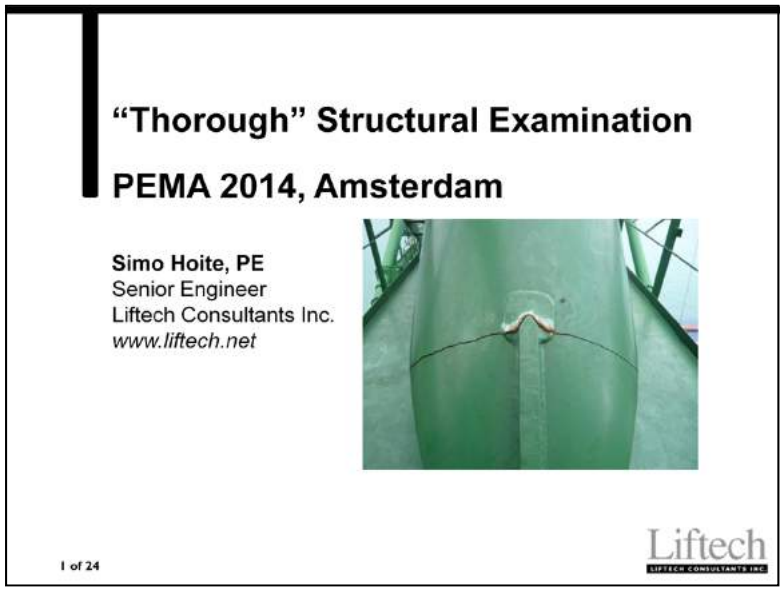
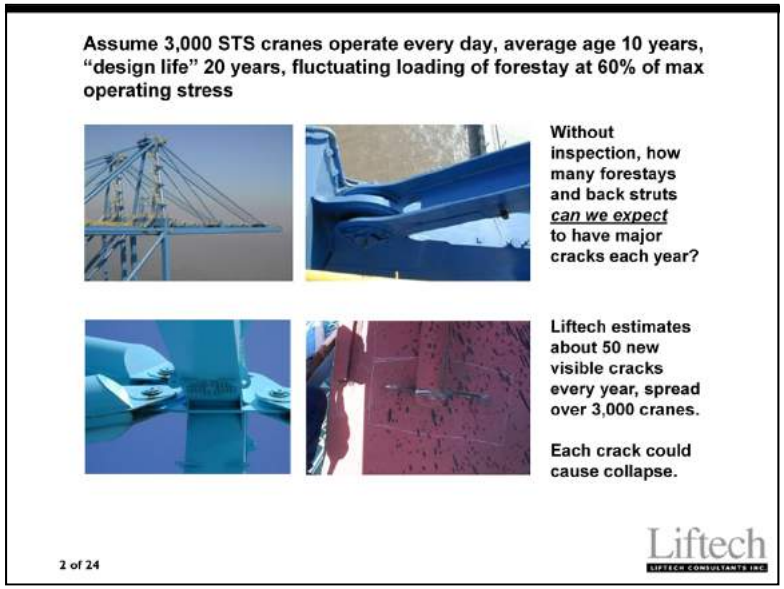


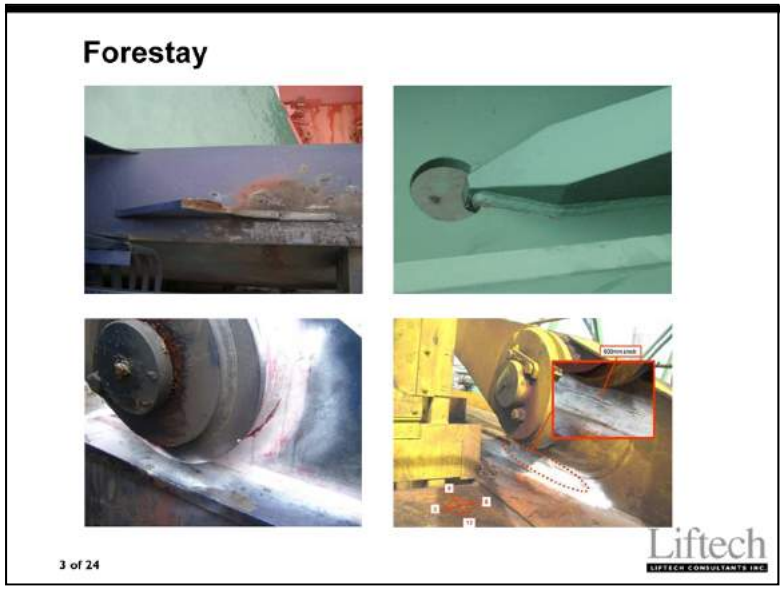
Liftech has been working with crane structures for over 50 years. A great deal of our effort has been concentrated on the design of structures that are resistant from damage due to cyclic loading, or fatigue.

Proper design and fabrication are only the initial steps in keeping cranes operating safely. The cranes must also be inspected. What are the guidelines that exist for these inspections? Can we add anything to these guidelines to make the operation of cranes safer?

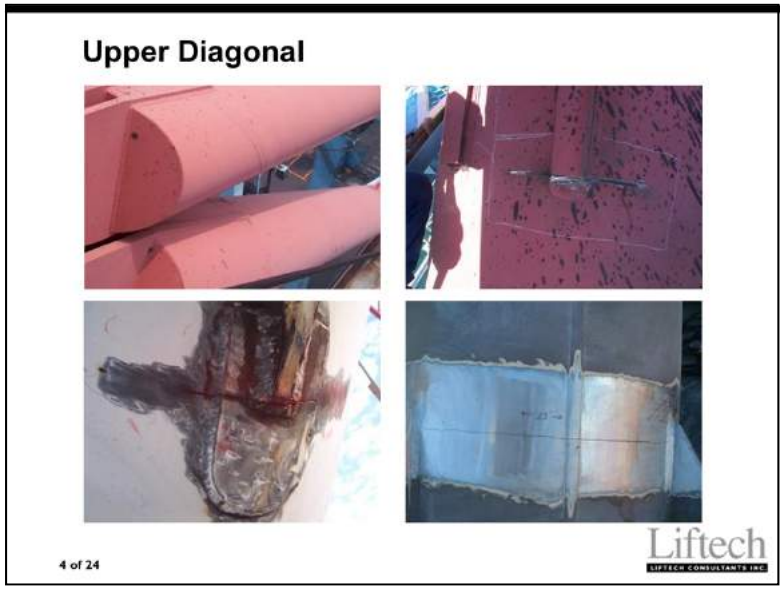


The forestay and upper diagonals on container cranes are perhaps the most critical members in the structures because their failure can result in dropping the boom, the trolley, and the load. We estimate there should be about 50 new visible cracks in these members every year, across the worldwide STS crane population of about 3,000 cranes. Any one of these cracks can lead to a catastrophic failure.

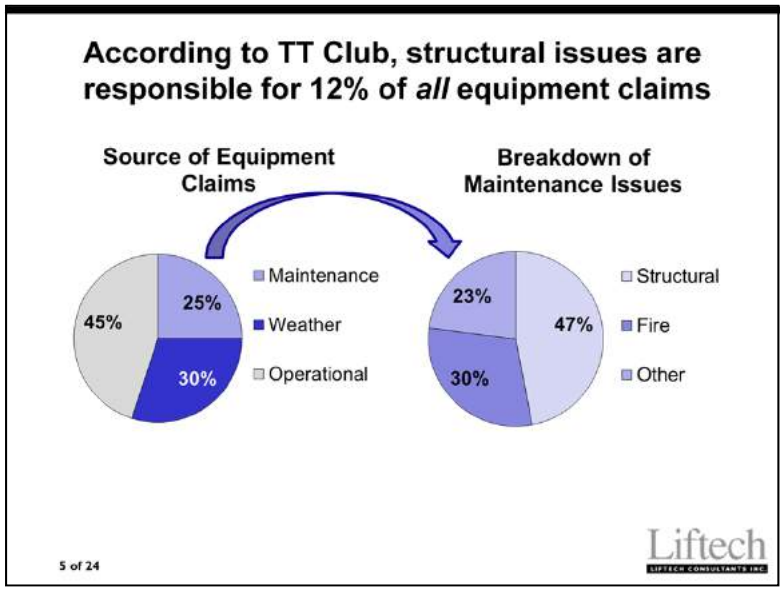
"Design life" is often a misnomer. The structural design life should establish a criterion for fatigue reliability, and is usually represented in terms of load cycles with a cubic average moving load. The assumption of a design life does not necessarily mean that the structure will no longer be fit for its purpose at the end of that period or that it will continue to be serviceable for that period without adequate and regular inspection and maintenance.



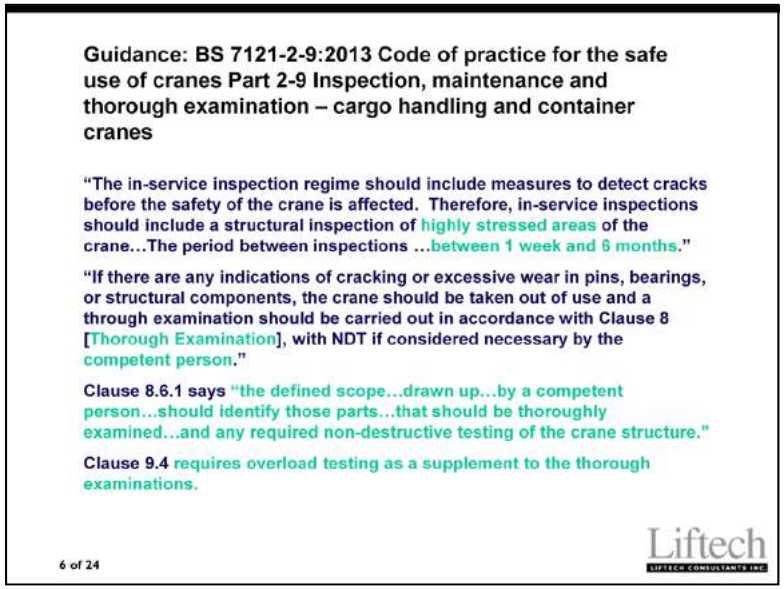
Here are some examples of cracks we have seen on forestays. In one case the member failed: first from the fatigue crack and then in yielding of the remaining section, seen on the upper left.



Here are some examples of cracks we have seen in the upper diagonal.



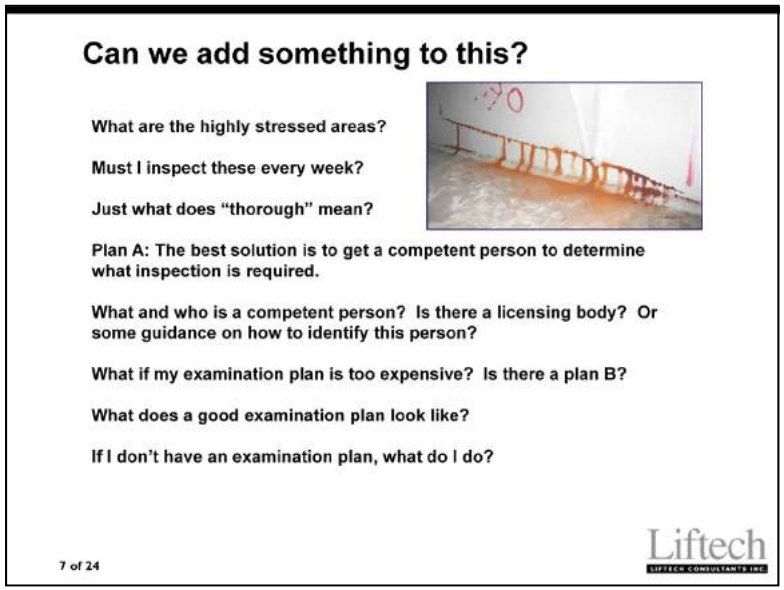
The slide shows data from TT Club from all types of equipment. What is remarkable is that of the maintenance related failures, 47% are due to structural issues.



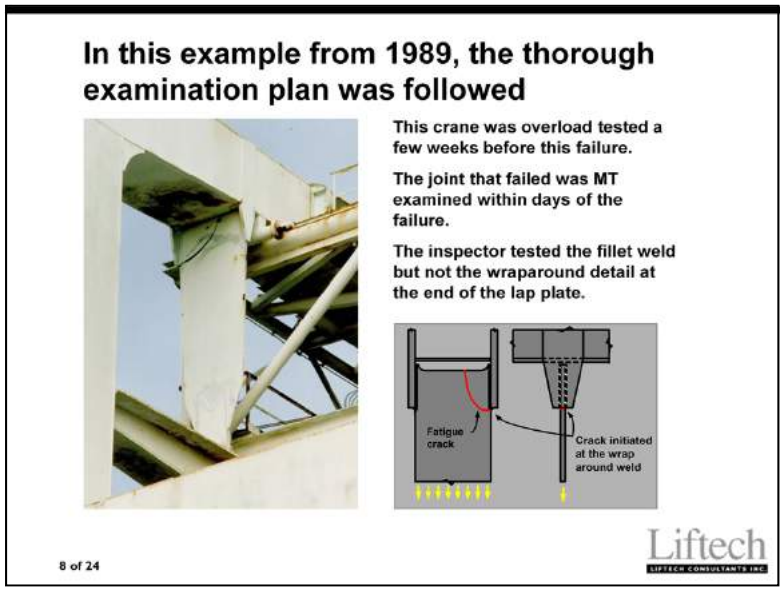
The BS 7121-2-9 standard gives excellent guidance on the overall maintenance of cranes. We have highlighted some statements about structural inspection.

This is a new British national standard with specific discussion about container cranes. There are also other standards on this subject.

The International Labor Organization Convention concerning Occupational Safety and Health in Dock Work (No. 152) says that cranes must be examined by a competent person every 12 months and must have a thorough examination every five years.



We think it is possible to provide some additional helpful guidance regarding structural inspection of cranes. We are talking about useful guidance for the owner or the user of the cranes, or most importantly, for the decision makers who set the maintenance and inspection budgets.



Here is an example where a structural inspection plan was followed, but because of incomplete understanding of some basic fatigue crack phenomena, a dangerous crack remained undetected.

Liftech's Opinion

Follow a Structural Examination Plan.

If you don't have a practical and satisfactory Structural Examination Plan from your crane maker, we recommend that you engage a competent party to develop an examination plan for your cranes. This plan will tell you where, how often, and by what methods to inspect your cranes, based on a rational analysis, to reduce your risk of dangerous failures to a reasonable minimum.

Short of that, you need to educate yourself. We think that PEMA can help you do this by publishing a document with practical guidance.

The following are some suggestions for what could be communicated in such a document.

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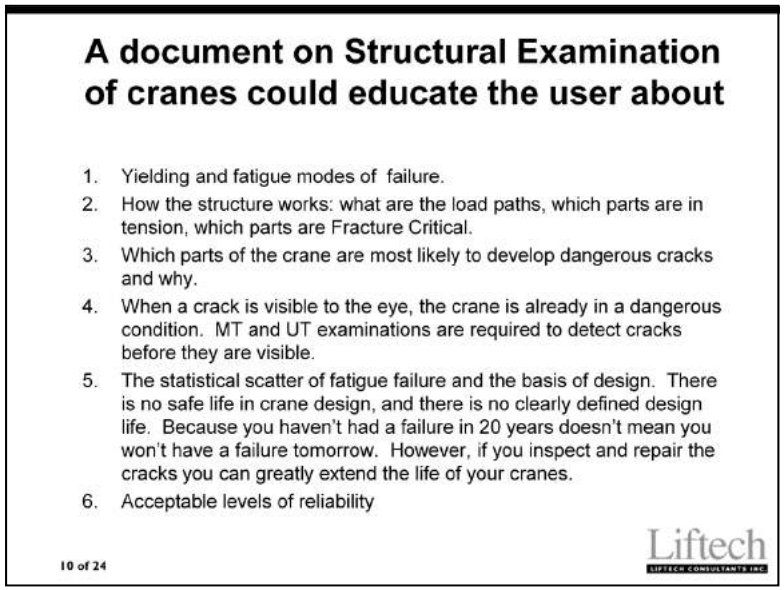
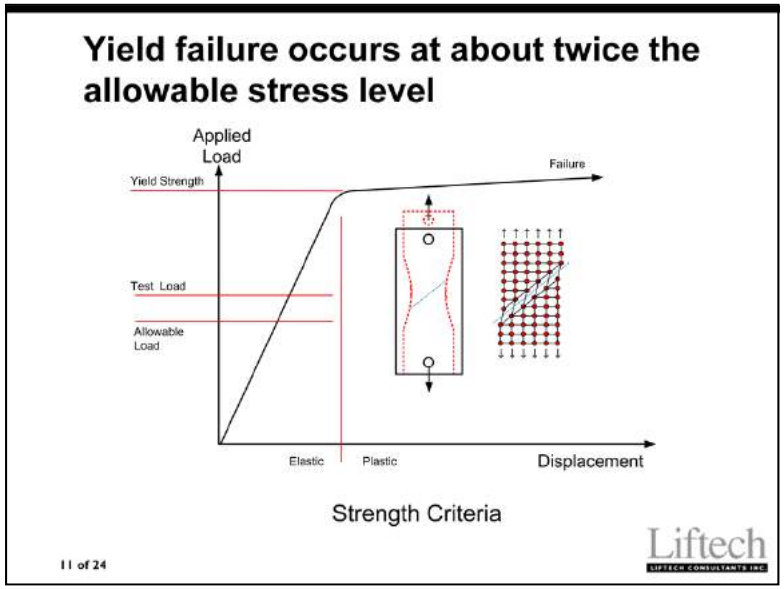
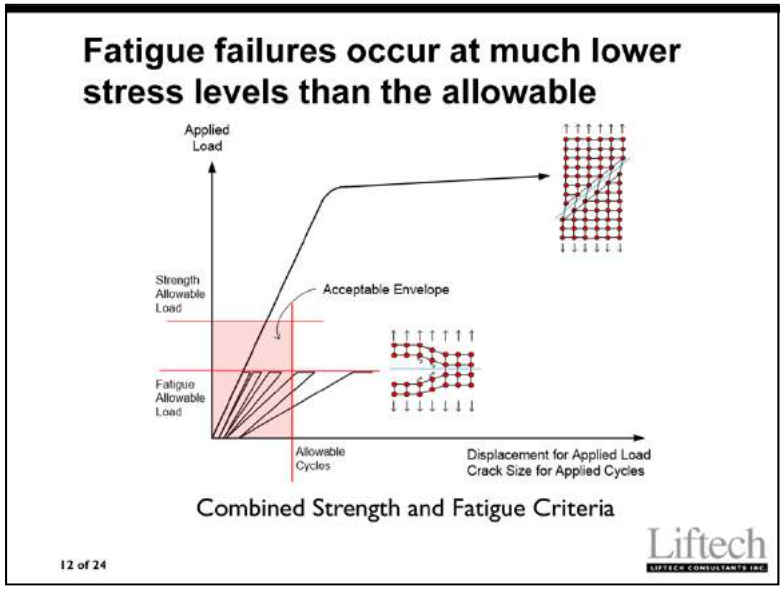


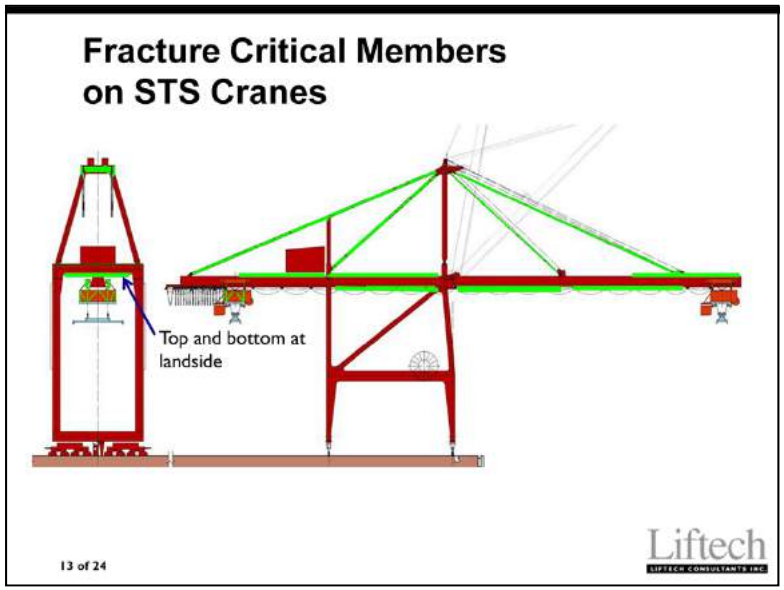
These are some suggestions for possible content for a supplementary document about Structural Examination. The following slides show some examples of content that might be incorporated into such a paper.



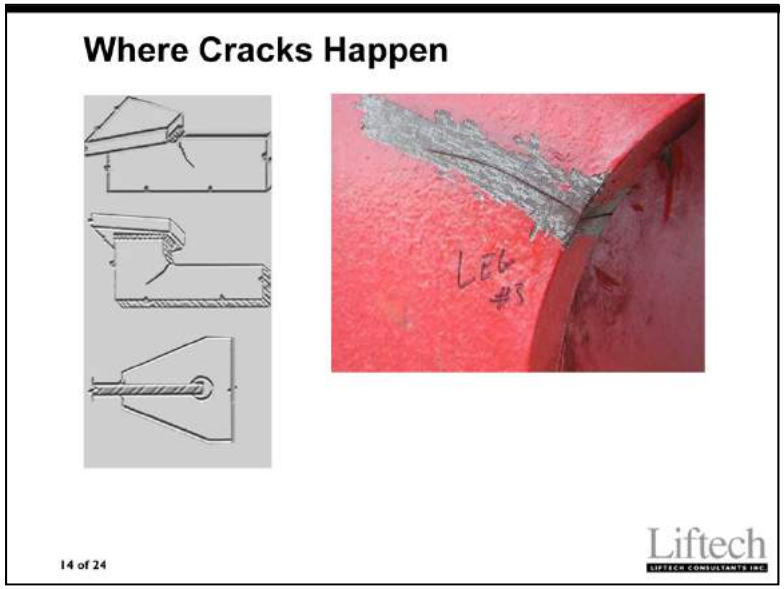
The user should understand the difference between yield failure and fatigue failure.



The physical phenomenon of fatigue failure is different from that of yield failure.



We can provide some general guidance about what members on the cranes are the most important to inspect.



We can educate the user about the sources of fatigue cracks and where they are likely to occur.

What is fatigue?

There are thousands of microscopic cracks in all welded structures. Metal fatigue is the phenomenon of growth of these cracks due to cyclic loading.

It is a progressive material failure.

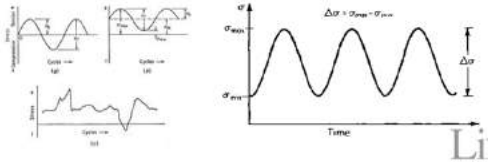
Final failure is sudden and can be catastrophic.

Cracks are difficult to see, but can be located by a specialized inspection.

Fatigue failure is primarily dependent on member stress range, local stress concentrations, and number of load cycles.

Allowable fatigue stress ranges are determined by testing, not by theory. This is because all welds are different, meaning they have different small cracks to start with and these cracks grow at different rates.

Because of these differences, no theory can define when fatigue failure will occur. Fatigue failure expectations are based on repeated testing of actual specimens.



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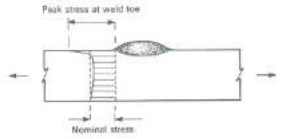
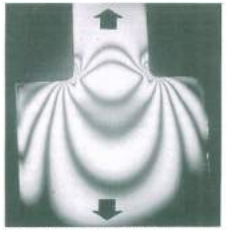
We won't go into detail here, but a number of phenomena related to fatigue loading and fatigue damage can be explained in plain language.

Stress concentrations from welding shrinkage or geometry cause fatigue cracks





14 Photoelastic fringe pattern indicating stress concentration at change in section under axial loading.

Source: S.J. Maddox, 1999

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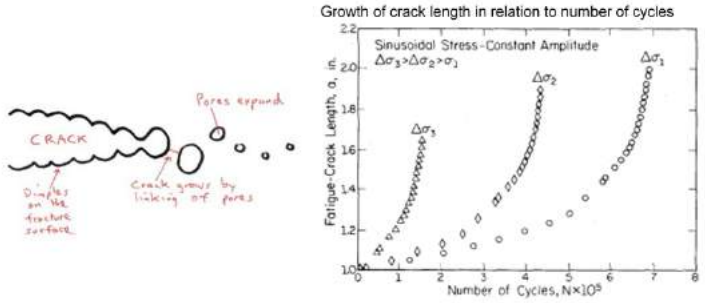
The sources of fatigue cracks is an important topic.

Cracks grow through repeated cycling of the load



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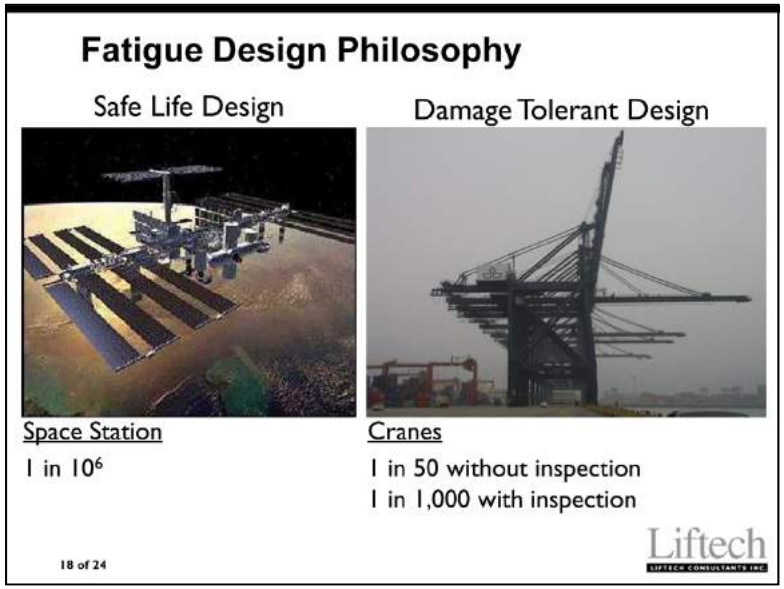
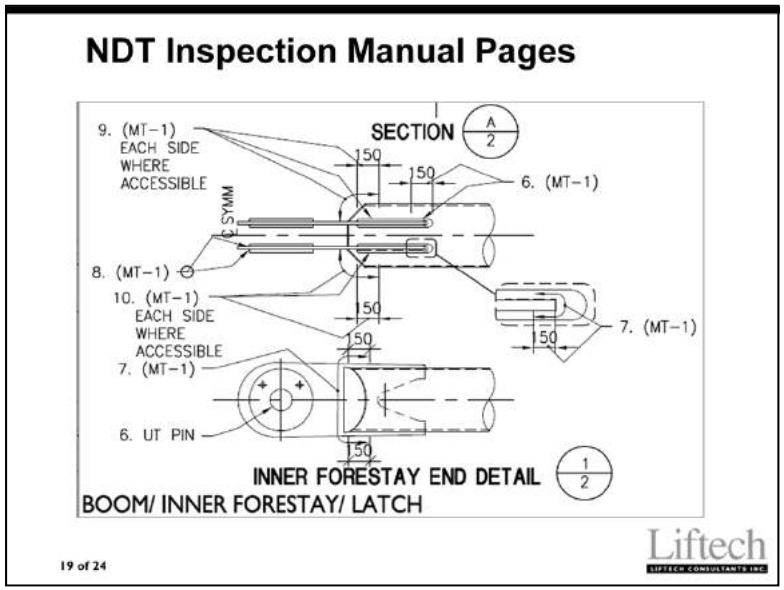
How cracks grow and eventually reach a critical state is an important topic.



It is important that the user understands the philosophy of fatigue design so he does not have a false sense of security about the reliability of his cranes.



We can present some simple examples of what a good inspection plan looks like and what it contains.

Inspection Intervals

NDT INSPECTION INTERVALS FOR CRANES 1 AND 2

Component	Inspection Location	FCM / NFCM	Inspection Intervals is the lesser of No. of Moves	Years
FRAME				
Trucks	F22	NFCM	960,000	12
Upper Diagonal	F3, F7	FCM	960,000	12
Landside Trolley Girder Hanger Connection	F12, B21 1 of 2	FCM	240,000	3
Waterside Trolley Girder Hanger Connection	F13,pp1-pp4 of B19	FCM	960,000	12
Trolley Girder and bracing beyond Landside Trolley Girder Support Beams, Panels 34-41	B18, B22, B23	FCM	960,000	12
Trolley Girder bottom flange between Legs, Panels 20-33	pp4 and pp5 of B23	FCM	240,000	3*
	pp4 and pp5 of B24			

Note: These intervals are not suitable for all cranes.

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We can say something about typical inspection intervals for different types of members.

This is a different topic, but we want to mention it when we are discussing the structural safety of cranes. PEMA might also present some guidance on avoiding this type of failure.

…and this type, which is often due to improper design of the crane-to-wharf tie-down connection.


Thank You
This presentation is available for download on our website:
www.liftech.net
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