WHITE PAPER:

Triple E-class container ships and the requirements of energy supply for STS cranes

Robust energy supply for high-performance cranes

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igus®

Contents

**Cover image: the container ship "Morten Maersk" moving up the Elbe toward Hamburg.
It is one of 31 Maersk Triple E-class container ships.**
Source: eyewave – stock.adobe.com

ROTTERDAM PORT: OOCL Hong Kong: the largest container ship in the world from 2017 to 2019
Source: Gudellaphoto – stock.adobe.com

OOCL Hong Kong: 21,413 TEU capacity
Source: Gudellaphoto – stock.adobe.com

Leader/abstract

To load and unload the new, larger Triple E-class container ships, newer, larger STS cranes must be built or existing cranes retrofitted. Crane availability and dependability requirements are also increasing. This affects the design and selection of the energy supply systems. There are many indications that self-monitoring systems fitted with sensors will be used here in the future, communicating with higher-level predictive maintenance tools via the cloud. This ensures the greatest possible availability for the energy chain – and thus for the crane.

Long-term trend: larger and larger container ships

In 1980, an average container ship had a capacity of 1,000 TEU, and the largest had 3,500. In 2014, the average size was 3,500 TEU (a growth factor of 3.5), and the largest was 18,500 (a growth factor of 5.3).

The current maximum is 20,586 TEU. These ships belong to Maersk Triple E class, the largest shipping company in the world. There are now about 30 of these with capacities between 19,600 and 20,586 TEU. Experts agree that the end of this development is not yet in sight. Future generations of ships could have even higher container capacities.

Effects on crane technology in the container terminal

The development of larger and larger container ships has significant effects on crane technology, which must grow along with the ships. This is true not only of new terminals, but also of existing cranes, which must be retrofitted.

This makes development all the more important, since ship growth is not just in length – that would merely require larger numbers of cranes – but also in height and width.

This makes the productivity of the cranes – which have to travel long distances, both horizontally and vertically, during loading and unloading – the bottleneck of STS cargo handling. Port operators are concerned with this issue.

This is one of the reasons crane manufacturers have developed solutions such as tandem lifts and dual trolleys to achieve higher performance. In any case, cranes – and their components, including energy supply systems – will face even greater stresses in the future than they do today.

The challenge: cranes for Triple E-class container ships

For Triple E ships, bridge height/crane stroke height must increase by about ten metres (three times the height of a container), which has effects, such as greater loads on the chassis. The ship's width means that the crane's outreach must also be increased by about ten metres (four times the width of a container) because these ships store 24 or 25 containers side-by-side.

For crane dimensions and performance, that means:

- Stroke height of 55 metres over rails
- Boom length up to 70 metres
- Overall height up to 96 metres
- Load on cable: up to 115 tonnes

Load cycles must also be quicker. The average container weight is increasing at the same time. These two factors make more powerful drives necessary:

- Lifting speed up to 240m/min
- Crane trolley travel up to 240m/min
- Anti-sway system with maximum damping performance

This package of measures can increase crane productivity from 22 to 25 cycles (current) to 32 to 35 – despite travels that are longer both horizontally and vertically.

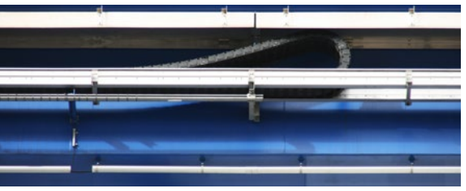
But it is not just speed, performance and dynamics that require much more of STS crane components. Availability must be enhanced as well: the new cranes are designed for four million cycles, where previous cranes were designed for two million. And because of the cranes' greater dimensions, their components are subjected to greater weathering effects (wind) and loads (vibration, container weight, oscillations, etc.).

And the development will in all likelihood not stop at the present level. In the past, larger container ships have been commissioned every three years. It is unlikely that this trend has reached its end point. The cranes to be built currently must be even larger and more powerful if they are not to be retrofitted again in three years time.

Maersk Mc-Kinney Møller maiden call to Bremerhaven
Source: Von Walter Rademacher/ Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=27770342

Much higher requirements on STS components are demanded, but with the same level of availability
Source: igus® GmbH

Cranes in port facilities must deliver very high performance. This is exactly where igus® energy chains and flexible cables are being used. They have proven themselves for many years in more than 10,000 ports with their corrosion-resistant, maintenance-free materials and long service life.
Source: igus® GmbH



2008 – The innovation: the distributed P4 rol e-chain® has been added to the rol e-chain®product range for applications involving very high speeds (more than 240m/min) and installations where noise is very important. In use: worldwide in STS crane systems, ASC cranes, etc.
Source: igus® GmbH

Roller energy chains are safe and compact and require very little maintenance; their cable lengths are up to 50% less than those used in festoons.
Source: igus® GmbH

In cable trolley systems (festoons), the cables "hang" from the cranes, unprotected from wind and weather.
Source: Fotolia and igus® GmbH

Stringent requirements on load capacity and availability

Productivity requirements for container cranes have always been extreme. The loading and unloading procedures are timed exactly. Every hour of downtime costs tens of thousands of euros. Many containers to be unloaded have already been scheduled for further transport. Unexpected crane failures have severe consequences. These requirements will become even more stringent for cranes serving Triple E-class ships.

Turnover rate will increase or at least remain the same. Currently, lifting speeds of up to 180m/min and trolley speeds of 240m/min are required, and the benchmark for component loading is at 125,000 strokes or movements per year. The trolley travels and spreader stroke height per cycle are increasing by up to 10 metres because of larger, wider ships.

This means that each component must meet the highest requirements for service life, and this extends to the energy chains/energy supply systems and cables. This is all the more true as maintenance work becomes more challenging the larger and more complex the crane is. At the same time, the crane operator expects longer crane service life and lower maintenance cost and time.

A comparison of energy and signal supply lines to the crane trolley

How can a crane manufacturer or operator meet these requirements with respect to supplying power and signals to the trolley?

Many STS container cranes are equipped with festoons. This principle has definitely proven reliable. But festooning has a weakness: the cable loops hang unprotected from the crane girder. In strong wind or at high travel speeds, the cables are subjected to very great stresses. The festooning's own weight is much higher than that of busbar systems and energy chains because the cables are longer and thus heavier than with an energy chain. This is unfavourable in view of the increasing requirements of performance and dynamics.

Busbar systems are also common in crane technology. But they are more susceptible to wear than energy chains because each trolley drive creates a moving contact (abrasion) between the cable and the current pick-up. The loads also make it difficult to ensure that data is reliably transmitted.

The third option, the energy chain, has established itself worldwide – both for initial equipping and for retrofitting existing STS cranes. For many years, igus® has been supporting this trend, and has good arguments for doing so. Among the advantages of energy chains is cable protection with low load, reproducible cable guidance, and resistance to environmental conditions (wind, moisture, vibrations, etc.).

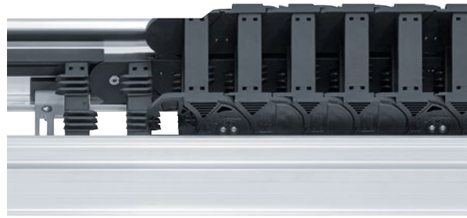
Robust energy chain for high-performance cranes

Given the high requirements and speeds, rol e-chains®, or chains with integrated rollers that roll in the guide trough, are used.

Energy chain requirements are continuously increasing because of the developments in container ships and cranes described here. Movements are faster and more dynamic, and the number of cycles is rising, so the load on the energy chain is too. And then there are other factors such as weather, vertical movements, and steel structure oscillations. The longer trolley travels (and associated longer energy chains) mean greater overall energy chain system weight, which also increases the load.

In order to continue to provide crane manufacturers and operators with high-performance energy chains during the Triple E era, igus® has developed a series for the specific requirements of the crane industry: the P4.1 series rol e-chains®.

The roller energy chain has been the tried-and-tested energy supply for long travels for about 20 years.
Source: igus® GmbH



Continuous improvement of roller energy chains for long travels resulted in the best e-chains® for cranes: the igus® P4.1 series.
Source: igus® GmbH

2018 – the sensation: the P4.1 smart rol e-chain®. The latest generation of rol e-chains® is the "endurance runner" that supersedes the P4. For ASC cranes, the P4.1 enables the primary supply of power and data and operates at very high speeds (more than 300m/min). In use: worldwide in STS crane systems, ASC cranes, etc.
Source: igus® GmbH

Energy chain systems are tested at speeds of up to 8m/s over a travel of 400 metres. You can see the test system in the video below: https://youtu.be/QusrqQ41ZEw
Source: igus® GmbH

Development goal: 375,000 kilometres of running performance

The central development goal, expressed in numbers, is as follows: 125,000 double strokes per year x 30 years of service life x 200 metres per double stroke = 375,000 kilometres of running performance.

The objectives have been achieved through measures such as the integration of maintenance-free tribo-polymer plain bearings into the chain link connections. Another design characteristic is distributed profile rollers, which reduce vibration and noise. These improvements and countless other detailed design optimisations allow the P4.1 series energy chains not only to reach the running performance goal of 375,000 kilometres, but also to be employed with travels of more than 1,000 metres and speeds of more than 300m/min.

This profile makes the P4.1 energy chains the new igus® standard for energy and signal supply for container cranes and other high-performance applications. And these properties are the basis for refinement of high-performance energy chains that produces intelligent energy chains (see below).

The next step: predictive maintenance

If you want to entirely network the machines in your manufacturing plant with the internet of things (IoT) in order to be Industry 4.0-compatible and optimise items such as maintenance, predictive maintenance is just what you need.
Source: igus® GmbH

Availability of 98% is expected from new container cranes. Since the cranes are designed for higher requirements and the load profiles are also higher, this goal can be achieved only with new technologies.

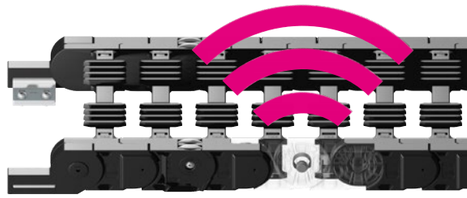
The trend is toward "smart" cranes and crane components that self-monitor (condition monitoring) and, in the next step, perform predictive maintenance. This affects drive components especially. For instance, oscillation analysis on motors and gearboxes identifies issues in bearings and shafts.

Development goal: the intelligent energy chain

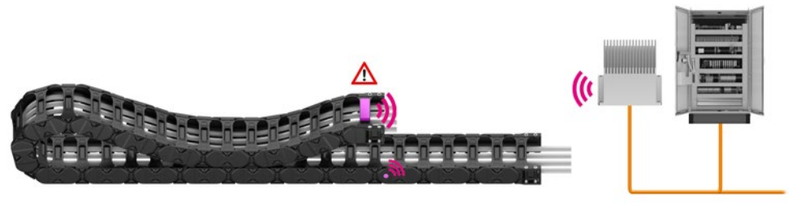
Energy chains are moving, system-relevant components subjected to high loads, so continuous monitoring for irregularities and wear also provides big advantages. The igus® "smart plastics" department has already developed suitable solutions under the iCee brand.

Sensors are integrated into the energy chain (type P4.1 in this case) to continuously monitor such items as wear and push-pull movements and/or to detect irregularities. This can drive alarms or maintenance recommendations communicated by a radio module. The associated drive can be shut down automatically when it exceeds a prescribed power level in order to prevent a crash.

The power of this solution is even greater: status data of the energy chain is compared with experience from current applications via the iCee module. The user can plan maintenance predictively and based on the actual energy chain state. The service life prediction largely corresponds to reality – that is, with the state of the individual energy chain. There is another advantage, maintenance personnel can access energy chain service life data at any time, regardless of location. This greatly reduces the likelihood of unplanned downtime. igus® believes that this technology will become a part of container crane energy chain applications.



New maintenance-free plain bearings and an intelligent wear sensor ensure longer service life in the P4.1 rol e-chain® for crane and gantry systems.
Source: igus® GmbH



Predictive maintenance uses sensors, software and the elements of condition monitoring to create a system that allows dynamic service life calculation and determines the best times for the maintenance of igus® products.
Source: igus® GmbH

Sources

Erik Soderberg, Leah Olson, Jonathan Hsieh: Crane Loads – Triple E Class and Beyond. Paper by Liftech Consultants Inc. on the ASCE COPRI Ports Conference 2016, New Orleans/USA

Practical Observations about Electrical Cables for Container Cranes. A PEMA Information Paper. Editor: PEMA (Port Equipment Manufacturers Association), https://www.pema.org/download/4866/

Busbars vs. energy chains for crane electrification and applications with limited installation space. White paper by igus® GmbH, Cologne 2019

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