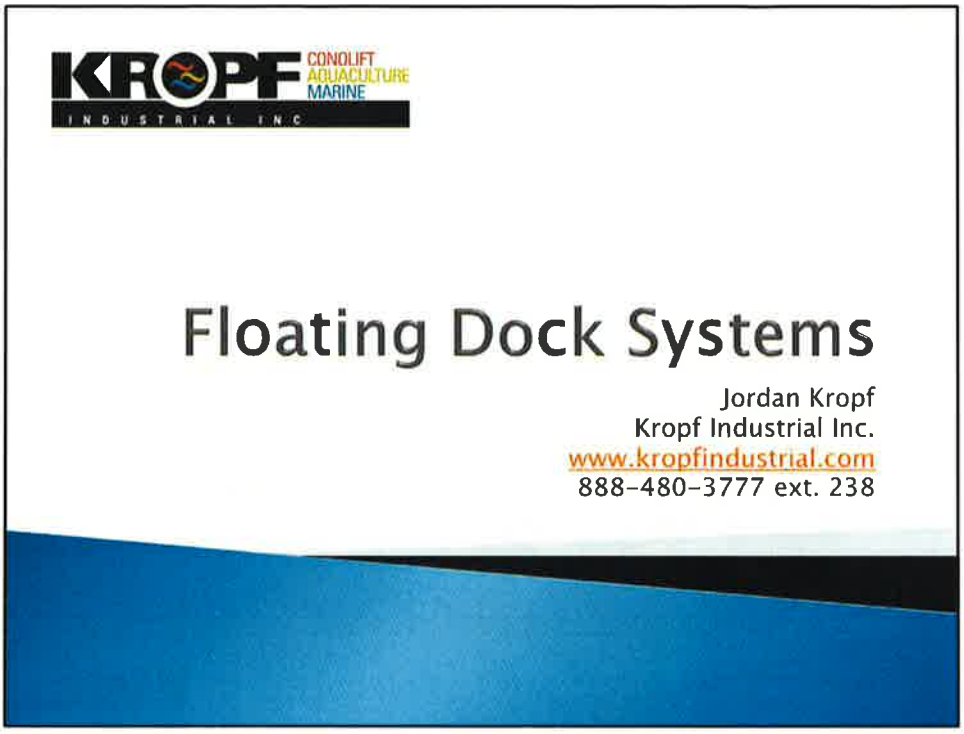
KROPF
CONOLIFT
AQUACULTURE
MARINE
INDUSTRIAL INC
Floating Dock Systems
Jordan Kropf
Kropf Industrial Inc.
www.kropfindustrial.com
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Kropf Industrial Inc.

- Located near Parry Sound, ON
- Founded in 1977
- Steel and HDPE floating dock systems
- Floating breakwaters

Agenda

- Introduction
- Fixed vs Floating Docks
- Floating Docks
  - Access
  - Anchoring
  - Utilities
- Winter
- Q & A

Fixed Docks – Advantages

- Stability
- Service life

- Fixed docks most commonly refers to docks on driven steel piles
  - Can also be sheet pile, caissons, cribs, or a whole bunch of other things that people have dumped in the water and tried to build on top of

- Fixed docks provide higher level of stability, especially in basins with more wave energy (although a well-designed floating dock is not far behind)
- Can often get away with narrower fingers
- Allows maximum use of space around the edges of your basin

- Modern fixed docks using coated steel piles or composite pilings can offer very long service life
- Failures tend to be slower as piles gradually degrade and weaken, rather than having a floating dock section develop a leak and sink
- Although most marinas find their slip mix requirements changes every 25 – 30 years or so anyways

Fixed Docks – Drawbacks

- Permitting
- Water levels
- Ice conditions

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- Typically more difficult to get permits for fixed docks (especially in certain areas)
- More restrictive timing windows on doing the construction

- Obviously changing water levels pose problems for fixed docks
    - Big steps down to boats
    - OR docks/utilities all under water
- So, what about fixed docks that are adjustable in height?
- I have not yet encountered a situation where this works well on a large scale
- It is possible to do, where I've seen it done is with perimeter style fingers coming off a shorewall, supported by a single pile at the outer end and then in a track-like system on the wall
- You typically still need equipment of some sort to adjust the system
- It's not an easy or quick process
- And if you are doing it on a larger scale, like a full dock system with mains and fingers, it would get quite complicated across the board
- It would also escalate the costs, as you are taking what is typically a more expensive method of installing docks and adding another layer of complexity and cost

- Winter conditions can also be a real problem for pile-supported docks
    - Piles can be bent or jacked in the ice
    - Once the damage is done it's very hard to repair

Floating Docks – Advantages

- Constant freeboard
- Simpler permitting
- Greater flexibility

- Design the docks for the freeboard that suits your boaters
- Never worry about freeboard again
- Can use boarding stairs etc if required

- Lower environmental impacts means simpler approvals from MNR, Conservation Authorities, etc
- In some cases (not all) placing anchors will be excepted from the in-water work timing windows

- Although still a major undertaking, reconfiguring or renovating portions of a floating dock system is typically easier and lower-cost than doing the same to a fixed system

Floating Docks – Disadvantages

- Stability
- Use of space

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- There is a broad range of floating dock designs available
- Stability is a much bigger concern for some as compared to others
- In general – they are floating structures, which means they will react to boat wakes, wind-driven waves, or surge energy
- With a well-designed dock system, this is mitigated to the point where it's not a big concern
- Go with something that's too light and cheap, and this will be an issue for your boaters

- Floating docks need a certain amount of water to float
- Which means you need to consider the lowest potential water level in your basin and make sure all your docks are located so as not to ground out at those levels
- Basins with sloped walls or shallow areas, this may mean your main walkways need to be further offshore than a fixed walkway would, reducing the amount of available space
- Or may require you to also consider some dredging, looking at sheet pile instead of rip rap, etc
- The other consideration is that the finger piers of a floating dock typically derive a lot of their stability from the connection to either the floating main walkway, or via a hinged ramp to the shorewall
- So if you currently have sloping basin walls, with fixed finger piers perpendicular to the wall, and you want to replace with a floating system, you may need to either sacrifice some finger length to make room for a main dock, or have concrete headblocks or something similar on shore for each access point

Floating Docks – Use of Space

- A few more comments on the use of space, just because space and capacity are always at a premium in a marina facility
- There are some work-arounds that can help maximize your basin while still providing stable finger piers
- One is a setup like this, where the finger piers are supplied in U or W sections, and joined together at the shore end with a heavy-duty piece of steel tubing

- Here you can see the tubing, which is bolted to the inner end of the two fingers, joining them together into a rigid U-shape
- Which makes both fingers stable, because they are supporting each other, like a catamaran hull basically

Floating Docks – Use of Space

- Another option is a setup like this, where the ramp is a heavy-duty design that's hinged at both ends
- So the ramp provides the finger pier both stability and its mooring, depending on the size of vessels you don't need any other anchoring with a setup like this
- This works with vertical walls like you see here, but would also work with sloped rock walls as long as you had a mounting point for the ramp that was properly designed

- ASCE Manual No 50 contains lots of good industry-standard and rule of thumb information to help design a dock system
- A good dock manufacturer or consulting engineer can help you with that part of the process
- Just keep in mind that those are industry-standards and often point towards a best-case scenario, which rarely exists
- You will typically be working with an existing set of boaters who are used to an existing set of docks
- So don't miss the opportunity to update your layout and ensure it will work for the next 25 years
- But obviously you have to also consider who your members and users are, and how you can continue to accommodate them as much as possible

- Where this often plays a role is in setting the width of your wells, the spaces between your fingers, and in designing fairways, the distance between one set of docks and the next
- Older facilities will almost always have slips that are too short, too narrow, and too close to the next set of docks
- Everybody has two-foot-itis, new boats are often beamier compared to older vessels of the same length, so the net result is that many of you are dealing with very tight facilities where you need to carefully assign slips in order to ensure two boats can fit in the same well
- How much you can change that is going to depend on a lot of factors that are unique to

your situation
    - Will take some awareness of the makeup both now and in the future of your membership
    - And the strategic goals and direction of your facility
- My point is simply that the design process has to consider both industry norms and also your unique requirements

- Where you can make changes with less impact is in looking at the widths of your main docks and your fingers
- Older fixed dock systems will often have fingers as narrow as 2', and main walkways that are less than 6' wide
- This is where you have an opportunity to give your boaters a system that feels and looks much more comfortable, without sacrificing much real estate
- In general, if a main walkway serves more than 8-12 boats I would recommend making it 8' wide if possible
- And there's very few occasions where I recommend fingers narrower than 3' wide
- I would suggest that in general boaters are becoming increasingly concerned about the amenities and comfort level of their facility, not just pure functionality
- So some small changes to your dock system parameters may go a long way in continuing to attract new members and ensuring your facility remains full

General Design Criteria

- Final word on design – don't be afraid to get creative
- You may be surprised at what's possible
- The worst thing a manufacturer like us can tell you is no

Floating Docks – Access

- Straight or arched ramps
- Adjustable landings
- Self-adjusting stairs

- You have made the decision to go with a floating dock system, you have the layout generally nailed down
- We're now going to spend some talking about some of the design and construction considerations for floating docks that are most directly tied to the changing water levels conversation we're having today
- The first one is access – getting from your fixed-elevation shorewall onto a floating structure that is not going to remain at a fixed horizontal or vertical distance from your access point

Straight Ramps

- This is the most common access system for floating docks
- Typically constructed from aluminum to save weight, can be decked in wood, composite, or a non-skid surface
- Usually they are hinged at the shore end and land on rollers at the dock end
- This allows the dock system the ability to move in waves, surge, etc
- And to self-adjust as the water levels change
- Because of the geometry involved, the shore mount point has to be **at least** flush with the deck level of the dock at anticipated high water, otherwise the ramp will bottom out and the wheels will be off the deck surface

Arched Ramps

- So what if that's not possible?
- What if you determine that at high water, or potential high water, your mount point is going to be 12" below the preferred freeboard of your dock?
- Well, you could possibly build a structure on shore to raise the mount point
- Maybe make that structure removable or temporary so that if the water level goes down you can move the ramp mount location down as well
- And there may be cases where that is the best option
- Another option to consider is an arched ramp like what you see in the picture
- What this design does is create more space between the ramp and the floating dock
- So that the ramp can actually slope up towards the dock without bottoming out

- The other big question is how long your access ramps should be
- This is based on a number of factors
    - Elevation change at low water versus high water
    - Does the ramp need to be arched or not
    - How much space do you have available on the dock itself to land the ramp? How far out can it go?
    - What are the requirements and capabilities of your users?
    - Does the system need to be AODA compliant?
- This photo is of a municipal project we installed in 2014
- The first ramp on the left hand side is hinged, so the angle changes with the water level
- The next two ramps are fixed at a 1:12 slope for AODA compliance

- And this is the same dock in 2019
- All that's left is the first ramp, and if the water goes any higher even that one will have to be looked at

Adjustable Landings

- This is another set of docks for the same municipality, also installed in 2014, also designed to meet AODA requirements
- Again the first ramp is hinged, the next two are fixed slope
- This one incorporates the switchback design on an extension off the main dock to make the docks fit better along the shoreline
- In hindsight, something we should have done and didn't was make at least the first ramp landing adjustable in height
- These wouldn't be landings that would be adjusted regularly, but it would be possible to design a landing that could be adjusted once or twice per season if required
- Which would allow for a lot more flexibility, and would also enable you to stay closer to being AODA compliant if required

- Another access option to consider if space is limited is a self-adjusting stairs like what's shown here
- These are hinged at the top, sit on a roller at the bottom
- And the tread height varies as the water level changes
- These can be supplied with anywhere from 3 treads and up
- In this particular site, the Club sometimes experiences surge that comes up over the shorewall
- So the mounts for these stairs have what is basically a shear bolt built into them, so that if the deck of the dock rises above the shorewall, the shear bolt breaks and the steps can continue to ride up without being damaged

- One of the most crucial components of any floating dock system is how it's going to be held in place
- Your mooring system needs to withstand loads from wind, waves, surge, boat impact, ice
- AND of course, changing water levels both from day to day as winds change, seasonally, and long term or in recent years relatively short term fluctuations in average levels
- You also ideally want an anchoring system with a certain level of redundancy, so that the failure of one chain or one pile won't cause a wholesale failure of the system
- Three primary options to consider
    - Traditional anchors and chain
    - Pile and vertical slide systems
    - Flexible moorings

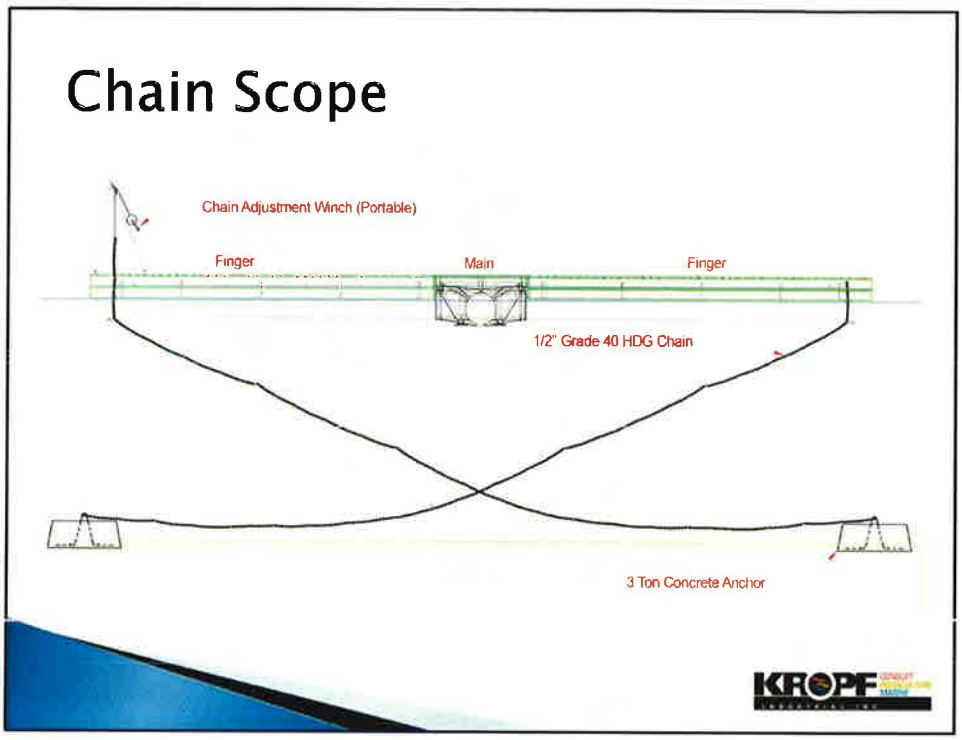
Anchors and Chain

- Most common and cost effective method

- The most common and often the most cost effective method of mooring is with concrete anchors and chain
- The weight of the anchors and size and grade of chain is part of the design process
- We typically use anchors ranging from 3 to 6 tons, minimum ½" Gr 40 galvanized chain

Anchors and Chain

- The chain will be shackled to the anchor and then attached to the dock using a chain tube assembly something like this
- The bell flange at the bottom reduces abrasion
- The chain locks into a key slot at the top of the vertical tube
- The chain is accessible for adjustment via removing the decking over top of the pocket
- So in extreme water level fluctuations you can go through your dock system and adjust the tension on the anchor chains as required
- But you want to design the system to minimize the amount of times that sort of effort will be required



- The key to reducing the amount of adjustment required is the scope of the chains in your anchoring system
- The more scope you have, ie the shallower the angle of the chains from the anchors to the dock, the more the geometry of the system and the weight of the chain itself is working in your favour
- We will typically target a minimum of 3:1 chain scope
- In other words if your basin is 10' deep, your anchor should be a minimum of 30' away from where the chain connects to the dock
- In many cases, we'll aim for more than that, depending on the layout of the dock system and other considerations
- This drawing shows a fairly typical anchor and chain setup, these are the lateral anchors that are shown
- You have the main dock in the center, the chains actually run from the finger ends back underneath the main dock and to an anchor placed an appropriate distance on the far side of the main walkway
- This provides lots of chain scope while also keeping the chains underneath the docks, so they can't become a hazard to the boats using the system
- Obviously there are limits to how much flexibility a chain and anchor system has for changes in water level without being adjusted
- There will come a point when you are either seeing dock sections being pulled down by chains that are too tight
- Or the docks will have a lot of horizontal movement in low water situations
- Occasional adjustments are going to be required

- However, a properly designed chain and anchor system can provide you with enough flexibility that those adjustments can be relatively rare

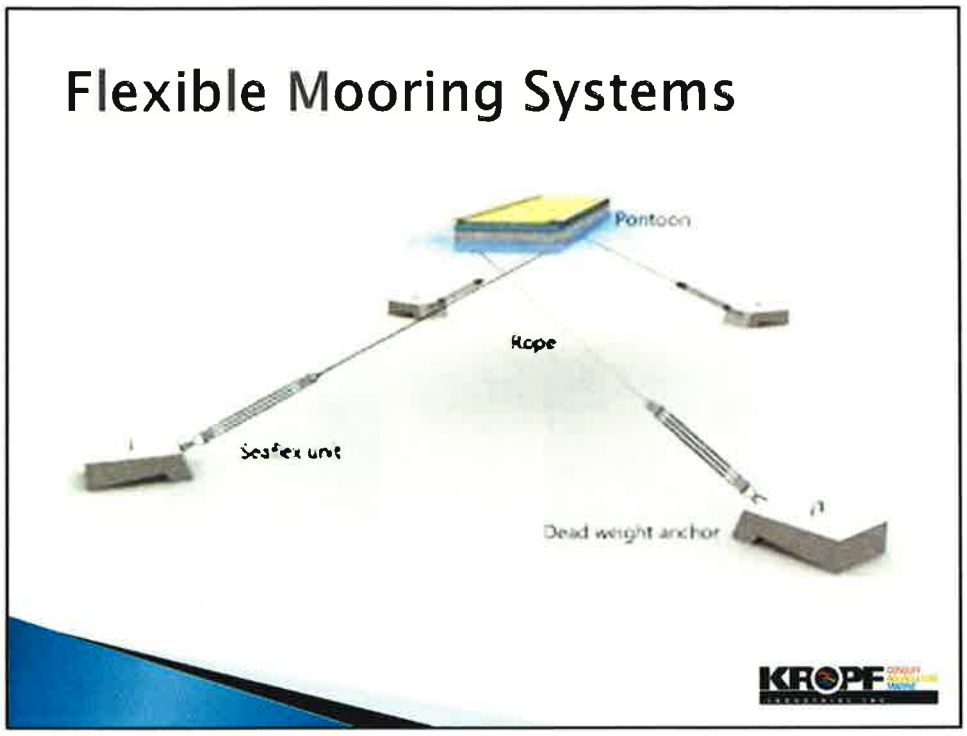
Pile Mooring Systems

- One alternative to block and chain moorings is a driven pile anchoring system
- There are a number of different ways to connect the docks to the piles to avoid binding, reduce noise, and mitigate the risk of damage in the winter time
- This is certainly a good option when it comes to dealing with large fluctuations in water levels
- However, in general, we are very cautious with using piles in environments that deal with any significant ice activity
- Of course the piles themselves are vulnerable to being jacked in the ice or bent over
- And then a floating dock on a fixed pile can also be a problem in winter conditions, if the dock freezes to the pile and gets hung up you can have structural damage to the dock, the pile guide, or both
- The other issue is that if your floating dock system is frozen into the ice sheet and the whole sheet moves, if the system is on blocks and chains the worst thing that will likely happen is you will break some anchor chains or drag anchors
- If it's a pile-moored system, you might bend every pile in your marina, or start damaging pile guides or docks
- Not saying piles are not an option, just saying consider your options, and weigh the cost of occasional chain adjustments versus bringing in a marine contractor to extract and re-drive piles

Vertical Slide Systems

- This is a design that is only applicable in situations where you are installing docks along a shorewall
- Very similar to driven piles except this design utilizes H-beams welded or bolted to a shorewall
- What we call a slipper plate is bolted to the dock and fits around the beam
- The beams can be as tall as they need to be, so even if your basin is subject to flood levels that are above your shorewalls, if you extend the steel beams high enough the docks can ride up on the beams with the surge
- When it comes to winter considerations, although we haven't seen any issues with the beams getting damaged by ice, we do recommend that systems like this get disconnected for the winter
- Ice will form between the dock and the wall, and as that ice expands, it can damage the slipper plate assembly

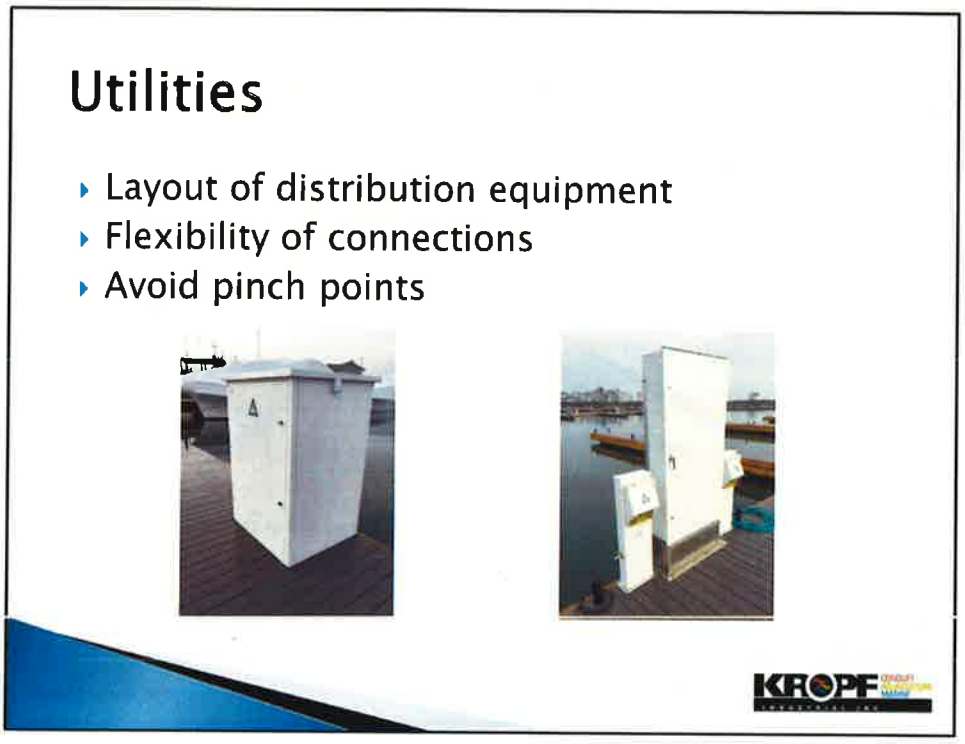
- Another option to consider is a flexible mooring rode system
- Seaflex is the most well-known supplier of systems like this
- They supply assemblies that look something like this
- The black lines are rubber hawsers that are engineered to stretch and contract
- The yellow lines are a safety bypass that limit the stretch of the unit to a predefined maximum
- The assemblies are designed to suit the site conditions
    - Water depth
    - Mooring loads
    - Wave heights
    - Water level fluctuations



- The finished mooring system looks something like this
- Concrete anchors, or screw anchors could be used as well
- The Seaflex unit, and then a high-strength rope from the Seaflex to the dock
- The mooring lines are tensioned during the installation to a pre-defined value based on the water level
- The finished system is then designed to maintain a near-constant tension on the mooring rodes through the full range of water level fluctuation
- Which means the moorings never have to be adjusted other than an occasional inspection and re-tensioning

- These systems have been deployed all over the world, including in reservoir lakes with 20' or more of fluctuation annually
- So they would certainly be able to accommodate even an extreme design for Great Lakes water level fluctuation

- There are a few drawbacks
    - The installation process is more complicated, takes longer, and usually requires divers
    - The biggest drawback is cost – each mooring line assembly, including the Seaflex unit and the rope, can easily cost over $2,500 USD
    - Calculate that over a whole marina system, versus the cost of a chain mooring system, and you can soon pay for a lot of chain adjustments

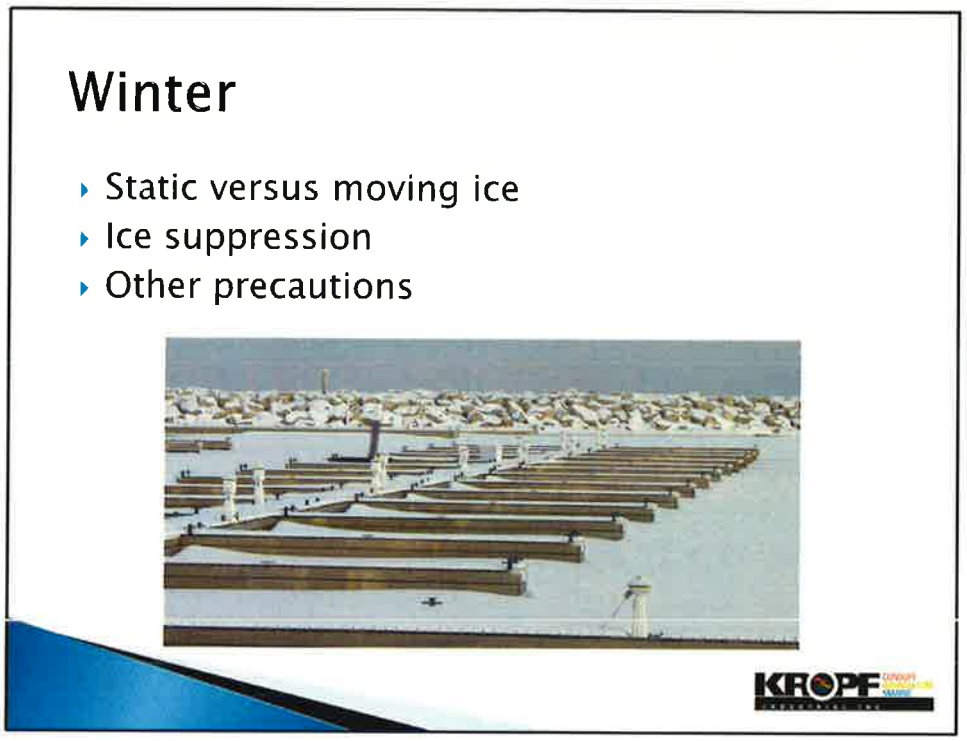


- Transformers and distribution panels can be installed either on shore or out on the floating docks themselves
- The layout of the electrical system is something that can be determined in consultation with the dock supplier, potentially an electrical engineer, and the electrician who will be installing the system
- And of course we also have to follow ESA guidelines

- One of the key considerations is the interface between your shorewall and the floating docks
- The utility runs need to have enough flexibility to allow for the shift from high to low water
- Usually this is done by using flexible cables at these points, having loops and slack in the lines, and using rollers and flexible hangars to support the utilities at these transitions

- Final consideration when routing utilities is to consider how the geometry and space available changes as the water levels change
- Visualize the impact of things like a change in the ramp angle at both the shorewall and the dock
- Also consider that depending on how your system is moored, it may also move horizontally at low water or in ice conditions
- If the docks get pushed 3' in towards shore, how does that impact your utility runs?
- The more these potential events are thought through during the design and installation, the less likely you are to sustain what could be very costly and time consuming damage

to your utilities and dock system



- For most of us winter brings increased storms and surge activity, and potentially either heavy ice or lots of pack ice
- Although no dock system, fixed or floating, will ever be entirely ice proof, well-designed floating systems can typically handle marina basin ice conditions without a lot of extra precautions or costs
- One of the keys is whether your ice is static, ie the basin freezes but the ice doesn't move
- Or whether you see a lot of moving ice, either due to current or storm surge activity
- The more static your ice is, the fewer precautions you will have to take

- One of the most frequent questions is whether you should be loosening your anchor chains for winter
- Provided you haven't seen an abnormal rise in water levels over the season, typically you don't have to
    - As long as the mooring system was properly designed with sufficient chain scope
    - The slack in the chains under their own weight provides enough flexibility for the system to move incrementally in the ice sheet
- The exception would be if your local conditions mean you're going to see significant water level rise while the system is still frozen in place
- The combination of increased tension on the chains combined with the movements of the ice sheet could cause problems, and might require you to loosen chains in the fall

- Depending on the ice conditions in your basin you may want to consider ice suppression

- This can be done using compressed air through perforated pipes or with impeller systems
- Often the aim is not to keep the entire basin ice free to but to provide relief zones or target certain areas to reduce the forces on the dock system

- Other precautions that can sometimes be taken
    - Slackening anchor chains, sometimes just in a few strategic locations
    - Disconnecting utilities might be worth considering, although this will typically mean bringing in an electrician twice a year
    - We have some customers in exposed locations that remove their access ramps

- Overall, just make sure you have the conversation with your dock supplier and your electrician and plumber about what winter conditions are like in your basin
- And what their recommendations would be as far as how to minimize the risk of damage to your dock system

Thank you - Q & A