



STUDIECENTRUM VOOR KERNENERGIE  
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE



Unclassified

# Technical Appendix of "Optimal Use of Broken Charpy Specimens from Surveillance Programs for the Application of the Master Curve Approach"

Convention Electrabel - SCK•CEN  
KNT 90 99 1165.01

M. Scibetta, E. Lucon and E. van Walle

RMR  
SCK•CEN, Mol, Belgium

BLG-888

September 2001

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## **ABSTRACT**

This report contains the technical appendix of the paper " Optimal Use of Broken Charpy Specimens from Surveillance Programs for the Application of the Master Curve Approach ".

This work is undertaken within the ELECTRABEL - SCK•CEN Convention 2001.

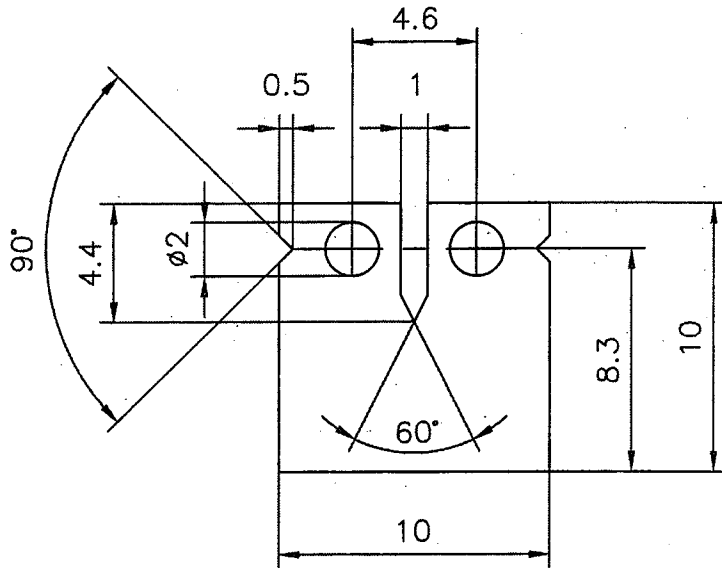
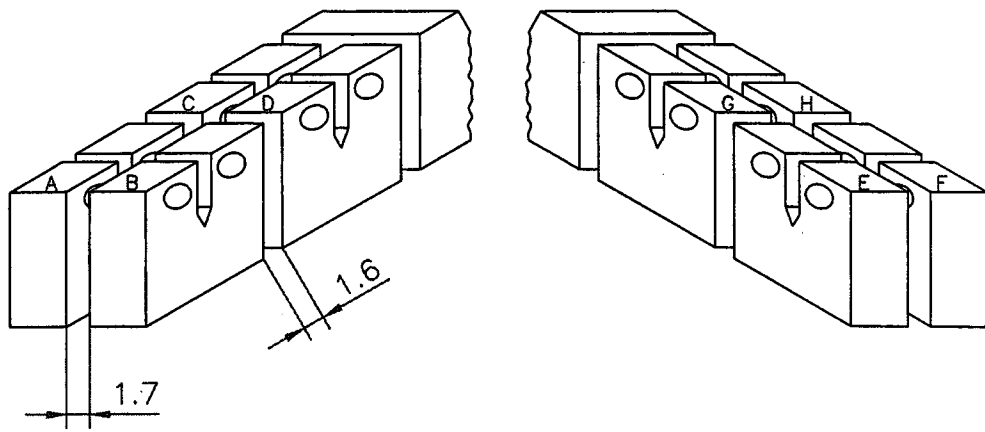
## **KEYWORDS**

Fracture toughness, Miniaturisation


## **Acknowledgements**

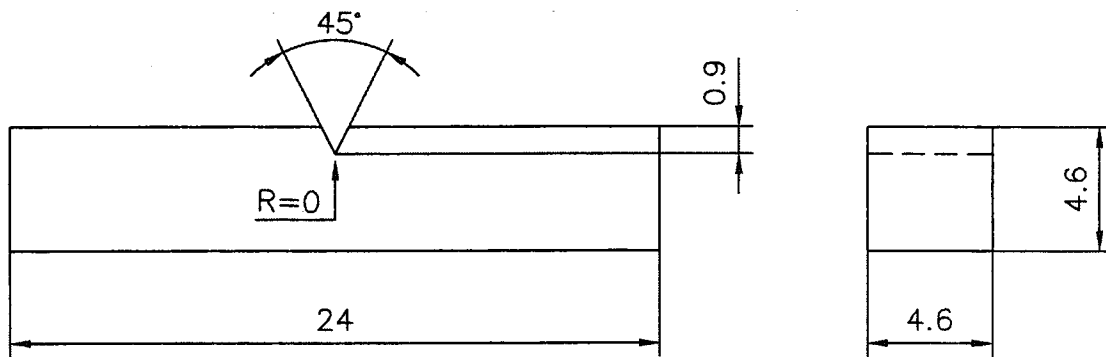
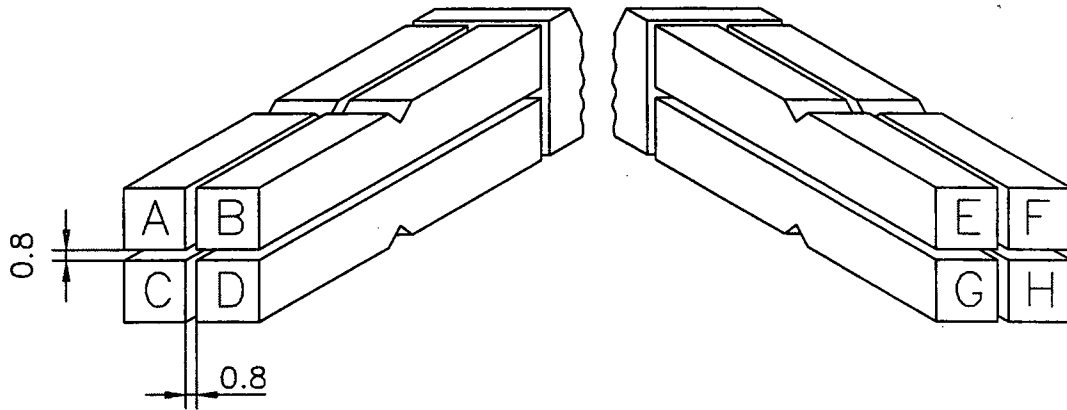
The Authors acknowledge the collaboration of R. Mertens and P. Beckers (specimen preparation), P. Wouters, L. Van Houdt and A. Pellettieri (dimensional measurements, test execution and preliminary analyses and Jozef Vreys and Maurice Thijs for the technical drawings.

The present work is partly financed by Tractebel Energy Engineering. Their support is kindly appreciated.



Thickness 4.15

Tek. Dess. Draw. <b>Mertens R.</b>						
Verificat.						
Approbat.		Ind.	Dat.	Wijziging - Modification - Up dating	Par.	App.
L.H.M.A.		Vrijmaat tol. Tol. libre TOL Free tol.		Afwerking Et. de surface AFW Finishing grade	Schaal Echelle Scale	2/1
	File <b>Scibet14</b>	Datum-Date-Date 2001-02-15		Nr. <b>RMO-169</b>		
	<b>Mini CT</b>					



Tek. Dess. Draw.	Mertens R.					
Verificat.						
Approbat.		Ind.	Dat.	Wijziging - Modification - Up dating	Par.	App.

L. H. M. A.

Vrijmaat tol.  
Tol. libre TOL  
Free tol.

Afwerking  
Et. de surface AFW  
Finishing grade

Schaal  
Echelle 2/1  
Scale



File  
**Scibet15**

Datum-Date-Date  
2001-02-16

Nr. **RM0-170**

**Mini PCCV 4.6 x 4.6 x 24**



**APPENDIX 1 Test results on mini SE(B) 22NiMoCr37**

**STANDARD TEST METHOD FOR THE DETERMINATION OF REFERENCE TEMPERATURE,  
T<sub>0</sub>, FOR FERRITIC STEELS IN THE TRANSITION RANGE**

[MULTI-TEMPERATURE APPROACH]

**1. Material characteristics**

Material specifications : 22NiMoCr37 - Sub-size PCCv (B = W = 4.6 mm) [ALL TESTS]

**2. Dimensional and crack growth requirements**

Specimen code	T (°C)	a <sub>0</sub> (mm)	W (mm)	B (mm)	b <sub>0</sub> (mm)	Δa (mm)	K <sub>Jc[exp]</sub> (MPa√m)	σ <sub>ys</sub> (MPa)	E (GPa)	K <sub>lim</sub> (MPa√m)	DATA VALID	K <sub>Jc[calc]</sub> (MPa√m)
X5D5A	-145	2.416	4.636	4.569	2.220	0.00	58.6	717.7	215.7	107.0	YES	58.6
X5D5B	-135	2.424	4.647	4.404	2.223	0.00	111.9	683.3	215.1	104.4	NO	104.4
X5D5C	-140	2.331	4.547	4.490	2.216	0.00	39.1	700.0	215.4	105.5	YES	39.1
X5D5D	-140	2.329	4.495	4.490	2.166	0.00	98.5	700.0	215.4	104.3	YES	98.5
X5D5E	-140	2.521	4.667	4.478	2.146	0.00	112.6	700.0	215.4	103.9	NO	103.9
X5D5F	-140	2.416	4.556	4.538	2.140	0.00	102.6	700.0	215.4	103.7	YES	102.6
X5D5G	-140	2.250	4.512	4.440	2.262	0.00	111.2	700.0	215.4	106.6	NO	106.6
X5D5H	-140	2.401	4.668	4.534	2.267	0.00	62.1	700.0	215.4	106.8	YES	62.1
X5D6A	-140	2.680	4.731	4.485	2.051	0.00	65.2	700.0	215.4	101.5	YES	65.2
X5D6B	-140	2.492	4.630	4.410	2.139	0.00	101.2	700.0	215.4	103.7	YES	101.2
X5D6C	-140	2.408	4.477	4.419	2.069	0.00	59.1	700.0	215.4	102.0	YES	59.1
X5D6D	-140	2.365	4.576	4.456	2.211	0.00	92.8	700.0	215.4	105.4	YES	92.8
X5D6E	-140	2.503	4.674	4.446	2.171	0.00	47.2	700.0	215.4	104.5	YES	47.2
X5D6F	-140	2.484	4.690	4.455	2.206	0.00	62.4	700.0	215.4	105.3	YES	62.4
X5D6G	-140	2.431	4.587	4.478	2.156	0.00	87.6	700.0	215.4	104.1	YES	87.6
X5D6H	-140	2.346	4.521	4.438	2.175	0.00	55.7	700.0	215.4	104.6	YES	55.7

**3. Application of the multi-temperature approach for the calculation of the reference temperature**

Specimen code	T (°C)	K <sub>Jc[calc]</sub> (MPa√m)	K <sub>Jc(17)</sub> (MPa√m)	δ <sub>i</sub>	n <sub>i</sub>	1° member	2° member
X5D5A	-145	58.6	45.1	1	0.125	0.0097	0.0011
X5D5B	-135	104.4	74.4	0	0.000	0.0000	0.0144
X5D5C	-140	39.1	32.4	1	0.125	0.0099	0.0001
X5D5D	-140	98.5	70.9	1	0.125	0.0099	0.0145
X5D5E	-140	103.9	74.3	0	0.000	0.0000	0.0188
X5D5F	-140	102.6	73.7	1	0.125	0.0099	0.0179
X5D5G	-140	106.6	76.0	0	0.000	0.0000	0.0212
X5D5H	-140	62.1	47.4	1	0.125	0.0099	0.0012
X5D6A	-140	65.2	49.3	1	0.125	0.0099	0.0016
X5D6B	-140	101.2	72.4	1	0.125	0.0099	0.0163
X5D6C	-140	59.1	45.3	1	0.125	0.0099	0.0009
X5D6D	-140	92.8	67.1	1	0.125	0.0099	0.0106
X5D6E	-140	47.2	37.6	1	0.125	0.0099	0.0002
X5D6F	-140	62.4	47.4	1	0.125	0.0099	0.0012
X5D6G	-140	87.6	63.8	1	0.125	0.0099	0.0079
X5D6H	-140	55.7	43.1	1	0.125	0.0099	0.0006

Sum of 1° member: 0.128

Sum of 2° member: 0.128

Difference: 0.000

**T<sub>0</sub> = -99.0 °C**  
(valid per ASTM E1921)

Σ n<sub>i</sub> = 1.63

N = 16  
r = 13

K<sub>min</sub> = 20 MPa√m

K<sub>0,eq</sub> = 65.9 MPa√m

K<sub>med,eq</sub> = 61.9 MPa√m

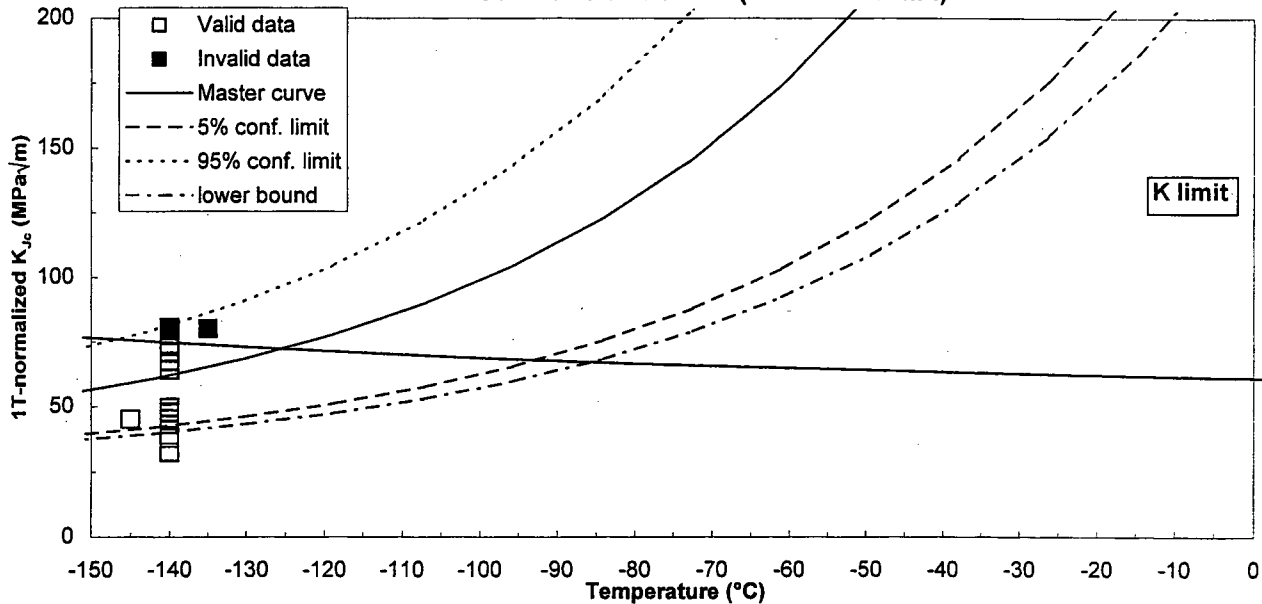
β = 20.1 °C  
2σ = 11 °C

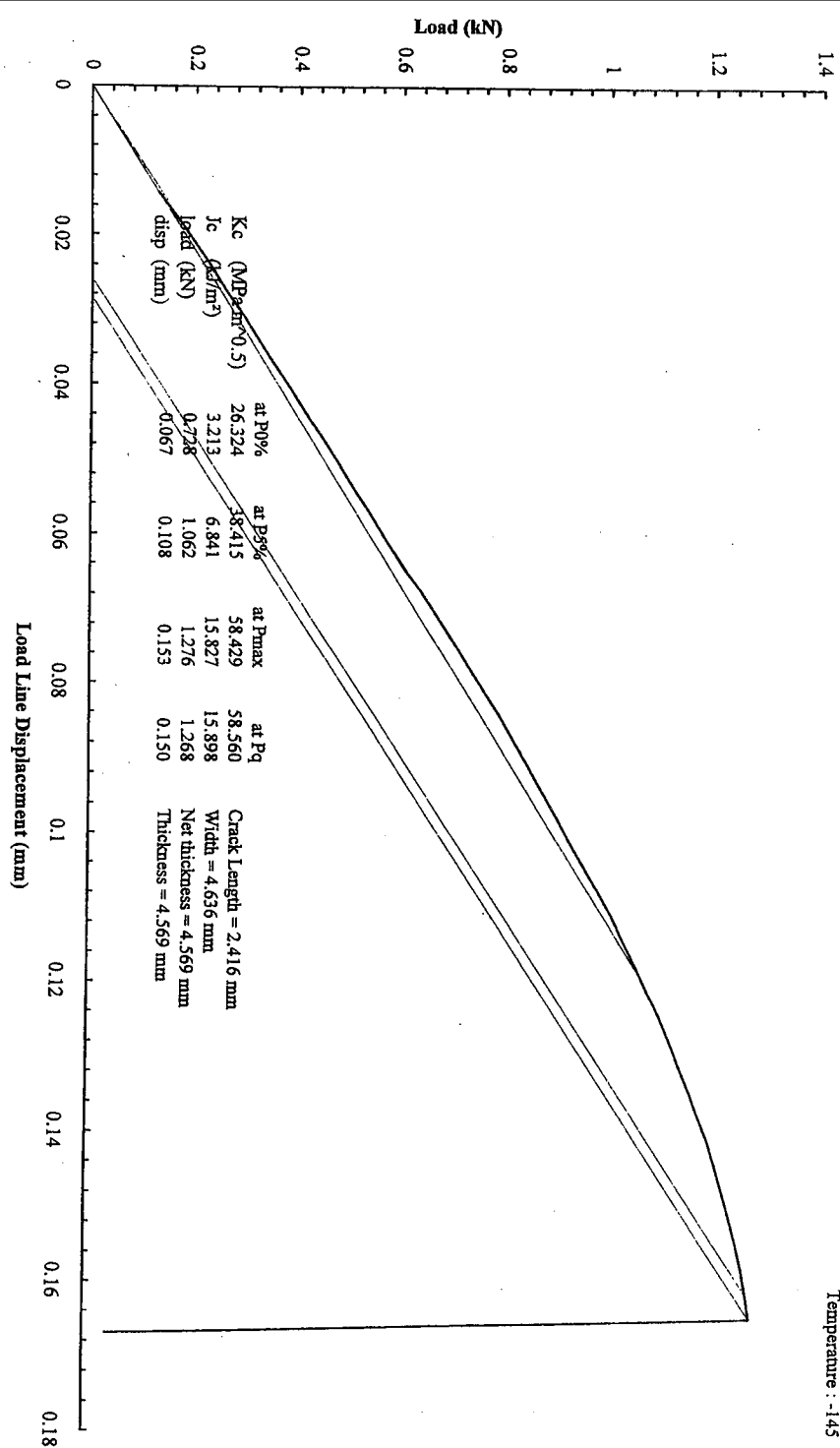
**4. Master curve fit to data**

Temperature adj. = 8.0 °C (est.) Stand. dev. on T<sub>0</sub> = 5.6 °C (est.)

T (°C)	K <sub>Jc(exp)</sub> (MPa√m)	K <sub>Jc(1T)</sub> (MPa√m)	K <sub>MC(1T)</sub> (MPa√m)	5% conf. (MPa√m)	95% conf. (MPa√m)	5% L.B. (MPa√m)
-145	58.6	45.2				
-135	111.9	80.1				
-140	39.1	32.5				
-140	98.5	70.9				
-140	112.6	80.6				
-140	102.6	73.8				
-140	111.2	79.2				
-140	62.1	47.6				
-140	65.2	49.7				
-140	101.2	73.1				
-140	59.1	45.3				
-140	92.8	67.4				
-140	47.2	37.8				
-140	62.4	47.8				
-140	87.6	64.0				
-140	55.7	43.2				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
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0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
-165			50.0	36.2	63.7	34.7
-153.4375			54.9	38.8	70.9	36.9
-141.875			61.0	42.1	79.8	39.8
-130.3125			68.6	46.2	90.9	43.3
-118.75			78.1	51.4	104.8	47.7
-107.1875			89.9	57.7	122.0	53.2
-95.625			104.6	65.7	143.5	60.0
-84.0625			122.9	75.6	170.2	68.5
-72.5			145.7	87.9	203.5	79.0
-60.9375			174.1	103.2	245.0	92.2
-49.375			209.6	122.4	296.8	108.6
-37.8125			253.7	146.2	361.2	129.1
-26.25			308.6	175.9	441.4	154.6
-14.6875			377.1	212.8	541.3	186.3
-3.125			462.4	258.9	665.8	225.8
8.4375			568.6	316.2	820.9	275.1
20			700.9	387.7	1014.1	336.4

**MASTER CURVE FOR 1TCT WITH CONFIDENCE LIMITS**  
**22NiCrMo37 - Sub-size PCCv (B = W = 4.6 mm)**





SCK CEN, ILMMA  
Boeretang 200  
B-2400 Mol (Belgium)

Date: 2001-07-05  
Software: KJC\_3PBv4.xls

**3PB FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	XSD5A
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.636
	Thickness (mm):	4.569
Net thickness (mm):	4.569	
Side grooving:	0%	

<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-145
	Test date:	17 May 2001
	Test operator:	PW
	Transducer type :	N/A

<b>Fatigue precracking</b>	K <sub>max</sub> (MPa√m):	25.1
	R:	0.1
	K <sub>final</sub> (MPa√m):	18.2

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
	a <sub>0</sub>		Δa <sub>0</sub>	
	a <sub>0</sub>	2.416	Δa <sub>0</sub>	0.000
	a <sub>0_1</sub>	2.083	Δa <sub>0_1</sub>	0.000
	a <sub>0_2</sub>	2.310	Δa <sub>0_2</sub>	0.000
	a <sub>0_3</sub>	2.434	Δa <sub>0_3</sub>	0.000
	a <sub>0_4</sub>	2.514	Δa <sub>0_4</sub>	0.000
	a <sub>0_5</sub>	2.526	Δa <sub>0_5</sub>	0.000
	a <sub>0_6</sub>	2.521	Δa <sub>0_6</sub>	0.000
	a <sub>0_7</sub>	2.492	Δa <sub>0_7</sub>	0.000
	a <sub>0_8</sub>	2.403	Δa <sub>0_8</sub>	0.000
	a <sub>0_9</sub>	2.177	Δa <sub>0_9</sub>	0.000

<b>Fracture toughness</b>	J <sub>c</sub> (kJ/m²):	15.90
	K <sub>Jc</sub> (MPa√m):	58.56

<b>Remarks</b>	0
----------------	---

Signature:

### Measure of $a_0$ and $a_f$

Date: 2001-05-17 File: X5D5A.xls Directory: MENTUMcc\_Test\test\22nimocr37\Mini\_PCC

Material: 22NiMoCr37

Charpy nr.: X5D5A

$a_{fmax}$  (mm): 1.250  $F_{max}$  (kN): 1.400  $F_{final}$  (kN): 0.500

Charpy W (mm): 4.636  $B_n$  \* (mm): 4.530  $B_n$  (mm): 4.569 B (mm): 4.569

Picture W (cm): XXXXXXXXXX  $B_n$  \* (cm): XXXXXXXXXX  $B_n$  (cm): XXXXXXXXXX B (cm): XXXXXXXXXX

$0.01 \cdot B$  0.046 mm  $10\% B$  0.555 mm Span (mm): 18.400

Picture	cm
a01	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a02	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a03	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a04	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a05	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a06	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a07	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a08	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
a09	<span style="background-color: black; color: black;">XXXXXXXXXX</span>

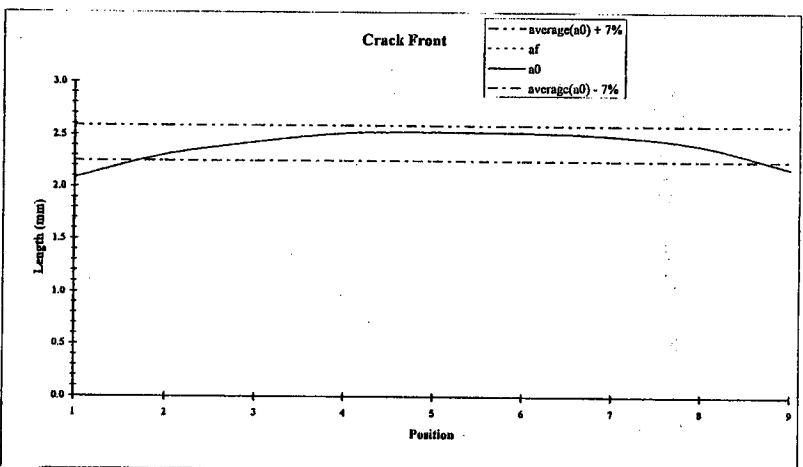
Picture	cm
af1	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af2	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af3	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af4	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af5	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af6	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af7	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af8	<span style="background-color: black; color: black;">XXXXXXXXXX</span>
af9	<span style="background-color: black; color: black;">XXXXXXXXXX</span>

Precracking Machine: INSTRON

$K_{max}$  (MPa $\sqrt{m}$ ): 25.146  
 $K_{final}$  (MPa $\sqrt{m}$ ): 18.187

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.083	-13.79%	af1	2.083	-13.79%	$\Delta a1$	0.000	0.00%
a02	2.310	-4.40%	af2	2.310	-4.40%	$\Delta a2$	0.000	0.00%
a03	2.434	0.73%	af3	2.434	0.73%	$\Delta a3$	0.000	0.00%
a04	2.514	4.05%	af4	2.514	4.05%	$\Delta a4$	0.000	0.00%
a05	2.526	4.54%	af5	2.526	4.54%	$\Delta a5$	0.000	0.00%
a06	2.521	4.34%	af6	2.521	4.34%	$\Delta a6$	0.000	0.00%
a07	2.492	3.14%	af6	2.492	3.14%	$\Delta a7$	0.000	0.00%
a08	2.403	-0.55%	af8	2.403	-0.55%	$\Delta a8$	0.000	0.00%
a09	2.177	-9.90%	af9	2.177	-9.90%	$\Delta a9$	0.000	0.00%
Average a0	2.416		Average af	2.416		-gen.	0.000	

Remark:



### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D5C
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.547
	Thickness (mm):	4.49
	Net thickness (mm):	4.49
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	18 May 2001
	Test operator:	PW
	Transducer type:	N/A

Fatigue precracking	$K_{max}$ (MPa $\sqrt{m}$ ):	26.7
	R:	0.1
	$K_{final}$ (MPa $\sqrt{m}$ ):	18.5

Crack	Initial crack length (mm):	Ductile crack extension (mm):
$a_0$	2.331	$\Delta a_0$ 0.000
$a_{0\_1}$	2.049	$\Delta a_{0\_1}$ 0.000
$a_{0\_2}$	2.258	$\Delta a_{0\_2}$ 0.000
$a_{0\_3}$	2.371	$\Delta a_{0\_3}$ 0.000
$a_{0\_4}$	2.419	$\Delta a_{0\_4}$ 0.000
$a_{0\_5}$	2.408	$\Delta a_{0\_5}$ 0.000
$a_{0\_6}$	2.415	$\Delta a_{0\_6}$ 0.000
$a_{0\_7}$	2.385	$\Delta a_{0\_7}$ 0.000
$a_{0\_8}$	2.321	$\Delta a_{0\_8}$ 0.000
$a_{0\_9}$	2.093	$\Delta a_{0\_9}$ 0.000

Fracture toughness	$J_c$ (kJ/m <sup>2</sup> ):	7.12
	$K_{Jc}$ (MPa $\sqrt{m}$ ):	39.15

Remarks:

Signature:

# Measure of A0 and Af

Date: 2001-05-18 File: X5D5C.xls Directory: NT\Mec\_Test\test\22nimocr37\Mini\_PCCVVA

Material: 22NiMoCr37 Charpy nr.: X5D5C

a\_max (mm): 1.250 Fmax (kN): 1.400 FFinal (kN): 0.500

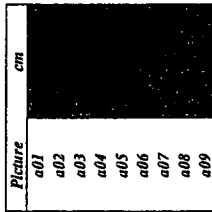
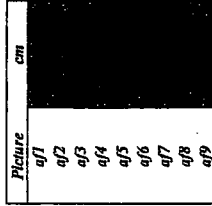
W (mm): 4.547 Bn\* (mm): 4.484 Bn (mm): 4.490 B (mm): 4.490

Picture W (cm): Bn\* (cm): Bn (cm): B (cm): Span (mm): 18.400

0.01\*B: 0.045 mm 10% B: 0.549 mm

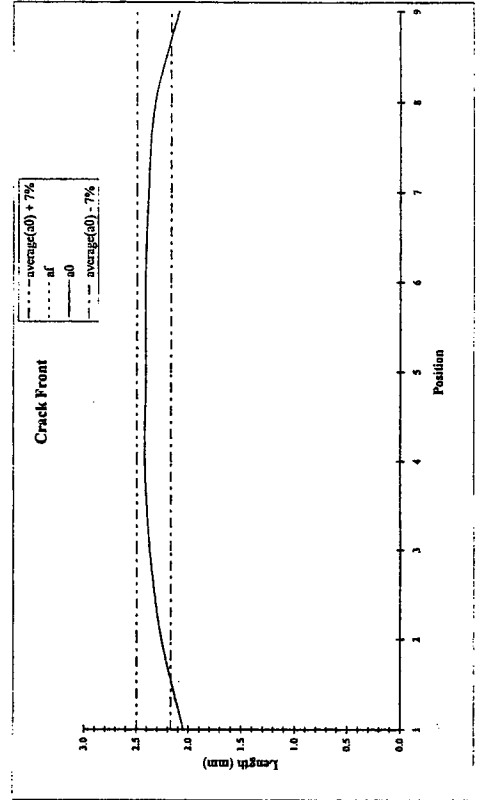
Precracking Machine: JNSVIRON

Kmax (MPaVm): 26.700  
Kfinal (MPaVm): 18.529



Charpy	mm	error	Charpy	mm	error
a01	2.049	-12.10%	a11	2.049	-12.10%
a02	2.258	-3.13%	a12	2.258	-3.13%
a03	2.371	1.72%	a13	2.371	1.72%
a04	2.419	3.78%	a14	2.419	3.78%
a05	2.408	3.30%	a15	2.408	3.30%
a06	2.415	3.60%	a16	2.415	3.60%
a07	2.385	2.32%	a17	2.385	2.32%
a08	2.321	-0.43%	a18	2.321	-0.43%
a09	2.093	-10.21%	a19	2.093	-10.21%
Average a0	2.331		Average a1	2.331	
			-gem.	0.000	0.00%

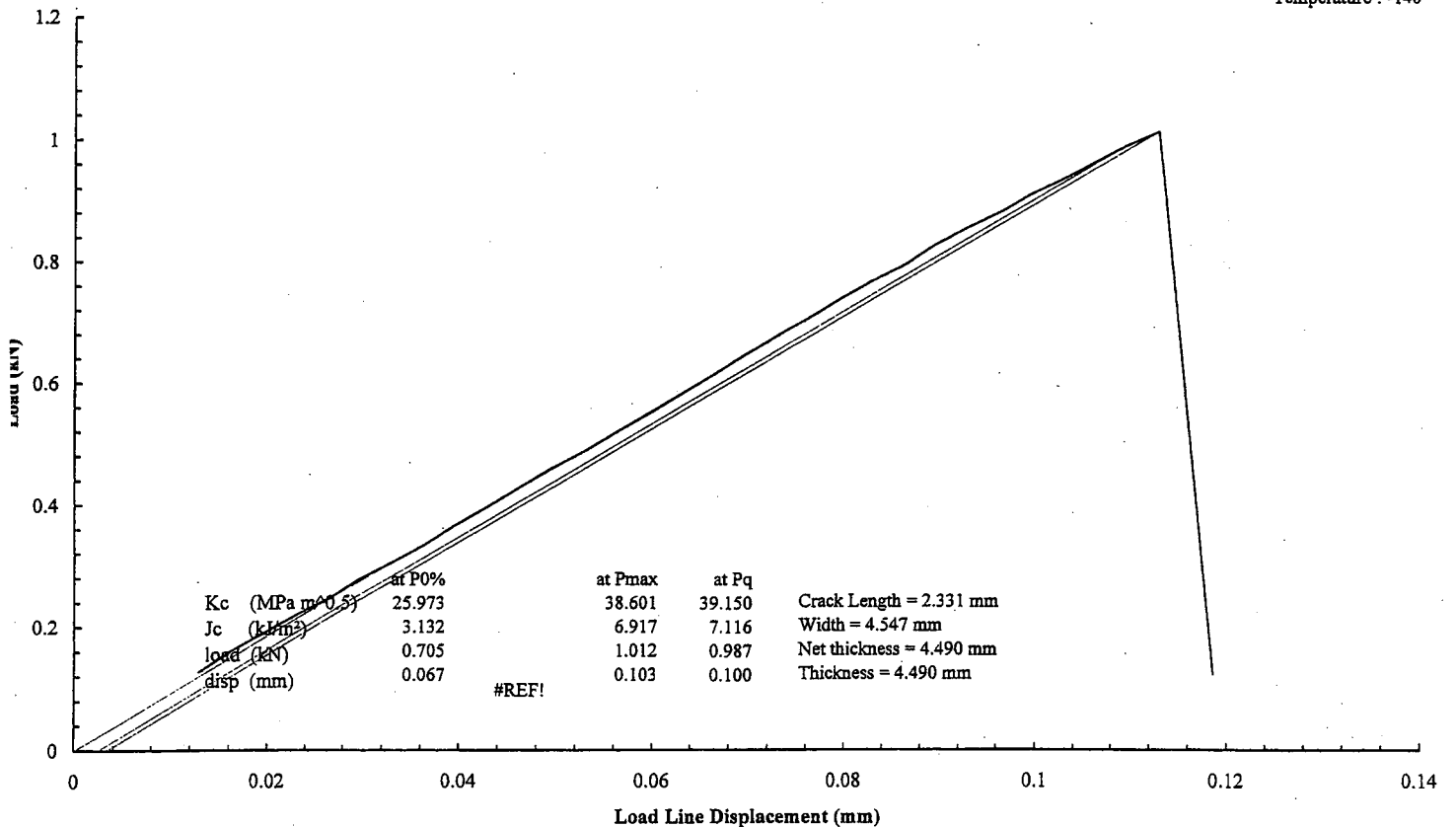
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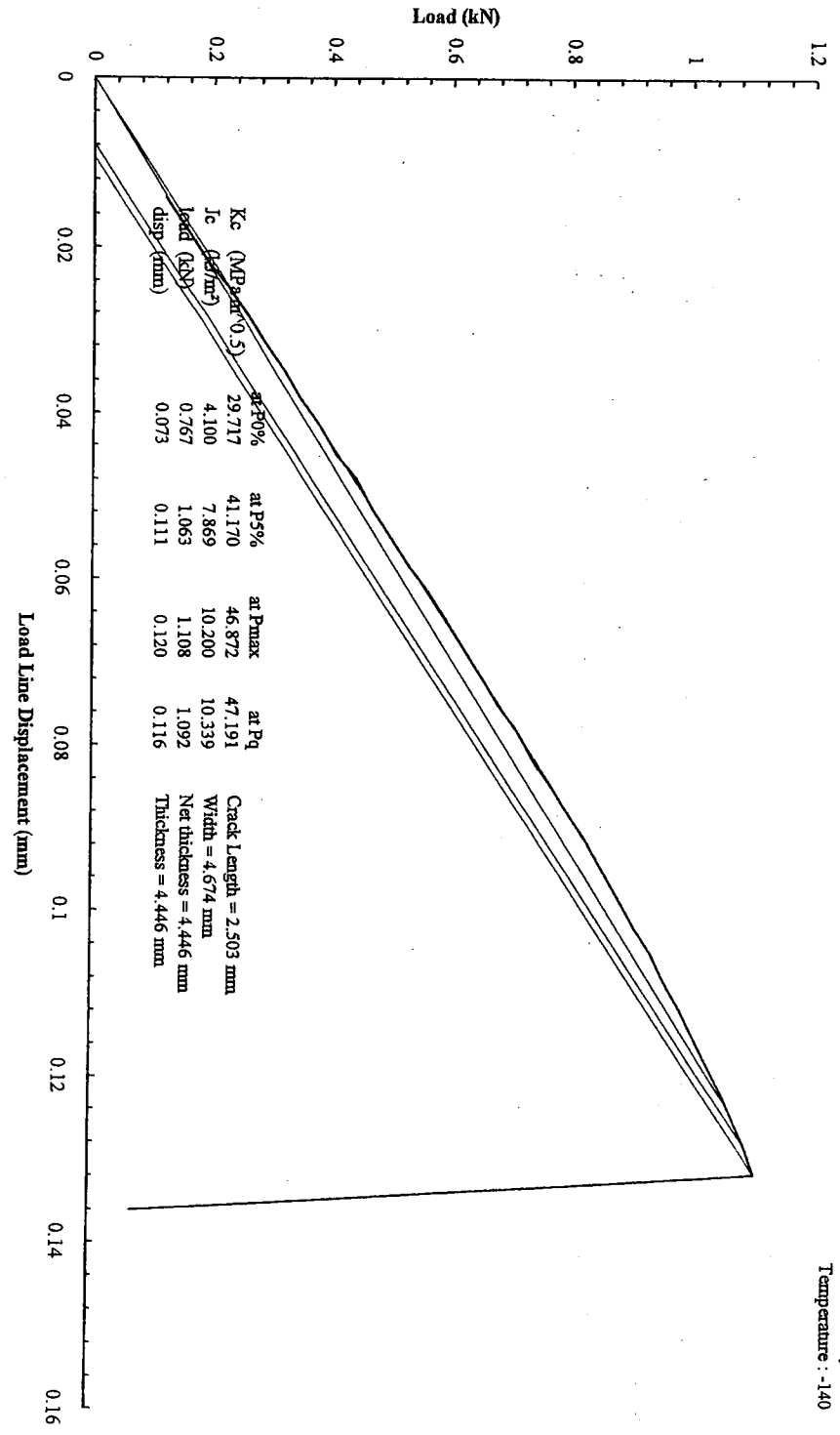


SCK-CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)

Conventie 2001  
Kjc

X5D5C.XLS  
Material : 22NiMoCr37  
Specimen id : X5D5C  
Test data : 18 May 2001  
Temperature : -140





**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6E
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.674
	Thickness (mm):	4.446
	Net thickness (mm):	4.446
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	22 May 2001
	Test operator:	LVH
	Transducer type :	N/A

Fatigue precracking	K <sub>max</sub> (MPa√m):	25.4
	R:	0.1
	K <sub>final</sub> (MPa√m):	19.4

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
	a <sub>0</sub>		Δa <sub>0</sub>	
	a <sub>0_1</sub>	2.503	Δa <sub>0_1</sub>	0.000
	a <sub>0_2</sub>	2.255	Δa <sub>0_2</sub>	0.000
	a <sub>0_3</sub>	2.445	Δa <sub>0_3</sub>	0.000
	a <sub>0_4</sub>	2.559	Δa <sub>0_4</sub>	0.000
	a <sub>0_5</sub>	2.583	Δa <sub>0_5</sub>	0.000
	a <sub>0_6</sub>	2.589	Δa <sub>0_6</sub>	0.000
	a <sub>0_7</sub>	2.585	Δa <sub>0_7</sub>	0.000
	a <sub>0_8</sub>	2.555	Δa <sub>0_8</sub>	0.000
	a <sub>0_9</sub>	2.445	Δa <sub>0_9</sub>	0.000
	a <sub>0_9</sub>	2.270	Δa <sub>0_9</sub>	0.000

Fracture toughness	J <sub>c</sub> (kJ/m²):	10.34
	K <sub>Jc</sub> (MPa√m):	47.19

Remarks	0
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Signature:

### Measure of Ao and Af

Date: 2001-05-23 File: X5D6E.xls Directory: NT\Mec\_Test\test22nimocr37\Mini\_PCCVA

Material: 22NiMoCr37

Charpy nr.: X5D6E

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.674 Bn \* (mm): 4.428 Bn (mm): 4.446 U (mm): 4.446

Picture W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B : 0.044 mm Span (mm): 18.400  
10% B : 0.542 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

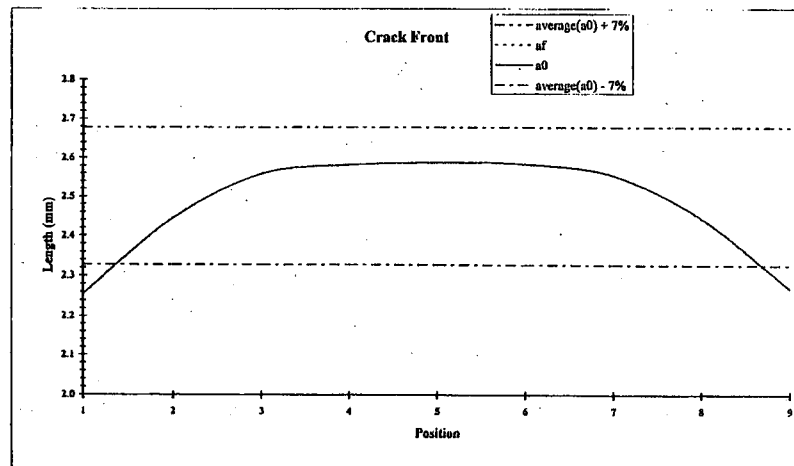
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPaVm): 25.385  
Kfinal (MPaVm): 19.365

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.255	-9.91%	af1	2.255	-9.91%	Δ a1	0.000	0.00%
a02	2.445	-2.31%	af2	2.445	-2.31%	Δ a2	0.000	0.00%
a03	2.559	2.24%	af3	2.559	2.24%	Δ a3	0.000	0.00%
a04	2.583	3.20%	af4	2.583	3.20%	Δ a4	0.000	0.00%
a05	2.589	3.44%	af5	2.589	3.44%	Δ a5	0.000	0.00%
a06	2.585	3.28%	af6	2.585	3.28%	Δ a6	0.000	0.00%
a07	2.555	2.08%	af6	2.555	2.08%	Δ a7	0.000	0.00%
a08	2.445	-2.31%	af8	2.445	-2.31%	Δ a8	0.000	0.00%
a09	2.270	-9.31%	af9	2.270	-9.31%	Δ a9	0.000	0.00%
Average a0	2.503		Average af	2.503		-gem.	0.000	

Remark:



### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6H
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.521
	Thickness (mm):	4.438
	Net thickness (mm):	4.438
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	23 May 2001
	Test operator:	L VH
	Transducer type :	N/A

Fatigue precracking	K <sub>max</sub> (MPa√m):	27.4
	R:	0.1
	K <sub>final</sub> (MPa√m):	19.3

Crack	Initial crack length (mm):	Ductile crack extension (mm):		
	a <sub>0</sub>	2.346	Δa <sub>0</sub>	0.000
	a <sub>0_1</sub>	2.092	Δa <sub>0_1</sub>	0.000
	a <sub>0_2</sub>	2.271	Δa <sub>0_2</sub>	0.000
	a <sub>0_3</sub>	2.373	Δa <sub>0_3</sub>	0.000
	a <sub>0_4</sub>	2.425	Δa <sub>0_4</sub>	0.000
	a <sub>0_5</sub>	2.436	Δa <sub>0_5</sub>	0.000
	a <sub>0_6</sub>	2.432	Δa <sub>0_6</sub>	0.000
	a <sub>0_7</sub>	2.381	Δa <sub>0_7</sub>	0.000
	a <sub>0_8</sub>	2.337	Δa <sub>0_8</sub>	0.000
	a <sub>0_9</sub>	2.137	Δa <sub>0_9</sub>	0.000

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	14.40
	K <sub>Jc</sub> (MPa√m):	55.69

Remarks: 0

Signature:



### Measure of A0 and Af

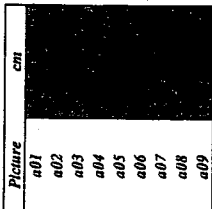
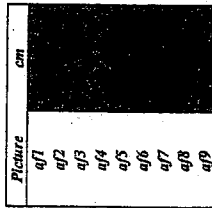
Date: 2001-05-23 File: X5D6H.xls Directory: NTM\ce\_Test\test122nimocr37\Mini\_PCCVVA1

Material: 22NiMoCr37

Charpy nr.: X5D6H

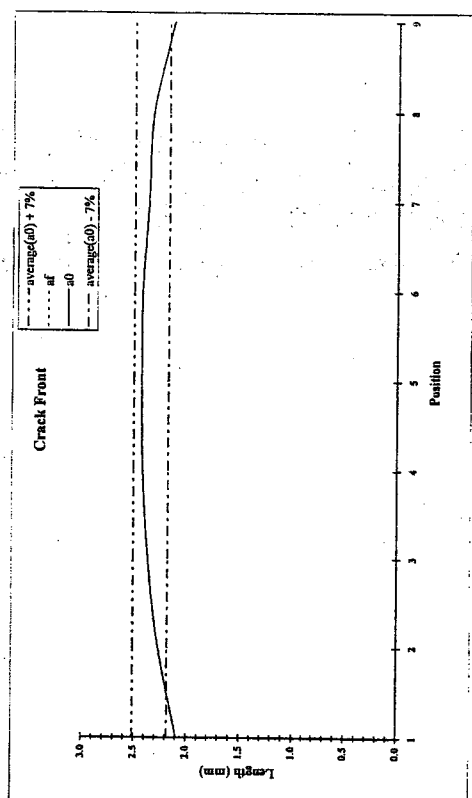
a\_fmax (mm): 1.250 Fmax (kN): 1.400 Final (kN): 0.300  
 Charpy W (mm): 4.521 Bn\* (mm): 4.398 Bn (mm): 4.438 B (mm): 4.438  
 Picture W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.044 mm Span (mm): 18.400  
 10% B 0.539 mm

Prepractring Machine: INSTRON  
 Kmax (MPaVm): 27.356  
 Kfinal (MPaVm): 19.301



Charpy	mm	error	Charpy	mm	error
a01	2.092	-10.83%	a01	2.092	-10.83%
a02	2.271	-3.20%	a02	2.271	-3.20%
a03	2.373	1.14%	a03	2.373	1.14%
a04	2.425	3.36%	a04	2.425	3.36%
a05	2.436	3.83%	a05	2.436	3.83%
a06	2.432	3.66%	a06	2.432	3.66%
a07	2.381	1.48%	a07	2.381	1.48%
a08	2.337	-0.39%	a08	2.337	-0.39%
a09	2.137	-8.92%	a09	2.137	-8.92%
Average a0	2.346		Average af	2.346	

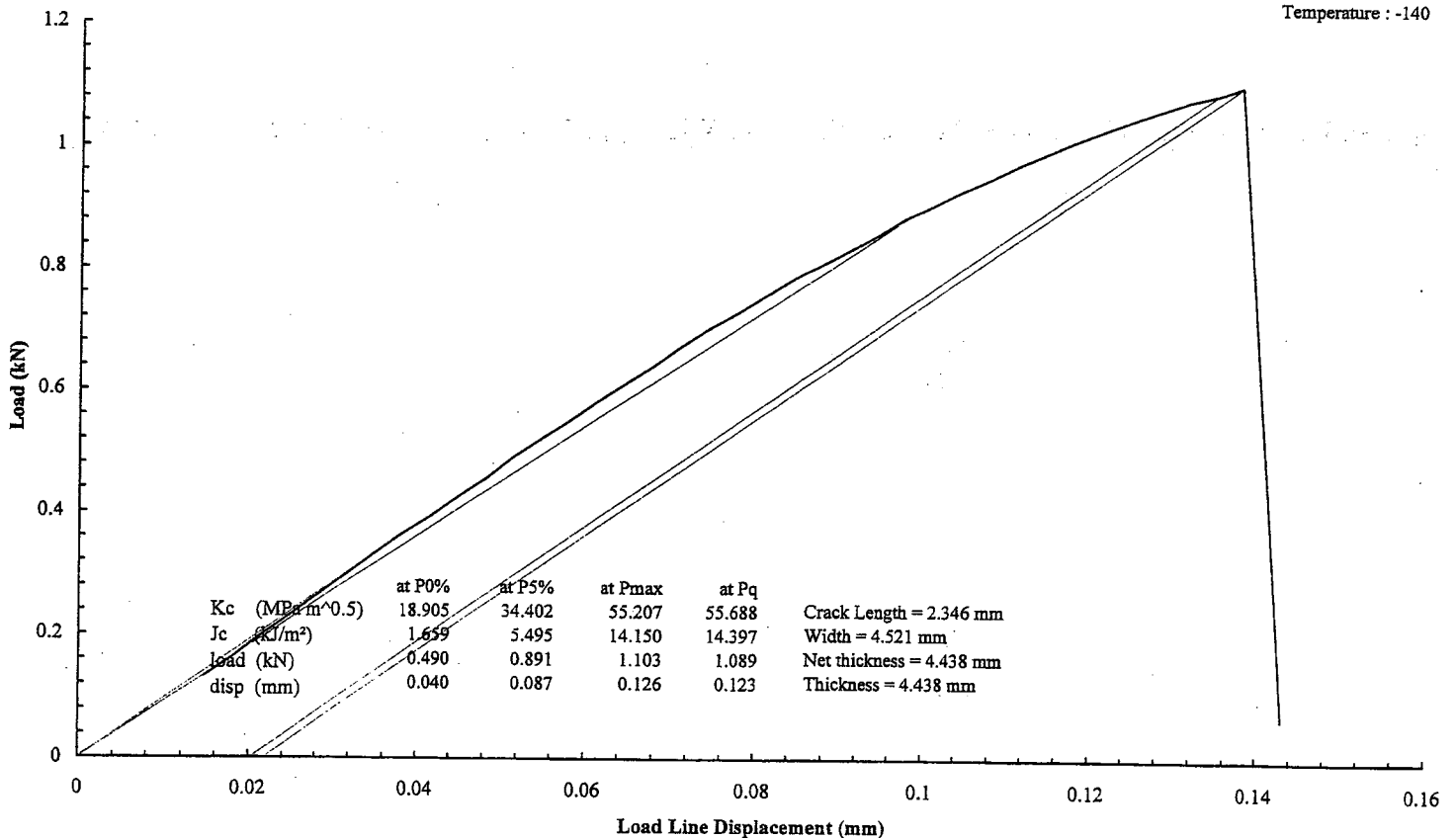
Remark: - rem.



SCK-CEN ; LHMA  
 Boerstang 200  
 B-2400 Mol (Belgium)

Conventie 2001  
 Kjc

X5D6H.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D6H  
 Test data : 23 May 2001  
 Temperature : -140



**3PB FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6C
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.477
	Thickness (mm):	4.419
Net thickness (mm):	4.419	
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	21 May 2001
	Test operator:	LVH
	Transducer type :	N/A

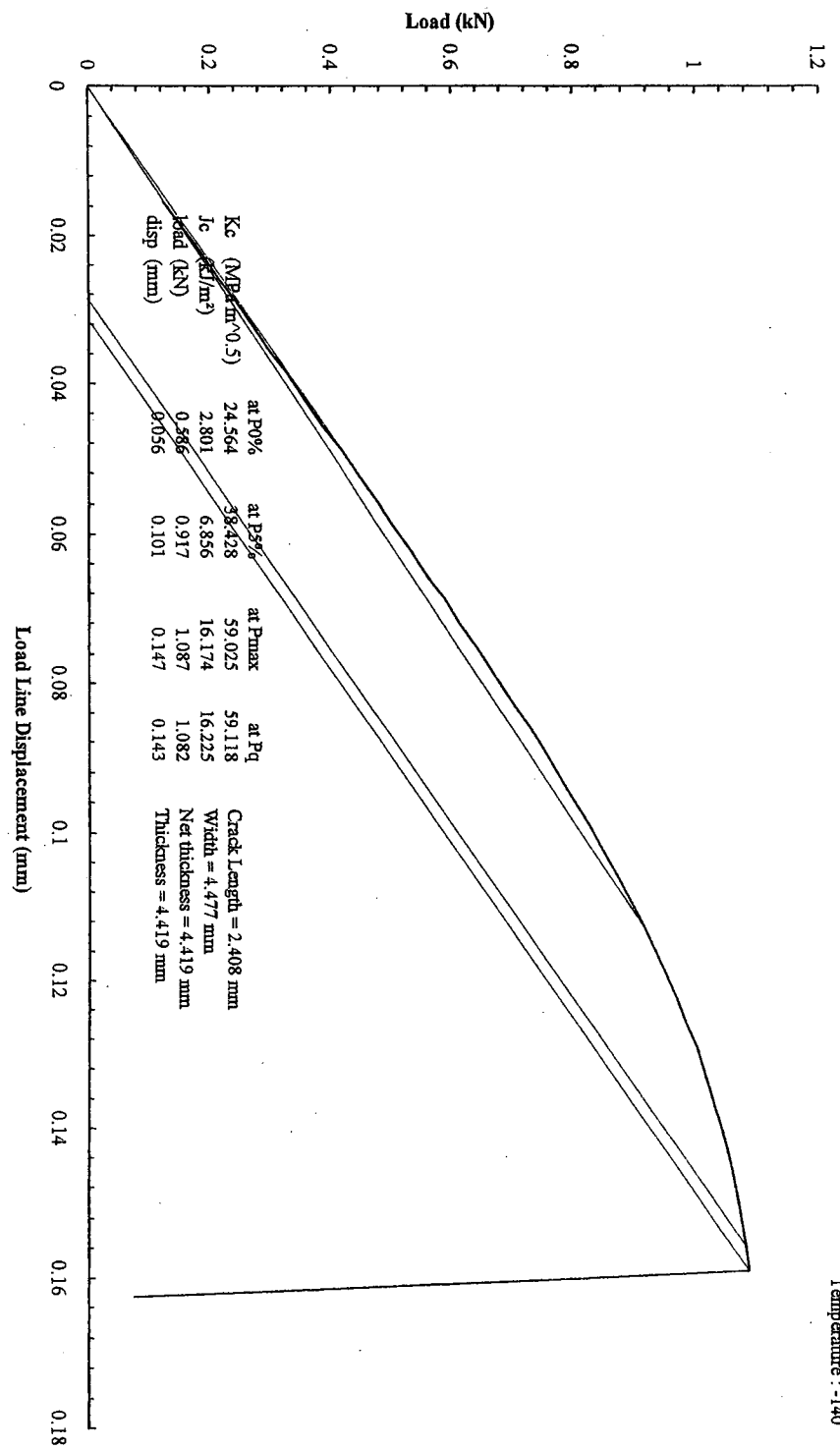
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	28.1
	R:	0.1
	$K_{final}$ (MPa√m):	20.9

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):		
	$a_0$	2.408	$\Delta a_0$	0.000
	$a_{0_1}$	2.193	$\Delta a_{0_1}$	0.000
	$a_{0_2}$	2.384	$\Delta a_{0_2}$	0.000
	$a_{0_3}$	2.464	$\Delta a_{0_3}$	0.000
	$a_{0_4}$	2.486	$\Delta a_{0_4}$	0.000
	$a_{0_5}$	2.487	$\Delta a_{0_5}$	0.000
	$a_{0_6}$	2.476	$\Delta a_{0_6}$	0.000
	$a_{0_7}$	2.437	$\Delta a_{0_7}$	0.000
	$a_{0_8}$	2.347	$\Delta a_{0_8}$	0.000
	$a_{0_9}$	2.171	$\Delta a_{0_9}$	0.000

<b>Fracture toughness</b>	$J_c$ (kJ/m <sup>2</sup> ):	16.23
	$K_{Jc}$ (MPa√m):	59.12

<b>Remarks</b>	0
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Signature: 



### Measure of Ao and Af

Date: 2001-05-23 File: X5D6C.xls Directory: NT\Mec\_Tes\test\22nimocr37\Mini\_PCCV\A

Material: 22NiMoCr37

Charpy nr.: X5D6C

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.477 Ba\* (mm): 4.468 Ba (mm): 4.419 B (mm): 4.419

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.044 mm  
10% B 0.547 mm

Span (mm): 18.400

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

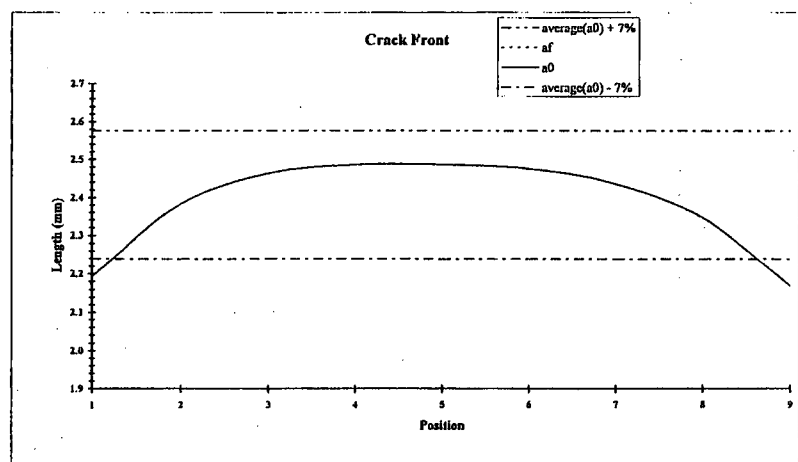
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 28.073  
Kfinal (MPa√m): 20.947

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.193	-8.92%	af1	2.193	-8.92%	Δa1	0.000	0.00%
a02	2.384	-0.99%	af2	2.384	-0.99%	Δa2	0.000	0.00%
a03	2.464	2.33%	af3	2.464	2.33%	Δa3	0.000	0.00%
a04	2.486	3.24%	af4	2.486	3.24%	Δa4	0.000	0.00%
a05	2.487	3.29%	af5	2.487	3.29%	Δa5	0.000	0.00%
a06	2.476	2.83%	af6	2.476	2.83%	Δa6	0.000	0.00%
a07	2.437	1.21%	af6	2.437	1.21%	Δa7	0.000	0.00%
a08	2.347	-2.53%	af8	2.347	-2.53%	Δa8	0.000	0.00%
a09	2.171	-9.84%	af9	2.171	-9.84%	Δa9	0.000	0.00%
Average a0	2.408		Average af	2.408		-gem.	0.000	

Remark:



### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D5H
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.668
	Thickness (mm):	4.534
	Net thickness (mm):	4.534
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	21 May 2001
	Test operator:	LVH
	Transducer type:	N/A

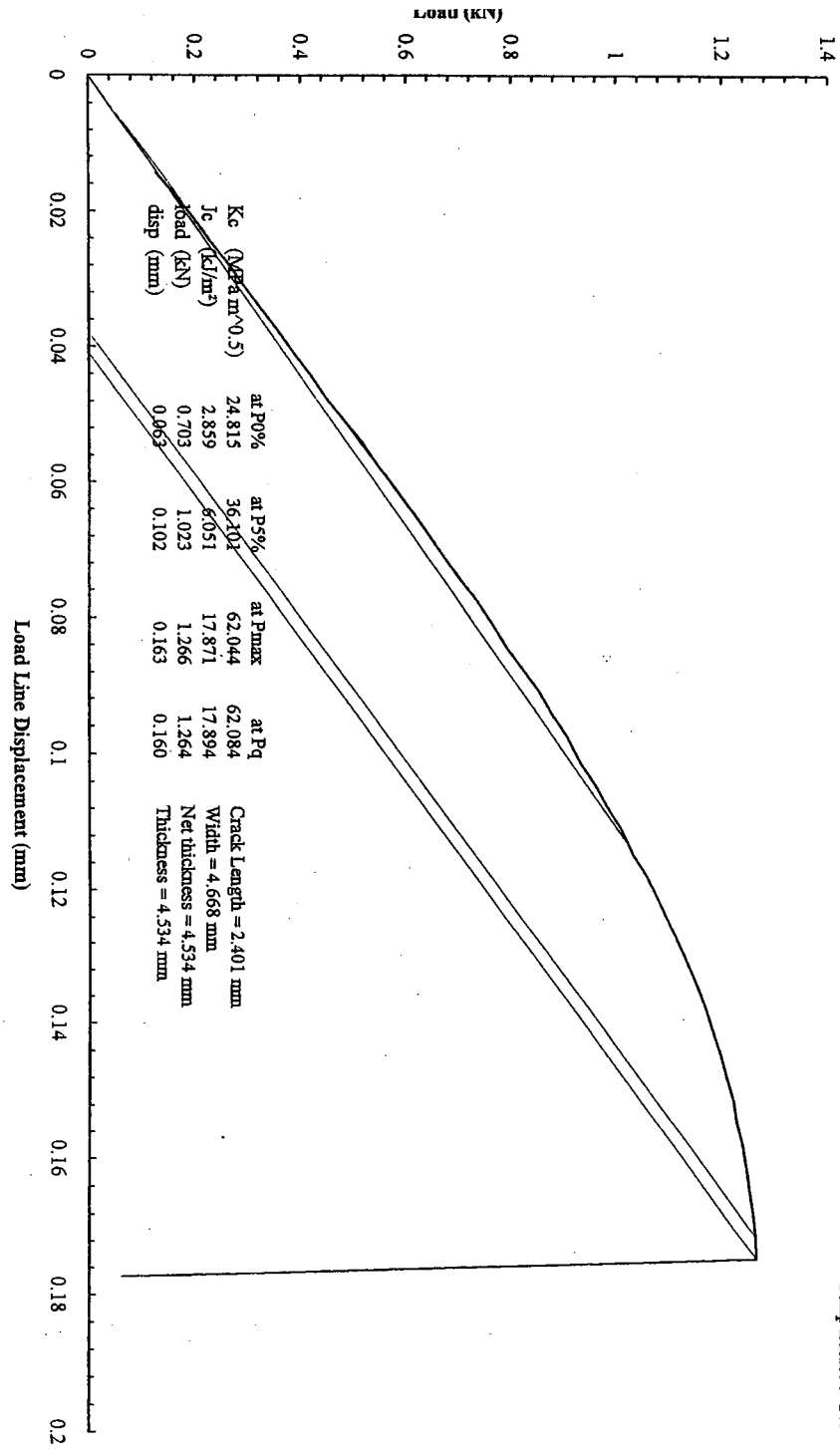
Fatigue precracking	K <sub>max</sub> (MPa√m):	25.0
	R:	0.1
	K <sub>final</sub> (MPa√m):	17.7

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a0	2.401	Δa0 0.000
a0_1	2.134	Δa0_1 0.000
a0_2	2.344	Δa0_2 0.000
a0_3	2.440	Δa0_3 0.000
a0_4	2.472	Δa0_4 0.000
a0_5	2.494	Δa0_5 0.000
a0_6	2.482	Δa0_6 0.000
a0_7	2.448	Δa0_7 0.000
a0_8	2.371	Δa0_8 0.000
a0_9	2.174	Δa0_9 0.000

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	17.89
	K <sub>Jc</sub> (MPa√m):	62.08

Remarks	0
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Signature:



SCK-CEN: LHM/A  
 Boerlang 200  
 B-2400 Mol (Belgium)

Conventie 2001  
 Kjc

XSD5H.XLS  
 Material : 22NiMoCr37  
 Specimen id : XSD5H  
 Test data : 21 May 2001  
 Temperature : -140

### Measure of Ao and Af

Date: 2001-05-23 File: XSD5H.xls Directory: NT\Mec\_Test\test22nimocr37\Mini\_PCCVVA

Material: 22NiMoCr37

Charpy nr.: XSD5H

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.668 Bn\* (mm): 4.472 Bn (mm): 4.534 B (mm): 4.534

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
 10% B 0.548 mm

Precracking Machine: INSTRON

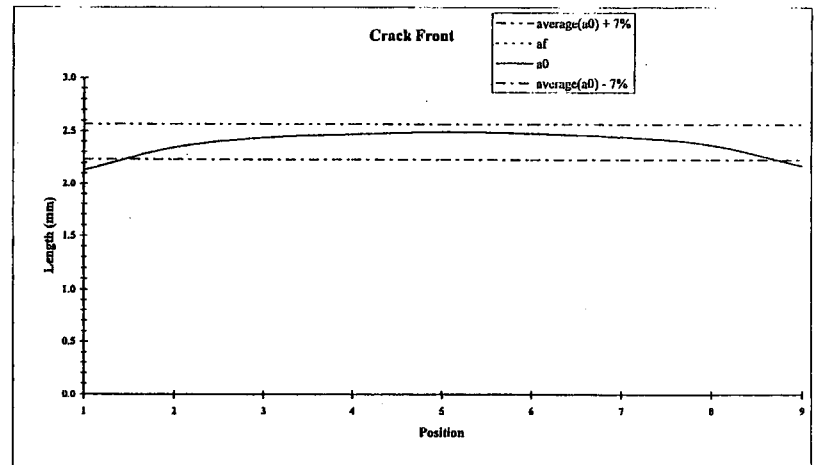
Kmax (MPaVm): 24.962  
 Kfinal (MPaVm): 17.734

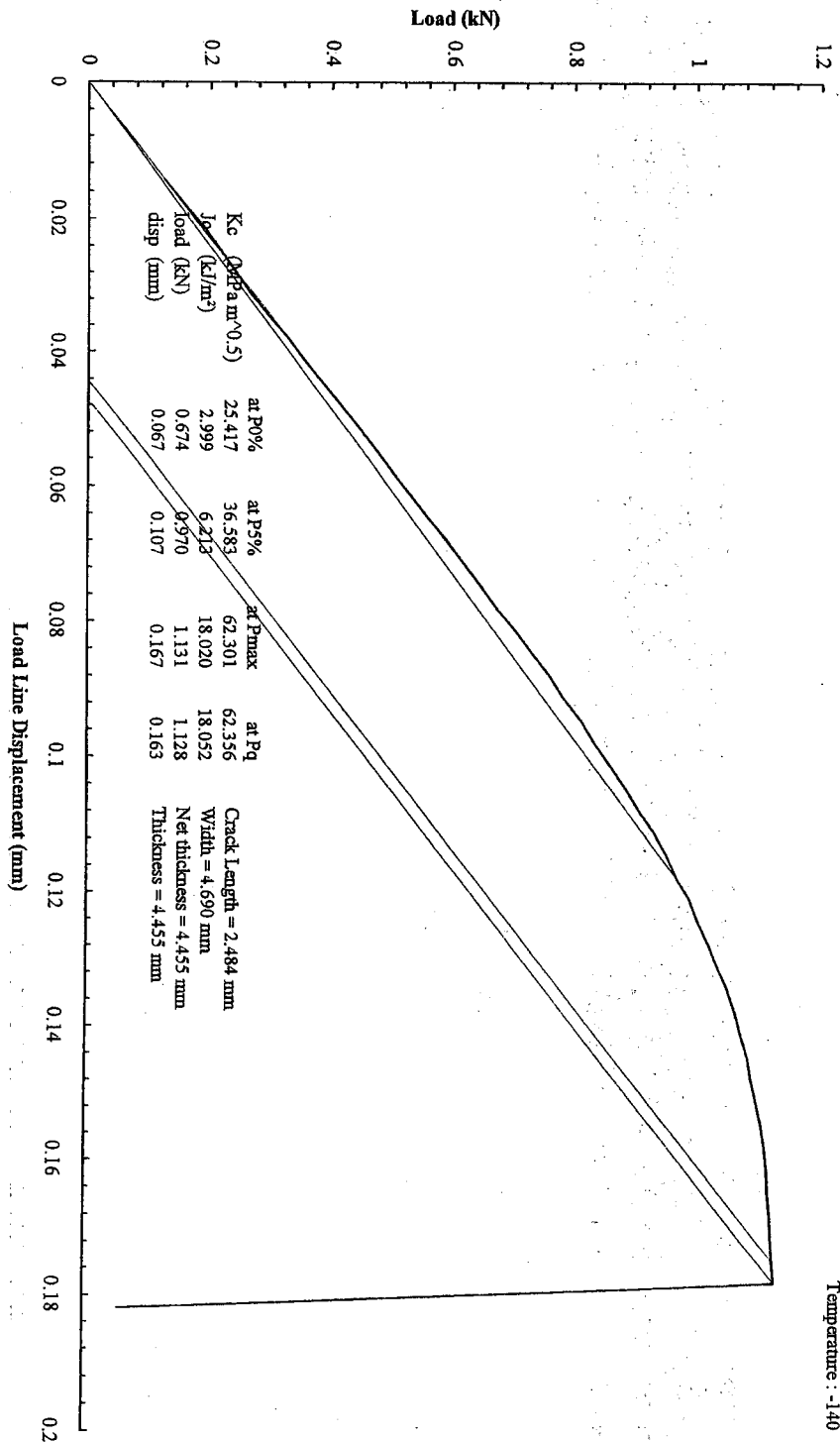
Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.134	-11.11%	af1	2.134	-11.11%	Δ a1	0.000	0.00%
a02	2.344	-2.36%	af2	2.344	-2.36%	Δ a2	0.000	0.00%
a03	2.440	1.64%	af3	2.440	1.64%	Δ a3	0.000	0.00%
a04	2.472	2.97%	af4	2.472	2.97%	Δ a4	0.000	0.00%
a05	2.494	3.89%	af5	2.494	3.89%	Δ a5	0.000	0.00%
a06	2.482	3.39%	af6	2.482	3.39%	Δ a6	0.000	0.00%
a07	2.448	1.97%	af6	2.448	1.97%	Δ a7	0.000	0.00%
a08	2.371	-1.23%	af8	2.371	-1.23%	Δ a8	0.000	0.00%
a09	2.174	-9.44%	af9	2.174	-9.44%	Δ a9	0.000	0.00%
Average a0	2.401		Average af	2.401		- gem.	0.000	

Remark:





SCK-CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)

Date: 2001-07-05  
Softwar: KJC\_3PBv4.xls

### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6F
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.69
	Thickness (mm):	4.455
	Net thickness (mm):	4.455
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	22 May 2001
	Test operator:	LVH
	Transducer type :	N/A

Fatigue precracking	K <sub>max</sub> (MPa√m):	25.1
	R:	0.1
	K <sub>final</sub> (MPa√m):	18.9

Crack	Initial crack length (mm):	Ductile crack extension (mm):
	a <sub>0</sub>	2.484
	Δa <sub>0</sub>	0.000
	a <sub>0_1</sub>	2.299
	Δa <sub>0_1</sub>	0.000
	a <sub>0_2</sub>	2.497
	Δa <sub>0_2</sub>	0.000
	a <sub>0_3</sub>	2.573
	Δa <sub>0_3</sub>	0.000
	a <sub>0_4</sub>	2.516
	Δa <sub>0_4</sub>	0.000
	a <sub>0_5</sub>	2.525
	Δa <sub>0_5</sub>	0.000
	a <sub>0_6</sub>	2.572
	Δa <sub>0_6</sub>	0.000
	a <sub>0_7</sub>	2.512
	Δa <sub>0_7</sub>	0.000
	a <sub>0_8</sub>	2.413
	Δa <sub>0_8</sub>	0.000
	a <sub>0_9</sub>	2.229
	Δa <sub>0_9</sub>	0.000

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	18.05
	K <sub>Jc</sub> (MPa√m):	62.36

Remarks	0
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Signature:

**Measure of Ao and Af**

Date: 2001-05-23 File: X5D6F.xls Directory: NT\Mec\_Test\test\22nimocr37\Mini\_PCCVA

Material: 22NiMoCr37

Charpy nr.: X5D6F

a<sub>fmax</sub> (mm): 1.250 F<sub>max</sub> (kN): 1.400 F<sub>final</sub> (kN): 0.500

Charpy W (mm): 4.690 Bn\* (mm): 4.381 Ba (mm): 4.455 B (mm): 4.455

Picture W (cm): Bn\* (cm): Ba (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
10% B 0.536 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

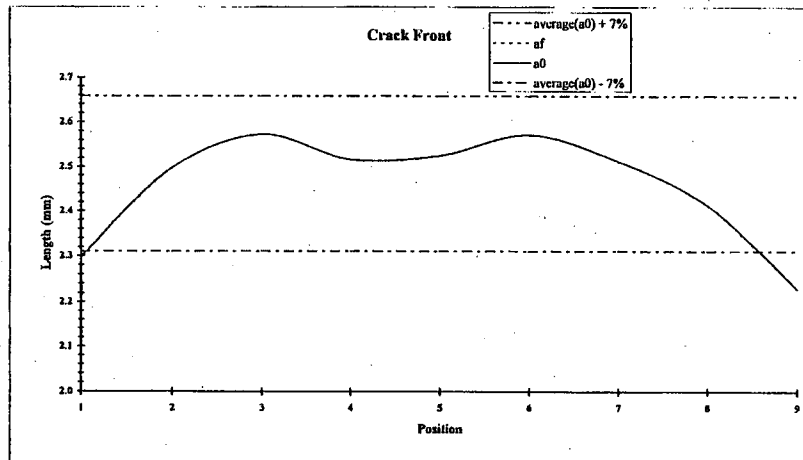
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

K<sub>max</sub> (MPa√m): 25.145  
K<sub>final</sub> (MPa√m): 18.852

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.299	-7.45%	af1	2.299	-7.45%	Δ a1	0.000	0.00%
a02	2.497	0.52%	af2	2.497	0.52%	Δ a2	0.000	0.00%
a03	2.573	3.58%	af3	2.573	3.58%	Δ a3	0.000	0.00%
a04	2.516	1.29%	af4	2.516	1.29%	Δ a4	0.000	0.00%
a05	2.525	1.65%	af5	2.525	1.65%	Δ a5	0.000	0.00%
a06	2.572	3.54%	af6	2.572	3.54%	Δ a6	0.000	0.00%
a07	2.512	1.13%	af6	2.512	1.13%	Δ a7	0.000	0.00%
a08	2.413	-2.86%	af8	2.413	-2.86%	Δ a8	0.000	0.00%
a09	2.229	-10.27%	af9	2.229	-10.27%	Δ a9	0.000	0.00%
Average a0	2.484		Average af	2.484		-gem.	0.000	

Remark:



**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6A
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.731
	Thickness (mm):	4.485
	Net thickness (mm):	4.485
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	21 May 2001
	Test operator:	LVH
	Transducer type:	N/A

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.5
	R:	0.1
	K <sub>final</sub> (MPa√m):	21.0

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	2.680	Δa <sub>0</sub> 0.000
a <sub>0_1</sub>	2.336	Δa <sub>0_1</sub> 0.000
a <sub>0_2</sub>	2.562	Δa <sub>0_2</sub> 0.000
a <sub>0_3</sub>	2.675	Δa <sub>0_3</sub> 0.000
a <sub>0_4</sub>	2.743	Δa <sub>0_4</sub> 0.000
a <sub>0_5</sub>	2.769	Δa <sub>0_5</sub> 0.000
a <sub>0_6</sub>	2.797	Δa <sub>0_6</sub> 0.000
a <sub>0_7</sub>	2.779	Δa <sub>0_7</sub> 0.000
a <sub>0_8</sub>	2.695	Δa <sub>0_8</sub> 0.000
a <sub>0_9</sub>	2.505	Δa <sub>0_9</sub> 0.000

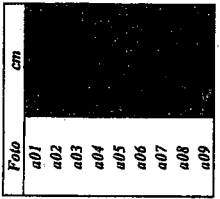
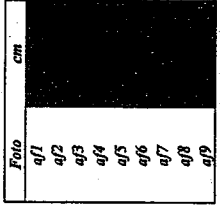
Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	19.72
	K <sub>Jc</sub> (MPa√m):	65.18

Remarks	0
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Signature:

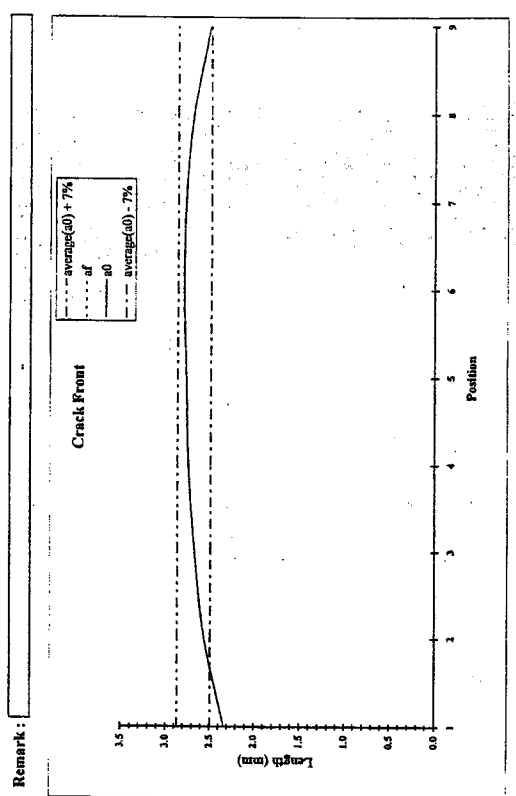
### Measure of Ao and Af

Date: 2001-05-22 File: X5D6A.xls Directory: NTWec\_Testtest22nimocr37Mini\_PCCVMA  
 Material: 22NiMoCr37 Charpy nr.: X5D6A  
 a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500  
 Charpy W (mm): 4.731 Bn\* (mm): 4.485 Bn (mm): 4.485 B (mm): 4.485  
 Foto W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.045 mm Span (mm): 18.400  
 10% B 0.549 mm



Prestraking Machine: RAYSTRON  
 Kmax (MPaVm): 24.508  
 Kfinal (MPaVm): 20.994

Charpy	mm	error	Charpy	mm	error
a01	2.336	-12.84%	a11	2.336	-12.84%
a02	2.562	-4.41%	a12	2.562	-4.41%
a03	2.675	-0.19%	a13	2.675	-0.19%
a04	2.743	2.35%	a14	2.743	2.35%
a05	2.769	3.32%	a15	2.769	3.32%
a06	2.797	4.36%	a16	2.797	4.36%
a07	2.779	3.69%	a17	2.779	3.69%
a08	2.695	0.56%	a18	2.695	0.56%
a09	2.505	-6.53%	a19	2.505	-6.53%
af gen.	2.680		af gen.	2.680	

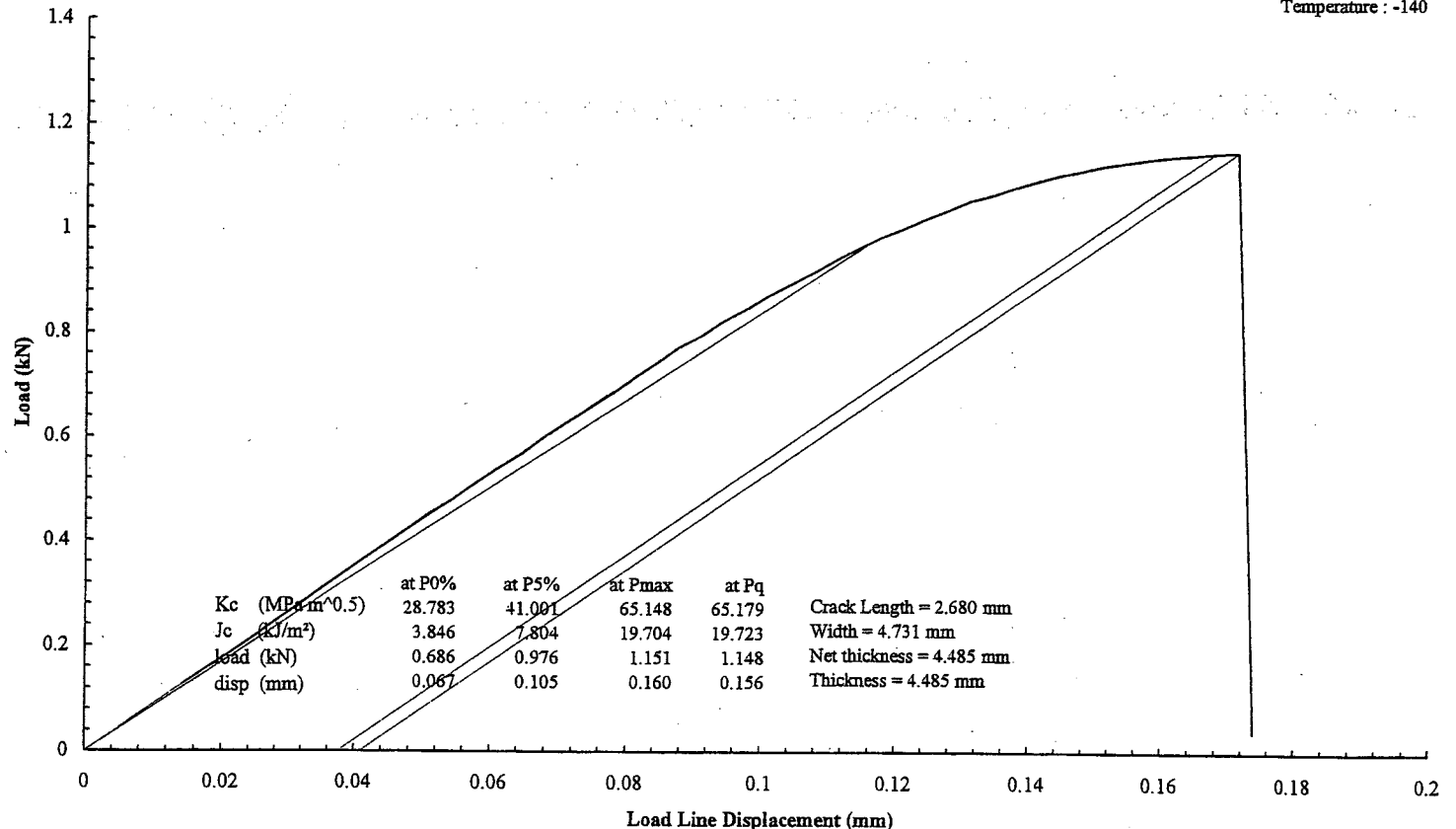


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Conventie 2001  
 Kjc

X5D6A.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D6A  
 Test data : 21 May 2001  
 Temperature : -140



Date: 2001-07-05  
Software: KJC\_3PBv5.xls

### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6G
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.587
	Thickness (mm):	4.478
	Net thickness (mm):	4.478
	Side grooving:	0%


Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	22 May 2001
	Test operator:	LVH
	Transducer type :	N/A

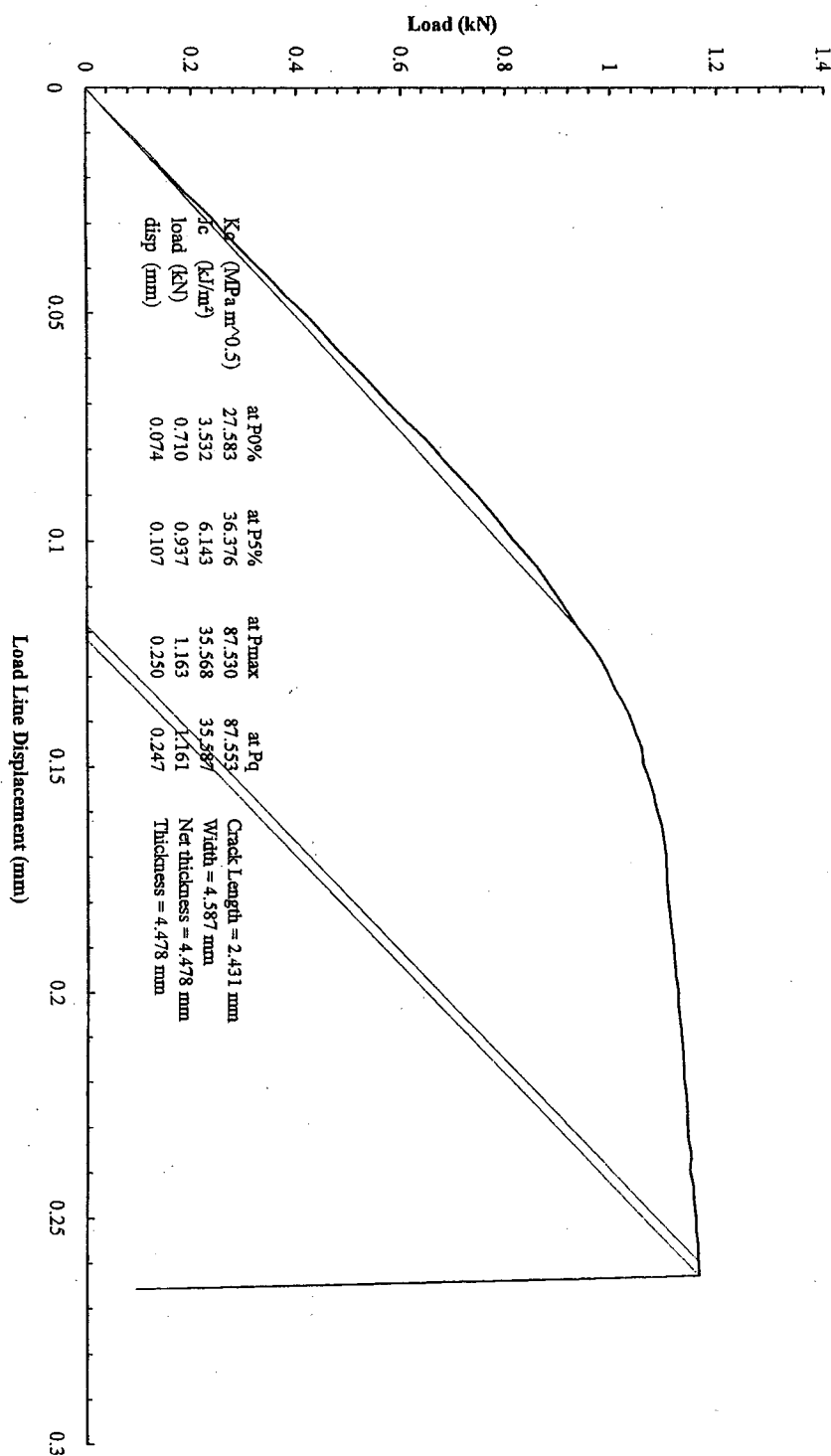
Fatigue precracking	$K_{max}$ (MPa√m):	26.3
	R:	0.1
	$K_{final}$ (MPa√m):	19.4

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
		$a_0$	2.431	$\Delta a_0$
	$a_{0\_1}$	2.296	$\Delta a_{0\_1}$	0.000
	$a_{0\_2}$	2.455	$\Delta a_{0\_2}$	0.000
	$a_{0\_3}$	2.509	$\Delta a_{0\_3}$	0.000
	$a_{0\_4}$	2.525	$\Delta a_{0\_4}$	0.000
	$a_{0\_5}$	2.519	$\Delta a_{0\_5}$	0.000
	$a_{0\_6}$	2.488	$\Delta a_{0\_6}$	0.000
	$a_{0\_7}$	2.436	$\Delta a_{0\_7}$	0.000
	$a_{0\_8}$	2.321	$\Delta a_{0\_8}$	0.000
	$a_{0\_9}$	2.095	$\Delta a_{0\_9}$	0.000

Fracture toughness	$J_c$ (kJ/m <sup>2</sup> ):	35.59
	$K_{Jc}$ (MPa√m):	87.55

Remarks	
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Signature: 





**Measure of Ao and Af**

Date: 2001-05-23 File: X5D6G.xls Directory: NTMec\_Test\test\22nimocr37\Mini\_PCCVVA

Material: 22NiMoCr37

Charpy nr.: X5D6G

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.587 Bn\* (mm): 4.421 Bn (mm): 4.478 B (mm): 4.478

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
10% B 0.541 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

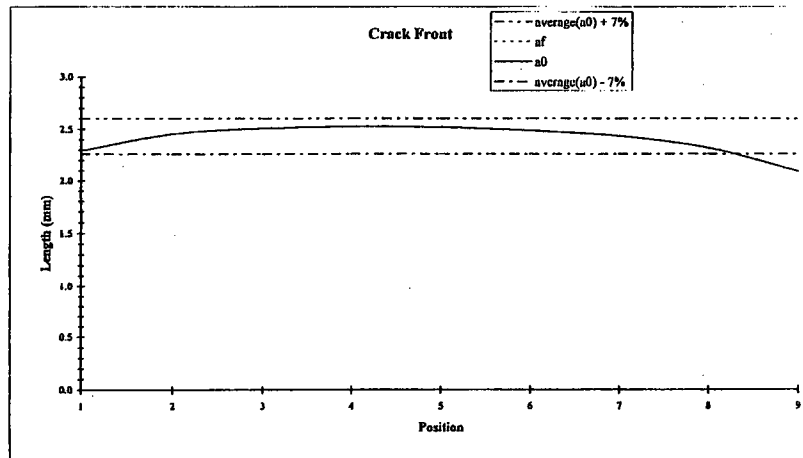
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 26.261  
Kfinal (MPa√m): 19.413

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.296	-5.56%	af1	2.296	-5.56%	Δ a1	0.000	0.00%
a02	2.455	0.98%	af2	2.455	0.98%	Δ a2	0.000	0.00%
a03	2.509	3.21%	af3	2.509	3.21%	Δ a3	0.000	0.00%
a04	2.525	3.86%	af4	2.525	3.86%	Δ a4	0.000	0.00%
a05	2.519	3.62%	af5	2.519	3.62%	Δ a5	0.000	0.00%
a06	2.488	2.34%	af6	2.488	2.34%	Δ a6	0.000	0.00%
a07	2.436	0.20%	af6	2.436	0.20%	Δ a7	0.000	0.00%
a08	2.321	-4.53%	af8	2.321	-4.53%	Δ a8	0.000	0.00%
a09	2.095	-13.82%	af9	2.095	-13.82%	Δ a9	0.000	0.00%
Average a0	2.431		Average af	2.431		- gem.	0.000	

Remark: -



**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6D
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.576
	Thickness (mm):	4.456
	Net thickness (mm):	4.456
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	22 May 2001
	Test operator:	LVH
	Transducer type:	N/A

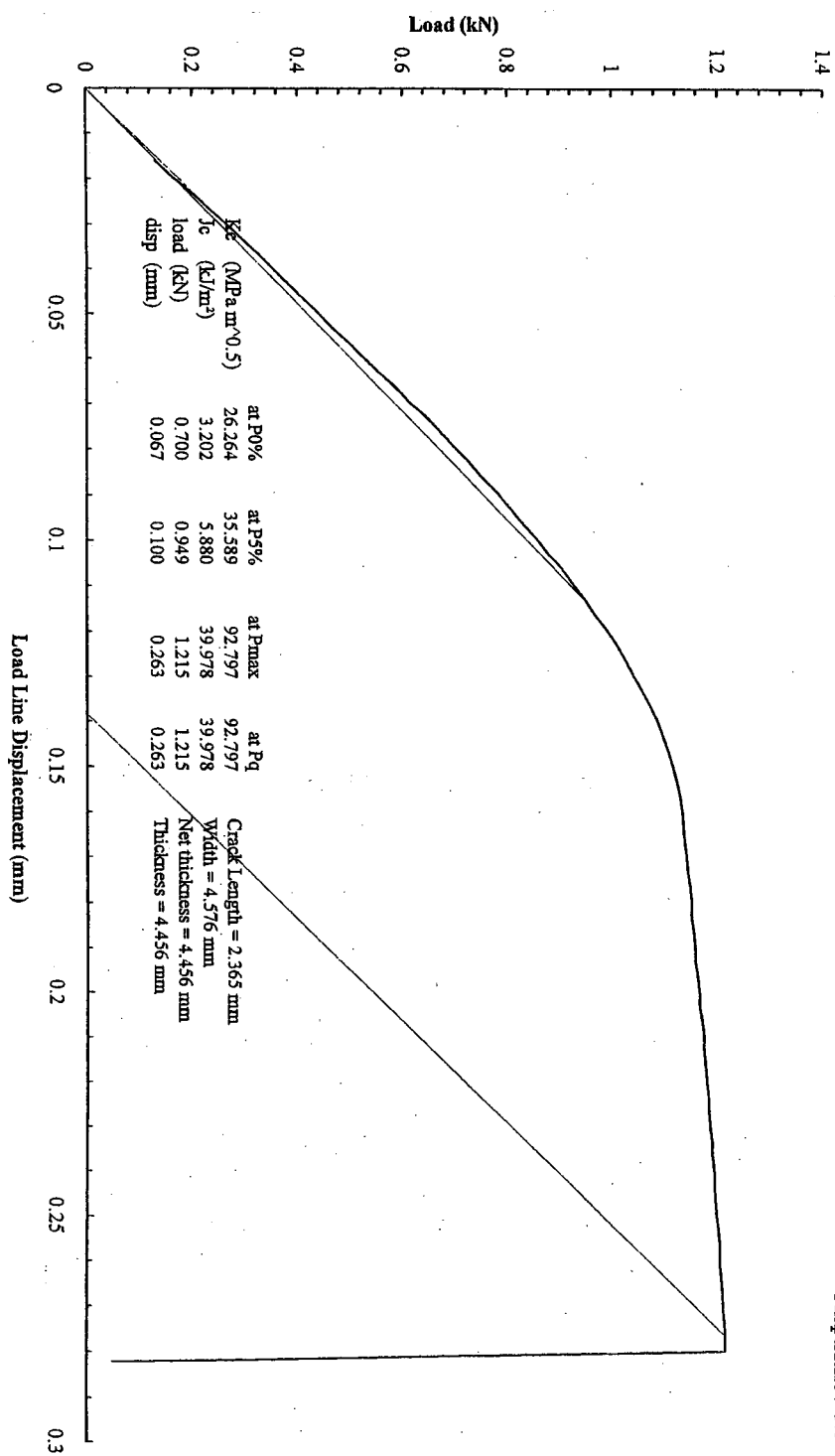
Fatigue precracking	K <sub>max</sub> (MPa√m):	26.5
	R:	0.1
	K <sub>final</sub> (MPa√m):	18.8

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	2.365	Δa <sub>0</sub> 0.000
a <sub>0_1</sub>	2.110	Δa <sub>0_1</sub> 0.000
a <sub>0_2</sub>	2.306	Δa <sub>0_2</sub> 0.000
a <sub>0_3</sub>	2.413	Δa <sub>0_3</sub> 0.000
a <sub>0_4</sub>	2.458	Δa <sub>0_4</sub> 0.000
a <sub>0_5</sub>	2.463	Δa <sub>0_5</sub> 0.000
a <sub>0_6</sub>	2.455	Δa <sub>0_6</sub> 0.000
a <sub>0_7</sub>	2.406	Δa <sub>0_7</sub> 0.000
a <sub>0_8</sub>	2.309	Δa <sub>0_8</sub> 0.000
a <sub>0_9</sub>	2.117	Δa <sub>0_9</sub> 0.000

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	39.98
	K <sub>Jc</sub> (MPa√m):	92.80

Remarks: 0

Signature:



SCK-CEN ; LHMA  
 Boerhang 200  
 B-2400 Mol (Belgium)

Conventie 2001

K<sub>Jc</sub>

XSD6D.XLS  
 Material : 22NiMoCr37  
 Specimen id : XSD6D  
 Test data : 22 May 2001  
 Temperature : -140

### Measure of A<sub>0</sub> and A<sub>f</sub>

Date: 2001-05-23 File: XSD6D.xls Directory: NTMec\_Test\test\22nimocr37\Mini\_PCCVVA

Material: 22NiMoCr37

Charpy nr.: XSD6D

a<sub>f</sub>max (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.576 Bn\* (mm): 4.408 Bn (mm): 4.456 B (mm): 4.456

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
 10% B 0.540 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

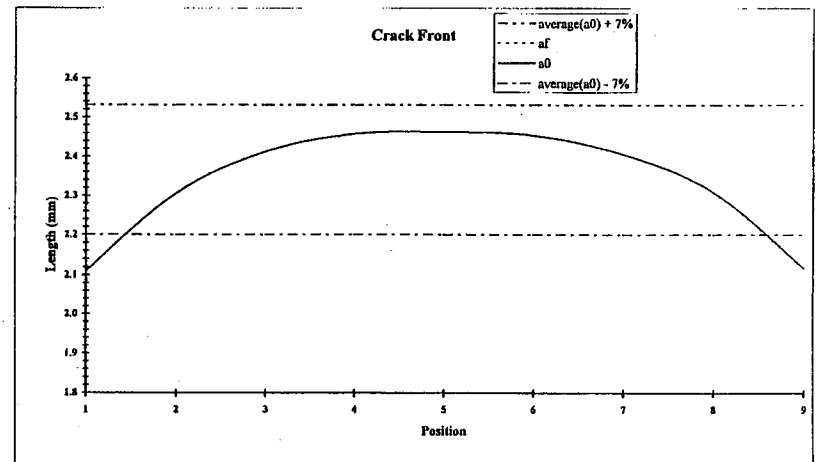
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

K<sub>max</sub> (MPaVm): 26.530  
 K<sub>final</sub> (MPaVm): 18.752

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.110	-10.80%	af1	2.110	-10.80%	Δ a1	0.000	0.00%
a02	2.306	-2.51%	af2	2.306	-2.51%	Δ a2	0.000	0.00%
a03	2.413	2.01%	af3	2.413	2.01%	Δ a3	0.000	0.00%
a04	2.458	3.91%	af4	2.458	3.91%	Δ a4	0.000	0.00%
a05	2.463	4.12%	af5	2.463	4.12%	Δ a5	0.000	0.00%
a06	2.455	3.79%	af6	2.455	3.79%	Δ a6	0.000	0.00%
a07	2.406	1.71%	af6	2.406	1.71%	Δ a7	0.000	0.00%
a08	2.309	-2.39%	af8	2.309	-2.39%	Δ a8	0.000	0.00%
a09	2.117	-10.50%	af9	2.117	-10.50%	Δ a9	0.000	0.00%
Average a0	2.365		Average af	2.365		-gem.	0.000	

Remark:



**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D5D
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.495
	Thickness (mm):	4.49
	Net thickness (mm):	4.49
	Side grooving:	0%


Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	18 May 2001
	Test operator:	PW
	Transducer type :	N/A

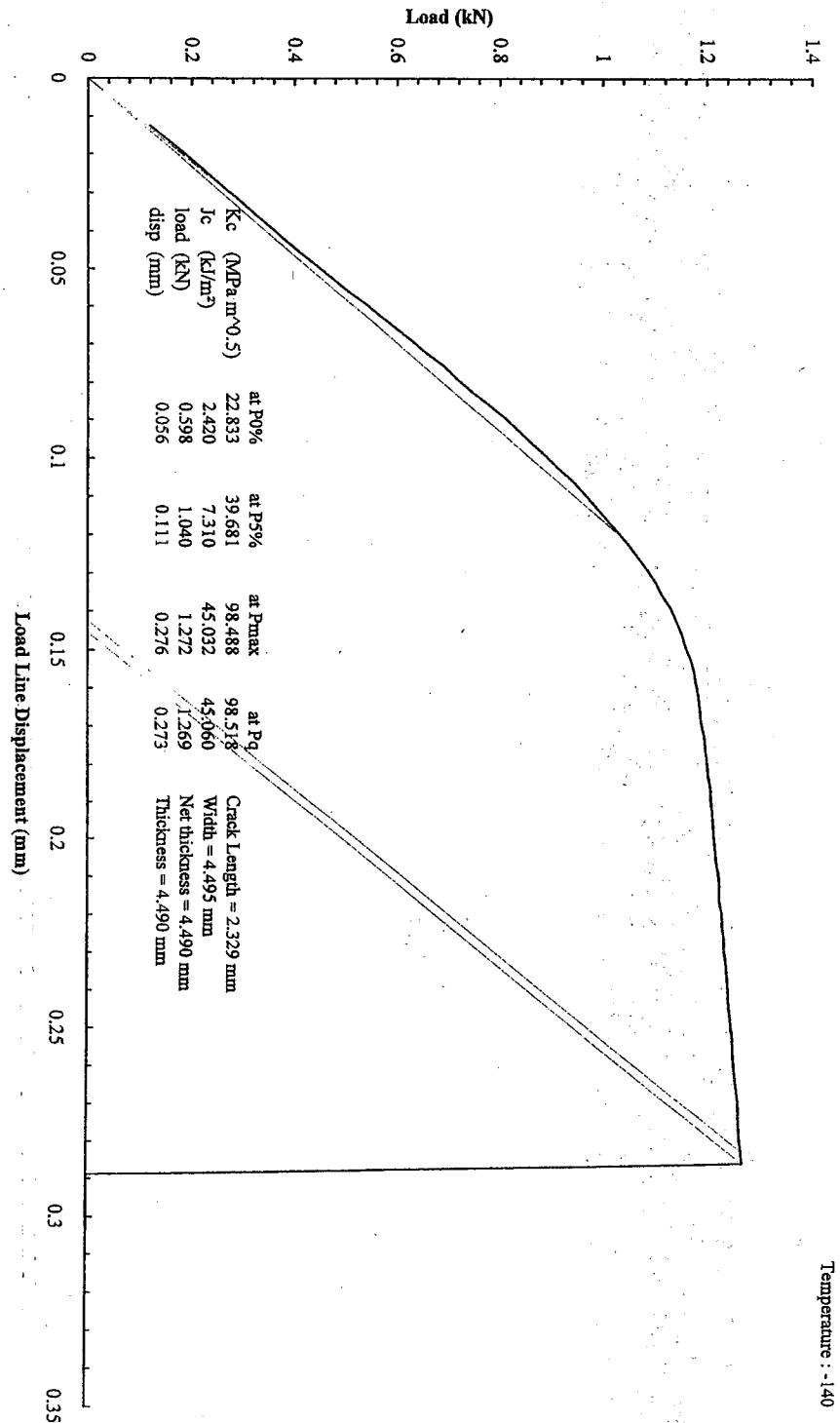
Fatigue precracking	$K_{max}$ (MPa√m):	27.4
	R:	0.1
	$K_{final}$ (MPa√m):	19.2

Crack	Initial crack length (mm):	Ductile crack extension (mm):
	$a_0$ 2.329	$\Delta a_0$ 0.000
	$a_{0_1}$ 2.114	$\Delta a_{0_1}$ 0.000
	$a_{0_2}$ 2.288	$\Delta a_{0_2}$ 0.000
	$a_{0_3}$ 2.366	$\Delta a_{0_3}$ 0.000
	$a_{0_4}$ 2.396	$\Delta a_{0_4}$ 0.000
	$a_{0_5}$ 2.393	$\Delta a_{0_5}$ 0.000
	$a_{0_6}$ 2.404	$\Delta a_{0_6}$ 0.000
	$a_{0_7}$ 2.371	$\Delta a_{0_7}$ 0.000
	$a_{0_8}$ 2.297	$\Delta a_{0_8}$ 0.000
	$a_{0_9}$ 2.116	$\Delta a_{0_9}$ 0.000

Fracture toughness	$J_c$ (kJ/m <sup>2</sup> ):	45.06
	$K_{Jc}$ (MPa√m):	98.52

Remarks	0
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Signature: 



### Measure of Ao and Af

Date: 2001-05-18 File: X5D5D.xls Directory: NTMcc\_Test\test22nimocr37\Mini\_PCCVAA

Material: 22NiMoCr37

Charpy nr.: X5D5D

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.495 Bn \* (mm): 4.372 Bn (mm): 4.490 B (mm): 4.490

Picture W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
10% B 0.535 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

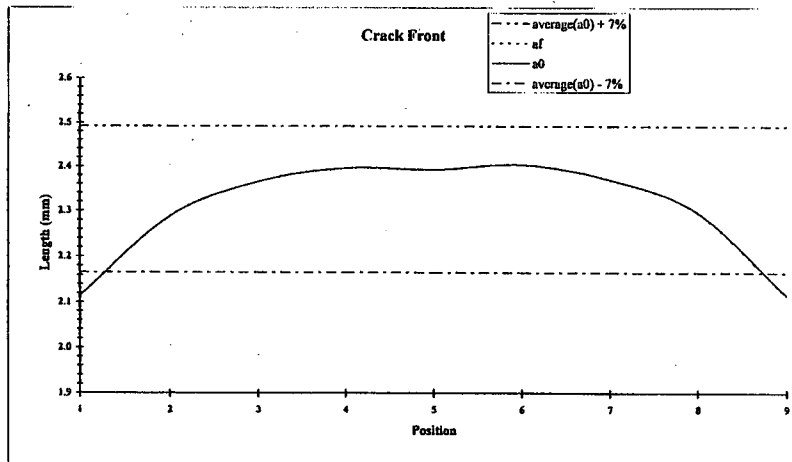
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 27.385  
Kfinal (MPa√m): 19.188

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.114	-9.22%	af1	2.114	-9.22%	Δa1	0.000	0.00%
a02	2.288	-1.75%	af2	2.288	-1.75%	Δa2	0.000	0.00%
a03	2.366	1.60%	af3	2.366	1.60%	Δa3	0.000	0.00%
a04	2.396	2.89%	af4	2.396	2.89%	Δa4	0.000	0.00%
a05	2.393	2.76%	af5	2.393	2.76%	Δa5	0.000	0.00%
a06	2.404	3.23%	af6	2.404	3.23%	Δa6	0.000	0.00%
a07	2.371	1.81%	af6	2.371	1.81%	Δa7	0.000	0.00%
a08	2.297	-1.36%	af8	2.297	-1.36%	Δa8	0.000	0.00%
a09	2.116	-9.14%	af9	2.116	-9.14%	Δa9	0.000	0.00%
Average a0	2.329		Average af	2.329		-gem.	0.000	

Remark:



### 3PB FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D6B
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.63
	Thickness (mm):	4.41
	Net thickness (mm):	4.41
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	21 May 2001
	Test operator:	LVH
	Transducer type:	N/A

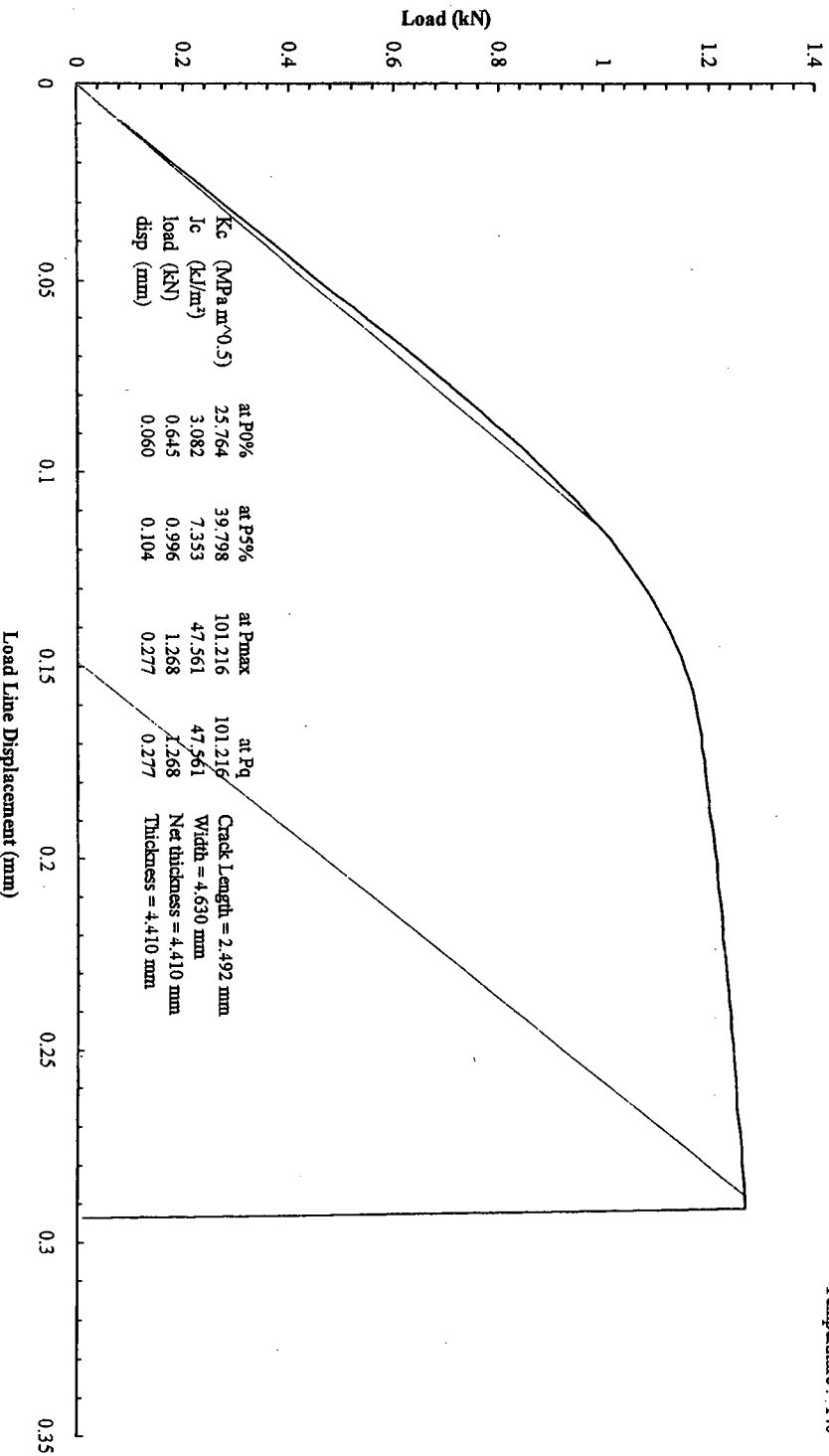
Fatigue precracking	K <sub>max</sub> (MPa√m):	26.1
	R:	0.1
	K <sub>final</sub> (MPa√m):	20.0

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	2.492	Δa <sub>0</sub> 0.000
a <sub>0_1</sub>	2.252	Δa <sub>0_1</sub> 0.000
a <sub>0_2</sub>	2.438	Δa <sub>0_2</sub> 0.000
a <sub>0_3</sub>	2.544	Δa <sub>0_3</sub> 0.000
a <sub>0_4</sub>	2.589	Δa <sub>0_4</sub> 0.000
a <sub>0_5</sub>	2.598	Δa <sub>0_5</sub> 0.000
a <sub>0_6</sub>	2.586	Δa <sub>0_6</sub> 0.000
a <sub>0_7</sub>	2.533	Δa <sub>0_7</sub> 0.000
a <sub>0_8</sub>	2.422	Δa <sub>0_8</sub> 0.000
a <sub>0_9</sub>	2.192	Δa <sub>0_9</sub> 0.000

Fracture toughness	J <sub>c</sub> (kJ/m²):	47.56
	K <sub>Ic</sub> (MPa√m):	101.22

Remarks: 0

Signature:



SCK-CEN : ITHMA  
 Boerang 200  
 B-2400 Mol (Belgium)

Conventie 2001

K<sub>Jc</sub>

X5D6B.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D6B  
 Test data : 21 May 2001  
 Temperature : -140

### Measure of Ao and Af

Date: 2001-05-23 File: X5D6B.xls Directory: NTMec\_Test\test22nimocr37\Mini\_PCCVAA

Material: 22NiMoCr37

Charpy nr.: X5D6B

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.630 Bn\* (mm): 4.363 Bn (mm): 4.410 B (mm): 4.410

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.044 mm Span (mm): 18.400  
 10% B 0.534 mm

Precracking Machine: INSTRON

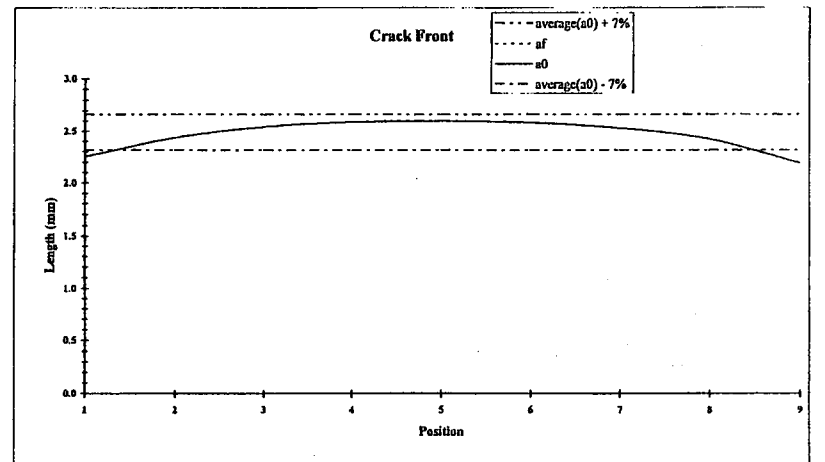
Kmax (MPaVm): 26.126  
 Kfinal (MPaVm): 19.978

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.252	-9.61%	af1	2.252	-9.61%	Δ a1	0.000	0.00%
a02	2.438	-2.15%	af2	2.438	-2.15%	Δ a2	0.000	0.00%
a03	2.544	2.11%	af3	2.544	2.11%	Δ a3	0.000	0.00%
a04	2.589	3.91%	af4	2.589	3.91%	Δ a4	0.000	0.00%
a05	2.598	4.27%	af5	2.598	4.27%	Δ a5	0.000	0.00%
a06	2.586	3.79%	af6	2.586	3.79%	Δ a6	0.000	0.00%
a07	2.533	1.67%	af7	2.533	1.67%	Δ a7	0.000	0.00%
a08	2.422	-2.79%	af8	2.422	-2.79%	Δ a8	0.000	0.00%
a09	2.192	-12.02%	af9	2.192	-12.02%	Δ a9	0.000	0.00%
Average a0	2.492		Average af	2.492		-gem.	0.000	

Remark :



**3PB FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	X5D5F
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.556
	Thickness (mm):	4.538
Net thickness (mm):	4.538	
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	18 May 2001
	Test operator:	PW
	Transducer type :	N/A

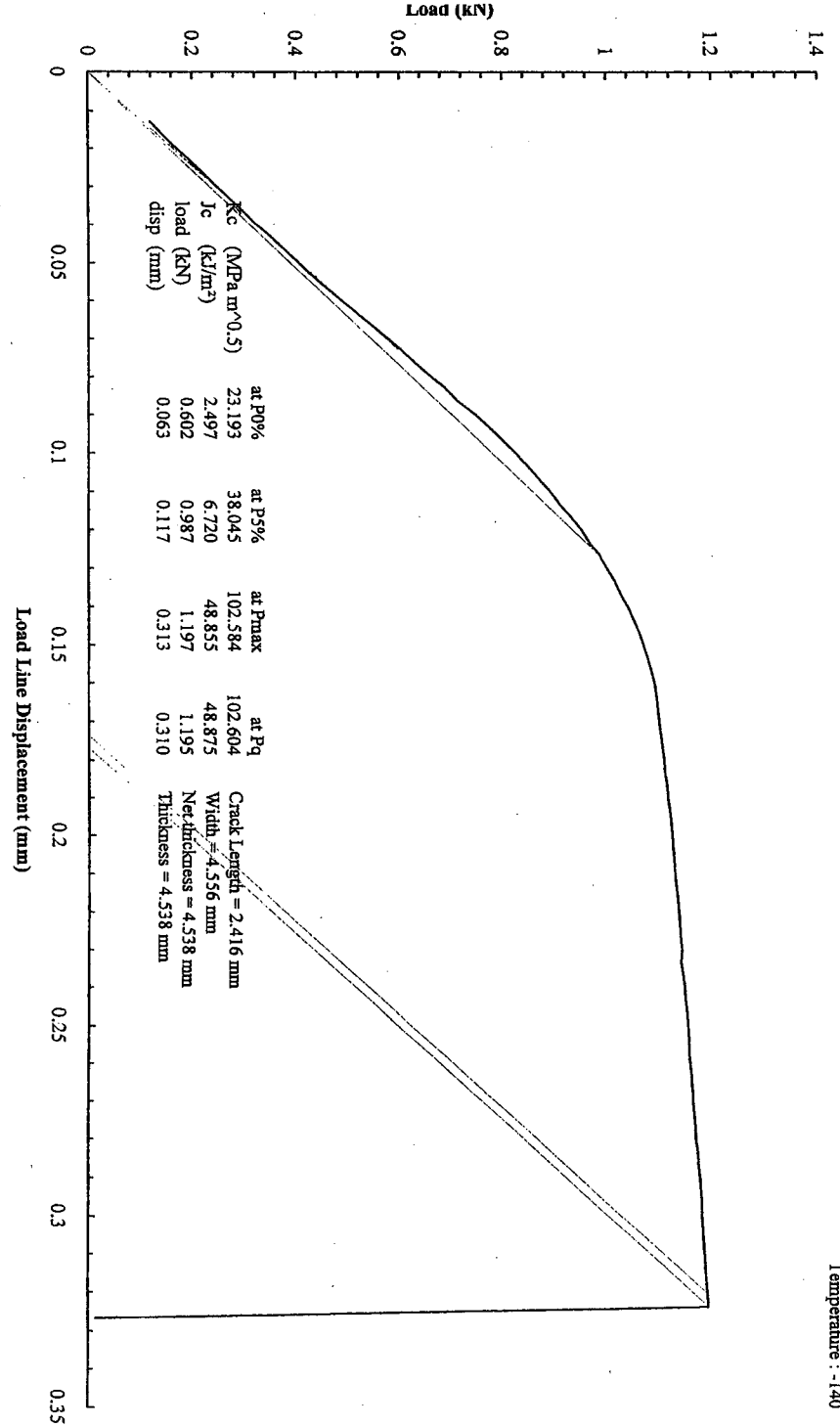
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	26.3
	R:	0.1
	$K_{final}$ (MPa√m):	19.4

	Initial crack length (mm):		Ductile crack extension (mm):	
	$a_0$		$\Delta a_0$	
$a_{0_1}$	2.416		$\Delta a_{0_1}$	0.000
$a_{0_2}$	2.317		$\Delta a_{0_2}$	0.000
$a_{0_3}$	2.470		$\Delta a_{0_3}$	0.000
$a_{0_4}$	2.543		$\Delta a_{0_4}$	0.000
$a_{0_5}$	2.531		$\Delta a_{0_5}$	0.000
$a_{0_6}$	2.515		$\Delta a_{0_6}$	0.000
$a_{0_7}$	2.464		$\Delta a_{0_7}$	0.000
$a_{0_8}$	2.385		$\Delta a_{0_8}$	0.000
$a_{0_9}$	2.243		$\Delta a_{0_9}$	0.000
	2.042		$\Delta a_{0_9}$	0.000

<b>Fracture toughness</b>	$J_c$ (kJ/m <sup>2</sup> ):	48.87
	$K_{Jc}$ (MPa√m):	102.60

<b>Remarks</b>	0
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Signature: 



**Measure of Ao and Af**

Date: 2001-05-18 File: XSD5F.xls Directory: NT\Mec\_Test\test\22nimocr37\Mini\_PCCVA

Material: 22NiMoCr37

Charpy nr.: XSD5F

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.556 Bn \* (mm): 4.483 Bn (mm): 4.538 B (mm): 4.538

Picture W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
10% B 0.549 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

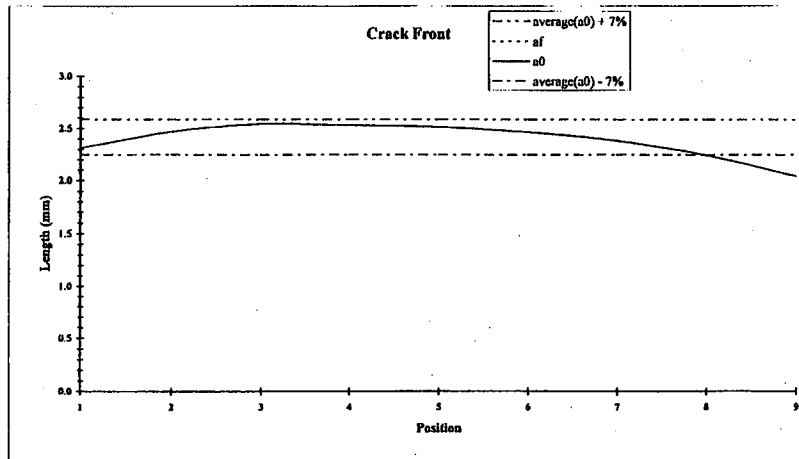
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 26.303  
Kfinal (MPa√m): 19.376

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.317	-4.11%	af1	2.317	-4.11%	Δ a1	0.000	0.00%
a02	2.470	2.22%	af2	2.470	2.22%	Δ a2	0.000	0.00%
a03	2.543	5.24%	af3	2.543	5.24%	Δ a3	0.000	0.00%
a04	2.531	4.75%	af4	2.531	4.75%	Δ a4	0.000	0.00%
a05	2.515	4.08%	af5	2.515	4.08%	Δ a5	0.000	0.00%
a06	2.464	1.97%	af6	2.464	1.97%	Δ a6	0.000	0.00%
a07	2.385	-1.30%	af6	2.385	-1.30%	Δ a7	0.000	0.00%
a08	2.243	-7.17%	af8	2.243	-7.17%	Δ a8	0.000	0.00%
a09	2.042	-15.49%	af9	2.042	-15.49%	Δ a9	0.000	0.00%
Average a0	2.416		Average af	2.416		- gem.	0.000	

Remark:



**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	SE(B)
	Specimen identification:	XSD5G
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	4.512
	Thickness (mm):	4.44
	Net thickness (mm):	4.44
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-140
	Test date:	21 May 2001
	Test operator:	LVH
	Transducer type :	N/A

Fatigue precracking	K <sub>max</sub> (MPa√m):	27.5
	R:	0.1
	K <sub>final</sub> (MPa√m):	18.1

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	2.250	Δa <sub>0</sub> 0.000
a <sub>0_1</sub>	1.949	Δa <sub>0_1</sub> 0.000
a <sub>0_2</sub>	2.198	Δa <sub>0_2</sub> 0.000
a <sub>0_3</sub>	2.294	Δa <sub>0_3</sub> 0.000
a <sub>0_4</sub>	2.323	Δa <sub>0_4</sub> 0.000
a <sub>0_5</sub>	2.330	Δa <sub>0_5</sub> 0.000
a <sub>0_6</sub>	2.327	Δa <sub>0_6</sub> 0.000
a <sub>0_7</sub>	2.303	Δa <sub>0_7</sub> 0.000
a <sub>0_8</sub>	2.233	Δa <sub>0_8</sub> 0.000
a <sub>0_9</sub>	2.031	Δa <sub>0_9</sub> 0.000

Fracture toughness	J <sub>0</sub> (kJ/m <sup>2</sup> ):	57.41
	K <sub>Jc</sub> (MPa√m):	111.20

Remarks: 0

Signature:

# Measure of Ao and Af

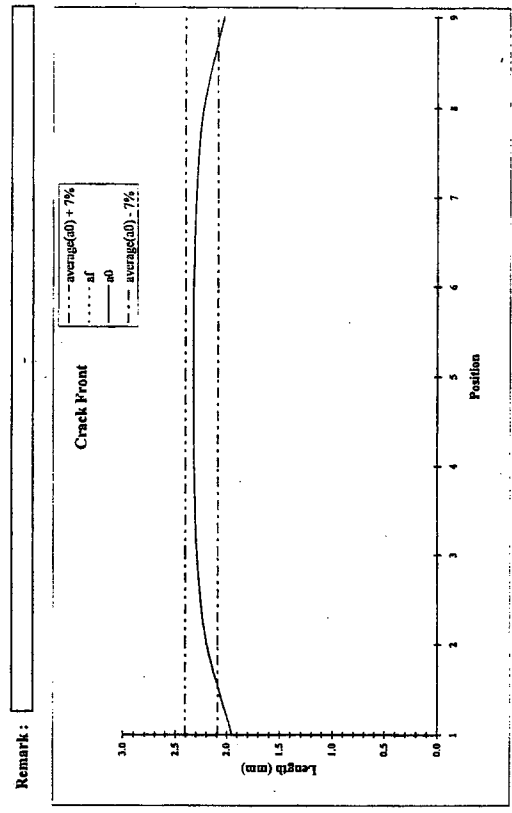
Date: 2001-05-23 File: X5D5G.xls Directory: NTM\loc\_1\test\test2\2mmcr37\Mini\_PCCVVA1  
 Material: 22NiMoCr37  
 Charpy nr.: X5D5G  
 a\_max (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500  
 W (mm): 4.512 Bn\* (mm): 4.356 Bn (mm): 4.440 B (mm): 4.440  
 W (cm): 4.512 Bn\* (cm): 4.356 Bn (cm): 4.440 B (cm): 4.440  
 0.01\*B: 0.044 mm 10% B: 0.533 mm Span (mm): 18.400

Precracking Machine: INSTRON  
 Kmax (MPa√m): 27.464  
 Kfinal (MPa√m): 18.123

Picture	cm
a/1	
a/2	
a/3	
a/4	
a/5	
a/6	
a/7	
a/8	
a/9	

Picture	cm
a/1	
a/2	
a/3	
a/4	
a/5	
a/6	
a/7	
a/8	
a/9	

Charpy	mm	error	Charpy	mm	error
a01	1.949	-13.37%	a11	1.949	-13.37%
a02	2.198	-2.30%	a12	2.198	-2.30%
a03	2.294	1.97%	a13	2.294	1.97%
a04	2.323	3.26%	a14	2.323	3.26%
a05	2.330	3.57%	a15	2.330	3.57%
a06	2.327	3.43%	a16	2.327	3.43%
a07	2.303	2.37%	a17	2.303	2.37%
a08	2.233	-0.74%	a18	2.233	-0.74%
a09	2.031	-9.72%	a19	2.031	-9.72%
Average a0	2.250		Average a1	2.250	

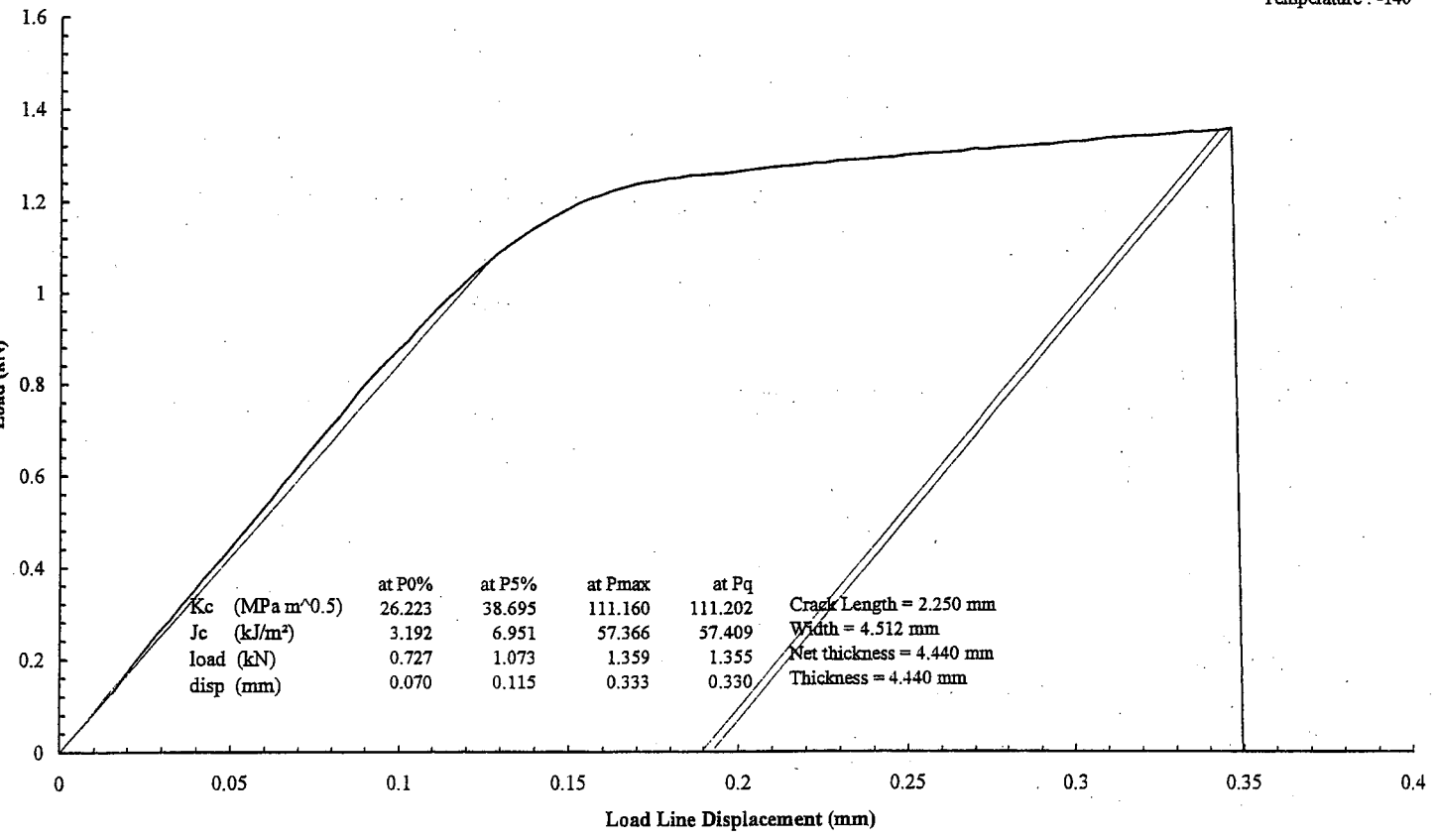


Remark:

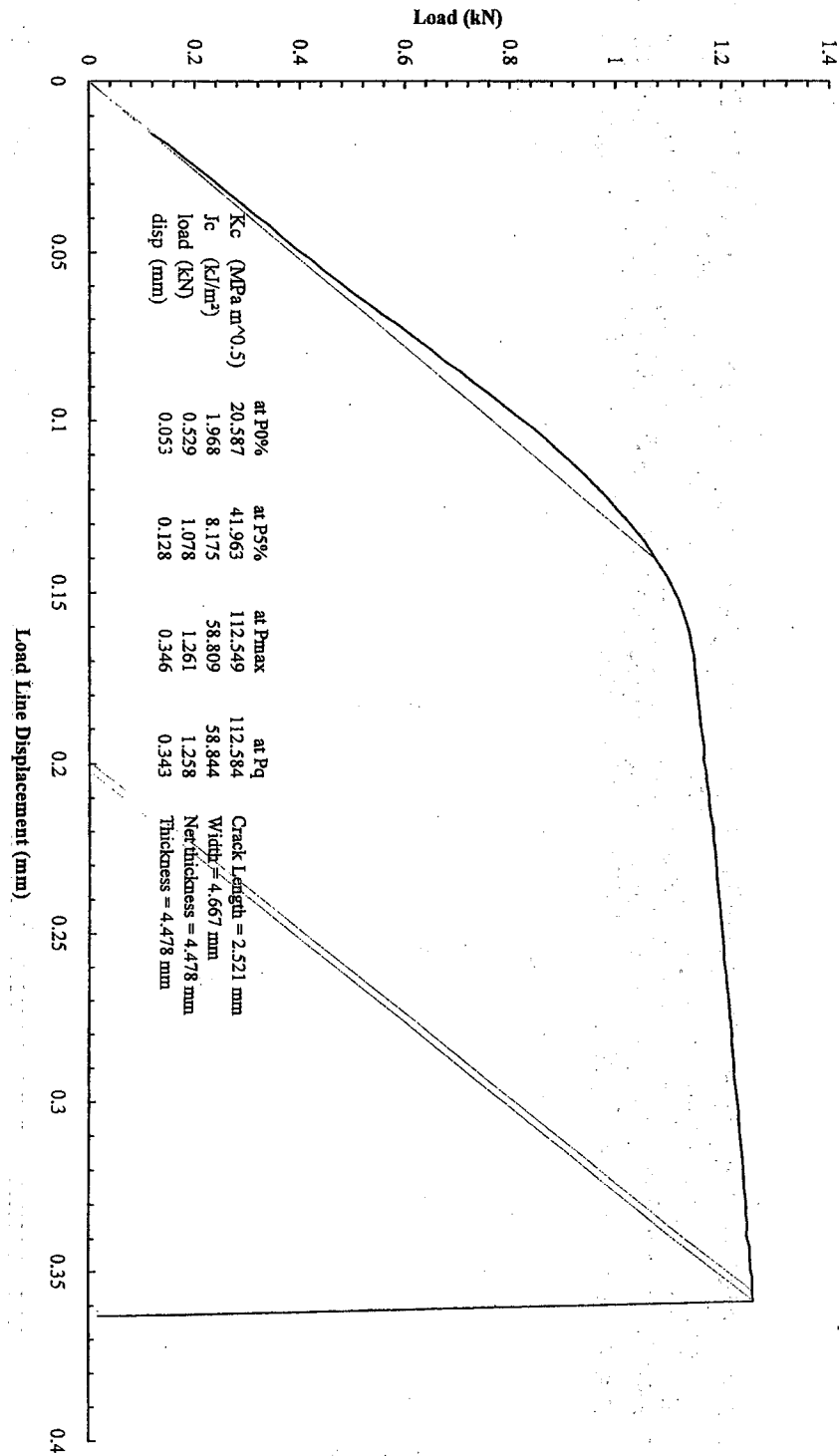
SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Conventie 2001  
 Kjc

X5D5G.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D5G  
 Test data : 21 May 2001  
 Temperature : -140







SCK•CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)  
Date: 2001-07-05  
Software: KJC\_3PBv4.xls

**3PB FRACTURE TOUGHNESS TEST**

Specimen parameters		
Material:	22NiMoCr37	
Specimen type:	SE(B)	
Specimen identification:	X5D5E	
Specimen orientation:	L-T	
Specimen dimensions		
Width (mm):	4.667	
Thickness (mm):	4.478	
Net thickness (mm):	4.478	
Side grooving:	0%	

Test parameters		
Test machine:	1362	
Test temperature (°C):	-140	
Test date:	18 May 2001	
Test operator:	PW	
Transducer type :	N/A	

Fatigue precracking		
K <sub>max</sub> (MPa√m):	25.3	
R:	0.1	
K <sub>final</sub> (MPa√m):	19.6	

Crack			
Initial crack length (mm):		Ductile crack extension (mm):	
a <sub>0</sub>	2.521	Δa <sub>0</sub>	0.000
a <sub>0_1</sub>	2.232	Δa <sub>0_1</sub>	0.000
a <sub>0_2</sub>	2.435	Δa <sub>0_2</sub>	0.000
a <sub>0_3</sub>	2.539	Δa <sub>0_3</sub>	0.000
a <sub>0_4</sub>	2.608	Δa <sub>0_4</sub>	0.000
a <sub>0_5</sub>	2.605	Δa <sub>0_5</sub>	0.000
a <sub>0_6</sub>	2.619	Δa <sub>0_6</sub>	0.000
a <sub>0_7</sub>	2.583	Δa <sub>0_7</sub>	0.000
a <sub>0_8</sub>	2.497	Δa <sub>0_8</sub>	0.000
a <sub>0_9</sub>	2.326	Δa <sub>0_9</sub>	0.000

Fracture toughness		
J <sub>c</sub> (kJ/m <sup>2</sup> ):	58.84	
K <sub>Jc</sub> (MPa√m):	112.58	

Remarks	
0	

Signature:

**Measure of Ao and Af**

Date: 2001-05-18 File: XSD5E.xls Directory: NTMee\_Test\ncst\22nimocr37\Mini\_PCCVVA

Material: 22NiMoCr37

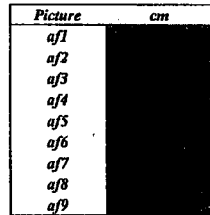
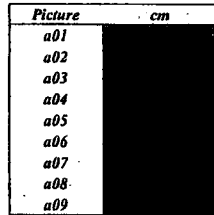
Charpy nr.: XSD5E

a\_fmax (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500

Charpy W (mm): 4.667 Ba\* (mm): 4.393 Bn (mm): 4.478 B (mm): 4.478

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.045 mm Span (mm): 18.400  
10% B 0.538 mm

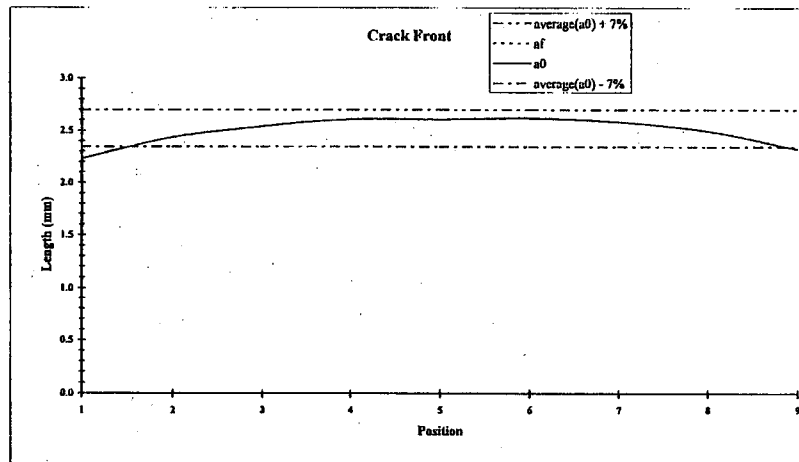


Precracking Machine: INSTRON

Kmax (MPa√m): 25.286  
Kfinal (MPa√m): 19.572

Charpy	mm	error	Charpy	mm	error	Charpy	mm	error
a01	2.232	-11.45%	af1	2.232	-11.45%	Δ a1	0.000	0.00%
a02	2.435	-3.40%	af2	2.435	-3.40%	Δ a2	0.000	0.00%
a03	2.539	0.73%	af3	2.539	0.73%	Δ a3	0.000	0.00%
a04	2.608	3.47%	af4	2.608	3.47%	Δ a4	0.000	0.00%
a05	2.605	3.35%	af5	2.605	3.35%	Δ a5	0.000	0.00%
a06	2.619	3.90%	af6	2.619	3.90%	Δ a6	0.000	0.00%
a07	2.583	2.47%	af6	2.583	2.47%	Δ a7	0.000	0.00%
a08	2.497	-0.94%	af8	2.497	-0.94%	Δ a8	0.000	0.00%
a09	2.326	-7.72%	af9	2.326	-7.72%	Δ a9	0.000	0.00%
Average a0	2.521		Average af	2.521		- gem.	0.000	

Remark:



**3PB FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material: 22NiMoCr37
	Specimen type: SE(B)
	Specimen identification: XSD5B
	Specimen orientation: L-T
	Specimen dimensions
	Width (mm): 4.647
	Thickness (mm): 4.404
	Net thickness (mm): 4.404
	Side grooving: 0%

<b>Test parameters</b>	Test machine: 1362
	Test temperature (°C): -135
	Test date: 18 May 2001
	Test operator: PW
	Transducer type: N/A

<b>Fatigue precracking</b>	K <sub>max</sub> (MPa√m): 26.0
	R: 0.1
	K <sub>final</sub> (MPa√m): 18.8

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):
	a <sub>0</sub> 2.424	Δa <sub>0</sub> 0.000
	a <sub>0_1</sub> 2.150	Δa <sub>0_1</sub> 0.000
	a <sub>0_2</sub> 2.361	Δa <sub>0_2</sub> 0.000
	a <sub>0_3</sub> 2.413	Δa <sub>0_3</sub> 0.000
	a <sub>0_4</sub> 2.511	Δa <sub>0_4</sub> 0.000
	a <sub>0_5</sub> 2.523	Δa <sub>0_5</sub> 0.000
	a <sub>0_6</sub> 2.516	Δa <sub>0_6</sub> 0.000
	a <sub>0_7</sub> 2.477	Δa <sub>0_7</sub> 0.000
	a <sub>0_8</sub> 2.400	Δa <sub>0_8</sub> 0.000
	a <sub>0_9</sub> 2.228	Δa <sub>0_9</sub> 0.000

<b>Fracture toughness</b>	J <sub>c</sub> (kJ/m <sup>2</sup> ): 58.26
	K <sub>Jc</sub> (MPa√m): 111.94

Remarks: 0

Signature:

# Measure of Ao and Af

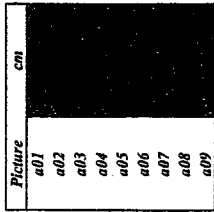
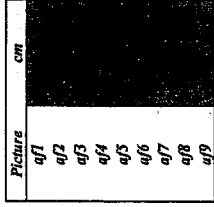
Date: 2001-05-18 File: X5D5B.xls Directory: N:\Mec\_Test\22nimocr37\mini\_PCCVVA1

Material: 22NiMoCr37

Charpy nr.: X5D5B

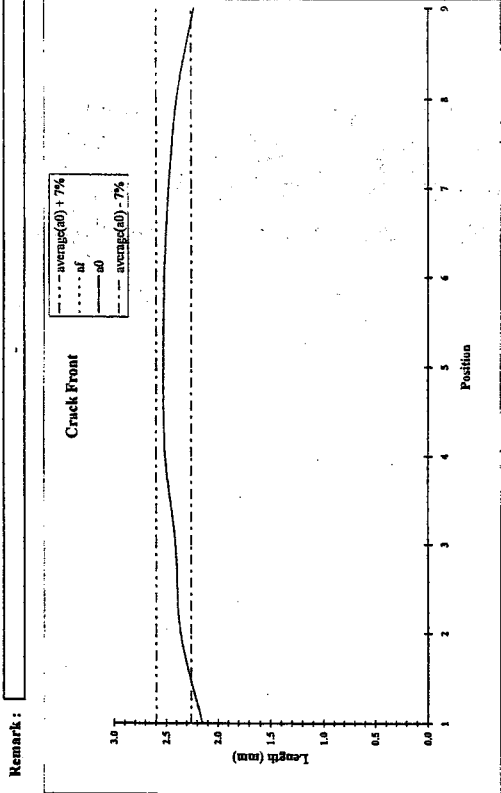
a\_max (mm): 1.250 Fmax (kN): 1.400 Ffinal (kN): 0.500  
 W (mm): 4.647 Ba\* (mm): 4.366 Ba (mm): 4.404 B (mm): 4.404  
 W (cm): 0.044 mm 10% B 0.535 mm

Charpy Picture a01 a02 a03 a04 a05 a06 a07 a08 a09  
 Ba\* (cm): B (cm): Span (mm): 18.400



Precracking Machine: INSTRON  
 Kmax (MPa Vm): 25.953  
 Kfinal (MPa Vm): 18.825

Charpy	mm	error	Charpy	mm	error
a01	2.150	-11.29%	a11	2.150	-11.29%
a02	2.361	-2.59%	a12	2.361	-2.59%
a03	2.413	-0.44%	a13	2.413	-0.44%
a04	2.511	3.60%	a14	2.511	3.60%
a05	2.523	4.09%	a15	2.523	4.09%
a06	2.516	3.81%	a16	2.516	3.81%
a07	2.477	2.20%	a17	2.477	2.20%
a08	2.400	-0.98%	a18	2.400	-0.98%
a09	2.228	-8.08%	a19	2.228	-8.08%
Average a0	2.424		Average a1	2.424	
			-Genm.	0.000	0.00%

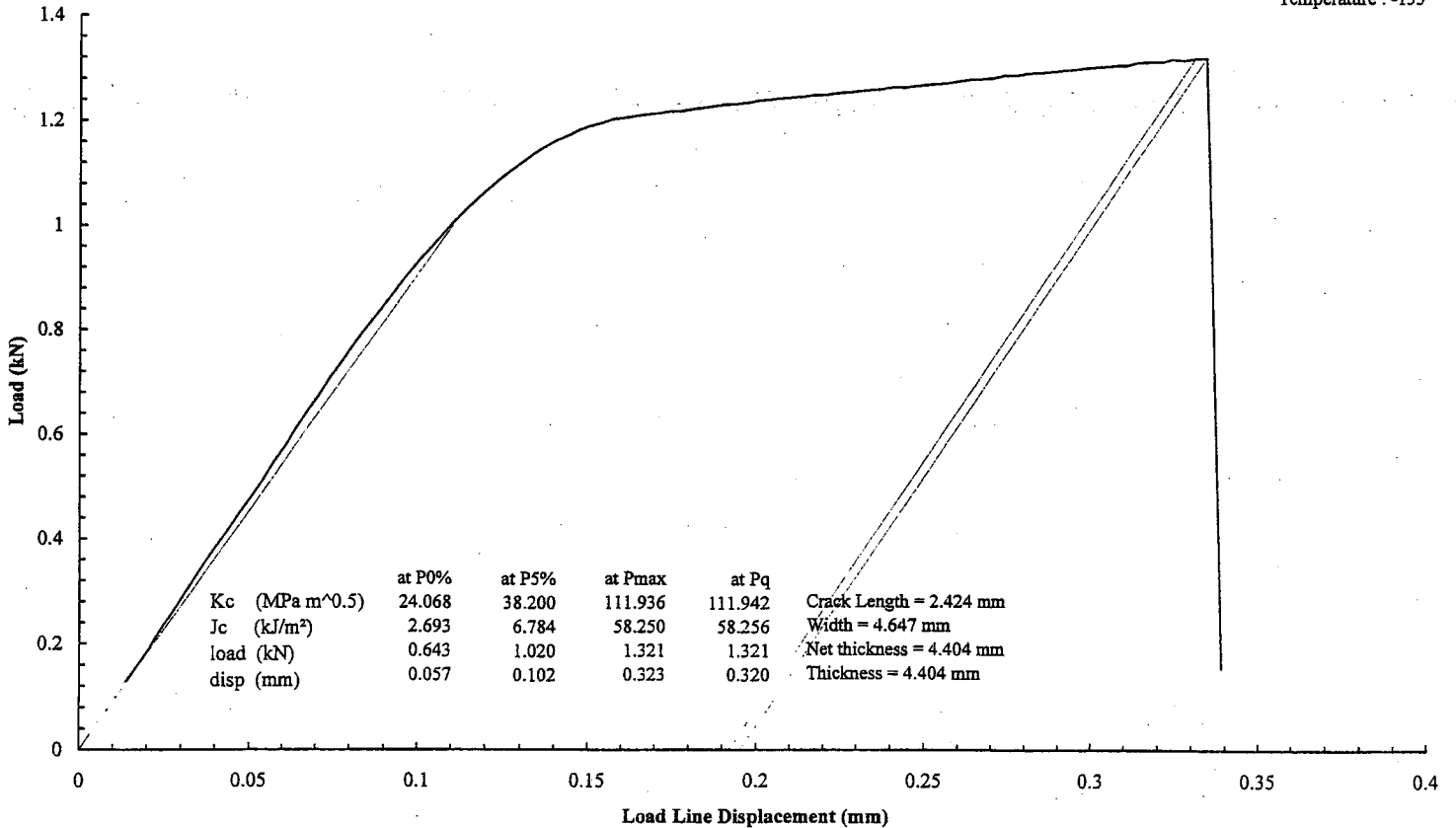


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Conventie 2001  
 Kjc

X5D5B.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D5B  
 Test data : 18 May 2001  
 Temperature : -135



**APPENDIX 2 Test results on mini C(T) 22NiMoCr37**

**STANDARD TEST METHOD FOR THE DETERMINATION OF REFERENCE TEMPERATURE,  
T<sub>0</sub>, FOR FERRITIC STEELS IN THE TRANSITION RANGE**

[MULTI-TEMPERATURE APPROACH]

**1. Material characteristics**

Material specifications : 22NiMoCr37 - Sub-size C(T)

**2. Dimensional and crack growth requirements**

Specimen code	T (°C)	a <sub>0</sub> (mm)	W (mm)	B (mm)	b <sub>0</sub> (mm)	Δa (mm)	K <sub>Jc[exp]</sub> (MPa√m)	σ <sub>ys</sub> (MPa)	E (GPa)	K <sub>lim</sub> (MPa√m)	DATA VALID	K <sub>Jc[calc]</sub> (MPa√m)
X5D3A	-120	4.195	8.352	4.053	4.157	0.00	79.2	638.7	214.2	137.7	YES	79.2
X5D3B	-120	4.133	8.378	4.071	4.245	0.00	90.5	638.7	214.2	139.1	YES	90.5
X5D3C	-120	4.197	8.346	4.065	4.149	0.00	96.1	638.7	214.2	137.5	YES	96.1
X5D3D	-120	4.462	8.350	4.063	3.888	0.00	87.3	638.7	214.2	133.2	YES	87.3
X5D3E	-120	4.300	8.353	4.082	4.053	0.09	195.5	638.7	214.2	136.0	NO	136.0
X5D3F	-120	4.116	8.353	4.098	4.237	0.04	157.3	638.7	214.2	139.0	NO	139.0
X5D3G	-120	4.408	8.366	4.080	3.958	0.00	134.4	638.7	214.2	134.4	NO	134.4
X5D3H	-120	4.541	8.357	4.064	3.816	0.00	82.9	638.7	214.2	131.9	YES	82.9
X5D4A	-120	4.402	8.377	4.073	3.975	0.00	138.5	638.7	214.2	134.6	NO	134.6
X5D4B	-120	4.407	8.356	3.909	3.949	0.00	111.9	638.7	214.2	134.2	YES	111.9
X5D4C	-120	4.508	8.332	4.052	3.824	0.08	179.8	638.7	214.2	132.1	NO	132.1
X5D4E	-130	4.079	8.340	4.026	4.261	0.00	108.3	667.6	214.8	142.7	YES	108.3
X5D4D	-130	4.503	8.344	4.017	3.841	0.00	73.5	667.6	214.8	135.5	YES	73.5
X5D4F	-130	4.398	8.355	3.948	3.957	0.00	84.6	667.6	214.8	137.5	YES	84.6
X5D4G	-130	4.372	8.361	3.937	3.989	0.00	60.3	667.6	214.8	138.1	YES	60.3
X5D4H	-130	4.561	8.344	4.059	3.783	0.00	80.7	667.6	214.8	134.5	YES	80.7
X5D2H	-130	4.328	8.362	4.048	4.034	0.00	119.8	667.6	214.8	138.9	YES	119.8
X5D2G	-130	4.493	8.357	4.090	3.864	0.00	70.0	667.6	214.8	135.9	YES	70.0
X5D2F	-130	4.444	8.352	4.084	3.908	0.00	70.5	667.6	214.8	136.7	YES	70.5
X5D2E	-130	4.465	8.352	4.077	3.887	0.00	92.6	667.6	214.8	136.3	YES	92.6
X5D2D	-120	5.327	8.361	4.070	3.034	0.00	103.5	638.7	214.2	117.6	YES	103.5
X5D2C	-120	4.537	8.336	4.081	3.799	0.00	137.7	638.7	214.2	131.6	NO	131.6
X5D2B	-120	4.537	8.412	4.080	3.875	0.00	94.5	638.7	214.2	132.9	YES	94.5
X5D2A	-120	4.871	8.349	4.075	3.478	0.00	59.9	638.7	214.2	125.9	YES	59.9

**3. Application of the multi-temperature approach for the calculation of the reference temperature**

Specimen code	T (°C)	K <sub>Jc[calc]</sub> (MPa√m)	K <sub>Jc(1T)</sub> (MPa√m)	δ <sub>i</sub>	n <sub>i</sub>	1° member	2° member
X5D3A	-120	79.2	57.4	1	0.143	0.0107	0.0013
X5D3B	-120	90.5	64.6	1	0.143	0.0107	0.0027
X5D3C	-120	96.1	68.2	1	0.143	0.0107	0.0037
X5D3D	-120	87.3	62.6	1	0.143	0.0107	0.0023
X5D3E	-120	136.0	93.4	0	0.000	0.0000	0.0199
X5D3F	-120	139.0	95.4	0	0.000	0.0000	0.0222
X5D3G	-120	134.4	92.4	0	0.000	0.0000	0.0188
X5D3H	-120	82.9	59.8	1	0.143	0.0107	0.0017
X5D4A	-120	134.6	92.5	0	0.000	0.0000	0.0190
X5D4B	-120	111.9	77.5	1	0.143	0.0107	0.0075
X5D4C	-120	132.1	90.8	0	0.000	0.0000	0.0172
X5D4E	-130	108.3	75.7	1	0.143	0.0103	0.0118
X5D4D	-130	73.5	53.7	1	0.143	0.0103	0.0016
X5D4F	-130	84.6	60.6	1	0.143	0.0103	0.0033
X5D4G	-130	60.3	45.3	1	0.143	0.0103	0.0005
X5D4H	-130	80.7	58.4	1	0.143	0.0103	0.0027
X5D2H	-130	119.8	83.1	1	0.143	0.0103	0.0194
X5D2G	-130	70.0	51.7	1	0.143	0.0103	0.0012
X5D2F	-130	70.5	52.0	1	0.143	0.0103	0.0013
X5D2E	-130	92.6	66.0	1	0.143	0.0103	0.0055
X5D2D	-120	103.5	72.8	1	0.143	0.0107	0.0053
X5D2C	-120	131.6	90.7	0	0.000	0.0000	0.0171
X5D2B	-120	94.5	67.2	1	0.143	0.0107	0.0034
X5D2A	-120	59.9	45.2	1	0.143	0.0107	0.0003

Sum of 1° member: 0.189

Sum of 2° member: 0.189

Difference: 0.000

**T<sub>0</sub> = -99.2 °C**  
(valid per ASTM E1921)

Σ n<sub>i</sub> = 2.57

N = 24  
r = 18

K<sub>min</sub> = 20 MPa√m

K<sub>0,eq</sub> = 78.2 MPa√m

K<sub>med,eq</sub> = 73.1 MPa√m

β = 18.8 °C

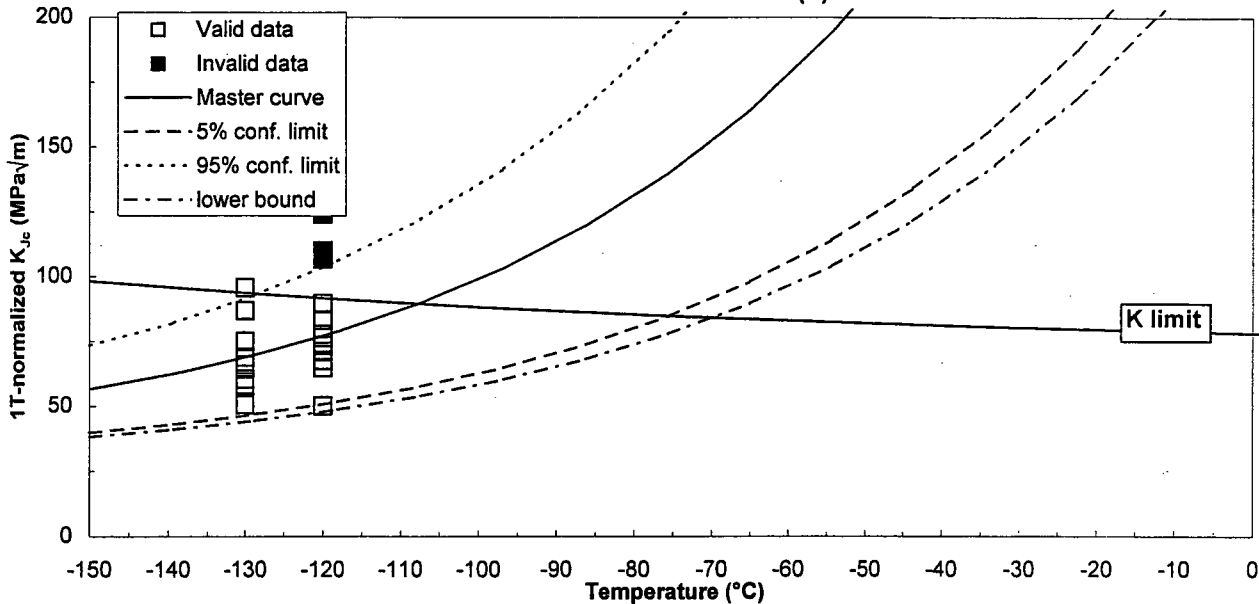
2σ = 9 °C

**4. Master curve fit to data**

Temperature adj. = 6.4 °C (est.) Stand. dev. on  $T_0$  = 4.4 °C (est.)

T (°C)	$K_{Jc(exp)}$ (MPa√m)	$K_{Jc(1T)}$ (MPa√m)	$K_{MC(1T)}$ (MPa√m)	5% conf. (MPa√m)	95% conf. (MPa√m)	5% L.B. (MPa√m)
-120	79.2	64.9				
-120	90.5	73.4				
-120	96.1	77.6				
-120	87.3	71.0				
-120	195.5	152.9				
-120	157.3	123.9				
-120	134.4	106.7				
-120	82.9	67.7				
-120	138.5	109.8				
-120	111.9	89.6				
-120	179.8	140.9				
-130	108.3	86.9				
-130	73.5	60.5				
-130	84.6	69.0				
-130	60.3	50.5				
-130	80.7	66.0				
-130	119.8	95.6				
-130	70.0	57.8				
-130	70.5	58.3				
-130	92.6	75.0				
-120	103.5	83.2				
-120	137.7	109.1				
-120	94.5	76.5				
-120	59.9	50.2				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
-150			56.7	39.8	73.6	38.2
-139.375			62.7	43.0	82.3	41.0
-128.75			70.0	47.0	92.9	44.5
-118.125			78.9	51.8	106.0	48.8
-107.5			89.8	57.7	122.0	54.0
-96.875			103.2	64.9	141.5	60.4
-86.25			119.6	73.8	165.4	68.3
-75.625			139.6	84.6	194.7	77.8
-65			164.2	97.8	230.5	89.6
-54.375			194.2	114.1	274.3	103.9
-43.75			230.9	133.9	327.9	121.5
-33.125			275.8	158.2	393.5	143.0
-22.5			330.8	187.8	473.8	169.3
-11.875			398.1	224.2	572.1	201.5
-1.25			480.5	268.7	692.3	240.9
9.375			581.2	323.1	839.4	289.1
20			704.5	389.7	1019.4	348.1

MASTER CURVE FOR 1TCT WITH CONFIDENCE LIMITS  
22NiMoCr37 - Sub-size C(T)



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	X5D4G
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.361
	Thickness (mm):	3.937
Net thickness (mm):	3.937	
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	PW

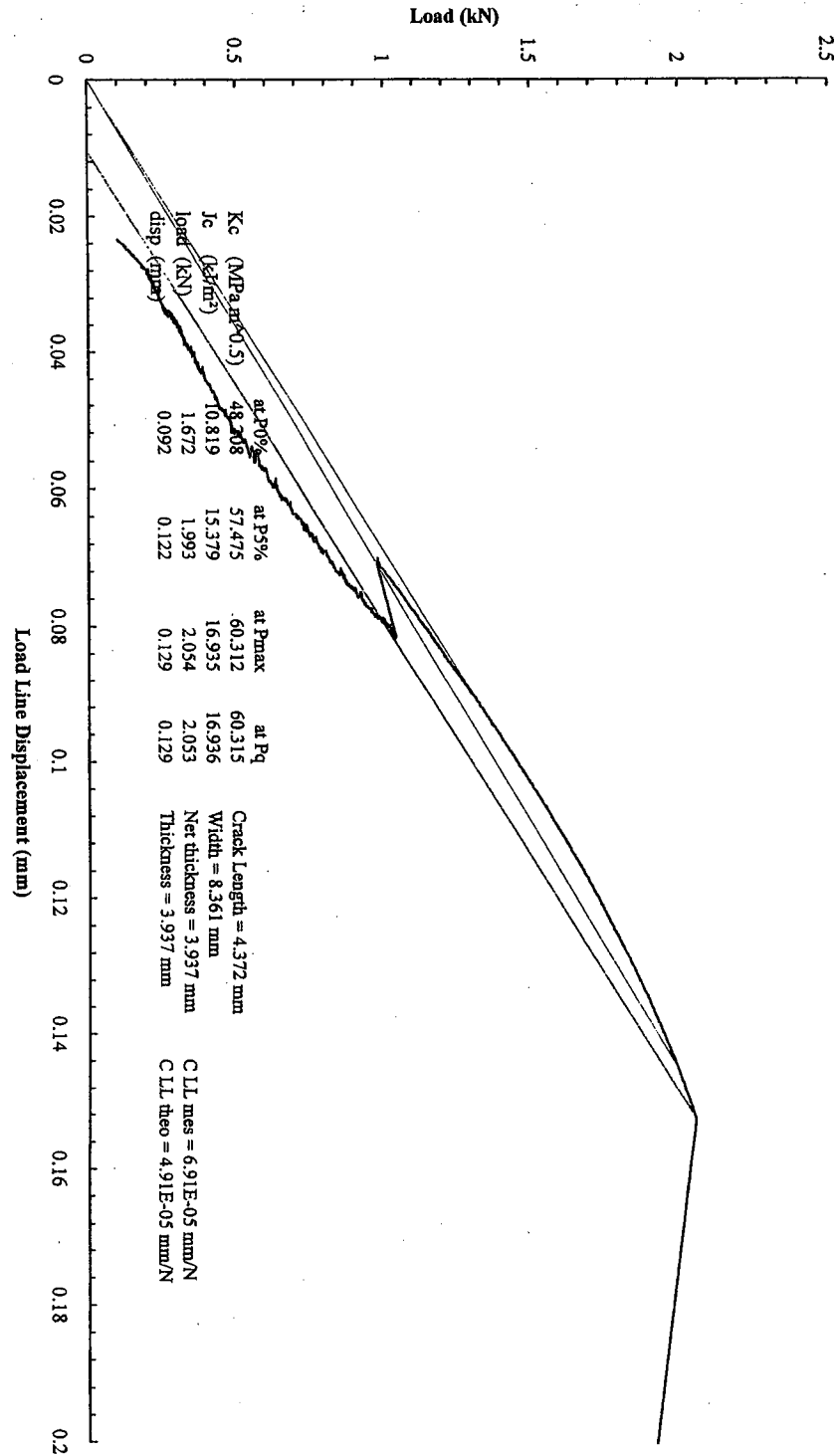
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	25.427
	R:	0.1
	$K_{f0.64}$ (MPa√m):	20.188

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
	$a_0$		$\Delta a_0$	
	4.37194		0	
$a_{0_1}$	4.081		0	
$a_{0_2}$	4.301		0	
$a_{0_3}$	4.405		0	
$a_{0_4}$	4.449		0	
$a_{0_5}$	4.483		0	
$a_{0_6}$	4.468		0	
$a_{0_7}$	4.416		0	
$a_{0_8}$	4.35		0	
$a_{0_9}$	4.126		0	

<b>Fracture toughness</b>	$J_c$ (kJ/m²):	16.94
	$K_{Jc}$ (MPa√m):	60.32

<b>Remarks</b>	V=0.2mm/min
----------------	-------------

Signature: 



### Measure of Ao and Af

Date: 2001-06-18 File: a0-X5D4G.xls Directory: ENTWec\_Tes(test22nimocr37)Mini\_CTAA0

Material: 22NiMoCr37

CT nr.: X5D4G

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.361 Bn \* (mm): 3.935 Bn (mm): 3.937 B (mm): 3.937

Picture W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.039 mm  
10% B 0.482 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

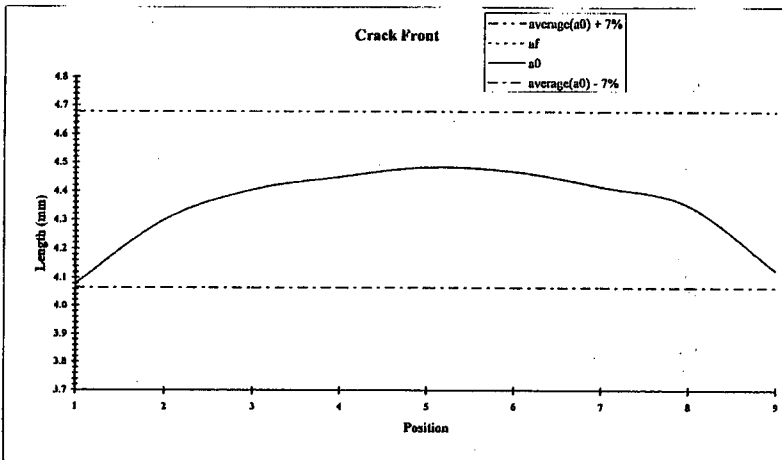
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 25.427  
Kfinal (MPa√m): 20.188

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.081	-6.65%	af1	4.081	-6.65%	Δ a1	0.000	0.00%
a02	4.301	-1.62%	af2	4.301	-1.62%	Δ a2	0.000	0.00%
a03	4.405	0.76%	af3	4.405	0.76%	Δ a3	0.000	0.00%
a04	4.449	1.76%	af4	4.449	1.76%	Δ a4	0.000	0.00%
a05	4.483	2.54%	af5	4.483	2.54%	Δ a5	0.000	0.00%
a06	4.468	2.20%	af6	4.468	2.20%	Δ a6	0.000	0.00%
a07	4.416	1.01%	af6	4.416	1.01%	Δ a7	0.000	0.00%
a08	4.350	-0.50%	af8	4.350	-0.50%	Δ a8	0.000	0.00%
a09	4.126	-5.63%	af9	4.126	-5.63%	Δ a9	0.000	0.00%
Average a0	4.372		Average af	4.372		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D2G
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.357
	Thickness (mm):	4.09
	Net thickness (mm):	4.09
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	19 Jun 2001
	Test operator:	JV

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.493
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	20.399

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.49263	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.245	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.432	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.535	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.574	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.577	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.583	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.549	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.443	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.251	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	22.79
	K <sub>Jc</sub> (MPa√m):	69.97

Remarks: V = 0.2 mm/min.

Signature:



# Measure of A0 and Af

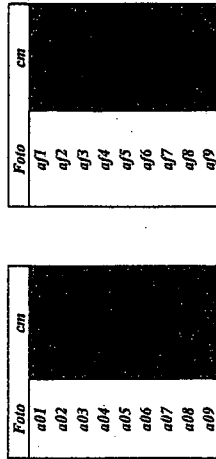
Date: 2001-06-19 File: X5D2G.xls Directory: 3\NT\Mec\_Test\test\22nimocr37\Mini\_C1\VAI

Material: 22NIMOCr37

CT nr.: X3D2G

a<sub>f</sub>max (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.357 Bn\* (mm): 4.070 Bn (mm): 4.090 B (mm): 4.090  
 H (cm): Bn\* (cm): Bn (cm): B (cm):

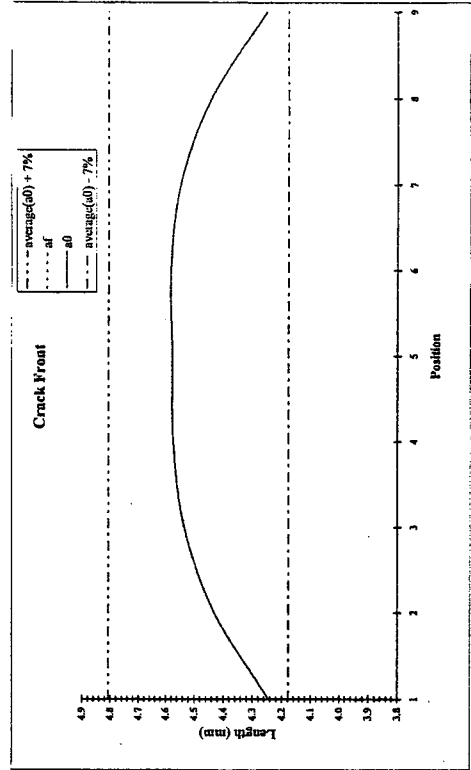
0.01\*B 0.041 mm  
 10% B 0.499 mm



Prerackling Machine: INSTRON  
 Kmax (MPaVm): 24.493  
 Kfinal (MPaVm): 20.399

CT	mm	error	mm	error	mm	error	
a01	4.245	-5.51%	a11	4.245	-a1	0.000	0.00%
a02	4.432	-1.35%	a12	4.432	-a2	0.000	0.00%
a03	4.535	0.94%	a13	4.535	-a3	0.000	0.00%
a04	4.574	1.81%	a14	4.574	-a4	0.000	0.00%
a05	4.577	1.88%	a15	4.577	-a5	0.000	0.00%
a06	4.583	2.01%	a16	4.583	-a6	0.000	0.00%
a07	4.549	1.25%	a17	4.549	-a7	0.000	0.00%
a08	4.443	-1.10%	a18	4.443	-a8	0.000	0.00%
a09	4.251	-5.38%	a19	4.251	-a9	0.000	0.00%
a0 gem.	4.493		a1 gem.	4.493	-gem.	0.000	0.00%

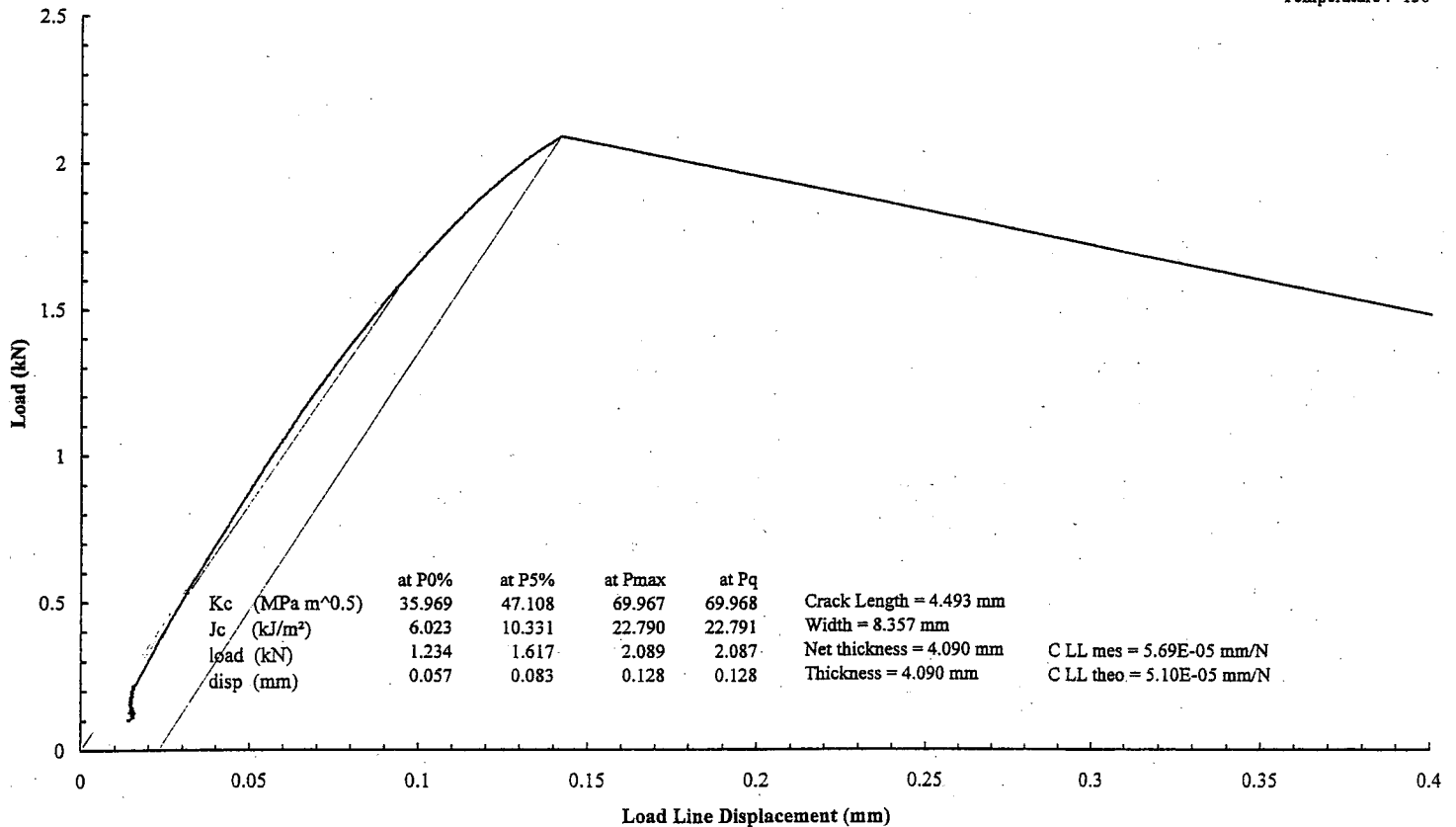
Remark:

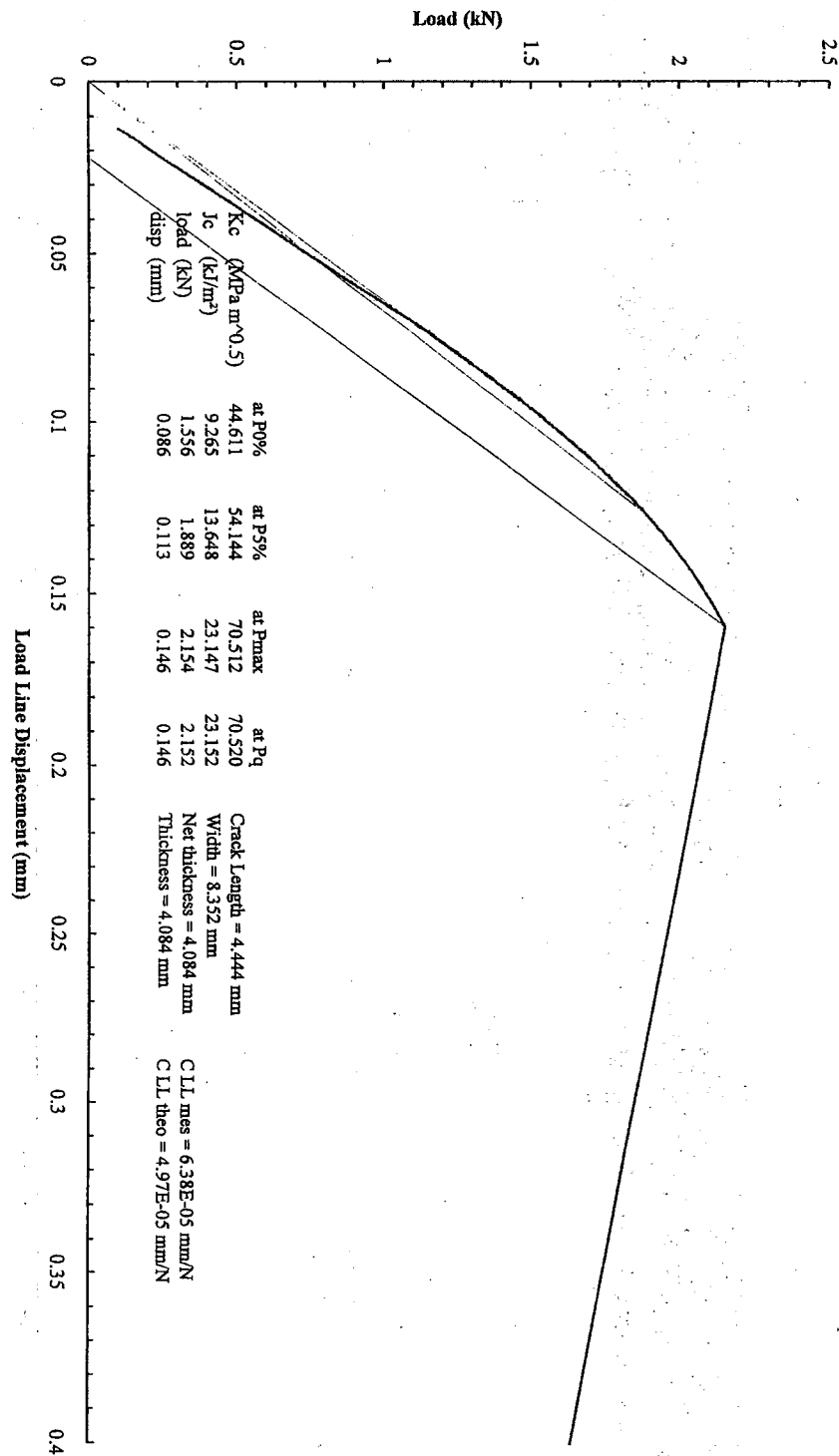


SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kje

X5D2G.XLS  
 Material : 22NIMOCr37  
 Specimen id : X5D2G  
 Test data : 19 Jun 2001  
 Temperature : -130





SCK-CEN ; LHMA  
Boerctang 200  
B-2400 Mol (Belgium)

Date: 2001-07-04  
Software: IC\_CTv4\_Excel97.

**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	X5D2F
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.352
	Thickness (mm):	4.084
Net thickness (mm):	4.084	
Side grooving:	0%	

<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	19 Jun 2001
	Test operator:	JV

<b>Fatigue precracking</b>	K <sub>max</sub> (MPa√m):	24.55
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	20.065

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
	a <sub>0</sub>	Δa <sub>0</sub>	a <sub>0</sub>	Δa <sub>0</sub>
a <sub>0_1</sub>	4.444	0	4.13	0
a <sub>0_2</sub>	4.327	0	4.327	0
a <sub>0_3</sub>	4.435	0	4.435	0
a <sub>0_4</sub>	4.481	0	4.481	0
a <sub>0_5</sub>	4.48	0	4.48	0
a <sub>0_6</sub>	4.553	0	4.553	0
a <sub>0_7</sub>	4.55	0	4.55	0
a <sub>0_8</sub>	4.487	0	4.487	0
a <sub>0_9</sub>	4.348	0	4.348	0

<b>Fracture toughness</b>	J <sub>c</sub> (kJ/m <sup>2</sup> ):	23.15
	K <sub>Jc</sub> (MPa√m):	70.52

<b>Remarks</b>	V = 0.2 mm/min.
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Signature: 

### Measure of Ao and Af

Date: 2001-06-19 File: X5D2F.xls Directory: 3NTMec\_Tes\test\22nimocr37\Mini\_CTA0

Material: 22NiMoCr37

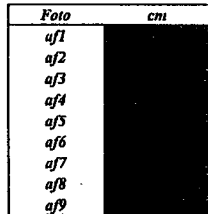
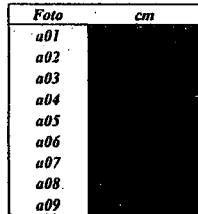
CT nr.: X5D2F

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.352 Bn \* (mm): 4.073 Bn (mm): 4.084 B (mm): 4.084

Foto W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.499 mm

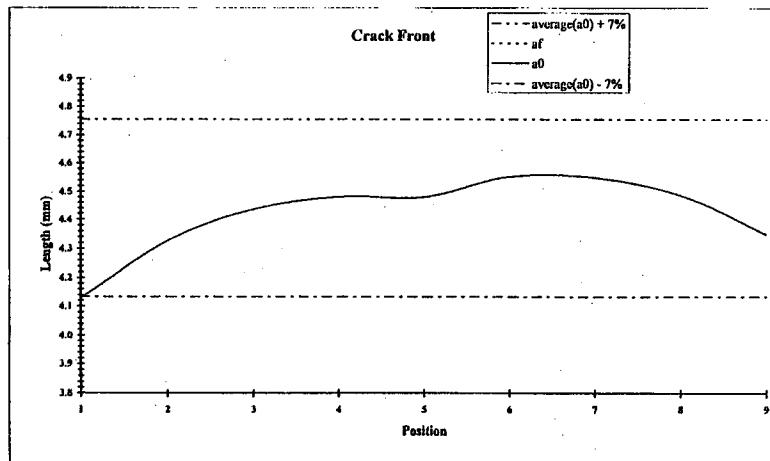


Precracking Machine: INSTRON

Kmax (MPa√m): 24.550  
Kfinal (MPa√m): 20.065

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.130	-7.07%	af1	4.130	-7.07%	-a1	0.000	0.00%
a02	4.327	-2.63%	af2	4.327	-2.63%	-a2	0.000	0.00%
a03	4.435	-0.20%	af3	4.435	-0.20%	-a3	0.000	0.00%
a04	4.481	0.83%	af4	4.481	0.83%	-a4	0.000	0.00%
a05	4.480	0.81%	af5	4.480	0.81%	-a5	0.000	0.00%
a06	4.553	2.45%	af6	4.553	2.45%	-a6	0.000	0.00%
a07	4.550	2.39%	af6	4.550	2.39%	-a7	0.000	0.00%
a08	4.487	0.97%	af8	4.487	0.97%	-a8	0.000	0.00%
a09	4.348	-2.16%	af9	4.348	-2.16%	-a9	0.000	0.00%
a0 gem.	4.444		af gem.	4.444		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D4D
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.344
	Thickness (mm):	4.017
	Net thickness (mm):	4.017
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.993
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	20.93

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.50281	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.391	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.556	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.612	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.639	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.598	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.541	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.485	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.353	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.086	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	25.14
	K <sub>Jc</sub> (MPa√m):	73.49

Remarks	V=0.2mm/min
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Signature: *[Signature]*

# Measure of Ao and Af

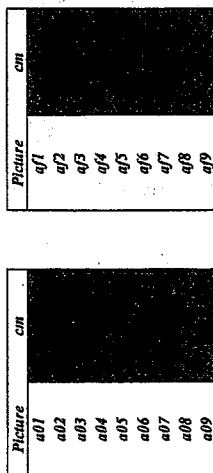
Date: 2001-06-18 File: a0-XSD4D.xls Directory: INT\Mec\_Tests\test22nimocr37\mini\_CTNA4

Material: 22NIMOC37

CT nr.: XSD4D

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.344 Bn\* (mm): 4.041 Bn (mm): 4.017 B (mm): 4.017

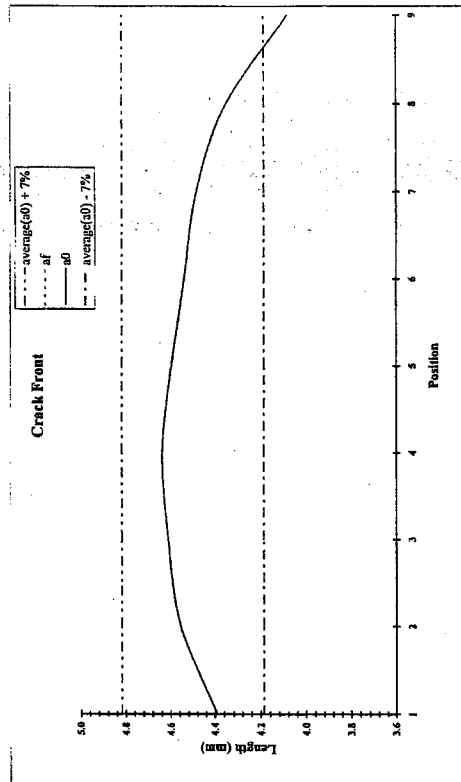
Picture W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.040 mm 10% B 0.495 mm



Precracking Machine: INSTRON  
 Kmax (MPa Vm): 24.993  
 Kfinal (MPa Vm): 20.930

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.391	-2.48%	a11	4.391	-2.48%	Δa1	0.000	0.00%
a02	4.556	1.18%	a12	4.556	1.18%	Δa2	0.000	0.00%
a03	4.612	2.42%	a13	4.612	2.42%	Δa3	0.000	0.00%
a04	4.639	3.02%	a14	4.639	3.02%	Δa4	0.000	0.00%
a05	4.598	2.11%	a15	4.598	2.11%	Δa5	0.000	0.00%
a06	4.541	0.85%	a16	4.541	0.85%	Δa6	0.000	0.00%
a07	4.485	-0.40%	a17	4.485	-0.40%	Δa7	0.000	0.00%
a08	4.353	-3.33%	a18	4.353	-3.33%	Δa8	0.000	0.00%
a09	4.086	-9.26%	a19	4.086	-9.26%	Δa9	0.000	0.00%
Average a0	4.503		Average a1	4.503		- fem.	0.000	0.00%

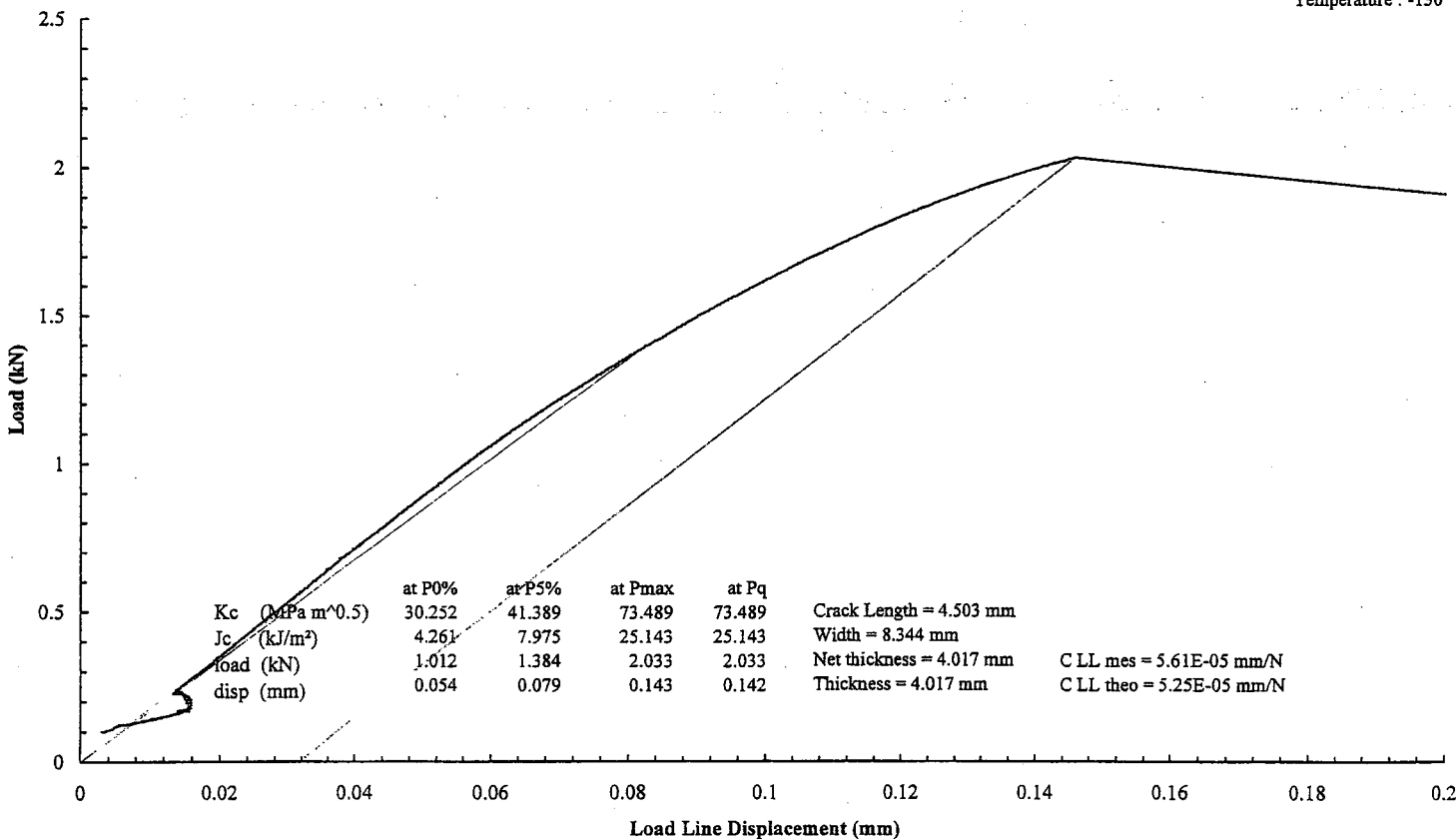
Remark:

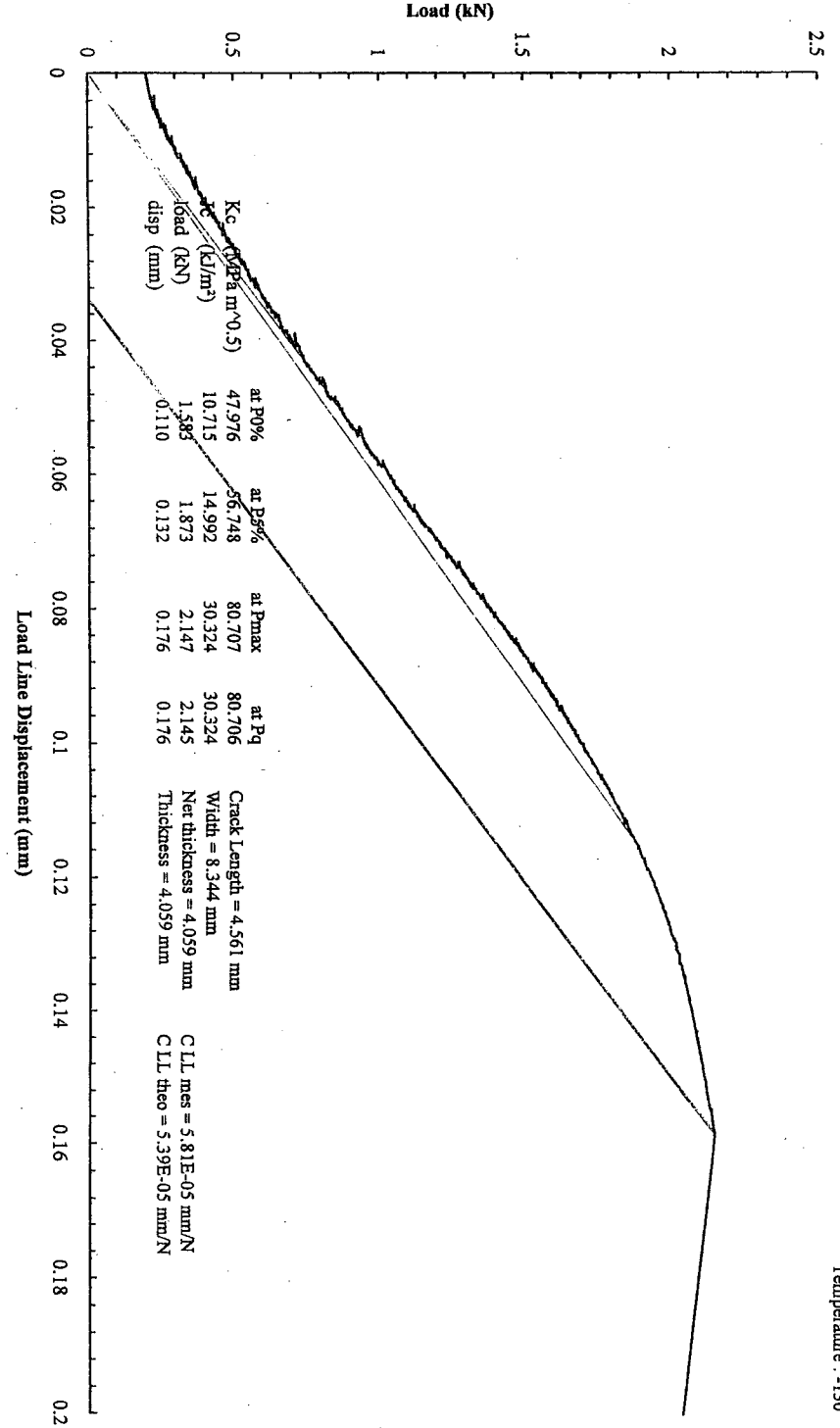


SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kje

XSD4D.XLS  
 Material : 22NIMOCR37  
 Specimen id : XSD4D  
 Test data : 18 Jun 2001  
 Temperature : -130





**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	XSD4H
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.344
	Thickness (mm):	4.059
Net thickness (mm):	4.059	
Side grooving:	0%	

<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	JV

<b>Fatigue precracking</b>	K <sub>max</sub> (MPa√m):	24.735
	R:	0.1
	K <sub>T0.64</sub> (MPa√m):	21.211

<b>Crack</b>	Initial crack length (mm):		Ductile crack extension (mm):	
	a <sub>0</sub>		Δa <sub>0</sub>	
	4.56131		0	
	4.333		0	
	4.545		0	
	4.63		0	
	4.647		0	
	4.663		0	
	4.63		0	
	4.579		0	
	4.48		0	
	4.3		0	

<b>Fracture toughness</b>	J <sub>c</sub> (kJ/m <sup>2</sup> ):	30.32
	K <sub>Jc</sub> (MPa√m):	80.71

<b>Remarks</b>	V = 0.2 mm/min.
----------------	-----------------

Signature:

### Measure of Ao and Af

Date: 2001-06-19 File: X5D4H.xls Directory: JMENT\Mec\_Test\test22nimocr37\Mini\_CT

Material: 22NiMoCr37

CT nr.: X5D4H

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.344 Bn \* (mm): 4.047 Bn (mm): 4.059 B (mm): 4.059

Foto W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.496 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

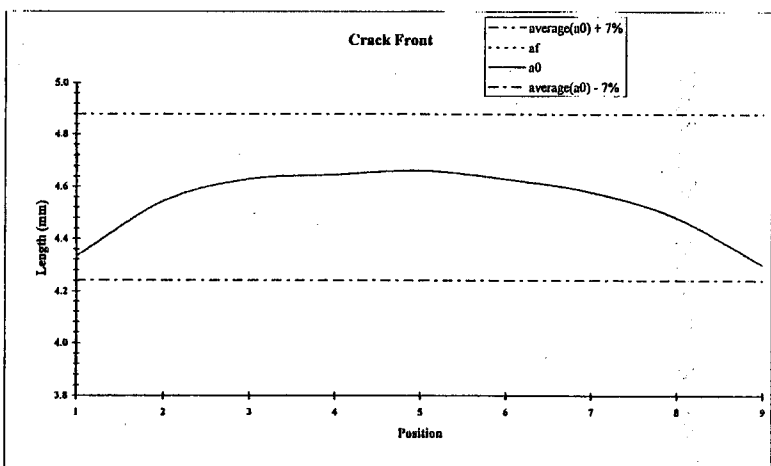
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.735  
Kfinal (MPa√m): 21.211

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.333	-5.01%	af1	4.333	-5.01%	-a1	0.000	0.00%
a02	4.545	-0.36%	af2	4.545	-0.36%	-a2	0.000	0.00%
a03	4.630	1.51%	af3	4.630	1.51%	-a3	0.000	0.00%
a04	4.647	1.88%	af4	4.647	1.88%	-a4	0.000	0.00%
a05	4.663	2.23%	af5	4.663	2.23%	-a5	0.000	0.00%
a06	4.630	1.51%	af6	4.630	1.51%	-a6	0.000	0.00%
a07	4.579	0.39%	af6	4.579	0.39%	-a7	0.000	0.00%
a08	4.480	-1.78%	af8	4.480	-1.78%	-a8	0.000	0.00%
a09	4.300	-5.73%	af9	4.300	-5.73%	-a9	0.000	0.00%
a0 gem.	4.561		af gem.	4.561		- gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D4F
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.355
	Thickness (mm):	3.948
	Net thickness (mm):	3.948
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	25.382
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	20.371

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.39831	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.192	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.391	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.482	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.485	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.489	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.467	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.417	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.316	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.087	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	33.35
	K <sub>Jc</sub> (MPa√m):	84.64

Remarks: V=0.2mm/min

Signature:

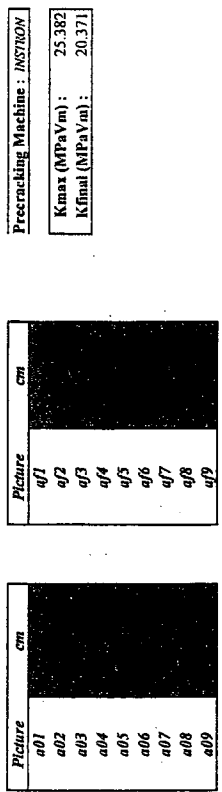
# Measure of A0 and Af

Date: 2001-06-18 File: a0-X5D4F.xls Directory: 3\NTM\cc\_test\test\22nimocr37\Mini\_CT\AA0

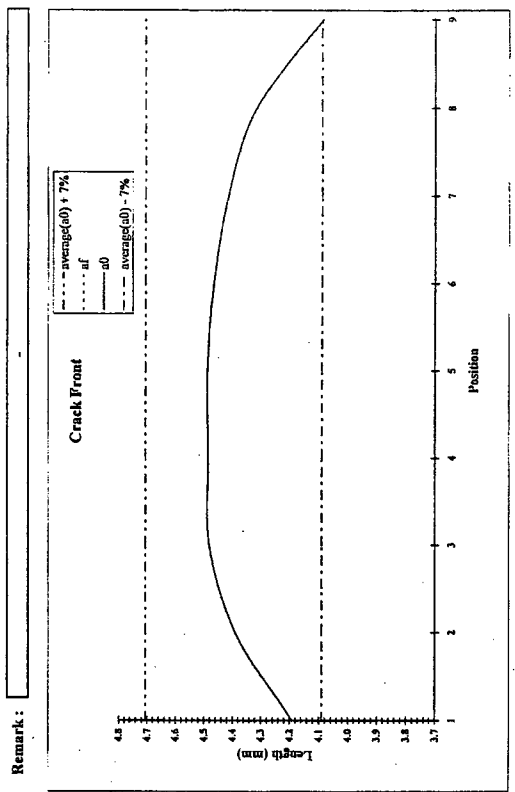
Material: 22NIMOCr37  
CT nr.: X5D4F

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.355 Bn\* (mm): 3.940 Bn (mm): 3.948 B (mm): 3.948  
 W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.039 mm  
 10% B 0.483 mm



CT	mm	error	CT	mm	error
a01	4.192	-4.69%	a11	4.192	0.00%
a02	4.391	-0.17%	a12	4.391	0.00%
a03	4.482	1.90%	a13	4.482	0.00%
a04	4.485	1.97%	a14	4.485	0.00%
a05	4.489	2.06%	a15	4.489	0.00%
a06	4.467	1.56%	a16	4.467	0.00%
a07	4.417	0.42%	a17	4.417	0.00%
a08	4.316	-1.87%	a18	4.316	0.00%
a09	4.087	-7.08%	a19	4.087	0.00%
Average a0	4.398		Average a1	4.398	

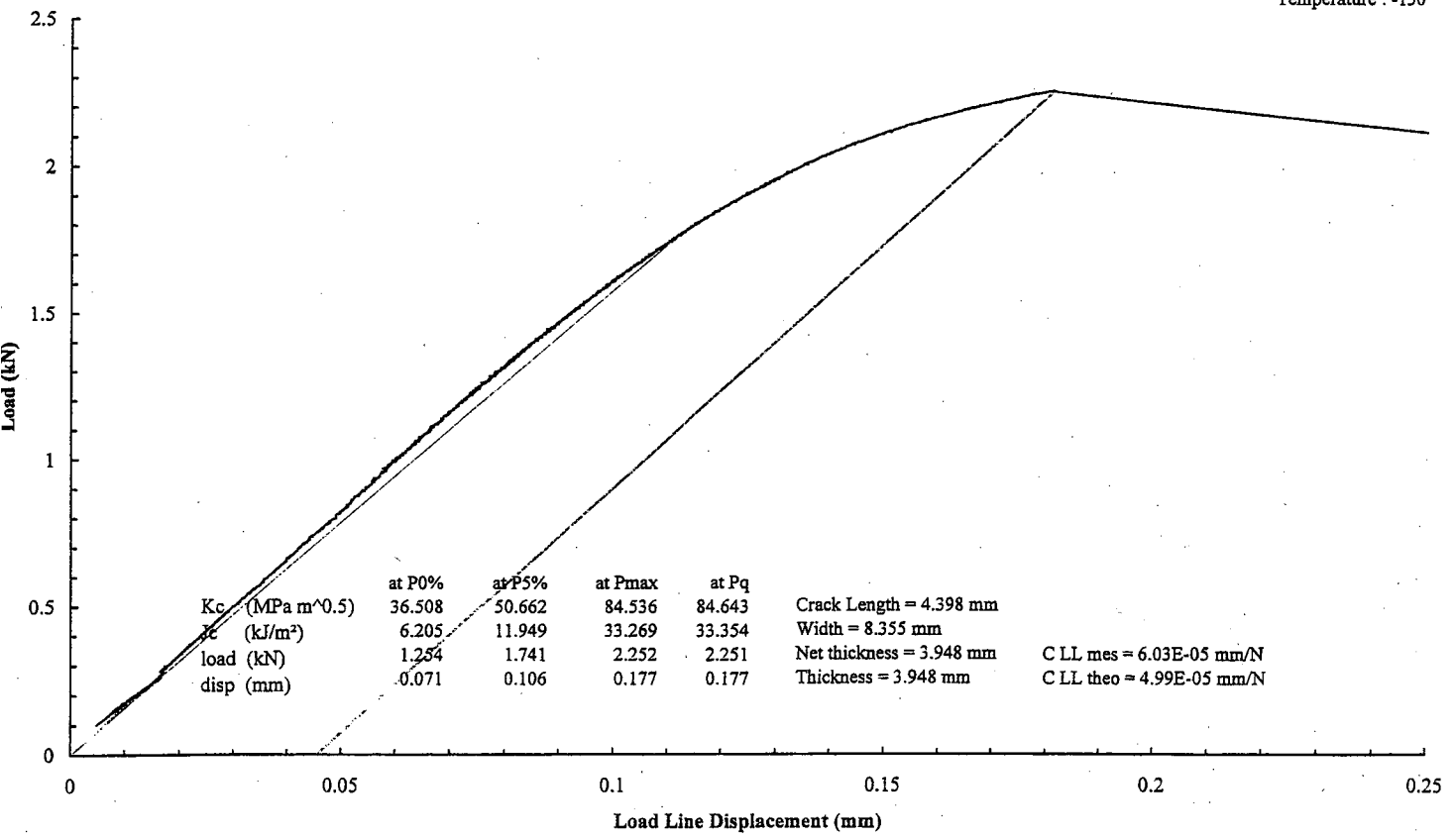


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kje

X5D4F.XLS  
 Material : 22NIMOCR37  
 Specimen id : X5D4F  
 Test data : 18 Jun 2001  
 Temperature : -130



**C(T) FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D2E
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.352
	Thickness (mm):	4.077
	Net thickness (mm):	4.077
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	19 Jun 2001
	Test operator:	JV

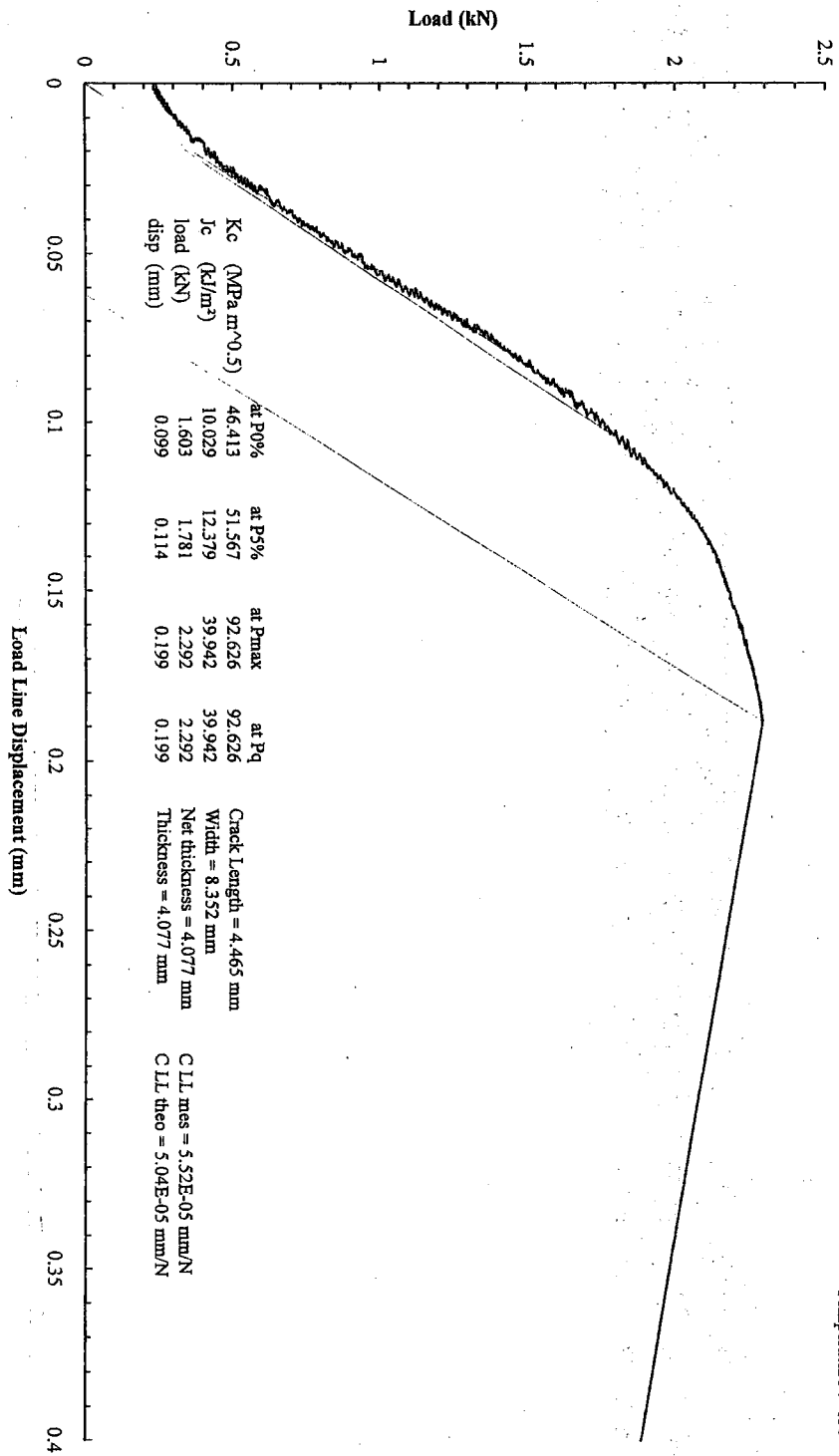
Fatigue precracking	$K_{max}$ (MPa√m):	24.592
	R:	0.1
	$K_{f0.64}$ (MPa√m):	20.268

Crack	Initial crack length (mm):	Ductile crack extension (mm):	
	$a_0$	4.46506	$\Delta a_0$ 0
	$a_{0,1}$	4.067	$\Delta a_{0,1}$ 0
	$a_{0,2}$	4.313	$\Delta a_{0,2}$ 0
	$a_{0,3}$	4.471	$\Delta a_{0,3}$ 0
	$a_{0,4}$	4.549	$\Delta a_{0,4}$ 0
	$a_{0,5}$	4.625	$\Delta a_{0,5}$ 0
	$a_{0,6}$	4.617	$\Delta a_{0,6}$ 0
	$a_{0,7}$	4.549	$\Delta a_{0,7}$ 0
	$a_{0,8}$	4.435	$\Delta a_{0,8}$ 0
	$a_{0,9}$	4.256	$\Delta a_{0,9}$ 0

Fracture toughness	$J_c$ (kJ/m²):	39.94
	$K_{Jc}$ (MPa√m):	92.63

Remarks	V = 0.2 mm/min.
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Signature: 





### Measure of Ao and Af

Date: 2001-06-19 File: X5D2E.xls Directory: 3NT\Mec\_Test\test\22nimocr37\Mini\_CTV40

Material: 22NiMoCr37

CT nr.: X5D2E

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.352 Bn \* (mm): 4.018 Bn (mm): 4.077 B (mm): 4.077

Foto W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.492 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

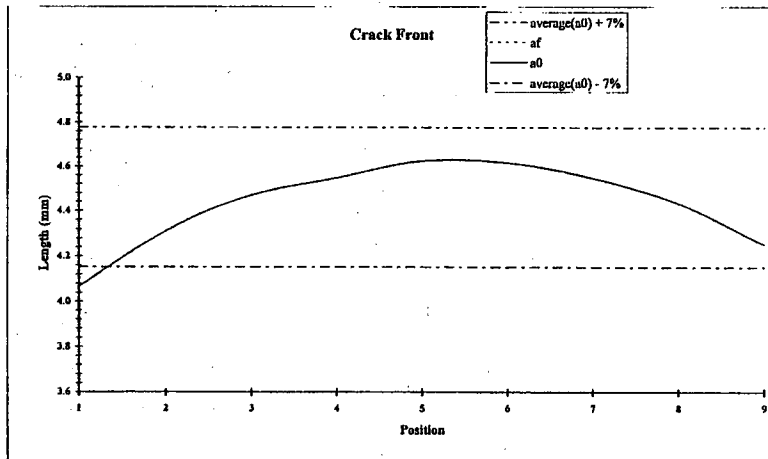
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.592  
Kfinal (MPa√m): 20.268

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.067	-8.92%	af1	4.067	-8.92%	-a1	0.000	0.00%
a02	4.313	-3.41%	af2	4.313	-3.41%	-a2	0.000	0.00%
a03	4.471	0.13%	af3	4.471	0.13%	-a3	0.000	0.00%
a04	4.549	1.88%	af4	4.549	1.88%	-a4	0.000	0.00%
a05	4.625	3.58%	af5	4.625	3.58%	-a5	0.000	0.00%
a06	4.617	3.40%	af6	4.617	3.40%	-a6	0.000	0.00%
a07	4.549	1.88%	af6	4.549	1.88%	-a7	0.000	0.00%
a08	4.435	-0.67%	af8	4.435	-0.67%	-a8	0.000	0.00%
a09	4.256	-4.68%	af9	4.256	-4.68%	-a9	0.000	0.00%
a0 gem.	4.465		af gem.	4.465		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	X5D4E
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.34
	Thickness (mm):	4.026
	Net thickness (mm):	4.026
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.955
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	17.791

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.07925	Δa <sub>0</sub> 0
a <sub>0_1</sub>	3.571	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	3.825	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	3.995	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.124	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.185	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.24	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.233	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.213	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.067	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	54.65
	K <sub>Jc</sub> (MPa√m):	108.34

Remarks:  V=0.2mm/min

Signature:

# Measure of $a_0$ and $a_f$

Date: 2001-06-18 File: a0X5D4E.xls Directory: 3NTWec\_Test\test122nimocr37\Mini\_CTVA0

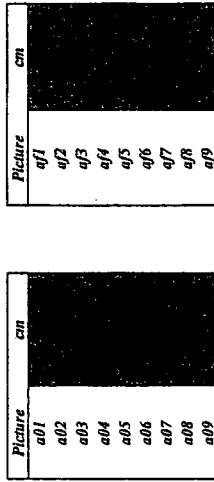
Material: 22NiMoCr37

CT nr.: X5D4E

$a_{fmax}$  (mm): 3.000  $F_{max}$  (kN): 1.400  $F_{final}$  (kN): 0.700  
 W (mm): 8.340  $B_n$  \* (mm): 3.980  $B_n$  (mm): 4.026  $B$  (mm): 4.026  
 Picture  $W$  (cm):  $B_n$  \* (cm):  $B_n$  (cm):  $B$  (cm):

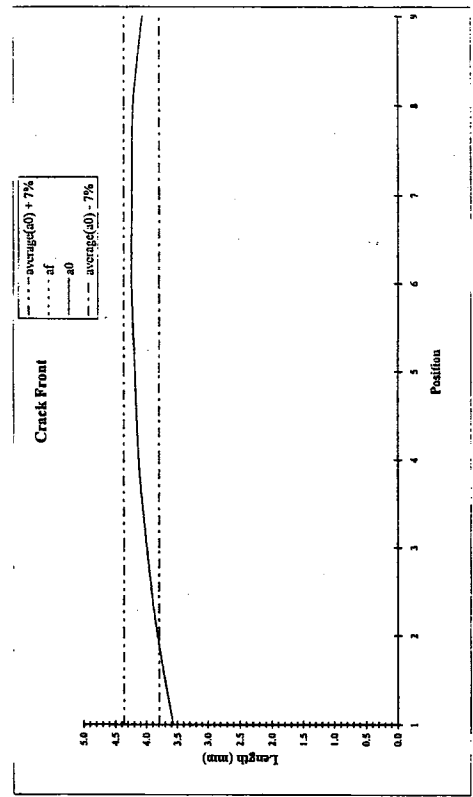
0.01\*B 0.040 mm  
 10% B 0.487 mm

Precracking Machine: INSZKOV  
 $K_{max}$  (MPaVm): 24.955  
 $K_{final}$  (MPaVm): 17.791



CT	mm	error	mm	error	mm	error
a01	3.571	-12.46%	a f1	3.571	$\Delta a_1$	0.000
a02	3.825	-6.23%	a f2	3.825	$\Delta a_2$	0.000
a03	3.995	-2.07%	a f3	3.995	$\Delta a_3$	0.000
a04	4.124	1.10%	a f4	4.124	$\Delta a_4$	0.000
a05	4.185	2.59%	a f5	4.185	$\Delta a_5$	0.000
a06	4.240	3.94%	a f6	4.240	$\Delta a_6$	0.000
a07	4.233	3.77%	a f7	4.233	$\Delta a_7$	0.000
a08	4.213	3.28%	a f8	4.213	$\Delta a_8$	0.000
a09	4.067	-0.30%	a f9	4.067	$\Delta a_9$	0.000
Average a0	4.079		Average a f	4.079	-gem.	0.000

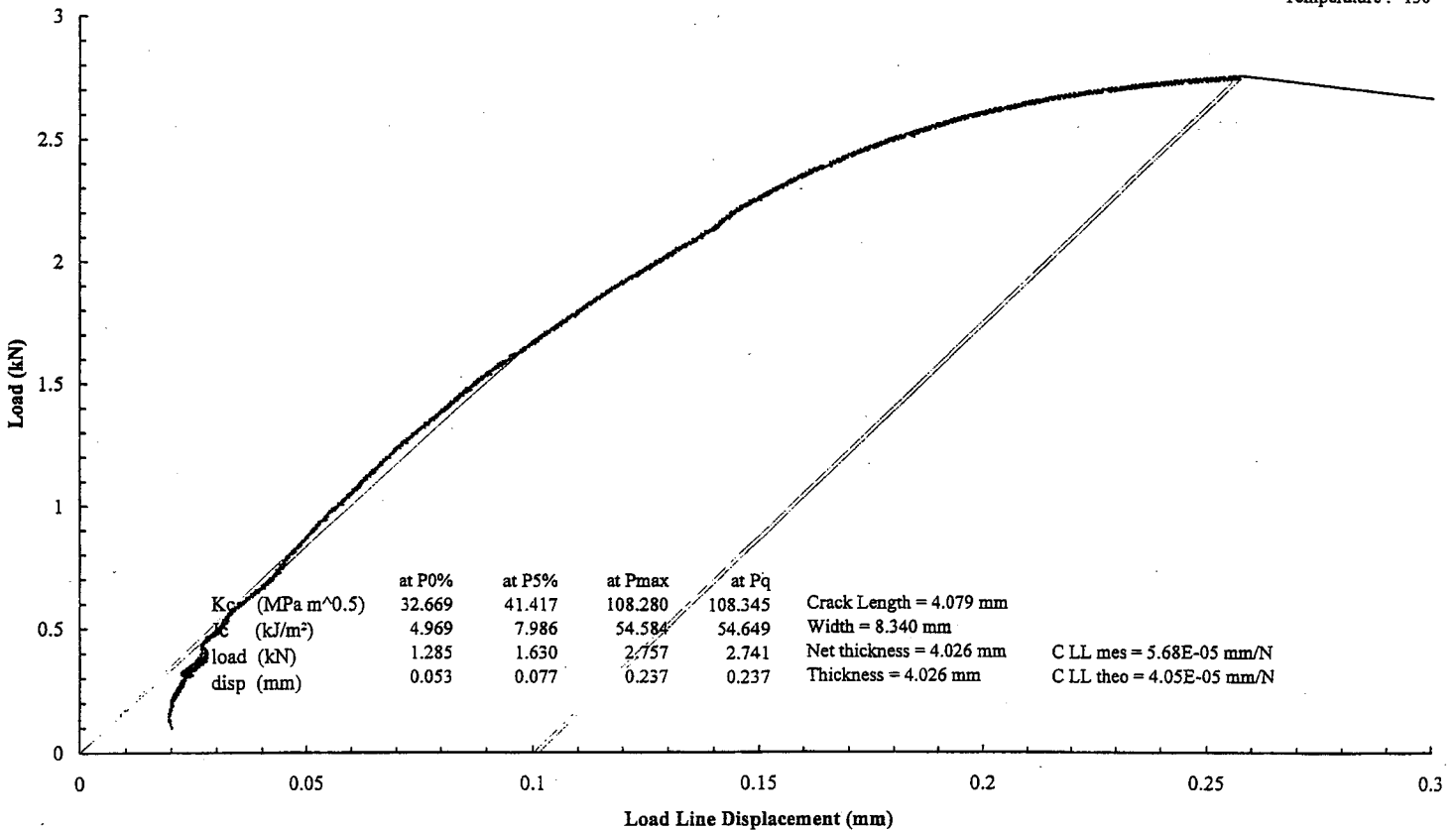
Remark:



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kjc

X5D4E.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D4E  
 Test data : 18 Jun 2001  
 Temperature : -130



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D2H
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.362
	Thickness (mm):	4.048
	Net thickness (mm):	4.048
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	8500
	Test temperature (°C):	-130
	Test date:	18 Jun 2001
	Test operator:	PW

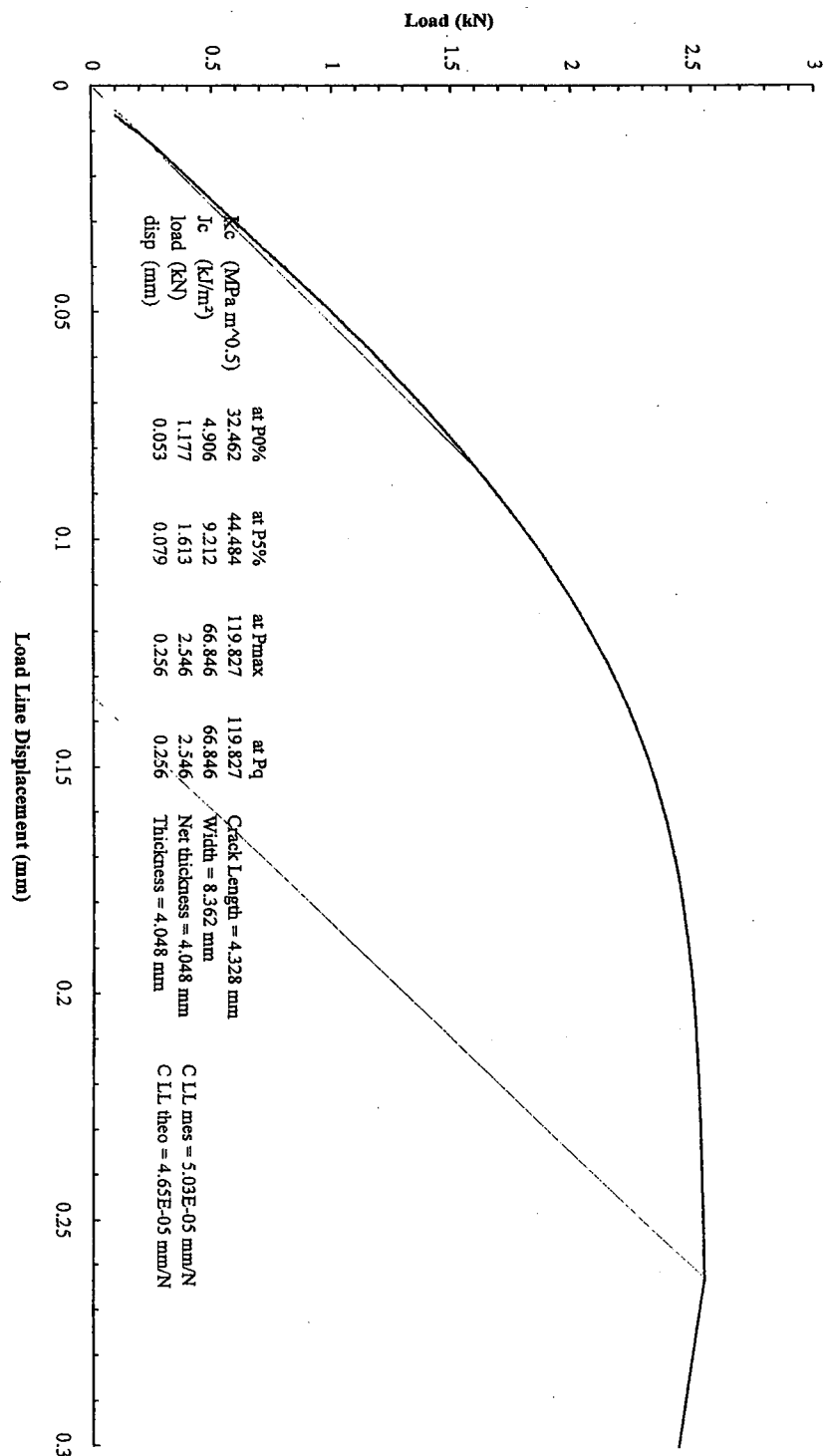
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	24.726
	R:	0.1
	$K_{f0.64}$ (MPa√m):	19.302

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):
	$a_0$ 4.32813	$\Delta a_0$ 0
	$a_{0_1}$ 4.1	$\Delta a_{0_1}$ 0
	$a_{0_2}$ 4.302	$\Delta a_{0_2}$ 0
	$a_{0_3}$ 4.381	$\Delta a_{0_3}$ 0
	$a_{0_4}$ 4.406	$\Delta a_{0_4}$ 0
	$a_{0_5}$ 4.416	$\Delta a_{0_5}$ 0
	$a_{0_6}$ 4.404	$\Delta a_{0_6}$ 0
	$a_{0_7}$ 4.36	$\Delta a_{0_7}$ 0
	$a_{0_8}$ 4.278	$\Delta a_{0_8}$ 0
$a_{0_9}$ 4.056	$\Delta a_{0_9}$ 0	

<b>Fracture toughness</b>	$J_c$ (kJ/m <sup>2</sup> ):	66.85
	$K_{Jc}$ (MPa√m):	119.83

<b>Remarks</b>	V = 0.2 mm/min.
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Signature: 



### Measure of Ao and Af

Date: 2001-06-19 File: X5D2H.xls Directory: N:\Mec\_Test\test22nimocr37\Mini\_CTV4-

Material: 22NiMoCr37

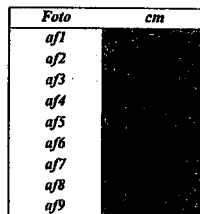
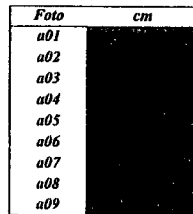
CT nr.: X5D2H

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.362 Bn\* (mm): 4.012 Bn (mm): 4.048 B (mm): 4.048

Foto W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.040 mm  
10% B 0.491 mm

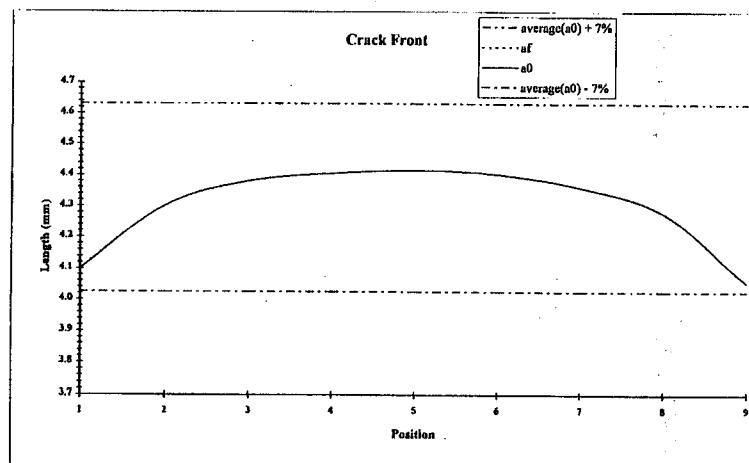


Precracking Machine: INSTRON

Kmax (MPa√m): 24.726  
Kfinal (MPa√m): 19.302

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.100	-5.27%	af1	4.100	-5.27%	-a1	0.000	0.00%
a02	4.302	-0.60%	af2	4.302	-0.60%	-a2	0.000	0.00%
a03	4.381	1.22%	af3	4.381	1.22%	-a3	0.000	0.00%
a04	4.406	1.80%	af4	4.406	1.80%	-a4	0.000	0.00%
a05	4.416	2.03%	af5	4.416	2.03%	-a5	0.000	0.00%
a06	4.404	1.75%	af6	4.404	1.75%	-a6	0.000	0.00%
a07	4.360	0.74%	af6	4.360	0.74%	-a7	0.000	0.00%
a08	4.278	-1.16%	af8	4.278	-1.16%	-a8	0.000	0.00%
a09	4.056	-6.29%	af9	4.056	-6.29%	-a9	0.000	0.00%
a0 gem.	4.328		af gem.	4.328		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3A
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.352
	Thickness (mm):	4.053
	Net thickness (mm):	4.053
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	11 Jun 2001
	Test operator:	P Wouters

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.738
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	18.382

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.19488	Δa <sub>0</sub> 0
a <sub>0_1</sub>	3.7225	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.0615	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.2265	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.2915	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.3405	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.3575	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.3015	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.1655	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	3.9065	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m²):	29.32
	K <sub>Jc</sub> (MPa√m):	79.24

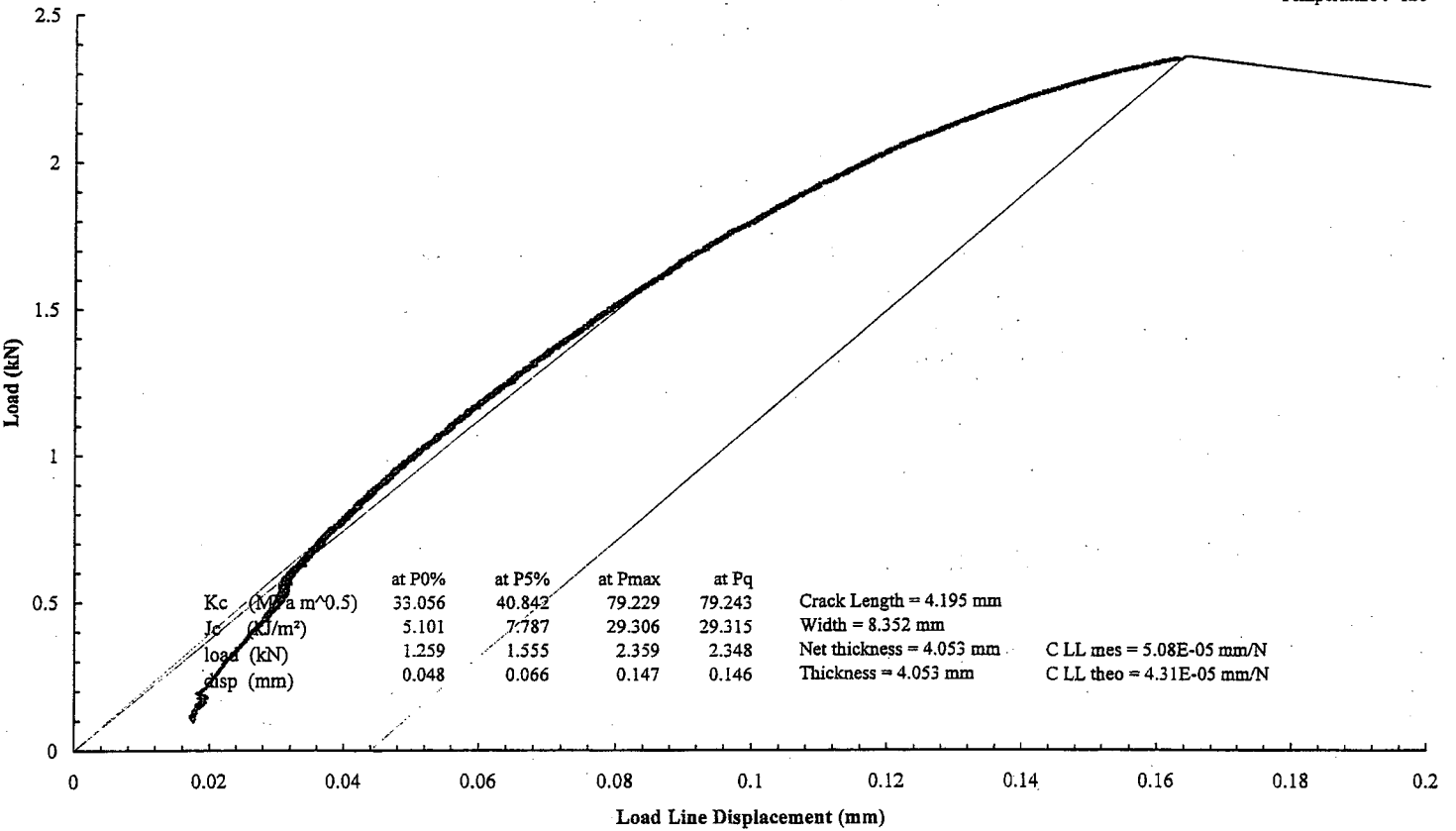
Remarks: V=0.2mm/min

Signature:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

X5D3A.XLS  
 Material : 22NIMOCR37  
 Specimen id : X5D3A  
 Test data : 11 Jun 2001  
 Temperature : -120

**K<sub>jc</sub>**



### Measure of Ao and Af

Date: 2001-06-11 File: X5D3A.xls Directory: J:\MENT\Mec\_Test\test\22nimocr37\Mini\_CT

Material: 22NiMoCr37

CT nr.: X5D3A

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.352 Bn\* (mm): 4.021 Bn (mm): 4.053 B (mm): 4.053

Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.492 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

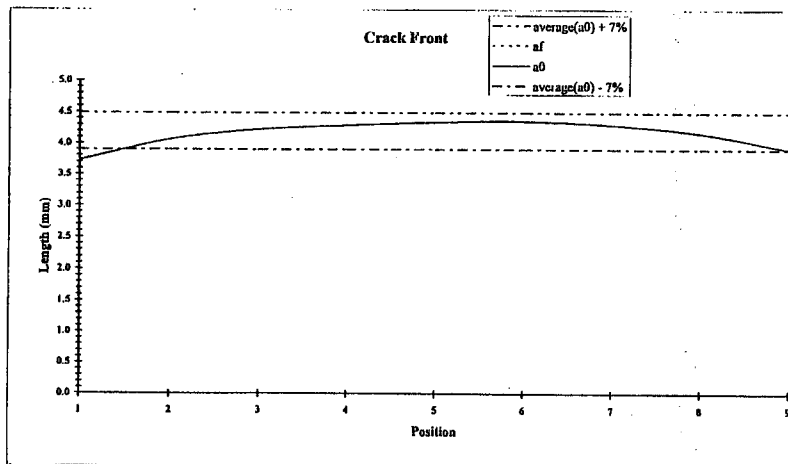
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.738  
Kfinal (MPa√m): 18.382

CT	mm	error	CT	mm	error	CT	mm	error
a01	3.723	-11.26%	af1	3.723	-11.26%	Δ a1	0.000	0.00%
a02	4.062	-3.18%	af2	4.062	-3.18%	Δ a2	0.000	0.00%
a03	4.227	0.75%	af3	4.227	0.75%	Δ a3	0.000	0.00%
a04	4.292	2.30%	af4	4.292	2.30%	Δ a4	0.000	0.00%
a05	4.341	3.47%	af5	4.341	3.47%	Δ a5	0.000	0.00%
a06	4.358	3.88%	af6	4.358	3.88%	Δ a6	0.000	0.00%
a07	4.302	2.54%	af6	4.302	2.54%	Δ a7	0.000	0.00%
a08	4.166	-0.70%	af8	4.166	-0.70%	Δ a8	0.000	0.00%
a09	3.907	-6.87%	af9	3.907	-6.87%	Δ a9	0.000	0.00%
Average a0	4.195		Average af	4.195		- gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3H
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.357
	Thickness (mm):	4.064
	Net thickness (mm):	4.064
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	14 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.65
	R:	0.1
	K <sub>F0.64</sub> (MPa√m):	20.932

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.54081	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.208	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.437	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.534	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.61	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.607	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.635	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.626	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.556	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.435	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m²):	32.10
	K <sub>Jc</sub> (MPa√m):	82.92

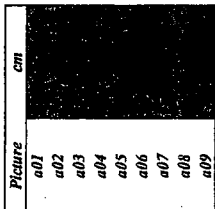
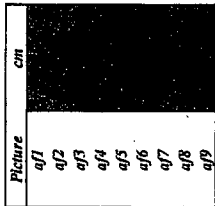
Remarks: V=0.2mm/min

Signature:

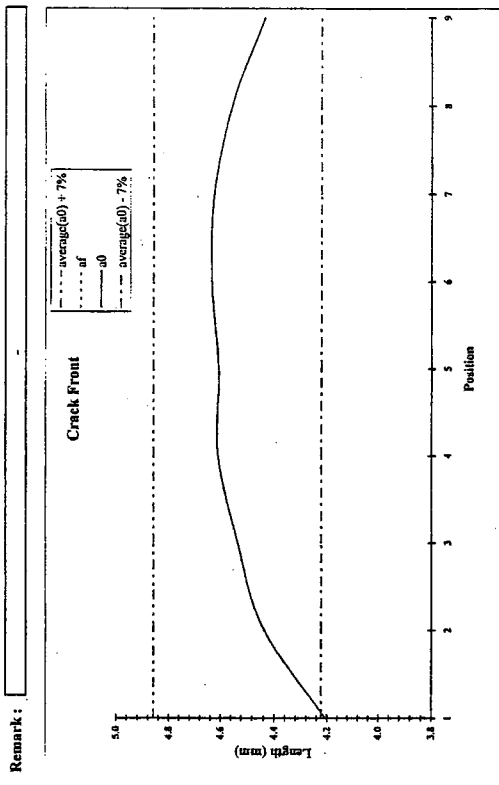
# Measure of Ao and Af

Date: 2001-06-14 File: X5D3H.xls Directory: J:\NTMec\_Test\test22nimocr37\Mini\_CTV\AO  
 Material: 22NIMOCr37  
 CT nr.: X5D3H  
 a\_max (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.357 Ba\* (mm): 4.040 Ba (mm): 4.064 B (mm): 4.064  
 Picture W (cm): Bn\* (cm): Bn (cm): B (cm):

Fracturing Machine: INSTRON  
 Kmax (MPaVm): 24.650  
 Kfinal (MPaVm): 20.932



CT	mm	error	mm	error	CT	mm	error
a01	4.208	-7.33%	a11	4.208	-7.33%	Δ a1	0.000
a02	4.437	-2.29%	a12	4.437	-2.29%	Δ a2	0.000
a03	4.534	-0.15%	a13	4.534	-0.15%	Δ a3	0.000
a04	4.610	1.52%	a14	4.610	1.52%	Δ a4	0.000
a05	4.607	1.46%	a15	4.607	1.46%	Δ a5	0.000
a06	4.635	2.07%	a16	4.635	2.07%	Δ a6	0.000
a07	4.626	1.88%	a17	4.626	1.88%	Δ a7	0.000
a08	4.556	0.33%	a18	4.556	0.33%	Δ a8	0.000
a09	4.435	-2.33%	a19	4.435	-2.33%	Δ a9	0.000
Average a0	4.541		Average a1	4.541		-gem.	0.000

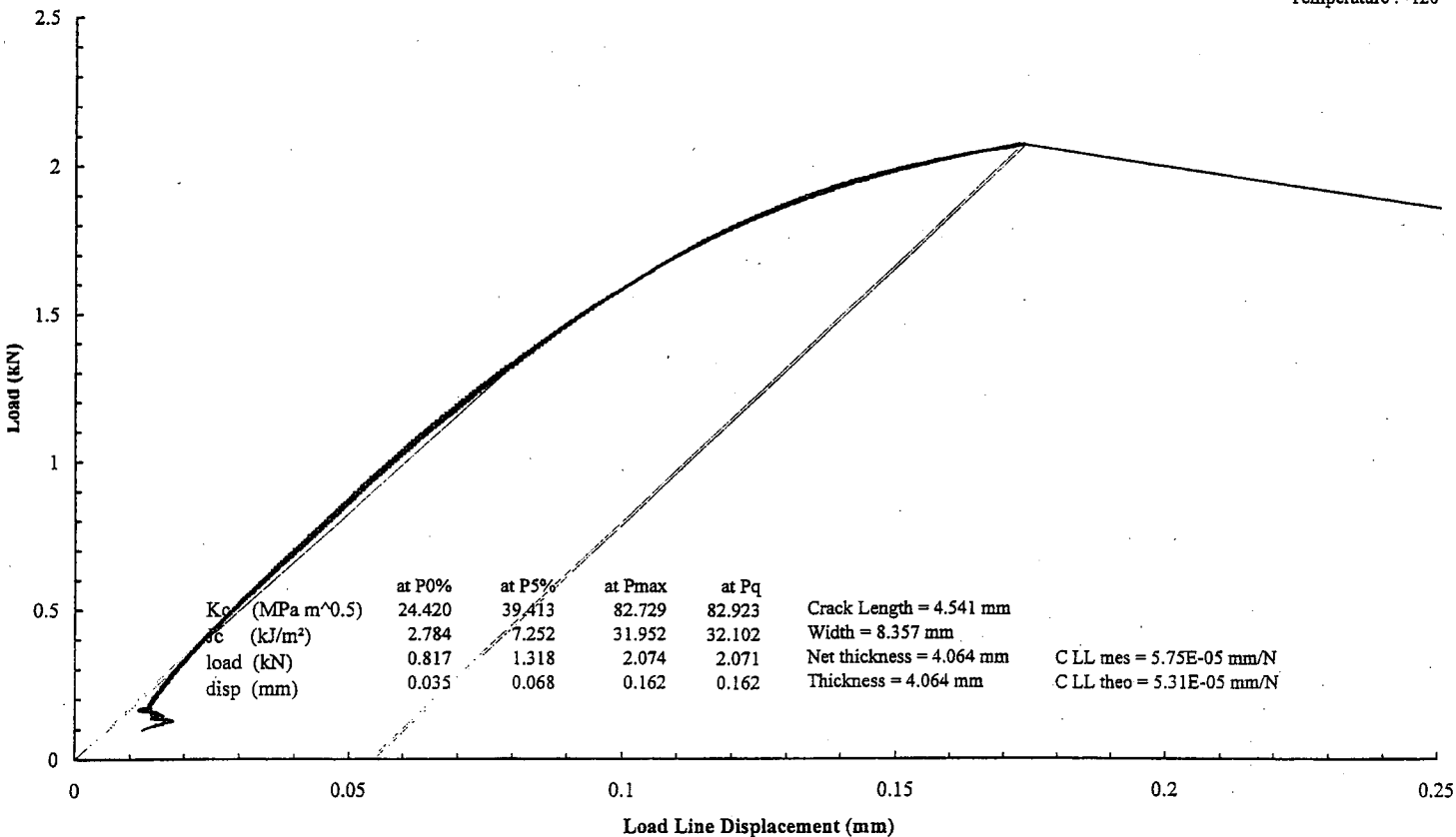


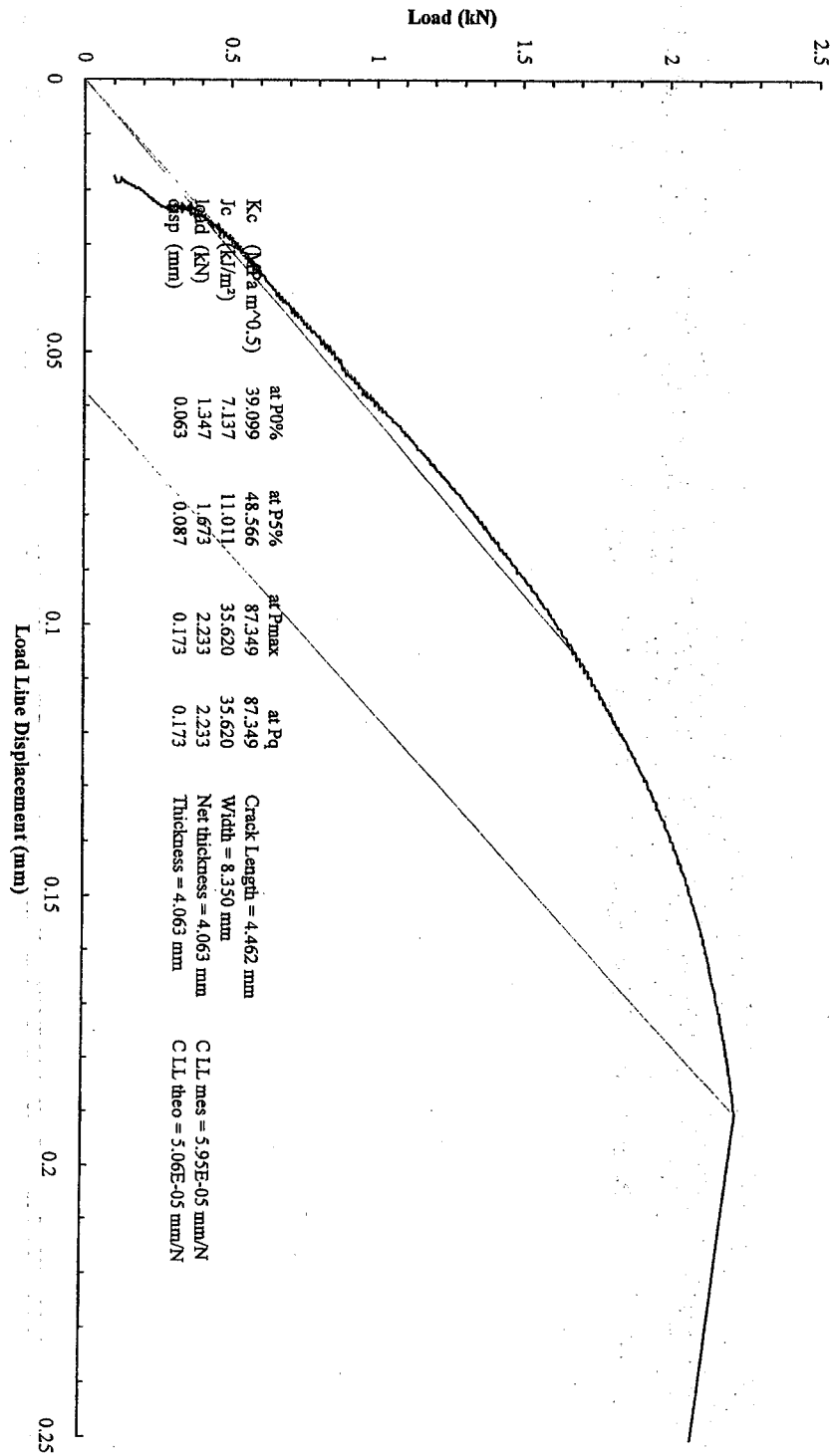
Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kje

X5D3H.XLS  
 Material : 22NIMOCr37  
 Specimen id : X5D3H  
 Test data : 14 Jun 2001  
 Temperature : -120





SCK-CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)  
Date: 2001-07-04  
Software: IC\_CTV4\_Excel97.

**C(T) FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	X5D3D
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.35
	Thickness (mm):	4.063
	Net thickness (mm):	4.063
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	12 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>r,max</sub> (MPa√m):	24.685
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	20.324

Crack	Initial crack length (mm):	Ductile crack extension (mm):		
	a <sub>0</sub>	4.46194	Δa <sub>0</sub>	0
	a <sub>0_1</sub>	4.103	Δa <sub>0_1</sub>	0
	a <sub>0_2</sub>	4.31	Δa <sub>0_2</sub>	0
	a <sub>0_3</sub>	4.457	Δa <sub>0_3</sub>	0
	a <sub>0_4</sub>	4.526	Δa <sub>0_4</sub>	0
	a <sub>0_5</sub>	4.568	Δa <sub>0_5</sub>	0
	a <sub>0_6</sub>	4.582	Δa <sub>0_6</sub>	0
	a <sub>0_7</sub>	4.575	Δa <sub>0_7</sub>	0
	a <sub>0_8</sub>	4.47	Δa <sub>0_8</sub>	0
	a <sub>0_9</sub>	4.312	Δa <sub>0_9</sub>	0

Fracture toughness	J <sub>c</sub> (kJ/m²):	35.62
	K <sub>Jc</sub> (MPa√m):	87.35

Remarks	V=0.5mm/min
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Signature:



### Measure of Ao and Af

Date: 2001-06-12 File: a0-X5D3D.xls Directory: 3NT\Mcc\_Test\test\22nimocr37\Mini\_CT\A0

Material: 22NiMoCr37

CT nr.: X5D3D

a<sub>fmax</sub> (mm): 3.000 F<sub>max</sub> (kN): 1.400 F<sub>final</sub> (kN): 0.700

CT W (mm): 8.350 B<sub>a</sub> \* (mm): 4.011 B<sub>b</sub> (mm): 4.063 B (mm): 4.063

Picture W (cm): B<sub>n</sub> \* (cm): B<sub>n</sub> (cm): B (cm):

0.01 \* B 0.041 mm  
10% B 0.491 mm

Picture	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

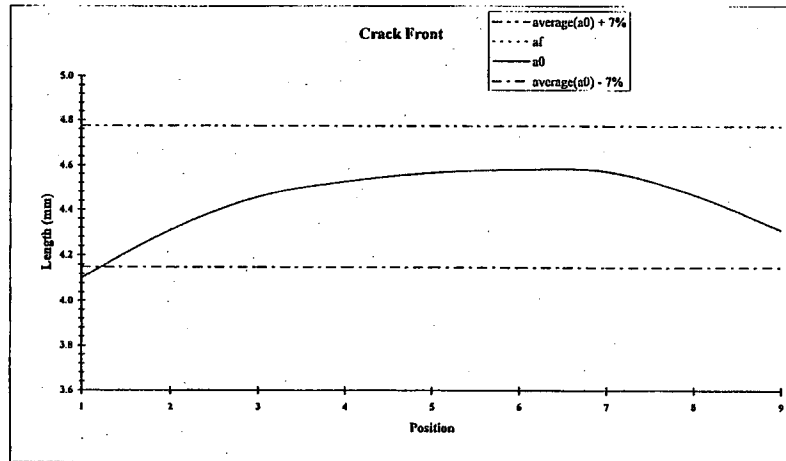
Picture	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

K<sub>max</sub> (MPa√m): 24.685  
K<sub>final</sub> (MPa√m): 20.324

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.103	-8.04%	af1	4.103	-8.04%	Δ a1	0.000	0.00%
a02	4.310	-3.41%	af2	4.310	-3.41%	Δ a2	0.000	0.00%
a03	4.457	-0.11%	af3	4.457	-0.11%	Δ a3	0.000	0.00%
a04	4.526	1.44%	af4	4.526	1.44%	Δ a4	0.000	0.00%
a05	4.568	2.38%	af5	4.568	2.38%	Δ a5	0.000	0.00%
a06	4.582	2.69%	af6	4.582	2.69%	Δ a6	0.000	0.00%
a07	4.575	2.53%	af6	4.575	2.53%	Δ a7	0.000	0.00%
a08	4.470	0.18%	af8	4.470	0.18%	Δ a8	0.000	0.00%
a09	4.312	-3.36%	af9	4.312	-3.36%	Δ a9	0.000	0.00%
Average a0	4.462		Average af	4.462		- gem.	0.000	

Remark: -



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3B
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.378
	Thickness (mm):	4.071
	Net thickness (mm):	4.071
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	11 Jun 2001
	Test operator:	P Wouters

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.519
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	17.779

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.13306	Δa <sub>0</sub> 0
a <sub>0_1</sub>	3.9105	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.0845	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.1675	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.2175	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.2285	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.2135	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.1625	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.0855	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	3.8995	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	38.24
	K <sub>Jc</sub> (MPa√m):	90.51

Remarks: V=0.5mm/min

Signature:

# Measure of A0 and Af

Date: 2001-06-12 File: a0-X5D3B.xls Directory: \NT\Mec\_Test\test22nimocr37\Mini\_CT1A0

Material: 22NiMoCr37

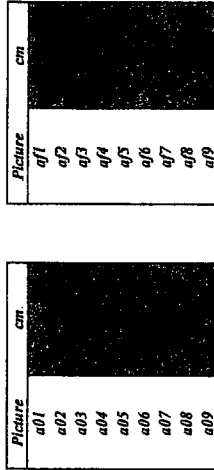
CT nr.: X5D3B

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.378 B0\* (mm): 4.015 B0 (mm): 4.071 B (mm): 4.071  
 Picture W (cm): B0\* (cm): B0 (cm): B (cm):

0.01\*B 0.041 mm  
 10%B 0.492 mm

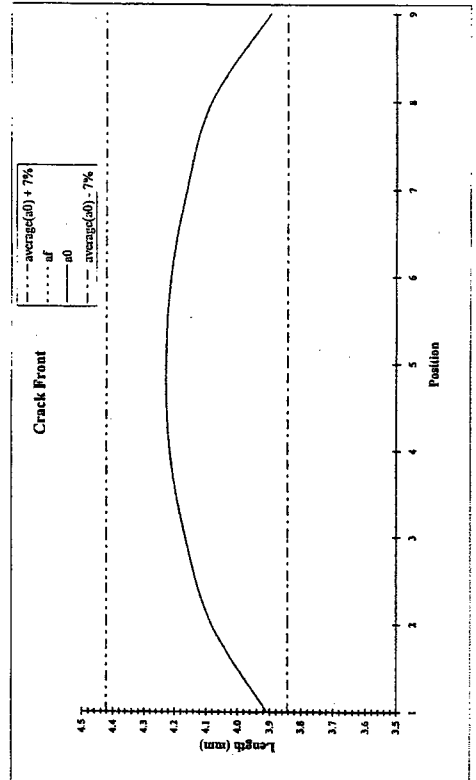
Precracking Machine: INSTRON

Kmax (MPaVm): 24.519  
 Kfinal (MPaVm): 17.779



CT	mm	error	CT	mm	error	CT	mm	error
a01	3.911	-5.38%	a01	3.911	-5.38%	Δa1	0.000	0.00%
a02	4.085	-1.17%	a02	4.085	-1.17%	Δa2	0.000	0.00%
a03	4.168	0.83%	a03	4.168	0.83%	Δa3	0.000	0.00%
a04	4.218	2.04%	a04	4.218	2.04%	Δa4	0.000	0.00%
a05	4.229	2.31%	a05	4.229	2.31%	Δa5	0.000	0.00%
a06	4.214	1.95%	a06	4.214	1.95%	Δa6	0.000	0.00%
a07	4.163	0.71%	a07	4.163	0.71%	Δa7	0.000	0.00%
a08	4.086	-1.15%	a08	4.086	-1.15%	Δa8	0.000	0.00%
a09	3.900	-5.65%	a09	3.900	-5.65%	Δa9	0.000	0.00%
Average a0	4.133		Average af	4.133		-gem.	0.000	0.00%

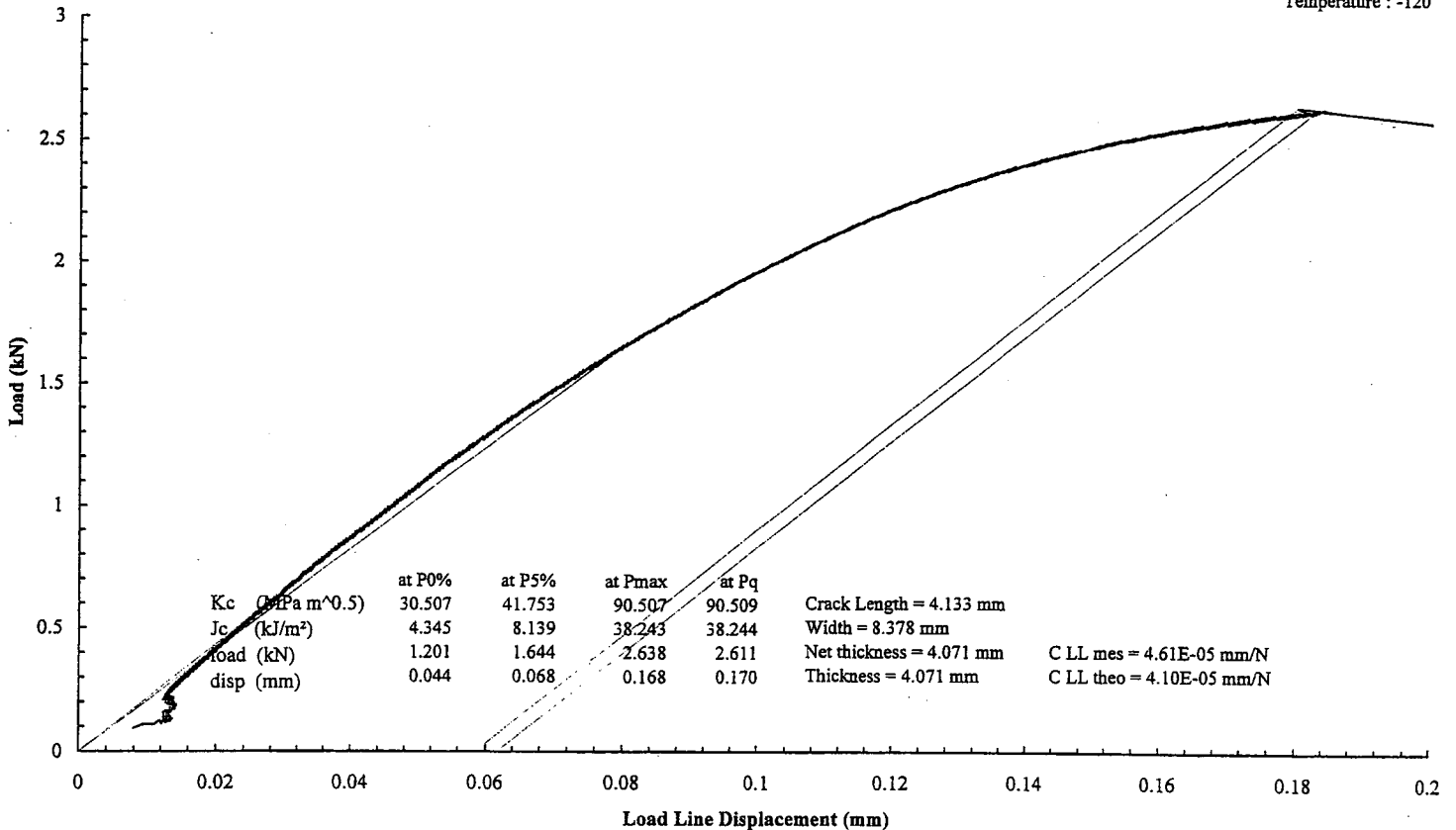
Remark:



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kjc

X5D3B.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D3B  
 Test data : 11 Jun 2001  
 Temperature : -120



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D2B
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.412
	Thickness (mm):	4.08
	Net thickness (mm):	4.08
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	20 Jun 2001
	Test operator:	JV

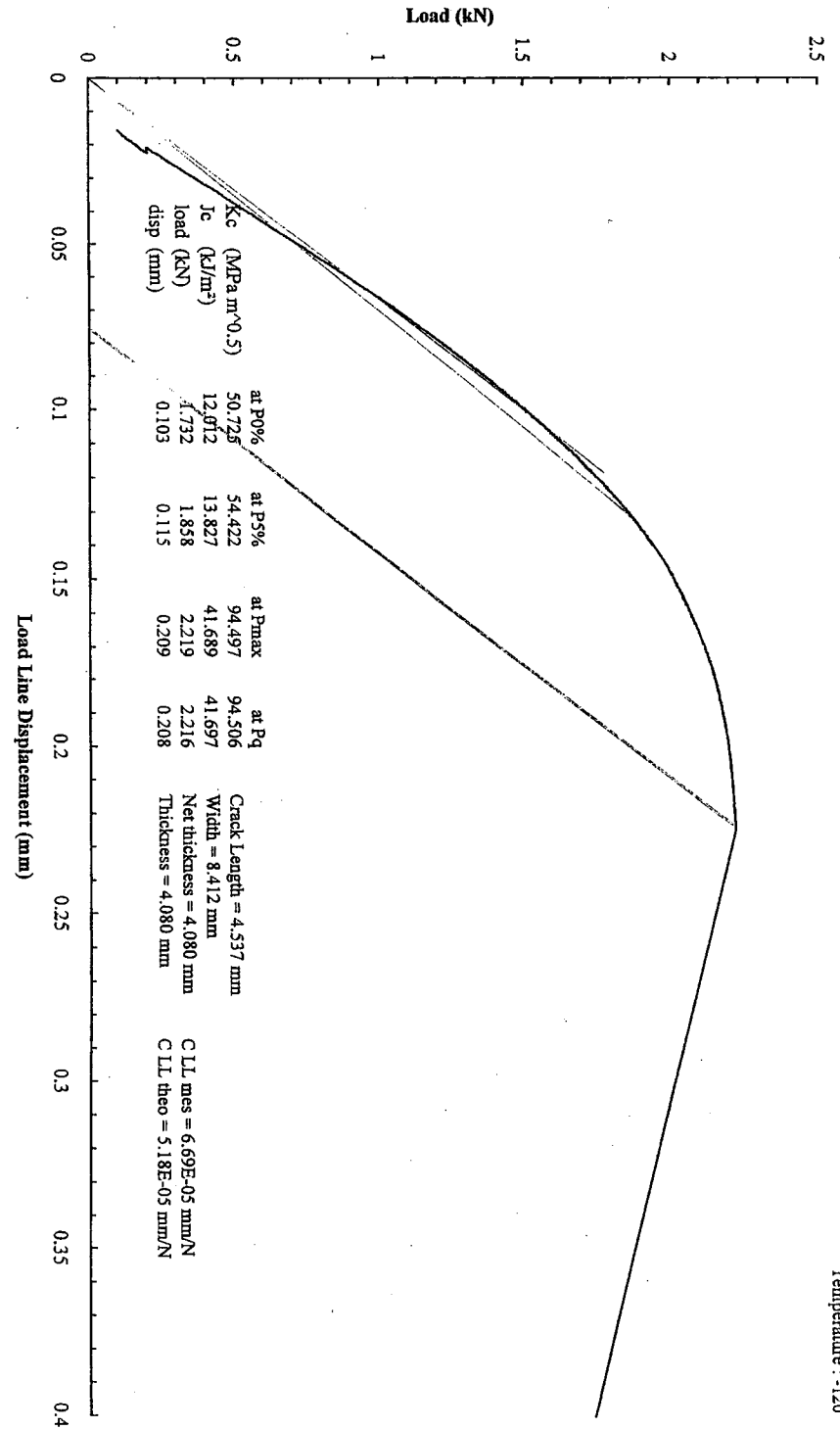
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	24.325
	R:	0.1
	$K_{f0.64}$ (MPa√m):	20.505

Crack	Initial crack length (mm):		Ductile crack extension (mm):	
	$a_0$		$\Delta a_0$	
	4.53725		0	
$a_{0_1}$	4.417		0	
$a_{0_2}$	4.544		0	
$a_{0_3}$	4.634		0	
$a_{0_4}$	4.656		0	
$a_{0_5}$	4.633		0	
$a_{0_6}$	4.592		0	
$a_{0_7}$	4.516		0	
$a_{0_8}$	4.414		0	
$a_{0_9}$	4.201		0	

<b>Fracture toughness</b>	$J_c$ (kJ/m <sup>2</sup> ):	41.70
	$K_{Jc}$ (MPa√m):	94.51

<b>Remarks</b>	V = 0.2 mm/min
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Signature: 



### Measure of Ao and Af

Date: 2001-06-20 File: a0-X5D2B.xls Directory: \ENT\Mec\_Tests\22nimocr37\Mini\_CTV40

Material: 22NiMoCr37

CT nr.: X5D2B

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.412 Bn\* (mm): 4.047 Ba (mm): 4.080 B (mm): 4.080

Foto W (cm): Bn\* (cm): Ba (cm): B (cm):

0.01\*B 0.041 mm  
 10% B 0.496 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

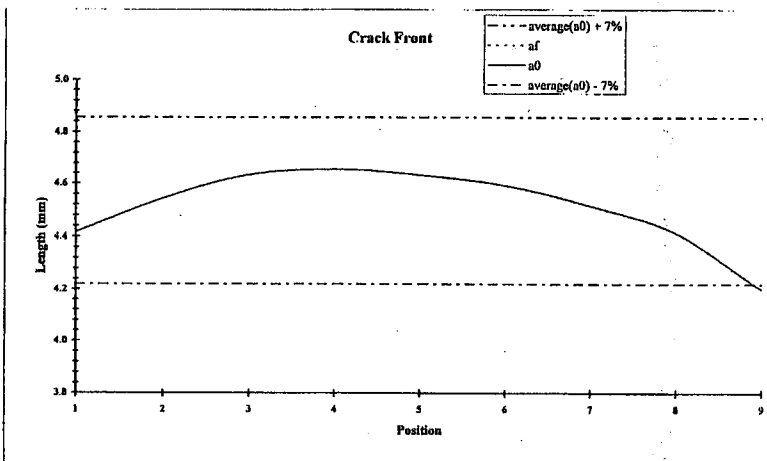
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.325  
 Kfinal (MPa√m): 20.505

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.417	-2.65%	af1	4.417	-2.65%	-a1	0.000	0.00%
a02	4.544	0.15%	af2	4.544	0.15%	-a2	0.000	0.00%
a03	4.634	2.13%	af3	4.634	2.13%	-a3	0.000	0.00%
a04	4.656	2.62%	af4	4.656	2.62%	-a4	0.000	0.00%
a05	4.633	2.11%	af5	4.633	2.11%	-a5	0.000	0.00%
a06	4.592	1.21%	af6	4.592	1.21%	-a6	0.000	0.00%
a07	4.516	-0.47%	af6	4.516	-0.47%	-a7	0.000	0.00%
a08	4.414	-2.72%	af8	4.414	-2.72%	-a8	0.000	0.00%
a09	4.201	-7.41%	af9	4.201	-7.41%	-a9	0.000	0.00%
a0 gem.	4.537		af gem.	4.537		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3C
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.346
	Thickness (mm):	4.065
	Net thickness (mm):	4.065
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	12 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.69
	R:	0.1
	K <sub>F0.64</sub> (MPa√m):	18.372

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.19738	Δa <sub>0</sub> 0
a <sub>0_1</sub>	3.97	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.176	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.261	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.297	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.296	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.276	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.214	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.12	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	3.908	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	43.14
	K <sub>Jc</sub> (MPa√m):	96.13

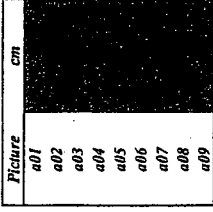
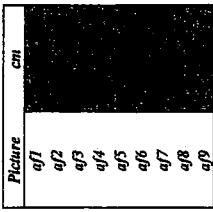
Remarks: V=0.5mm/min

Signature: *ED*

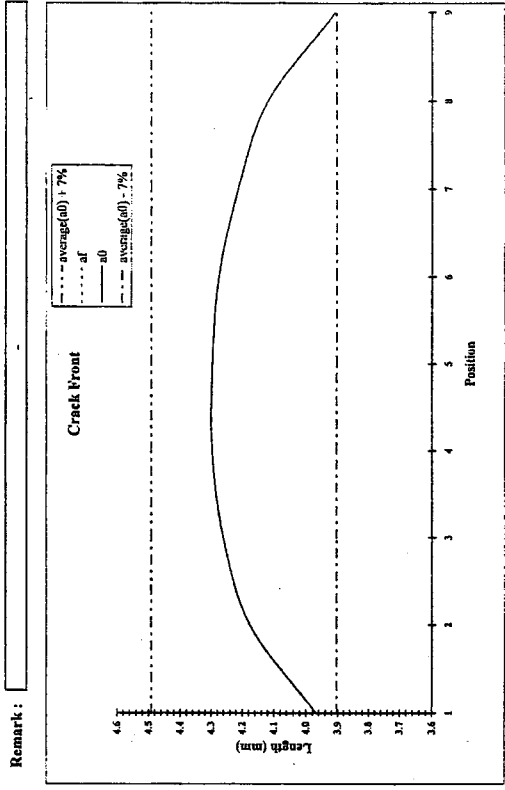
**Measure of Ao and Af**

Date: 2001-06-12 File: a0-X5D3C.xls Directory: ENTMec\_Test\test\22nimoer37\Mini\_CTVAR  
 Material: 22NIMOC37 CT nr.: X5D3C  
 a\_fmax (mm): 3.000 Fmax (kN): 1.400 Kfinal (kN): 0.700  
 W (mm): 8.346 Bn\* (mm): 4.008 Bn (mm): 4.065 B (mm): 4.065  
 CT Picture W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.041 mm  
 10% B 0.491 mm

Precracking Machine: INSTRON  
 Kmax (MPaVm): 24.690  
 Kfinal (MPaVm): 18.372



CT	mm	error	CT	mm	error
a/1	3.970	-5.42%	a/1	3.970	0.00%
a/2	4.176	-0.51%	a/2	4.176	0.00%
a/3	4.261	1.52%	a/3	4.261	0.00%
a/4	4.297	2.37%	a/4	4.297	0.00%
a/5	4.296	2.35%	a/5	4.296	0.00%
a/6	4.276	1.87%	a/6	4.276	0.00%
a/7	4.214	0.40%	a/7	4.214	0.00%
a/8	4.120	-1.84%	a/8	4.120	0.00%
a/9	3.908	-6.89%	a/9	3.908	0.00%
Average a/0	4.197		Average a/f	4.197	0.00%

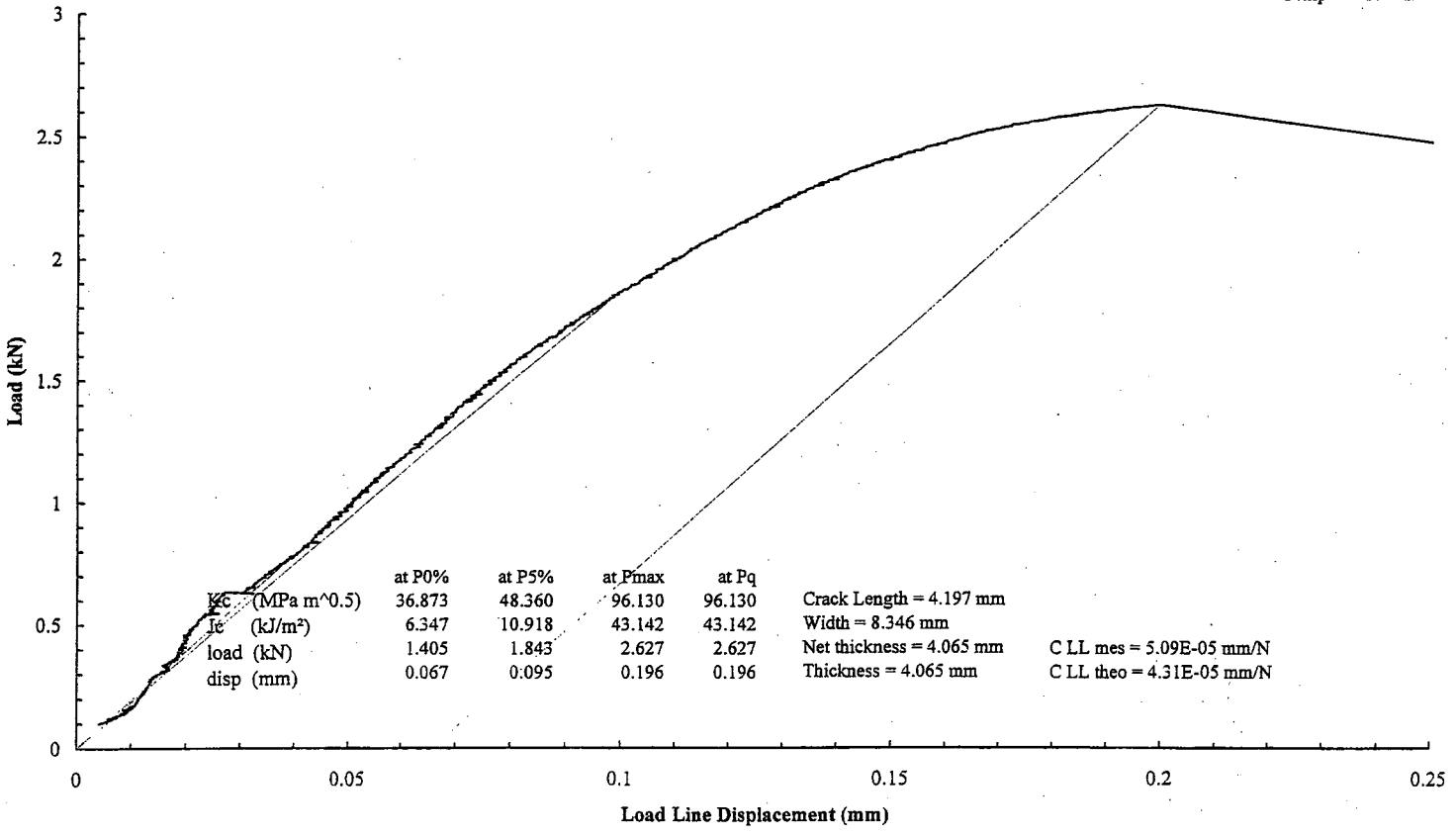


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kjc

X5D3C.XLS  
 Material : 22NIMOC37  
 Specimen id : X5D3C  
 Test data : 12 Jun 2001  
 Temperature : -120



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D2D
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.361
	Thickness (mm):	4.07
Net thickness (mm):	4.07	
Side grooving:	0%	

<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	
	Test date:	19 Jun 2001
	Test operator:	JV

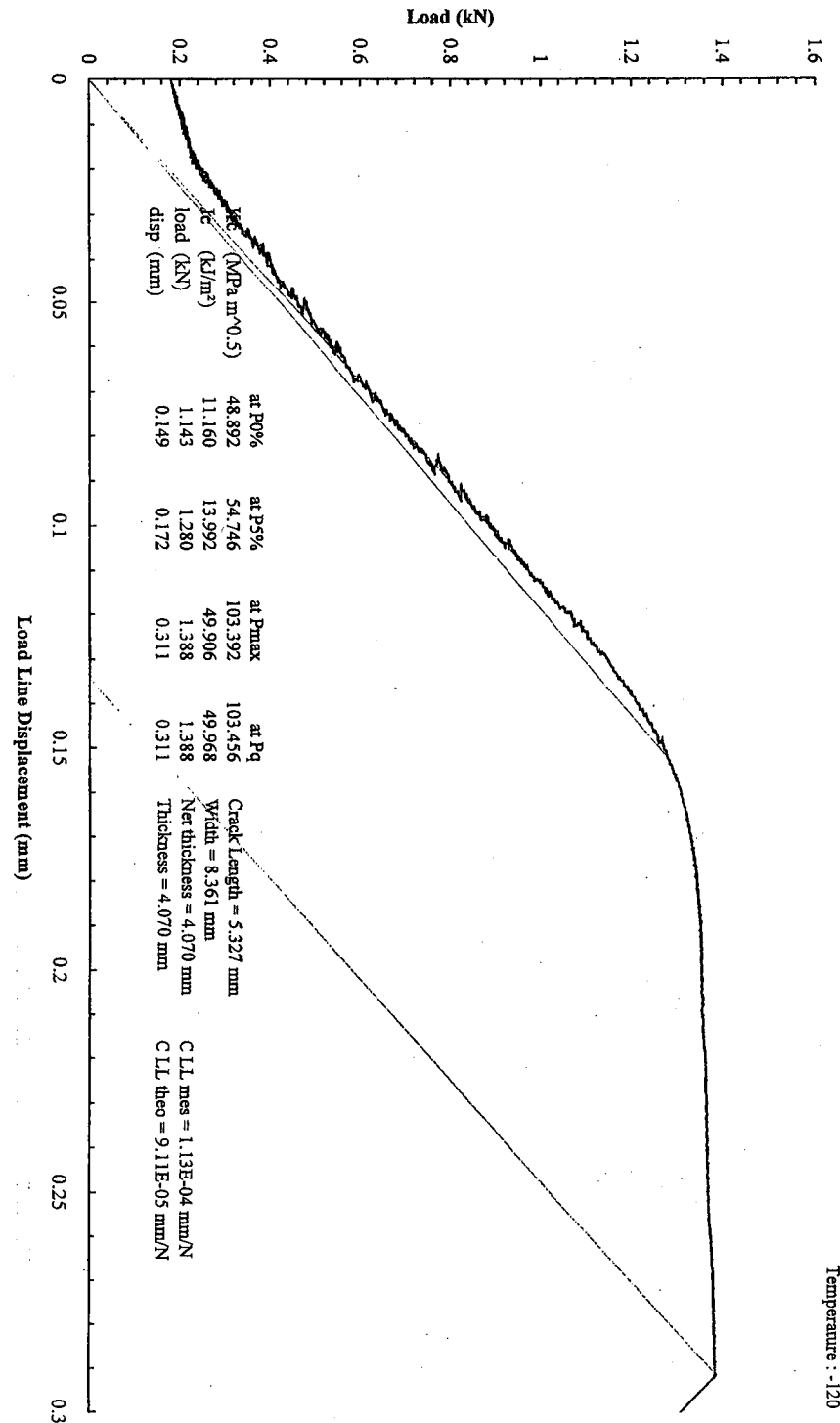
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	29.944
	R:	0.1
	$K_{r0.64}$ (MPa√m):	29.944

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):		
	$a_0$	5.32706	$\Delta a_0$	0
	$a_{0_1}$	5.15	$\Delta a_{0_1}$	0
	$a_{0_2}$	5.265	$\Delta a_{0_2}$	0
	$a_{0_3}$	5.33	$\Delta a_{0_3}$	0
	$a_{0_4}$	5.38	$\Delta a_{0_4}$	0
	$a_{0_5}$	5.396	$\Delta a_{0_5}$	0
	$a_{0_6}$	5.409	$\Delta a_{0_6}$	0
	$a_{0_7}$	5.368	$\Delta a_{0_7}$	0
	$a_{0_8}$	5.299	$\Delta a_{0_8}$	0
$a_{0_9}$	5.189	$\Delta a_{0_9}$	0	

<b>Fracture toughness</b>	$J_c$ (kJ/m²):	49.97
	$K_{Jc}$ (MPa√m):	103.46

**Remarks** V = 0.2 mm/min.

Signature: *[Handwritten Signature]*



### Measure of Ao and Af

Date: 2001-06-19 File: a0-XSD2D.xls Directory: 3NT\Mcc\_Test\test\22nimocr37\Mini\_CTV40

Material: 22NiMoCr37

CT nr.: XSD2D

a<sub>f</sub>max (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.361 Bn\* (mm): 4.043 Bn (mm): 4.070 B (mm): 4.070

Foto W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.495 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

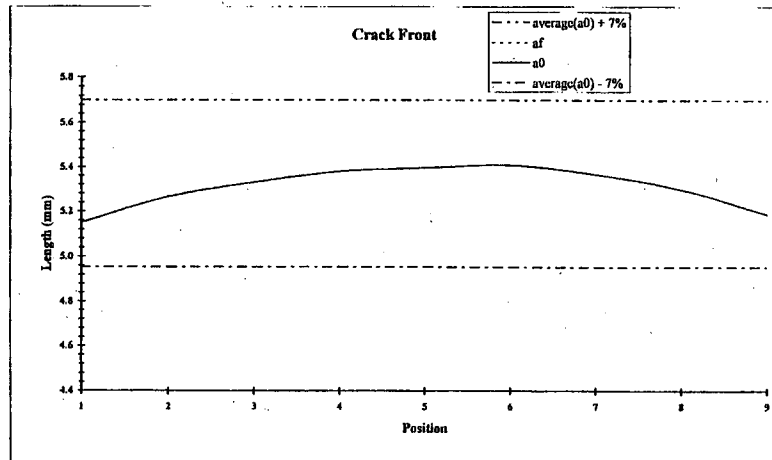
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 29.944  
Kfinal (MPa√m): 29.944

CT	mm	error	CT	mm	error	CT	mm	error
a01	5.150	-3.32%	af1	5.150	-3.32%	-a1	0.000	0.00%
a02	5.265	-1.17%	af2	5.265	-1.17%	-a2	0.000	0.00%
a03	5.330	0.06%	af3	5.330	0.06%	-a3	0.000	0.00%
a04	5.380	0.99%	af4	5.380	0.99%	-a4	0.000	0.00%
a05	5.396	1.29%	af5	5.396	1.29%	-a5	0.000	0.00%
a06	5.409	1.54%	af6	5.409	1.54%	-a6	0.000	0.00%
a07	5.368	0.77%	af6	5.368	0.77%	-a7	0.000	0.00%
a08	5.299	-0.53%	af8	5.299	-0.53%	-a8	0.000	0.00%
a09	5.189	-2.59%	af9	5.189	-2.59%	-a9	0.000	0.00%
a0 gem.	5.327		af gem.	5.327		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D4B
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.356
	Thickness (mm):	3.909
	Net thickness (mm):	3.909
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	15/06/01
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	25.631
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	20.637

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.40681	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.182	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.307	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.387	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.432	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.473	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.462	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.469	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.45	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.367	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	58.43
	K <sub>Jc</sub> (MPa√m):	111.87

Remarks: V=0.2mm/min Programma Crack Arrest

Signature:

# Measure of Ao and Af

Date: 2001-06-15 File: X5D4B.xls Directory: Z:\NT\Mec\_Test\test22nimocr37\Mini\_CTVAA0

Material: 22NiMoCr37

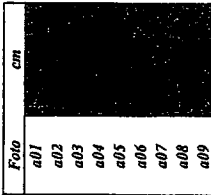
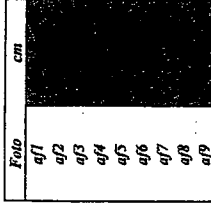
CT nr.: X5D4B

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Final (kN): 0.700  
 W (mm): 8.356 Bn\* (mm): 3.897 Bn (mm): 3.909 B (mm): 3.909  
 W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.039 mm  
 10% B 0.417 mm

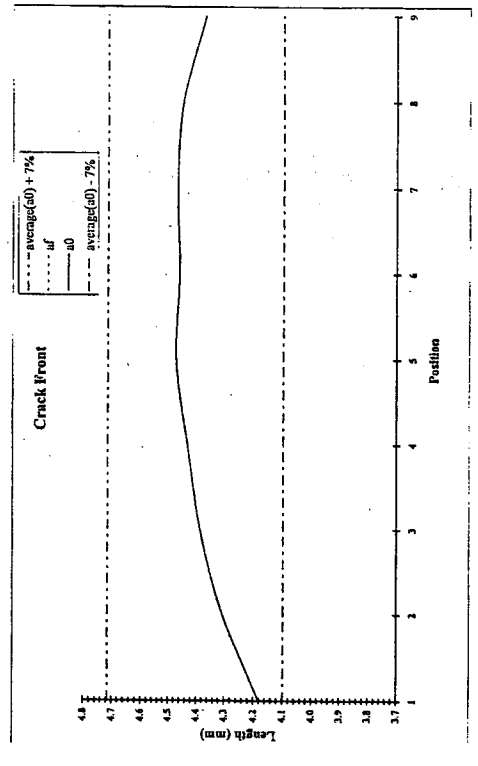
Preracking Machine: INSTRON

Kmax (MPa Vm): 25.631  
 Kfinal (MPa Vm): 20.637



CT	min	error	CT	min	error
a01	4.182	-5.10%	a11	4.182	-5.10%
a02	4.307	-2.26%	a12	4.307	-2.26%
a03	4.387	-0.45%	a13	4.387	-0.45%
a04	4.432	0.57%	a14	4.432	0.57%
a05	4.473	1.50%	a15	4.473	1.50%
a06	4.462	1.25%	a16	4.462	1.25%
a07	4.469	1.41%	a17	4.469	1.41%
a08	4.450	0.98%	a18	4.450	0.98%
a09	4.367	-0.90%	a19	4.367	-0.90%
a0 gen.	4.407		af gen.	4.407	
			- gen.	0.000	0.00%

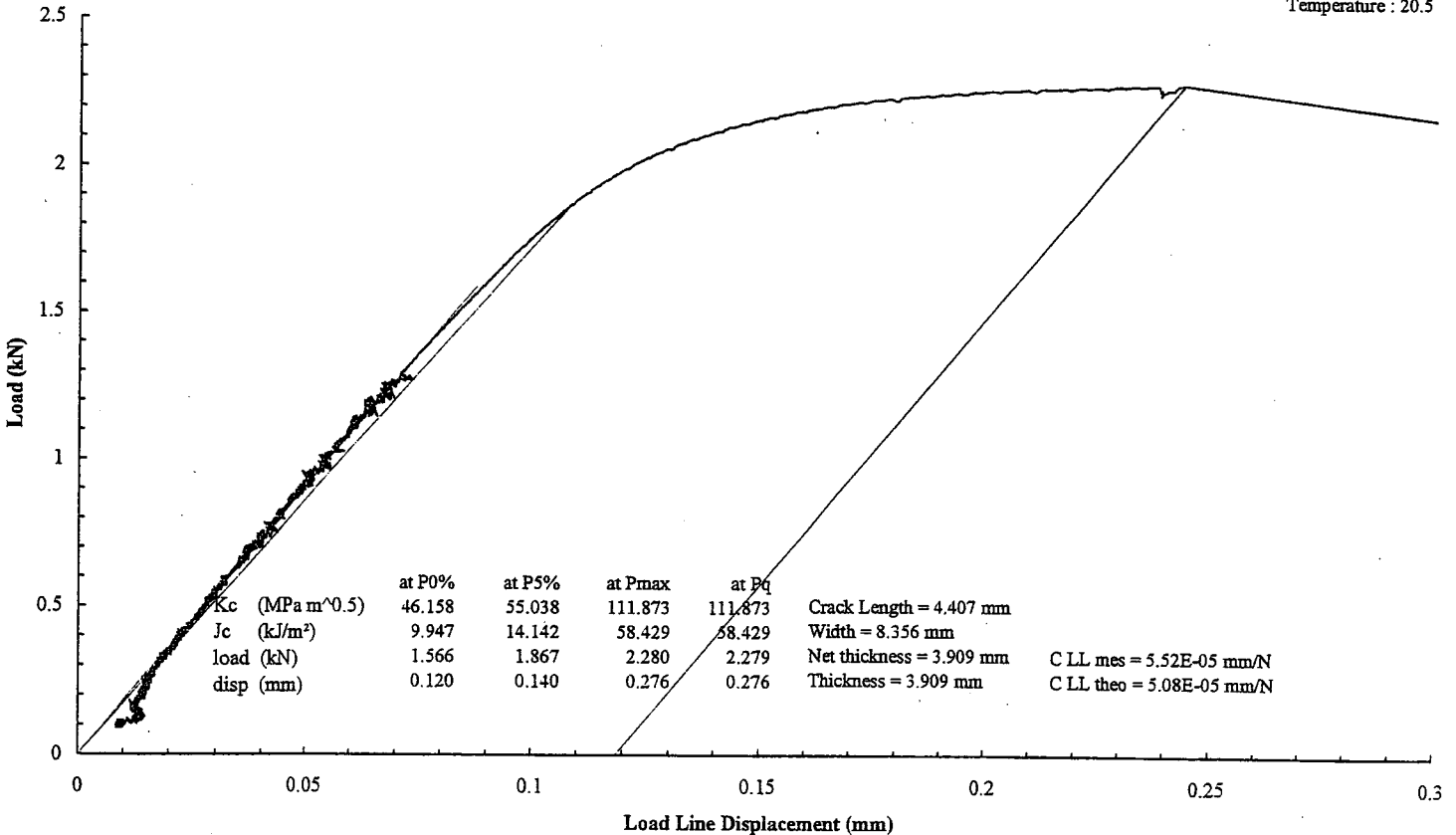
Remark:



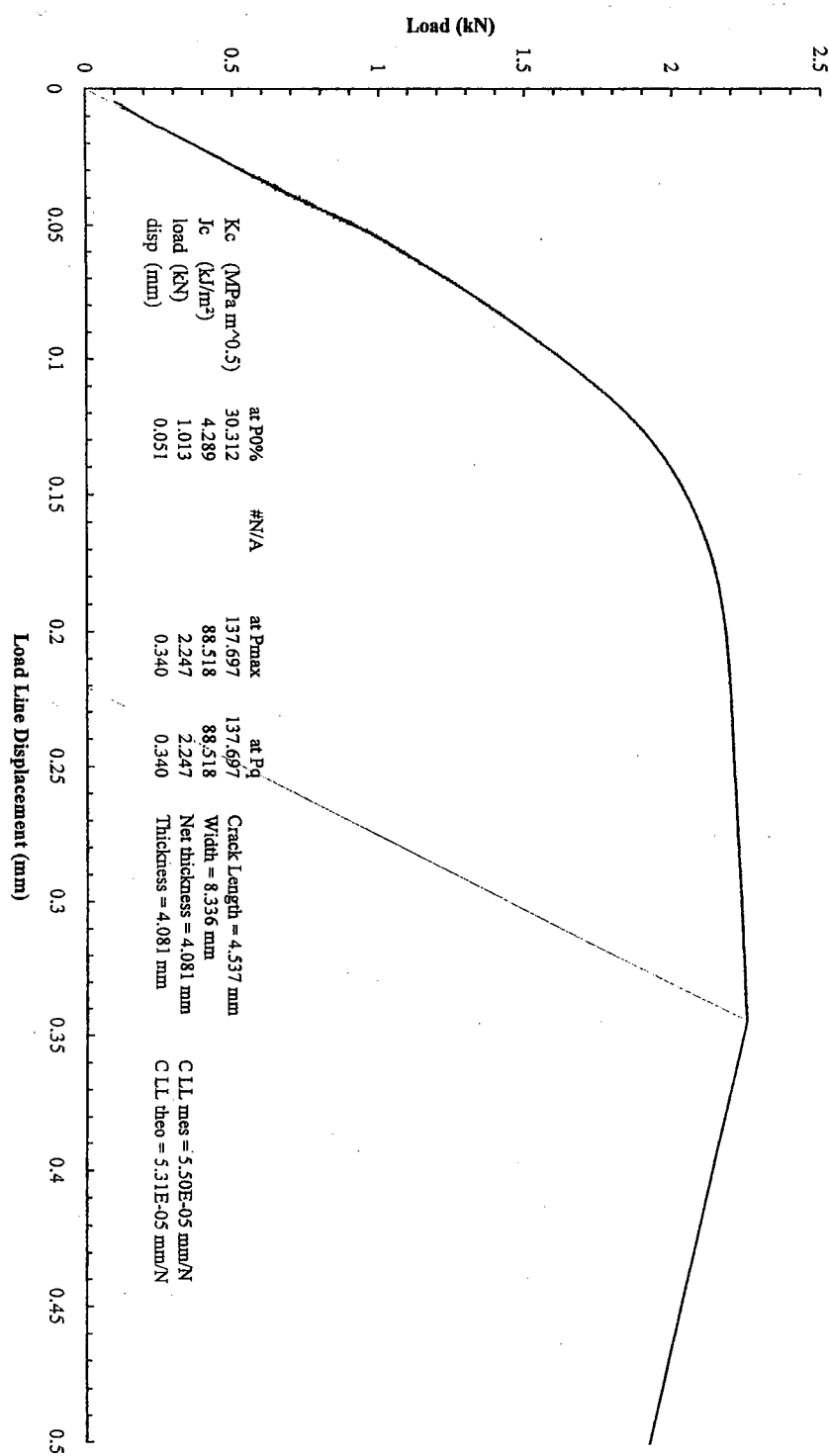
SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

Kjc

x5d4b\_XLS  
 Material : 22NiMoCr37  
 Specimen id : x5d4b\_  
 Test data : 15/06/01  
 Temperature : 20.5







**C(T) FRACTURE TOUGHNESS TEST**

Specimen parameters	Material:	22NiMoCr37
	Specimen type:	CT
	Specimen identification:	X5D2C
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.336
	Thickness (mm):	4.081
	Net thickness (mm):	4.081
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	19 Jun 2001
	Test operator:	JV

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.635
	R:	0.1
	K <sub>f0.64</sub> (MPa√m):	20.939

Crack	Initial crack length (mm):	Ductile crack extension (mm):
	a <sub>0</sub> 4.53738	Δa <sub>0</sub> 0
	a <sub>0_1</sub> 4.315	Δa <sub>0_1</sub> 0
	a <sub>0_2</sub> 4.517	Δa <sub>0_2</sub> 0
	a <sub>0_3</sub> 4.616	Δa <sub>0_3</sub> 0
	a <sub>0_4</sub> 4.654	Δa <sub>0_4</sub> 0
	a <sub>0_5</sub> 4.635	Δa <sub>0_5</sub> 0
	a <sub>0_6</sub> 4.622	Δa <sub>0_6</sub> 0
	a <sub>0_7</sub> 4.563	Δa <sub>0_7</sub> 0
	a <sub>0_8</sub> 4.436	Δa <sub>0_8</sub> 0
	a <sub>0_9</sub> 4.197	Δa <sub>0_9</sub> 0

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	88.52
	K <sub>Jc</sub> (MPa√m):	137.70

Remarks	V = 0.2 mm/min.
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Signature:

### Measure of Ao and Af

Date: 2001-06-20 File: a0-X5D2C.xls Directory: 3NTMcc\_TestNest\22nimocr37\Mini\_CTV40

Material: 22NiMoCr37

CT nr.: X5D2C

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.336 Bn \* (mm): 4.026 Bn (mm): 4.081 B (mm): 4.081

Foto W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.493 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

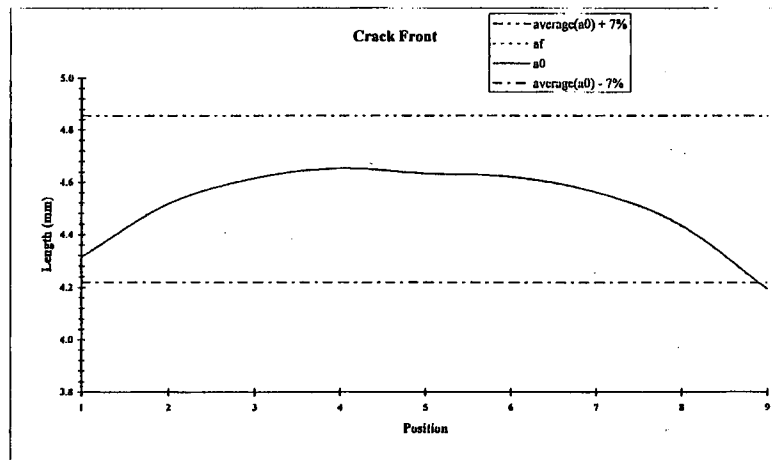
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPaVm): 24.635  
Kfinal (MPaVm): 20.939

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.315	-4.90%	af1	4.315	-4.90%	-a1	0.000	0.00%
a02	4.517	-0.45%	af2	4.517	-0.45%	-a2	0.000	0.00%
a03	4.616	1.73%	af3	4.616	1.73%	-a3	0.000	0.00%
a04	4.654	2.57%	af4	4.654	2.57%	-a4	0.000	0.00%
a05	4.635	2.15%	af5	4.635	2.15%	-a5	0.000	0.00%
a06	4.622	1.87%	af6	4.622	1.87%	-a6	0.000	0.00%
a07	4.563	0.56%	af6	4.563	0.56%	-a7	0.000	0.00%
a08	4.436	-2.23%	af8	4.436	-2.23%	-a8	0.000	0.00%
a09	4.197	-7.50%	af9	4.197	-7.50%	-a9	0.000	0.00%
a0 gem.	4.537		af gem.	4.537		-gem.	0.000	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3G
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.366
	Thickness (mm):	4.08
	Net thickness (mm):	4.08
	Side grooving:	0%

Test parameters	Test machine:	1342
	Test temperature (°C):	-120
	Test date:	14 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPaVm):	24.515
	R:	0.1
	K <sub>f0.64</sub> (MPaVm):	19.727

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.40775	Δa <sub>0</sub> 0
a <sub>0_1</sub>	4.242	Δa <sub>0_1</sub> 0
a <sub>0_2</sub>	4.427	Δa <sub>0_2</sub> 0
a <sub>0_3</sub>	4.511	Δa <sub>0_3</sub> 0
a <sub>0_4</sub>	4.544	Δa <sub>0_4</sub> 0
a <sub>0_5</sub>	4.519	Δa <sub>0_5</sub> 0
a <sub>0_6</sub>	4.474	Δa <sub>0_6</sub> 0
a <sub>0_7</sub>	4.38	Δa <sub>0_7</sub> 0
a <sub>0_8</sub>	4.26	Δa <sub>0_8</sub> 0
a <sub>0_9</sub>	4.052	Δa <sub>0_9</sub> 0

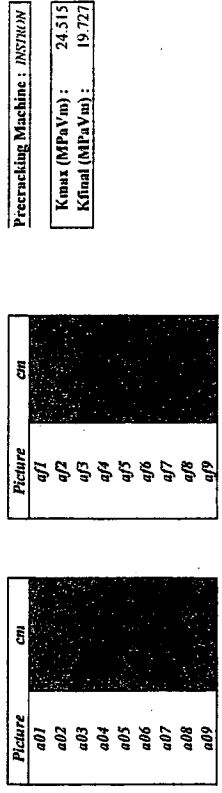
Fracture toughness	J <sub>c</sub> (kJ/m²):	84.35
	K <sub>Jc</sub> (MPaVm):	134.42

Remarks: V=0.2mm/min

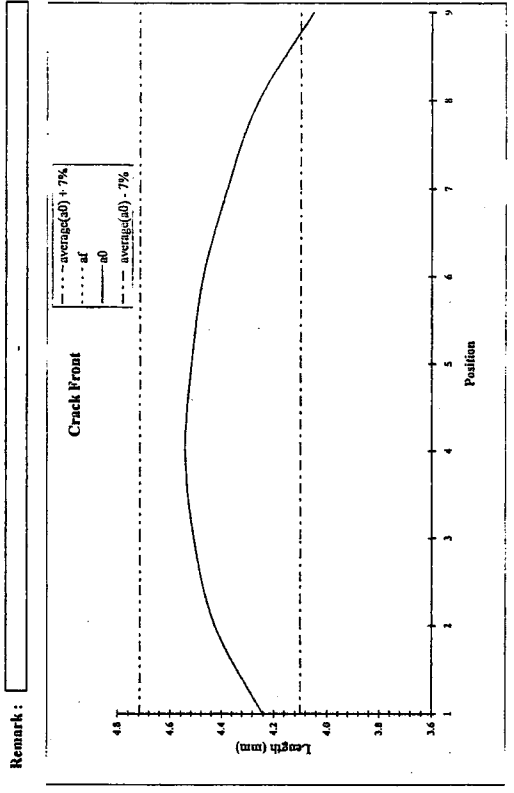
Signature:

**Measure of Ao and Af**

Date: 2001-06-14 File: ab-X5D3G.xls Directory: SNTUMec\_Testtest22nimocr37\Mini\_CTVAD  
 Material: 22NiMoCr37  
 CT nr.: X5D3G  
 a\_max (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.366 Ba\* (mm): 3.971 Bn (mm): 4.080 B (mm): 4.080  
 Picture W (cm): Ba\* (cm): Bn (cm): B (cm):



CT	num	error	mm	error	CT	num	error
a01	4.242	-3.76%	a11	4.242	Δa1	0.000	0.00%
a02	4.427	0.44%	a12	4.427	Δa2	0.000	0.00%
a03	4.511	2.34%	a13	4.511	Δa3	0.000	0.00%
a04	4.544	3.09%	a14	4.544	Δa4	0.000	0.00%
a05	4.519	2.52%	a15	4.519	Δa5	0.000	0.00%
a06	4.474	1.50%	a16	4.474	Δa6	0.000	0.00%
a07	4.380	-0.63%	a17	4.380	Δa7	0.000	0.00%
a08	4.260	-3.35%	a18	4.260	Δa8	0.000	0.00%
a09	4.052	-8.07%	a19	4.052	Δa9	0.000	0.00%
Average a0	4.408		Average a1	4.408	-geom.	0.000	

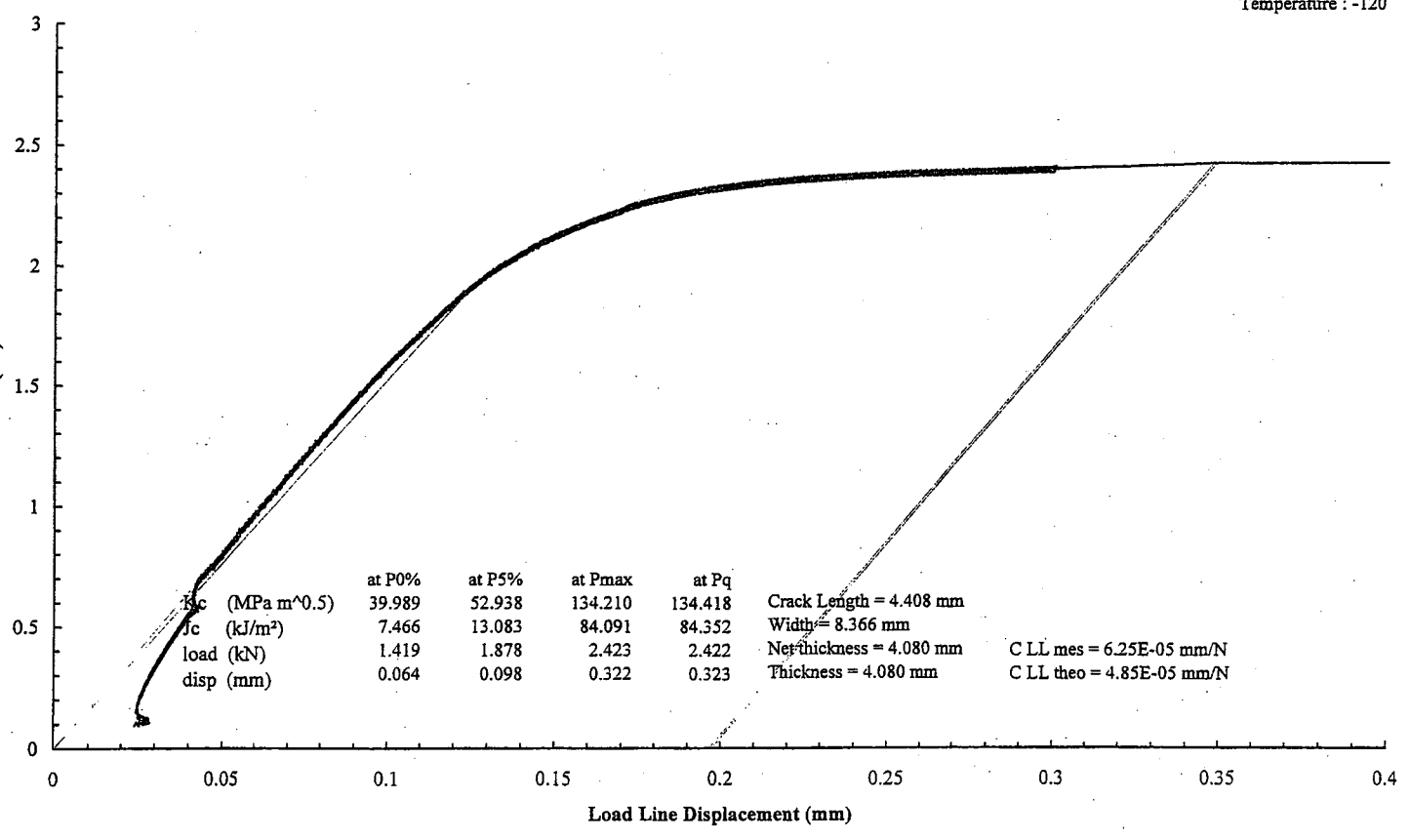


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**Kjc**

X5D3G.XLS  
 Material : 22NiMoCr37  
 Specimen id : X5D3G  
 Test data : 14 Jun 2001  
 Temperature : -120



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D4A
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.377
	Thickness (mm):	4.073
Net thickness (mm):	4.073	
Side grooving:	0%	


<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	14 Jun 2001
	Test operator:	PW

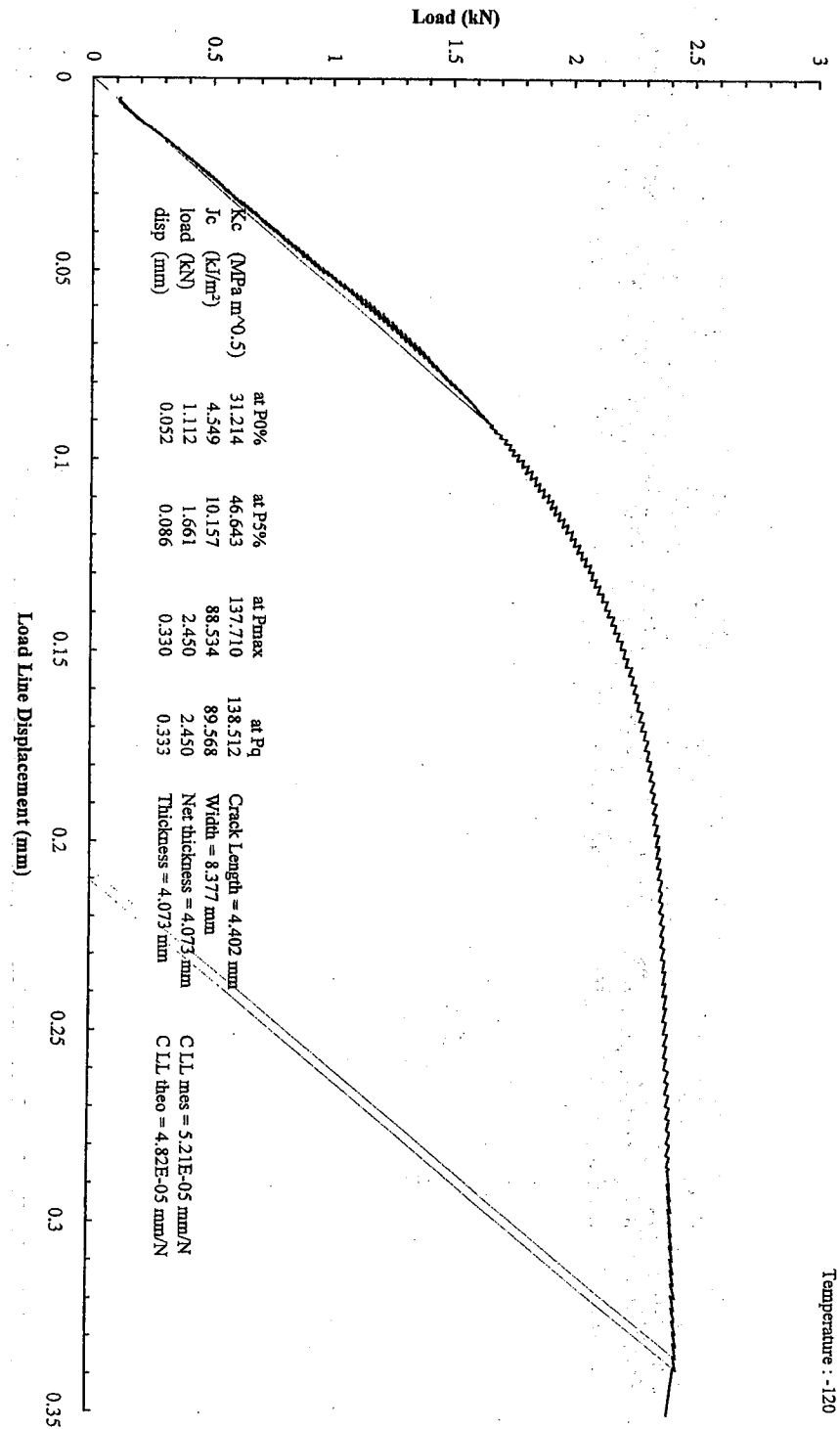
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	24.512
	R:	0.1
	$K_{r0.64}$ (MPa√m):	19.657

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):		
	$a_0$	4.40163	$\Delta a_0$	0
	$a_{0_1}$	4.279	$\Delta a_{0_1}$	0
	$a_{0_2}$	4.434	$\Delta a_{0_2}$	0
	$a_{0_3}$	4.523	$\Delta a_{0_3}$	0
	$a_{0_4}$	4.57	$\Delta a_{0_4}$	0
	$a_{0_5}$	4.535	$\Delta a_{0_5}$	0
	$a_{0_6}$	4.463	$\Delta a_{0_6}$	0
	$a_{0_7}$	4.351	$\Delta a_{0_7}$	0
	$a_{0_8}$	4.126	$\Delta a_{0_8}$	0
$a_{0_9}$	4.143	$\Delta a_{0_9}$	0	

<b>Fracture toughness</b>	$I_c$ (kJ/m <sup>2</sup> ):	89.57
	$K_{Jc}$ (MPa√m):	138.51

<b>Remarks</b>	V=0.2mm/min
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Signature: 



### Measure of Ao and Af

Date: 2001-06-15 File: X5D4A.xls Directory: \3NTMec\_Test\est\22nimocr37\Mini\_CT\A0

Material: 22NiMoCr37

CT nr.: X5D4A

a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.377 Bn \* (mm): 3.976 Bn (mm): 4.073 B (mm): 4.073

Foto W (cm): Bn \* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.487 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

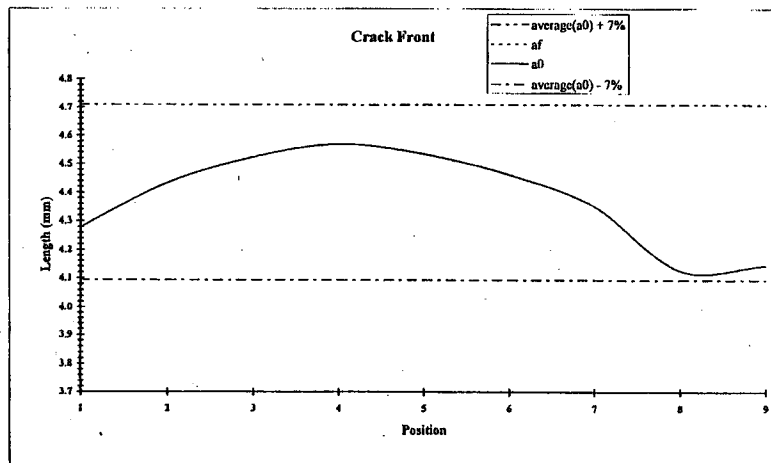
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.512  
Kfinal (MPa√m): 19.657

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.279	-2.79%	af1	4.279	-2.79%	-a1	0.000	0.00%
a02	4.434	0.74%	af2	4.434	0.74%	-a2	0.000	0.00%
a03	4.523	2.76%	af3	4.523	2.76%	-a3	0.000	0.00%
a04	4.570	3.83%	af4	4.570	3.83%	-a4	0.000	0.00%
a05	4.535	3.03%	af5	4.535	3.03%	-a5	0.000	0.00%
a06	4.463	1.39%	af6	4.463	1.39%	-a6	0.000	0.00%
a07	4.351	-1.15%	af6	4.351	-1.15%	-a7	0.000	0.00%
a08	4.126	-6.26%	af8	4.126	-6.26%	-a8	0.000	0.00%
a09	4.143	-5.88%	af9	4.143	-5.88%	-a9	0.000	0.00%
a0 gem.	4.402		af gem.	4.402		-gem.	0.000	

Remark: \_\_\_\_\_



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3F
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.353
	Thickness (mm):	4.098
	Net thickness (mm):	4.098
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	12 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.462
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	17.655

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.11569	Δa <sub>0</sub> 0.04338
a <sub>0_1</sub>	3.92	Δa <sub>0_1</sub> 0.022
a <sub>0_2</sub>	4.115	Δa <sub>0_2</sub> 0.027
a <sub>0_3</sub>	4.192	Δa <sub>0_3</sub> 0.047
a <sub>0_4</sub>	4.216	Δa <sub>0_4</sub> 0.048
a <sub>0_5</sub>	4.22	Δa <sub>0_5</sub> 0.063
a <sub>0_6</sub>	4.177	Δa <sub>0_6</sub> 0.068
a <sub>0_7</sub>	4.114	Δa <sub>0_7</sub> 0.036
a <sub>0_8</sub>	4.024	Δa <sub>0_8</sub> 0.03
a <sub>0_9</sub>	3.815	Δa <sub>0_9</sub> 0.034

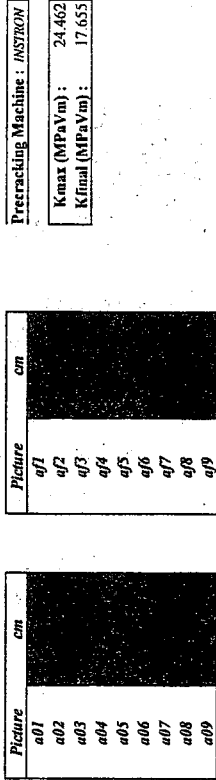
Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	115.47
	K <sub>Jc</sub> (MPa√m):	157.27

Remarks	V=0.2mm/min
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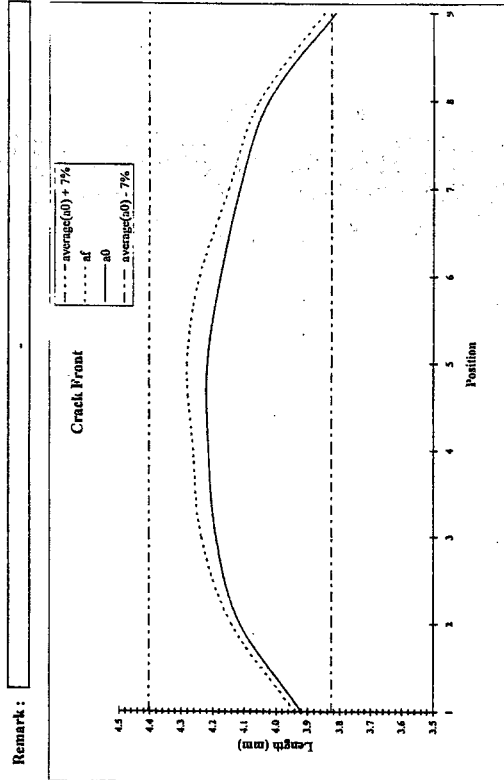
Signature:

# Measure of Ao and Af

Date: 2001-06-12 File: a0-X5D3F.xls Directory: 3NT\Mec\_Test\test22nimocr37\Mini\_CTVA0-  
 Material: 22NiMoCr37 CT nr.: X5D3F  
 a\_fmax (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.353 Bn\* (mm): 4.011 Bn (mm): 4.098 B (mm): 4.098  
 Picture W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.041 mm  
 10% B 0.491 mm



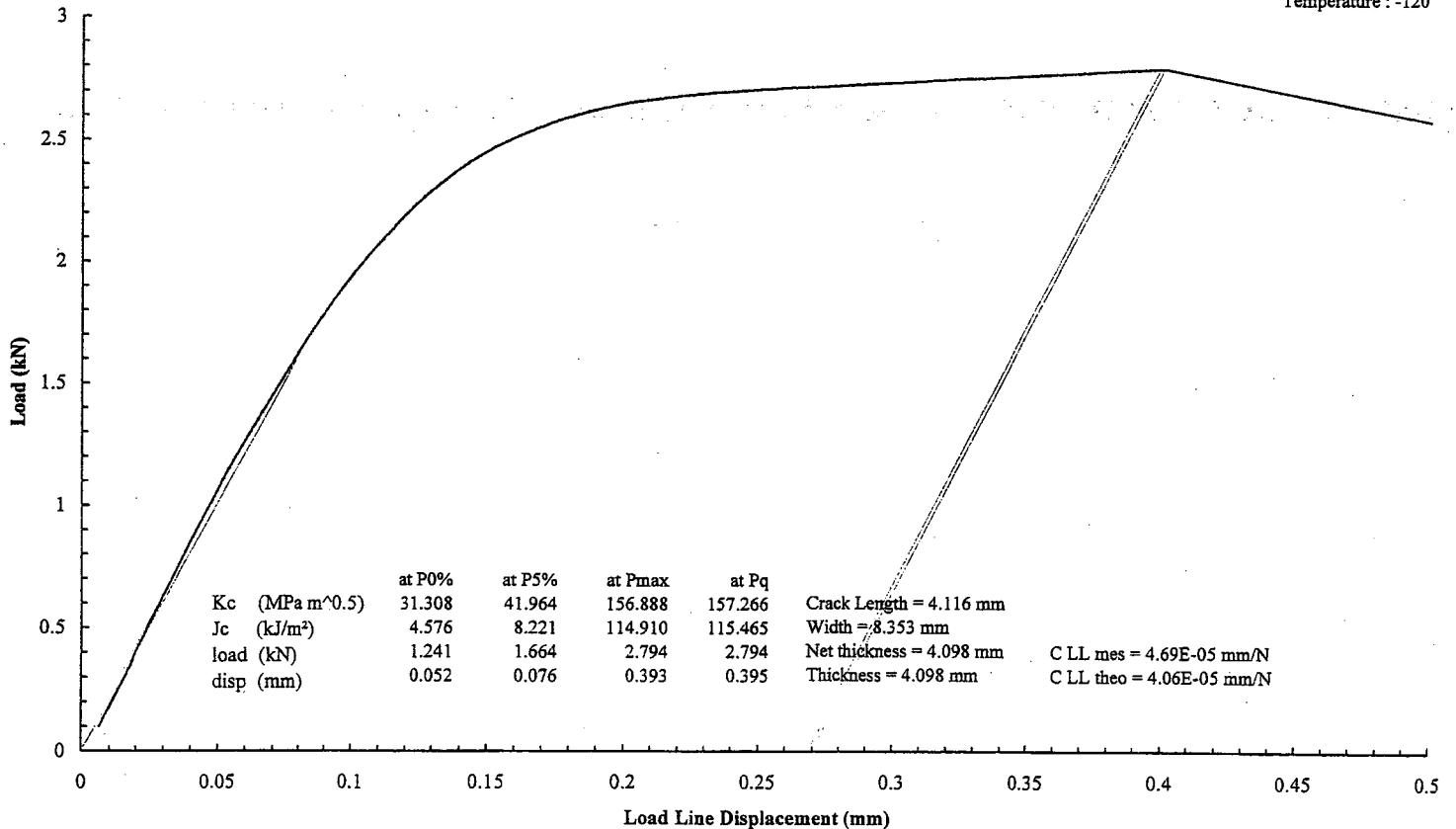
CT	mm	error	CT	mm	error
a01	3.920	-4.75%	a1	3.942	-5.22%
a02	4.115	-0.02%	a2	4.142	-0.41%
a03	4.192	1.85%	a3	4.239	1.92%
a04	4.216	2.44%	a4	4.264	2.52%
a05	4.220	2.53%	a5	4.283	2.98%
a06	4.177	1.49%	a6	4.245	2.07%
a07	4.114	-0.04%	a7	4.150	-0.22%
a08	4.024	-2.23%	a8	4.054	-2.53%
a09	3.815	-7.31%	a9	3.849	-7.46%
Average a0	4.116		Average a1	4.159	



SCK-CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)

Kjc

X5D3F.XLS  
Material : 22NiMoCr37  
Specimen id : X5D3F  
Test data : 12 Jun 2001  
Temperature : -120



**C(T) FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D4C
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.332
	Thickness (mm):	4.052
Net thickness (mm):	4.052	
Side grooving:	0%	

<b>Test parameters</b>	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	15 Jun 2001
	Test operator:	PW

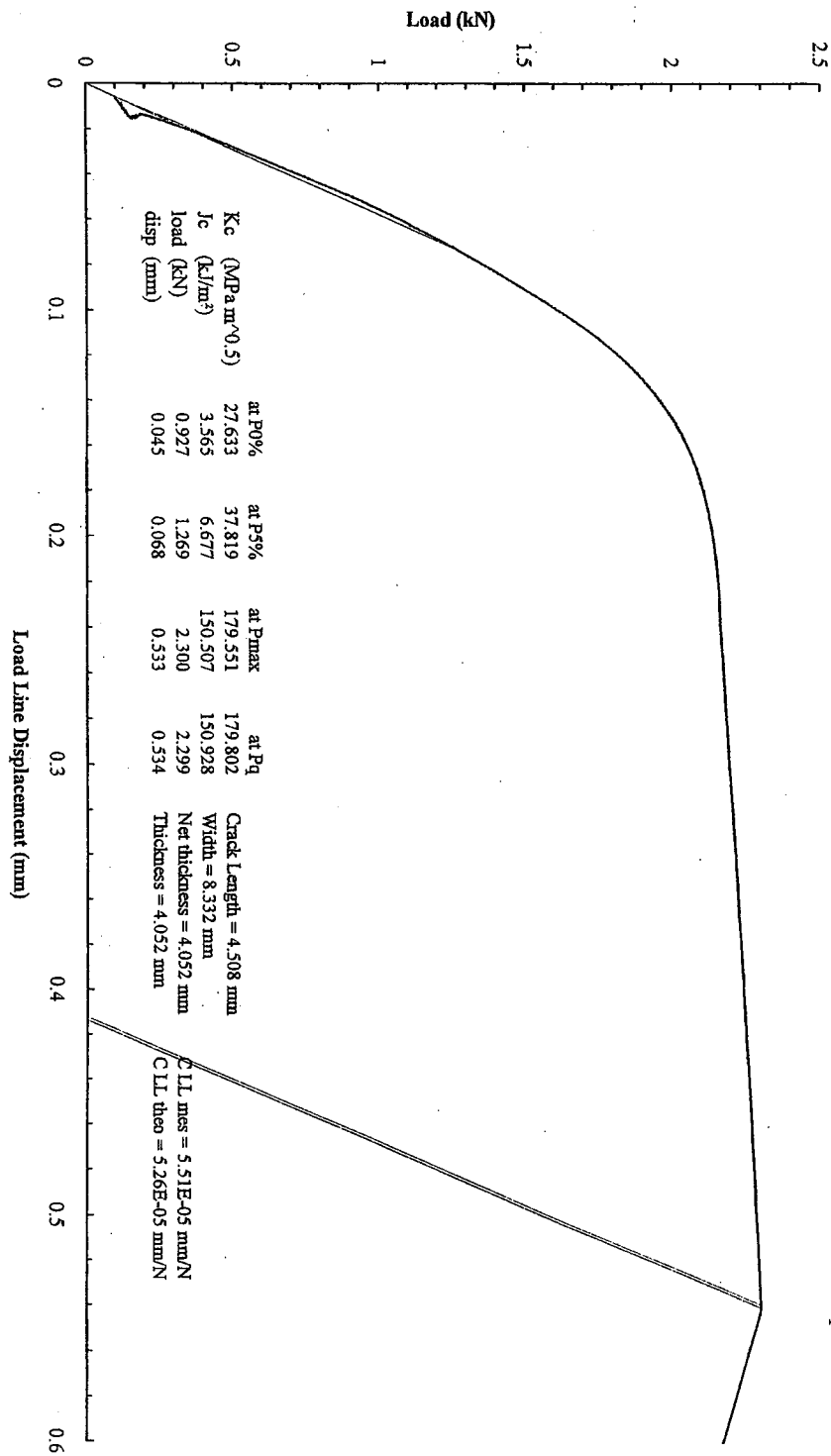
<b>Fatigue precracking</b>	$K_{max}$ (MPa√m):	24.828
	R:	0.1
	$K_{f0.64}$ (MPa√m):	20.863

<b>Crack</b>	Initial crack length (mm):	Ductile crack extension (mm):
	$a_0$ 4.50813	$\Delta a_0$ 0.07831
	$a_{0_1}$ 4.32	$\Delta a_{0_1}$ 0.052
	$a_{0_2}$ 4.501	$\Delta a_{0_2}$ 0.054
	$a_{0_3}$ 4.588	$\Delta a_{0_3}$ 0.081
	$a_{0_4}$ 4.601	$\Delta a_{0_4}$ 0.127
	$a_{0_5}$ 4.62	$\Delta a_{0_5}$ 0.08
	$a_{0_6}$ 4.568	$\Delta a_{0_6}$ 0.097
	$a_{0_7}$ 4.515	$\Delta a_{0_7}$ 0.091
	$a_{0_8}$ 4.399	$\Delta a_{0_8}$ 0.062
$a_{0_9}$ 4.226	$\Delta a_{0_9}$ 0.017	

<b>Fracture toughness</b>	$J_c$ (kJ/m <sup>2</sup> ):	150.93
	$K_{Jc}$ (MPa√m):	179.80

<b>Remarks</b>	V=0.2mm/min
----------------	-------------

Signature: 



### Measure of Ao and Af

Date: 2001-06-15 File: X5D4C.xls Directory: 3NT\Mcc\_Test\test\22nimocr37\Mini\_CTV40

Material: 22NIMOCr37

CT nr.: X5D4C

a<sub>f</sub>max (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700

CT W (mm): 8.332 Bn\* (mm): 3.933 Bn (mm): 4.052 B (mm): 4.052

Foto W (cm): Bn\* (cm): Bn (cm): B (cm):

0.01\*B 0.041 mm  
10% B 0.481 mm

Foto	cm
a01	
a02	
a03	
a04	
a05	
a06	
a07	
a08	
a09	

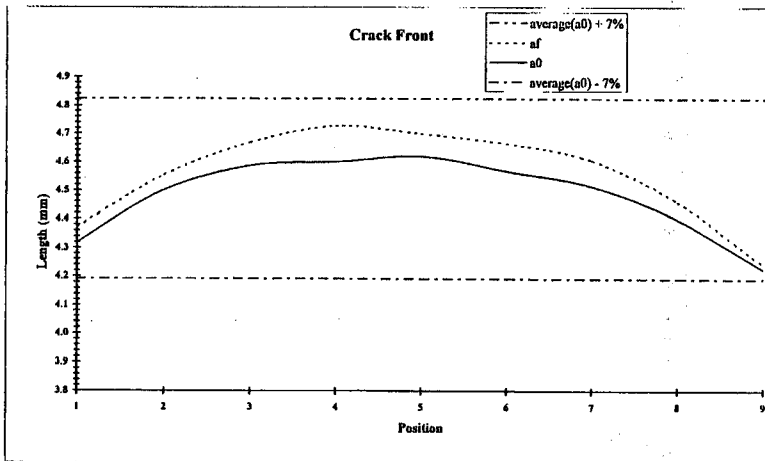
Foto	cm
af1	
af2	
af3	
af4	
af5	
af6	
af7	
af8	
af9	

Precracking Machine: INSTRON

Kmax (MPa√m): 24.828  
Kfinal (MPa√m): 20.863

CT	mm	error	CT	mm	error	CT	mm	error
a01	4.320	-4.17%	af1	4.372	-4.68%	-a1	0.052	-33.60%
a02	4.501	-0.16%	af2	4.555	-0.69%	-a2	0.054	-31.05%
a03	4.588	1.77%	af3	4.669	1.80%	-a3	0.081	3.43%
a04	4.601	2.06%	af4	4.728	3.09%	-a4	0.127	62.17%
a05	4.620	2.48%	af5	4.700	2.48%	-a5	0.080	2.15%
a06	4.568	1.33%	af6	4.665	1.71%	-a6	0.097	23.86%
a07	4.515	0.15%	af6	4.606	0.43%	-a7	0.091	16.20%
a08	4.399	-2.42%	af8	4.461	-2.73%	-a8	0.062	-20.83%
a09	4.226	-6.26%	af9	4.243	-7.49%	-a9	0.017	-78.29%
a0 gem.	4.508		af gem.	4.586		-gem.	0.078	

Remark:



### C(T) FRACTURE TOUGHNESS TEST

Specimen parameters	Material:	22NIMOCR37
	Specimen type:	CT
	Specimen identification:	X5D3E
	Specimen orientation:	L-T
	Specimen dimensions	
	Width (mm):	8.353
	Thickness (mm):	4.082
	Net thickness (mm):	4.082
	Side grooving:	0%

Test parameters	Test machine:	1362
	Test temperature (°C):	-120
	Test date:	12 Jun 2001
	Test operator:	PW

Fatigue precracking	K <sub>max</sub> (MPa√m):	24.558
	R:	0.1
	K <sub>r0.64</sub> (MPa√m):	18.982

Crack	Initial crack length (mm):	Ductile crack extension (mm):
a <sub>0</sub>	4.30025	Δa <sub>0</sub> 0.08781
a <sub>0_1</sub>	4.168	Δa <sub>0_1</sub> 0.045
a <sub>0_2</sub>	4.297	Δa <sub>0_2</sub> 0.068
a <sub>0_3</sub>	4.383	Δa <sub>0_3</sub> 0.082
a <sub>0_4</sub>	4.397	Δa <sub>0_4</sub> 0.112
a <sub>0_5</sub>	4.39	Δa <sub>0_5</sub> 0.108
a <sub>0_6</sub>	4.352	Δa <sub>0_6</sub> 0.117
a <sub>0_7</sub>	4.295	Δa <sub>0_7</sub> 0.092
a <sub>0_8</sub>	4.2	Δa <sub>0_8</sub> 0.077
a <sub>0_9</sub>	4.008	Δa <sub>0_9</sub> 0.048

Fracture toughness	J <sub>c</sub> (kJ/m <sup>2</sup> ):	178.49
	K <sub>Jc</sub> (MPa√m):	195.53

Remarks: V=0.2mm/min

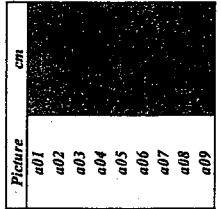
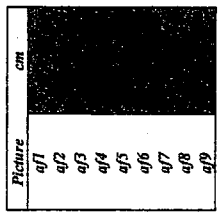
Signature:



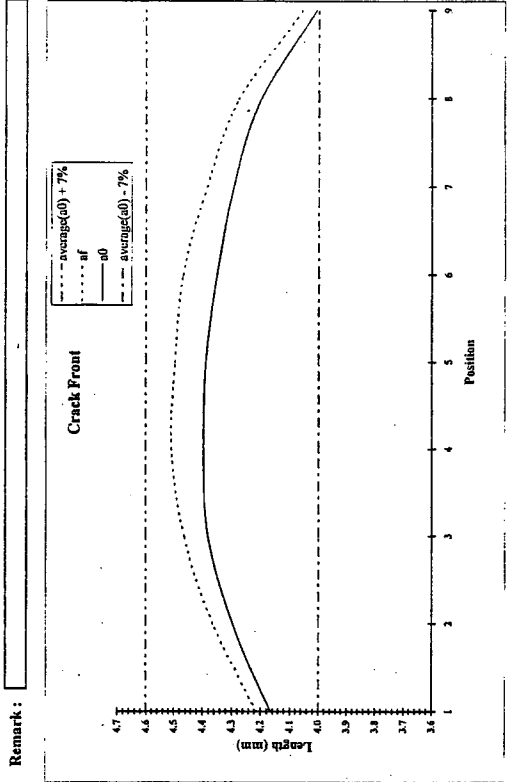
# Measure of $a_0$ and $a_f$

Date: 2001-06-12 File: a0-X5D3E.xls Directory: 3NTIMec\_TestVest22nimocr37Mini\_CTAA0-  
 Material: 22NiMoCr37  
 CT nr.: X5D3E  
 $a_{fmax}$  (mm): 3.000 Fmax (kN): 1.400 Ffinal (kN): 0.700  
 W (mm): 8.353 Bn\* (mm): 4.011 Bn (mm): 4.082 B (mm): 4.082  
 Picture W (cm): Bn\* (cm): Bn (cm): B (cm):  
 0.01\*B 0.041 mm 10% B 0.491 mm

Precracking Machine: INSTRON  
 Kmax (MPa Vm): 24.558  
 Kfinal (MPa Vm): 18.982



CT	mm	error	CT	mm	error	CT	mm	error
a01	4.168	-3.08%	a11	4.213	-3.99%	Δa1	0.045	-48.75%
a02	4.297	-0.08%	a12	4.365	-0.53%	Δa2	0.068	-22.56%
a03	4.383	1.92%	a13	4.465	1.75%	Δa3	0.082	-6.62%
a04	4.397	2.25%	a14	4.509	2.76%	Δa4	0.112	27.54%
a05	4.390	2.09%	a15	4.498	2.51%	Δa5	0.108	22.99%
a06	4.352	1.20%	a16	4.469	1.84%	Δa6	0.117	33.24%
a07	4.295	-0.12%	a18	4.387	-0.02%	Δa7	0.092	4.77%
a08	4.200	-2.33%	a19	4.277	-2.53%	Δa8	0.077	-12.31%
a09	4.008	-6.80%	Average af	4.056	-7.57%	Δa9	0.048	-45.34%
Average a0	4.300			4.388		- gem.	0.088	

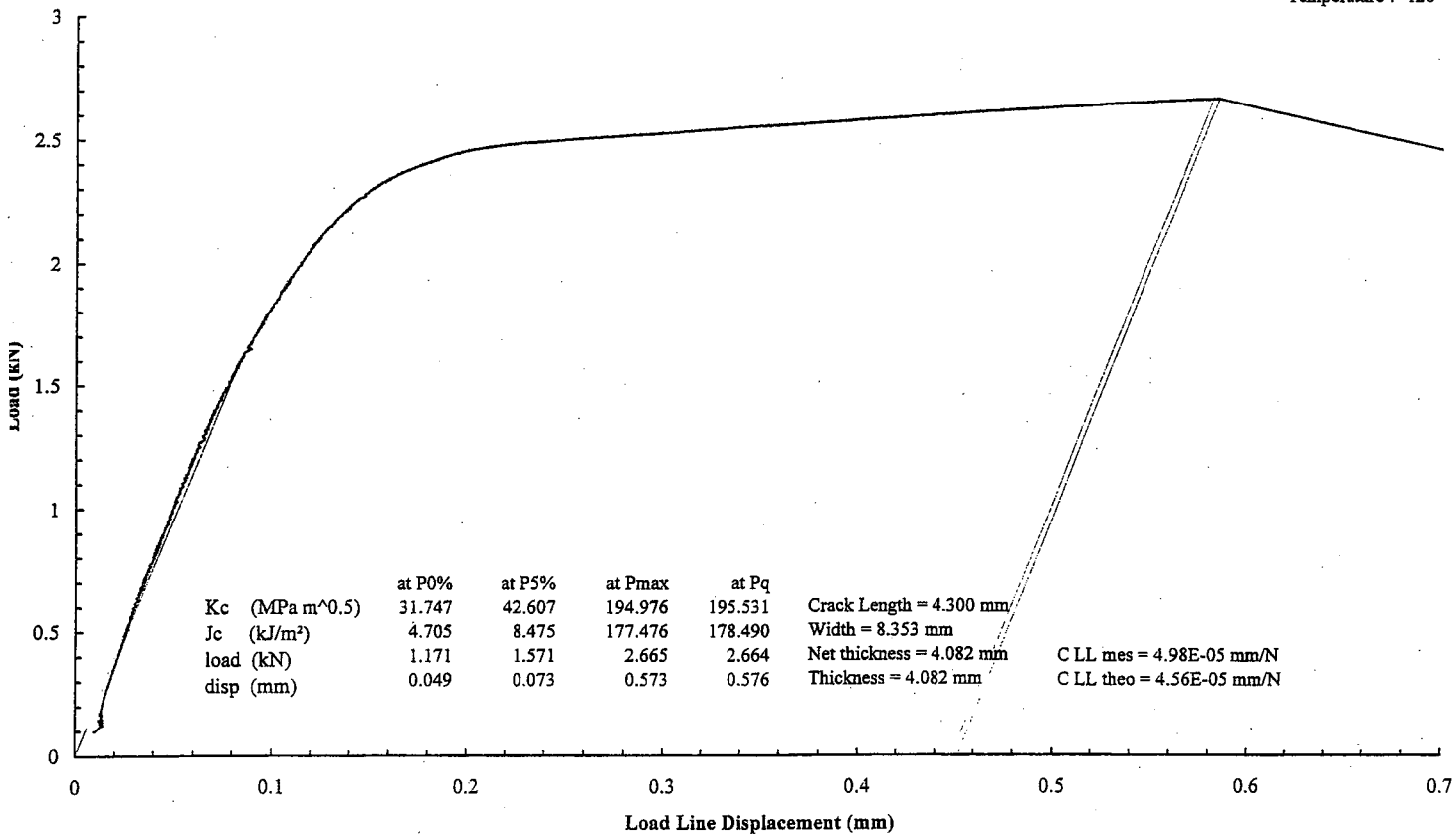


Remark:

SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

## Kjc

X5D3E.XLS  
 Material : 22NIMOCR37  
 Specimen id : X5D3E  
 Test data : 12 Jun 2001  
 Temperature : -120



Kc (MPa m <sup>0.5</sup> )	at P0%	at P5%	at Pmax	at Pq	Crack Length = 4.300 mm
Jc (kJ/m <sup>2</sup> )	31.747	42.607	194.976	195.531	Width = 8.353 mm
load (kN)	4.705	8.475	177.476	178.490	Net thickness = 4.082 mm
disp (mm)	1.171	1.571	2.665	2.674	Thickness = 4.082 mm
	0.049	0.073	0.573	0.576	C LL mes = 4.98E-05 mm/N
					C LL theo = 4.56E-05 mm/N

**APPENDIX 3 Test results on mini CRB 22NiMoCr37**

**STANDARD TEST METHOD FOR THE DETERMINATION OF REFERENCE TEMPERATURE,  
T<sub>0</sub>, FOR FERRITIC STEELS IN THE TRANSITION RANGE**

[MULTI-TEMPERATURE APPROACH]

**1. Material characteristics**

Material specifications : **22NiMoCr37 CRB 5**

**2. Dimensional and crack growth requirements**

Specimen code	T (°C)	a <sub>0</sub> (mm)	R (mm)	2 π b <sub>0</sub> (mm)	b <sub>0</sub> (mm)	Δa (mm)	K <sub>Jc[exp]</sub> (MPa√m)	σ <sub>ys</sub> (MPa)	E (GPa)	K <sub>lim</sub> (MPa√m)	DATA VALID	K <sub>Jc[calc]</sub> (MPa√m)
x5b13	-115	1.242	2.492	7.855	1.250	0.00	137.9	625.5	213.9	182.9	YES	137.9
x5b14	-115	1.211	2.488	8.026	1.277	0.00	134.5	625.5	213.9	184.9	YES	134.5
x5b15	-115	1.250	2.489	7.782	1.239	0.00	157.4	625.5	213.9	182.1	YES	157.4
x5b16	-115	1.264	2.496	7.738	1.232	0.00	148.6	625.5	213.9	181.5	YES	148.6
x5b17	-115	1.218	2.476	7.905	1.258	0.00	183.9	625.5	213.9	183.5	NO	183.5
x5b19	-115	1.189	2.492	8.187	1.303	0.00	99.7	625.5	213.9	186.7	YES	99.7
x5b20	-115	1.248	2.496	7.839	1.248	0.00	101.7	625.5	213.9	182.7	YES	101.7
x5b21	-115	1.239	2.494	7.888	1.255	0.00	104.4	625.5	213.9	183.3	YES	104.4
x5b22	-115	1.264	2.506	7.804	1.242	0.00	128.3	625.5	213.9	182.3	YES	128.3
x5b24	-115	1.254	2.504	7.851	1.250	0.00	91.8	625.5	213.9	182.9	YES	91.8
x5b25	-115	1.294	2.490	7.516	1.196	0.00	123.5	625.5	213.9	178.9	YES	123.5
x5b26	-115	1.257	2.489	7.741	1.232	0.00	122.8	625.5	213.9	181.6	YES	122.8
x5b27	-115	1.286	2.500	7.628	1.214	0.00	138.9	625.5	213.9	180.2	YES	138.9
X5b1	-91	1.257	2.504	7.835	1.247	0.00	208.0	572.1	212.5	174.1	NO	174.1
X5b2	-91	1.324	2.509	7.446	1.185	0.00	242.3	572.1	212.5	169.7	NO	169.7
X5b3	-91	1.277	2.501	7.691	1.224	0.00	206.1	572.1	212.5	172.5	NO	172.5
X5b4	-91	1.390	2.514	7.062	1.124	0.00	209.3	572.1	212.5	165.3	NO	165.3
X5b5	-91	1.314	2.511	7.521	1.197	0.00	139.5	572.1	212.5	170.6	YES	139.5
X5b6	-91	1.332	2.507	7.383	1.175	0.00	123.74	572.1	212.5	169.0	YES	123.7

**3. Application of the multi-temperature approach for the calculation of the reference temperature**

Specimen code	T (°C)	K <sub>Jc[calc]</sub> (MPa√m)	K <sub>Jc(1T)</sub> (MPa√m)	δ <sub>i</sub>	n <sub>i</sub>	1° member	2° member
x5b13	-115	137.9	76.5	1	0.143	0.0105	0.0097
x5b14	-115	134.5	75.1	1	0.143	0.0105	0.0088
x5b15	-115	157.4	85.7	1	0.143	0.0105	0.0178
x5b16	-115	148.6	81.3	1	0.143	0.0105	0.0136
x5b17	-115	183.5	98.4	0	0.000	0.0000	0.0362
x5b19	-115	99.7	58.6	1	0.143	0.0105	0.0021
x5b20	-115	101.7	59.1	1	0.143	0.0105	0.0022
x5b21	-115	104.4	60.5	1	0.143	0.0105	0.0026
x5b22	-115	128.3	71.8	1	0.143	0.0105	0.0069
x5b24	-115	91.8	54.4	1	0.143	0.0105	0.0013
x5b25	-115	123.5	69.0	1	0.143	0.0105	0.0055
x5b26	-115	122.8	69.1	1	0.143	0.0105	0.0055
x5b27	-115	138.9	76.5	1	0.143	0.0105	0.0098
X5b1	-91	174.1	93.7	0	0.000	0.0000	0.0066
X5b2	-91	169.7	90.7	0	0.000	0.0000	0.0056
X5b3	-91	172.5	92.6	0	0.000	0.0000	0.0062
X5b4	-91	165.3	87.7	0	0.000	0.0000	0.0047
X5b5	-91	139.5	76.6	1	0.167	0.0113	0.0023
X5b6	-91	123.7	68.9	1	0.167	0.0113	0.0013

Sum of 1° member:

Sum of 2° member:

Difference:

**T<sub>0</sub> = -88.5 °C**  
(valid per ASTM E1921)

$\sum n_i = 2.05$

N = 19  
r = 14

K<sub>min</sub> = 20 MPa√m

**K<sub>o,eq</sub> = 81.2 MPa√m**

**K<sub>msd,eq</sub> = 75.8 MPa√m**

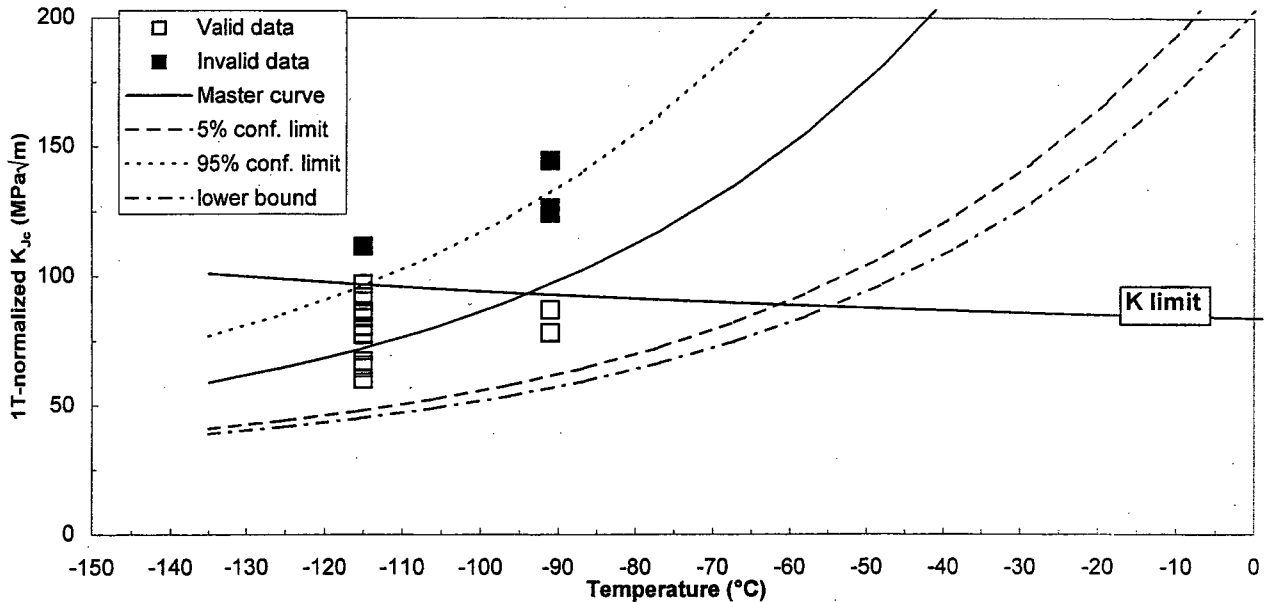
**β = 18.8 °C**  
**2σ = 10 °C**

**4. Master curve fit to data**

Temperature adj. = 7.2 °C (est.) Stand. dev. on  $T_0$  = 5.0 °C (est.)

T (°C)	$K_{Jc(exp)}$ (MPa $\sqrt{m}$ )	$K_{Jc(1T)}$ (MPa $\sqrt{m}$ )	$K_{MC(1T)}$ (MPa $\sqrt{m}$ )	5% conf. (MPa $\sqrt{m}$ )	95% conf. (MPa $\sqrt{m}$ )	5% L.B. (MPa $\sqrt{m}$ )
-115	137.9	86.0				
-115	134.5	84.0				
-115	157.4	96.9				
-115	148.6	92.0				
-115	183.9	111.6				
-115	99.7	64.6				
-115	101.7	65.7				
-115	104.4	67.2				
-115	128.3	80.7				
-115	91.8	60.3				
-115	123.5	77.9				
-115	122.8	77.5				
-115	138.9	86.6				
-91	208.0	125.3				
-91	242.3	144.6				
-91	206.1	124.3				
-91	209.3	126.2				
-91	139.5	87.0				
-91	123.7	78.1				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
0	#N/A	#N/A				
-135			58.9	41.0	76.9	39.0
-125.3125			64.8	44.2	85.4	41.8
-115.625			71.8	48.0	95.7	45.1
-105.9375			80.3	52.5	108.0	49.1
-96.25			90.4	58.0	122.8	53.8
-86.5625			102.6	64.6	140.7	59.6
-76.875			117.3	72.6	162.1	66.5
-67.1875			135.0	82.1	187.9	74.8
-57.5			156.2	93.5	218.8	84.8
-47.8125			181.7	107.3	256.0	96.8
-38.125			212.3	123.9	300.8	111.2
-28.4375			249.2	143.8	354.6	128.6
-18.75			293.5	167.7	419.3	149.4
-9.0625			346.7	196.4	497.0	174.5
0.625			410.7	231.0	590.5	204.6
10.3125			487.7	272.5	702.8	240.8
20			580.2	322.5	837.8	284.3

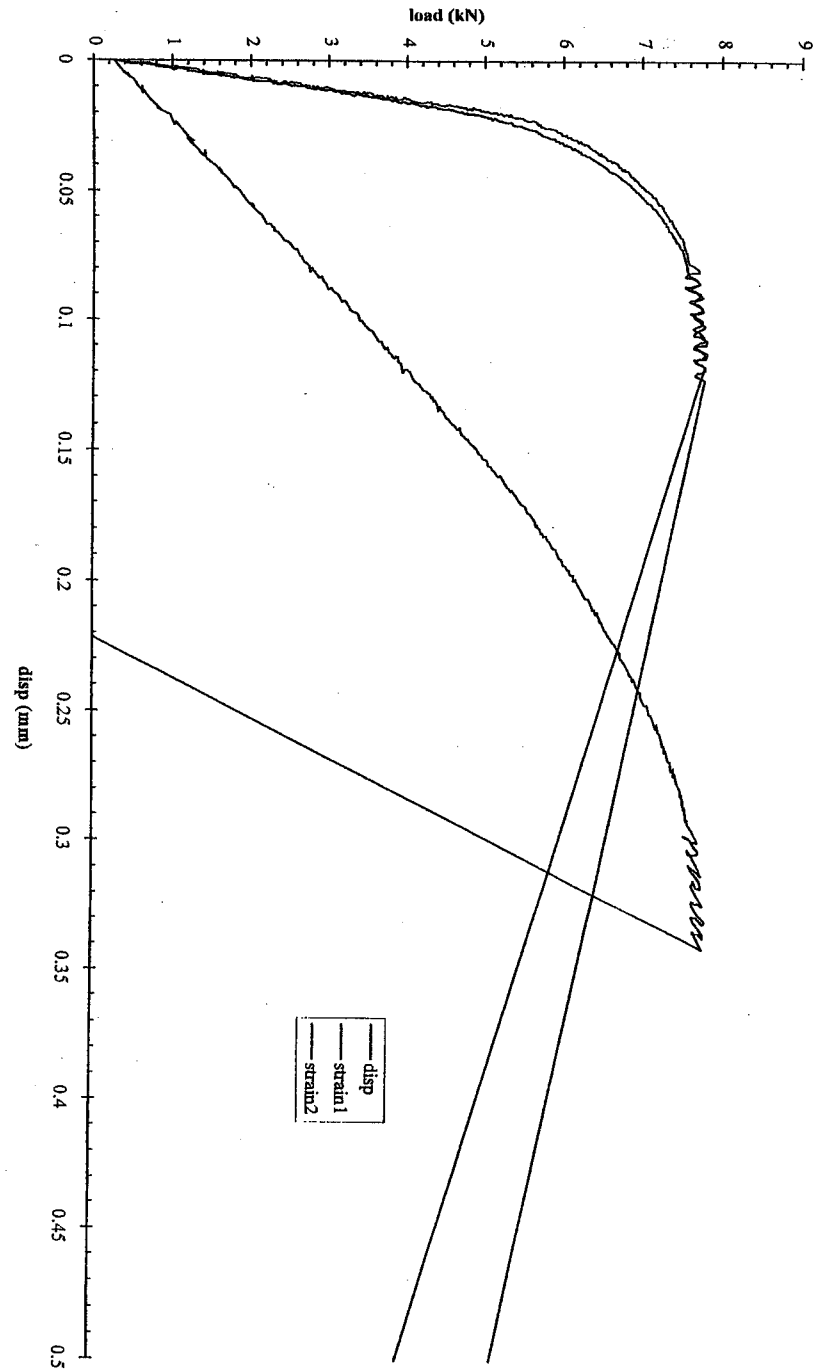
MASTER CURVE FOR 1TCT WITH CONFIDENCE LIMITS  
22NIMOCR37 CRB5



**CRB FRACTURE TOUGHNESS TEST**

<b>Specimen parameters</b>	Material:	22NiMoCr37
	Specimen type:	CRB
	Specimen identification:	x5b13
	Specimen orientation:	L
	Specimen dimensions	
	Diameter(mm):	4.984
	Gage length(mm):	12.5
	Overall length(mm):	27
<b>Test parameters</b>	Test machine:	instron 8803
	Test temperature(°C):	-115
	Test date:	Jun 27 08:29:29 2001
	Test operator:	JV
	Number of extensometers:	2
	Speed(mm/min):	0.1
<b>Fatigue precracking</b>	Kmax(MPaVm):	20
	R:	-1
<b>Ligament</b>	Radius(mm)	Ductile extension(mm)
b1	1.254	0.000
b2	1.254	0.000
b3	1.242	0.000
b4	1.258	0.000
b5	1.265	0.000
b6	1.246	0.000
b7	1.242	0.000
b8	1.241	0.000
mean	1.250	0.000
	Excentricity(mm):	0.050
	Excentricity/b(%):	4%
	Irregularity(mm):	0.014
	Irregularity/b(%):	1%
	Ratio a/R:	0.498
<b>Test results</b>	Compliance(mm/kN):	0.004010
	Theoretical compliance(mm/kN):	0.004185
	Compliance difference(%):	4%
	Average disp. at break(mm):	0.120
	MinMax disp. at break(mm):	0.123
	Bending at break (%):	2%
	Jc(kJ/m <sup>2</sup> ):	88.93
	Kc(MPaVm):	137.92

Remarks



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b14  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.976  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 28 10:46:01 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

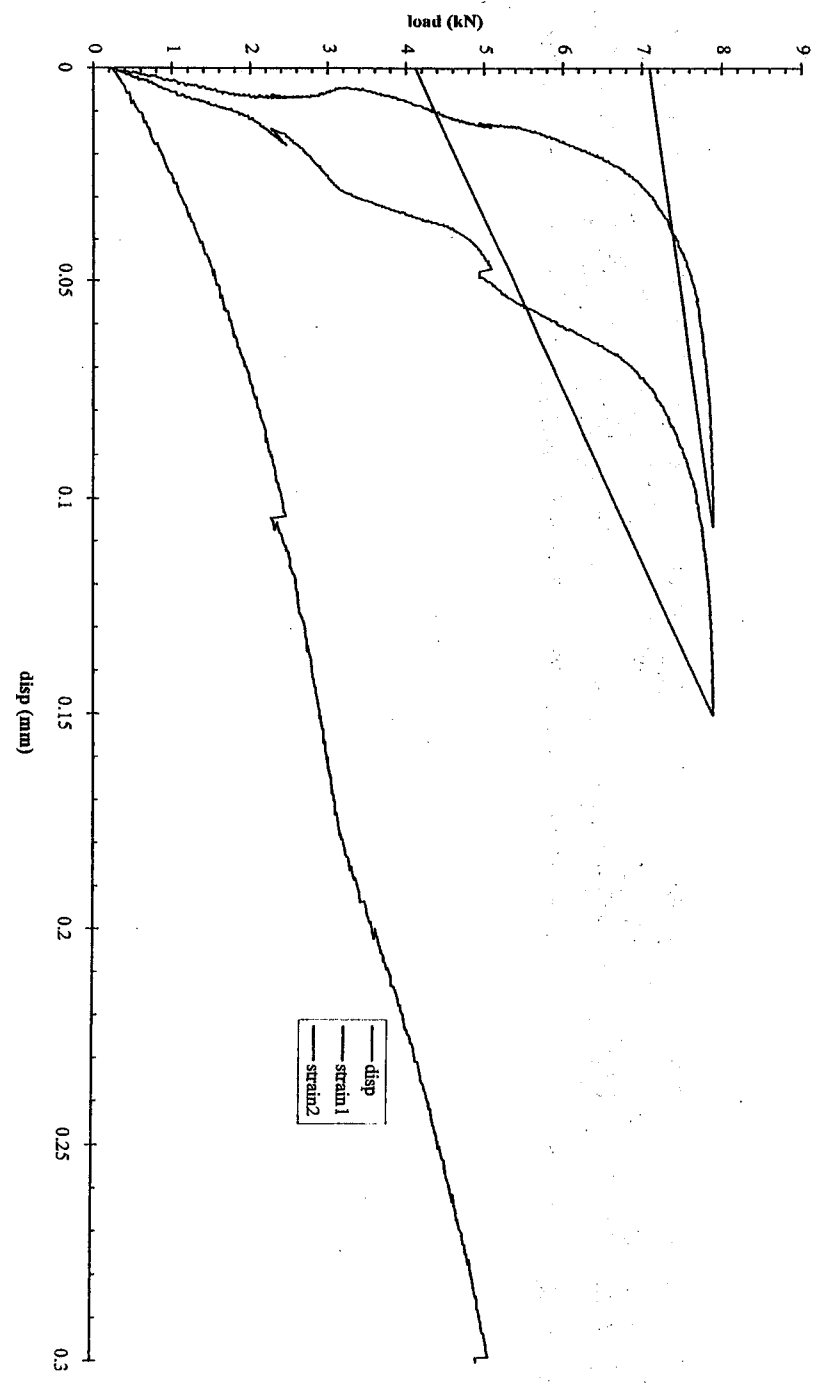
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.285	0.000
b2	1.271	0.000
b3	1.278	0.000
b4	1.282	0.000
b5	1.283	0.000
b6	1.266	0.000
b7	1.279	0.000
b8	1.274	0.000
mean	1.277	0.000

Excentricity(mm): 0.029  
 Excentricity/b(%): 2%  
 Irregularity(mm): 0.011  
 Irregularity/b(%): 1%  
 Ratio a/R: 0.487

**Test results** Compliance(mm/kN): 0.005149  
 Theoretical compliance(mm/kN): 0.004127  
 Compliance difference(%): 25%  
 Average disp. at break(mm): 0.129  
 MinMax disp. at break(mm): 0.150  
 Bending at break (%): 17%  
 Jc(kJ/m^2): 84.55  
 Kc(MPaVm): 134.48

**Remarks** Abnormal displacement due to ice



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters**  
 Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b15  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.978  
 Gage length(mm): 12.5  
 Overall length(mm): 27

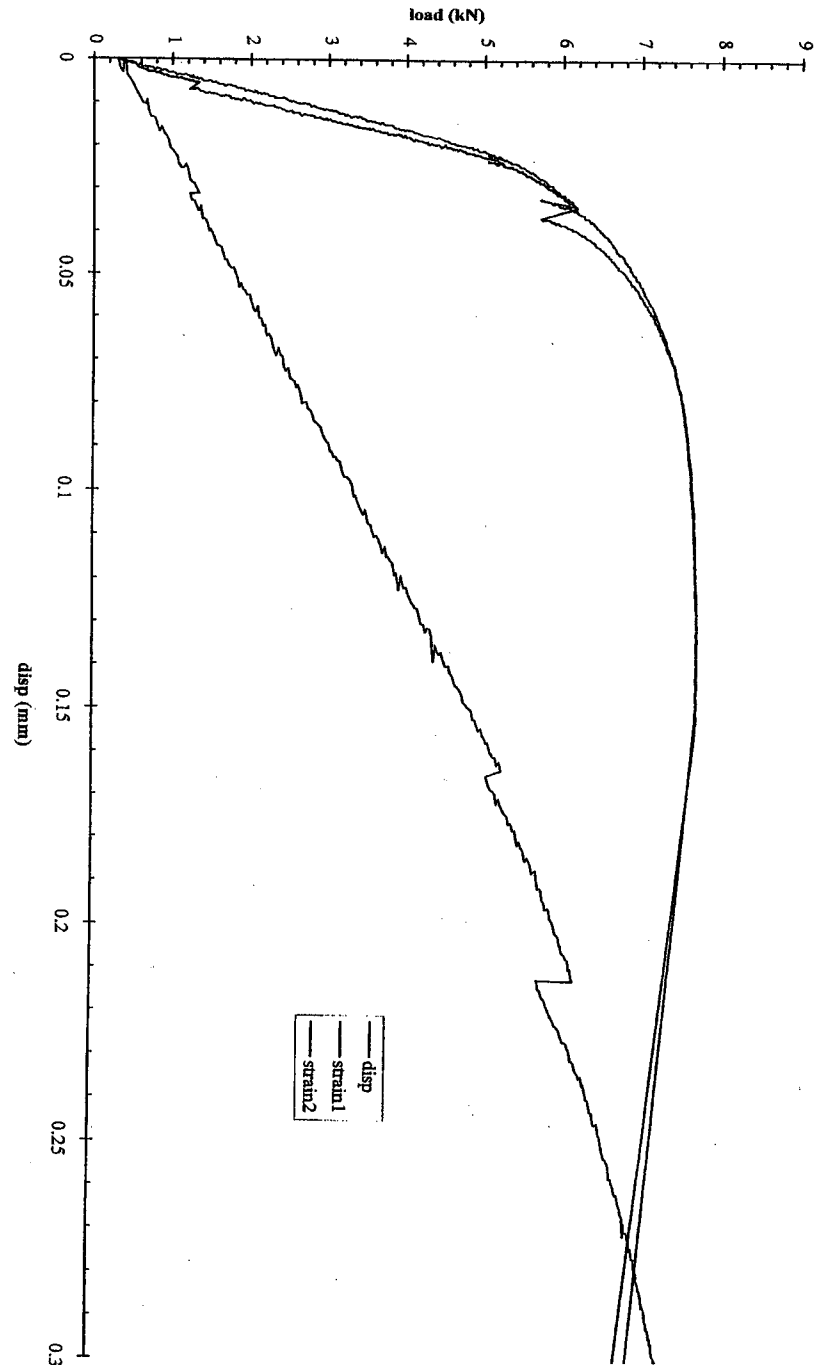
**Test parameters**  
 Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 27 13:54:42 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

**Fatigue precracking**  
 Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.247	0.000
b2	1.233	0.000
b3	1.238	0.000
b4	1.245	0.000
b5	1.257	0.000
b6	1.242	0.000
b7	1.207	0.000
b8	1.239	0.000
mean	1.239	0.000
Excentricity(mm):		0.081
Excentricity/b(%):		7%
Irregularity(mm):		0.031
Irregularity/b(%):		3%
Ratio a/R:		0.502

**Test results**  
 Compliance(mm/kN): 0.004092  
 Theoretical compliance(mm/kN): 0.004219  
 Compliance difference(%): 3%  
 Average disp. at break(mm): 0.153  
 MinMax disp. at break(mm): 0.155  
 Bending at break (%): 1%  
 Jc(kJ/m<sup>2</sup>): 115.87  
 Kc(MPaVm): 157.43

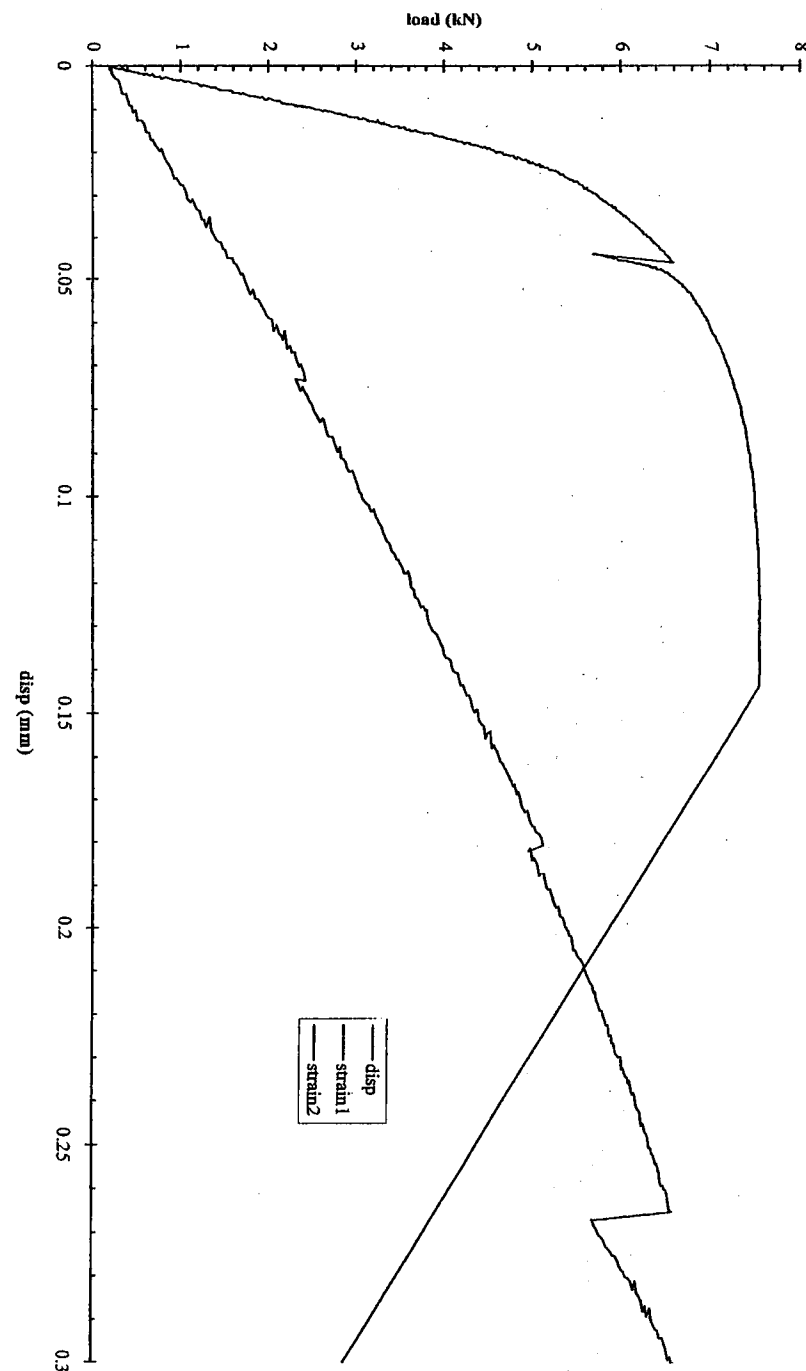
**Remarks**



SCK-CEN ; LHMA  
Boeretang 200  
B-2400 Mol (Belgium)

### CRB FRACTURE TOUGHNESS TEST

<b>Specimen parameters</b>	Material:	22NiMoCr37	
	Specimen type:	CRB	
	Specimen identification:	x5b16	
	Specimen orientation:	L	
	Specimen dimensions		
	Diameter(mm):	4.992	
Gage length(mm):	12.5		
Overall length(mm):	27		
<b>Test parameters</b>	Test machine:	instron 8803	
	Test temperature(°C):	-115	
	Test date:	Jun 27 15:08:30 2001	
	Test operator:	JV	
	Number of extensometers:	1	
	Speed(mm/min):	0.1	
<b>Fatigue precracking</b>	Kmax(MPaVm):	20	
	R	-1	
<b>Ligament</b>	Radius(mm)	Ductile extension(mm)	
	b1	1.246	0.000
	b2	1.213	0.000
	b3	1.242	0.000
	b4	1.235	0.000
	b5	1.218	0.000
	b6	1.239	0.000
	b7	1.227	0.000
	b8	1.232	0.000
	mean	1.232	0.000
		Excentricity(mm):	0.037
		Excentricity/b(%):	3%
		Irregularity(mm):	0.019
	Irregularity/b(%):	2%	
	Ratio a/R:	0.507	
<b>Test results</b>	Compliance(mm/kN):	0.004170	
	Theoretical compliance(mm/kN):	0.004225	
	Compliance difference(%):	1%	
	Average disp. at break(mm):	0.144	
	MinMax disp. at break(mm):	0.144	
	Bending at break (%):	0%	
	Jc(kJ/m <sup>2</sup> ):	103.22	
Kc(MPaVm):	148.59		
<b>Remarks</b>	Only one extensometer available		





**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters**  
 Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b17  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.952  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters**  
 Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 28 08:20:42 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

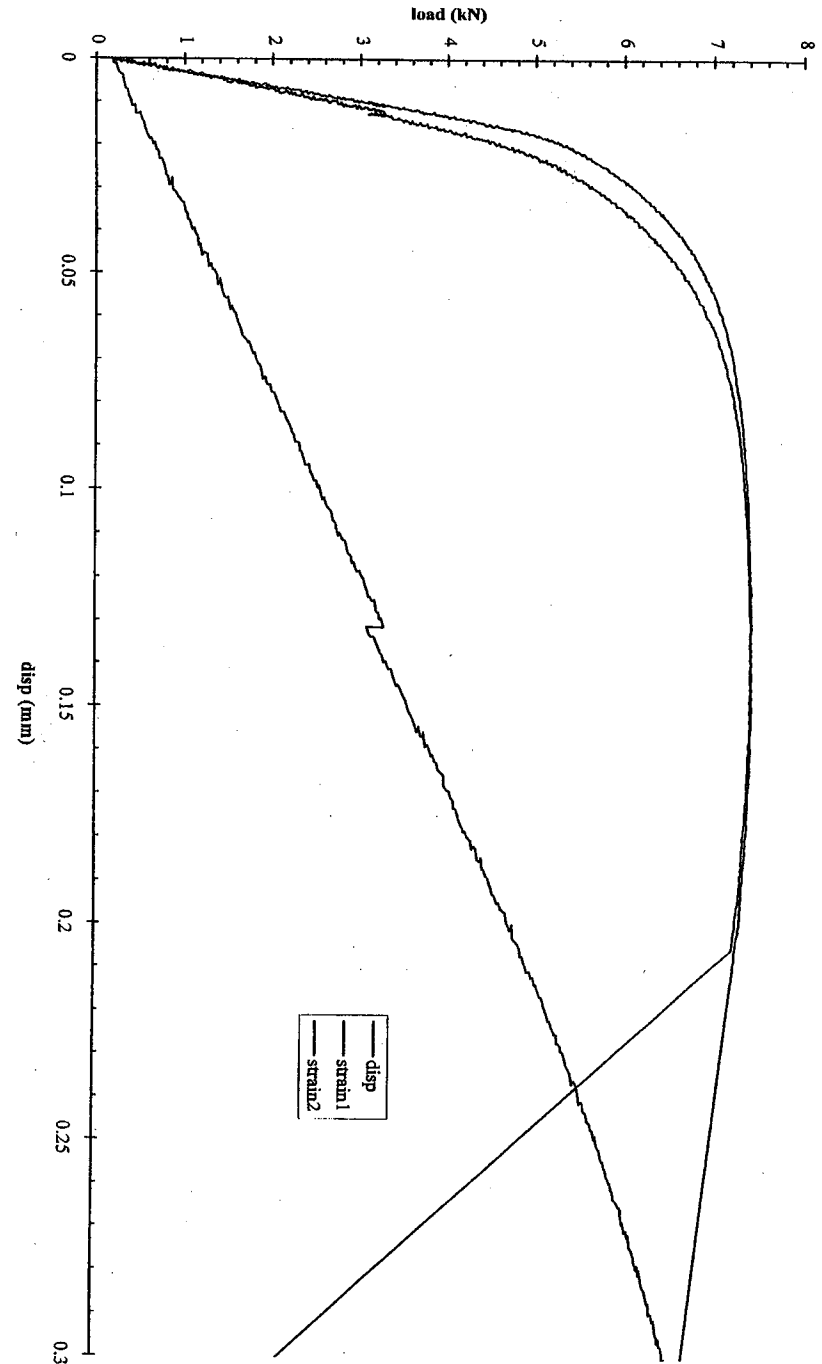
**Fatigue precracking**  
 Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.276	0.000
b2	1.230	0.000
b3	1.279	0.000
b4	1.254	0.000
b5	1.242	0.000
b6	1.231	0.000
b7	1.267	0.000
b8	1.286	0.000
mean	1.258	0.000

Excentricity(mm): 0.030  
 Excentricity/b(%): 2%  
 Irregularity(mm): 0.028  
 Irregularity/b(%): 2%  
 Ratio a/R: 0.492

**Test results**  
 Compliance(mm/kN): 0.003749  
 Theoretical compliance(mm/kN): 0.004193  
 Compliance difference(%): 11%  
 Average disp. at break(mm): 0.210  
 MinMax disp. at break(mm): 0.214  
 Bending at break (%): 2%  
 Jc(kJ/m<sup>2</sup>): 158.11  
 Kc(MPaVm): 183.90

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b19  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.984  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 28 12:33:49 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

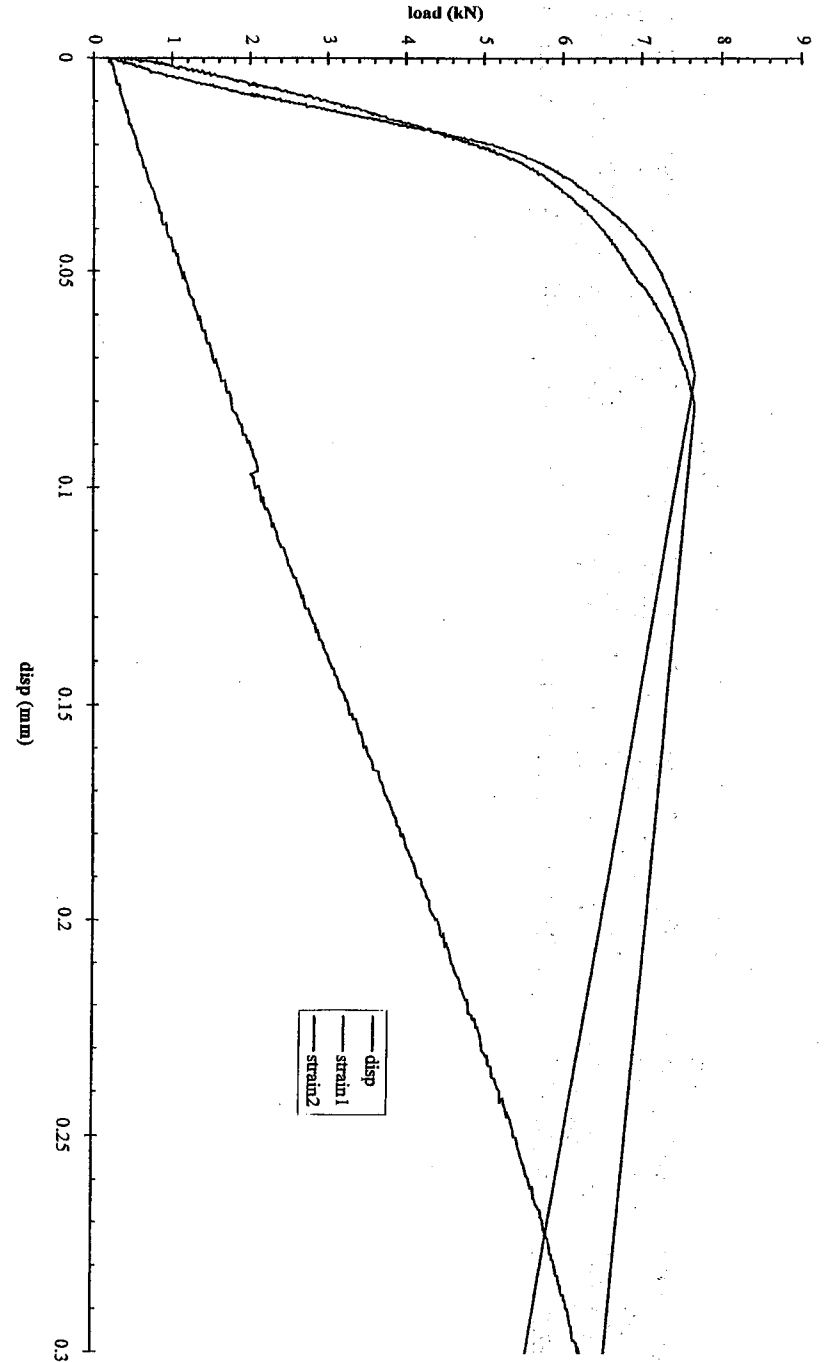
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.296	0.000
b2	1.303	0.000
b3	1.309	0.000
b4	1.295	0.000
b5	1.257	0.000
b6	1.291	0.000
b7	1.344	0.000
b8	1.329	0.000
mean	1.303	0.000

Excentricity(mm): 0.080  
 Excentricity/b(%): 6%  
 Irregularity(mm): 0.046  
 Irregularity/b(%): 4%  
 Ratio a/R: 0.477

**Test results** Compliance(mm/kN): 0.004040  
 Theoretical compliance(mm/kN): 0.004061  
 Compliance difference(%): 1%  
 Average disp. at break(mm): 0.078  
 MinMax disp. at break(mm): 0.081  
 Bending at break (%): 5%  
 Jc(kJ/m<sup>2</sup>): 46.50  
 Kc(MPaVm): 99.74

**Remarks**



**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b20  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.992  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 28 13:42:51 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

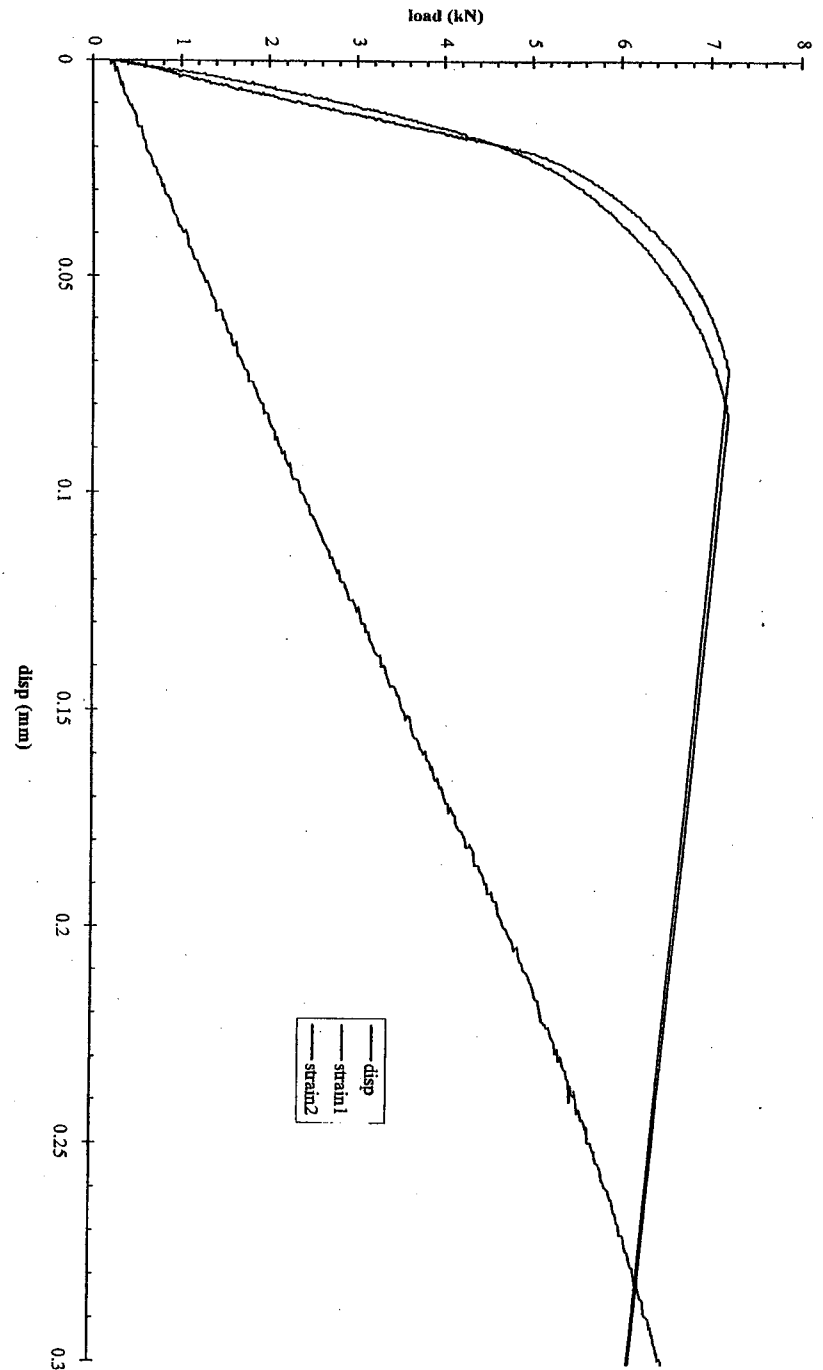
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.261	0.000
b2	1.231	0.000
b3	1.259	0.000
b4	1.248	0.000
b5	1.205	0.000
b6	1.233	0.000
b7	1.273	0.000
b8	1.272	0.000
mean	1.248	0.000

Excentricity(mm): 0.082  
 Excentricity/b(%): 7%  
 Irregularity(mm): 0.043  
 Irregularity/b(%): 3%  
 Ratio a/R: 0.500

**Test results** Compliance(mm/kN): 0.004178  
 Theoretical compliance(mm/kN): 0.004185  
 Compliance difference(%): 0%  
 Average disp. at break(mm): 0.077  
 MinMax disp. at break(mm): 0.082  
 Bending at break (%): 7%  
 Jc(kJ/m<sup>2</sup>): 48.33  
 Kc(MPaVm): 101.68

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b21  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.988  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 28 14:44:36 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

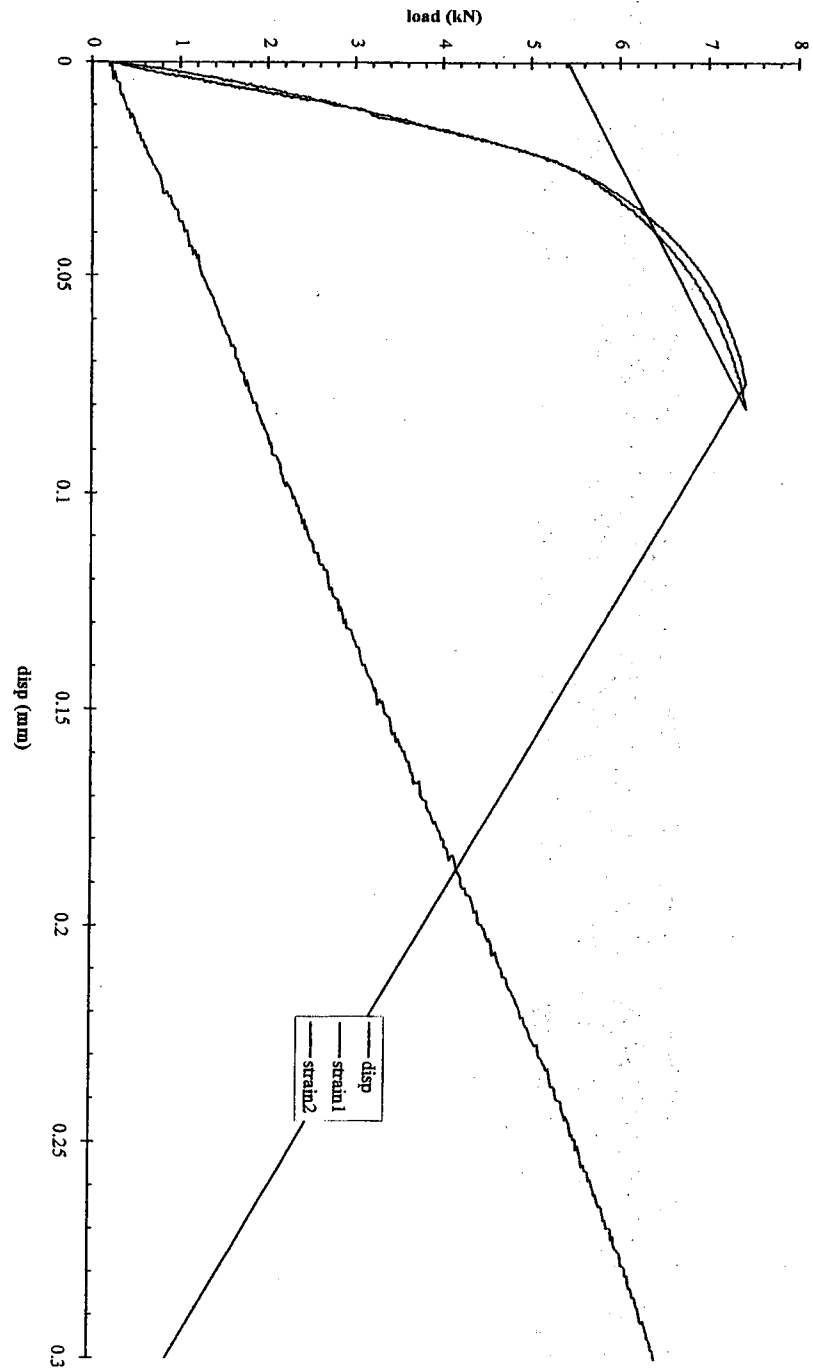
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.265	0.000
b2	1.238	0.000
b3	1.270	0.000
b4	1.251	0.000
b5	1.287	0.000
b6	1.250	0.000
b7	1.245	0.000
b8	1.236	0.000
mean	1.255	0.000

Excentricity(mm): 0.059  
 Excentricity/b(%): 5%  
 Irregularity(mm): 0.032  
 Irregularity/b(%): 3%  
 Ratio a/R: 0.497

**Test results** Compliance(mm/kN): 0.003843  
 Theoretical compliance(mm/kN): 0.004169  
 Compliance difference(%): 8%  
 Average disp. at break(mm): 0.078  
 MinMax disp. at break(mm): 0.081  
 Bending at break (%): 4%  
 Jc(kJ/m<sup>2</sup>): 50.95  
 Kc(MPaVm): 104.40

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b22  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 5.012  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 29 08:22:25 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

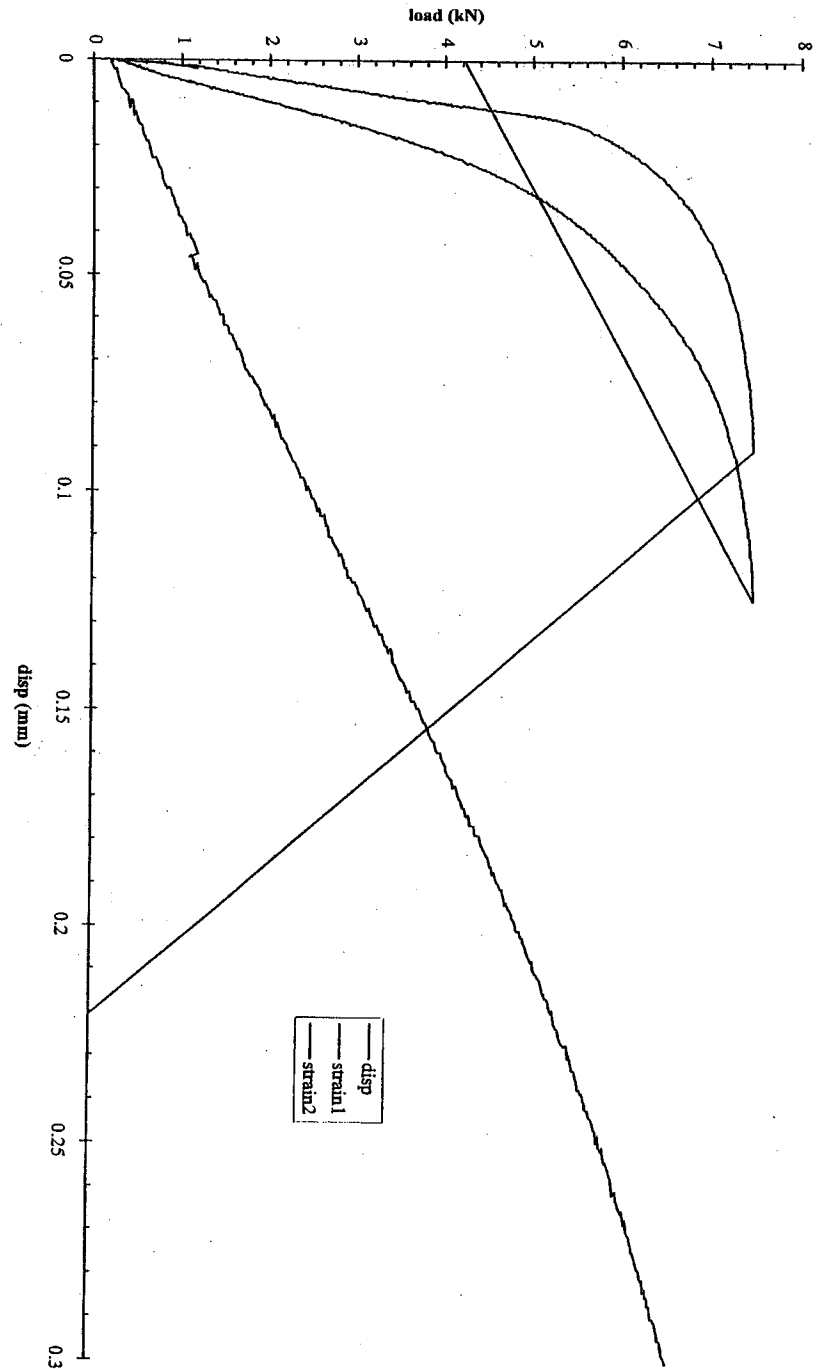
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.267	0.000
b2	1.226	0.000
b3	1.242	0.000
b4	1.260	0.000
b5	1.237	0.000
b6	1.203	0.000
b7	1.218	0.000
b8	1.282	0.000
mean	1.242	0.000

Excentricity(mm): 0.046  
 Excentricity/b(%): 4%  
 Irregularity(mm): 0.040  
 Irregularity/b(%): 3%  
 Ratio a/R: 0.504

**Test results** Compliance(mm/kN): 0.003940  
 Theoretical compliance(mm/kN): 0.004182  
 Compliance difference(%): 6%  
 Average disp. at break(mm): 0.107  
 MinMax disp. at break(mm): 0.124  
 Bending at break (%): 16%  
 Jc(kJ/m<sup>2</sup>): 76.95  
 Kc(MPaVm): 128.29

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b24  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 5.008  
 Gage length(mm): 12.5  
 Overall length(mm): 27

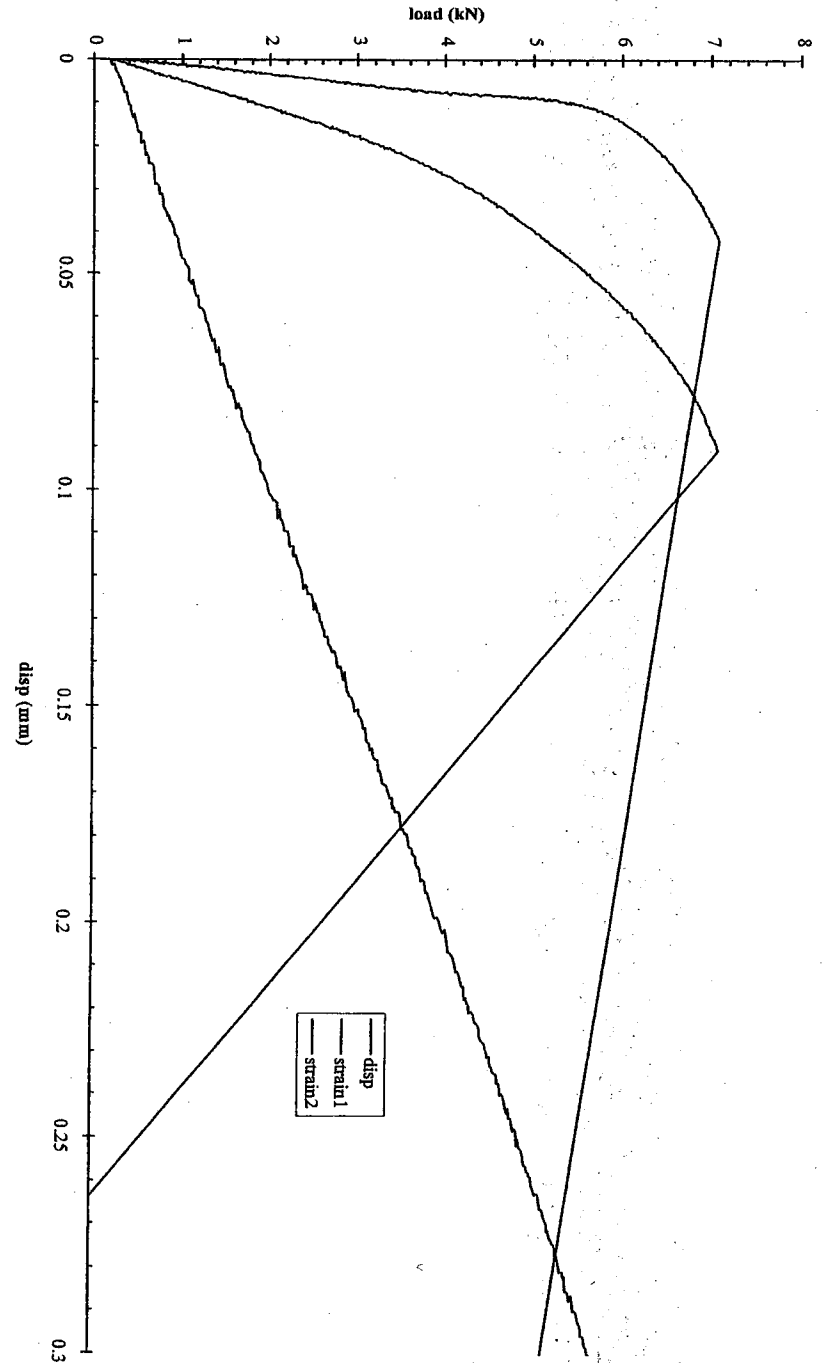
**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 29 09:07:31 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.270	0.000
b2	1.233	0.000
b3	1.253	0.000
b4	1.264	0.000
b5	1.261	0.000
b6	1.222	0.000
b7	1.239	0.000
b8	1.255	0.000
mean	1.250	0.000
Excentricity(mm): 0.056		
Excentricity/b(%): 4%		
Irregularity(mm): 0.028		
Irregularity/b(%): 2%		
Ratio a/R: 0.501		

**Test results** Compliance(mm/kN): 0.004101  
 Theoretical compliance(mm/kN): 0.004167  
 Compliance difference(%): 2%  
 Average disp. at break(mm): 0.066  
 MinMax disp. at break(mm): 0.091  
 Bending at break (%): 37%  
 $J_c(k/m^2)$ : 39.44  
 $K_c(MPaVm)$ : 91.84

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters**  
 Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b25  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.98  
 Gage length(mm): 12.5  
 Overall length(mm): 27

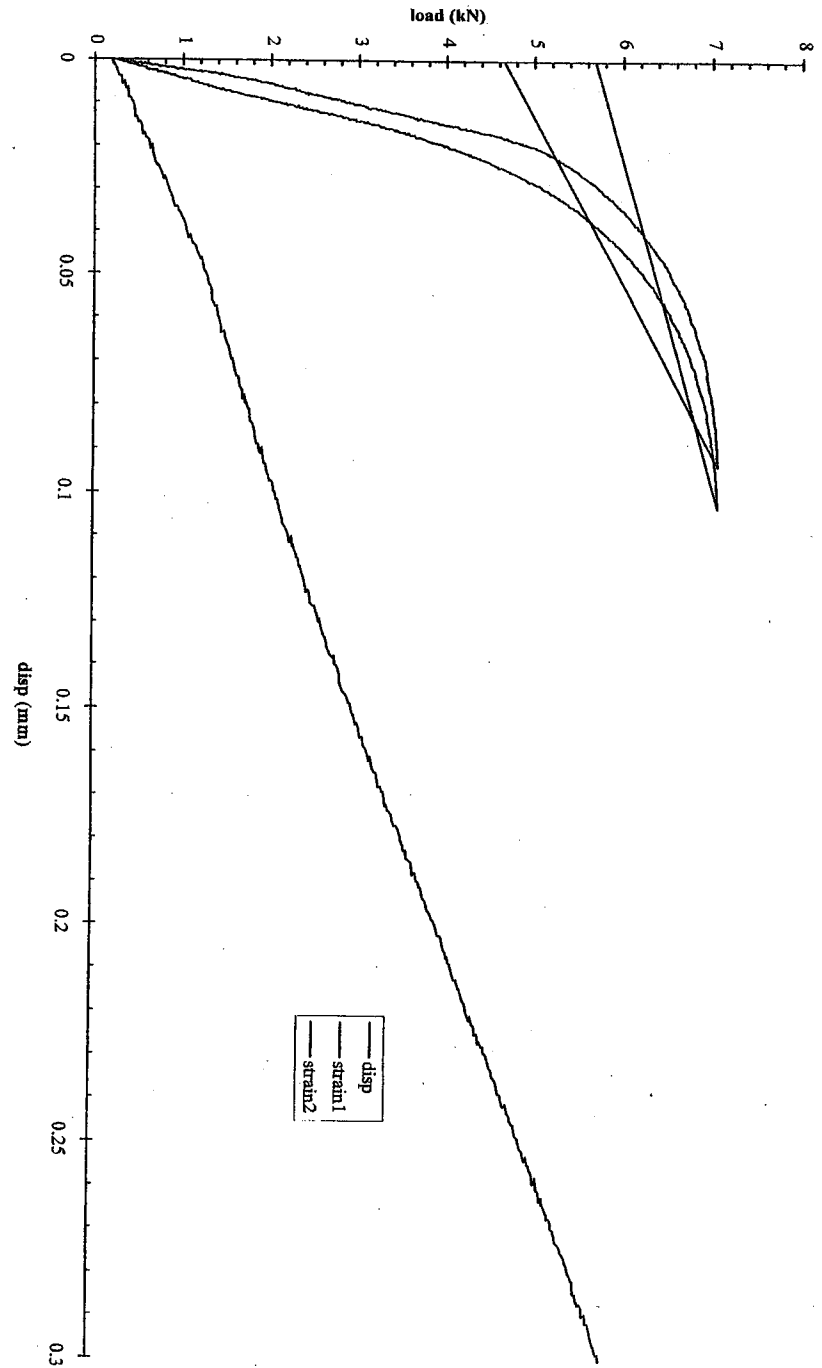
**Test parameters**  
 Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 29 09:54:33 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

**Fatigue precracking**  
 Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.201	0.000
b2	1.195	0.000
b3	1.195	0.000
b4	1.201	0.000
b5	1.123	0.000
b6	1.210	0.000
b7	1.235	0.000
b8	1.210	0.000
mean	1.196	0.000
Excentricity(mm):		0.079
Excentricity/b(%):		7%
Irregularity(mm):		0.073
Irregularity/b(%):		6%
Ratio a/R:		0.520

**Test results**  
 Compliance(mm/kN): 0.004261  
 Theoretical compliance(mm/kN): 0.004328  
 Compliance difference(%): 2%  
 Average disp. at break(mm): 0.098  
 MinMax disp. at break(mm): 0.103  
 Bending at break (%): 5%  
 Jc(kJ/m<sup>2</sup>): 71.27  
 Kc(MPaVm): 123.47

**Remarks**



SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters** Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b26  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 4.978  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters** Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 29 10:57:48 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

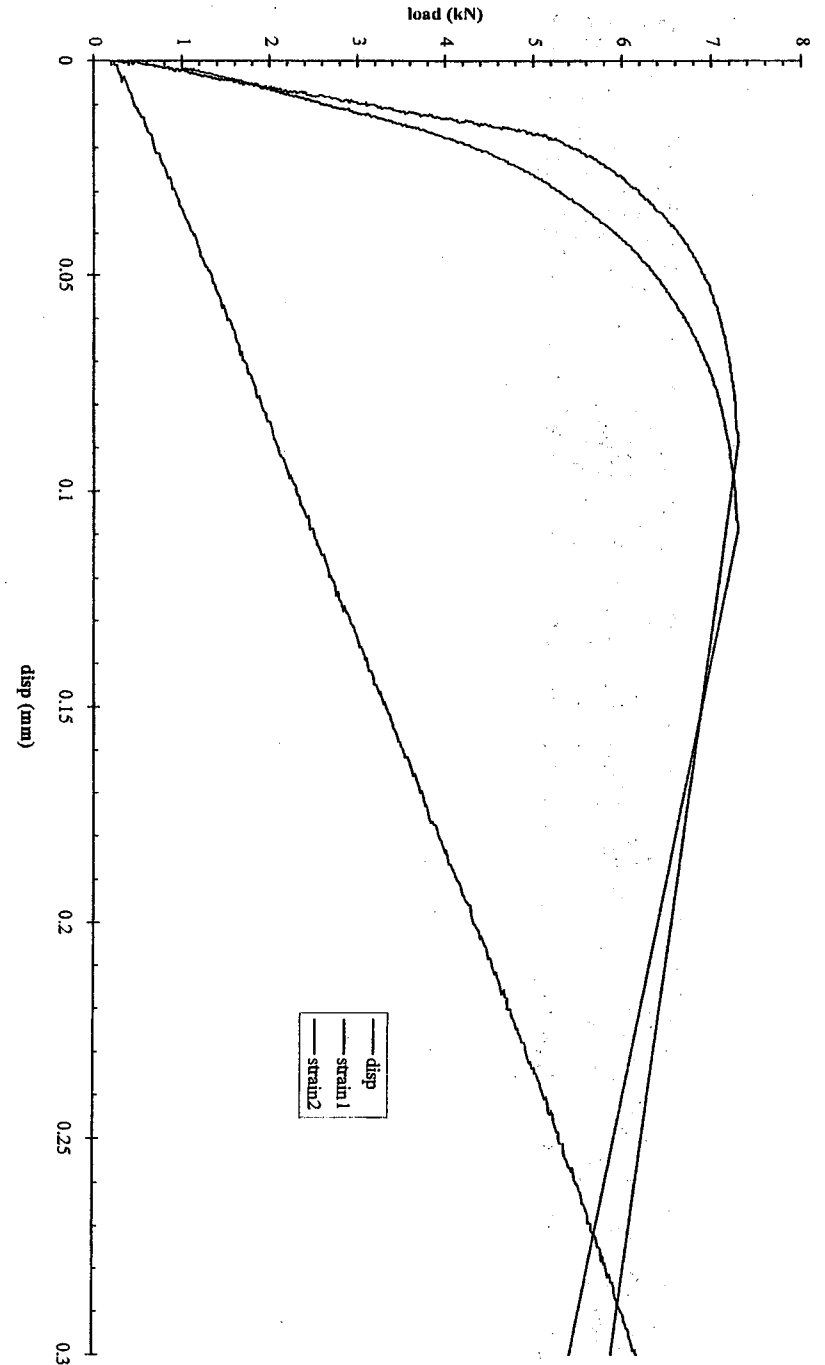
**Fatigue precracking** Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.247	0.000
b2	1.223	0.000
b3	1.230	0.000
b4	1.244	0.000
b5	1.230	0.000
b6	1.204	0.000
b7	1.239	0.000
b8	1.240	0.000
mean	1.232	0.000

Excentricity(mm): 0.114  
 Excentricity/b(%): 9%  
 Irregularity(mm): 0.028  
 Irregularity/b(%): 2%  
 Ratio a/R: 0.505

**Test results** Compliance(mm/kN): 0.003861  
 Theoretical compliance(mm/kN): 0.004236  
 Compliance difference(%): 9%  
 Average disp. at break(mm): 0.099  
 MinMax disp. at break(mm): 0.109  
 Bending at break (%): 10%  
 Jc(kJ/m<sup>2</sup>): 70.52  
 Kc(MPaVm): 122.82

**Remarks**





SCK-CEN ; LHMA  
 Boeretang 200  
 B-2400 Mol (Belgium)

**CRB FRACTURE TOUGHNESS TEST**

**Specimen parameters**  
 Material: 22NiMoCr37  
 Specimen type: CRB  
 Specimen identification: x5b27  
 Specimen orientation: L  
 Specimen dimensions  
 Diameter(mm): 5  
 Gage length(mm): 12.5  
 Overall length(mm): 27

**Test parameters**  
 Test machine: instron 8803  
 Test temperature(°C): -115  
 Test date: Jun 29 11:59:21 2001  
 Test operator: JV  
 Number of extensometers: 2  
 Speed(mm/min): 0.1

**Fatigue precracking**  
 Kmax(MPaVm): 20  
 R: -1

Ligament	Radius(mm)	Ductile extension(mm)
b1	1.232	0.000
b2	1.206	0.000
b3	1.209	0.000
b4	1.230	0.000
b5	1.201	0.000
b6	1.187	0.000
b7	1.219	0.000
b8	1.227	0.000
mean	1.214	0.000

Excentricity(mm):	0.068
Excentricity/b(%):	6%
Irregularity(mm):	0.027
Irregularity/b(%):	2%
Ratio a/R:	0.514

**Test results**  
 Compliance(mm/kN): 0.004321  
 Theoretical compliance(mm/kN): 0.004264  
 Compliance difference(%): 1%  
 Average disp. at break(mm): 0.122  
 MinMax disp. at break(mm): 0.132  
 Bending at break (%): 9%  
 Jc(kJ/m<sup>2</sup>): 90.17  
 Kc(MPaVm): 138.88

**Remarks**

