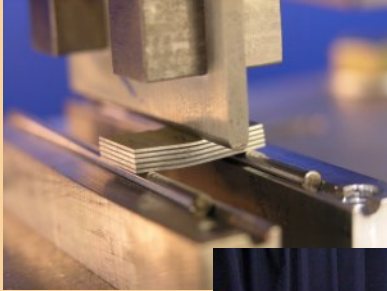


# The costs of Non Testing

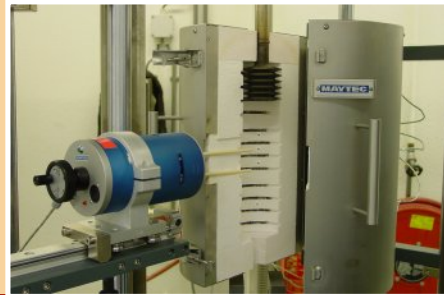
D. Gillissen  
Stork FDO



# Stork Materials Technology

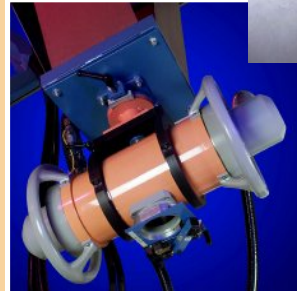


An operating company within  
the Stork Technical Services Group



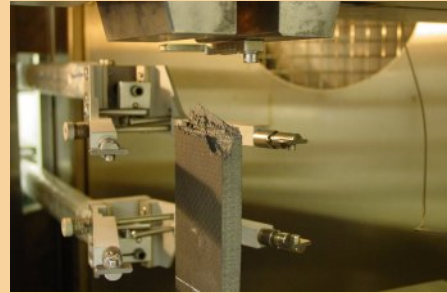
# Core activities

- Material testing
- Non destructive testing
- Calibration
- Consultancy



# Materials testing

- Mechanical testing (  $-80^{\circ}\text{C}$  to  $+900^{\circ}\text{C}$  )
- Bearing strength
- Poisson's ratio
- Tensile, peel and tear
- Bending fatigue
- Special tests



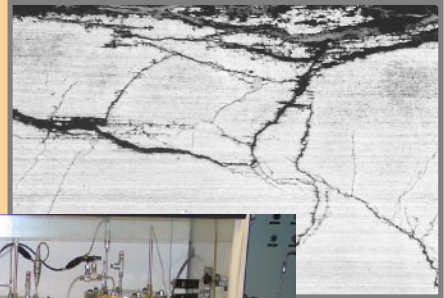
# Consultancy

- Applied mechanics
- Strain and stress measurements
- Failure calculations
- Vibration measurements
- Product testing and evaluations
- Sound measurements



# Consultancy

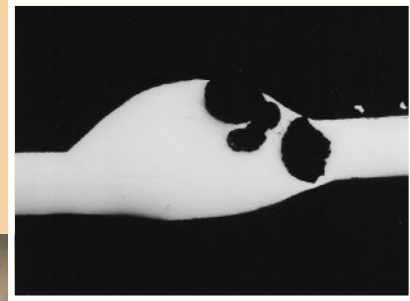
- Corrosion
- Exposition tests
- SSCC tests
- Corrosion potential measurements
- HIC tests
- Etc.



# Consultancy

Failure analyses

- Failure mechanism
- Failure cause
- Repair procedures
- Failure prevention



# Experiences of non testing and the consequences

- Testing after or during production
- Proven knowledge and changing of the environment
- Designing with stronger materials
- Lighter construction and the role of fatigue
- Upgrading of components
- Applying new techniques



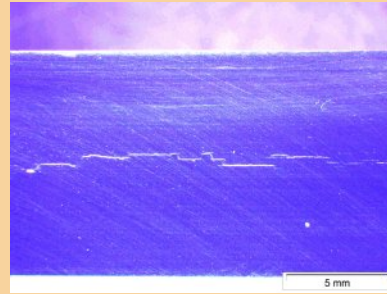
# Testing after production

- Industrial components short delivery times
- Test is frequently done during production
- The results are not according specification
- The manufacturer has a lot of cost and effort to repair the vessel and find back the confidence



# Example of a pressure vessel

- HIC test for Hydrogen induced cracking
- Test failed
- Vessel subjected to be rejected by the client



# Designing based on proven knowledge

- Swimming pools upgraded to leisure pools
- Trent higher temperatures in in the hall
- Higher level of chemicals for disinfection
- Frequently used materials are subjected to stress corrosion cracking
- Result



In 2001, the suspended ceiling of a municipal swimming pool collapsed. The reason was the catastrophic failure of stainless steel grade 304 fasteners, which had suffered stress corrosion cracking (SCC)



# Situation after incident



Ruimte voor uw  
eigen logo!

***ENVIRONMENTAL TESTING OF THE FUTURE***



[WWW.PLOT.NL](http://WWW.PLOT.NL)

# Microscopic examination

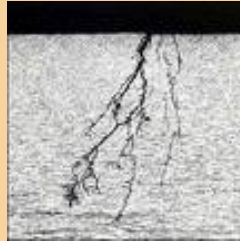
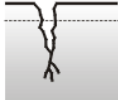
A. SCC or Fatigue Cracks  
nudeate at pits



B. SCC Cracks are  
highly branched



C. Corrosion  
fatigue cracks  
have little  
branching



# Actions and costs

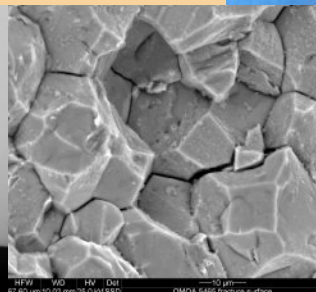
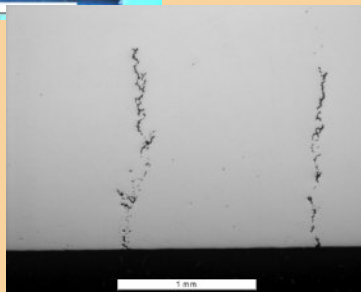
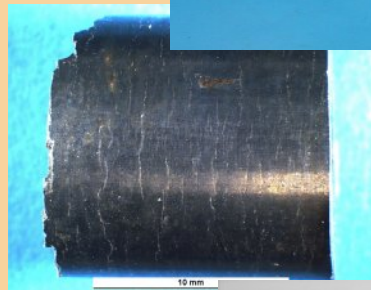
- Inspection of at least 30 swimming pools with the same construction
- Later on more swimming pools were inspected
- Most of the ceiling have to be replaced
- New design criteria had to be made



# Designing with stronger materials

- Tension bar in gas handling equipment
- Tension shall be increased to ensure stiffness
- Material with higher tensile strength
- Result failure during test
- Failure analyses shows hydrogen induced cracking from a corrosion process





# Lesson

- High cost for the failure of a very expensive piece of equipment
- Material is not suitable for this application
- Searching for new material
- If no material is available design shall be changed
- Test program for the new selected material



# Lighter constructions

- Aluminum is one of the favorable materials to decrease weight
- Lighter construction lower forces
- Fatigue strength is lower
- Some processes reduces fatigue



# Example

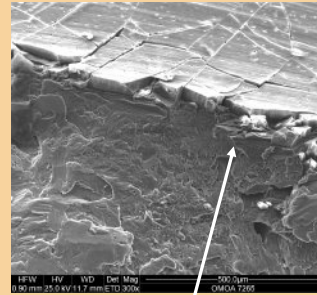
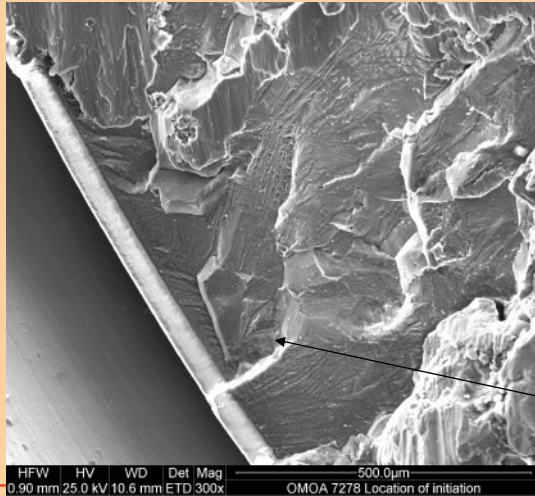
- Support roll
- Material changed into aluminum
- To improve wear resistance a hard anodizing coating was applied
- Fracture in short time notice



Location of fracture



# Examination Scanning Electron Microscope



Initiation point

# Failure cause

- Cracks in the hard anodized layer
- Reduction of fatigue strength especially by high strength aluminum after hard anodizing



# Effects of anodizing on fatigue strength

Alloy	Fatigue strength at E10-6 cycles	
	Not anodized	Anodized
	MPa	MPA
2024	130	105
6061	105	40
7075	150	60



# Lessons

- Although extensive calculations failure
- Hard anodizing caused a lower fatigue strength as expected
- Testing should have tracked this abnormality
- All produced and built in supports shall be replaced

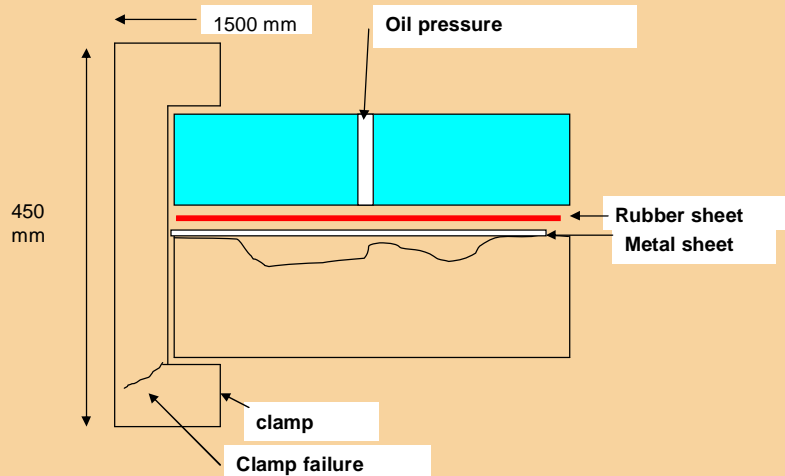


# Upgrading of components

- Upgrading of machinery requires thicker materials
- Three axial stress conditions can play a role
- These stress conditions are difficult to establish even with Finite elements



# Example Fluid Forming Press



# History of the clamp rings

- First statically calculated two halves
- Failure in two weeks
- Design adapted according finite element analyses
- Key hole design
- Lifetime 3 months



# New design

- Clamp ring built in segments
- Three axial forces are lower
- Lifetime over 10 years

