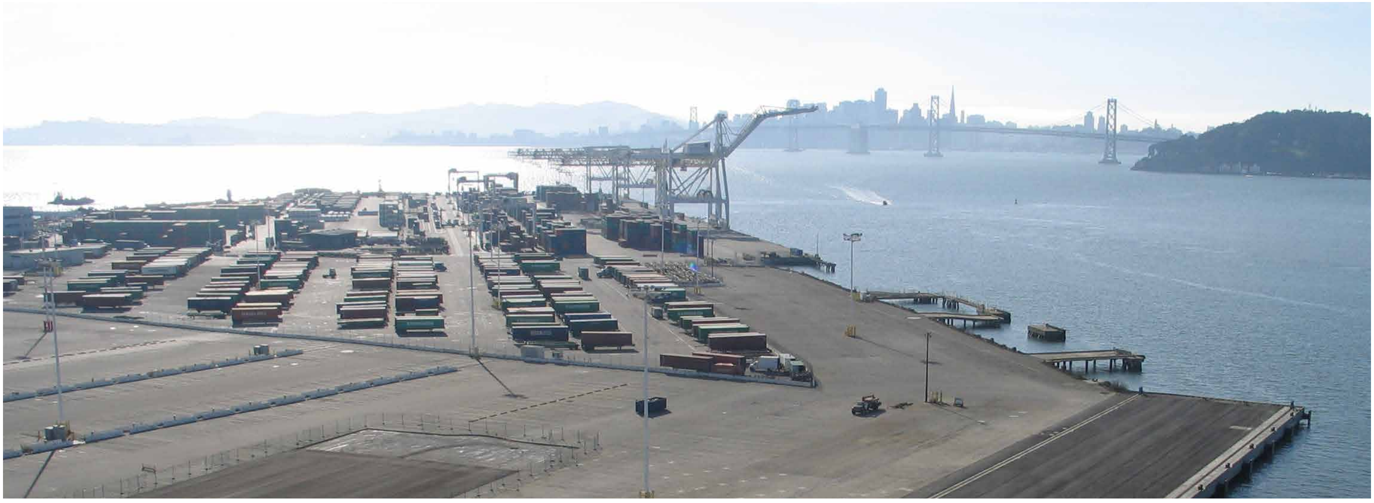
Practical Observations for Rail Mounted Crane Interfaces

A PEMA Information Paper



This information paper provides commentary and practical guidance about the design and design coordination of civil infrastructure for rail mounted cranes. It aims to help reduce problems and costs during installation and operation of rail mounted cranes.

The guidance in the paper will be revisited over time and developed further based on industry feedback, new technologies and new examples of problems.

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INTRODUCTION

DOCUMENT PURPOSE

This Information Paper provides commentary and practical guidance about issues related to design and design coordination of civil infrastructure for rail mounted cranes. It does not provide guidance about quality assurance during construction.

The Paper's goal is to help reduce challenges and costs during installation and operation of rail mounted cranes.

Over time, PEMA will further develop this guidance based on industry feedback, new technologies and as new examples of problems arise. In addition, some topics covered here will be looked at in greater depth in separate PEMA papers, for instance rail installation.

For further information about this paper or to provide feedback, please contact the PEMA Secretariat at **info@pema.org**.

ABOUT THIS DOCUMENT

This document is one of a series of Information Papers developed by the Equipment Design and Infrastructure Committee (EDI) of the Port Equipment Manufacturers Association (PEMA). The series is designed to provide those involved in port and terminal operations with advice on standards and their application to the design of port equipment, together with guidance on issues related to equipment design and equipment interfaces with port infrastructure.

This document does not constitute professional advice, nor is it an exhaustive summary of the information available on the subject matter to which it refers.

Every effort is made to ensure the accuracy of the information, but neither the author, PEMA nor any member company is responsible for any loss, damage, costs or expenses incurred whether or not in negligence, arising from reliance on or interpretation of this information.

The comments set out in this publication are not necessarily the views of PEMA or any member company.

1 | EXECUTIVE SUMMARY

Continuity and reliability of operation are key considerations for crane operators and where there is significant disruption such as during large crane installations, the down-time and the subsequent knock-on effects can impact profitability.

An efficient installation requires all interfaces between infrastructure and cranes to be carefully specified and coordinated yet many types of problems can still be encountered.

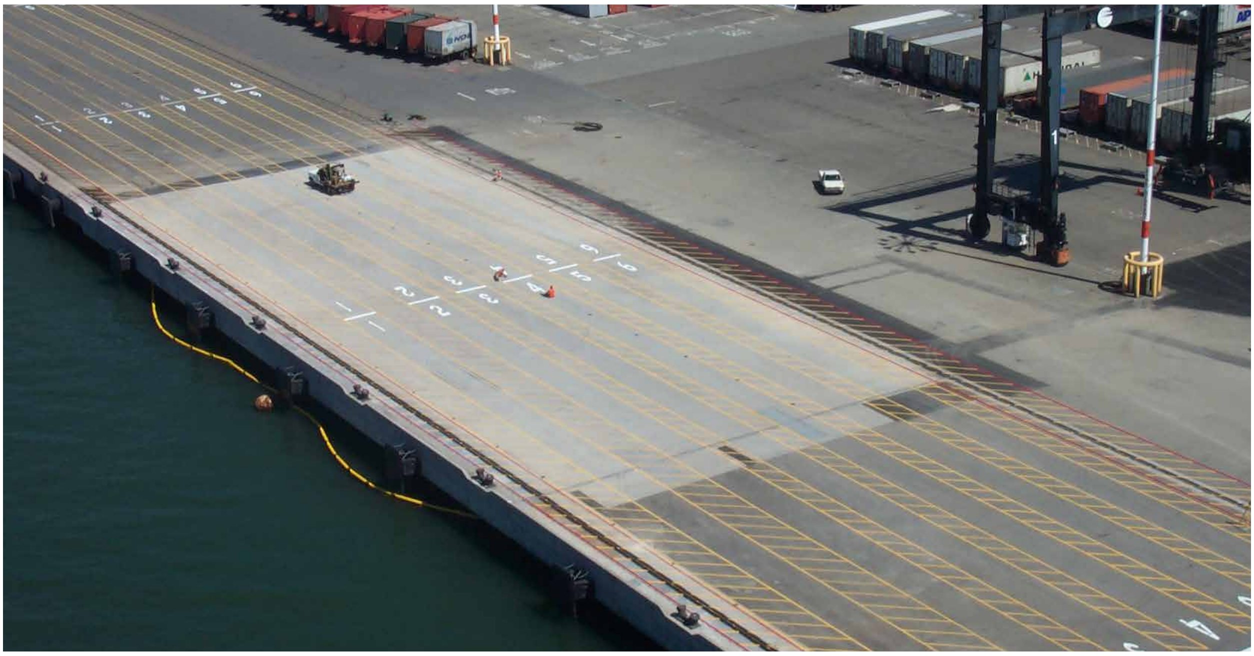
To minimize the chance of errors or misunderstanding in the coordination of infrastructure design with crane design, all interfaces should be clearly defined on one or more interface drawings.

These include specifically considering the design and installation of the following:

- Wheel loads, wheel diameter and spacing and equalizer center distance
- Stowage pin loads and geometry
- Tie-down loads and geometry
- Crane jacking locations and loads
- Rail type, geometry, gauge, rail levels and tolerances
- Rail end stop design load and height
- Crane foot print, operating area and obstructions
- Quay wall/fender distance from the seaside rail *(needed for outreach calculation)*
- Tidal Water level - distance to the seaside rail *(needed for hoist height calculation)*
- Power cable or bus bar geometry data, slot location relative to rail if applicable etc.
- Flag or transponder geometry data
- Light poles located at the STS backreach area - distance from landside rail and height of light pole *(needed to check if such poles interfere with the trolley path or crane height at the backreach area)*
- Other port operation equipment - i.e. straddle carrier height or hopper silo height, etc. *(required to calculate the height of the portal cross beam from seaside rail)*

In addition to coordinating the interfaces between new cranes and infrastructure, consideration must also be given to any interfaces between new cranes and existing equipment in a terminal, as applicable.

A single interface drawing reviewed and approved by the relevant parties, identifying all loads and interfaces between the crane and infrastructure, is the recommended approach to avoid expensive delays during crane installation and is a solid basis for trouble free operations.

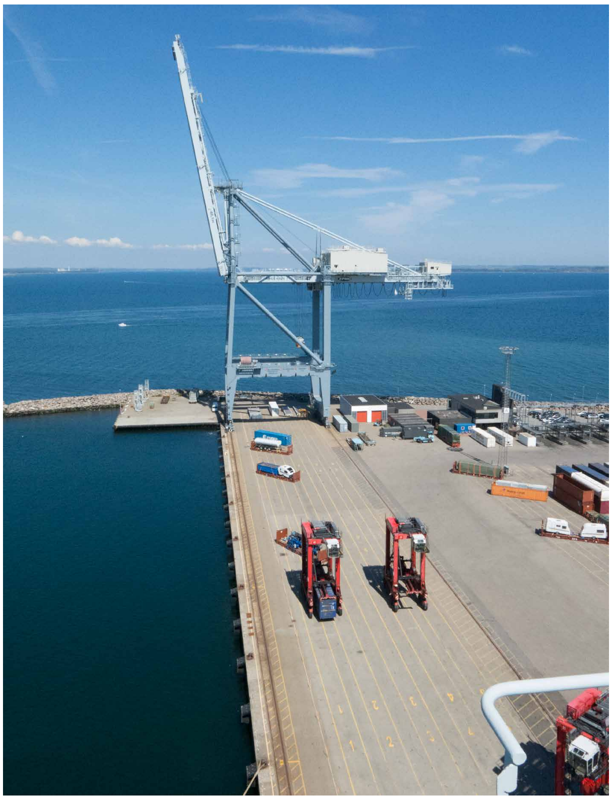


2 | BACKGROUND

Reliable maintenance and operation are the key factors to profitability for crane operators. Sometimes difficulties in fit or function between cranes and fixed infrastructure result in unforeseen problems that impact upon crane operation.

Installation of large cranes involves a significant disruption to operations. If the installation and commissioning period of cranes is longer than expected, costs can be substantial. An efficient installation requires all interfaces between infrastructure and cranes to be carefully specified and coordinated.

There can be many types of challenges. For instance, a crane may not fit properly on the rails, or smoothly traverse an operating area. The power cable may not fit in the designated slot, or may be too short to allow operation in the full area. Crane pins and tie-down hardware may not be properly located, or may not fit with the provided infrastructure hardware. More importantly, wharf rail beams may not be strong enough for the operating crane, or for the out-of-service wind loads. Transponders in the crane beam may not be properly located for the crane to pick up their signal.



Photograph A: STS crane wharf

Sometimes the basis of crane design wheel loads, and appropriate design safety factors, are unclear to the wharf or rail foundation designer and in some cases, load and safety factors prescribed for buildings in national codes are applied to cranes, resulting in overly conservative designs.

Here an analysis of some of these potential problems is given so that they may be avoided on future projects. Separate attention must be paid to interfaces with existing equipment, as applicable.

In looking at crane interfaces, it is important to consider the following areas:

- Wheel loads, wheel diameter and spacing and equalizer center distance
- Stowage pin loads and geometry
- Tie-down loads and geometry
- Crane jacking locations and loads
- Rail type, geometry, gauge, and tolerances
- Rail end stop design load and height
- Crane foot print, operating area, and obstructions
- Quay wall/fender distance from the seaside rail *(needed for outreach calculation)*
- Tidal Water level - distance to the seaside rail *(needed for hoist height calculation)*
- Power cable or bus bar geometry data, slot location relative to rail if applicable etc.
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- Light poles located at the STS backreach area - distance from landside rail and height of light pole *(needed to check if such poles interfere with the trolley path or crane height at the backreach area)*
- Other port operation equipment - i.e. straddle carrier height or hopper silo height, etc. *(required to calculate the height of the portal cross beam from seaside rail)*

2 | BACKGROUND

The information exchanged between crane supplier and infrastructure design engineer varies depending on the situation:

- Where a new crane is supplied to an existing facility, specific information about what exists already must be provided to the crane supplier and it is recommended that the crane supplier summarizes the information in one document and has the infrastructure engineer review and approve it.
- Where a facility is modified, or a new one is constructed for new or existing cranes, if the facility is designed solely for the cranes, the crane supplier should provide a summary document with crane design loads to the infrastructure engineer. The infrastructure engineer should make a summary interpreting the information provided, and the crane supplier should review and approve this document. If the facility must be designed for different or larger cranes in the future, this must be considered by the end user.

Photograph B: RMG rail yard

3 | INTERFACE DRAWING

To minimize the chance of errors or misunderstanding in the coordination of infrastructure design with crane design, all interfaces should be clearly defined on drawings. Figures 1 and 2 below, (also included in Appendix A in larger size) show examples of such interface drawings.

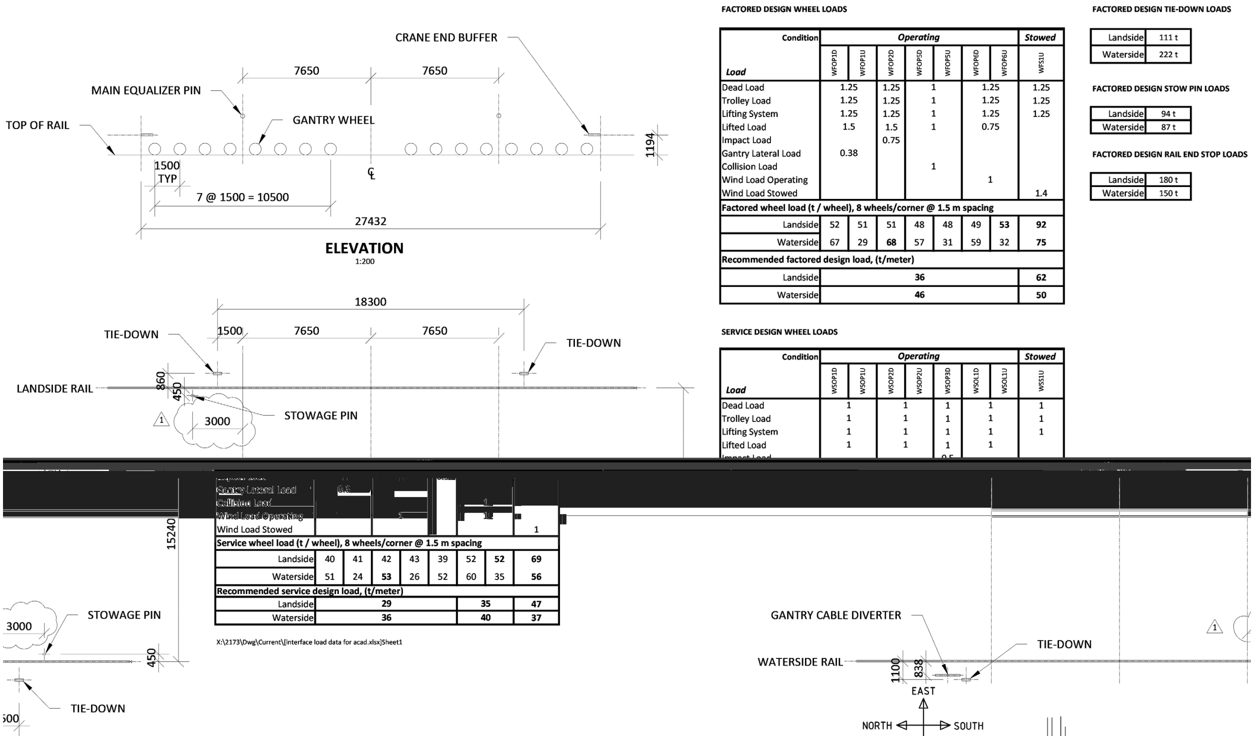


Figure 1: Interface drawing for a ship-to-shore (STS) crane defining wheel spacing, tie- down and pin positions, and interface loads. See Appendix 1A at the end of this document for larger size.

Interface items should be defined, as detailed on the drawings above and may include:

- Wheel loads, wheel diameter and spacing and equalizer centre distance
- Stowage pin loads and geometry
- Tie-down loads and geometry
- Crane jacking locations and loads
- Rail type, geometry, gauge, and tolerances
- Rail end stop design load and height
- Crane operating area and obstructions
- Power cable or bus bar geometry data
- Flag or transponder geometry data

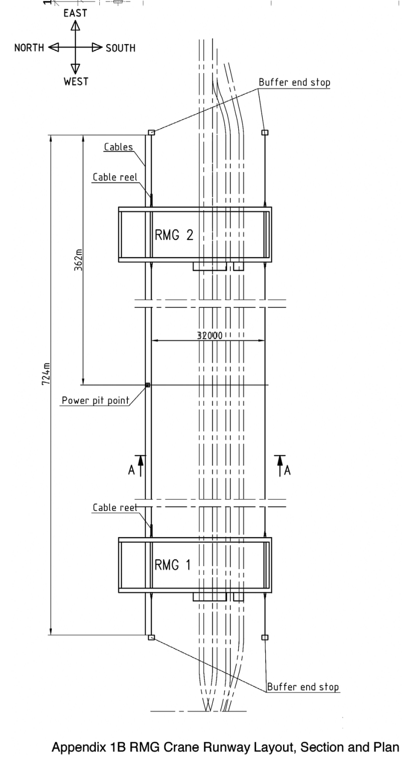


Figure 2: Interface drawing for rail mounted gantry (RMG) cranes showing operating area. See Appendix 1B at the end of this document for larger size

3.1 | WHEEL LOADS

Among the most important information to be coordinated are crane wheel loads. If the crane wheel loads exceed what is allowable, it cannot operate at the facility. Operation must be restricted, or expensive and lengthy improvements must be made to the supporting structure.

It is recommended that design wheel loads, and the factors used in their calculation, are shown on interface drawings.

Operating wheel loads are a combination of dead, wind, lifted, and other loads. The wind angle and all possible positions of the load, as well as simultaneous operation of different crane drives must be considered. The loads are added in different combinations reflecting actual operations. Crane wheel load calculations also consider overload and extreme load conditions such as snag events, storm wind, and earthquake.

Crane makers typically calculate wheel loads without factors (called "service loads") because they are the actual loads expected on the rails. Infrastructure engineers, however, typically work with factored loads which are the expected loads increased by load factors. Typical factors for buildings are 1.2 to1.4 for dead load and 1.5 to 1.7 for live load, reflecting the greater uncertainty of floor live load, compared to dead load, in a building.

The different load factors reflect the degree of certainty with which the magnitude of the loads is known.

If protective measures are in place, the likelihood of a crane picking a load greater than the rated load is relatively small. The maximum weight of the headblock and spreader are accurately known. If a crane has been weighed after construction, the crane weight is also accurately known. These considerations may justify smaller load factors than required by standard design codes.

When crane suppliers provide "service" wheel loads, the load factor for all loads is 1.0. If the wharf designer is given a service load criteria, but the wharf girder is designed using a factored load approach, which is most common, what load factor does the wharf designer use for the wharf design? Since the crane is moving and operating on the wharf, is the crane weight a dead load or a live load?

Photograph C: Construction of STS container crane wharf

3.1 | WHEEL LOADS

It is recommended that crane beam design is based on factored design wheel loads, not service loads, and that the load factors reflect a reasonable consideration of the certainty with which the loads are known, consistent with applicable codes. The factors depend on the design standards used, which vary between regions and countries. In some cases, it may be reasonable, and consistent with the applicable codes, to modify a load factor in view of the certainty with which the load is known.

An example of factored design wheel loads for a crane girder design for an STS crane in Canada is shown in the following table.

The load factors shown are based on local codes and experience with the design of cranes and container wharves.

Perpendicular to gantry rail direction lateral loads for the storm load condition are resisted by the rails. Parallel to gantry rail direction storm loads are resisted by the stowage pins. Vertical axis direction loads are resisted by the crane rails, except for uplift, where they are resisted by the tie-downs.

<table>
<tr><th>Condition</th><th colspan="7">Operating</th><th>Stowed</th></tr>
<tr><th>Load</th><th>WFOP1D</th><th>WFOP1U</th><th>WFOP2D</th><th>WFOP5D</th><th>WFOP5U</th><th>WFOP6D</th><th>WFOP6U</th><th>WFS1U</th></tr>
<tr><td>Dead Load</td><td colspan="2">1.25</td><td>1.25</td><td colspan="2">1</td><td colspan="2">1.25</td><td>1.25</td></tr>
<tr><td>Trolley Load</td><td colspan="2">1.25</td><td>1.25</td><td colspan="2">1</td><td colspan="2">1.25</td><td>1.25</td></tr>
<tr><td>Lifting System</td><td colspan="2">1.25</td><td>1.25</td><td colspan="2">1</td><td colspan="2">1.25</td><td>1.25</td></tr>
<tr><td>Lifted Load</td><td colspan="2">1.5</td><td>1.5</td><td colspan="2">1</td><td colspan="2">0.75</td><td></td></tr>
<tr><td>Impact Load</td><td colspan="2"></td><td>0.75</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Gantry Lateral Load</td><td colspan="2">0.38</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Collision Load</td><td colspan="2"></td><td></td><td colspan="2">1</td><td colspan="2"></td><td></td></tr>
<tr><td>Wind Load Operating</td><td colspan="2"></td><td></td><td colspan="2"></td><td colspan="2">1</td><td></td></tr>
<tr><td>Wind Load Stowed</td><td colspan="2"></td><td></td><td colspan="2"></td><td colspan="2"></td><td>1.4</td></tr>
<tr><td colspan="9">Factored wheel load (t / wheel), 8 wheels/corner @ 1.5 m spacing</td></tr>
<tr><td>Landside</td><td>52</td><td>51</td><td>51</td><td>48</td><td>48</td><td>49</td><td>53</td><td>92</td></tr>
<tr><td>Waterside</td><td>67</td><td>29</td><td>68</td><td>57</td><td>31</td><td>59</td><td>32</td><td>75</td></tr>
<tr><td colspan="9">Recommended factored design load, (t/meter)</td></tr>
<tr><td>Landside</td><td colspan="7">36</td><td>62</td></tr>
<tr><td>Waterside</td><td colspan="7">46</td><td>50</td></tr>
</table>

Landside	111 t
Waterside	222 t

FACTORED DESIGN STOW PIN LOADS

Landside	94 t
Waterside	87 t

FACTORED DESIGN RAIL END STOP LOADS

Landside	180 t
Waterside	150 t

Figure 3: An example of factored crane design loads for crane girder design

3.2 | STOWAGE PINS

Although cranes are provided with motor and auxiliary brakes on the traverse system, these brakes are typically only adequate for operating wind loads up to a specified limit. When wind loads exceed this value, if a crane will be unattended for a period, or if brakes are being services, the crane must be pinned, meaning a vertical steel pin on the crane is inserted into an appropriately designed slot in the wharf. The stowage pin is designed to resist loads parallel to the rail only.

In addition to allowable pin loads, the interface drawing should identify the pin locations, dimensions, and vertical travel distance as well as the size of the opening in the wharf. The pin clearance in the socket should be adequate to allow pin placement at near and far rails of the crane with some relative displacement of the two sides along the rail, and allowing for lateral movement of the wheels on the rail.

Photograph D: Combined tie-down and stowage pin socket

Photograph E: RMG crane pin socket

The crane operating runway should be equipped with enough stowage pin locations to allow all cranes to be pinned quickly, before the operating wind load is exceeded, in case a storm wind is approaching.

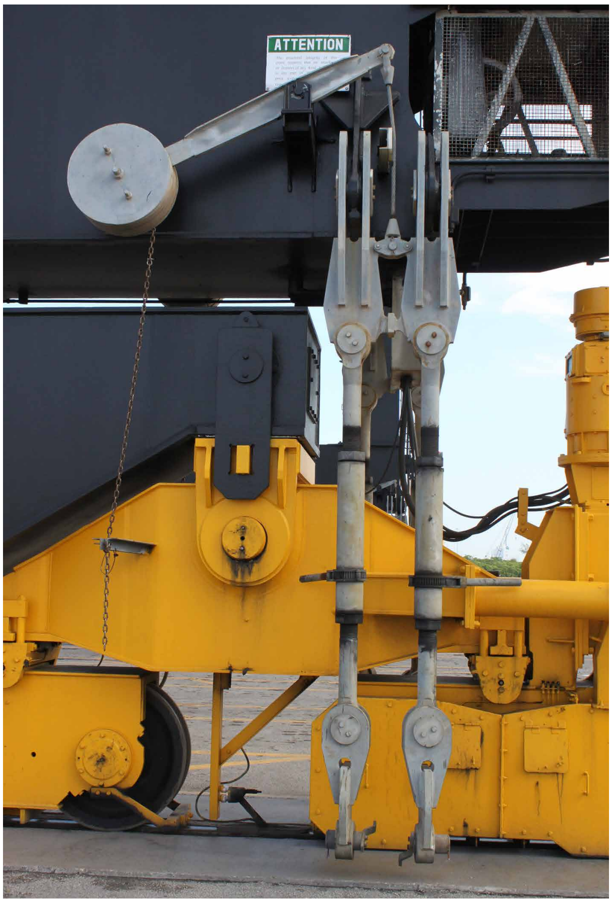
Photograph F: STS crane stowage pin

3.3 | TIE-DOWNS

While stowage pins and crane rails resist horizontal loads in the event of a storm, tie-downs are required to resist the overturning forces developed on tall cranes, particularly STS cranes, in high winds.

Crane stability should be checked by the crane designer under the most adverse loading conditions including angled wind. If it is believed a crane can overturn under a load condition, considering suitable load factors, ballast must be added to the crane, or tie-downs provided.

The simplest solution is to have one tie-down per crane corner. If multiple tie-downs are required at a specific corner, a means of equalization of the load between them must be provided.



Photograph G: STS twin crane tie-downs

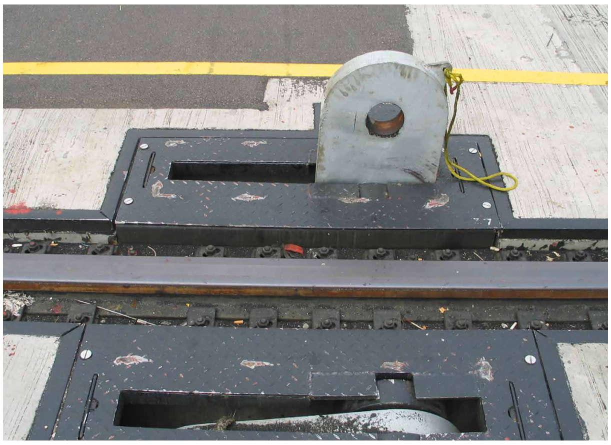
In adverse weather, consideration should be given to enable one person to install the tie-downs within the agreed safe time.

As with the stowage sockets, the possible racking of the crane structure when positioning at the tie-down point should be accounted for.

For tie-down calculations, a worst-case scenario is assumed in which a reduced crane dead load factor is used, typically 0.9, and the destabilizing loads are factored upward. If the dead load is based on weighing the crane, the dead load factor can be 1.0. For out-of-service situations, wind load may be factored upward in the range of 1.2 to 1.6. The factors are dependent upon local code requirements and practice.

For out-of-service wind, the tie-downs may be designed to resist the loading calculated with the factors discussed above, with a safety factor of 0.9 of the yield stress of steel, or a safety factor of 2.0 on the allowable working capacity of rigging hardware, such as turnbuckles, again dependent on local codes and practice.

The interface drawing should identify the factored tie-down loads, the locations of the tie-down connection points in the wharf, and show required interface geometry - such as pin and plate opening dimensions - and height of wharf hardware connection point in relation to the top of rail.



Photograph H: STS crane rail and twin tie-down hardware in a different configuration

For clarity, it is also valuable to show the factors used in the calculation of the tie-down load and the accompanying design criteria for the crane and wharf hardware.

When tie-downs are required, it is not unusual that the out-of-service storm wind loading condition controls the wheel loads and girder design. At some facilities, strengthened areas for the storm wind load are provided at the tie-downs only, which should be clearly designated on the interface drawing.

3.4 | CRANE JACKING LOCATIONS

Some cranes are designed with designated locations for jacking the crane off the rail, for example, during crane installation or to change wheels or equalizer pins. The loading for this condition may control the rail support design over operating cases. For this reason, some facilities are designed with designated strong points that can be used for jacking the crane up.

The loading and position of the jacking points must be coordinated between the crane and infrastructure designer and shown on the interface drawing.

Photograph I: Designated strong jacking points

3.5 | CRANE RAILS

Photograph J: STS crane gantry, wheel, rail, cable, trench, and crane buffer

Crane rails are significant cost components of an installation. Properly designed and installed crane rails are critical to a trouble-free crane operation. A poor rail installation can result in significant ongoing maintenance cost and downtime resulting from replacement of wheels or wearing of rail. Replacing worn crane rails will result in significant operational interruption in any facility.

A rail installation consists of rail, clips, rail pad, bearing plates, bearing plate bolts, and grout. Other critical factors in the installation are rail welding procedures, expansion joint design, and installation tolerances.

When selecting crane rails consideration should be given to the operating load, wheel diameter and the width of the rail head, as well as the hardness of the elements. Undersized rails result in premature wear and may require replacement within five to ten years, while a proper rail installation should last 20 years or more.

3.5 | CRANE RAILS

As cranes are electrically grounded to the rail, the rail must also be grounded at regular intervals. Special designs are required for expansion joints in concrete wharves, and for curved rails.

The selection of a crane rail must include consideration for how it will operate. For fast running and continuous gantrying RMG cranes in a rail yard or ASC cranes in a container yard, a sufficiently sized rail is critical. STS cranes have higher wheel loads, but also lower operating speeds and fewer hours of gantry operation. For today's large STS cranes and fast running wide span cantilever RMG cranes, a practical rail should have a wearing surface 100 mm wide or greater.

Rails that are out of tolerance in the horizontal plane, in local or total variation of gauge, will result in premature wear of rails and wheels—only time will show if the rail will wear the wheel flanges or the wheels will wear the rail. With a good rail installation there should be little or no discernible wear of rail or wheel—assuming the crane is also properly aligned and does not rack excessively while driving.

Rails improperly aligned vertically can induce racking loads in cranes that can lead to premature failures in the crane structure.

ISO 12488-1 is a practical guide for rail installation tolerances. This standard provides tolerances for both rail installation and crane manufacture of gantry systems, for three grades of installation accuracy, correlated with the expected travel distance of the crane during its life. The standard includes requirements for vertical angle of rail and straightness of rail end stops.

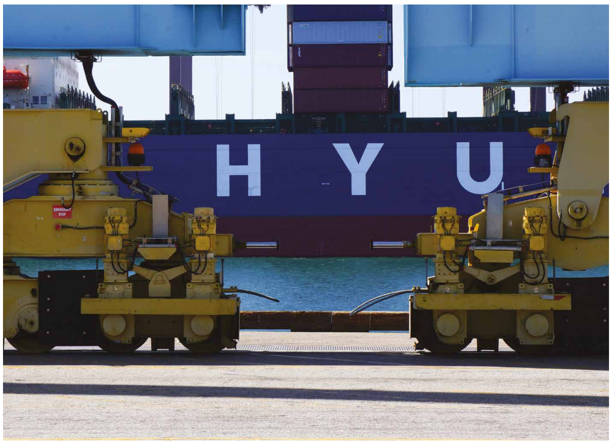
Normally flanged wheels are used with or without side rollers. When side guide rollers are used, typically on RMG and ASC cranes, the sides of the selected rail head should be square and vertical, not tapered, and adequate space must be provided for the rollers on each side of the head of the rail. When wheels are flanged, the shape of the inside of the flanges must be consistent with the shape of the rail head.

Where the top of the rail is flush with the surrounding pavement, as is typical for STS cranes, the height of the adjacent crane structure must be considered, bearing in mind that in some cases rails settle and the crane structure may bind against the ground.

Photograph K: RMG crane rail worn from the side by wheels, likely due to crane racking while driving

3.6 | RAIL END STOPS

Cranes are typically equipped with end buffers with capacity to absorb the energy of a full speed collision. The purpose of a crane end stop is to stop the crane during normal operations, and to prevent damage in a runaway incident during which the crane speed can be greater than its maximum operating speed.



Photograph L: Buffers on two adjacent STS cranes

The same protection against damage should be provided for a crane running into an end stop as when running into an adjacent crane. Since each crane is equipped with buffers and the kinetic energy for two moving cranes is the same as for one crane coming up against a stop, no buffer is required at an end stop for a standard collision case.

In the case of run-away cranes, the energy can be much higher and the most conservative assumption is that a crane overturns without failing the stop.

Photograph M: STS crane end stop with twin hydraulic buffers

In some cases, large end stop buffers are provided to slow down and stop cranes safely at the greater “run-away” energy.

The interface drawing should show end stop design load and the centre height over the rail. It is recommended that the diameter of the contact surface be 125 mm or greater to account for any deviations in the height of the buffers on the crane.

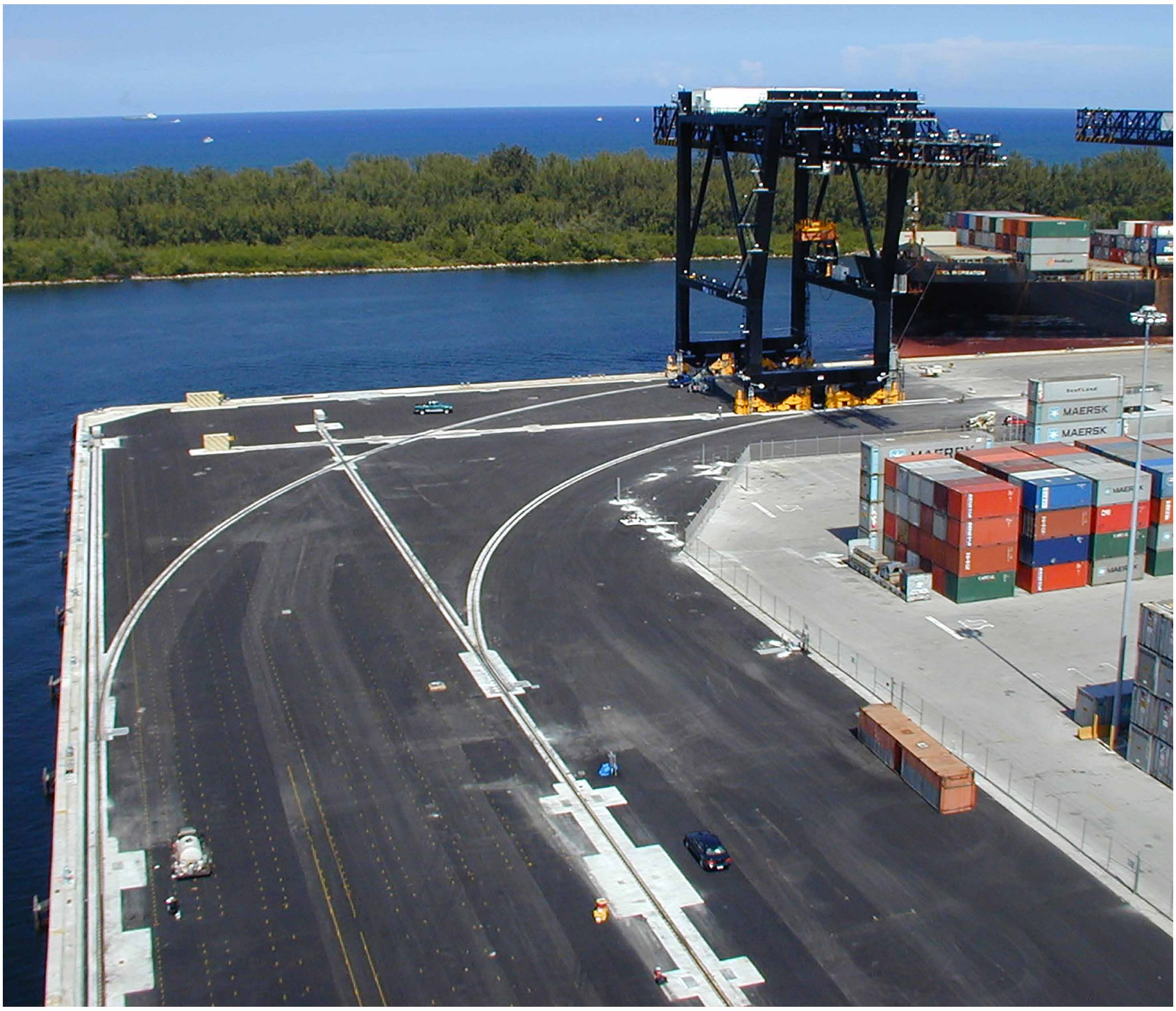
Photograph N: STS crane end stop without buffer

3.7 | CRANE FOOT PRINT, OPERATING AREA AND OBSTRUCTIONS

If STS cranes operate on adjacent non-linear wharves, they can collide in the corner at the backreach, outside the view of standard anti-collision functions. RMG cranes may operate near workshops or light poles that restrict trolley operation or the rotation of containers in certain areas, or other obstacles may exist. With crane positioning systems and PLCs, it is possible to program "safety" functions on cranes preventing them from colliding with fixed objects or other cranes.

Interfaces with existing equipment, such as other cranes along the rail, must also be considered carefully.

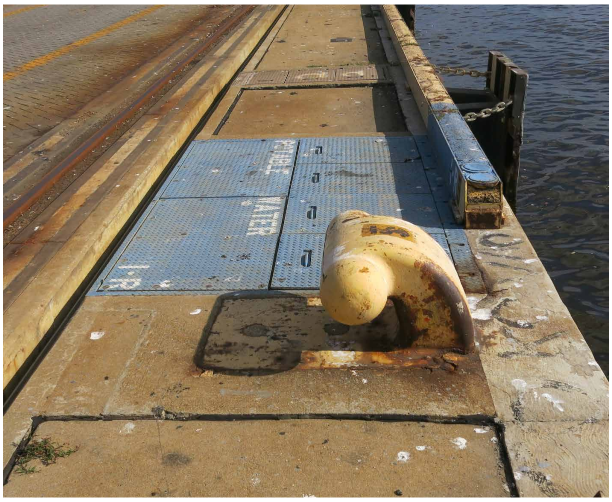
Such "obstruction areas" should be clearly defined on the crane-interface infrastructure drawings and agreed by relevant parties.



Photograph O: Low profile cranes with sliding booms operating on intersecting wharves connected by a curved rail

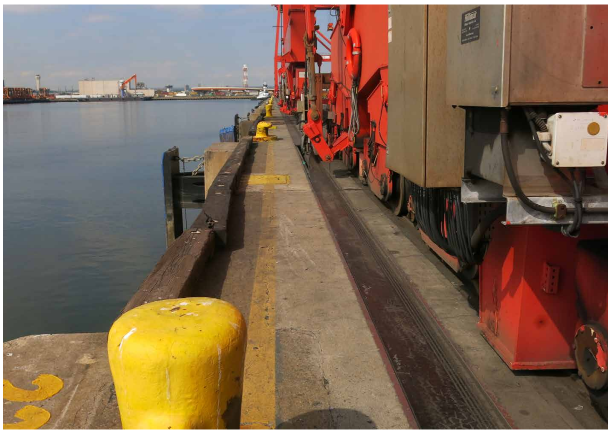
3.8 | POWER SUPPLY AND COMMUNICATIONS

Cranes are typically powered either through a cable, usually wound on a reel or drum mounted on the crane, or through a power pick-up fixed to the crane that slides on a bus bar running the length of the crane runway. A third alternative is the use of a cable chain underground for STS cranes, or above ground for ASC or RMG cranes. When electrical cable is used, it can incorporate fiber optic cables allowing fixed communication between the crane and maintenance or operations. One alternative to fixed communication is a local wireless radio network.



Photograph P: STS crane open waterside cable trench

The key infrastructure crane issues here are to coordinate the location and size of the cable, and the number of operating cranes, with the location and size of the trench or other means of cable support. If it is a covered trench, or covered bus bars, a device for opening the cover (which can be a steel cover or a rubber belt) is fitted to the cranes. The design of the infrastructure should consider the addition of further cranes in the future, or lengthening of the crane runway.



Photograph Q: STS crane waterside cable trench covered with flexible reinforced rubber

Photograph R: RMG crane with elevated bus bar power supply

Photograph S: The pick-up system on STS crane powered by underground bus bar

3.8 | POWER SUPPLY AND COMMUNICATIONS

Photograph T: Standard cable reel solution on RMG

The crane power supply can be as low as 400V in Europe, but is typically in the range 3kV to 20kV normally. For safety, the cable is typically separated from regular crane access areas and in many cases physically protected in an open or covered trench underground. The same considerations apply to bus bars or cable chains.

It is common to locate the power supply on RMG cranes on the non-cantilever side to reduce the possibility of dropping a container on the power supply. On STS cranes, the power supply is typically located on the waterside as terminal equipment must regularly cross over landside rails and would also have to cross over, under or around supports for a landside power supply, if it was elevated.

The interface drawing should define the location of the cable in relation to the rail, the cable diameter, and the size of the trench the cable will run in, if applicable. If a bus bar is used, the specific geometry must be coordinated between the parties.

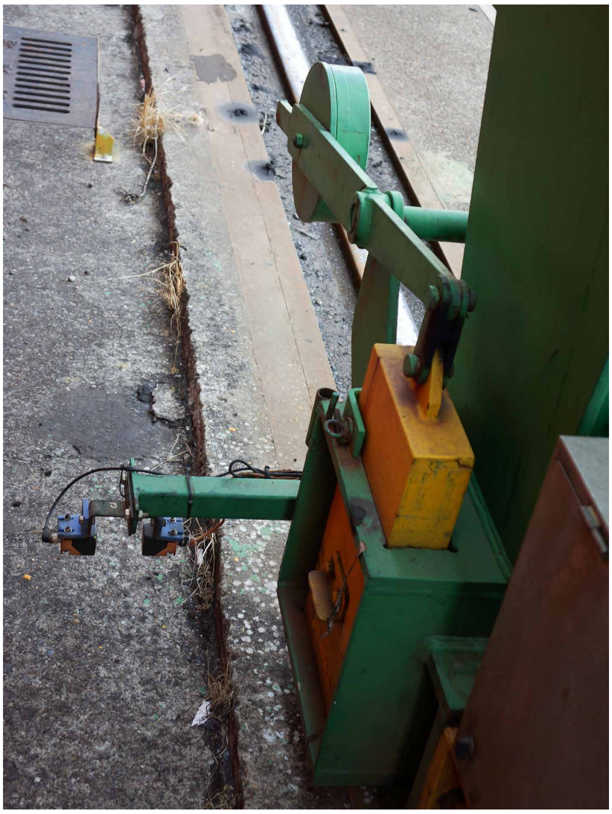
For more detailed considerations regarding crane power supply and communications, reference it made to the German engineering guideline VDI 3572, "Lifting equipment, power feeding for mobile users."

Photograph U: One type of cable support. The sign says "lethal cable."

Photograph V: Power disconnect location for RMG crane powered by protected ground level bus bar

3.9 | POSITIONING

For any type of automated cranes and for cranes built with anti-collision safety systems, an accurate positioning system is critical. The positioning system may also be used to reduce racking of the crane-relative displacements of the two driven sides.



Photograph W: RMG positioning reader gate and flag in the background. Stowage pin in foreground

An encoder on a crane wheel is a typical crane positioning solution. Over time, the encoder may lose accuracy due to wheel slip on the rail. When positional accuracy is critical, such as in automatic operations, use of fixed flags or transponders along the rail can provide an independent absolute position for calibration of the encoder. When the flag is passed, it is read by the gate and the encoder position is reset to give an accurate position for operation and safety. A transponder solution works in a similar manner.

Photograph X: The same RMG runway position flag indicated on top, in Photograph T

Photograph Y: RMG wheel rotational position encoder

3.9 | POSITIONING

As with other interfaces, the position of flags and transponders must be agreed between the crane supplier and infrastructure designer, or the systems will not work properly. It is recommended that these positions be clearly shown on the interface drawing and reviewed and approved by each party. In many cases, the installation of the flags and transponders is included in the scope of the crane supplier to avoid issues with the installation.

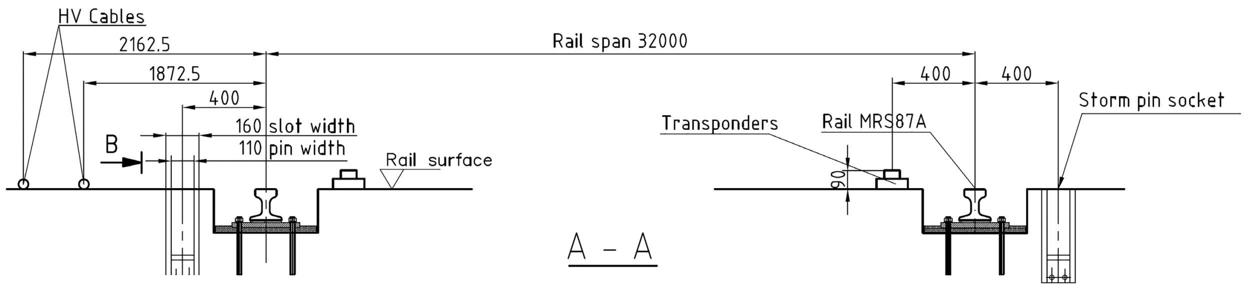


Figure 4: Cross section showing the exact height and location of transponders and other interfaces for an RMG installation. See Appendix 1B for larger size.

To ensure a clear signal, several considerations apply when installing transponders. Figure 5 above provides some guidance. The literature of the transponder supplier must be reviewed carefully, and the crane supplier must confirm that the installation will meet their criteria.

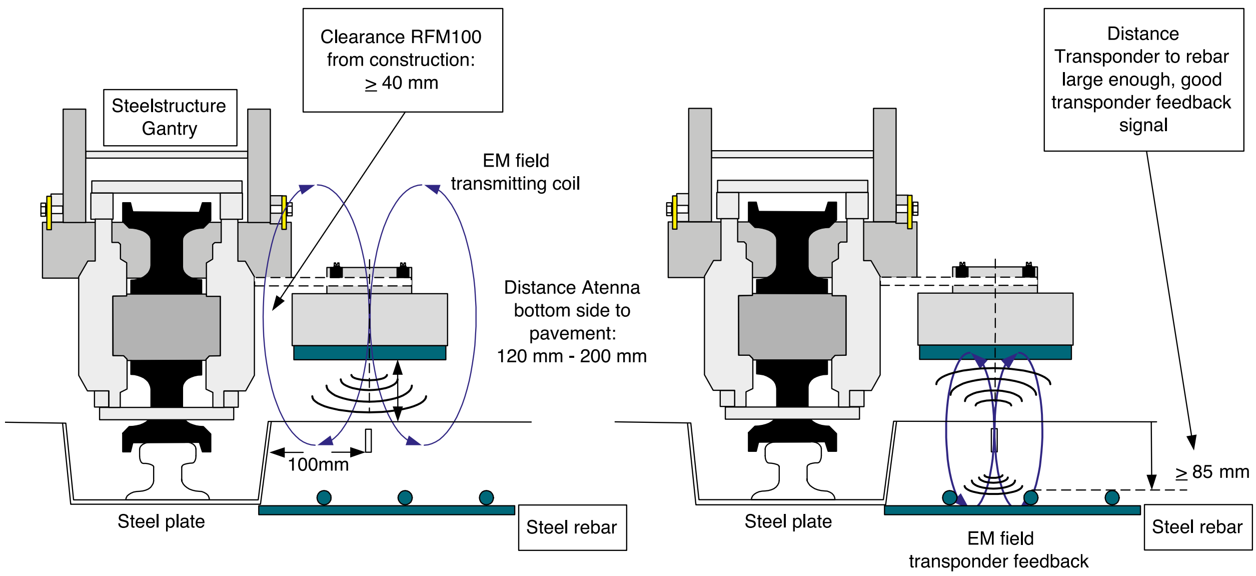


Figure 5: Guiding clearances for transponder installations

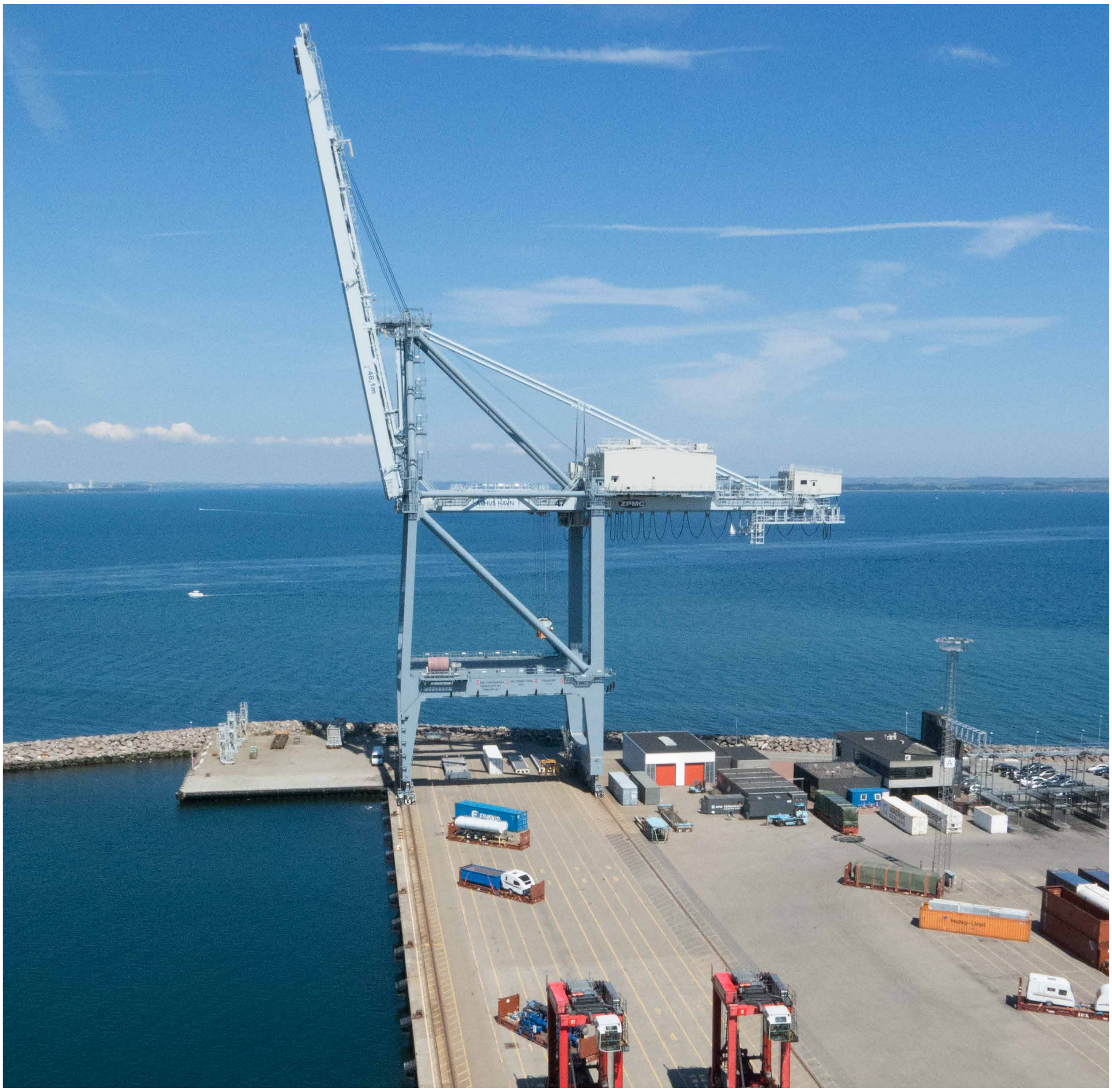
4 | CONCLUSION

A single interface drawing reviewed and approved by the relevant parties, identifying all loads and interfaces between the crane and infrastructure, is the recommended approach to avoid expensive delays during crane installation and a solid basis for trouble-free operations. Interfaces of new cranes with existing equipment must also be considered.

Some guidance is provided regarding each area that should be covered by the interface drawing. This information should be a useful guideline for crane suppliers, infrastructure design engineers and the end user's project manager.

5 | REFERENCES

Images are courtesy of Liftech Consultants Inc. Figure 5 is courtesy of BTG and appendix 1B is courtesy of Konecranes



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Founded in 2004, PEMA provides a forum and public voice for the global port equipment and technology sectors. The Association has seen strong growth in recent years, and now has more than 100 member companies representing all facets of the industry, including crane, equipment and component manufacturers; automation, software and technology providers; consultants and other experts.

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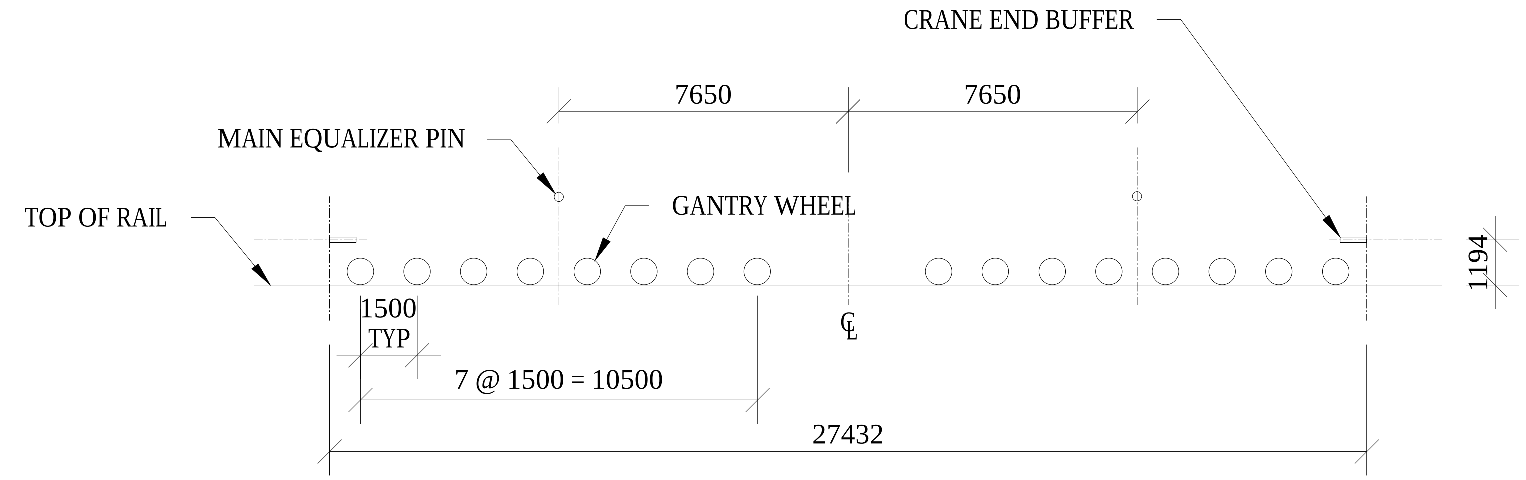
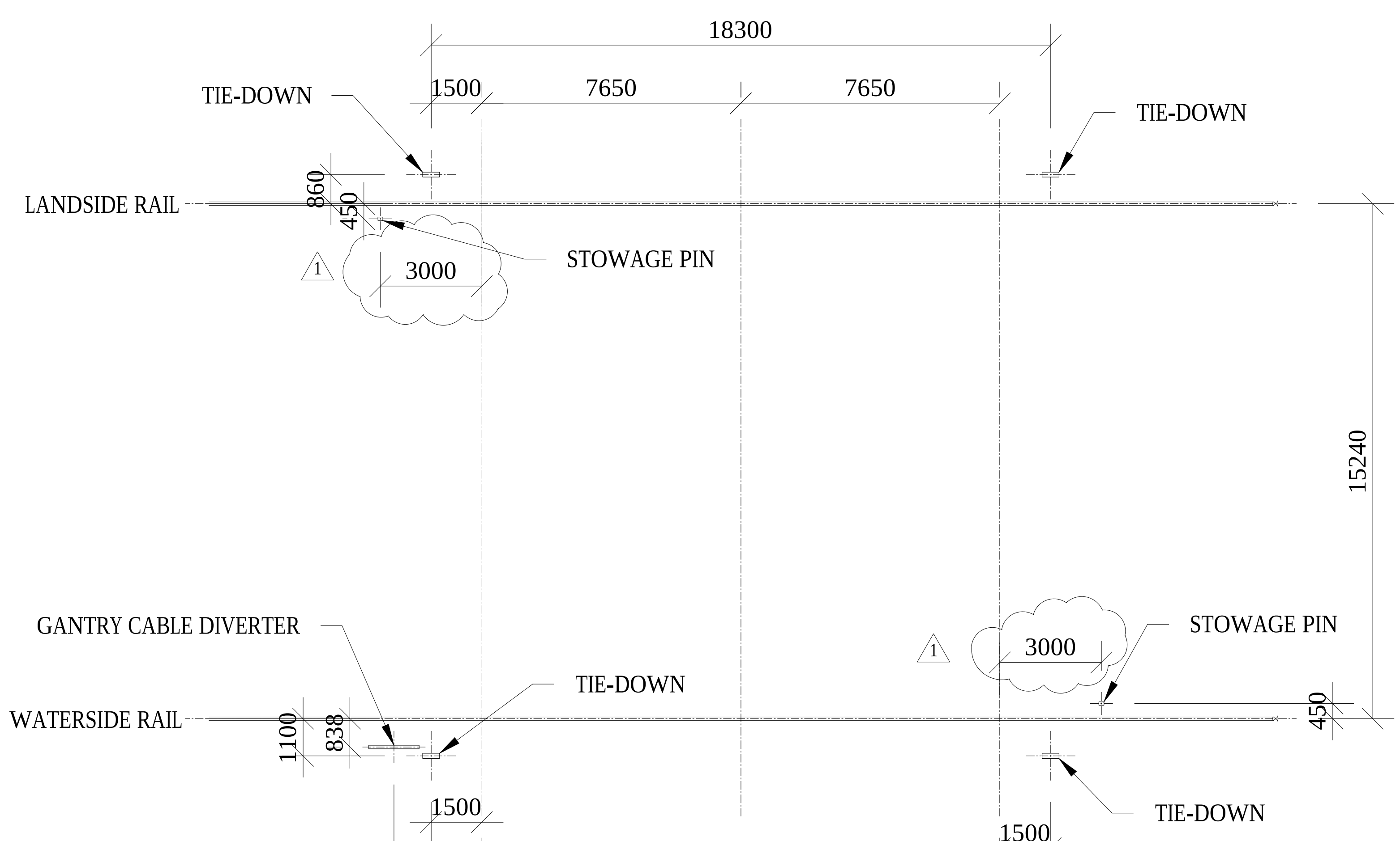


ELEVATION
1:200



PLAN
1:200

FACTORED DESIGN WHEEL LOADS

Condition / *Load*	*Operating* WFOP1D	WFOP1U	WFOP2D	WFOP5D	WFOP5U	WFOP6D	WFOP6U	*Stowed* WFS1U
Dead Load	1.25		1.25	1		1.25		1.25
Trolley Load	1.25		1.25	1		1.25		1.25
Lifting System	1.25		1.25	1		1.25		1.25
Lifted Load	1.5		1.5	1		0.75		
Impact Load			0.75					
Gantry Lateral Load	0.38							
Collision Load				1				
Wind Load Operating						1		
Wind Load Stowed								1.4
Factored wheel load (t / wheel), 8 wheels/corner @ 1.5 m spacing								
Landside	52	51	51	48	48	49	**53**	**92**
Waterside	67	29	**68**	57	31	59	32	**75**
Recommended factored design load, (t/meter)								
Landside	**36**							**62**
Waterside	**46**							**50**

FACTORED DESIGN TIE-DOWN LOADS

Landside	111 t
Waterside	222 t

FACTORED DESIGN STOW PIN LOADS

Landside	94 t
Waterside	87 t

FACTORED DESIGN RAIL END STOP LOADS

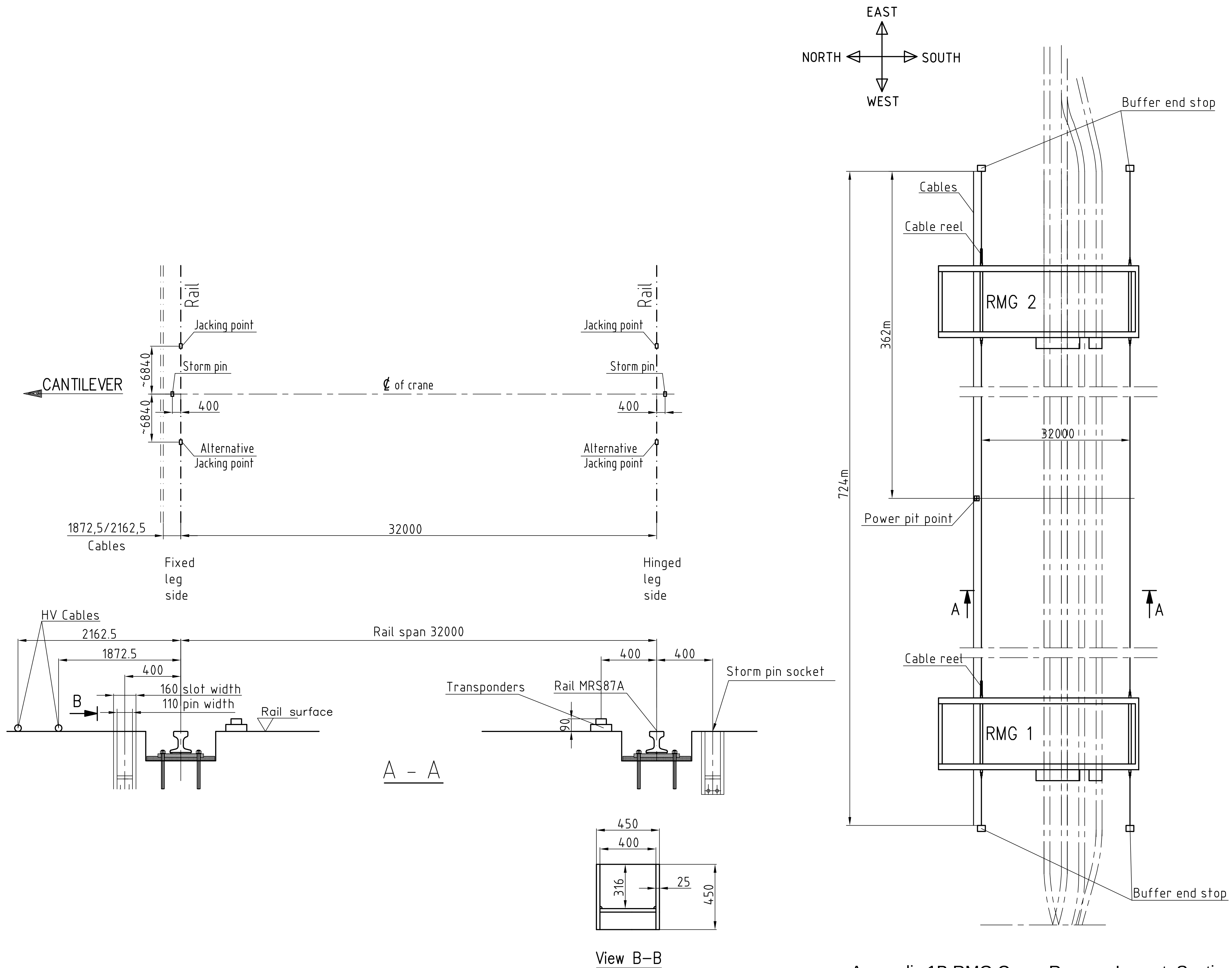
Landside	180 t
Waterside	150 t

SERVICE DESIGN WHEEL LOADS

Condition / *Load*	*Operating* WSOP1D	WSOP1U	WSOP2D	WSOP2U	WSOP3D	WSOL1D	WSOL1U	*Stowed* WSS1U
Dead Load	1		1		1	1		1
Trolley Load	1		1		1	1		1
Lifting System	1		1		1	1		1
Lifted Load	1		1		1	1		
Impact Load					0.5			
Gantry Lateral Load	0.3							
Collision Load						1		
Wind Load Operating			1			1		
Wind Load Stowed								1
Service wheel load (t / wheel), 8 wheels/corner @ 1.5 m spacing								
Landside	40	41	42	43	39	52	**52**	**69**
Waterside	51	24	**53**	26	52	60	35	**56**
Recommended service design load, (t/meter)								
Landside	**29**					**35**		**47**
Waterside	**36**					**40**		**37**

X:\2173\Dwg\Current\[interface load data for acad.xlsx]Sheet1

Appendix 1A STS Crane Interface points, wheel loads, and other interface loads



Appendix 1B RMG Crane Runway Layout, Section and Plan