

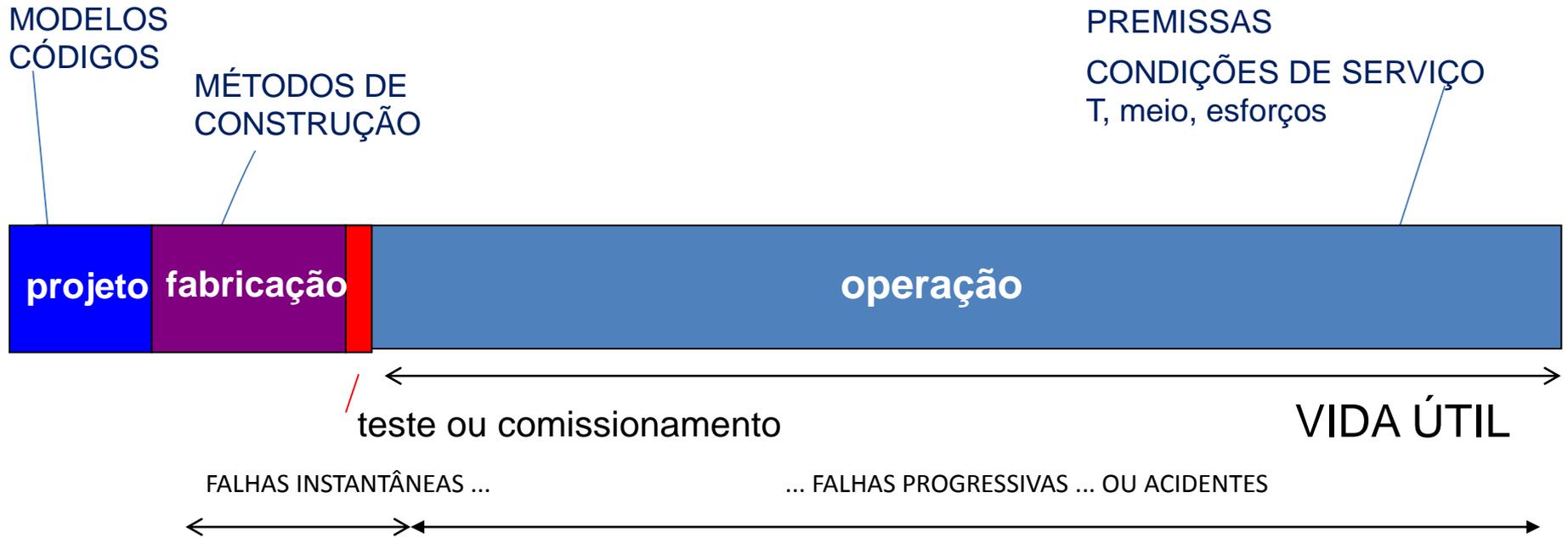
The background of the slide is a grayscale scanning electron microscope (SEM) micrograph of a metal fracture surface. The image shows a complex, porous, and fibrous structure, characteristic of a ductile fracture process. The surface is highly textured with various sized particles and interconnected fibers, creating a rough, irregular appearance. The lighting highlights the three-dimensional nature of the fracture, with some areas appearing more prominent than others.

MATERIALS LIFE: UMA FERRAMENTA PARA A ANÁLISE METALÚRGICA DE FALHAS

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Uma FALHA em um equipamento, estrutura, componente, tubulação, é **um NÃO ATENDIMENTO A UM REQUISITO** de utilização.

Um vazamento em uma válvula, um processo corrosivo em uma tubulação, o desgaste em uma engrenagem, o trincamento de uma estrutura, o rompimento de uma mola, ...

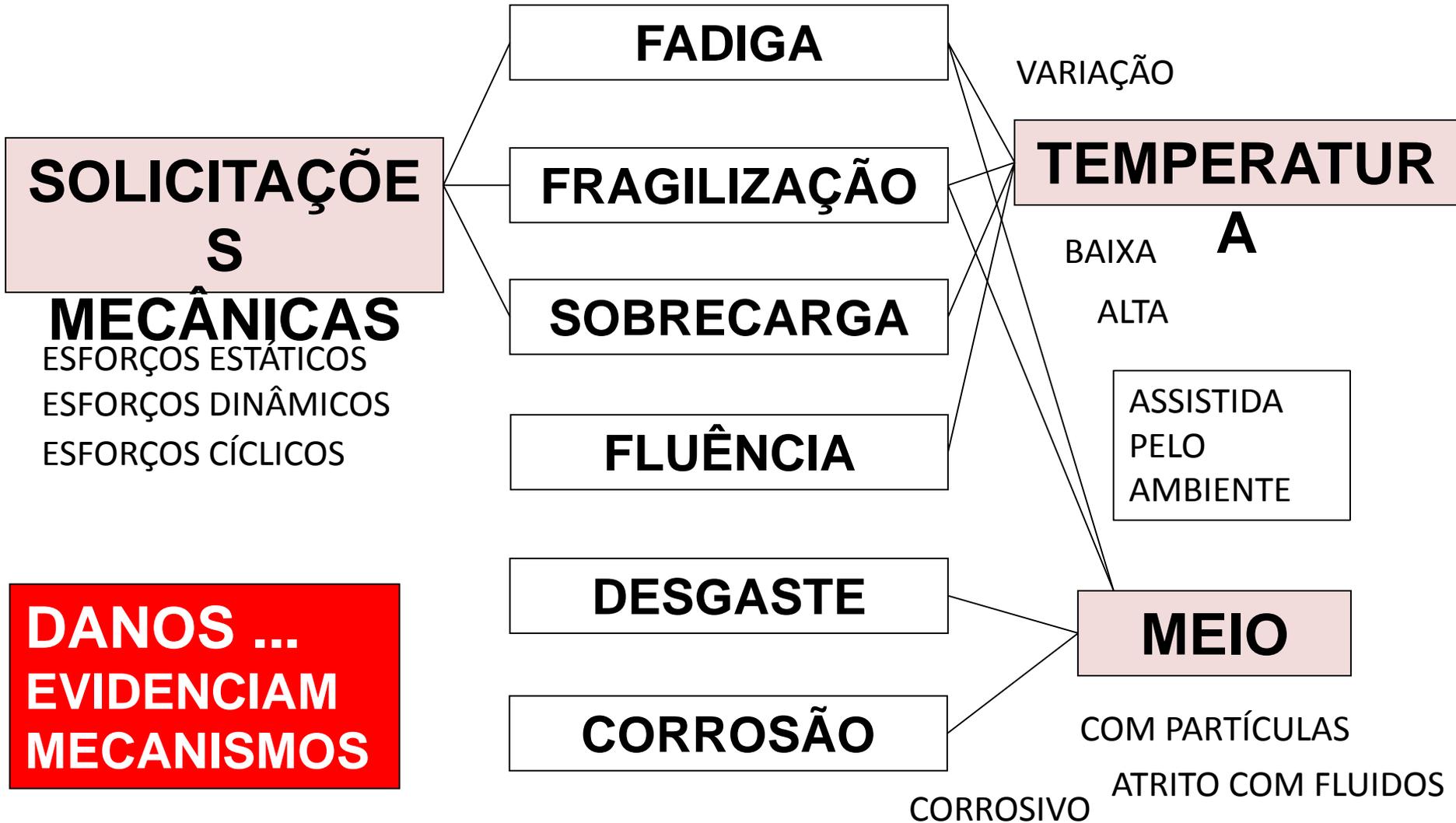


MOMENTO DA FALHA (o equipamento precisa resistir toda a sua vida útil

MECÂNISMO DE FALHA ... ← **ANÁLISE METALÚRGICA DE FALHAS**

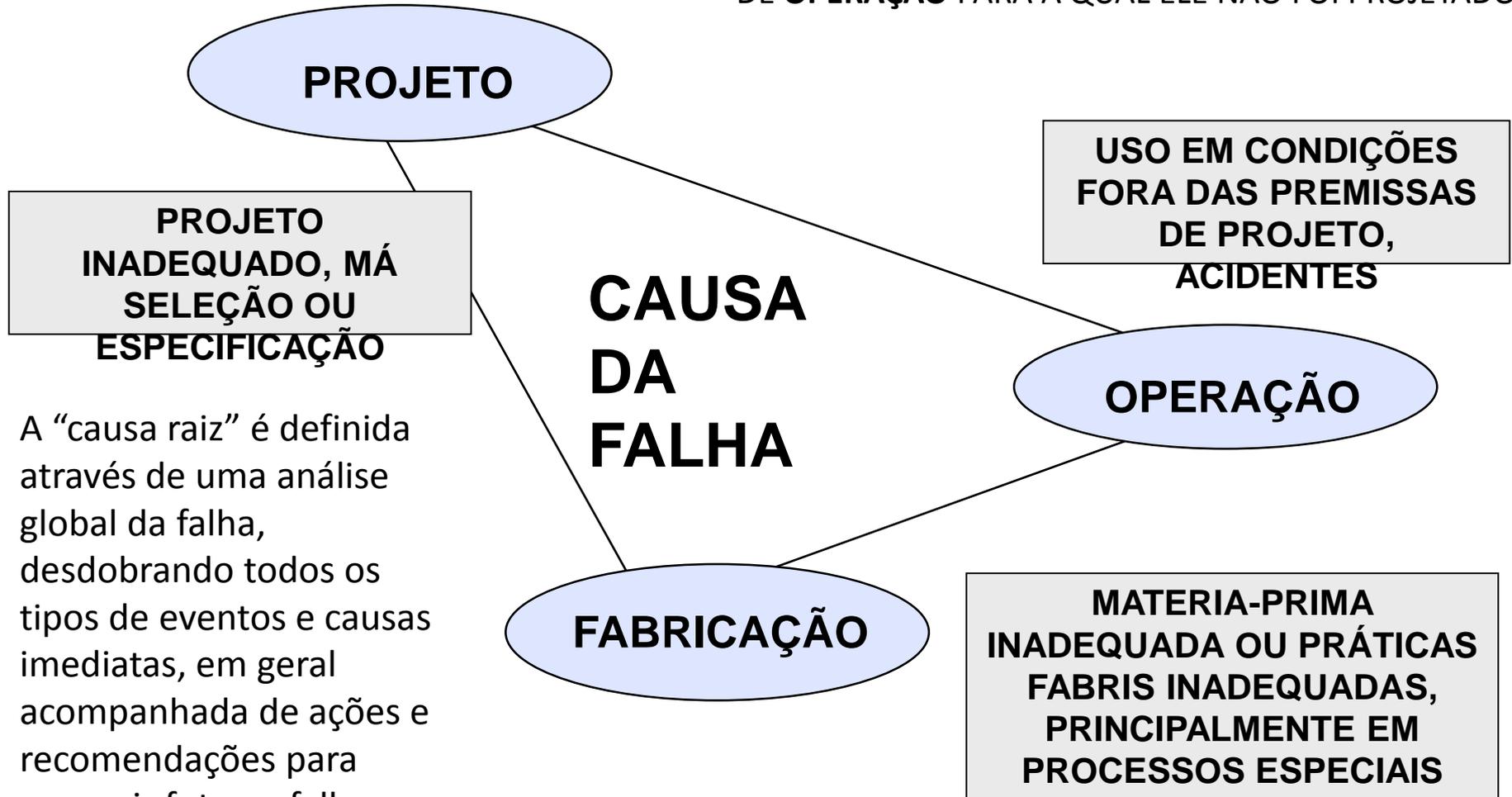
CAUSA DA FALHA ... QUAIS OS FATORES CONTRIBUÍRAM PARA QUE OCORRESSE?
EM QUE CONDIÇÕES SIMILARES (ATUAIS) ELA (AINDA) PODE ACONTECER?
DE QUE FORMA SEUS EFEITOS PODEM SER ELIMINADOS OU MINIMIZADOS?

MECANISMOS DE FALHA



COMO A VISÃO METALÚRGICA APOIA A ANÁLISE DE FALHAS ?

POR QUÊ O MATERIAL NÃO SE COMPORTOU COMO SERIA ESPERADO?
QUAL FOI A CONDIÇÃO QUE O LEVOU A EXCEDER SUA CAPACIDADE?
UMA **SELEÇÃO** INADEQUADA DO MATERIAL PARA A APLICAÇÃO?
UMA **FABRICAÇÃO** INADEQUADA?
UM **TESTE** MAL FEITO?
OU SE FOI IMPOSTA UMA CONDIÇÃO DE **OPERAÇÃO** PARA A QUAL ELE NÃO FOI PROJETADO?



A “causa raiz” é definida através de uma análise global da falha, desdobrando todos os tipos de eventos e causas imediatas, em geral acompanhada de ações e recomendações para prevenir futuras falhas.

CARACTERIZAÇÃO DOS MATERIAIS

1. O QUE É O MATERIAL ?

Ensaio e análises POSSÍVEIS. Análise microestrutural. Análise química e durezas. Ensaio de tração e Charpy V. Ensaio de corrosão.

FÁCIL EXECUÇÃO

2. O QUE DEVERIA SER O MATERIAL PARA ATENDER AOS REQUISITOS ?
Especificação . Tem ?

3. O MATERIAL É O QUE DEVERIA SER ?
Comparativo.

CARACTERIZAÇÃO DOS DANOS

1. QUAL FOI O DANO ?

Análise de informações, visual, MEV, análise microestrutural. Deformou ? rompeu ? trincou ? corroeu ? desgastou ?

2. QUAL A PROPRIEDADE FOI EXIGIDA MAS O MATERIAL NÃO TINHA ?

A DEFINIÇÃO DOS ENSAIOS EXIGE QUALIFICAÇÃO

A INTERPRETAÇÃO EXIGE QUALIFICAÇÃO

RESULTADOS OBJETIVOS

INTERPRETAÇÃO

AVALIAÇÃO

- A – PORQUE O MATERIAL NÃO É O QUE DEVERIA SER ?
B – SE O MATERIAL É O QUE DEVERIA SER (PELA ESPECIFICAÇÃO) PORQUE NÃO APRESENTOU A PROPRIEDADE QUE FOI EXIGIDA ?
C – O MATERIAL É ADEQUADO À APLICAÇÃO ?

ANÁLISE METALÚRGICA DE FALHA

Crowdfunding com ideia em outubro 2016
Lançamento do site na internet em janeiro 2017
Lançamento para associação em janeiro 2018
Retorno à condição gratuita e procura por patrocínio em abril 2018...

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MATERIALS
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Search by keywords

COMBINE YOUR SEARCH

M  <input checked="" type="checkbox"/> MATERIAL	P  <input checked="" type="checkbox"/> PRODUCT	Ap  <input checked="" type="checkbox"/> APPLICATION
C  <input checked="" type="checkbox"/> CONDITION	Cm  <input checked="" type="checkbox"/> CAPTURE METHOD	Df  <input checked="" type="checkbox"/> DETAIL FOCUS

ML00071 - Nov.2017

donated by:

Reheating Cracking of a CrMo Vessel Weld

M - CrMo Steel **P** - In Field Weld **Ap** - Energy **Cd** - Welding Defect



1 **Cm** - Aspect by NDT **Df** - Cracks

187

Image of the magnetic particle test, using a white contrast, presenting the cracks at the surface of the weld metal. The cracks are transverse to the weld and do not propagate into the base metals. A forged T in the

M

Material	ASTM A 234 WPB12 CL2
CrMo Steel	ASTM A 335 grade P12

C

Chemistry (% in weight)

Weld Metal Analysis

0.085C; 0.33Si; 0.91Mn; 0.028P; 0.013S; 1.07Cr;
0.08Ni; 0.53Mo; 0.02Cu; 0.023V.

Ap

Application

High Temperature (500°C), High Pressure (100bar)

- Energy

P

Product

- Forged T
- In Field Weld

ND 28", Thickness 2"

Pr

Properties

Forged T Hardness

☉ 180 HB

Tube Hardness

☉ 167 HB

Cracked Weld Metal Hardness

☉ 272 HB

Mc

Microstructure

Weld Metal

- Ferritic Bainitic

PROCURA DE CASES POR:

Search by keywords

COMBINE YOUR SEARCH

M

MATERIAL

- Combinations
- Ferrous Alloys**
- Non Ferrous Alloys

MATERIAL

- Carbon Steel
- Cast Iron
- High Alloy Steel
- Low Alloy Steel**

- CMn Steel
- CrMo Steel
- High Strength Low Alloy
- Low Alloy Low Carbon QT
- Low Alloy Medium Carbon QT
- Low Alloy for Thermochemical Treatment
- Microalloyed Steel

X

M

P

Ap

C

Cm

Df

P

PRODUCT

- Finished Product
- Raw Material**
- Welded Joint

PRODUTO

- Heat Treated Part
- Machined Part
- Pipe**
- Plate
- Rod
- Rolled Bar
- Rolled Plate
- Rolled Shape
- Sheet
- Tube

- Centrifugally Cast Pipe
- Longitudinal Seam Welded Pipe
- Seamless Pipe

C

CONDITION

- Damage
- Sound
- Used
- WPS

CONDIÇÃO

- Brittle Behavior
- Corrosion
- Ductile Behavior
- Fabrication Defect
- Fatigue**
- High Temperature
- Hydrogen
- Wear

- Mechanical Fatigue
- Thermal Fatigue
- Vibration Induced Fatigue

Ap

APPLICATION

- Acqueduct
- Automotive
- Boiler
- Chemical Industry
- Energy
- Engine
- FPSO
- Gas Turbine

APLICAÇÃO

PROCURA DE FOTOS POR:

Cm 	<input checked="" type="checkbox"/>
CAPTURE.METHOD	
 Aspect Before Analysis	
 Aspect by NDT	
 Identification drawing	
 Naked Eye or Stereoscope >	
 Optical Microscope >	
 Replication Technique >	
 Scanning Electron Microscope >	

 Electrolytic Etch Micrography by SEM
 Fractography by SEM
 Kalling Etched Micrography by SEM
 Micrography by SEM
 Nital Etched Micrography by SEM
 Surface Aspect by SEM

MÉTODO DE CAPTURA

Df 	<input checked="" type="checkbox"/>
DETAIL.FOCUS	
 Damage >	
 Microstructure >	
 Sampling and Analysis >	
 Soundness >	
 Welding Defect >	

 Ferrite
 Ferrite and Austenite
 Ferrite and Bainite
 Ferrite and Pearlite
 Ferritic Weld Metal
 Free Carbides in Pearlite Colonies
 Fusion Line
 Grain refined structure
 Granular structure
 Graphite Type A (ASTM A247)

DETALHE EM FOCO

MATERIALS — .LIFE

Search by keywords



COMBINE YOUR SEARCH

Df	<input checked="" type="checkbox"/>	Interconnected Cracks
DETAIL.FOCUS		Intergranular Corrosion
Damage >		Intergranular Cracking
Microstructure >		Intergranular Fracture
Sampling and Analysis >		Lap
Soundness >		Layer Detachment
Welding Defect >		Leakage
		Localized Corrosion
		Localized Thinning
		Margin of the Weld Crack

Seleção pela categoria desejada do detalhe em foco ...

- X
- M
- P
- Ap
- C
- Cm
- Df**



ML00009 / Sep.2017

Hydrogen Cracking of a 5" Drill Pipe S135

M - Low Alloy Medium Carbon QT
P - Drill Pipe
Ap - Subsea
Cd - Hydrogen Embrittlement

Cm - Fractography by SEM
Df - Intergranular Cracking

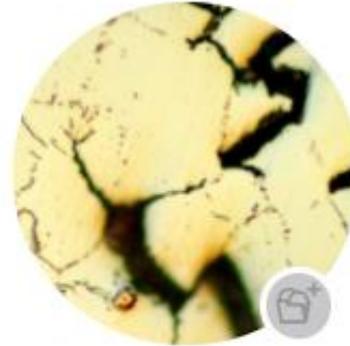


ML00042 / Apr.2017

Gas Turbine Blade IN 939, Coated

M - NiCrCo Alloy
P - Cast
Ap - Gas Turbine
Cd - Intergranular Cracking

Cm - H2SO4+HNO3+H3PO4 Etched Micro
Df - Intergranular Cracking



ML00075 / Dec.2017

Hydrogen Cracking of IN 718 Subsea Fasteners

M - NiCrFe Alloy
P - Bolt
Ap - Subsea
Cd - Hydrogen Embrittlement

Cm - Kalling Etched Micrography by OM
Df - Intergranular Cracking



ML00127 / Mar.2018

Hydrogen Cracks of Cadmium Plated Studs

M - Low Alloy Medium Carbon QT
P - Allen Stud
Ap - Oil and Gas
Cd - Hydrogen Embrittlement

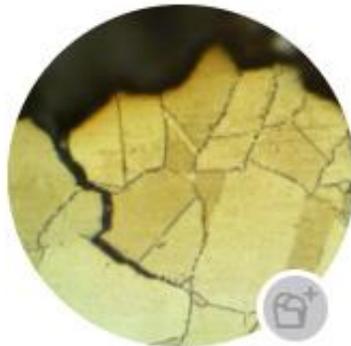
Cm - Fractography by SEM
Df - Intergranular Cracking



ML00011 / Oct.2017

Intergranular SCC of Pure Nickel

M - Unalloyed Nickel



ML00078 / Jun.2017

Hydrogen Cracking of IN 718 Subsea Connector



ML00079 / Jul.2017

Hydrogen Cracking of a Maritime Chain Link

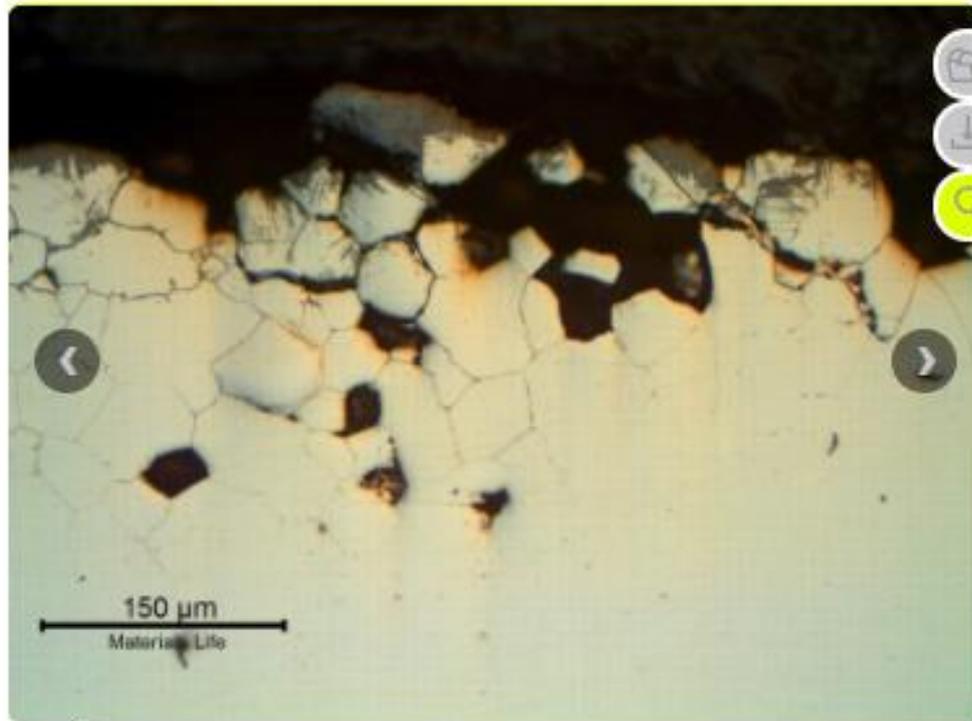


ML00015 / Oct.2017

Intergranular Corrosion of 304SS Plate

Intergranular Corrosion of 304SS Plate

[M - Austenitic Stainless Steel](#) [P - Rolled Plate](#) [Ap - Refinery](#) [Cd - Intergranular Corrosion](#)



1 [Cm - Micrograph by DM](#) [Df - Intergranular Corrosion](#)

The micrograph of the transverse section of the plate, as polished, close to the surface. The material presents intergranular corrosion and some grains were lost.

Legenda em cada foto

Outras imagens associadas

M

Material

Austenitic Stainless Steel

UN 8 E30400
A 3TM A 240 TP 304

Especificação do material

C

Chemistry (% In weight)

Product Analytic

0.05C; 0.50Si; 1.75Mn; 0.027P; 0.007S; 18.03Cr; 8.18Ni; 0.25Mo; 0.36Cu.

Análise química

Ap

Application

High Temperature Duct Plate

- Waste Heat Recovery Unit
- Refinery

P

Product

- Rolled Plate Thickness 1/4"

Aplicação
Produto

Pr

Properties

Surface Hardness

84 HRB

Mc

Microstructure

Sensitized Plate

- Grain Boundary Carbide Precipitation
- Austenitic

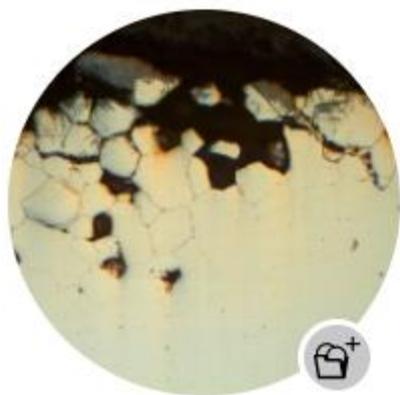
Propriedades
Microestrutura

Obs

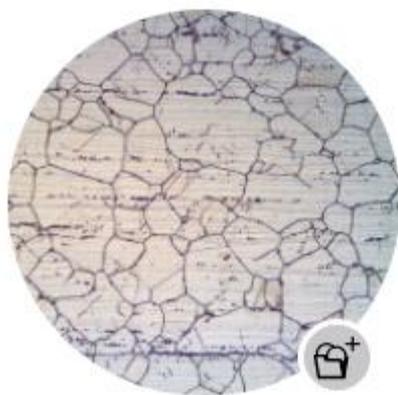
The WHRU duct was operating at 485°C and after several years in service the plate material presented local damage and a repair welding was conducted. During repair, several cracks appear adjacent to the weld. The metallurgical investigation indicated that the plate has been sensitized during service and suffered intergranular corrosion in several locations along the surface. The stresses imposed by the repair welding in these embrittled regions (with intergranular corrosion) opened the cracks.

Histórico

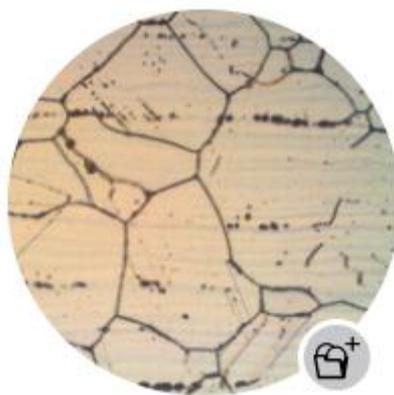
Associated Images



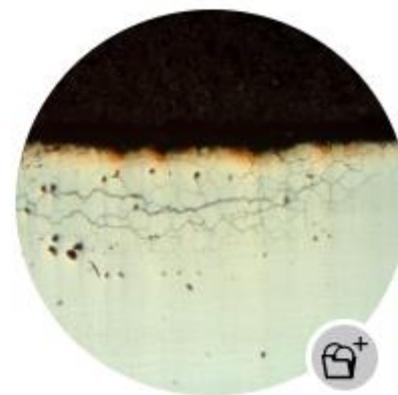
Cm - Micrography by OM
Df - Intergranular Corrosion



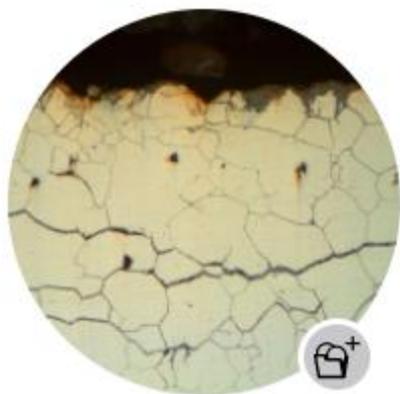
Cm - Micrography by OM using A262 Method A
Df - Intergranular Precipitation



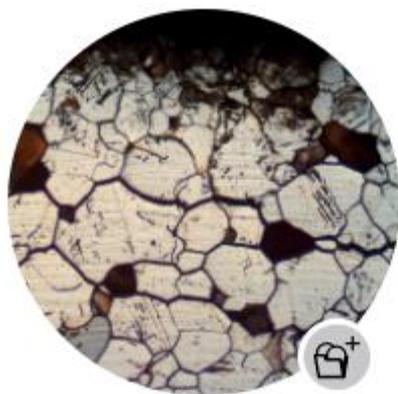
Cm - Micrography by OM using A262 Method A
Df - Intergranular Precipitation



Cm - Micrography by OM
Df - Intergranular Corrosion



Cm - Micrography by OM
Df - Intergranular Corrosion



Cm - Micrography by OM using A262 Method A
Df - Intergranular Corrosion



Cm - Aspect by NDT
Df - At the Surface



Cm - Micrography by OM using A262 Method A
Df - Intergranular Cracking



☰
most recent



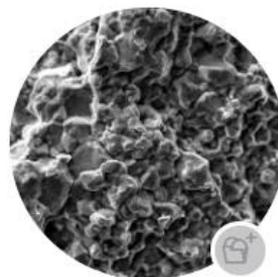
ML00128 / Apr.2018

MIC of a Stored Hydraulic Cylinder



ML00127 / Mar.2018

Hydrogen Cracks of Cadmium Plated Studs



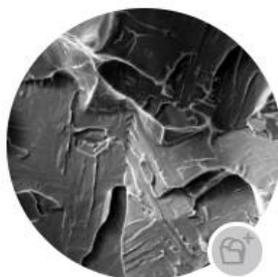
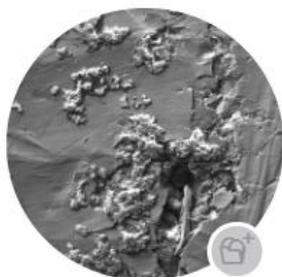
ML00126 / Mar.2018

Hydrogen Fracture of Subsea Allen Bolts



ML00125 / Mar.2018

Dezincification of a Cooler Tubesheet



Vitrine na home

Vitrine na home



ML00118 / Jan.2018

Non qualified GMAW of Aluminum Plates



ML00112 / Dec.2017

1" XXS Pipe Not Qualified For Low Temp



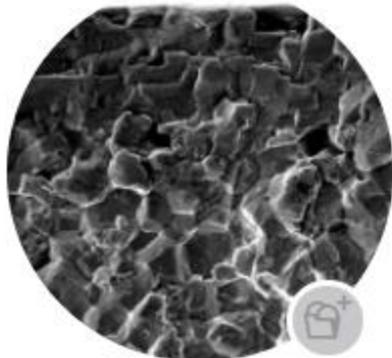
ML00107 / Dec.2017

Carburized 9Cr1MoV Superheater Tube



ML00104 / Dec.2017

Thermal Fatigue of a Boiler Tube



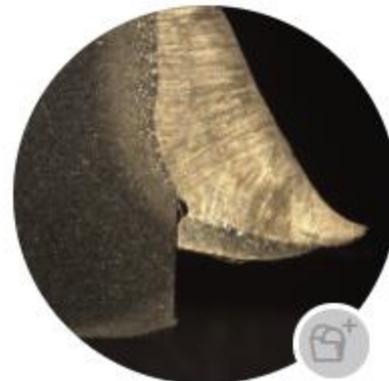
ML00081 / Aug.2017

Hydrogen Cracking of a Chromium Plated Carburized Pin



ML00059 / Feb.2018

Intergranular Corrosion of Aluminum Piping



ML00052 / Apr.2017

Cold Cracks in API 5CT L80 Tube Welded to a Structural Part



ML00010 / Oct.2017

Cold Cracks in a Gouged Weld Metal

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- [ML00127 Hydrogen Cracks of Cadmium Plated Studs - 16 images](#)
- [ML00126 Hydrogen Fracture of Subsea Allen Bolts - 15 images](#)
- [ML00125 Dezincification of a Cooler Tubesheet - 19 images](#)
- [ML00124 MIC of a Martensitic Valve Ring - 17 images](#)
- [ML00123 Non Qualified Superduplex for Subsea - 9 images](#)
- [ML00122 Crevice Corrosion in a Subsea System - 17 images](#)
- [ML00121 Pitting Corrosion in a Subsea System - 20 images](#)
- [ML00120 Ductile Rupture of a Carbon Steel Eye Bolt - 11 images](#)
- [ML00119 Thermal Fatigue of a Marine Boiler - 22 images](#)
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- [ML00115 CMn Steel Structural Tubing 5 mm thick - 5 images](#)
- [ML00114 CMn Steel Structural Tubing 8 mm thick - 5 images](#)
- [ML00113 Autogenous Weld of a Carbon Steel Wire - 10 images](#)
- [ML00112 1" XXS Pipe Not Qualified For Low Temp - 8 images](#)
- [ML00111 3/4" XXS Pipe Not Qualified for Low Temp - 8 images](#)
- [ML00110 Non Conformance in Spray and Fuse Pin - 12 images](#)
- [ML00109 Thermal Spray and Fuse Layer in Forged Pin - 9 images](#)
- [ML00108 Thermal Spray Layer in a Pinion Shaft - 13 images](#)

The background of the image is a scanning electron micrograph (SEM) showing a complex, porous, and cracked surface structure. The material appears to have a cellular or honeycomb-like morphology with irregular, interconnected cells and a network of fine cracks. The overall texture is rough and highly detailed.

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