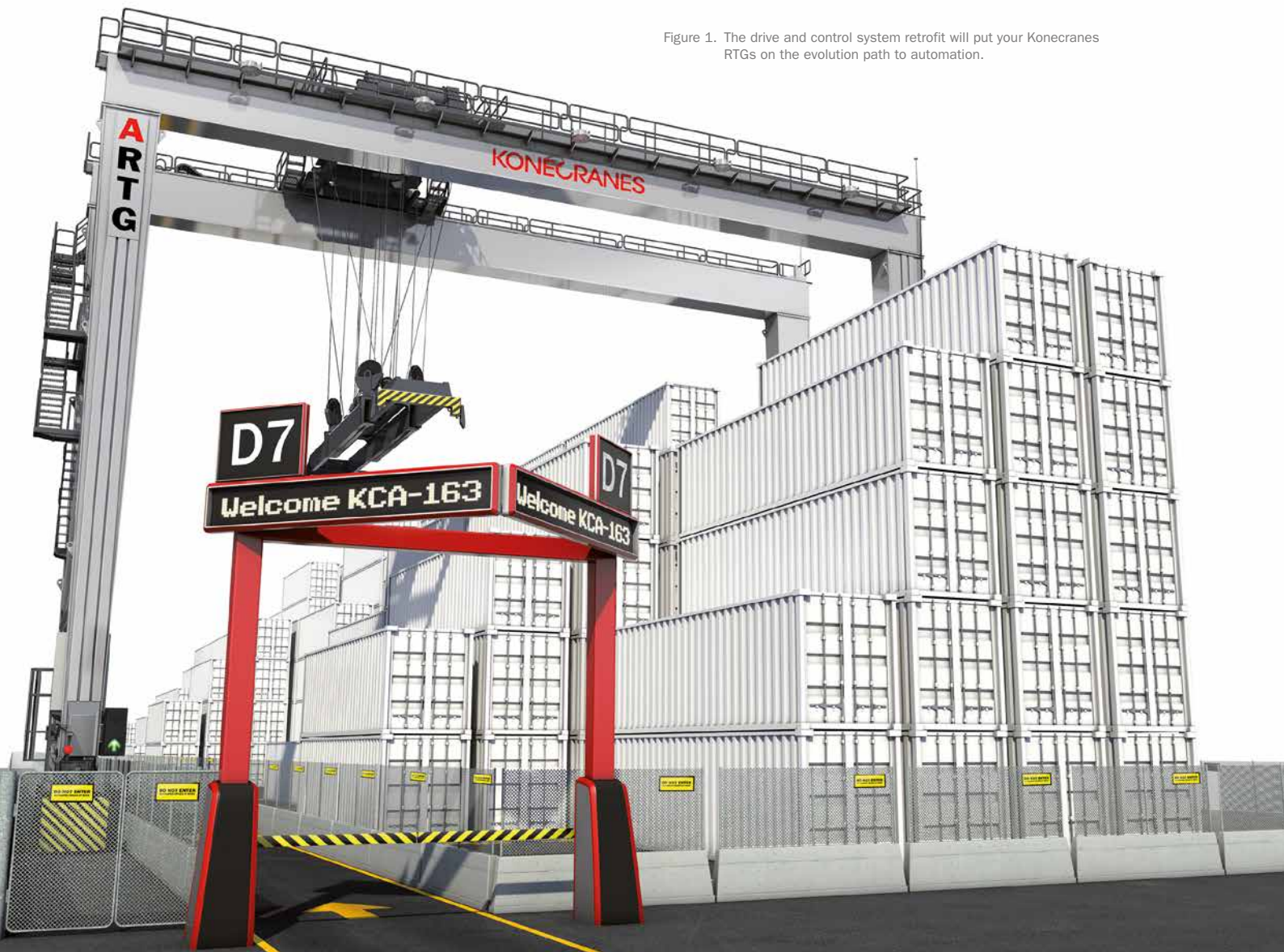
Because:

- We know your RTG cranes better than anyone else: we made them
- You keep communication simple by having one point of contact for your cranes
- We retrofit only proven technology
- You know that both the hardware and the software have been designed specifically for your cranes and your application
- We have an excellent safety record
- We don't just replace old components and upgrade software; we redesign features and engineer new ones to improve safety and performance
- We cover all aspects of a retrofit project

2. DRIVE AND CONTROL SYSTEM RETROFIT

Automation technology has been advancing very quickly in recent years. Konecranes has been leading the way in the automation of yard cranes in container terminals. With the introduction of the Konecranes Automated RTG (ARTG), automation can be applied to your RTG-based container terminal without major infrastructure investment. The drive and control system retrofit described here will put your existing Konecranes RTGs on the evolution path to automation. It will bring many other benefits as well.

Figure 1. The drive and control system retrofit will put your Konecranes RTGs on the evolution path to automation.



WHY DO THIS RETROFIT?

If your RTGs are 10–15 years old, their steel structures should still be in good condition. However, the crane electronics and components will have aged and will gradually become outdated. We offer the drive and control system retrofit to prevent wear-based breakdowns from increasing, to ensure spare parts availability, and to generally future-proof the cranes.

When you retrofit the newest technology from the latest generation of Konecranes RTGs to your existing fleet, you empower your cranes, your crane operators and your business. The functionality and operation of your older Konecranes RTGs will be brought up to the level of the latest generation of Konecranes RTGs.

A drive and control system retrofit on your Konecranes 16-wheel RTG2000 cranes will build in the following proven Konecranes technology from our latest generation of RTGs, improving performance and decreasing downtime:

- New generation D2V inverters provide better functionality for their respective systems, and have better technical and spare part support.
- The Crane Management System (CMS) increases crane reliability by providing much more information on how your crane is working, making diagnostics and troubleshooting easier. An optional CMS server can bring this information directly from the crane CMS to your technical office via a WiFi connection.
- The new Proface operator touch panel has a faster response time and a more intuitive interface. This improves operational performance by reducing the chances of human error.
- The Simatic S7-300 PLC with Ethernet, fully compatible with the Konecranes CMS and remote connectivity, gives you better technical support and a reduced response time.
- TRUCONNECT remote services allow the expert engineers at Konecranes Global Technical Support to analyze the condition of your crane at any given time, improving our response time for troubleshooting.

We recommend an electrification retrofit in conjunction with the drive and control system retrofit. Doing both at the same time will minimize downtime during the retrofit process, reduce the environmental impact of your RTGs, and reduce energy consumption. Our power retrofits are described in detail in Section 3 of this booklet.

2.1. STANDARD DRIVE AND CONTROL SYSTEM RETROFIT

If you have a Konecranes 16-wheel RTG2000, it is eligible for a standard drive and control system retrofit. Please refer to the eligibility table in the Appendix, cross-checking your crane's G-number to find the available retrofits.

NOTE: if you have older-model Konecranes RTGs needing a drive and control system retrofit, they are also eligible on a case-by-case basis.

Technical highlights

The standard drive and control system retrofit is designed and engineered specifically for 16-wheel Konecranes RTG2000 cranes. The following list highlights some of the technological improvements included in this retrofit:

New equipment:

- New generation drives, shared by the hoist and the gantry
- New generation drives to operate the trolley
- New generation drives in the e-room replace the old ACM drives in the trolley cubicle
- New braking resistors replace the old ACM braking resistors
- New PLC system based on Siemens S7-300 replaces the old S7-400 in the e-room with a new remote PLC in the cabin
- New Proface operator touch panel replaces the old operator panel cabin display
- New Crane Monitoring System (CMS) replaces the operator panel in the e-room
- New 3G / WiFi modem for remote connectivity and troubleshooting

When you order this retrofit, you can add any of the other retrofits in this booklet as options to add extra value to your retrofit project and further increase the functionality, safety, and performance of your Konecranes RTG.

How long does this retrofit take?

All of the components for our standard drive and control system retrofit are assembled and tested at our factory in Hyvinkää, Finland.

The lead time, including engineering for the retrofit components, is approximately 3 months.

When more than one crane is being retrofitted, the lead time for the first crane will be 3 months. Then add 2 weeks for each additional crane in the retrofit project.

The transportation time from our factory to your site depends on the country you are in, the type of transport used (air, sea, road), customs clearance time, and other possible administrative requirements. It usually takes from 1 to 5 weeks.

Site works – removal of old components, installation of new components, electrical connections, start-up, commissioning – take 3 weeks for the first crane. Then add 2 weeks for each additional crane. Your cranes will be out of operation for about 2–3 days less than the total site works time.

Normally, there is a period of 7 days for site mobilization. If you would like to retrofit more than one RTG, but cannot make your RTGs available to our site crew consecutively, you can order your retrofit at the same price, and we will charge only one mobilization fee to close and re-open the retrofit site if the second stage of work takes place within 6 months of the first stage of the retrofit. Please ask us about scaled payment terms in this case.

2.2 HOW DO I DECIDE ON THIS RETROFIT?

There is no one right way to run a retrofit project with Konecranes RTGs. Although there is a limited number of Konecranes RTG types, every container yard is different. Every container terminal has unique long-term plans, finances, and operating needs. Here we illustrate the decision-making process for the drive and control system upgrade with a sample case.

Drive and control system retrofit, sample case

John Smith runs a medium-sized container terminal close to a major urban area on the west coast of the United States. He has Konecranes RTGs as follows: 4 RTG2000 cranes, 2 RTG2005 cranes, 2 RTG 8W cranes, and 2 first-generation RTGs from 1998. Part of the container terminal's business plan is to modernize the entire yard, including retrofitting all the RTGs.

John contacts his local Konecranes office, discusses his circumstances, and gains the following understanding of his RTG retrofit situation:

- John's RTG2000 cranes are eligible for the standard drive and control system retrofit. These are the most-used cranes in the yard. They are in constant demand and cannot spend much time out of service.
- John's first-generation RTGs can receive a drive and control system retrofit, but these are non-standard and will have to be adapted for each specific crane.
- John's remaining Konecranes RTGs do not need a drive and control system retrofit: they are already equipped with the latest technology.

In total, John orders 6 drive and control system retrofits for his RTG2000 and first-generation RTG cranes. To ensure that they are out of service as little as possible, he asks that the retrofits be completed within a 6-month period.

The components arrive on-site. The first RTG2000 retrofit takes 3 weeks, the second one 2 weeks. Two months later, the remaining two RTG2000 cranes are out of service for 2 weeks each as their retrofits are done.

Two months after that, the 2 first-generation RTGs are retrofitted. These retrofits are two unique cases, so each one takes 3 weeks, for a total of 6 weeks.

3. POWER RETROFITS

INTRODUCTION

Reducing fuel costs is in the best interest of every crane owner. Recent advances in technology can substantially improve how your RTG cranes consume power, reducing operating costs.

The environmental impact of heavy machinery is increasingly under the microscope. Customers are ranking environmental friendliness higher as a selection criterion when choosing crane providers. Eco-efficiency has always been a driver of Konecranes RTG design. Our power option retrofits make Konecranes RTGs even more eco-efficient.

We provide a complete range of power option retrofits for our RTGs. Whether you choose to stay with diesel or switch to electrical power, Konecranes has you covered. We designed and built your Konecranes RTGs, so we know them better than anyone else. When we do a power retrofit, we look at the big picture, ensuring that the power system and the software, mechanical and electrical systems are fully integrated.

You can choose from 3 different kinds of retrofits to suit your budget and site needs:

- Diesel fuel saver
- Cable reel (electrification)
- Busbar (electrification)

You'll save money and reduce your carbon emissions with a Konecranes RTG power retrofit. Their modular design ensures that they neatly add on to your existing RTG crane.

3.1 DIESEL FUEL SAVER RETROFIT

The Konecranes 2-step diesel fuel saver retrofit reduces fuel consumption when your RTGs are idling. It eliminates high-speed idling: the diesel engine always runs at maximum efficiency. This retrofit can be applied to all fixed-speed diesel gensets.

Why do this retrofit?

On average, about 40% of the running time of a typical RTG is spent idling. Fixed-speed diesel engines run at an unnecessarily high speed when idling, causing high fuel consumption, excess carbon emissions, unnecessary noise, and premature component wear.

This retrofit ensures that the diesel engine runs at optimal efficiency at all times. It lowers the RPMs when idling, cutting fuel consumption dramatically, in some cases up to 30%, without compromising crane performance. If your RTGs idle a lot, this retrofit can provide you with major savings every year.

In addition, because you are using less fuel, your crane emits less carbon. Since it is running at a lower speed, it makes less noise. And wearing components last longer.

Technical highlights

The diesel fuel saver retrofit is installed with electrical components mounted onto the main diesel genset enclosure. This unit controls the speed of your diesel engine.

The following list highlights some of the technological advances included in this retrofit:

- Automatic voltage regulator
- Konecranes control voltage inverter
- 30kVA single-output or multi-output transformer
- Power line filter



Figure 2. The diesel fuel saver is retrofitted in the genset enclosure (1) while the necessary modifications to the electrical systems are made in the e-house (2) above it. Some software modifications are also done at the same time.

A power retrofit will often be done in conjunction with the drive and control system retrofit (Section 2). This adds extra value to your retrofit project and further increases the functionality, safety, and performance of your RTG.

How long does this retrofit take?

All of the components for this retrofit are assembled and tested at our premises in Hyvinkää, Finland. Site installation and commissioning are completed within 2–4 days.

3.2 CABLE REEL RETROFIT

This retrofit eliminates the need for a diesel genset on your RTG crane by installing and fully integrating a cable reel feed that brings electricity directly from the port mains. The cable reel retrofit is available in high and medium voltage, and most Konecranes RTGs are eligible.

Why do this retrofit?

Running a crane on diesel can be expensive. It also produces carbon emissions, and the diesel genset makes noise. Have your Konecranes RTGs retrofitted with cable reels, and you can solve all of these problems at the same time.

The cable reel retrofit converts your RTG to fully electric operation. It will save you money from the start: electricity is cheaper than diesel, less maintenance is required, and there is less chance of a breakdown. You will lower the environmental impact of the crane: electricity is more eco-efficient, produces less noise, and reduces CO₂ emissions and other environmental pollution.

Technical highlights

In a cable reel retrofit, a cable reel is installed on the side of your RTG crane (see Figure 3 below). The cable is connected to the electrical grid, and winds on and off the reel as the crane moves along the stack.

The following list highlights some of the technological advances included in this retrofit:

- Core component package from leading supplier
- Custom-made Konecranes transformer room
- Konecranes DynaReg (optional)

A drive and control system retrofit (Section 2) goes well with this power retrofit. Also, a cable reel retrofit will often be done in conjunction with a gantry collision prevention retrofit. Doing multiple retrofits at the same time adds extra value to your retrofit project and further increases the safety, economy and performance of your RTG.

How long does this retrofit take?

All of the components are assembled and tested at a Konecranes factory. The lead time, including engineering, is 18 weeks – approximately 4.5 months.

The transportation time from our factory to your site depends on the country you are in, the type of transport used (air, sea, road), customs clearance time, and other possible administrative requirements. If the factory is in Finland, shipping usually takes 3 weeks to the USA, 2 weeks to the Middle East, and 1 week to a location in Europe.

Figure 3. We have delivered over 250 yard cranes with a cable reel.



The time needed for site works – removal of old components, installation of new components, electrical connections, startup, commissioning – is 4 weeks for the first crane, then add 3 weeks for each additional crane.

3.3 BUSBAR RETROFIT

This retrofit converts your RTG to fully electric operation. The power is supplied by a low electrified fence, and there are no diesel emissions at all. There is also no refueling, and much less noise. Components are fully integrated: there are no additional interfaces.

Why do this retrofit?

Running a crane on diesel can be expensive. It also produces carbon emissions, and the diesel genset makes noise. Have your Konecranes RTGs retrofitted with busbars, and you can solve all of these problems at the same time.

The busbar retrofit will save you money from the start: electricity is cheaper than diesel, less maintenance is required, and there is less chance of a breakdown. You will lower the environmental impact of the crane: electricity is more eco-efficient, produces less noise, and reduces CO₂ emissions and other environmental pollution.



Figure 4. The busbar retrofit converts your RTG to fully electric operation. Power is supplied by a low, electrified fence.

Technical highlights

In a busbar retrofit, a collector arm is installed on your RTG, connecting it to a low electrified fence that provides power alongside the running path of your crane (see Figure 4 below). The collector arm and fence eliminate the need for external cables.

The following list highlights some of the technology included in this retrofit:

- Core component package from leading supplier
- Konecranes DynaReg (optional)
- Sub-zero package (optional, but recommended if temperatures at your port go below zero)

A drive and control system retrofit (Section 2) fits well with the busbar retrofit. This retrofit will often be done in conjunction with a gantry collision prevention retrofit. Ordering multiple retrofits adds extra value to your retrofit project and further increases the functionality, safety, and performance of your RTG.



Figure 5. The Georgia Ports Authority (GPA) operates over 120 Konecranes RTGs including the fully electric busbar RTG pictured here at the Port of Savannah. The GPA plans to operate over 150 fully electric RTGs by 2022 via purchases of new electric RTGs and retrofitting existing RTGs.

How long does this retrofit take?

All of the components for the busbar retrofit are assembled and tested at a Konecranes factory. The lead time, including engineering, is 17 weeks – just over 4 months.

If the factory is in Finland, shipping takes 3 weeks to the USA, 2 weeks to the Middle East, and 1 week to a location in Europe.

On-site, the first crane will take 3 weeks to retrofit, plus 2 weeks for each additional crane.

3.4 HOW DO I DECIDE ON A POWER RETROFIT?

There is no one right way to run a power retrofit project with Konecranes RTGs. Although there are a limited number of Konecranes RTG types, every container terminal is different, with its own unique long-term plans, finances, and operating needs. Here we illustrate the decision-making process with a sample case.

Power option retrofit, sample case

John Smith has already ordered 6 RTG retrofits: the standard drive and control system retrofit for his 4 RTG2000 cranes, and a non-standard drive and control system retrofit for each of his 2 first-generation RTGs.

When he spoke with his local Konecranes office, he also discussed power retrofits for his RTGs and he's interested in this as well. The benefits seem clear.

All of John's RTG cranes are eligible for power retrofits. They could be done at the same time as the 6 drive and control system retrofits, which would minimize the time each crane would be out of service while being retrofitted.

The diesel fuel saver retrofit is quick and easy, so John decides to do it on every one of his 10 cranes. The container terminal's long-term business plan includes going all-electric within 10 years, but John wasn't aware of all the power options at his disposal until now.

John is not sure which power option is best for his equipment. After careful consideration of his yard infrastructure, he chooses a busbar retrofit for two of his RTG2000 cranes: busbar is more suitable for his yard because of stack changing requirements. The busbar RTGs will be closely monitored during the first 12 months of their operation. Depending upon their performance, his management team will make a decision on the power retrofitting of the other cranes.

In total, John orders 12 power retrofits: 2 busbar and 10 diesel fuel saver. The time commitment is manageable. Six of the RTGs receive drive and control system retrofits and power retrofits at the same time. So only 4 diesel fuel saver retrofits – for the 2 RTG2005 and 2 RTG 8W cranes – take extra time, because these cranes don't receive the drive and control retrofit. But the diesel fuel saver retrofits take only a few days each, so yard operations are not unduly interrupted.

4. SAFETY-ASSISTING RETROFITS

INTRODUCTION

Safety is always the top priority in container handling operations. In the container stack, every effort must be made to avoid errors leading to collisions involving RTGs – injury and damage can result. We at Konecranes take safety very seriously and are proud to offer the safety-assisting retrofits described here in order to make your yard safer for everyone.

Our safety-assisting retrofits focus on:

- Avoiding collisions, when RTGs are in motion or when they are handling loads
- Trucks, trailers, and tractors that move around your stacks

4.1 GANTRY COLLISION PREVENTION RETROFIT

The Gantry Collision Prevention retrofit¹ has been specifically designed to improve the safety of personnel working near your RTGs. It helps the operator to avoid crane-to-crane collisions and crane-to-obstacle collisions when the RTG travels in the stack and between stacks.

Why do this retrofit?

As standard, Konecranes RTGs are equipped with a Gantry Collision Prevention system that uses ultrasonic sensors.

Our Gantry Collision Prevention retrofit replaces this system with new laser sensor technology. A laser sensor is installed on each RTG bogie. The laser sensors use an echo pulse system that is highly resistant to adverse weather conditions.

As part of this retrofit, to maximize safety in your yard, we preprogram safety zones to comply with local regulations and your own yard requirements. If a laser sensor detects something inside the safety zone, the RTG stops moving. The system works in every mode of gantry travel: normal, cross, and rotate. You can monitor and troubleshoot the system locally and your RTG operators are informed about the system status at all times.

With a sensor range of up to 20m and a scanning angle of up to 270 degrees, this retrofit can completely eliminate blind zones from cross-gantry travel.

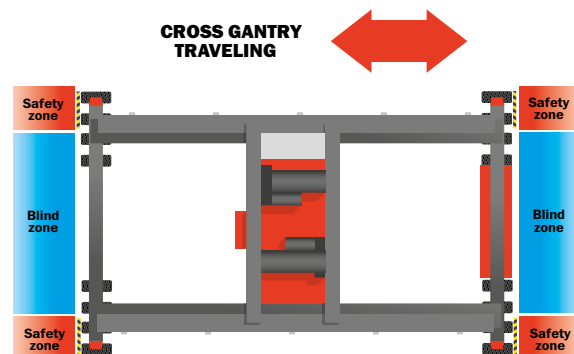
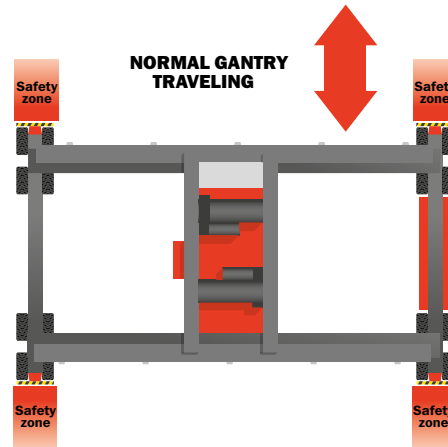


Figure 6 and 7. The safety zones are preprogrammed according to local regulations and your own yard requirements. Seen here: normal and cross gantry travel. “Rotate” is also available. In cross-gantry travel, the “blind zones” can be eliminated by adding more laser sensors.

¹This safety-assisting retrofit is applicable to Konecranes RTGs that have an S7 Programmable Logic Controller (PLC) with Profinet. GPS antenna cabling also needs to be installed and ready. RTGs without this cabling are also eligible for this retrofit on a case-by-case basis.

4.2 STACK COLLISION PREVENTION RETROFIT

This retrofit² helps the operator to avoid collisions between the spreader (loaded or unloaded) and containers in the stack. During stacking operations, the trolley slows down if an object is detected in its path, thus reducing the chances of tipping containers over, or of damaging the load or the crane.

Why do this retrofit?

Conditions in the container yard are rarely ideal. There can be inclement weather like rain or snow. The container stacks are usually uneven in height, so your operators do not always have complete visibility. In these situations, there is a greater chance of collision between a container under the spreader and a container in the stack. This is very dangerous for personnel and can damage the container, the crane or yard infrastructure. We have developed the Stack Collision Prevention retrofit to help avoid such collisions.

This retrofit uses the latest laser sensor technology. Two laser scanners constantly check the running bay when the trolley is in motion. Scanning starts the moment the gantry brakes are engaged. With 2 laser

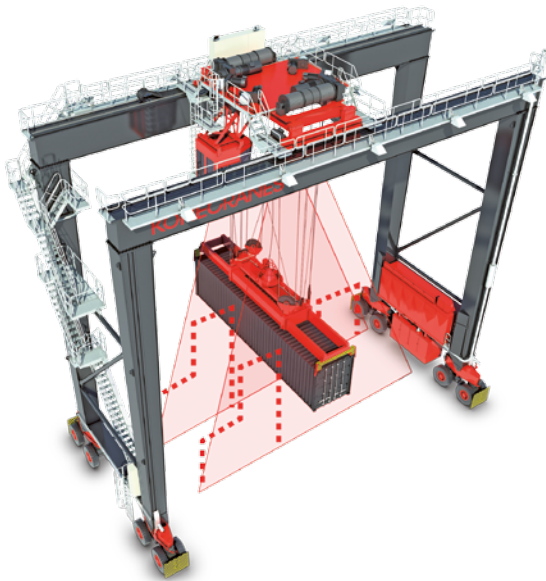


Figure 8. The Stack Collision Prevention system uses two laser scanners. They constantly check the running bay when the trolley is in motion.

scanners, the system detects both 20-foot and 40-foot containers in the same bay. For increased safety and redundancy, both laser scanners operate independently. The system analyzes the scans from both sides, always taking the highest measurement from each container row into account.

If an obstacle appears in one of the preprogrammed safety zones, the crane's PLC decreases the speed of the trolley towards the obstacle. Fine positioning is still possible. The risk of collision and tipping a container, or damaging a load, is much reduced thanks to the lower speed. It works with both an empty and loaded spreader.

Stack Collision Prevention remembers the layout of your container bay. Using this information, the system knows the height of the stack and limits the hoist speed during pick and place operations. This provides a soft landing, so there is only a small impact between the load in the spreader and the container directly below.

The system also helps with crane alignment. If the crane is not properly aligned with the container bay, the spreader might not be correctly positioned above a container. A badly-positioned spreader has a high risk of dropping its load or releasing a container that then overbalances.

We recommend that the Konecranes Stack Collision Prevention retrofit is combined with the Auto-Steering retrofit, using finely-tuned GPS positioning to make sure the crane is properly aligned with the bay.

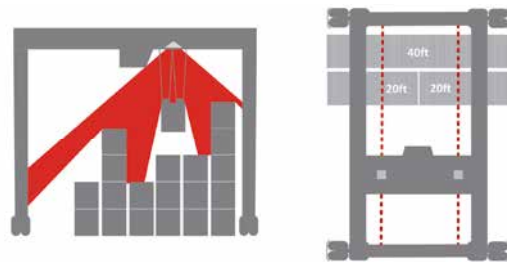


Figure 9. Stack Collision Prevention remembers the layout of your container bay. Here is a sample layout from the side (left) and the top (right).

² This safety-assisting retrofit is applicable to Konecranes RTGs that have an S7 Programmable Logic Controller (PLC) with Profinet. GPS antenna cabling also needs to be installed and ready. RTGs without this cabling are also eligible for this retrofit on a case-by-case basis.

4.3 AUTO TRUCK GUIDING RETROFIT

The Konecranes Auto Truck Guiding retrofit helps truck drivers position their trucks accurately under the RTG, in line with the container bay. It uses signaling lights to guide the driver as the truck approaches the base of the crane. For the driver, it's just like entering a car wash.

Why do this retrofit?

A semi-trailer truck is difficult to maneuver in a small space. To ensure safe load handling, the truck needs to be properly in line with the container bay. If the driver gets the alignment wrong, it takes valuable yard time to reposition it.

As the truck approaches the base of the crane, the Konecranes Auto Truck Guiding feature uses truck container scanning and traffic lights to tell the driver when to slow down. If the truck passes the target position, the system then tells the driver to reverse. Auto Truck Guiding enables faster truck handling without gantry inching.

In addition, to further improve safety, the system also stops the spreader from moving if the truck moves while being served under the crane.

4.4 TRAILER LIFT PREVENTION RETROFIT

Using the latest laser technology, the Konecranes Trailer Lift Prevention retrofit³ helps to make truck loading and unloading operations safer.

Why do this retrofit?

Container yard operations can be hectic. When schedules get very tight, stress and fatigue increase the chances of human error, especially when new, inexperienced personnel are working.

With this in mind, truck loading and unloading operations need special attention. A container can be brought to the stack by a terminal tractor, a road truck, or an AGV. In each case, all the twistlocks must be disengaged before the RTG starts to lift the container. If not, the trailer will be partially or completely lifted along with the container. This is extremely dangerous for personnel and could damage the cargo, equipment, and the vehicle. The Konecranes Trailer Lift Prevention retrofit monitors the trailer and prevents lifting of the container if a trailer lift is detected.

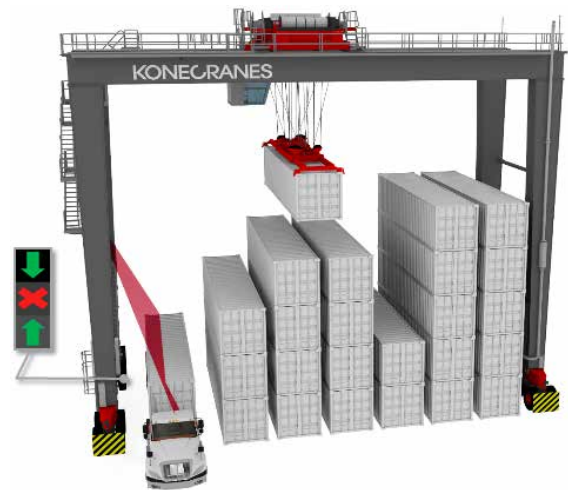


Figure 10. Auto Truck Guiding uses truck container scanning to tell the driver when to slow down. A traffic light feature guides the driver to a precise position.

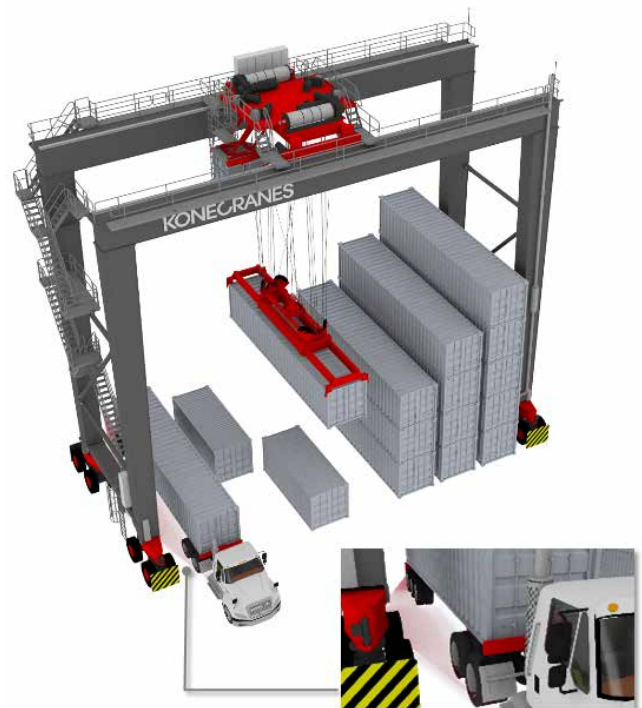


Figure 11. All twist locks must be disengaged before lifting. Trailer Lift Prevention stops lifting if a trailer lift by monitoring the trailer wheels.

³This safety-assisting retrofit is applicable to Konecranes RTGs that have an S7 Programmable Logic Controller (PLC) with Profinet. GPS antenna cabling also needs to be installed and ready. RTGs without this cabling are also eligible for this retrofit on a case-by-case basis.

4.5 SAFETY-ASSISTING RETROFITS: TECHNICAL DETAILS

The following is a list of equipment and services provided by Konecranes for each of our safety-assisting retrofits:

- Power supply unit and brackets
- Laser sensors with weather hood
- Hardware and additional installation materials required
- Project management, installation and commissioning
- Software integration and training

These retrofits use the same laser sensor technology. Depending on the retrofit(s) you choose, lasers will be mounted on different parts of your RTG crane.

How long do these retrofits take?

Every safety-assisting retrofit is a turnkey project. The goal is to minimize downtime. Training on the system, its functionality and maintenance requirements, is included.

The delivery lead time depends on your location. Site works, including commissioning, normally take 2 working days for each individual retrofit.

4.6 HOW DO I DECIDE ON THESE RETROFITS?

There is no one right way to run a safety-assisting retrofit project with Konecranes RTGs. Although there are a limited number of Konecranes RTG types, every container terminal is different, with its own unique long-term plans, finances, and operating needs. Here we illustrate the decision-making process with a sample case.

Safety-assisting retrofit, sample case

John Smith has already ordered power retrofits for all of his RTGs, and drive and control system retrofits for all of his RTGs that need them.

After consulting with Konecranes, John is interested in the safety-assisting retrofits since they fit well with the power and control system retrofits.

All of John's RTG cranes are eligible for safety-assisting retrofits. They could be done at the same time as the other retrofits, minimizing the amount of out-of-service time per crane.

The Gantry Collision Prevention, Stack Collision Prevention, Auto Truck Guiding and Trailer Lift Prevention retrofits are quick and easy, so John decides to have them installed on every one of his 10 RTGs.

Some of John's crane operators have complained about visibility problems in the winter, so safety-assisting retrofits were always on the agenda. Sooner is always better where safety is concerned, and the new safety-assisting features will probably lower insurance premiums.

John's container terminal can't afford to add the safety-assisting retrofits to all of its RTGs immediately, but it will be possible to do it in phases to the 10 RTGs over the next 2 years. With this plan, the safety-assisting retrofits would be done at the same time as the electrification power retrofits. So there would be 2 busbar retrofits to start with, and then the safety-assisting retrofits would be added as the other cranes are power-retrofitted.

In total, John orders 10 Gantry Collision Prevention retrofits, 10 Stack Collision Prevention retrofits, 10 Auto Truck Guiding retrofits and 10 Trailer Lift Prevention retrofits. If the management team changes its mind and wants the safety-assisting retrofits installed earlier, this can be done. Every safety-assisting retrofit is a turnkey project that is efficiently delivered and installed, causing minimum crane downtime and bringing the maximum benefit to safety.

5. OPERATOR-ASSISTING RETROFITS

INTRODUCTION

Operating a crane is a complex activity, requiring a high level of focus and attention. While maintaining full control of the crane, the operator must also be completely aware of what is around the crane, so that the safety of any nearby personnel is maximized and loads can be moved quickly and efficiently as needed.

Operator-assisting retrofits simplify the work of your operators by helping them to be more productive, which is good for your customers and therefore good for your business. In addition, by performing some of the operator's tasks automatically, these retrofits let your operators concentrate more on their core tasks, like load handling and communications within the yard. Operators with more focused attention will greatly improve the safety and performance of your yard.

With the Konecranes automated RTG (ARTG), automation is easy to install without changing anything major in your terminal infrastructure. Operator-assisting retrofits are another exciting step on the path towards automation and the benefits that come with that.

5.1 AUTO-STEERING RETROFIT

Konecranes Auto-Steering guides your RTG crane along predefined drive tracks. In essence, it creates virtual rails for the RTG to follow. While your operator controls the speed and direction of the gantry, Auto-Steering allows a greater focus on load handling and watching for collision risks such as other equipment moving in the port area.

Why do this retrofit?

An RTG crane is on wheels. Usually an experienced driver can keep it straight. However, weather conditions such as rain or snow, or an unexpected hazard like spilled oil, can make steering a vehicle as large as an RTG difficult, even for a skilled operator.

Have your Konecranes RTGs retrofitted with Auto-Steering and you immediately make the job easier for drivers of any experience level, from novices to veterans. You will also enhance the safety of your crane for all weather conditions.

Accuracy is important when moving in a busy port area. The Konecranes RTG Auto-Steering system uses GPS to give your RTG crane an operative steering accuracy of 50 millimeters on an even surface. However, we know that it's rare to have a yard with a completely even surface. Auto-Steering can be preset to take misalignments into account. It also supports moderate curves up to a turning radius of 850 meters.

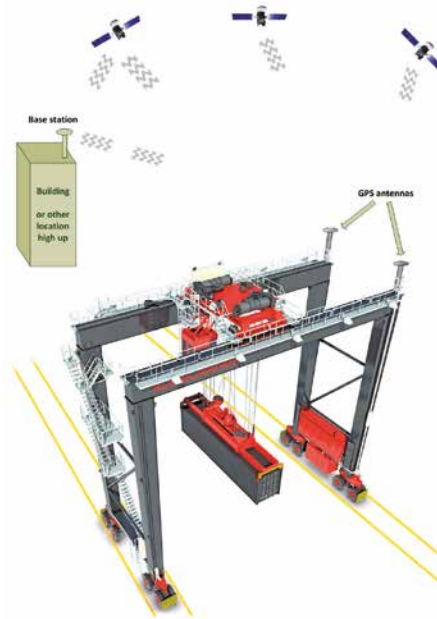


Figure 12. Auto-Steering creates virtual rails (the yellow lines) using on-board GPS receivers.

5.2 AUTO-TOS-REPORTING RETROFIT

Konecranes Auto-TOS-reporting tells the terminal operating system (TOS) about container moves within any given container block. In this way, the TOS is constantly aware of where the containers are, and whether the movement of the container follows TOS instructions, is diverted from those instructions, or is unauthorized.

Why do this retrofit?

It's good for business to know the precise location of each and every container at all times. The Auto-TOS makes keeping this data up-to-date in real time easy and efficient. This process can be invisible to the operator, simply recording all container movements as they are done.

However, Auto-TOS is best used when combined with job orders coming from the TOS and the Yardscreen map display, which acts like a virtual navigator, highlighting the target slot and guiding the operator towards it. Auto-TOS can also be used to block twist locks if the spreader is not above the slot that matches the job order.

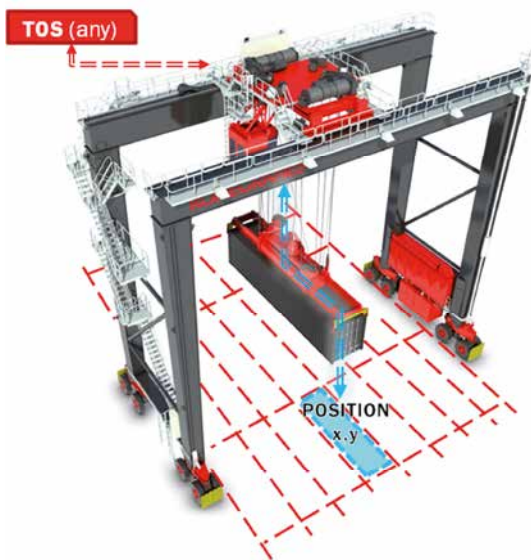


Figure 13. The Auto-TOS can act as a virtual navigator, highlighting the target container slot.

5.3 AUTO-POSITIONING RETROFIT

The Konecranes Auto-Positioning retrofit stops the crane gantry and trolley exactly on top of container pick and place target positions. Because the crane can only move towards the target, human error is eliminated because the automated system makes a much more precise movement, allowing the operator to focus on the core task of lifting.

Why do this retrofit?

An RTG crane is a very large machine. Usually an experienced operator can place it exactly where it needs to be. However, weather conditions such as rain or snow can make it more difficult to drive. Even with clear weather, an operator with less experience or one who is fatigued might require more time or might be unable to put the RTG in exactly the right position to manage a load.

When your Konecranes RTGs are retrofitted with Auto-Positioning, placing the RTG in precisely the right spot to raise or lower a load is easy, making it faster to move containers in your yard. With more accurate load handling, your crane is also safer to operate.

When it is switched on, Auto-Positioning receives its target position from the TOS, and the crane can only move towards the target. The operator still controls the gantry and trolley, but gantry movement is limited to a defined area around the target. Auto-Positioning helps the driver reduce speed and brake to a stop.

The system also works when positioning over trucks and railway cars, which are sometimes not in fixed locations and are not always in the container yard.

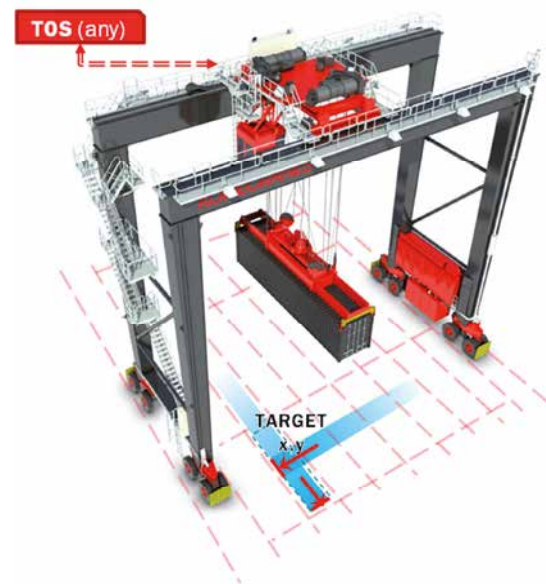


Figure 14. Auto-Positioning helps make load movements more precise.

5.4 YARDSCREEN ADD-ON

Konecranes Yardscreen is a handy add-on to Auto-Positioning, as it helps your operator easily find the target slot using a graphical interface in the cabin rather than by searching for slot markings on the ground.

Why get this add-on?

The graphical view of the container yard below the crane gives the operator a more complete awareness of positioning – of the crane, of the spreader, and of the target – than looking out of the window. This makes it easier for the operator to concentrate on driving the crane and delivering the container efficiently and safely to its target.

When used only with Konecranes Auto-TOS-Reporting, Yardscreen shows the current position of the crane in which it is installed and the position of the spreader on a map of the surrounding container bays.

When combined with Konecranes Auto-Positioning, Yardscreen also displays the target slot, so that repositioning the RTG is as simple as using any GPS map. An auto-zoom function shows the target according to how far away it is.



Figure 15. Yardscreen uses a graphical interface to show current crane position and locate container slots.

5.5 OPERATOR-ASSISTING RETROFITS: TECHNICAL DETAILS

The operator-assisting retrofits use two GPS receivers on the RTG, working with a GPS base station to send messages to the crane over a radio link. Dual antennas provide redundancy and fast signal recovery if one of the GPS receivers loses its satellite connection. Auto-TOS uses either an Ethernet or a WLAN connection.

The Auto-Steering and Auto-Positioning retrofits are hold-to-run systems, which means that they work automatically only when the operator is driving the crane.

The following list highlights some of the technology included in these retrofits:

- Two GPS receivers (for the RTG)
- GPS base station (for the container terminal)
- Graphical display (on the RTG operator panel)
- Distance lasers (for the Auto-TOS)
- Touch screen (for Yardscreen)

The operator-assisting retrofits are designed to work together. Auto-TOS or Auto-Steering can be used separately, but the Auto-Positioning retrofit requires Auto-TOS reporting and Auto-Steering to work.

Each of the operator-assisting retrofits uses the same technology and equipment, so once one is installed, there are no additional hardware requirements if you would like to add the others.

How long do these retrofits take?

Every operator-assisting retrofit is a turnkey project. The goal is to minimize downtime. Training on the system, its functionality and maintenance requirements is included.

The delivery lead time depends on your location. Site works, including commissioning, normally take no more than one week per crane, depending on the type of crane you have and which retrofit(s) you select.

5.6 HOW DO I DECIDE ON THESE RETROFITS?

There is no one right way to run an operator-assisting retrofit project with Konecranes RTGs. Although there are a limited number of Konecranes RTG types, every container terminal is different, with its own unique long-term plans, finances, and operating needs. Here we illustrate the decision-making process with a sample case.

Operator-assisting retrofit, sample case

John Smith has already ordered power retrofits for all of his RTGs, and drive and control system retrofits for all of his RTGs that need them. He has also requested safety-assisting retrofits across a two-year period.

Some of John's crane operators have mentioned how hard it can be to find the right slot markings on the ground in a full container yard. They have also said it can be challenging to maneuver the RTG small distances for a more exact placement of the crane and more precise load handling.

After discussing the issue with Konecranes, John is interested in the operator-assisting retrofits since they make work easier and his operators are therefore more productive. In addition, he is impressed with the way the operator-assisting retrofits also improve safety at every level and the extensive references.

All of John's RTG cranes are eligible for operator-assisting retrofits. They could be done at the same time as the other retrofits, minimizing the amount of out-of-service time per crane.

John's container terminal can't afford to add the operator-assisting retrofits to all of its RTGs immediately, but it will be possible to do it in phases to the 10 RTGs, at the same time as the safety-assisting retrofits and the power retrofits.

In total, John orders 10 Auto-TOS retrofits, 10 Auto-Steering retrofits, 10 Stack Profiling retrofits, 10 Auto-Positioning retrofits and 10 Yardscreen add-ons. If the management team decides it wants the operator-assisting retrofits on a different schedule, this can be done. Every operator-assisting retrofit is a turnkey project that is efficiently delivered and installed, causing minimum crane downtime and bringing maximum benefit to crane operators.

6. WHAT DO I HAVE TO DO?

Once you have decided to retrofit your Konecranes RTG cranes, the ordering process goes as follows:

1. Contact your Konecranes Ports representative
2. Discuss your retrofit needs
3. Konecranes makes a quotation based on your needs
4. Discuss the quotation with your Konecranes Ports rep
5. If you want to revise the parameters, go back to step 2
6. Fill in an order form – your Konecranes Ports rep will help you
7. Your delivery is underway

BEFORE THE RETROFIT

Before we do any work on your cranes, you need to get them ready:

With each crane, please do the following:

1. Find a safe working area for the RTG on your site and drive it there
2. Put the gantry wheels in normal mode
3. Secure the wheels by placing chocks under them
4. Put the trolley in parking position
5. Shut down all crane operation
6. Shut down the diesel engines
7. Disconnect the battery
8. Provide external lighting
9. Connect the shore power

Please also provide the following to help us work as efficiently as possible:

- Access to the port, free of charge, for Konecranes personnel
- A site escort as required
- Access to the canteen and washrooms
- Shore power as required
- An adequate work area away from terminal operations
- Adequate fencing around the job site
- Free terminal transportation as required
- Free access to workshops as required
- All permits and licenses under local, state, or national laws as required
- Customs clearance, if necessary
- The RTG crane itself, with all defects documented
- A skilled crane operator for start-up, commissioning, and acceptance tests
- A test weight physically adjacent to the RTG

WHAT KONECRANES DOES

During the retrofit, Konecranes will:

- Provide project management and supervision for the entire project
- Inspect the crane's mechanical and electrical components before the work begins
- Modify the crane's drawings as per the mechanical and electrical work to be carried out during the retrofit
- Manufacture and assemble the components
- Carry out factory testing of the assembled components
- Pack and stow the assembled components for shipment
- Ship the components
- At your site, supervise the removal of old components as required
- Install the new components, looking after the mechanical and electrical details
- Upload new software and customize as necessary
- Start up and commission the retrofitted RTG
- Initiate and attend the take-over and acceptance procedures
- Deliver the amended technical documentation related to the retrofit

AFTER THE RETROFIT

When the retrofit has been completed, start-up and commissioning are done and the acceptance tests are carried out. When these have been successfully completed, Konecranes hands the project over to you and you give your acceptance by signing the commissioning protocol.

APPENDIX

Find the G-codes of your Konecranes RTGs in the left-most column, and check the retrofits available for them. You can find your Konecranes RTG G-codes on the cranes' documentation folders and on the crane nameplates.

NOTE: The retrofits shown in this table are available for Konecranes RTGs only.

- Available as standard retrofit
- Available upon request. We offer case-by-case
- Not available
- Not required

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits <ul style="list-style-type: none"> • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator- assisting retrofits |
|---------------|--|--|---|------------------------------------|---|-------------------------------------|
| G146 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G147 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G163 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G164 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G165 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G166 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G168 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G169 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G170-G176 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G178-G183 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G213 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G214 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G216 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G217 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G219-G222 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G226 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G227 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G230-G235 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G241-G244 | Yellow | Yellow | Yellow | Blue | Yellow | Blue |
| G245-G250 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G253 | Yellow | Blue | Yellow | Blue | Blue | Blue |
| G254 | Yellow | Blue | Yellow | Blue | Blue | Blue |

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator- assisting retrofits |
|---------------|--|--|---|------------------------------------|---|-------------------------------------|
| G255 | | | | | | |
| G256 | | | | | | |
| G259-G270 | | | | | | |
| G271-G272 | | | | | | |
| G273 | | | | | | |
| G274-G276 | | | | | | |
| G277-G281 | | | | | | |
| G282-G285 | | | | | | |
| G319-G322 | | | | | | |
| G326-G328 | | | | | | |
| G329-G332 | | | | | | |
| G333-G338 | | | | | | |
| G339 | | | | | | |
| G340 | | | | | | |
| G348-G350 | | | | | | |
| G359 | | | | | | |
| G360-G364 | | | | | | |
| G367 | | | | | | |
| G372-G374 | | | | | | |
| G375 | | | | | | |
| G376 | | | | | | |
| G380-G389 | | | | | | |
| G396-G399 | | | | | | |
| G400-G413 | | | | | | |
| G415-G420 | | | | | | |
| G421-G423 | | | | | | |
| G427-G432 | | | | | | |
| G433-G437 | | | | | | |
| G440 | | | Power supply voltage <1000V | | | |
| G442-G465 | | | | | | |
| G466-G468 | | | | | | |
| G466-G468 | | | | | | |
| G477 | | | | | | |
| G478 | | | | | | |
| G480-G485 | | | | | | |
| G486-G489 | | | | | | |

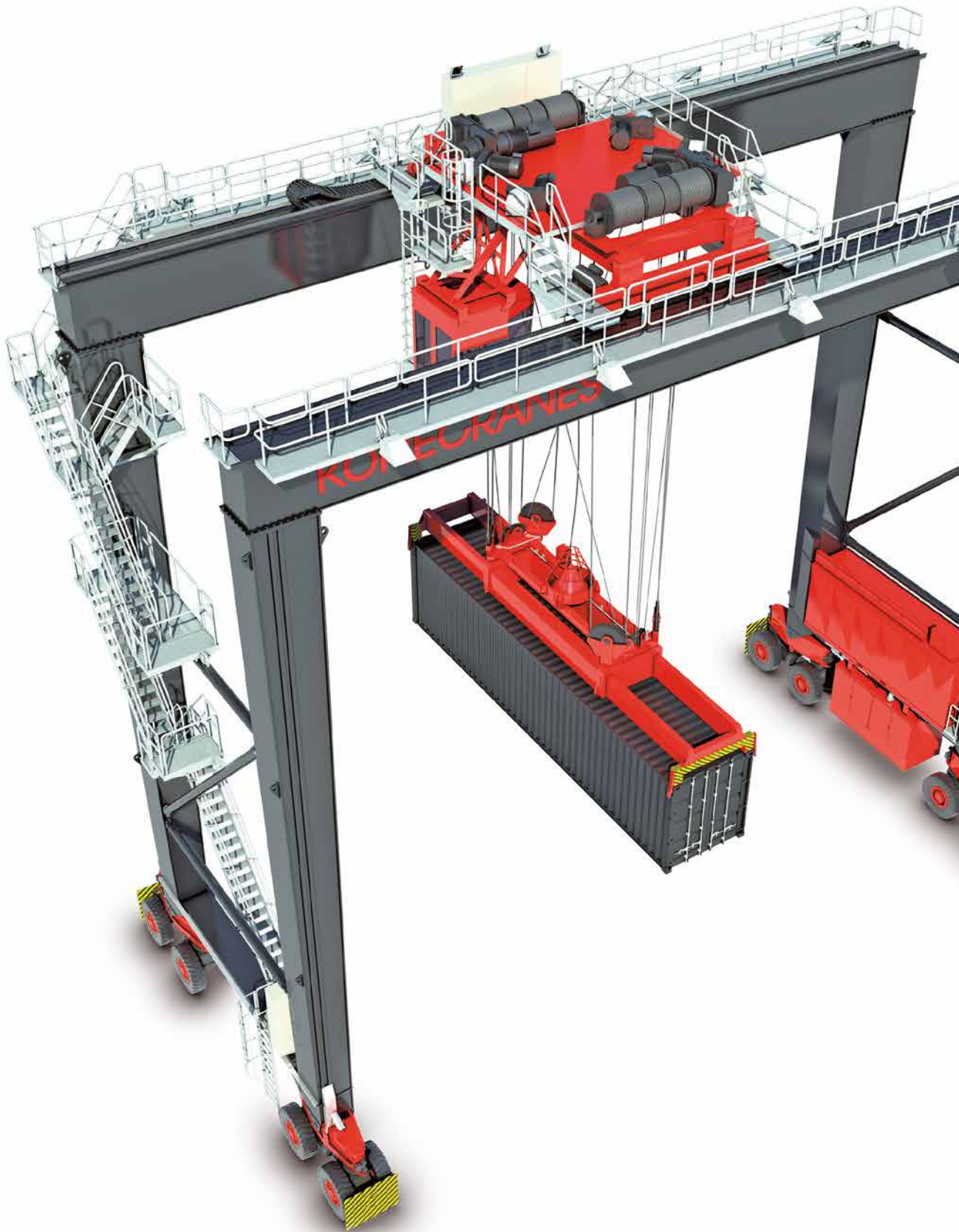
| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits <ul style="list-style-type: none"> · Gantry Collision Prevention · Stack Collision Prevention · Trailer Lift Prevention | Operator- assisting retrofits |
|-----------------------|--|--|---|---|---|--|
| G490-G492 | | | | | | |
| G494-G500 | | | | | | |
| G502-G505 | | | | | | |
| G506 | | | Power supply voltage <1000V | | | |
| G507 | | | Power supply voltage <1000V | | | |
| G508 | | | Power supply voltage <1000V | | | |
| G522-G524 | | | Power supply voltage <1000V | | | |
| G556-G562 | | | | | | |
| G563 | | | | | | |
| G564 | | | | | | |
| G572-G583 | | | | | | |
| G584-G593 | | | Power supply voltage <1000V | | | |
| G594-G599 | | | Power supply voltage <1000V | | | |
| G600-G611 | | | | | | |
| G612 | | | | | | |
| G613 | | | | | | |
| G614-G623 | | | | | | |
| G626-G630 | | | | | | |
| G631 | | | | | | |
| G632 | | | | | | |
| G638 | | | | | | |
| G639 | | | | | | |
| G640 | | | | | | |
| G641-G645 | | | | | | |
| G646-G649 | | | Power supply voltage <1000V | | | |
| G650-G653 | | | | | | |
| G654-G669 | | | | | | |
| G670-G675 | | | Power supply voltage <1000V | | | |
| G676-G680 | | | | | | |
| G681-G686 | | | | | | |
| G687 | | | | | | |
| G688-G703 | | | | | | |
| G705-G707 | | | | | | |

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits <ul style="list-style-type: none"> • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator-assisting retrofits |
|------------|---------------------------------|---|----------------------------------|------------------------------|---|------------------------------|
| G708-G715 | | | | | | |
| G720 | | | | | | |
| G721-G723 | | | | | | |
| G733 | | | | | | |
| G734 | | | | | | |
| G736-G741 | | | | | | |
| G748 | | | | | | |
| G749 | | | | | | |
| G750-G764 | | | | | | |
| G765-G770 | | | | | | |
| G775-G782 | | | Power supply voltage <1000V | | | |
| G783-G786 | | | | | | |
| G798 | | | Power supply voltage <1000V | | | |
| G799 | | | Power supply voltage <1000V | | | |
| G800-G802 | | | Power supply voltage <1000V | | | |
| G803 | | | | | | |
| G804 | | | | | | |
| G805-G812 | | | Power supply voltage <1000V | | | |
| G818-G821 | | | | | | |
| G822 | | | | | | |
| G823 | | | | | | |
| G826 | | | Power supply voltage <1000V | | Gantry collision prevention already included | |
| G827-G831 | | | Power supply voltage <1000V | | | |
| G832-G836 | | | Power supply voltage <1000V | | | |
| G837-G840 | | | Power supply voltage <1000V | | | |
| G842-G851 | | | Power supply voltage <1000V | | | |
| G852-G863 | | | | | | |
| G864 | | | | | | |
| G865 | | | | | | |
| G885 | | | Power supply voltage <1000V | | | |
| G886 | | | | | | |

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits <ul style="list-style-type: none"> • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator- assisting retrofits |
|-----------------------|--|--|---|---|---|--|
| G890-G893 | | | | | | |
| G895-G904 | | | | | | |
| G910-G915 | | | | | | |
| G916 | | | | | | |
| G917 | | | | | | |
| G922 | | | | | | |
| G923 | | | | | | |
| G924 | | | | | | |
| G925 | | | | | | |
| G929-G938 | | | | | | |
| G939-G942 | | | | | | |
| G948-G951 | | | | | | |
| G952-G954 | | | | | | |
| G955-G958 | | | | | | |
| G959 | | | | | | |
| G960-G964 | | | | | | |
| G965-G967 | | | | | | |
| G971-G977 | | | | | | |
| G978 | | | | | Gantry collision prevention already included | |
| G979-G983 | | | | | | |
| G987-G990 | | | | | | |
| G991-G1001 | | | | | | |
| G1002-G1005 | | | | | | |
| G1013-G1022 | | | | | | |
| G1028-G1030 | | | | | | |
| G1038 | | | | | | |
| G1039 | | | | | | |
| G1040-G1050 | | | | | | |
| G1059-G1062 | | | | | | |
| G1065-G1069 | | | | | | |
| G1077 | | | | | | |
| G1078-G1080 | | | | | | |
| G1081-G1100 | | | Power supply voltage <1000V | | | |
| G1137-G1144 | | | Power supply voltage <1000V | | | |
| G1158-G1166 | | | | | | |

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator- assisting retrofits |
|---------------|--|--|---|------------------------------------|---|-------------------------------------|
| G1167-G1172 | | | Power supply voltage <1000V | | | |
| G1075-G1080 | | | | | | |
| G1181-G1205 | | | | | | |
| G1207-G1211 | | | Power supply voltage <1000V | | | |
| G1212 | | | Power supply voltage <1000V | | | |
| G1213-G1218 | | | | | | |
| G1222-G1226 | | | | | | |
| G1227-G1229 | | | | | | |
| G1230-G1233 | | | Power supply voltage <1000V | | | |
| G1241-G1243 | | | | | | |
| G1244 | | | | | Stack collision prevention already included | |
| G1245 | | | | | Stack collision prevention already included | |
| G1247 | | | | | | |
| G1248 | | | | | | |
| G1279-G1282 | | | | | | |
| G1284-G1289 | | | | | | |
| G1294-G1309 | | | | | | |
| G1310-G1313 | | | | | | |
| G1315-G1324 | | | Power supply voltage <1000V | | | |
| G1341 | | | Power supply voltage <1000V | | | |
| G1342 | | | Power supply voltage <1000V | | | |
| G1343 | | | | | | |
| G1349-G1355 | | | | | | |
| G1356-G1365 | | | Power supply voltage <1000V | | | |
| G1366-G1368 | | | | | | |
| G1375-G1378 | | | Power supply voltage <1000V | | | |
| G1379-G1381 | | | | | | |
| G1385 | | | | | | |
| G1386 | | | | | | |
| G1407-G1414 | | | | | | |

| RTG G-CODE | DRIVE & CONTROL SYSTEM RETROFIT | POWER OPTION Diesel fuel saver retrofit | POWER OPTION Cable reel retrofit | POWER OPTION Busbar retrofit | Safety-assisting retrofits <ul style="list-style-type: none"> • Gantry Collision Prevention • Stack Collision Prevention • Trailer Lift Prevention | Operator- assisting retrofits |
|-----------------------|--|--|---|---|---|--|
| G1415-G1417 | | | | | | |
| G1419-G1430 | | | | | | |
| G1432-G1435 | | | Power supply voltage <1000V | | | |
| G1436-G1440 | | | Power supply voltage <1000V | | | |
| G1442-G1449 | | | Power supply voltage <1000V | | | |
| G1450-G1453 | | | Power supply voltage <1000V | | | |
| G1456-G1463 | | | | | | |
| G1505-G1508 | | | | | | |
| G1509 | | | | | | |
| G1510 | | | | | | |
| G1526-G1528 | | | | | | |
| G1529-G1532 | | | Power supply voltage <1000V | | | |
| G1533-G1536 | | | Power supply voltage <1000V | | | |
| G1537-G1540 | | | Power supply voltage <1000V | | | |





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HEAVY-DUTY
LIFT TRUCKS




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MACHINE
TOOL
SERVICE



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