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

# **INSTRUMENTED TESTING OF BCR-SPECIMENS**



**E. van Walle, R. Vosch and JL. Puzzolante**  
*SCK•CEN, Mol, Belgium*

**R. Varma**  
*NPL, Teddington, United Kingdom*

**December 18, 1996**

**BLG-728**

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R. Varma  
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## **1. Introduction**

The aim of this research is to obtain and evaluate instrumented Charpy-V impact tests on BCR reference specimens in order to compare the results with future tests to be done on non-instrumented, so-called conventional, Charpy-V impact equipment. The sets of BCR-specimens used for this work are two 80J and two 160J sets: respectively, Batch 34 and 36 (80J) and Batch 011C and 009C (160J). The specific sample numbers can be found in Table 1.

## **2. Test equipment and conditions**

The instrumented Charpy-V impact tests were executed on a 300J Wolpert impact tester equipped with a calibrated DIN-tup. The test equipment's specifications exceed the requirements of the ISO/CD 14556 Standard [1]. It has a bandwidth of 1MHz, has special provisions to assure central notch positioning and disposes of a tup that was calibrated in-situ. The tests were performed at ambient temperature.

## **3. Test results**

The impact results can be found in Tables 1 and 2 and on the Individual Test Records given in Annex 1. In Table 1, the 'E dial' is the energy value as read from the machine; the 'E corr' value is E dial corrected for friction. The 'Wo' value in Table 2

is the integrated energy value from the individual load-time records shown in Annex 1. Table 2, as well as Annex 1, indicate the typical load values,  $F_y$  and  $F_m$ , obtained at a typical integrated displacement,  $S_y$  and  $S_m$ , during the test. Also given are the Shear Fracture Appearance (SFA) value and the measured lateral expansion.

#### **4. Discussion**

It is clear from the energy values that there exists a slight systematic difference between the batches 34 and 36 (80J). This energy difference does not exist between batches 011C and 009C (160J). On the other hand, no difference can be found in the recorded load values  $F_y$  and  $F_m$  and the corresponding integrated displacements for the respective 80J and 160J batches. This leads to the conclusion that the energy difference for the 80J-batches occurs due to a post-maximum load event: indeed, as a mean value, the total time - or total displacement - for a test is systematically longer for batch 36 than for batch 34. This might be a consequence of a small but systematic difference in length of the specimens of the two batches, although no systematic difference occurs in the lateral expansion of the broken specimens.

Interesting to remark is the small variation in typical load values for a specific nominal energy set. It is clear that the yield strength of the 80J material is higher than that of the 160J material, whereas the displacements are smaller: this demonstrates the difference in ductility of the two materials.

Although the machine was calibrated in-situ there exists a small systematic difference between the corrected energy value and the integrated value for the 80J sets: the integrated value is systematically 2% lower than the corrected energy. The match is almost perfect for the 160J batches. No obvious reason exists although it seems clear that these differences occur for spectra where the registered forces are quite high (above 25 kN): it seems as if dynamic effects occur in these force regions.

#### **5. Conclusion**

Two times two reference batches of BCR material with nominal energies of 80J and 160J were impact tested on an instrumented machine. A good correspondance was found between the friction-corrected dial energy and the integrated energy. Systematic differences have been detected between the two 80J batches: these differences do not occur in the typical force values and are a consequence of a post-maximum event. A small calibration difference exists for the 80J batches: this seems a consequence of the higher impact forces involved and suggests the influence of dynamic effects on the calibration (done static, in-situ).

The next step is to test similar batches on a non-instrumented impact tester to detect an eventual influence of the physical presence of instrumentation on the impact tup. The authors believe this effect will be minor.

#### **6. References**

- [1] ISO/CD 14556 Standard 'Steel- Charpy V Pendulum impact test - Instrumented test method', ISO/TC164/SC4/N191 (Rev.1)

Tab. 1 INSTRUMENTED MINI-CHARPY IMPACT TEST RESULTS FOR  
Material: Bureau Community of Reference ( BCR ).

Sample Number	T (°C)	E dial (J)	E corr. (J)	SFA (%)	L.E. (mm)	Remarks	Date of test
2B-60-3	23	80.80	78.78	100	0.980	Specimen broken	26/9/96
2B-60-4	23	82.00	79.84	100	0.978	Specimen broken	26/9/96
2B-60-5	23	79.00	76.76	100	0.963	Specimen broken	26/9/96
2B-61-0	23	82.20	80.10	100	0.952	Specimen broken	26/9/96
2B-61-1	23	79.00	76.50	100	0.970	Specimen broken	26/9/96
2B-62-1	23	84.00	81.96	100	1.012	Specimen broken	26/9/96
2B-62-2	23	84.20	82.23	100	1.001	Specimen broken	26/9/96
2B-62-3	23	79.50	77.29	100	0.968	Specimen broken	26/9/96
2B-62-4	23	84.20	82.32	100	0.961	Specimen broken	26/9/96
2B-62-5	23	85.00	82.76	100	0.962	Specimen broken	26/9/96
3-160-C1	23	159.80	157.70	100	1.952	Specimen broken	26/9/96
3-160-C2	23	156.00	154.01	100	2.082	Specimen broken	26/9/96
3-160-C3	23	164.20	162.44	100	1.976	Specimen broken	26/9/96
3-160-C4	23	151.80	149.55	100	1.748	Specimen broken	26/9/96
3-160-C5	23	162.20	160.70	100	1.935	Specimen broken	26/9/96
3-160-C6	23	160.20	158.47	100	1.765	Specimen broken	26/9/96
3-160-C7	23	158.20	156.15	100	1.988	Specimen broken	26/9/96
3-160-C8	23	158.80	157.41	100	1.976	Specimen broken	26/9/96
3-160-C9	23	157.50	155.27	100	1.870	Specimen broken	26/9/96
-160-C1	23	157.00	155.18	100	1.897	Specimen broken	26/9/96

Tab. 2 INSTRUMENTED MINI-CHARPY IMPACT TEST RESULTS FOR  
Material: Bureau Community of Reference ( BCR ).

Sample	T (°C)	Fy (kN)	Sy (mm)	Wy (J)	Fm (kN)	Sm (mm)	Wm (J)	Fu (kN)	Su (mm)	Wu (J)	Fa (kN)	Sa (mm)	Wa (J)	So (mm)	Wo (J)	SFA %
2B-60-3	23	19.97	0.36	3.81	25.48	0.94	17.90							8.50	76.43	100
2B-60-4	23	19.95	0.36	4.00	25.77	0.98	18.86							8.55	77.54	100
2B-60-5	23	20.00	0.38	4.08	25.64	0.98	18.63							8.60	74.51	100
2B-61-0	23	19.98	0.38	4.27	25.53	0.97	18.46							8.50	78.06	100
2B-61-1	23	19.86	0.36	3.93	25.45	0.96	18.09							8.55	74.40	100
2B-62-1	23	20.03	0.36	3.86	25.37	0.96	18.21							10.73	80.89	100
2B-62-2	23	19.84	0.39	4.51	25.55	0.93	17.55							9.51	80.24	100
2B-62-3	23	19.90	0.38	4.20	25.72	0.91	17.13							8.75	75.22	100
2B-62-4	23	19.86	0.38	4.07	25.77	0.98	18.66							8.87	80.72	100
2B-62-5	23	19.83	0.38	4.07	25.62	0.95	17.88							11.30	81.00	100
3-160-C1	23	17.42	0.37	3.73	23.18	1.89	36.69							21.54	158.45	100
3-160-C2	23	17.16	0.36	3.43	23.06	1.71	32.48							20.40	152.78	100
3-160-C3	23	17.15	0.38	3.68	23.15	1.79	34.05							20.40	163.19	100
3-160-C4	23	17.06	0.45	4.42	23.17	2.10	40.38							20.40	149.18	100
3-160-C5	23	17.34	0.37	3.69	23.20	1.75	33.40							20.40	161.29	100
3-160-C6	23	17.06	0.39	3.86	23.12	1.82	34.69							20.40	158.80	100
3-160-C7	23	17.20	0.38	3.85	23.23	1.81	34.76							20.00	155.79	100
3-160-C8	23	16.62	0.40	3.92	23.16	1.89	36.01							19.00	158.11	100
3-160-C9	23	17.16	0.39	3.81	23.18	1.92	36.98							19.00	155.44	100
-160-C1	23	16.43	0.39	3.64	23.20	1.84	34.89							19.00	156.42	100

**ANNEX 1: Instrumented impact traces (sequence of Table 1 and 2)**

Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

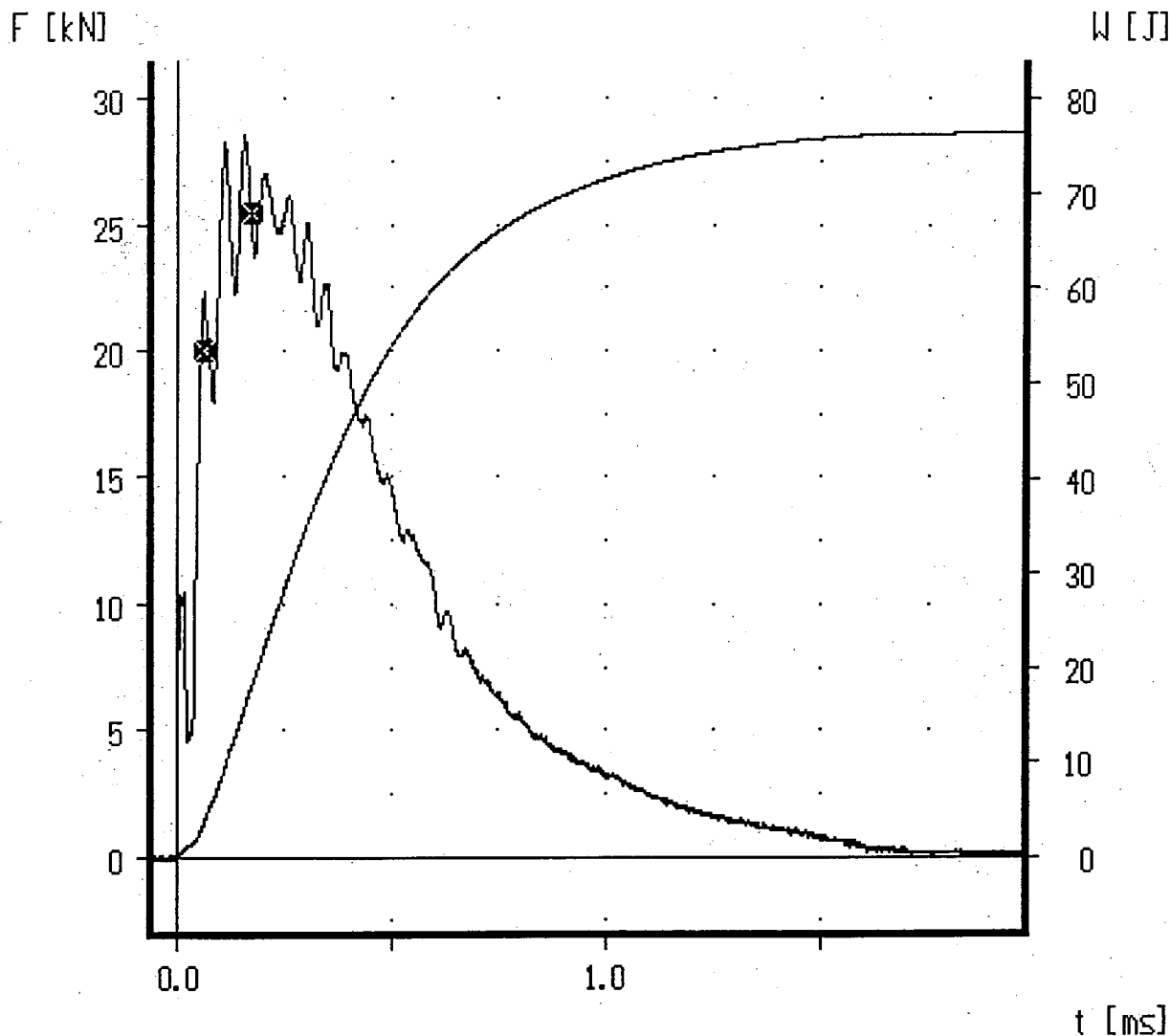
Operator: R. VOSCH  
Material: BATCH 34

Budget : B032050  
Nr. : 11  
Specimen: 2B-60-3

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 80.80 J  
E corr. : 78.78 J  
E incr. : 79.98 J  
E comp. : 76.43 J  
SFA : 100.00 %  
Lat. exp. : 0.980 mm

Time	Load	Energy	Displacement
t_gy= 0.066 ms	F_gy= 19.97 kN	W_gy= 3.81 J	s_gy= 0.358 mm
t_m = 0.174 ms	F_m = 25.48 kN	W_m = 17.90 J	s_m = 0.944 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm





Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

Operator: R. VOSCH  
Material: BATCH 34

Budget : B032050  
Nr. : 12  
Specimen: 2B-60-4

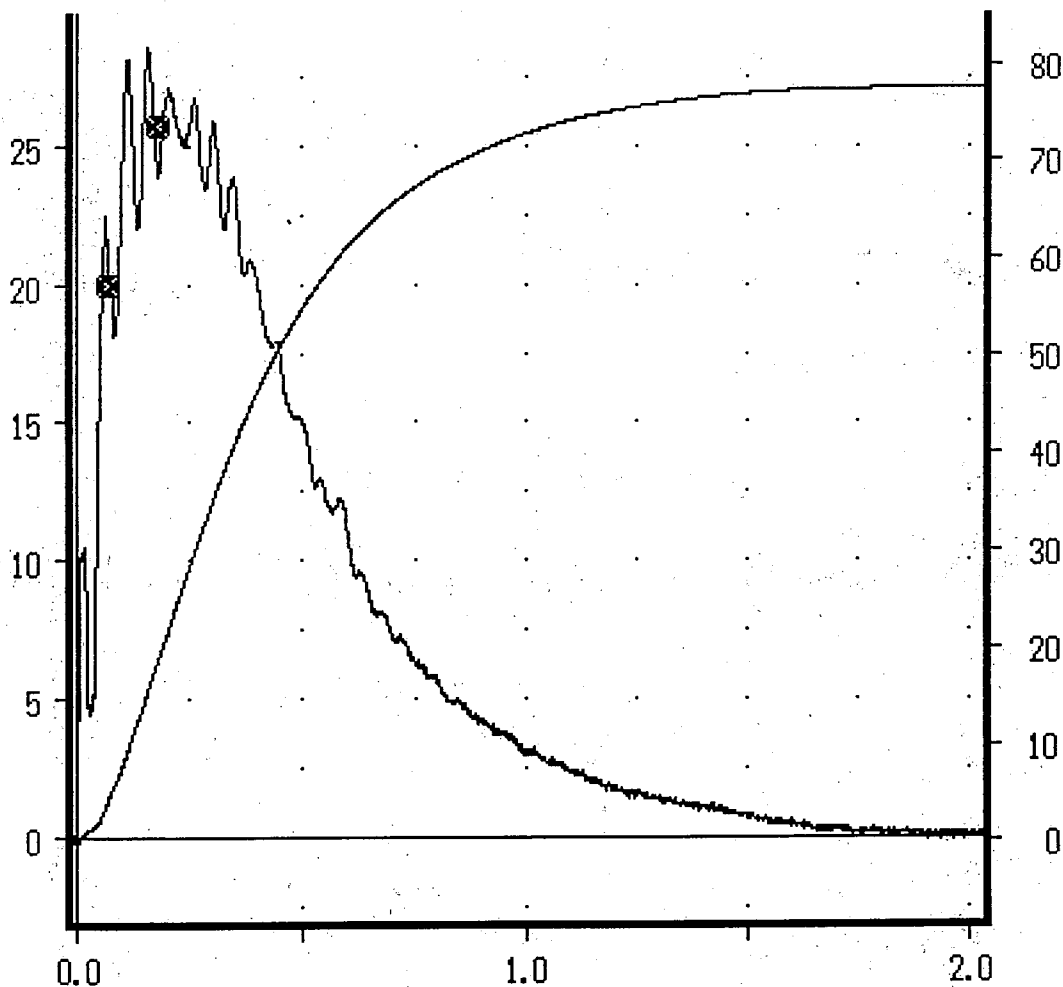
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 82.00 J  
E corr. : 79.84 J  
E incr. : 81.03 J  
E comp. : 77.54 J  
SFA : 100.00 %  
Lat. exp. : 0.978 mm

Time	Load	Energy	Displacement
t_gy= 0.067 ms	F_gy= 19.95 kN	W_gy= 4.00 J	s_gy= 0.364 mm
t_m = 0.181 ms	F_m = 25.77 kN	W_m = 18.86 J	s_m = 0.981 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



t [ms]

Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 34

Nr. : 13

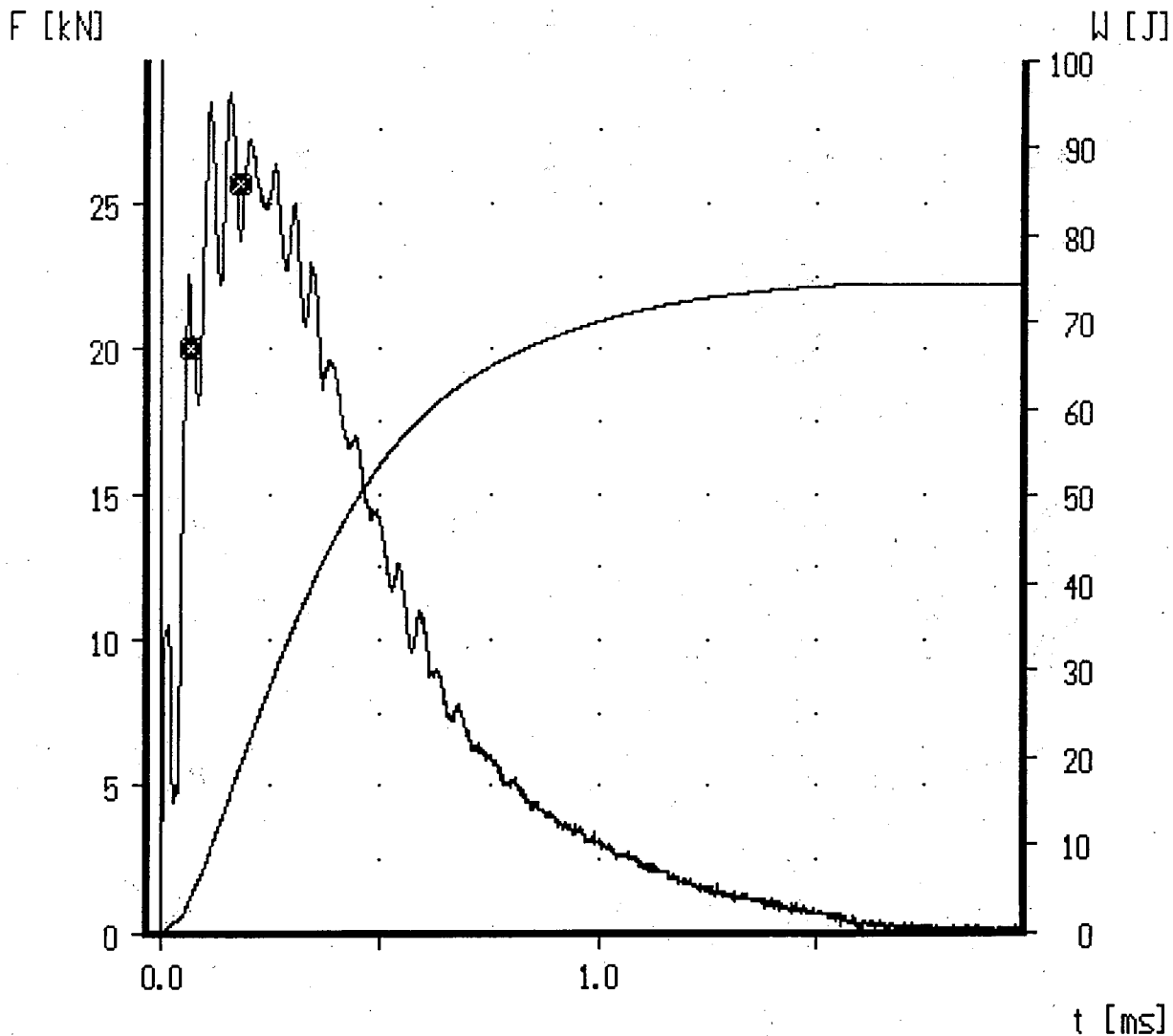
Hammer: Charpy 300J F, displ.

Specimen: 2B-60-5

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 79.00 J  
E corr. : 76.76 J  
E incr. : 77.96 J  
E comp. : 74.51 J  
SFA : 100.00 %  
Lat. exp. : 0.963 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.068 ms	F <sub>gy</sub> = 20.00 kN	W <sub>gy</sub> = 4.08 J	s <sub>gy</sub> = 0.375 mm
t <sub>m</sub> = 0.179 ms	F <sub>m</sub> = 25.64 kN	W <sub>m</sub> = 18.63 J	s <sub>m</sub> = 0.976 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm



```

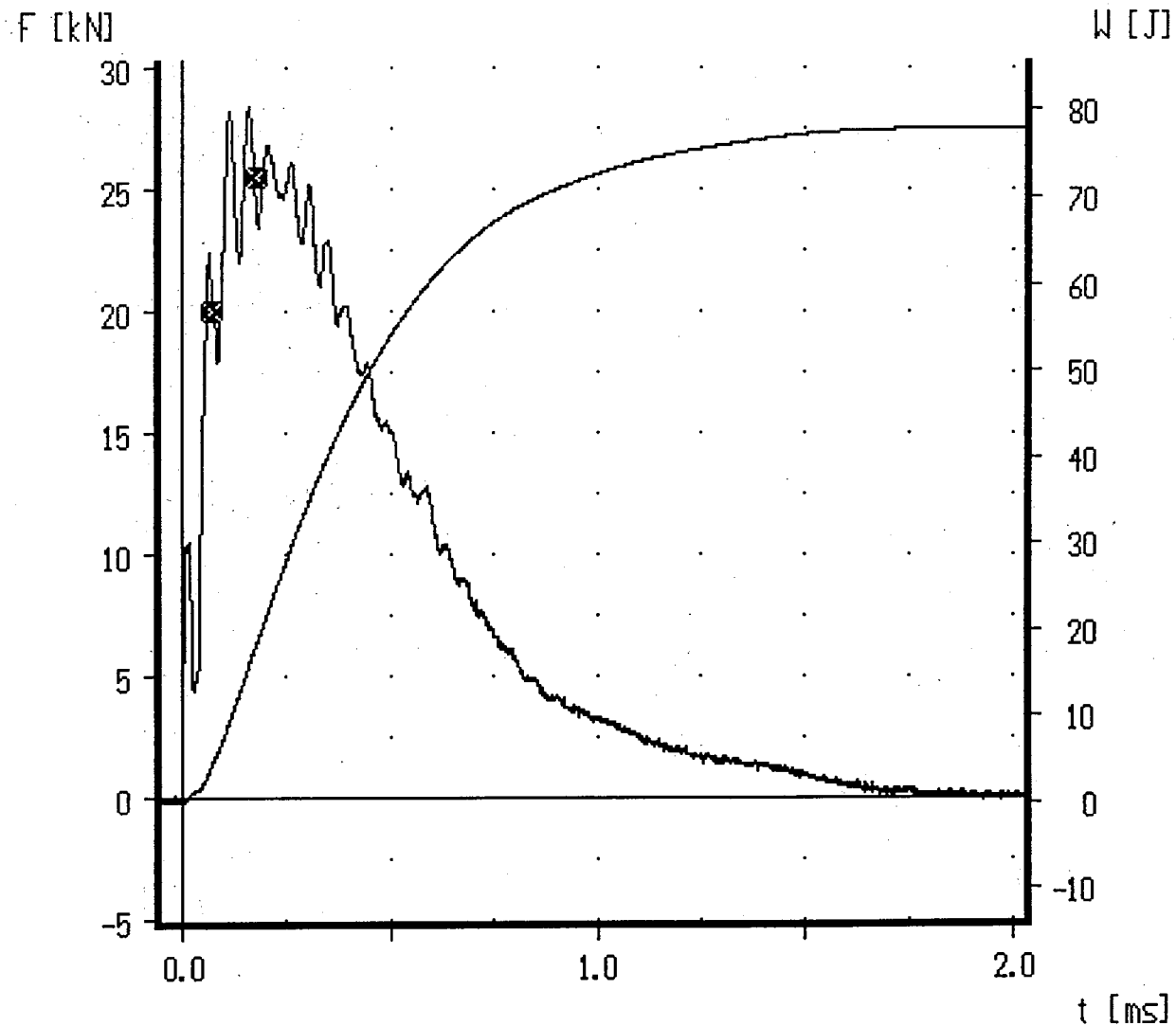
=====
Date   : 26.09.1996      Operator: R. VOSCH      Budget  : B032050
Tup    : DIN-2970       Material: BATCH 34     Nr.     : 14
Hammer: Charpy 300J F,displ. Specimen: 2B-61-0
  
```

```

-----
Temperature : 23.00 deg.C      Fg load      : 1000.00 kHz
Velocity Vo  : 5.52 m/s        E dial       : 82.20 J
Avail. energy : 300.02 J       E corr.      : 80.10 J
Fall. height h : 1554.56 mm    E incr.      : 81.30 J
Fall. angle α : 160.60 deg.    E comp.      : 78.06 J
Time         : 8.00 ms         SFA          : 100.00 %
Comment      : SPECIMEN BROKEN Lat. exp.         : 0.952 mm
  
```

```

-----
Time          Load          Energy          Displacement
t_gy= 0.070 ms  F_gy= 19.98 kN  W_gy= 4.27 J   s_gy= 0.380 mm
t_m = 0.179 ms  F_m = 25.53 kN  W_m = 18.46 J  s_m = 0.971 mm
t_u = -- ms     F_u = -- kN     W_u = -- J     s_u = -- mm
t_a = -- ms     F_a = -- kN     W_a = -- J     s_a = -- mm
  
```



Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 34

Nr. : 15

Hammer: Charpy 300J F, displ.

Specimen: 2B-61-1

Temperature : 23.00 deg.C

Fg load : 1000.00 kHz

Velocity Vo : 5.52 m/s

E dial : 79.00 J

Avail. energy : 300.02 J

E corr. : 76.50 J

Fall. height h : 1554.56 mm

E incr. : 77.70 J

Fall. angle  $\alpha$  : 160.60 deg.

E comp. : 74.40 J

Time : 8.00 ms

SFA : 100.00 %

Comment : SPECIMEN BROKEN

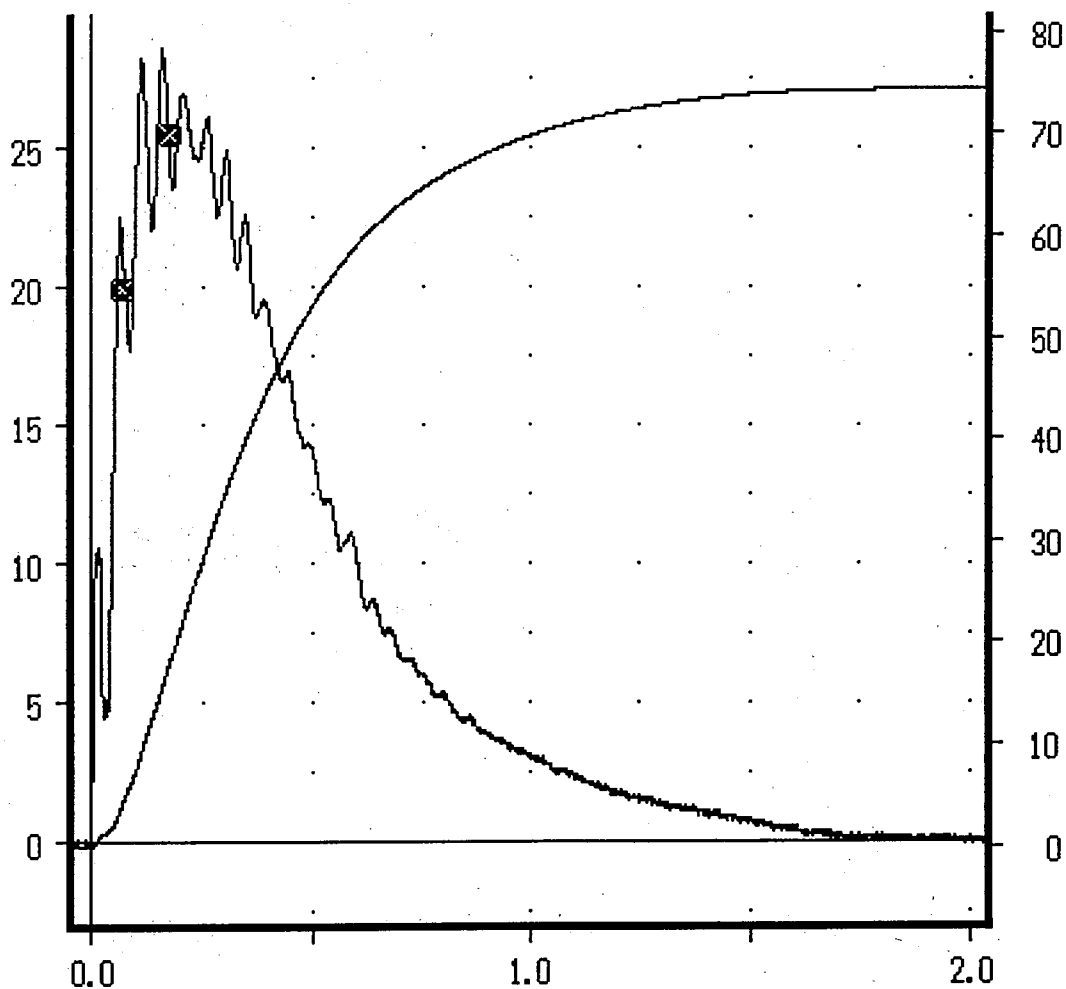
Lat. exp. : 0.970 mm

Time Load Energy Displacement

t <sub>gy</sub> = 0.067 ms	F <sub>gy</sub> = 19.86 kN	W <sub>gy</sub> = 3.93 J	s <sub>gy</sub> = 0.364 mm
t <sub>m</sub> = 0.176 ms	F <sub>m</sub> = 25.45 kN	W <sub>m</sub> = 18.09 J	s <sub>m</sub> = 0.955 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm

F [kN]

W [J]



t [ms]

Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

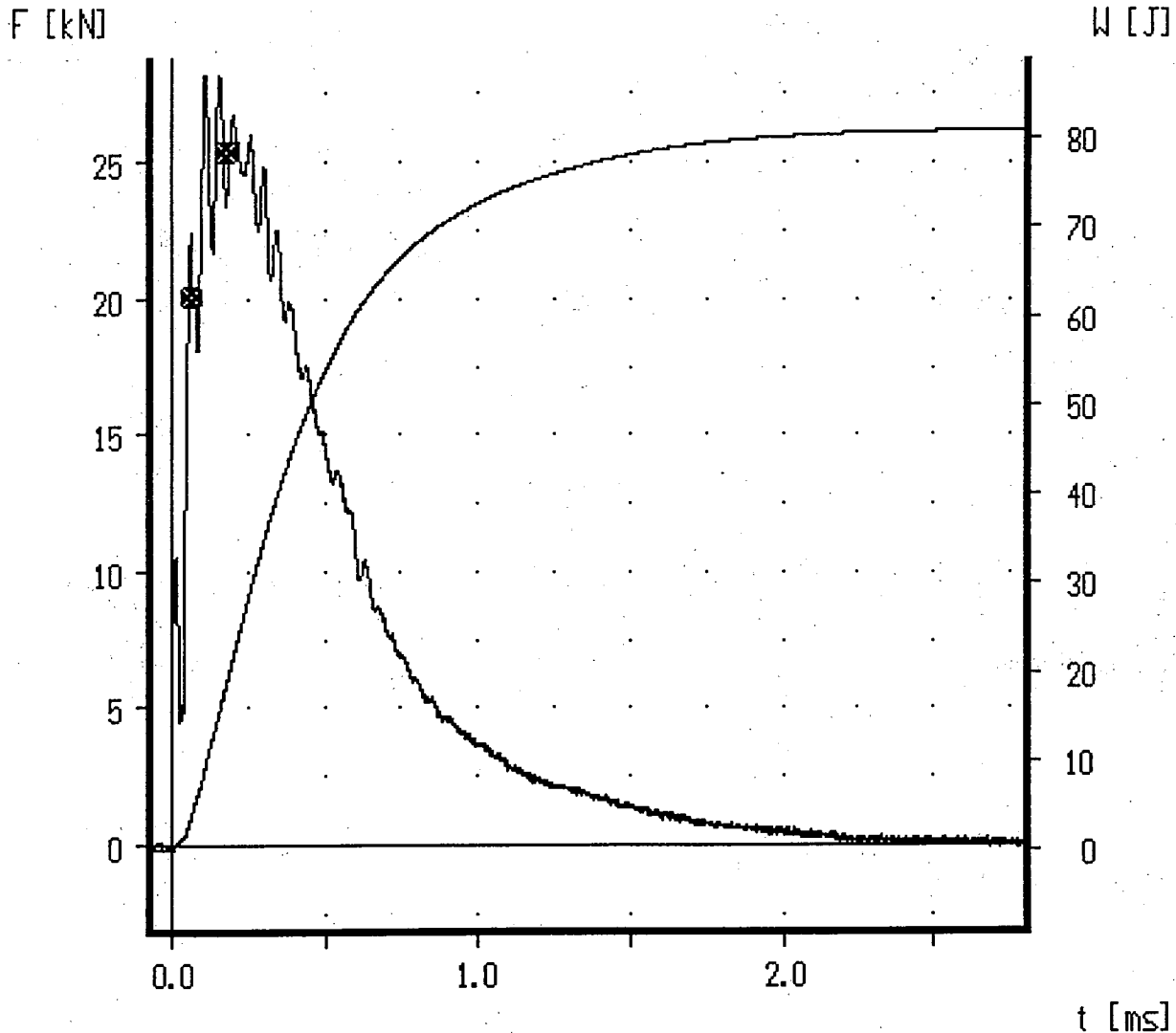
Operator: R. VOSCH  
Material: BATCH 36

Budget : B032050  
Nr. : 20  
Specimen: 2B-62-1

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 84.00 J  
E corr. : 81.96 J  
E incr. : 83.15 J  
E comp. : 80.89 J  
SFA : 100.00 %  
Lat. exp. : 1.012 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.066 ms	F <sub>gy</sub> = 20.03 kN	W <sub>gy</sub> = 3.86 J	s <sub>gy</sub> = 0.358 mm
t <sub>m</sub> = 0.177 ms	F <sub>m</sub> = 25.37 kN	W <sub>m</sub> = 18.21 J	s <sub>m</sub> = 0.960 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm



Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 36

Nr. : 19

Hammer: Charpy 300J F, displ.

Specimen: 2B-62-2

Temperature : 23.00 deg.C

Fg load : 1000.00 kHz

Velocity Vo : 5.52 m/s

E dial : 84.20 J

Avail. energy : 300.02 J

E corr. : 82.23 J

Fall. height h : 1554.56 mm

E incr. : 83.42 J

Fall. angle  $\alpha$  : 160.60 deg.

E comp. : 80.24 J

Time : 8.00 ms

SFA : 100.00 %

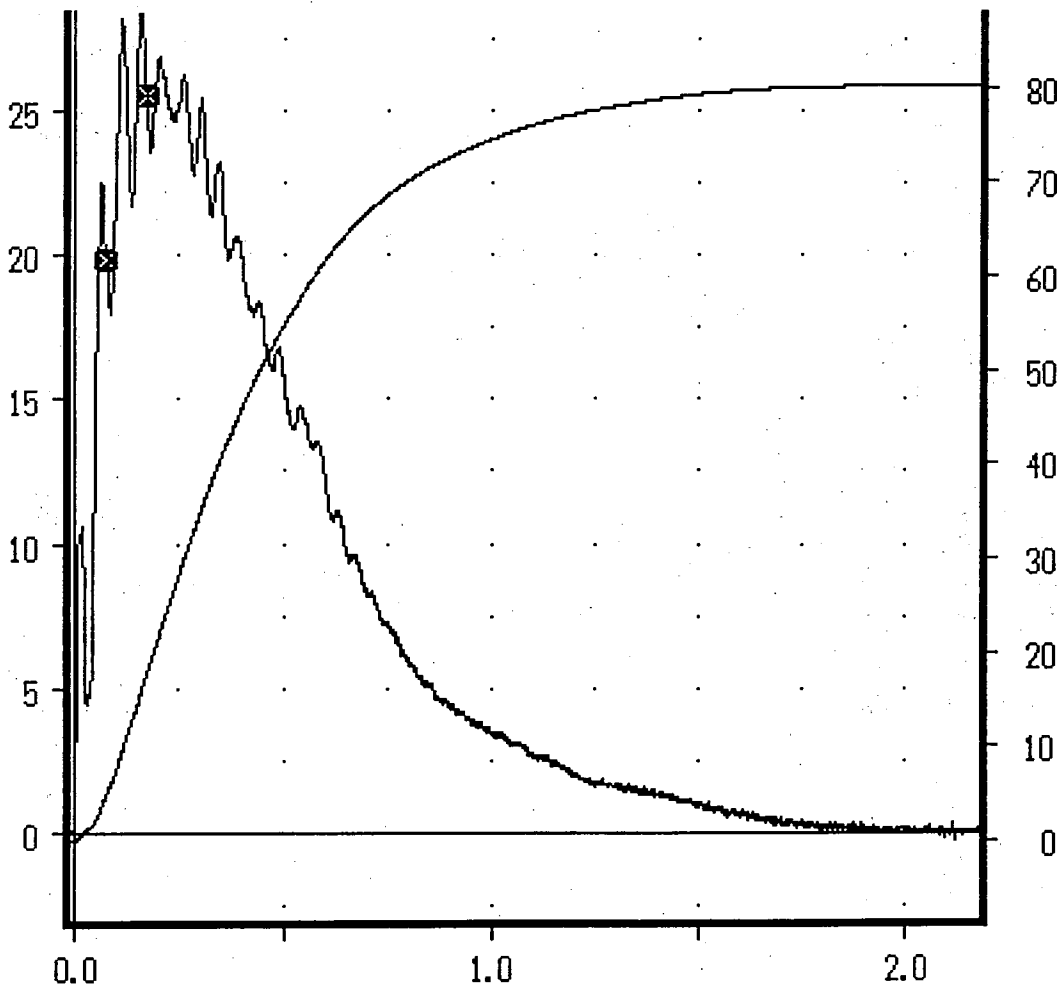
Comment : SPECIMEN BROKEN

Lat. exp. : 1.001 mm

Time	Load	Energy	Displacement
t_gy= 0.071 ms	F_gy= 19.84 kN	W_gy= 4.51 J	s_gy= 0.385 mm
t_m = 0.171 ms	F_m = 25.55 kN	W_m = 17.55 J	s_m = 0.928 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



t [ms]

Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 36

Nr. : 18

Hammer: Charpy 300J F, displ.

Specimen: 2B-62-3

Temperature : 23.00 deg.C

Fg load : 1000.00 kHz

Velocity Vo : 5.52 m/s

E dial : 79.50 J

Avail. energy : 300.02 J

E corr. : 77.29 J

Fall. height h : 1554.56 mm

E incr. : 78.49 J

Fall. angle  $\alpha$  : 160.60 deg.

E comp. : 75.22 J

Time : 8.00 ms

SFA : 100.00 %

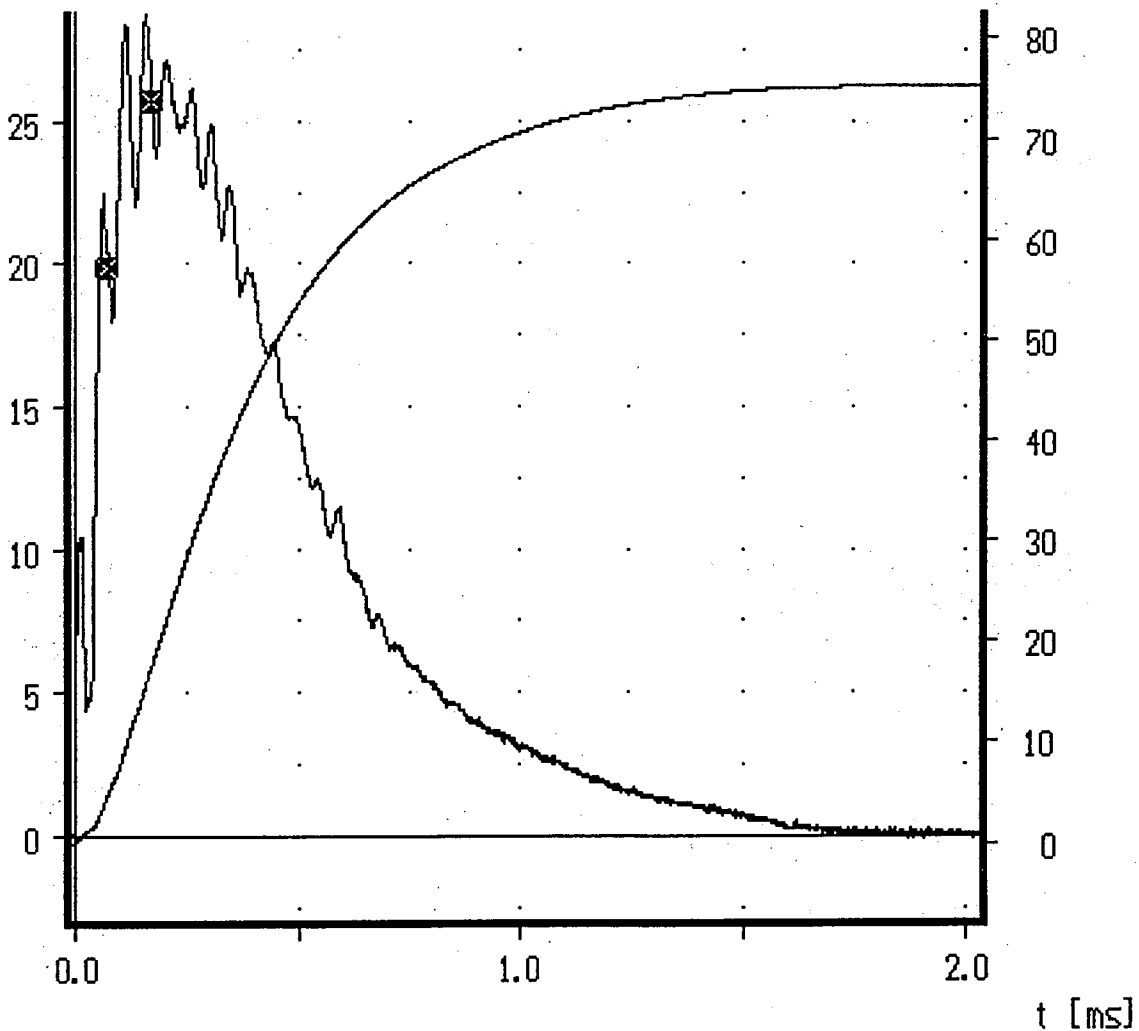
Comment : SPECIMEN BROKEN

Lat. exp. : 0.968 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.069 ms	F <sub>gy</sub> = 19.90 kN	W <sub>gy</sub> = 4.20 J	s <sub>gy</sub> = 0.375 mm
t <sub>m</sub> = 0.168 ms	F <sub>m</sub> = 25.72 kN	W <sub>m</sub> = 17.13 J	s <sub>m</sub> = 0.912 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm

F [kN]

W [J]



Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

Operator: R. VOSCH  
Material: BATCH 36

Budget : B032050  
Nr. : 17  
Specimen: 2B-62-4

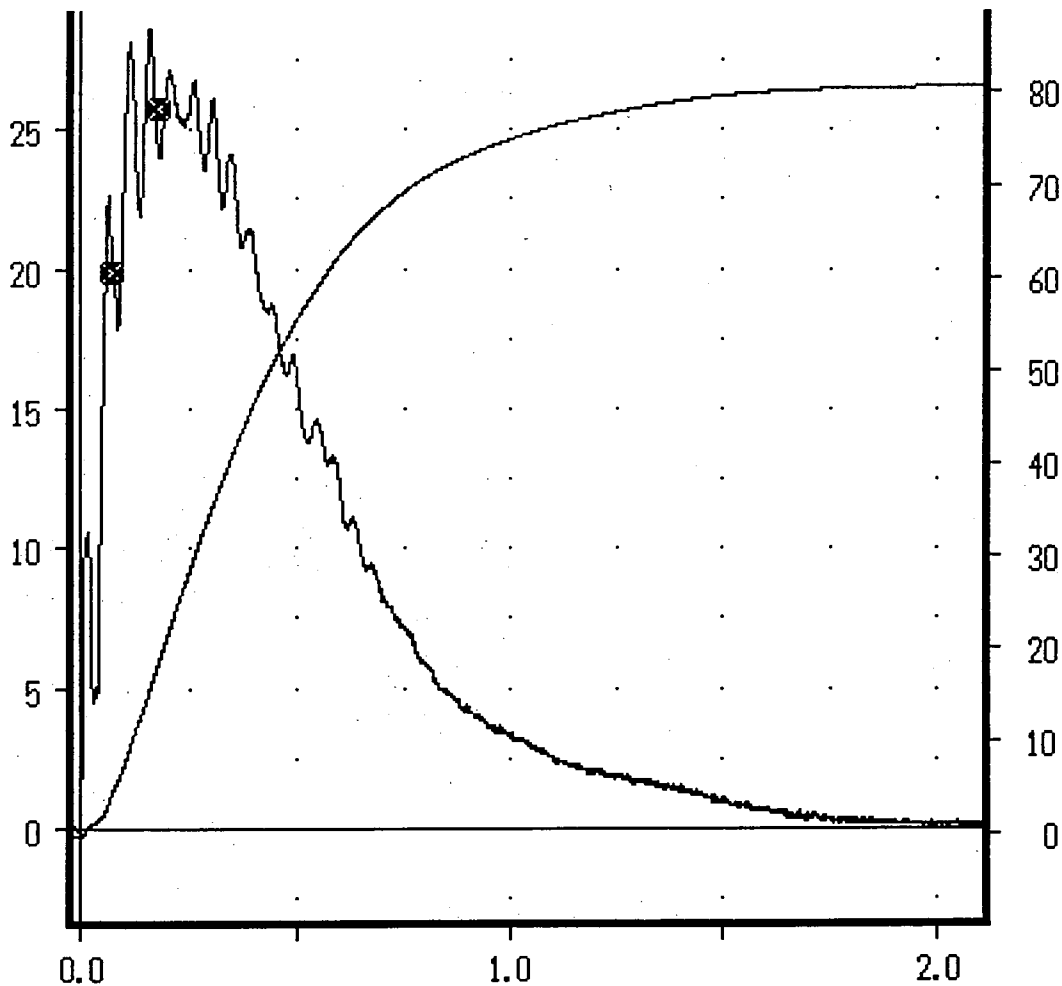
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 84.20 J  
E corr. : 82.32 J  
E incr. : 83.51 J  
E comp. : 80.72 J  
SFA : 100.00 %  
Lat. exp. : 0.961 mm

Time	Load	Energy	Displacement
t_gy= 0.068 ms	F_gy= 19.86 kN	W_gy= 4.07 J	s_gy= 0.375 mm
t_m = 0.180 ms	F_m = 25.77 kN	W_m = 18.66 J	s_m = 0.982 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



t [ms]



Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 36

Nr. : 16

Hammer: Charpy 300J F, displ.

Specimen: 2B-62-5

Temperature : 23.00 deg.C

Fg load : 1000.00 kHz

Velocity Vo : 5.52 m/s

E dial : 85.00 J

Avail. energy : 300.02 J

E corr. : 82.76 J

Fall. height h : 1554.56 mm

E incr. : 83.95 J

Fall. angle  $\alpha$  : 160.60 deg.

E comp. : 81.00 J

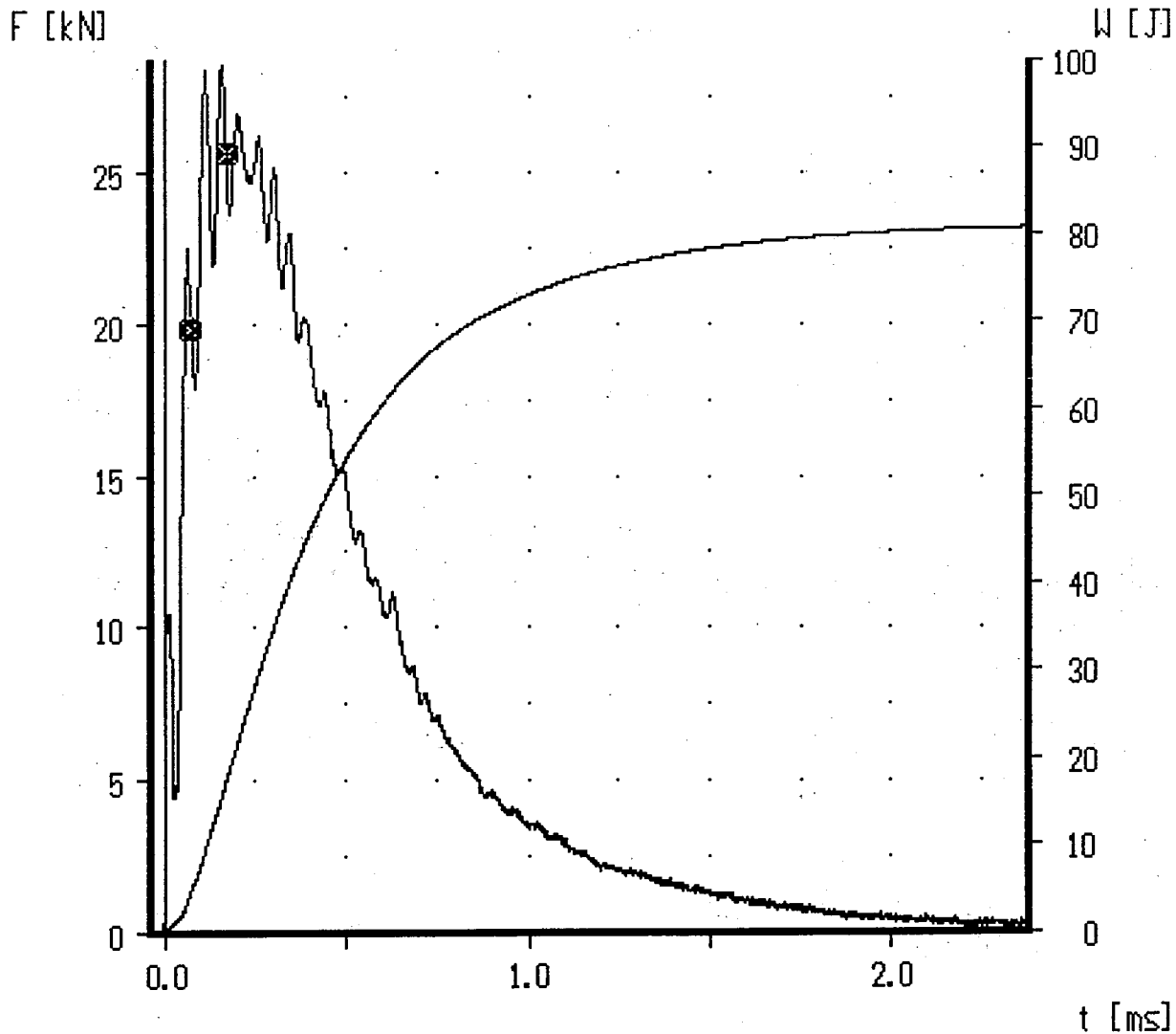
Time : 8.00 ms

SFA : 100.00 %

Comment : SPECIMEN BROKEN

Lat. exp. : 0.962 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.068 ms	F <sub>gy</sub> = 19.83 kN	W <sub>gy</sub> = 4.07 J	s <sub>gy</sub> = 0.375 mm
t <sub>m</sub> = 0.174 ms	F <sub>m</sub> = 25.62 kN	W <sub>m</sub> = 17.88 J	s <sub>m</sub> = 0.950 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm



Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Tup : DIN-2970

Material: BATCH 011 C

Nr. : 21

Hammer: Charpy 300J F, displ.

Specimen: 3-160-C1

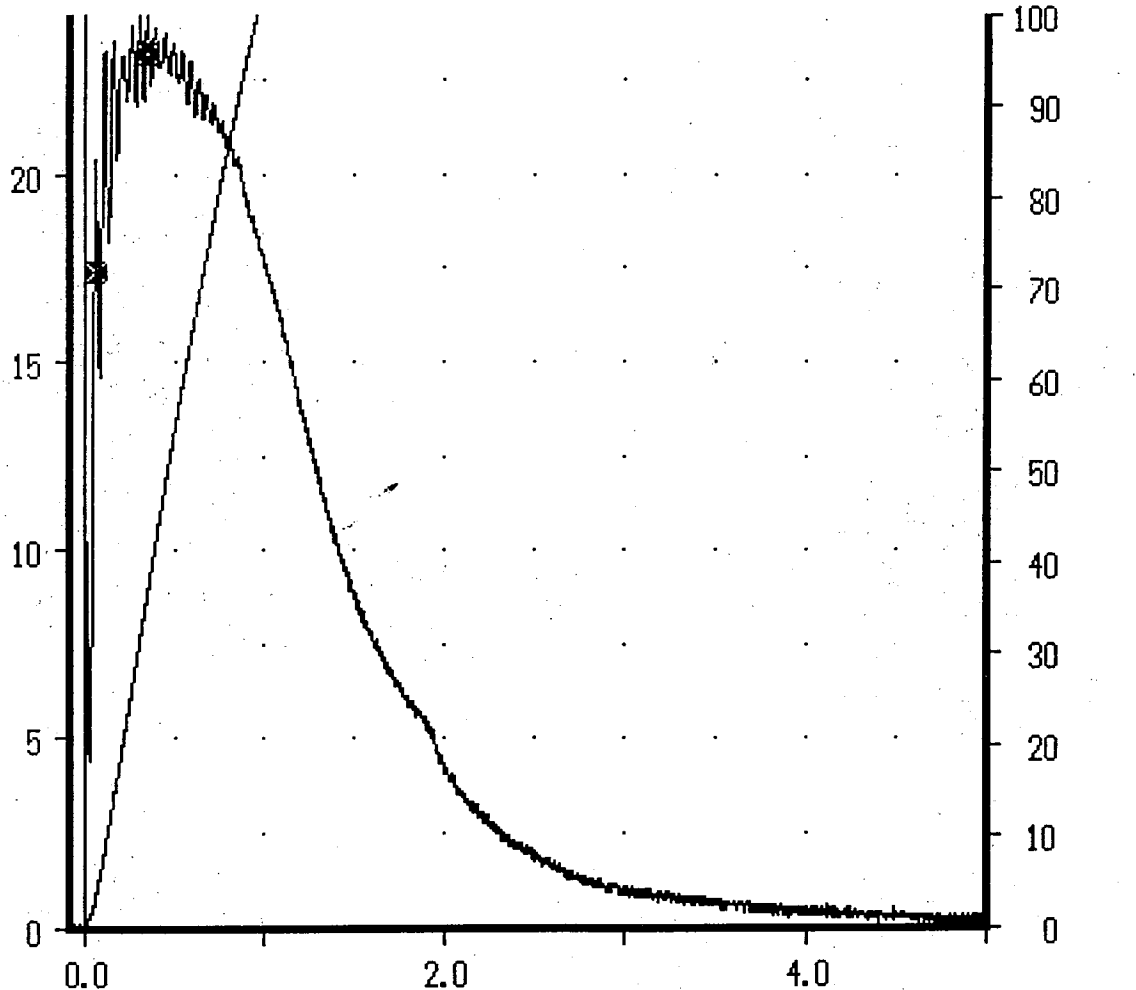
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 159.80 J  
E corr. : 157.70 J  
E incr. : 158.71 J  
E comp. : 158.45 J  
SFA : 100.00 %  
Lat. exp. : 1.952 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.068 ms	F <sub>gy</sub> = 17.42 kN	W <sub>gy</sub> = 3.73 J	s <sub>gy</sub> = 0.369 mm
t <sub>m</sub> = 0.353 ms	F <sub>m</sub> = 23.18 kN	W <sub>m</sub> = 36.69 J	s <sub>m</sub> = 1.890 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm

F [kN]

W [J]



t [ms]

Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

Operator: R. VOSCH  
Material: BATCH 011 C

Budget : B032050  
Nr. : 22  
Specimen: 3-160-C2

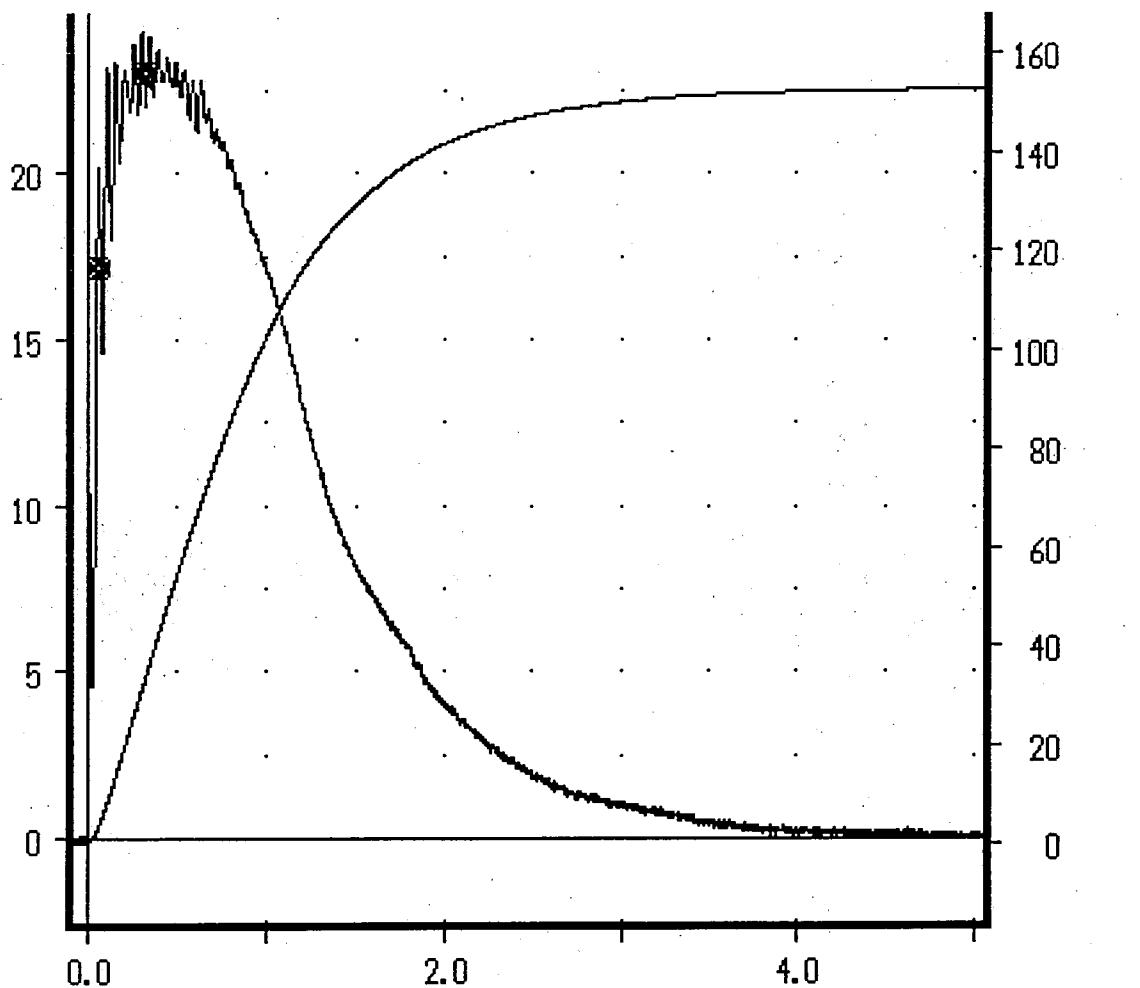
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 12.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 156.00 J  
E corr. : 154.01 J  
E incr. : 155.03 J  
E comp. : 152.78 J  
SFA : 100.00 %  
Lat. exp. : 2.082 mm

Time	Load	Energy	Displacement
t_gy= 0.065 ms	F_gy= 17.16 kN	W_gy= 3.43 J	s_gy= 0.355 mm
t_m = 0.318 ms	F_m = 23.06 kN	W_m = 32.48 J	s_m = 1.714 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



t [ms]

```

=====
Date   : 26.09.1996      Operator: R. VOSCH      Budget  : B032050
Tup    : DIN-2970       Material: BATCH 011 C  Nr.     : 23
Hammer: Charpy 300J F,displ. Specimen: 3-160-C3
=====

```

```

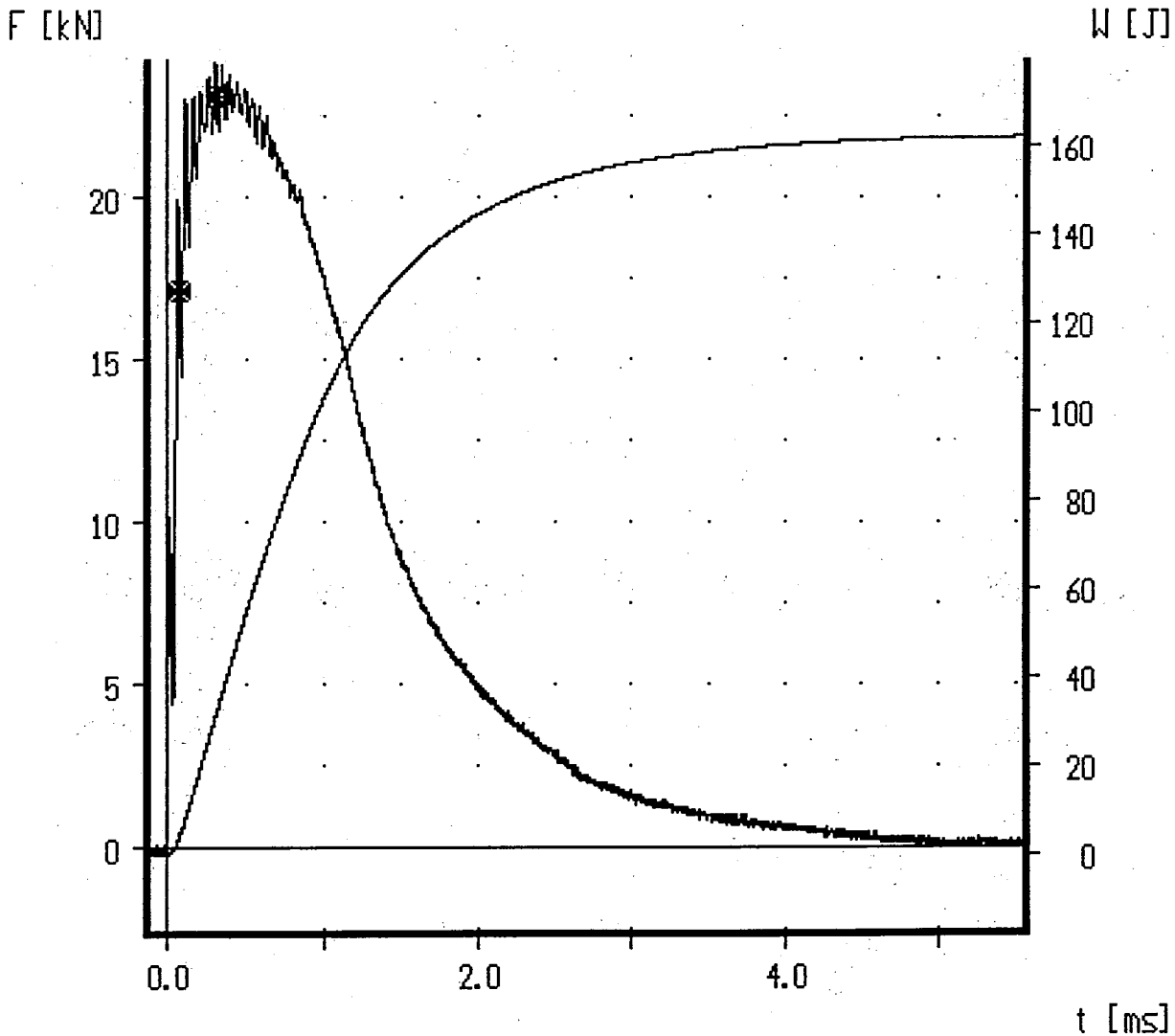
-----
Temperature : 23.00 deg.C      Fg load   : 1000.00 kHz
Velocity Vo  : 5.52 m/s        E dial    : 164.20 J
Avail. energy : 300.02 J      E corr.   : 162.44 J
Fall. height h : 1554.56 mm    E incr.   : 163.44 J
Fall. angle α : 160.60 deg.    E comp.   : 163.19 J
Time         : 8.00 ms         SFA       : 100.00 %
Comment      : SPECIMEN BROKEN Lat. exp.     : 1.976 mm
-----

```

```

-----
Time          Load          Energy          Displacement
t_gy= 0.069 ms  F_gy= 17.15 kN  W_gy= 3.68 J   s_gy= 0.375 mm
t_m = 0.333 ms  F_m = 23.15 kN  W_m = 34.05 J   s_m = 1.787 mm
t_u = -- ms     F_u = -- kN     W_u = -- J     s_u = -- mm
t_a = -- ms     F_a = -- kN     W_a = -- J     s_a = -- mm
-----

```



```

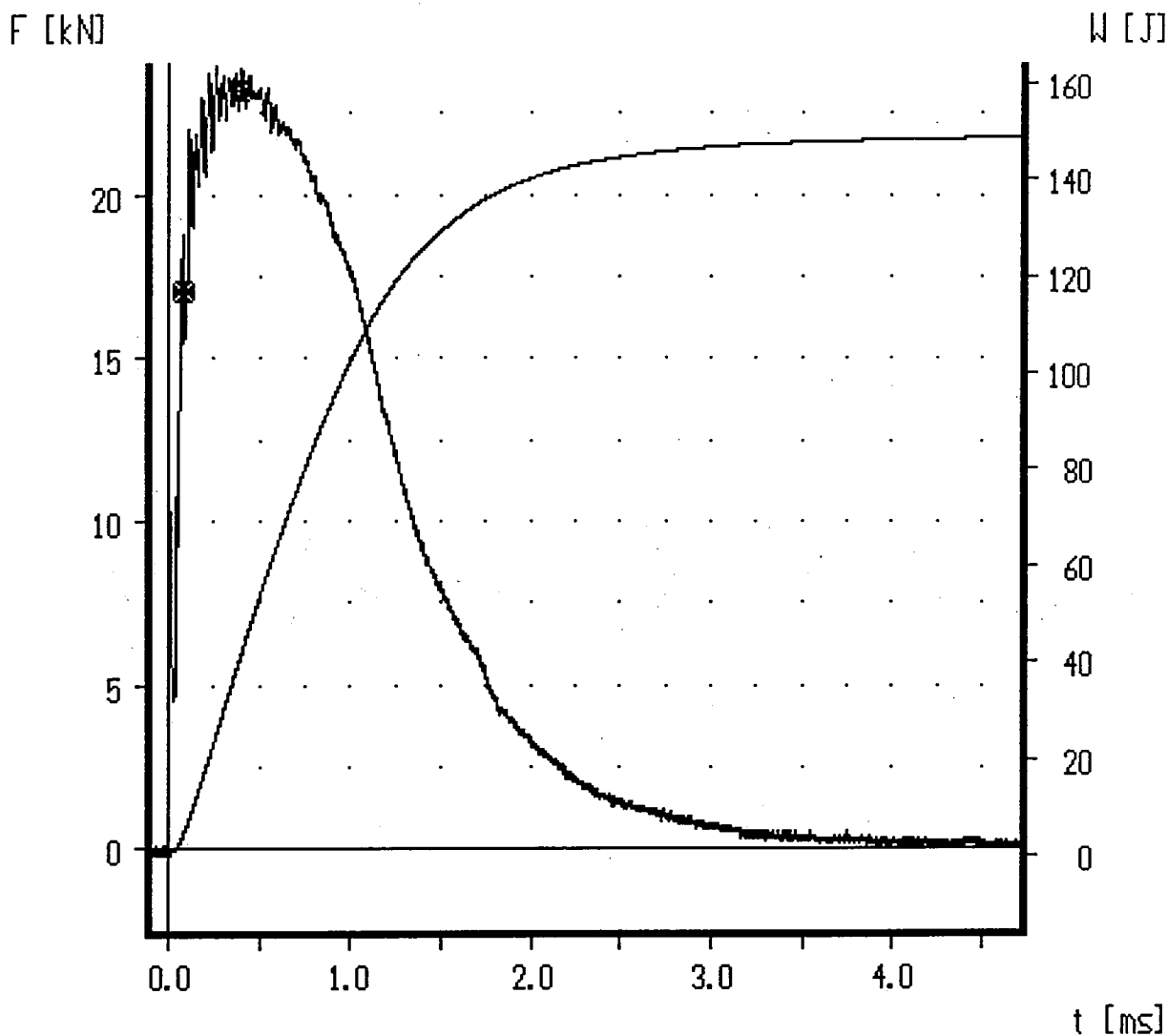
=====
Date      : 26.09.1996           Operator: R. VOSCH           Budget   : B032050
Tup       : DIN-2970            Material: BATCH 011 C      Nr.      : 24
Hammer: Charpy 300J F, displ.   Specimen: 3-160-C4
  
```

```

-----
Temperature : 23.00 deg.C      Fg load      : 1000.00 kHz
Velocity Vo  : 5.52 m/s        E dial       : 151.80 J
Avail. energy : 300.02 J       E corr.      : 149.55 J
Fall. height h : 1554.56 mm    E incr.      : 150.57 J
Fall. angle  $\alpha$  : 160.60 deg.   E comp.      : 149.18 J
Time         : 8.00 ms         SFA          : 100.00 %
Comment      : SPECIMEN BROKEN Lat. exp.       : 1.748 mm
  
```

```

-----
Time          Load          Energy          Displacement
t_gy= 0.082 ms  F_gy= 17.06 kN  W_gy= 4.42 J   s_gy= 0.451 mm
t_m = 0.392 ms  F_m = 23.17 kN  W_m = 40.38 J  s_m = 2.100 mm
t_u = -- ms     F_u = -- kN     W_u = -- J     s_u = -- mm
t_a = -- ms     F_a = -- kN     W_a = -- J     s_a = -- mm
  
```



Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

Operator: R. VOSCH  
Material: BATCH 011 C

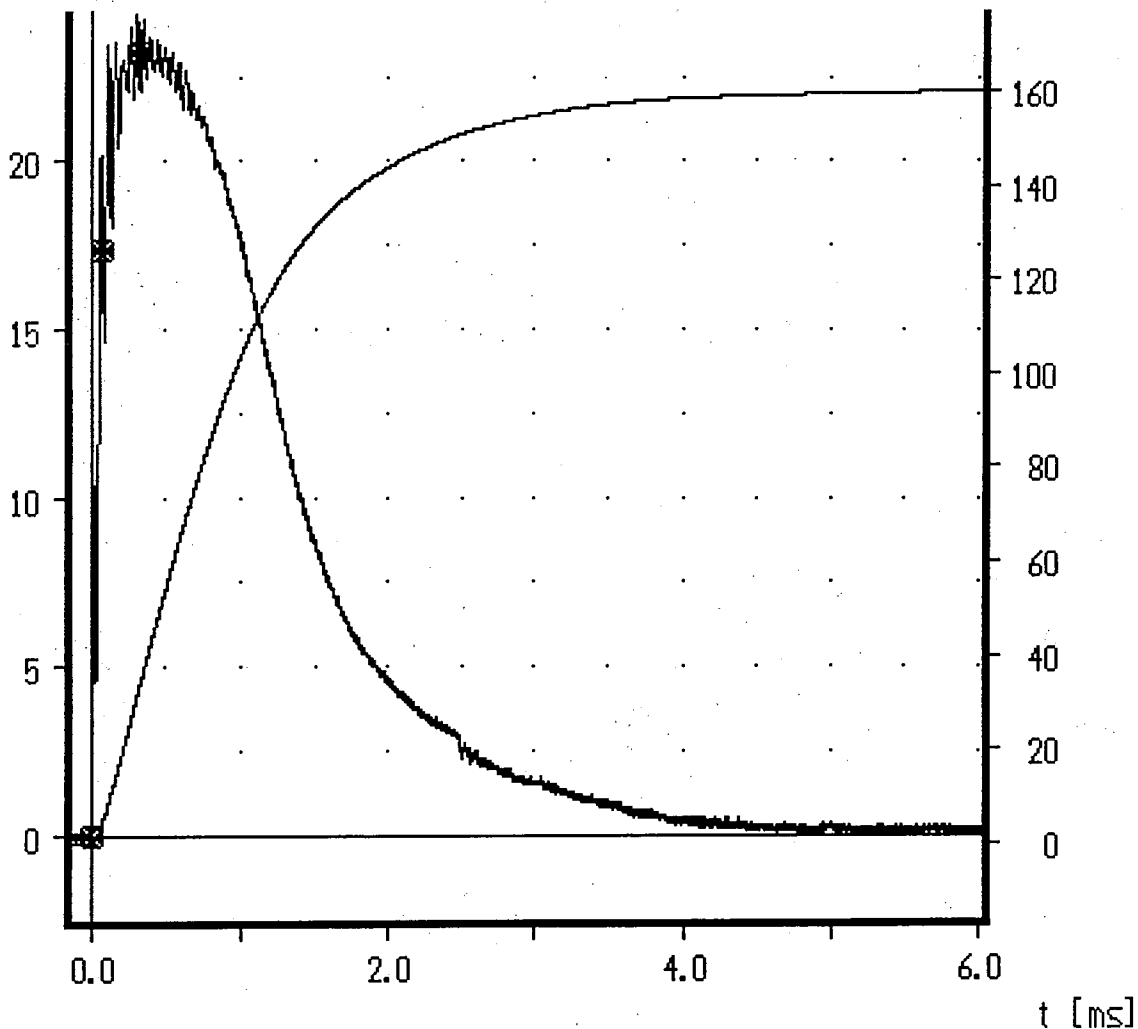
Budget : B032050  
Nr. : 25  
Specimen: 3-160-C5

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN  
Fg load : 1000.00 kHz  
E dial : 162.20 J  
E corr. : 160.70 J  
E incr. : 161.70 J  
E comp. : 161.29 J  
SFA : 100.00 %  
Lat. exp. : 1.935 mm

Time	Load	Energy	Displacement
t_gy= 0.067 ms	F_gy= 17.34 kN	W_gy= 3.69 J	s_gy= 0.369 mm
t_m = 0.325 ms	F_m = 23.20 kN	W_m = 33.40 J	s_m = 1.750 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F,displ.

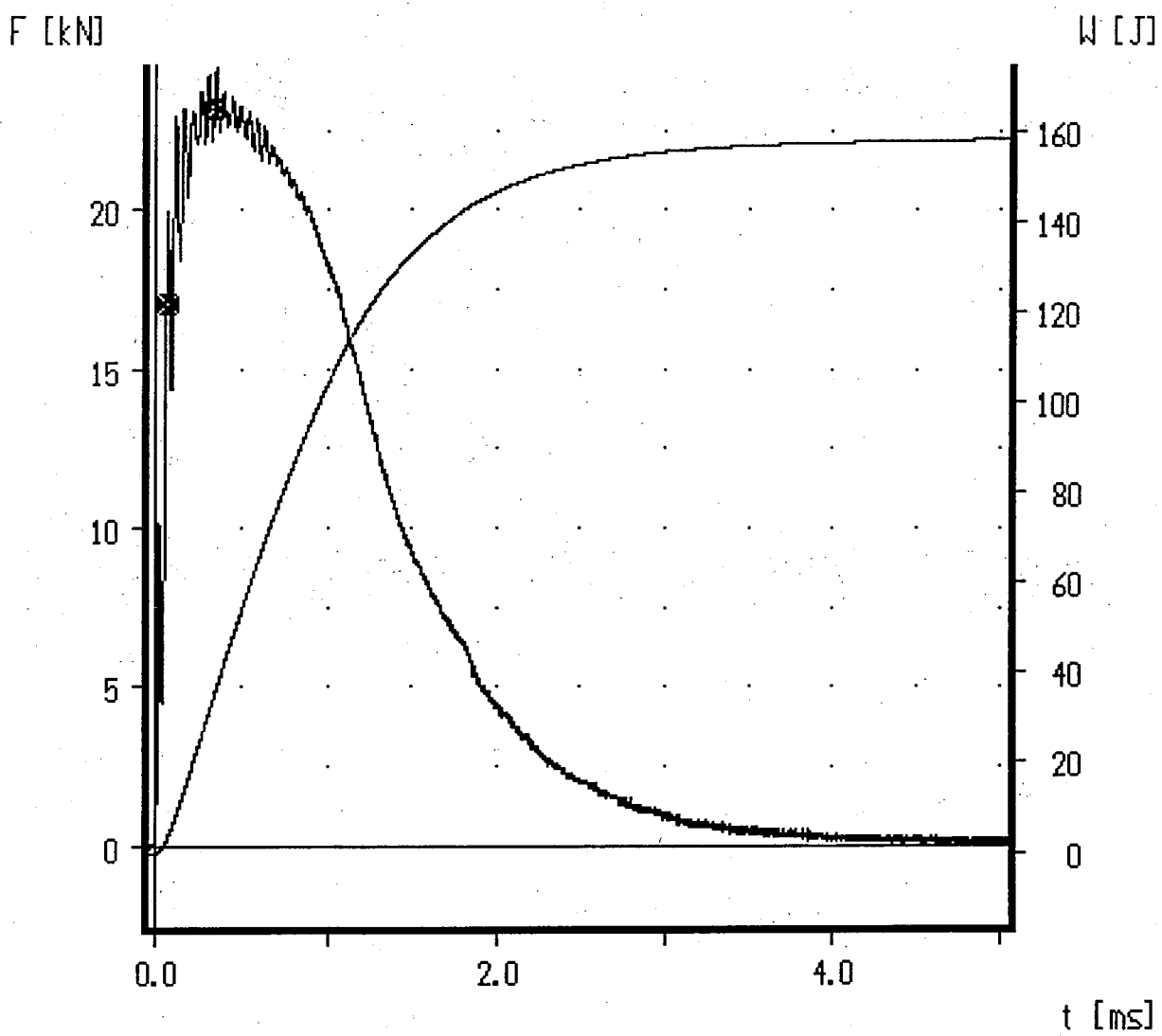
Operator: R. VOSCH  
Material: BATCH 009 C

Budget : B032050  
Nr. : 27  
Specimen: 3-160-C6

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 160.20 J  
E corr. : 158.47 J  
E incr. : 159.48 J  
E comp. : 158.80 J  
SFA : 100.00 %  
Lat. exp. : 1.765 mm

Time	Load	Energy	Displacement
t_gy= 0.071 ms	F_gy= 17.06 kN	W_gy= 3.86 J	s_gy= 0.391 mm
t_m = 0.339 ms	F_m = 23.12 kN	W_m = 34.69 J	s_m = 1.824 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm



Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F,displ.

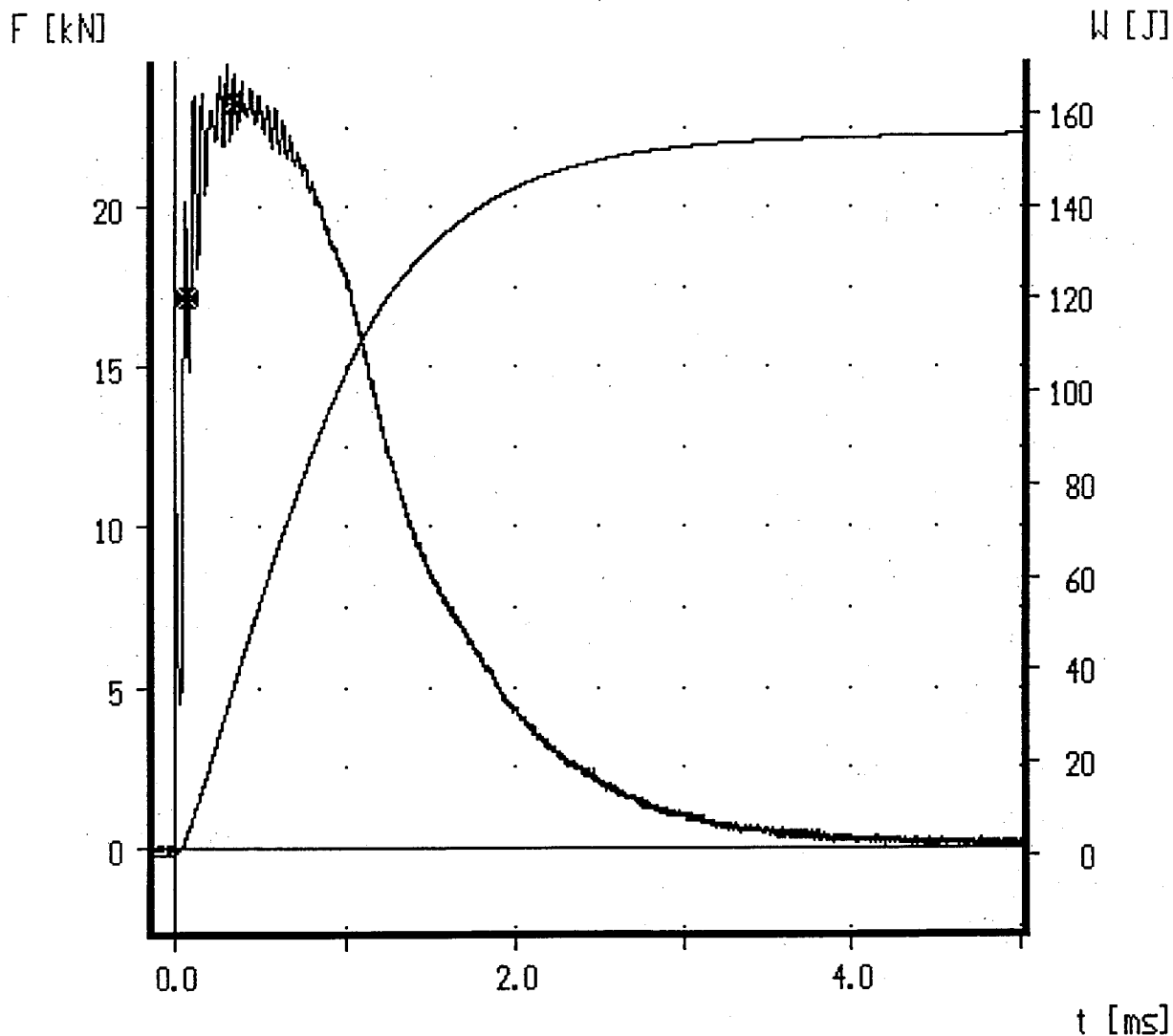
Operator: R. VOSCH  
Material: BATCH 009 C

Budget : B032050  
Nr. : 28  
Specimen: 3-160-C7

Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 158.20 J  
E corr. : 156.15 J  
E incr. : 157.16 J  
E comp. : 155.79 J  
SFA : 100.00 %  
Lat. exp. : 1.988 mm

Time	Load	Energy	Displacement
t_gy= 0.068 ms	F_gy= 17.20 kN	W_gy= 3.85 J	s_gy= 0.375 mm
t_m = 0.336 ms	F_m = 23.23 kN	W_m = 34.76 J	s_m = 1.807 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm





Date : 26.09.1996

Operator: R. VOSCH

Budget : B032050

Typ : DIN-2970

Material: BATCH 009 C

Nr. : 29

Hammer: Charpy 300J F, displ.

Specimen: 3-160-C8

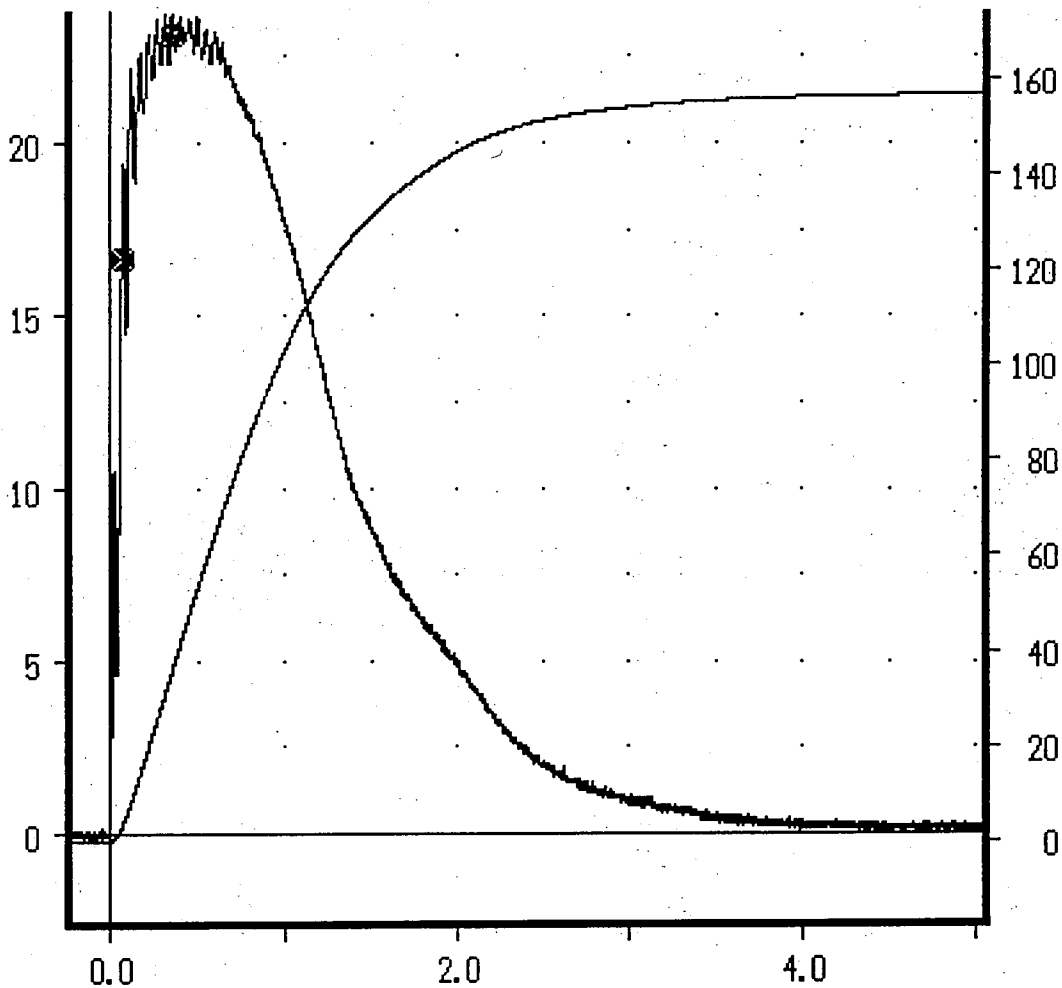
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 158.80 J  
E corr. : 157.41 J  
E incr. : 158.42 J  
E comp. : 158.11 J  
SFA : 100.00 %  
Lat. exp. : 1.976 mm

Time	Load	Energy	Displacement
t <sub>gy</sub> = 0.073 ms	F <sub>gy</sub> = 16.62 kN	W <sub>gy</sub> = 3.92 J	s <sub>gy</sub> = 0.402 mm
t <sub>m</sub> = 0.352 ms	F <sub>m</sub> = 23.16 kN	W <sub>m</sub> = 36.01 J	s <sub>m</sub> = 1.892 mm
t <sub>u</sub> = -- ms	F <sub>u</sub> = -- kN	W <sub>u</sub> = -- J	s <sub>u</sub> = -- mm
t <sub>a</sub> = -- ms	F <sub>a</sub> = -- kN	W <sub>a</sub> = -- J	s <sub>a</sub> = -- mm

F [kN]

W [J]



t [ms]

Date : 26.09.1996  
Tup : DIN-2970  
Hammer: Charpy 300J F, displ.

Operator: R. VOSCH  
Material: BATCH 009 C

Budget : B032050  
Nr. : 26  
Specimen: 3-160-C9

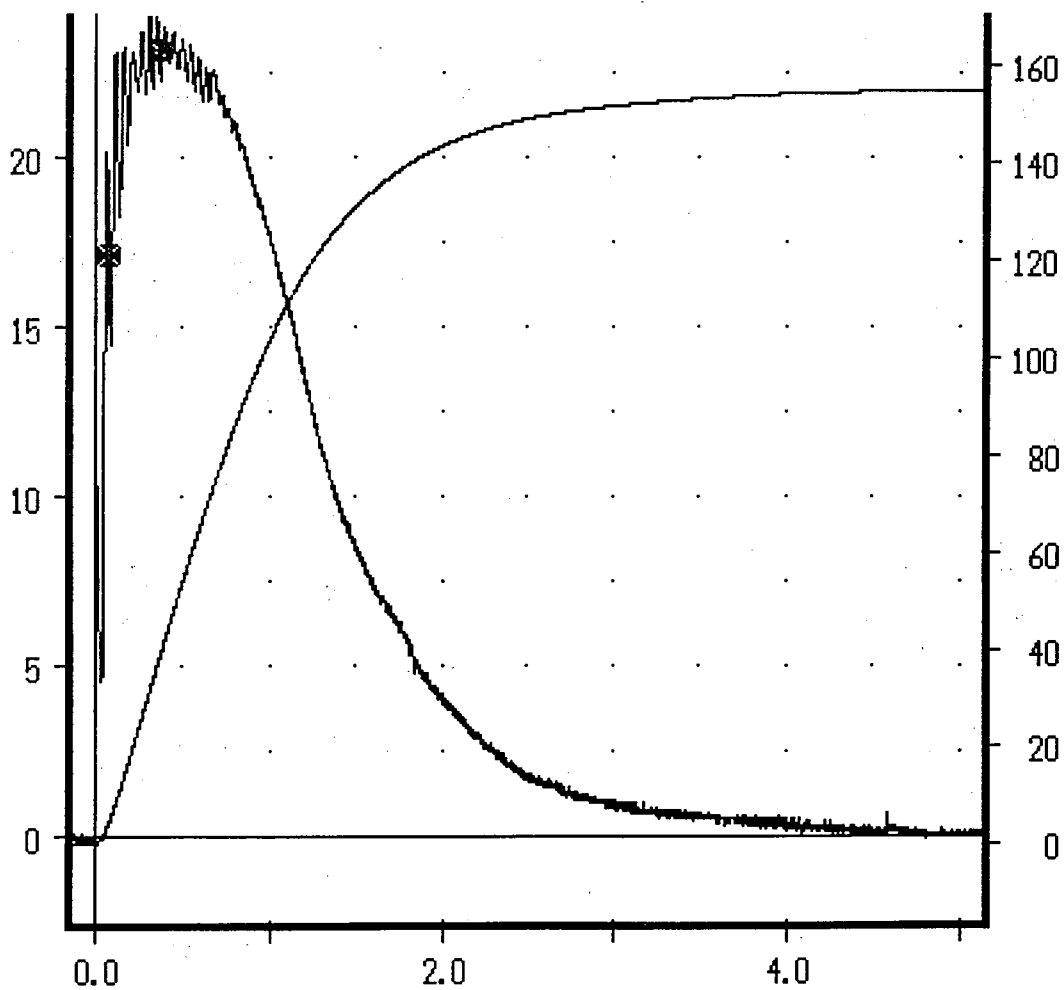
Temperature : 23.00 deg.C  
Velocity Vo : 5.52 m/s  
Avail. energy : 300.02 J  
Fall. height h : 1554.56 mm  
Fall. angle  $\alpha$  : 160.60 deg.  
Time : 8.00 ms  
Comment : SPECIMEN BROKEN

Fg load : 1000.00 kHz  
E dial : 157.50 J  
E corr. : 155.27 J  
E incr. : 156.29 J  
E comp. : 155.44 J  
SFA : 100.00 %  
Lat. exp. : 1.870 mm

Time	Load	Energy	Displacement
t_gy= 0.070 ms	F_gy= 17.16 kN	W_gy= 3.81 J	s_gy= 0.386 mm
t_m = 0.357 ms	F_m = 23.18 kN	W_m = 36.98 J	s_m = 1.917 mm
t_u = -- ms	F_u = -- kN	W_u = -- J	s_u = -- mm
t_a = -- ms	F_a = -- kN	W_a = -- J	s_a = -- mm

F [kN]

W [J]



t [ms]

```

=====
Date   : 26.09.1996      Operator: R. VOSCH      Budget  : B032050
Tup    : DIN-2970       Material: BATCH 009 C  Nr.     : 30
Hammer: Charpy 300J F,displ. Specimen: 3-160-C10
=====

```

```

-----
Temperature : 23.00 deg.C      Fg load   : 1000.00 kHz
Velocity Vo  : 5.52 m/s        E dial    : 157.00 J
Avail. energy : 300.02 J      E corr.   : 155.18 J
Fall. height h : 1554.56 mm    E incr.   : 156.19 J
Fall. angle  $\alpha$  : 160.60 deg.  E comp.   : 156.42 J
Time         : 8.00 ms        SFA       : 100.00 %
Comment      : SPECIMEN BROKEN Lat. exp.    : 1.897 mm
-----

```

```

-----
Time          Load          Energy          Displacement
t_gy= 0.071 ms  F_gy= 16.43 kN  W_gy= 3.64 J   s_gy= 0.391 mm
t_m = 0.342 ms  F_m = 23.20 kN  W_m = 34.89 J  s_m = 1.840 mm
t_u = -- ms     F_u = -- kN    W_u = -- J     s_u = -- mm
t_a = -- ms     F_a = -- kN    W_a = -- J     s_a = -- mm
-----

```

