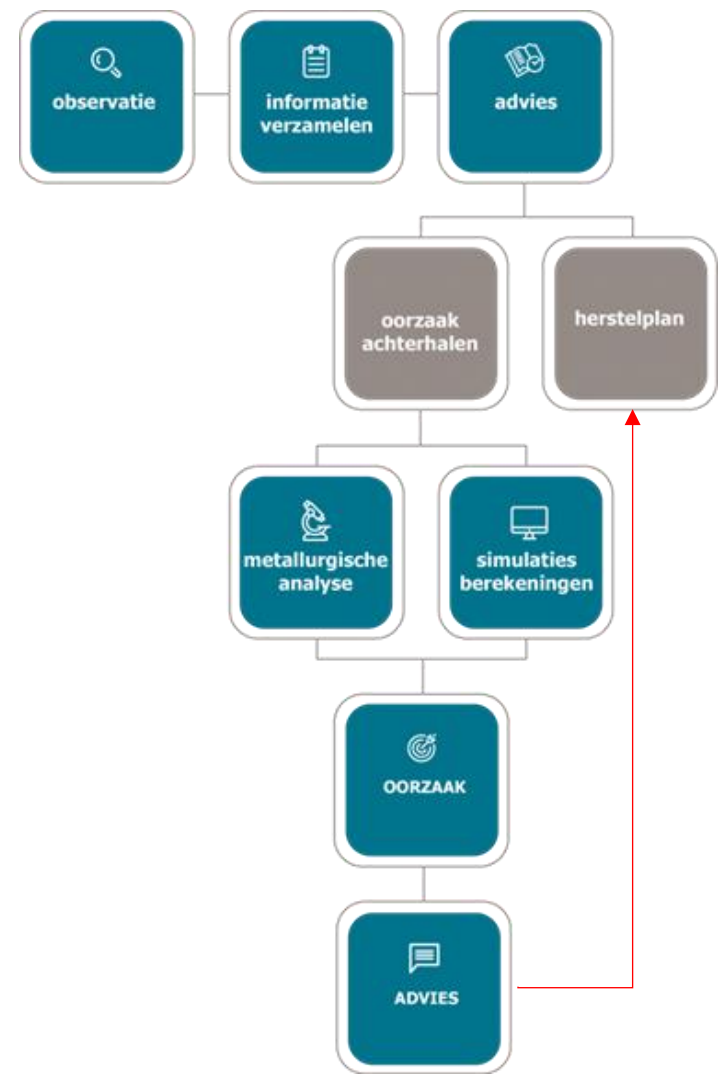




Asset Integrity

Onderhoud, schadeanalyse en herstellassen

ing. David Kimpe, IWE, IWI-C
Belgian Welding Institute - Industry



Case 1 – gescheurde buizen stoomketel | Beschrijving case



Case 1 – gescheurde buizen stoomketel | Beschrijving case

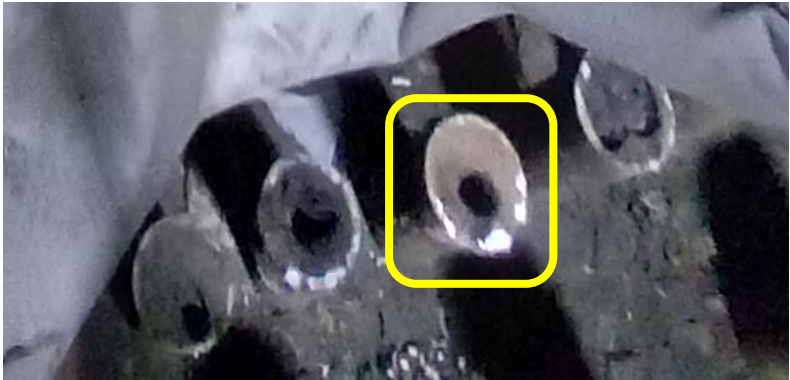




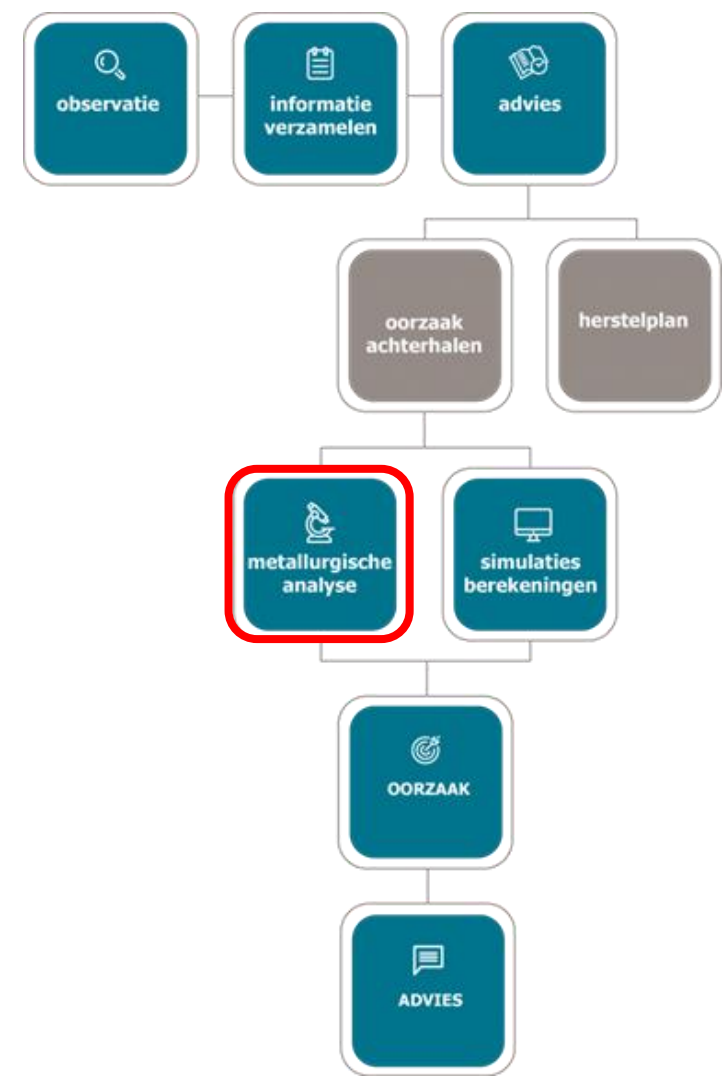
observatie



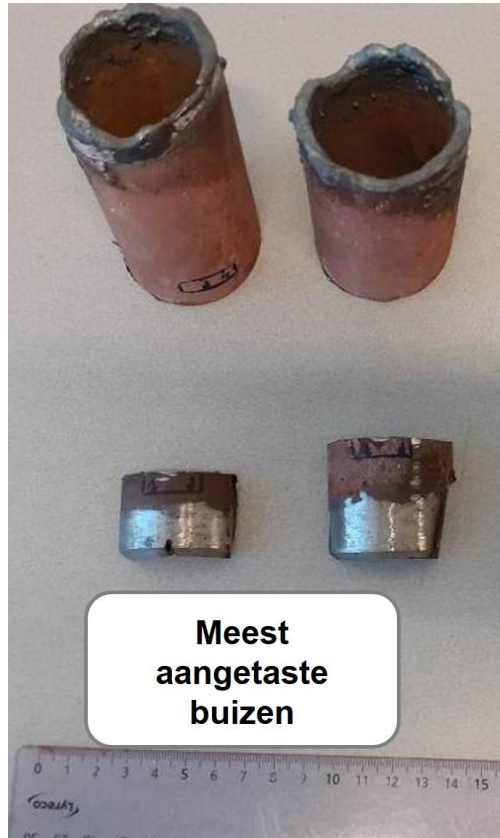
informatie
verzamelen



Case 1 – gescheurde buizen stoomketel | Samples

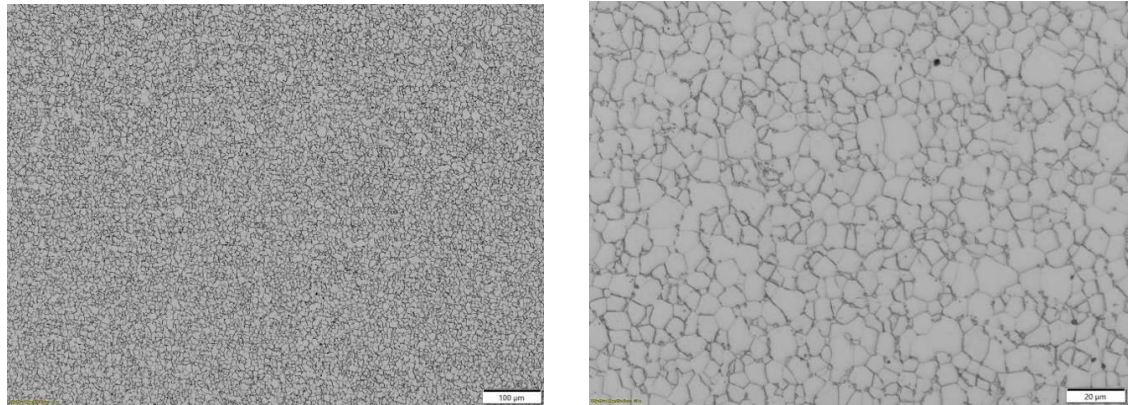
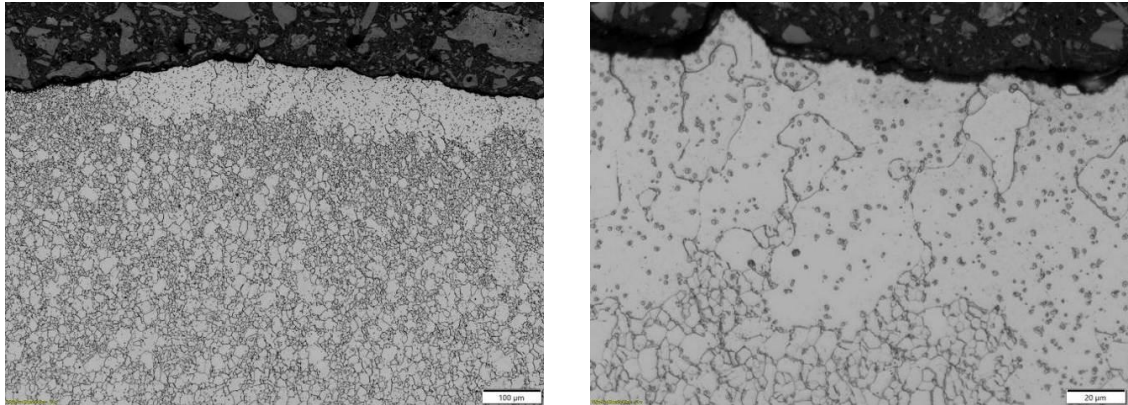


Case 1 – gescheurde buizen stoomketel | Samples

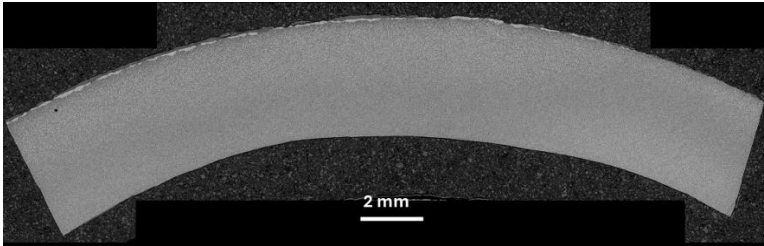
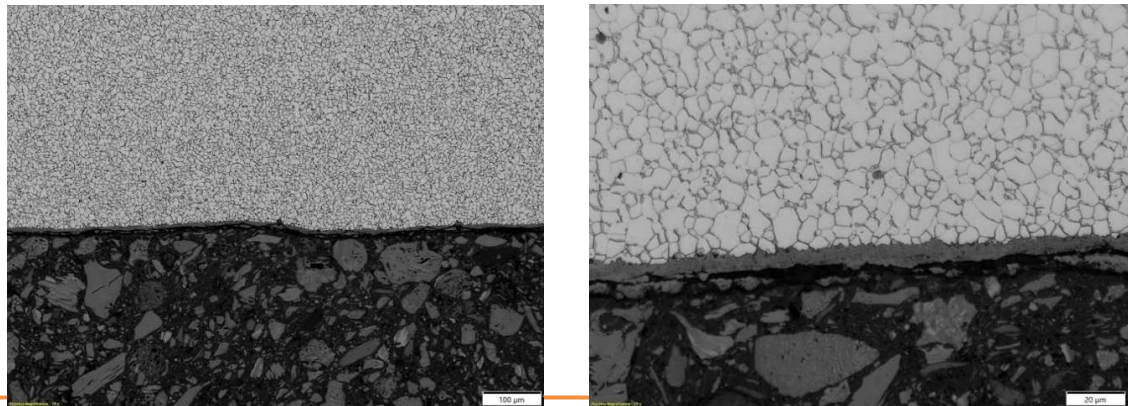


Case 1 – gescheurde buizen stoomketel | Microstructuur

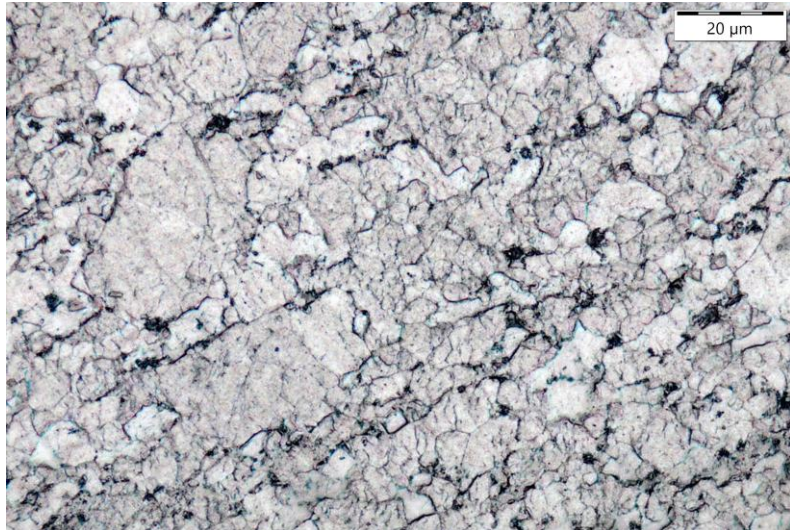
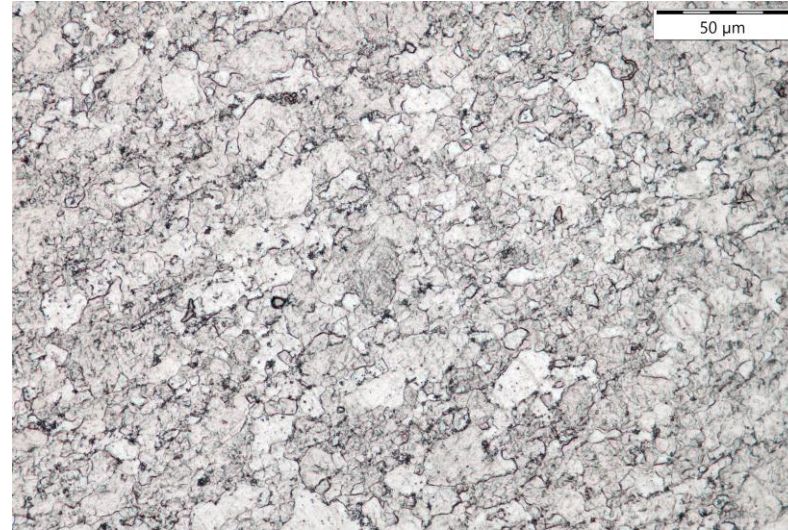
Outer Diameter



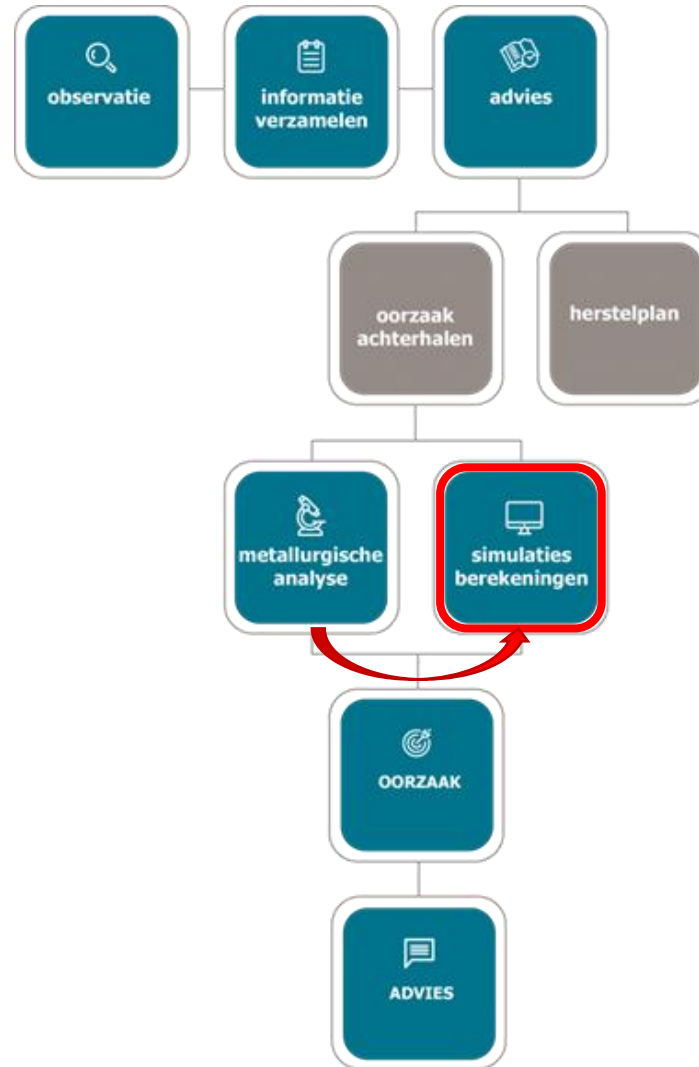
Inner Diameter



Case 1 – gescheurde buizen stoomketel | Replica's

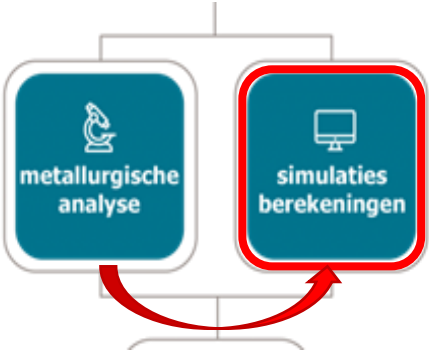


Case 1 – gescheurde buizen stoomketel | Korrelvergroving – wat nu?

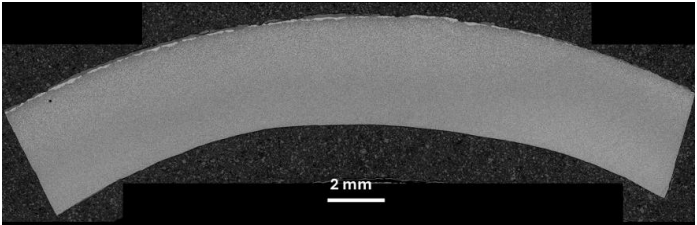


Case 1 – gescheurde buizen stoomketel | Korrelvergroving – wat nu?

p_t	Real hydrostatic test pressure of assembly	1,40	N/mm ²	(Art.6.1)
t_c	Calculation temperature	200	°C	
<u>Shell</u>				
	Material	P235GH		
$R_{p0.2tc}$	Minimum value of yield point at calculation temperature	170	N/mm ²	



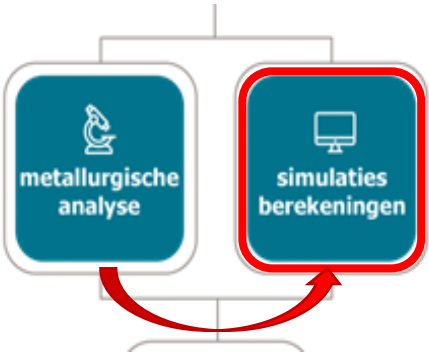
CALCULATION :				
f	Nominal design stress	113,33	N/mm ²	(6.3-1)
	$f = \min(\frac{R_{p0,2tc}}{1,5}; \frac{R_m}{2,4})$			
e_{ct}	Required wall thickness of shell without allowances	0,31	mm	(11.2-2)
e'_t	Required wall thickness of shell with allowances	2,70	mm	(11.2-1)
	$e_t = \frac{p_c * d_0}{(2 * f - p_c) * \nu + 2 * p_c} + c_1 + c_2$			



Minimaal ongeaffecteerde wanddikte

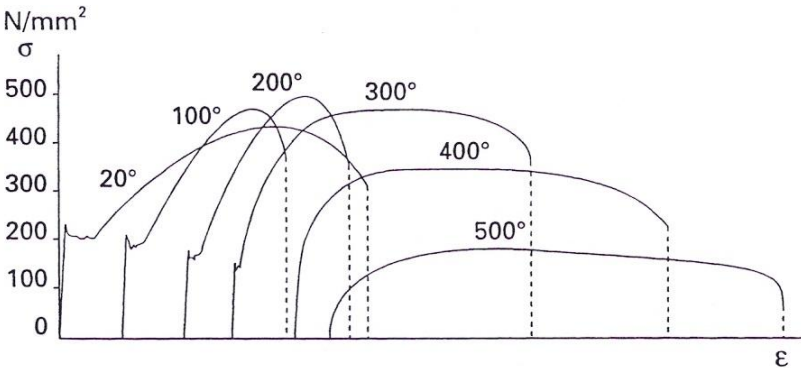
Case 1 – gescheurde buizen stoomketel | Korrelvergroving – wat nu?

p_t	Real hydrostatic test pressure of assembly	1.40	N/mm ²	
t_c	Calculation temperature	200	°C	(Art.6.1)
Shell				
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$R_{p0.2tc}$	Minimum value of yield point at calculation temperature	170	N/mm ²	

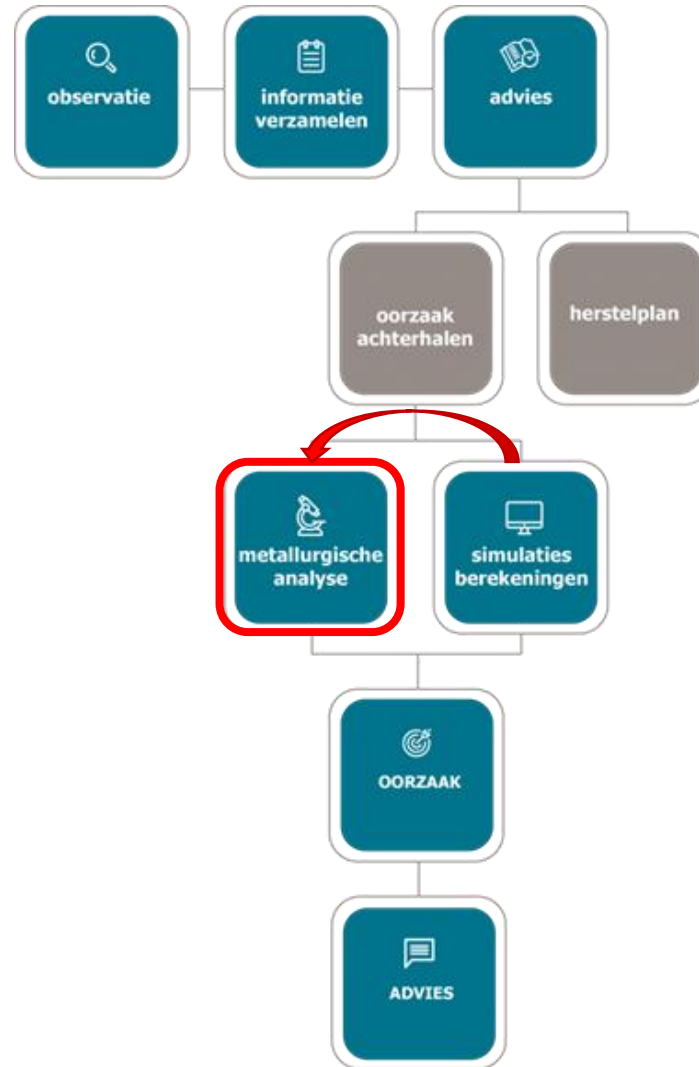


Alternatief: halen we dit nog op 200°C?

CALCULATION :				
f	Nominal design stress	113,33	N/mm ²	(6.3-1)
	$f = \min(\frac{R_{p0.2tc}}{1.5}; \frac{R_m}{2.4})$			
e_{ct}	Required wall thickness of shell without allowances	0,31	mm	(11.2-2)
e'_t	Required wall thickness of shell with allowances	2,70	mm	(11.2-1)
	$e_t = \frac{p_c * d_0}{(2 * f - p_c) * \nu + 2 * p_c} + c_1 + c_2$			



Case 1 – gescheurde buizen stoomketel | Korrelvergroving – wat nu?



Case 1 – gescheurde buizen stoomketel | Hot Tensile Test

Warme trekproeven van samples uit geaffecteerde zijde

- Op designtemperatuur 200°C
- Minimum rekgrens van 170 MPa te behalen (EN 10216-2 P235GH)

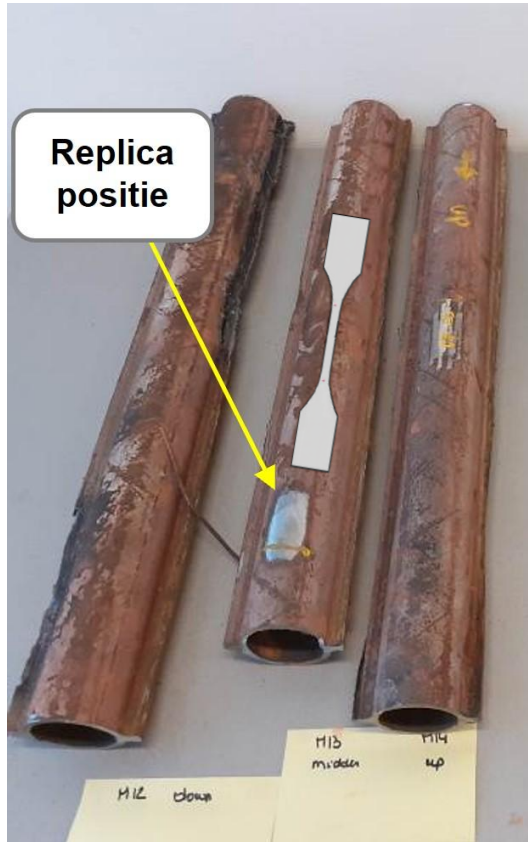
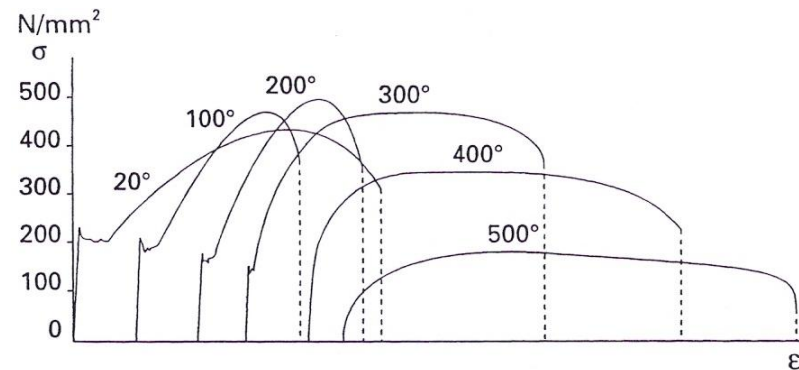


Table 5 — Minimum proof strength $R_{p0,2}$ at elevated temperature

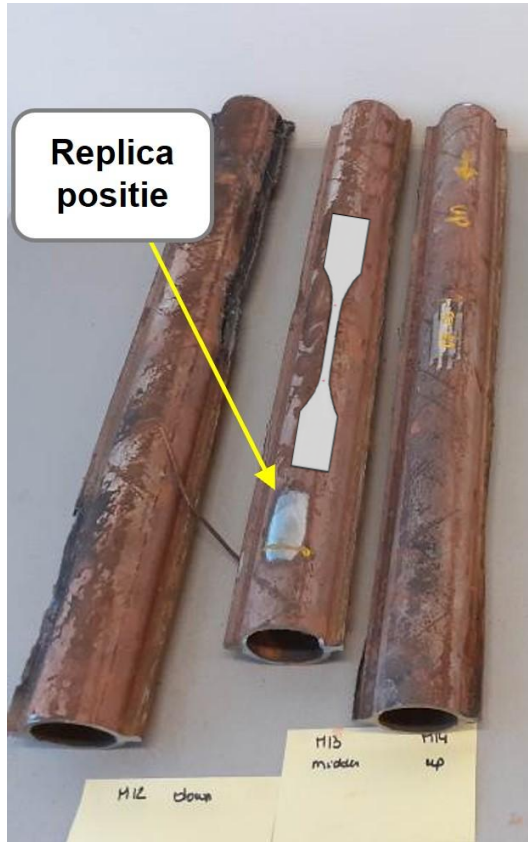
Steel grade		Wall thickness mm	Minimum proof strength $R_{p0,2}$ MPa ^a at a temperature of °C										
Steel name	Steel number		100	150	200	250	300	350	400	450	500	550	600
P195GH	1.0348	≤ 16	175	165	150	130	113	102	94	-	-	-	-
P235GH	1.0345	≤ 60	198	187	170	150	132	120	112	108	-	-	-
P265GH	1.0425	≤ 60	226	213	192	171	154	141	134	128	-	-	-
20MnNb6	1.0471	≤ 60	312	292	264	241	219	200	186	174	-	-	-
16Mo3	1.5415	≤ 60	243	237	224	205	173	159	156	150	146	-	-



Case 1 – gescheurde buizen stoomketel | Hot Tensile Test

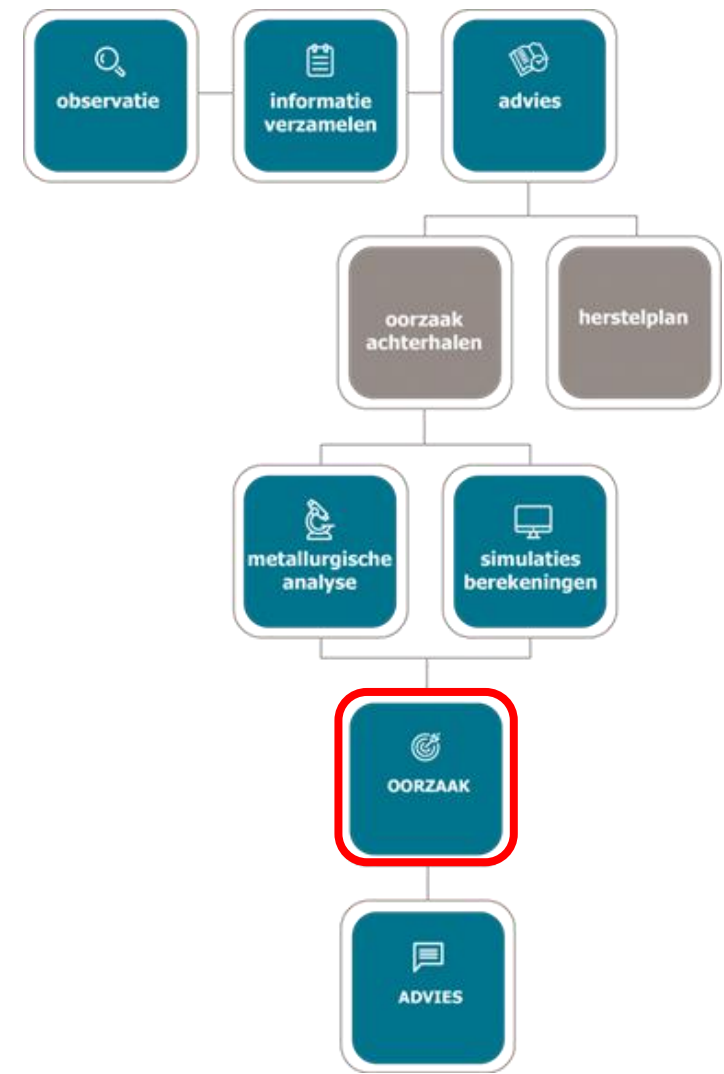
Warme trekproeven van samples uit geaffecteerde zijde

- Op designtemperatuur 200°C
- Minimum rekgrens van 170 MPa te behalen (EN 10216-2 P235GH)



- Buitenzijde:
 - 311 MPa
 - Thermisch belaste zijde:
 - 276 MPa
- Terugval,
maar wel nog steeds >170 MPa!
- Enkele andere locaties met verhoogde thermische belasting:
 - 321 MPa
 - 299 MPa

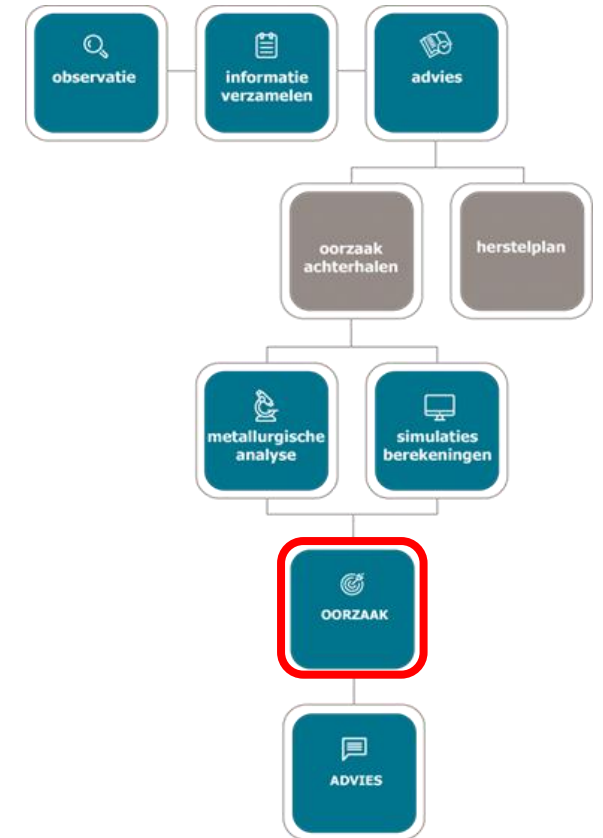
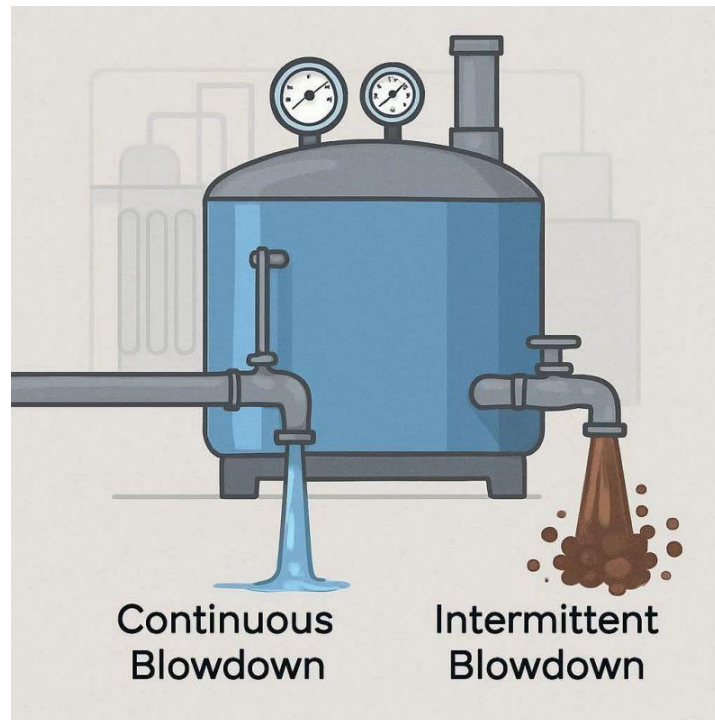
Case 1 – gescheurde buizen stoomketel | Oorzaak



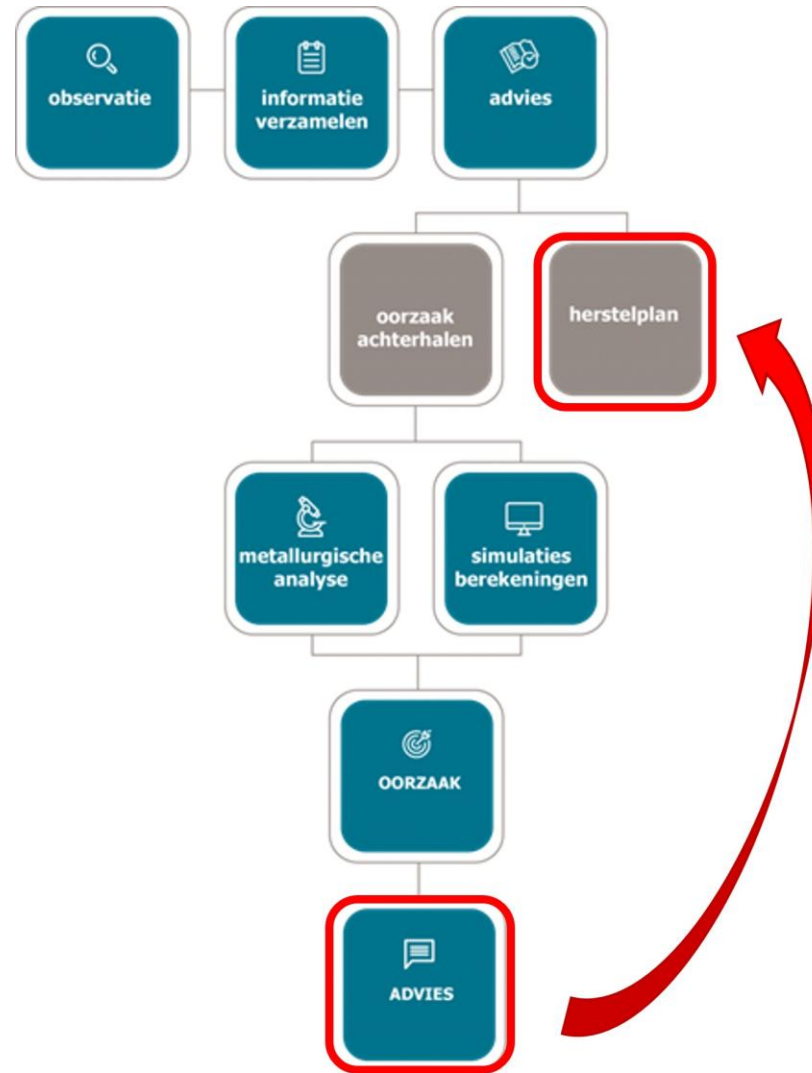
Case 1 – gescheurde buizen stoomketel | Oorzaak

➤ Verstopping t.g.v. combinatie van:

1. Gebruik slibrijk water
2. Ontwerpfout:
 - Bottom blowdown van een deel van het circuit niet mogelijk

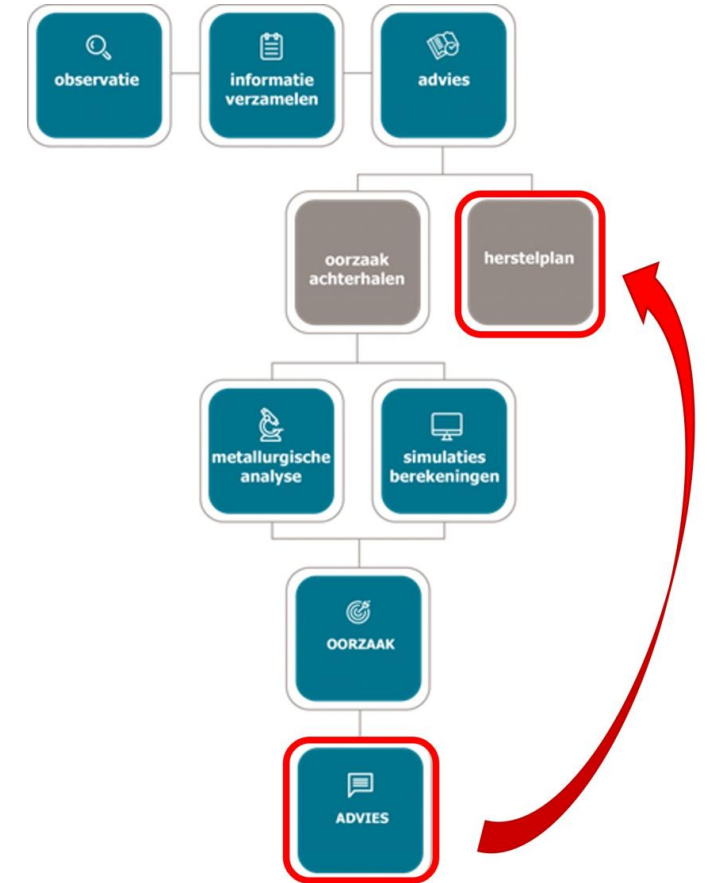


Case 1 – gescheurde buizen stoomketel | Conclusie

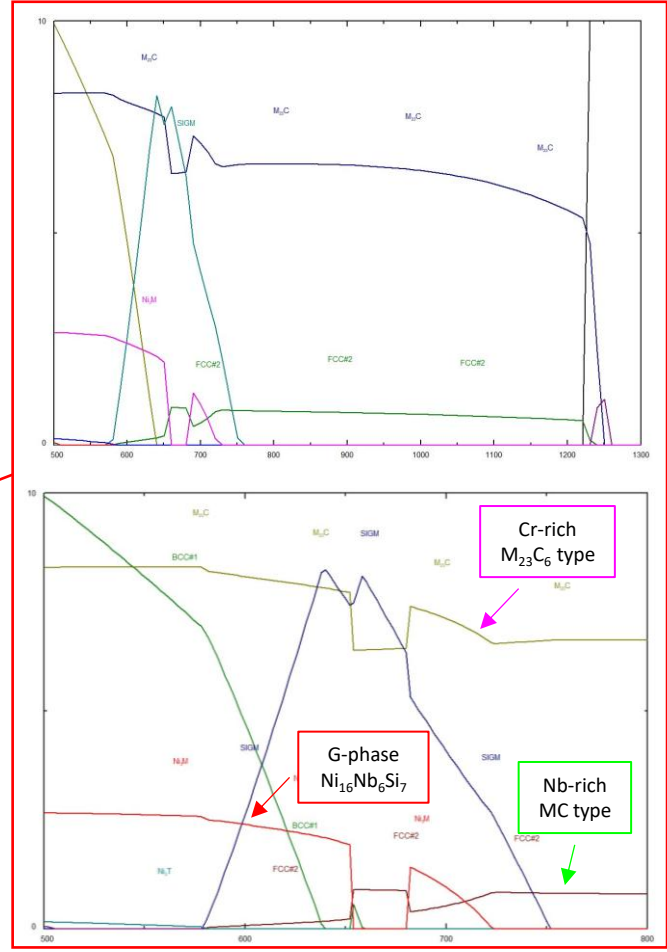
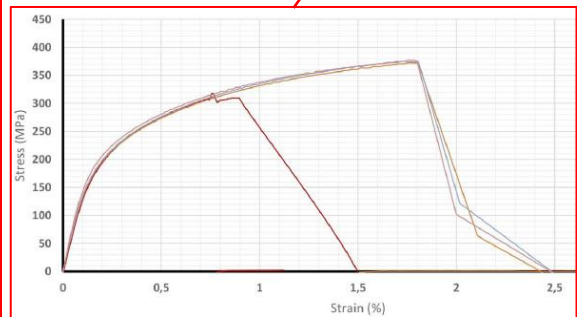
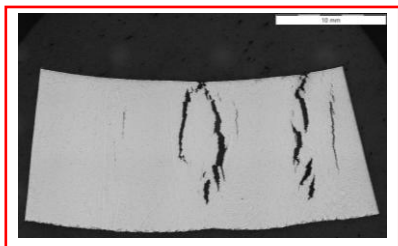
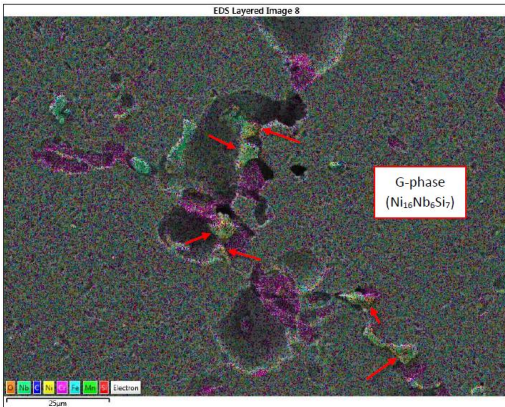
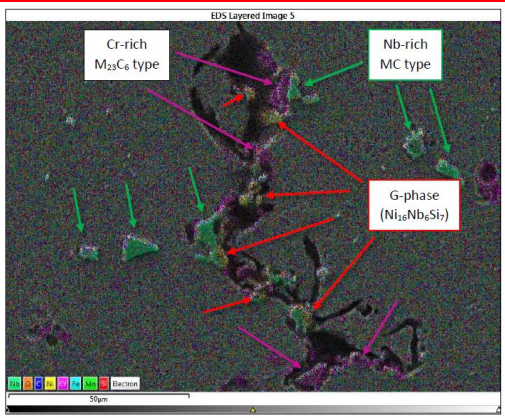
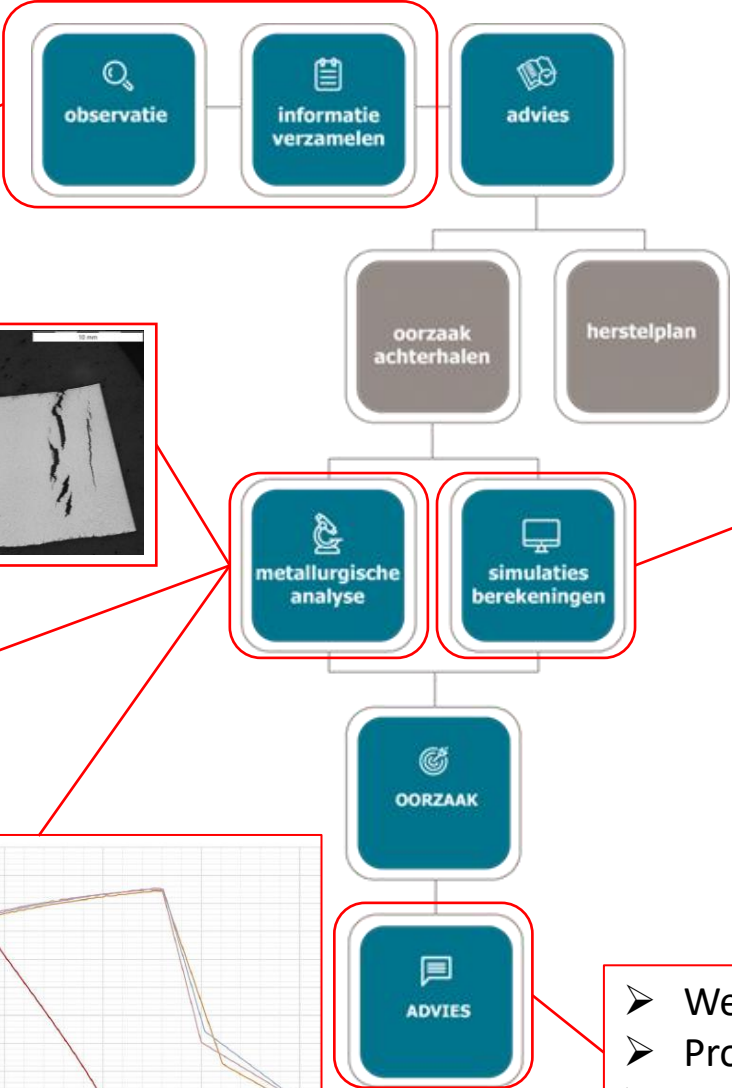
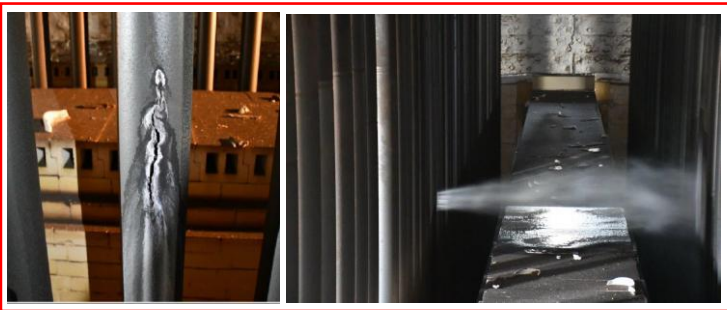


Case 1 – gescheurde buizen stoomketel | Conclusie

- Scope herstellingen significant te reduceren!
 - Beperken tot:
 - Gebarsten buizen
 - Vervormde buizen
- Tijdens herstelling: aanpassing design
 - Blowdown mogelijk maken in laagste deel circuit
- Kost onderzoek: €5 000 – €20 000
- Kostreductie klant: ca. €100 000 à €150 000

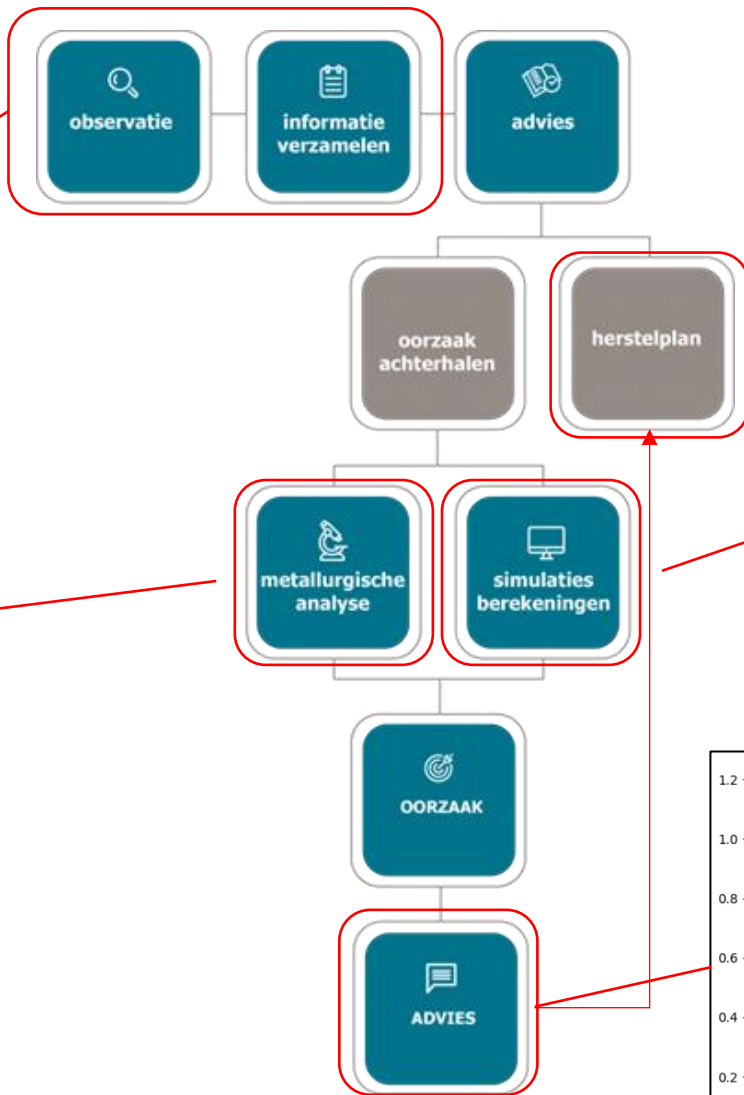
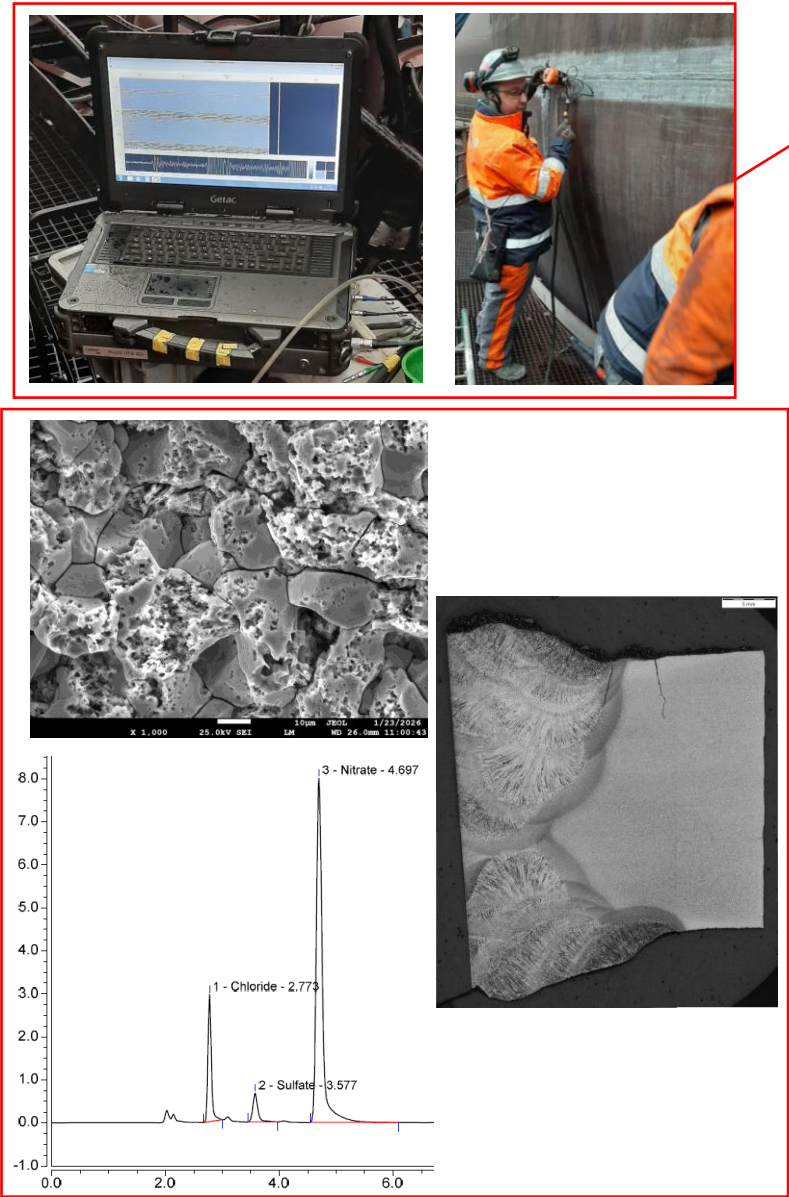


Case 2 | Precipitaten karakterisatie en CALPHAD

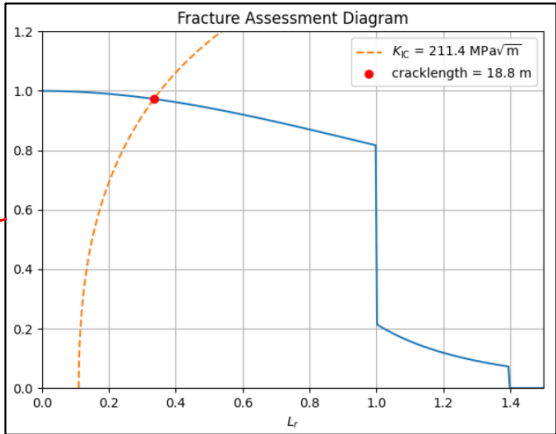
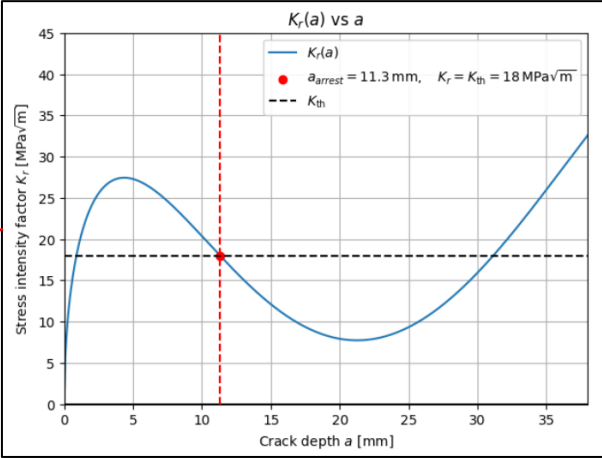


- Weld repair niet aangeraden (geen rek!)
- Procescondities bekijken
- Desnoods ander material toepassen

Case 3 | Breukmechanica en Fracture Assessment



Hestelplan met sterke focus op beperken residuele spanning



➤ Evidence-driven approach

- Single point of contact
- Selection of best methods of analysis
- No one-size-fits-all – exact tools for the job

➤ Root cause engineering

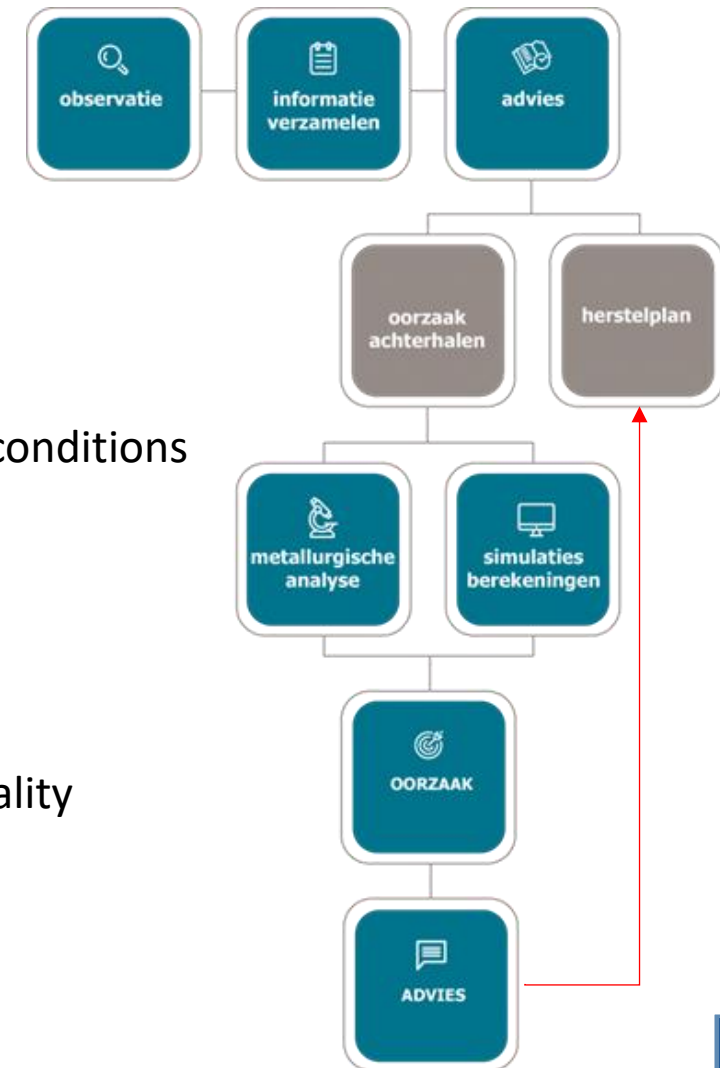
- Definitive solutions that break the cycle of repetitive repairs
- Identifying fundamental flaws in material selection or process conditions
- Moving past “temporary band-aid” solutions → structural fixes

➤ Full multidisciplinary package

- Seamless integration of NDT oversight, metallurgical analysis, structural calculations and repair welding engineering
- Iterative feedback loops ensuring engineering logic matches reality

➤ Universal cross industry application

- Proven framework adaptable to all high-stakes industries (Energy, Chemical, Maritime, Infrastructure, ...)



Thank you for your
attention!



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