SCK•CEN

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

INSTRUMENTED IMPACT RESULTS ON BCR SPECIMENS: AN INTERIM REPORT

Eric van Walle, Jean-Louis Puzzolante and Ronny Vosch
SCK•CEN, Mol, Belgium

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SCK•CEN, Boeretang 200, B-2400 Mol, Belgium

BCR contract number: MAT1-CT94OO53

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1. Aim

The aim of this work is to test, validate and certify BCR specimens with instrumented and conventional Charpy impact pendulums.
In a first phase, proof of testing machine certification and software validation should be shown. Consequently two sets (each set contains 5 specimens) of BCR specimens, the so-called 60J and 80J level specimens, are tested with instrumented equipment. As these two sets are known to have a low scatter on the energy value, they allow to demonstrate the possible differences — due to systematic errors — between different test laboratories. They also are expected to allow to look in a consistent way at the information from the instrumentation of the pendulum strikers used.
In a next phase BCR-sets of other energy levels will be tested.

2. Testing machine

The instrumented impact pendulum that will be used for this exercise is a Wolpert 300J instrumented impact pendulum that was constructed in 1993 and that is erected in the LHMA hot-cell laboratory of SCK•CEN. The impact striker has the ISO geometry. As is demonstrated on the test certificate given in

Annex 1, the machine complies with the EN 10045 standard and is also certified to allow testing according to ASTM E23. The machine had an in-situ static calibration as is shown on the certificate in Annex 1; the calibration procedure was repeated before the testing and no deviation with the former calibration was detected.

3. Software qualification

Dr. Ravi Varma of NPL provided instrumented test information in ASCII format. The test was identified as EP-370. After reshuffling the data, two analysis methodologies were applied: the regular Wolpert software analysis programme and the in-house developed routine. The output results are given in Annex 2. As can be seen both respective methods give good correspondence between the integrated energies (resp. 55.4J and 55.6J); the nominal value of the set of specimens to which EP-370 belonged being 56.3J. From the instrumented load-time spectrum it is not straightforward to determine the F_{gy} point. The Wolpert computer program puts it almost correct and gives quasi identical results as the manual method used by an experienced technician.

4. Testing of 60J and 80J BCR-sets

Two sets of specimens with unknown nominal energy value were provided for testing. The instrumented and conventional test results on both sets of specimens are given in Table 1 of Annex 3. The instrumented test spectra and their respective data are respectively given in Figures 1 to 10 and Tables 2 to 11 of this Annex.

5. Interpretation

Table 1 of Annex 3 gives E_{corr}, i.e. the dial energy E_{dial} corrected for friction. The mean E_{corr} value of the 5 tests in each set is given and must be compared with the nominal value given by BCR (this info was only given after the tests were performed). The correspondence is very good for both the 60J and 80J specimen sets.
Although the mean value of the integrated energy value W_o is still within the standard deviation of the nominal BCR-value, it is interesting to note that W_o is systematically ~3% lower than the corrected dial energy, and this for all specimens (see Tables 2 to 11). Figure 11 of Annex 3 shows an instrumented test on a typical reactor pressure vessel steel (RPVS): here the deviation between corrected and integrated energy, in the range of 70J, is always smaller than 1%. The difference between the two types of instrumented curves, i.e. the BCR-type and the 'RPVS'-type are the force values and the length of the test. Indeed, for the BCR-type samples the maximum forces are of the order of 28 kN, while in an RPVS-type they are 18 kN. A typical BCR-test takes 1.5 milliseconds (small

deflection), while a RPVS-test typical lasts 4 milliseconds. Although the static tup calibration is valid in the range between 0 and 40 kN, we believe that we detect a dynamic effect on the static calibration. This would make the BCR specimens less attractive for precise calibration of instrumentation. It would be interesting to compare these ISO-tup tests with ASTM-tests on the same energy level BCR-specimens. In principle we expect the same behaviour (as the deflection is small before rupture).
Another point to touch is the yield force. As can be seen from Figures 1 to 10 it is not easy to define the yield force on the BCR kind of spectra; this in contrast to RPVS, where less doubt exists.

6. Conclusion

- the software used for the analysis of the BCR tests was validated on a spectrum provided in ASCII format by the project leader;
- the corrected dial energy for the 60J and 80J BCR specimens corresponds very well with the nominal energy value given by BCR;
- although the integrated energy values are within the standard deviation of the nominal BCR-value, a systematic deviation between the integrated and experimental energy value has been observed for all tests. This effect is assigned to a dynamic effect on the calibration of the tup;
- the yield force is not easy to define on the BCR-spectra.

Annex 1: Test machine certificate

Annex 1

AMSLER OTTO WOLPERT-WERKE GMBH
Industriestraße 19, Postfach 211480
D-6700 Ludwigshafen
Telefon (0621) 6907-0, Telefax (0621) 6907-160
Telex 464705 testa d oder 464428 testa d

PRÜFZEUGNIS
TEST CERTIFICATE
CERTIFICAT D'ESSAI

Empfänger / Consignee / Destinataire: Studiencentrum voor Kernenergie

Maschinen-Typ / Machine type / Type de la machine: WOLPERT Pendelschlagwerk PW 30/15

Baujahr / Year of construction / Année de construction: 1993

Maschinen-Nr. / Serial No. / No. de la machine: 93 03018/0001

Die Maschine wurde vor der Auslieferung durch unsere Werks-Abnahme geprüft.
Prior to delivery, the machine was tested by our works inspection department.
La machine a été contrôlée en usine par notre bureau d'inspection.

Die Prüfung erfolgte mit
The tests were performed by means of
Le contrôle a été effectué par/avec

☐ direkter Gewichtsbelastung
direct weight loading
mise en charge directe

☒ Kraftmeßeinrichtung (MPA geprüft)
calibrating load equipment (officially tested by MPA)
des anneaux dynamométriques (étalonnés par la MPA)

☐ Kontrollplatten (MPA geprüft)
control plates (officially tested by MPA)
des plaques de contrôle (étalonnés par la MPA)

Die Maschine entspricht / The machine corresponds to / La machine répond à: EN 10 045 (ASTM E 23)

Die Genauigkeit liegt innerhalb der von der Norm vorgeschriebenen Grenzen.
The accuracy lies within the limits prescribed by the standard.
La précision de la machine est dans les limites prescrites par la norme.

Der Lieferumfang entspricht der Auftragsbestätigung.
The scope of delivery corresponds to the confirmation of order.
L'étendue de la livraison correspond à celle de la confirmation de la commande.

D-6700 Ludwigshafen

2.12.1993
Datum/Date

Werks-Abnahme / Inspection Department / Bureau d'inspection

Annex 2: Software validation

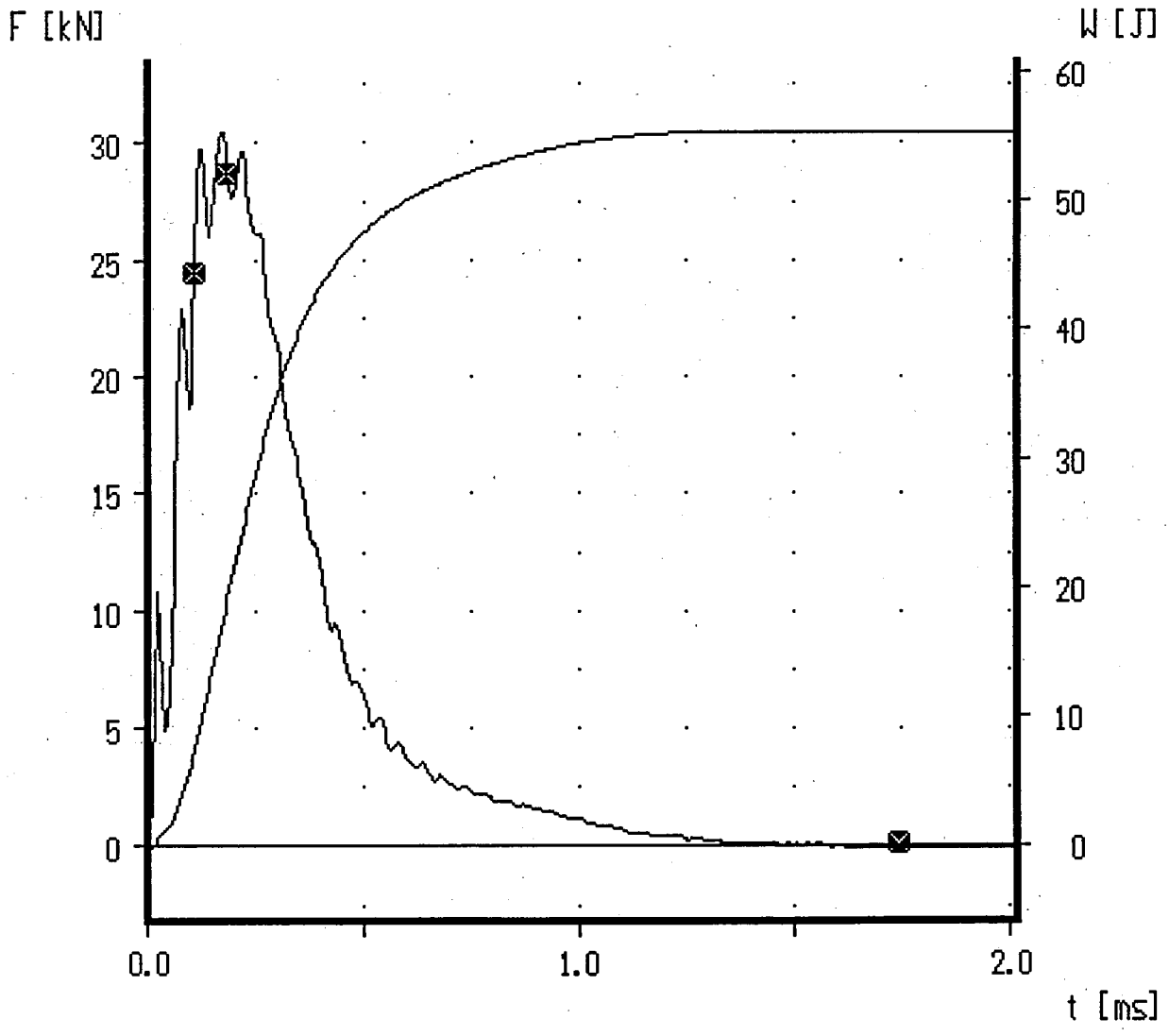
SCK*CEN LHMA CHARPY IMPACT TEST REPORT WOLPERT PW 300

==========

Date : 22.04.1996 Operator: R. VOSCH Budget : B032050
Tup : ASTM-vosch22NEW Material: BCR Nr. : 13
Hammer: Charpy 300J Force,di Specimen: EP-370

Temperature	: 21.00	deg.C	Fg load	: 1000.00	kHz
Velocity Vo	: 5.52	m/s	E dial	: 0.00	J
Avail. energy	: 300.00	J	E corr.	: 0.00	J
Fall. height h	: 1554.45	mm	E incr.	: --	J
Fall. angle α	: 160.57	deg.	E comp.	: 55.38	J
Time	: 8.00	ms	SFA	: 100.00	%
Comment	: Fa and Fu not valid		Lat. exp.	: 0.000	mm

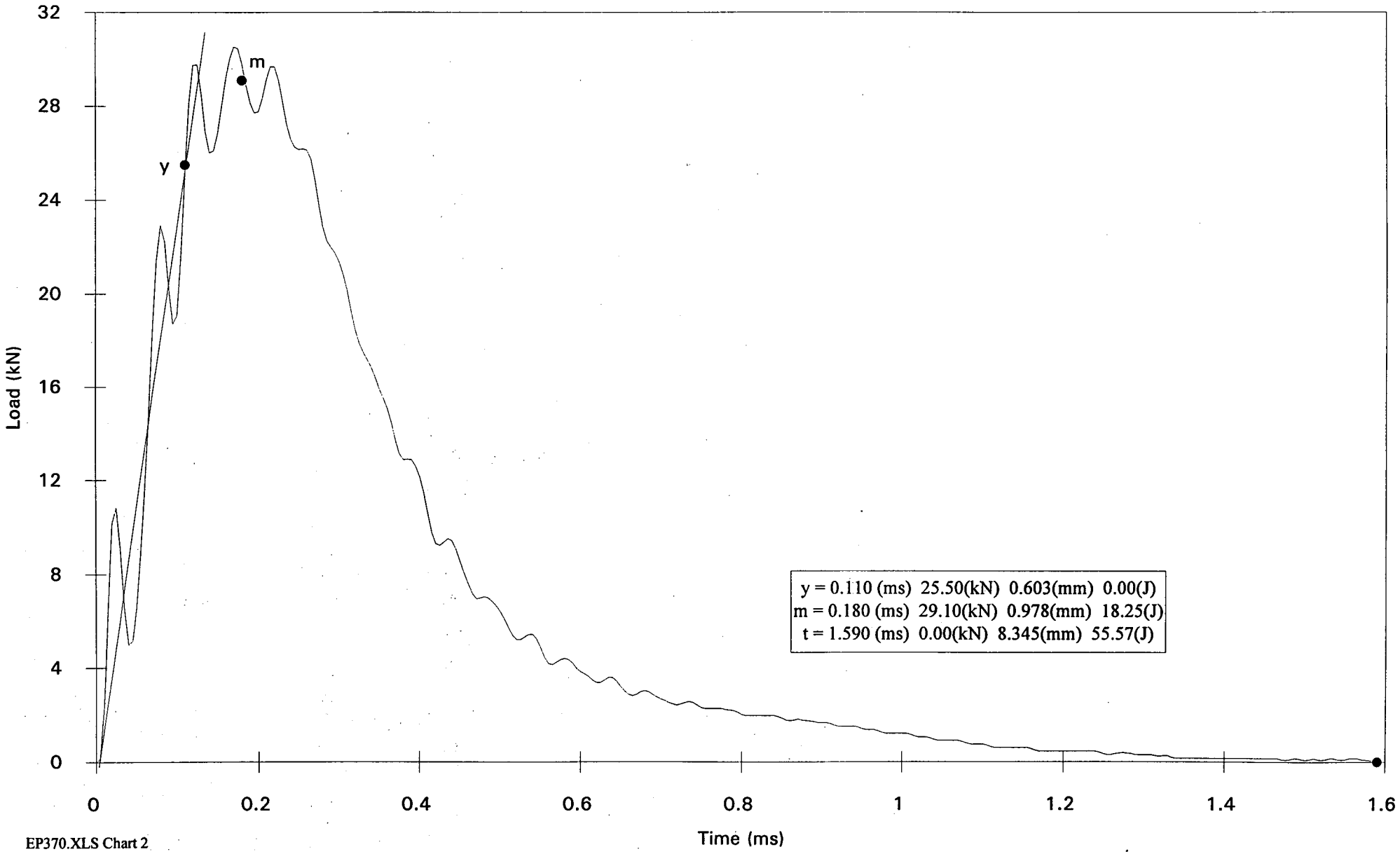
Time		Load		Energy		Displacement	
t_gy=	0.107 ms	F_gy=	24.41 kN	W_gy=	6.89 J	s_gy=	0.522 mm
t_m =	0.180 ms	F_m =	28.70 kN	W_m =	18.26 J	s_m =	0.928 mm
t_u =	1.744 ms	F_u =	0.16 kN	W_u =	55.38 J	s_u =	8.809 mm
t_a =	1.744 ms	F_a =	0.19 kN	W_a =	55.38 J	s_a =	8.809 mm



Annex 2: Wolpert procedure

Annex 2: In house analysis

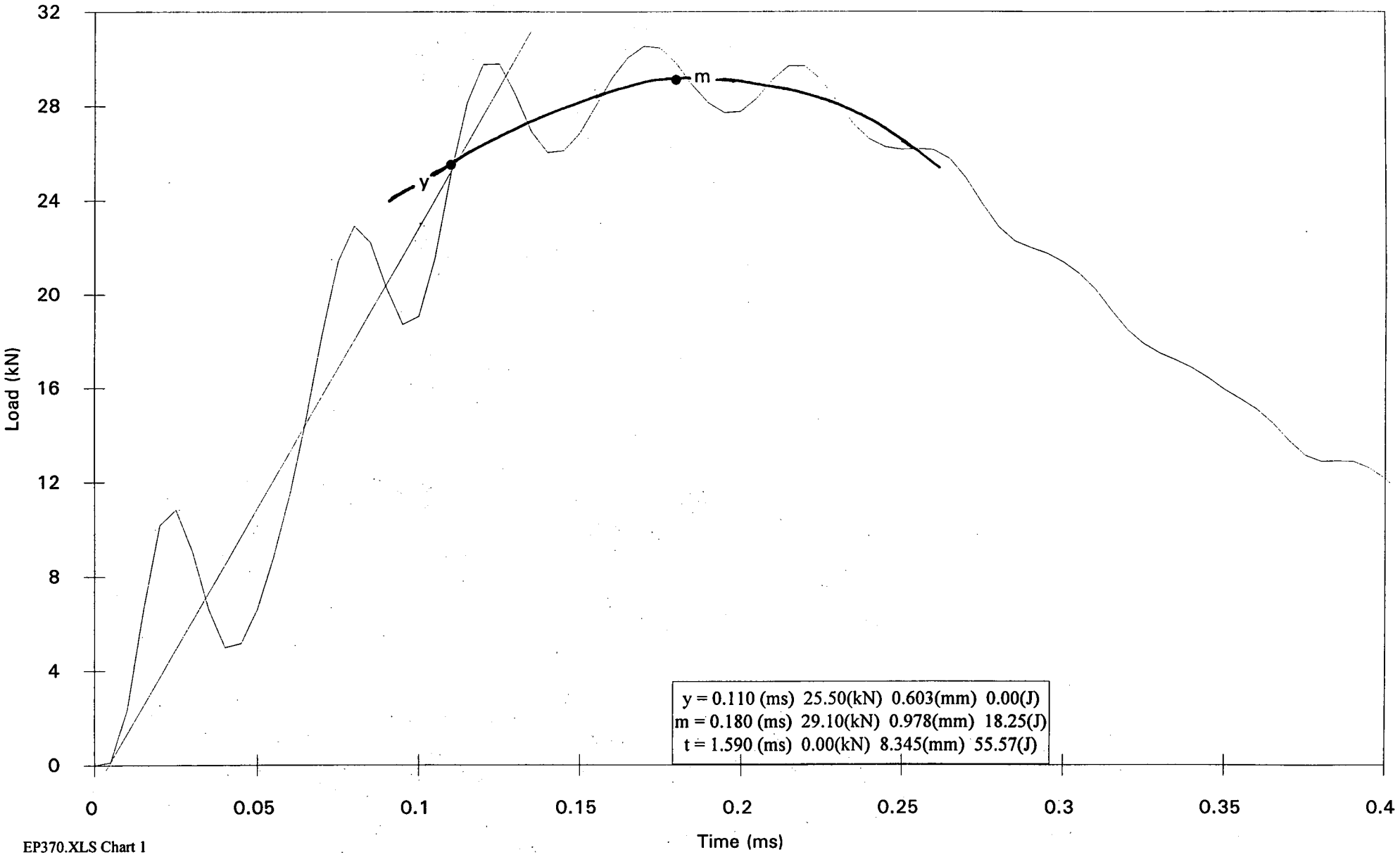
EP-370



EP370.XLS Chart 2

Annex 2: In house analysis (blow up)

EP-370



EP370.XLS Chart 1

Annex 3: BCR-tests

Tab. 1 INSTRUMENTED CHARPY IMPACT TEST RESULTS FOR BCR As-recieved Unirradiated Reference material

Sample Number	T (°C)	E dial (J)	E corr. (J)	SFA (%)	L.E. (mm)	Remarks	Edial-Ecorr (J)		Date of test
E-P-1-2	21	57.00	55.27	100	0.542	Specimen broken	1.73		5/10/95
E-P-20-6L	21	59.00	57.11	100	0.658	Specimen broken	1.89		5/10/95
E-P-67-5	21	56.50	54.64	100	0.675	Specimen broken	1.86		5/10/95
E-P-55-1	21	61.50	59.61	100	0.609	Specimen broken Badly positioned	1.89		5/10/95
E-P-85-8L	21	58.00	55.91	100	0.655	Specimen broken	2.09		5/10/95
Mean Value SCK.CEN =			**56.5**			Nominal Value = 56.3 -/+ 1.8			
1	21	82.20	80.37	100	1.041	Specimen broken	1.83		11/10/95
2	21	80.00	77.99	100	1.094	Specimen broken	2.01		11/10/95
3	21	81.80	79.57	100	0.888	Specimen broken	2.23		11/10/95
4	21	82.20	80.37	100	0.925	Specimen broken	1.83		11/10/95
5	21	85.00	82.76	100	1.061	Specimen broken	2.24		11/10/95
Mean Value SCK.CEN =			**80.2**			Nominal Value = 80.2 -/+ 2.3			

Tab. 1 INSTRUMENTED CHARPY IMPACT TEST RESULTS FOR
Continued BCR As-recieved Unirradiated Reference material

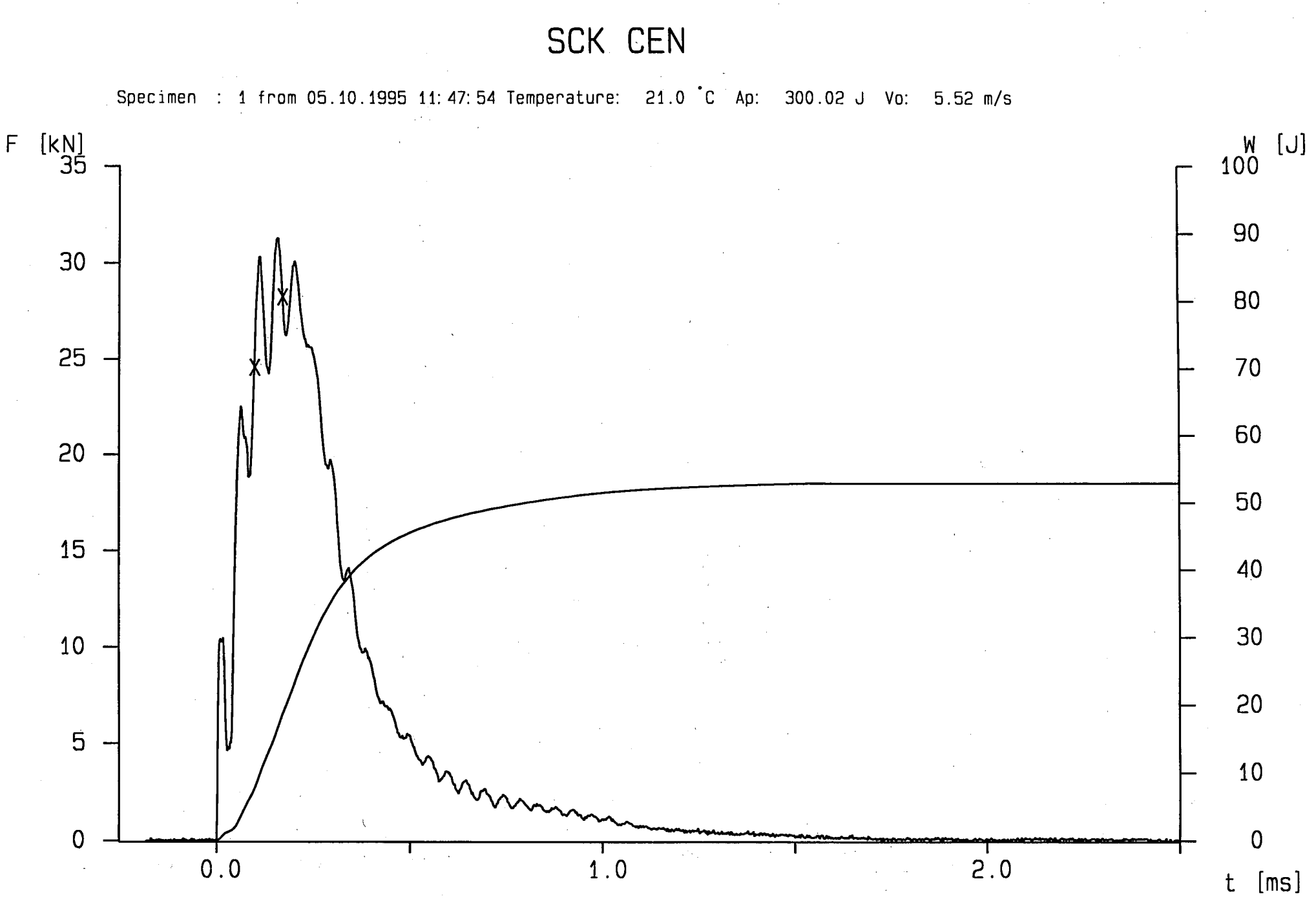
Sample	T (°C)	Fy (kN)	Sy (mm)	Wy (J)	Fm (kN)	Sm (mm)	Wm (J)	Fu (kN)	Su (mm)	Wu (J)	Fa (kN)	Sa (mm)	Wa (J)	So (mm)	Wo (J)	SFA %
E-P-1-2	21	24.57	0.55	7.80	28.25	0.94	18.75							8.60	52.92	100
E-P-20-6L	21	24.80	0.55	7.70	29.45	0.94	18.86							9.75	55.72	100
E-P-67-5	21	23.99	0.57	7.43	27.73	0.98	18.73							8.65	53.26	100
E-P-55-1	21	22.99	---	7.38	28.11	---	17.92							---	57.41	100
E-P-85-8L	21	24.49	0.56	7.80	27.72	0.93	18.01							7.33	54.34	100
Mean Value Fy =		**24.2**	+S.D =	**0.72**												
Mean Value Fm =		**28.3**	+S.D =	**0.71**												
Mean Value Wo =		**54.7**	+S.D =	**1.85**												
1	21	24.48	0.54	7.49	27.64	0.97	19.28							10.06	78.84	100
2	21	24.42	0.54	7.39	27.32	0.98	19.39							9.99	77.00	100
3	21	24.34	0.56	7.50	27.50	1.04	20.26							8.78	76.99	100
4	21	24.82	0.56	7.78	27.40	1.00	19.74							8.56	78.45	100
5	21	24.12	0.55	7.68	27.40	0.98	19.36							10.52	80.90	100
Mean Value Fy =		**24.4**	+S.D =	**0.25**												
Mean Value Fm =		**27.5**	+S.D =	**0.12**												
Mean Value Wo =		**78.4**	+S.D =	**1.61**												

Date : 05.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-60-B Nr. : 1
Hammer: Charpy 300J Force,fr Specimen: EP-1-2

Temperature	21.00	deg.C	Fg load	1000.00	kHz
Velocity Vo	5.52	m/s	E dial	57.00	J
Avail. energy	300.02	J	E corr.	55.27	J
Fall. height h	1554.57	mm	E incr.	56.53	J
Fall. angle α	160.60	deg.	E comp.	52.92	J
Time	16.00	ms	SFA	100.00	%
Comment	SPECIMEN BROKEN		Lat. exp.	0.542	mm

Time		Load		Energy		Displacement	
t_gy=	0.100 ms	F_gy=	24.57 kN	W_gy=	7.80 J	s_gy=	0.550 mm
t_m =	0.172 ms	F_m =	28.25 kN	W_m =	18.75 J	s_m =	0.938 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

Annex 3: Table 2



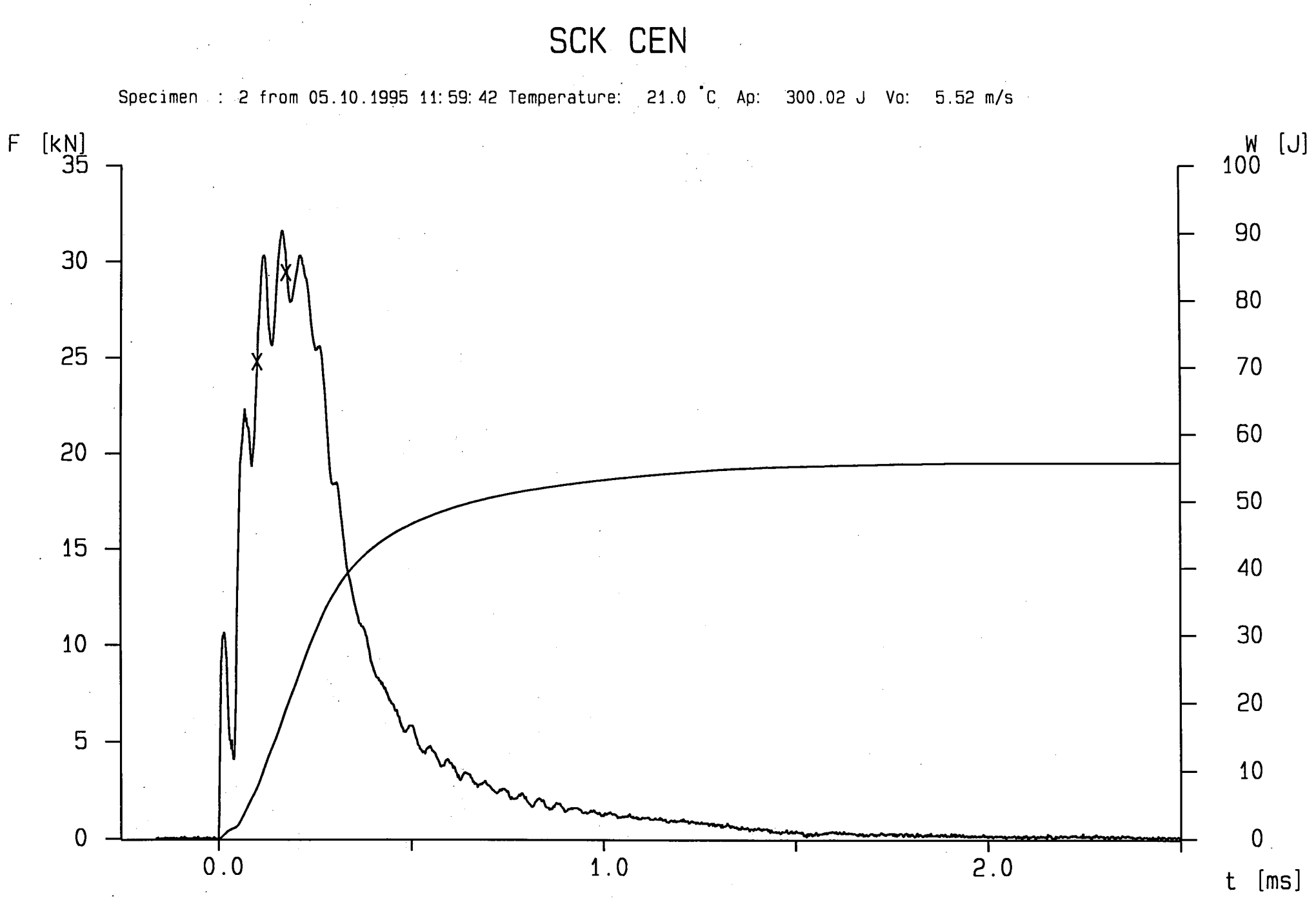
Annex 3: Figure 1 BCR MAT. - N° E-P-1-2 - DIN TUP

Date : 05.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-60-B Nr. : 2
Hammer: Charpy 300J Force,fr Specimen: EP-20-6L

Temperature	21.00	deg.C	Fg load	1000.00	kHz
Velocity Vo	5.52	m/s	E dial	59.00	J
Avail. energy	300.02	J	E corr.	57.11	J
Fall. height h	1554.56	mm	E incr.	58.36	J
Fall. angle α	160.60	deg.	E comp.	55.72	J
Time	16.00	ms	SFA	100.00	%
Comment	SPECIMEN BROKEN		Lat. exp.	0.658	mm

Time	Load	Energy	Displacement
t_gy= 0.101 ms	F_gy= 24.80 kN	W_gy= 7.70 J	s_gy= 0.550 mm
t_m = 0.175 ms	F_m = 29.45 kN	W_m = 18.86 J	s_m = 0.939 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

Annex 3: Table 3



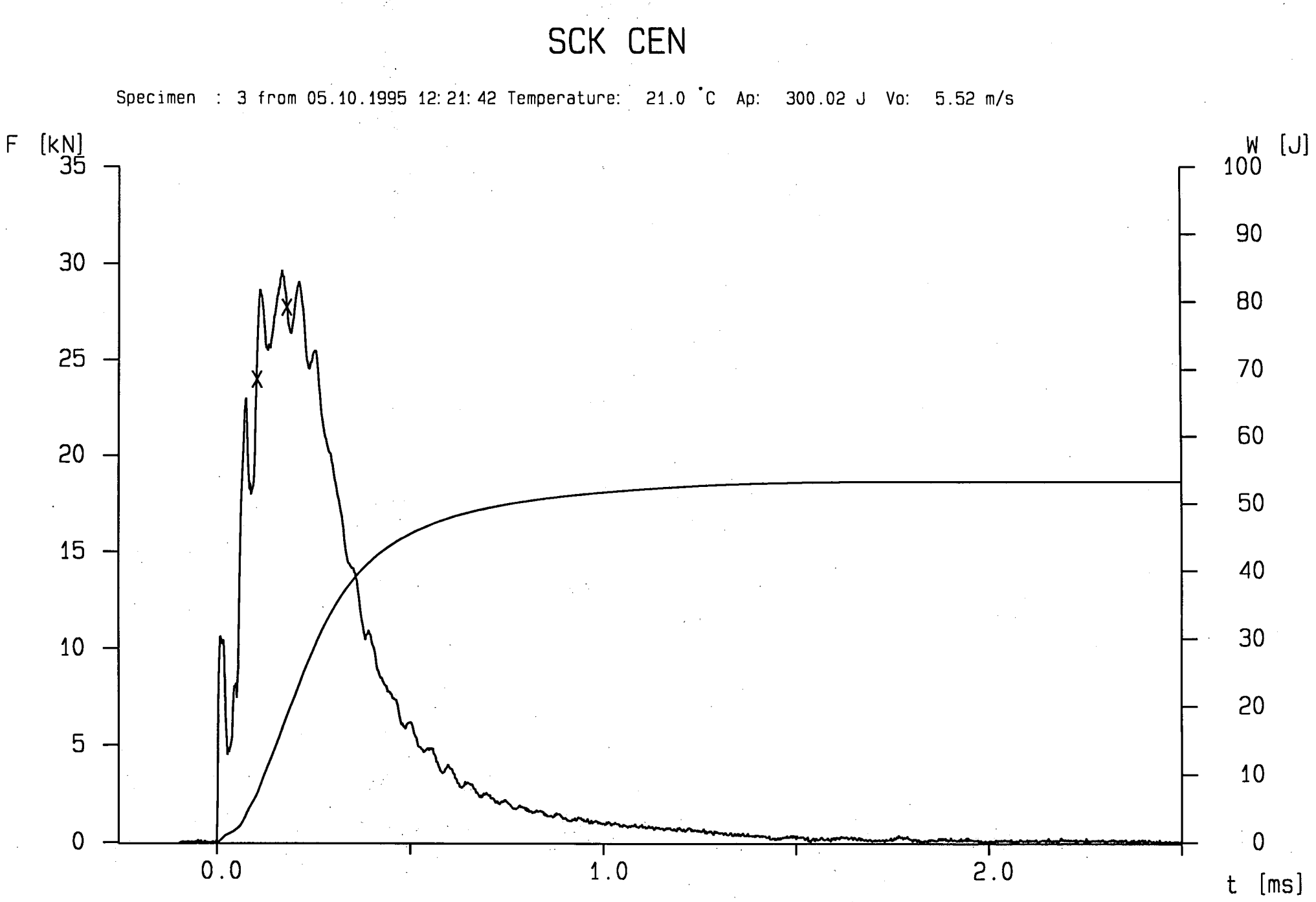
Annex 3: Figure 2 BCR MAT. - N°E-P-20-6L - DIN TUP

Date : 05.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-60-B Nr. : 3
Hammer: Charpy 300J Force,fr Specimen: EP-67-5

Temperature	: 21.00	deg.C	Fg load	: 1000.00	kHz
Velocity Vo	: 5.52	m/s	E dial	: 56.50	J
Avail. energy	: 300.02	J	E corr.	: 54.64	J
Fall. height h	: 1554.56	mm	E incr.	: 55.90	J
Fall. angle α	: 160.60	deg.	E comp.	: 53.26	J
Time	: 16.00	ms	SFA	: 100.00	%
Comment	: SPECIMEN BROKEN		Lat. exp.	: 0.675	mm

Time	Load	Energy	Displacement
t_gy= 0.106 ms	F_gy= 23.99 kN	W_gy= 7.43 J	s_gy= 0.572 mm
t_m = 0.182 ms	F_m = 27.73 kN	W_m = 18.73 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

Annex 3: Table 4



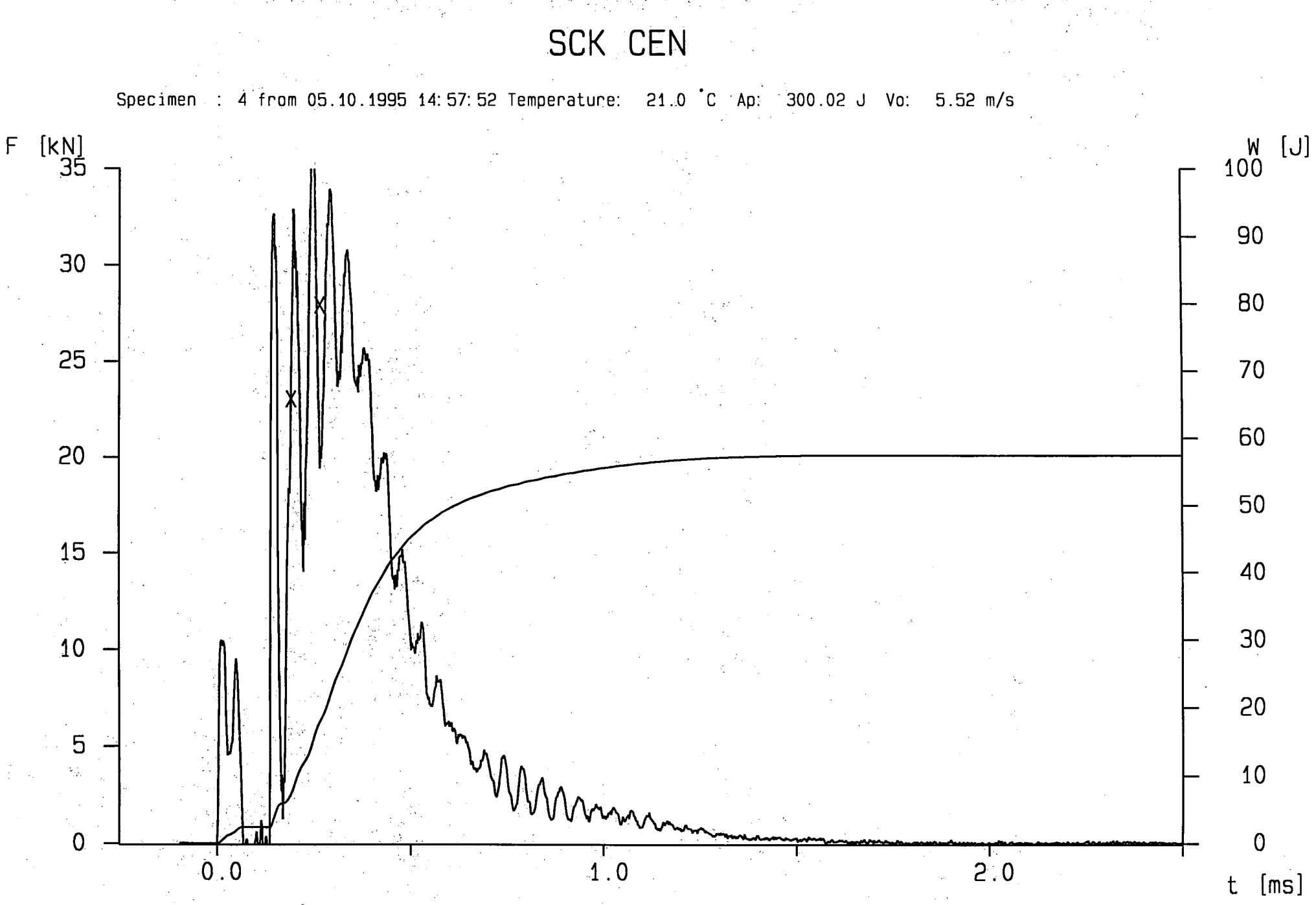
Annex 3: Figure 3 BCR MAT - N° E-P-67-5 - DIN TUP

Date	: 05.10.1995	Operator: R. VOSCH		Budget	: B032050
Tup	: DIN-2970	Material: BCR 1-60-B		Nr.	: 4
Hammer: Charpy 300J Force,fr				Specimen: EP-55-1	

Temperature	: 21.00	deg.C	Fg load	: 1000.00	kHz
Velocity Vo	: 5.52	m/s	E dial	: 61.50	J
Avail. energy	: 300.02	J	E corr.	: 59.61	J
Fall. height h	: 1554.56	mm	E incr.	: 60.86	J
Fall. angle α	: 160.60	deg.	E comp.	: 57.41	J
Time	: 16.00	ms	SFA	: 100.00	%
Comment	: SPECIMEN BROKEN		Lat. exp.	: 0.609	mm

Time	Load	Energy	Displacement
t_gy= 0.192 ms	F_gy= 22.99 kN	W_gy= 7.38 J	s_gy= 1.044 mm
t_m = 0.266 ms	F_m = 28.11 kN	W_m = 17.92 J	s_m = 1.444 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

Annex 3: Table 5



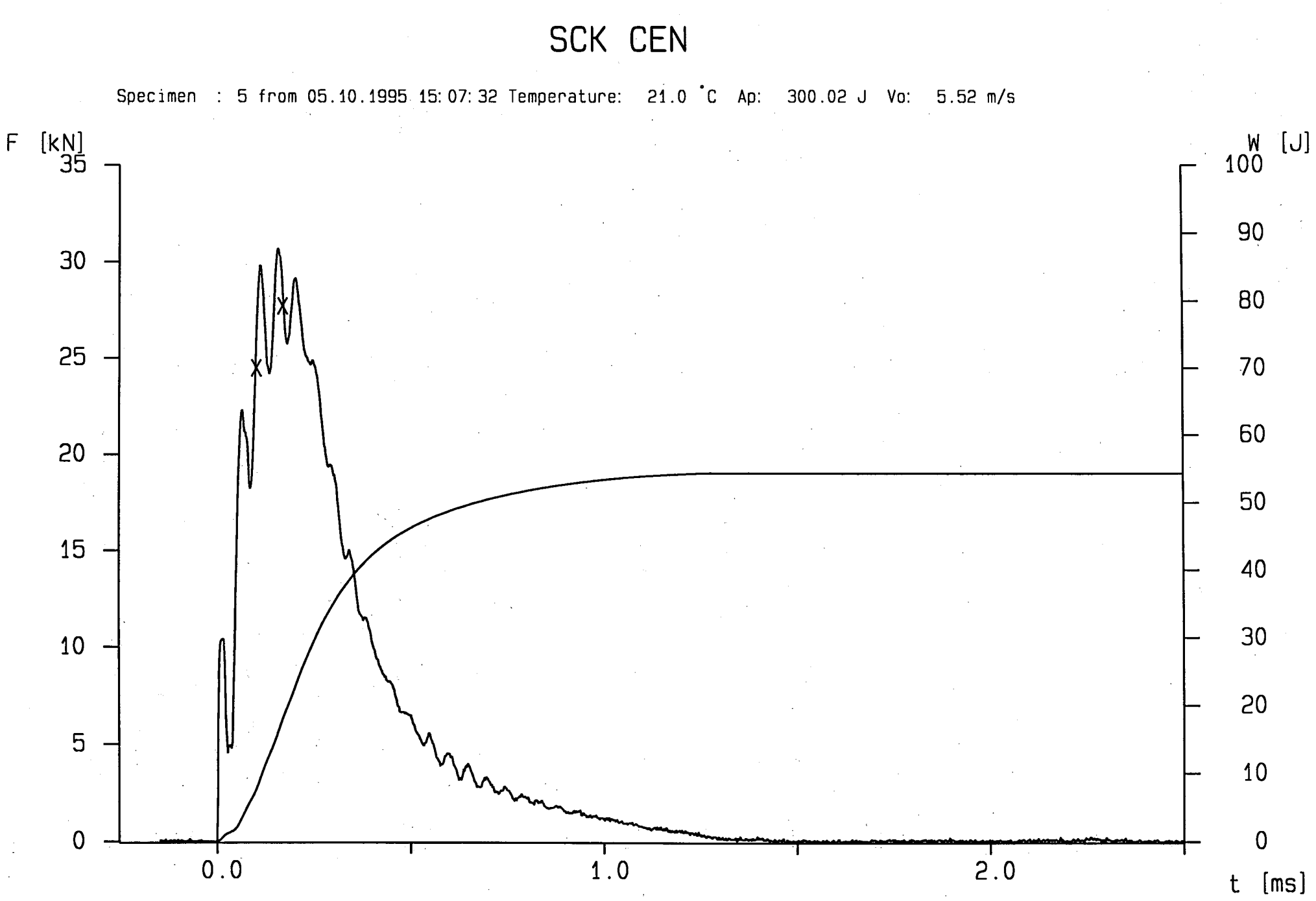
Annex 3: Figure 4 BCR MAT - N° E-P-55-1 - DIN TUP

Date : 05.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-60-B Nr. : 5
Hammer: Charpy 300J Force,fr Specimen: EP-85-8L

Temperature	: 21.00	deg.C	Fg load	: 1000.00	kHz
Velocity Vo	: 5.52	m/s	E dial	: 58.00	J
Avail. energy	: 300.02	J	E corr.	: 55.91	J
Fall. height h	: 1554.56	mm	E incr.	: 57.17	J
Fall. angle α	: 160.60	deg.	E comp.	: 54.34	J
Time	: 16.00	ms	SFA	: 100.00	%
Comment	: SPECIMEN BROKEN		Lat. exp.	: 0.655	mm

Time	Load	Energy	Displacement
t_gy= 0.102 ms	F_gy= 24.49 kN	W_gy= 7.80 J	s_gy= 0.561 mm
t_m = 0.170 ms	F_m = 27.72 kN	W_m = 18.01 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

Annex 3: Table 6



Annex 3: Figure 5 BCR MAT. - N° E-P-85-8L - DIN TUP

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================================================================================

Date   : 11.10.1995          Operator: R. VOSCH          Budget   : B032050
Tup    : DIN-2970            Material: BCR 1-80-G        Nr.      :     6
Hammer: Charpy 300J Force,fr                             Specimen: 01

--------------------------------------------------------------------------------

Temperature     :   21.00  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.      :   80.37   J
Fall. height h  : 1554.56  mm         E incr.      :   81.56   J
Fall. angle  α  :  160.60  deg.       E comp.      :   78.84   J
Time            :   16.00  ms         SFA          :  100.00   %
Comment         : SPECIMEN BROKEN     Lat. exp.    :    1.041  mm

--------------------------------------------------------------------------------

Time                  Load                  Energy              Displacement

t_gy=  0.098 ms       F_gy= 24.48 kN        W_gy=   7.49 J       s_gy=  0.539 mm
t_m =  0.178 ms       F_m = 27.64 kN        W_m =  19.28 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

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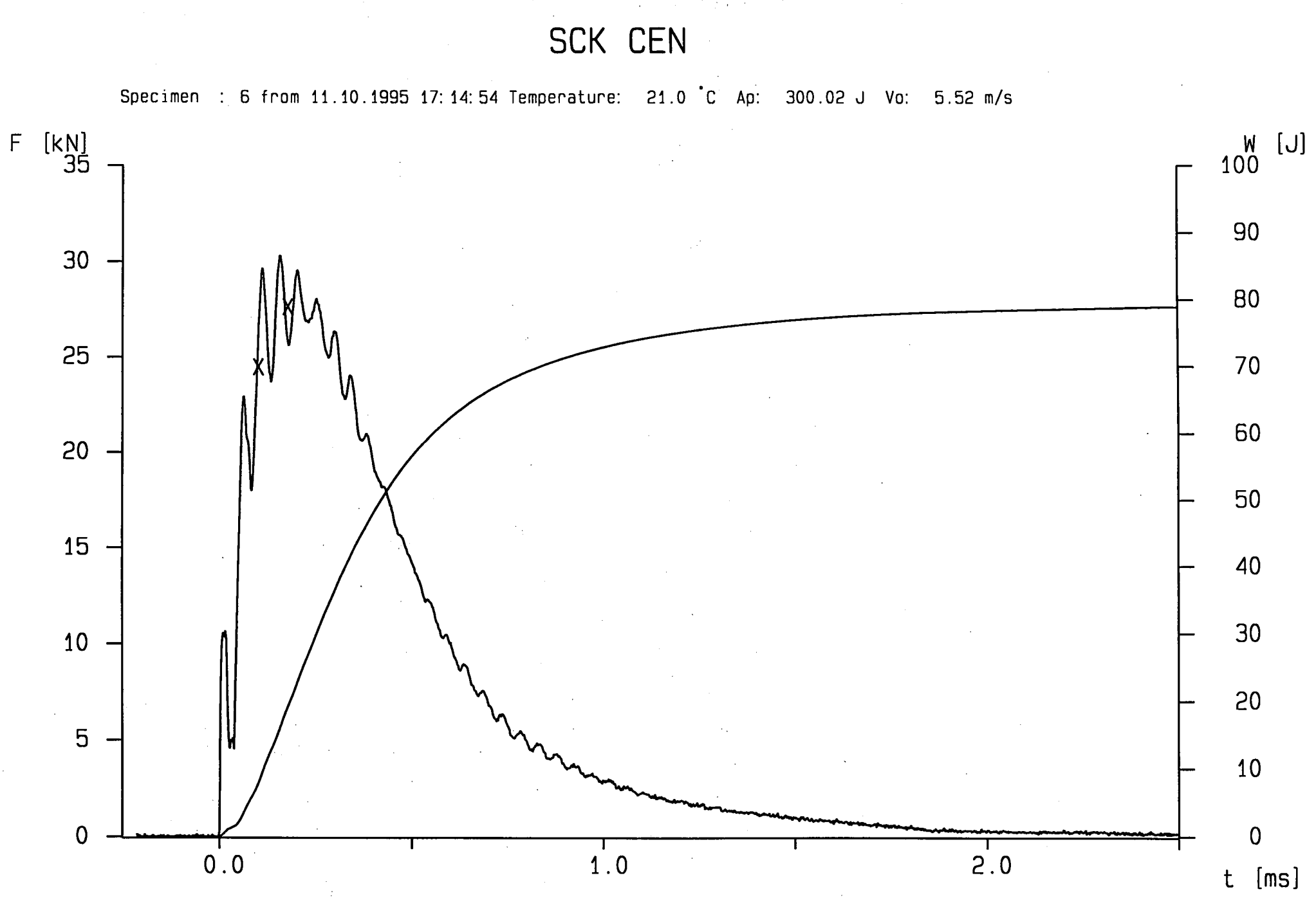
Annex 3: Table 7



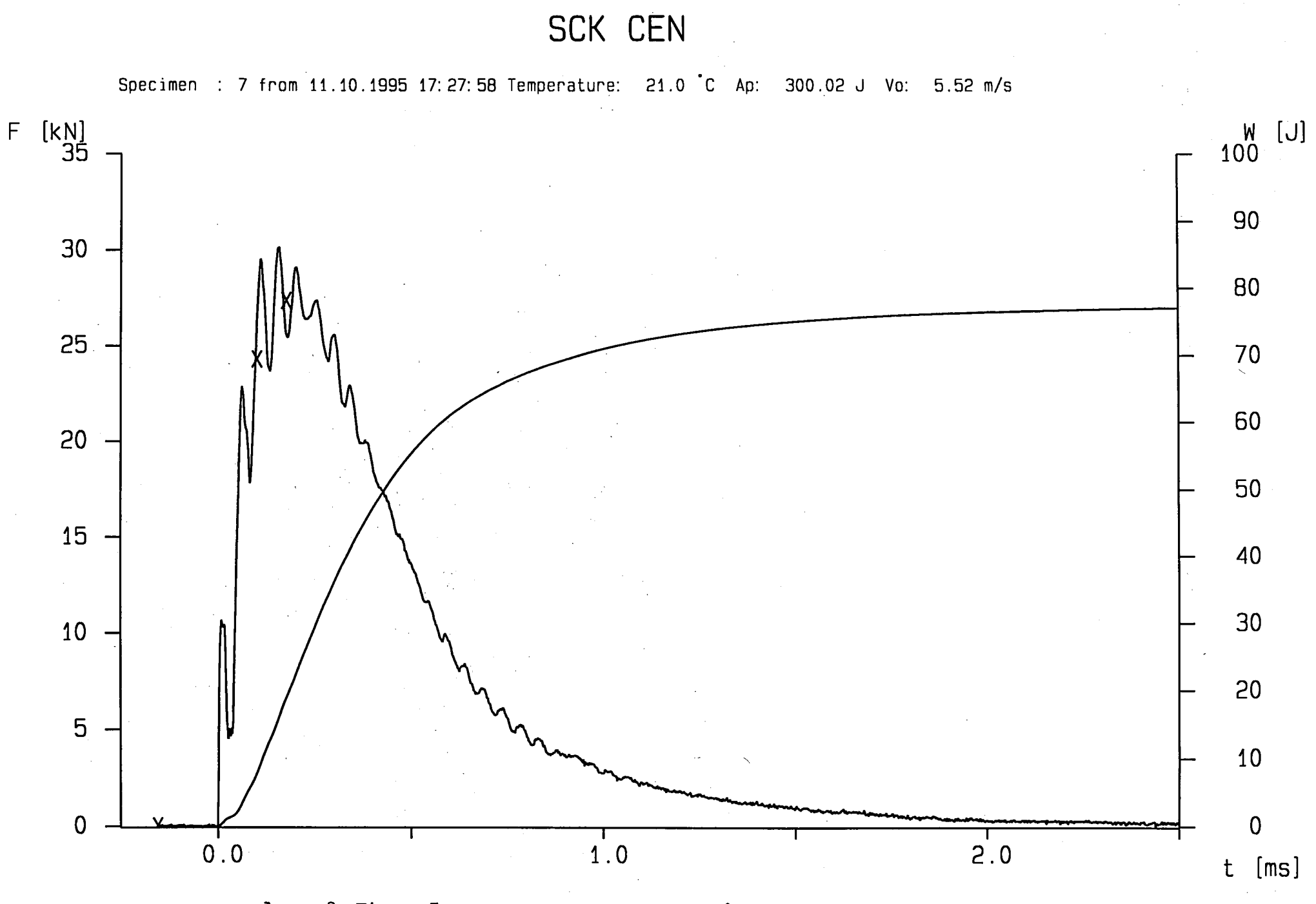
Annex 3: Figure 6 BCR MAT - 80 J LEVEL - N°1 - DIN TUP

Date : 11.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-80-G Nr. : 7
Hammer: Charpy 300J Force,fr Specimen: 02

Temperature	21.00	deg.C	Fg load	1000.00	kHz
Velocity Vo	5.52	m/s	E dial	80.00	J
Avail. energy	300.02	J	E corr.	77.99	J
Fall. height h	1554.56	mm	E incr.	79.19	J
Fall. angle α	160.60	deg.	E comp.	77.00	J
Time	16.00	ms	SFA	100.00	%
Comment	SPECIMEN BROKEN		Lat. exp.	1.094	mm

Time		Load		Energy		Displacement	
t_gy=	0.098 ms	F_gy=	24.42 kN	W_gy=	7.39 J	s_gy=	0.539 mm
t_m =	0.179 ms	F_m =	27.32 kN	W_m =	19.39 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

Annex 3: Table 8



Annex 3: Figure 7 BCR MAT. - 80 J LEVEL - N° 2 - DIN TUP

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================================================================================

Date   : 11.10.1995          Operator: R. VOSCH          Budget  : B032050
Tup    : DIN-2970            Material: BCR 1-80-G        Nr.     :      8
Hammer: Charpy 300J Force,fr                             Specimen: 03

--------------------------------------------------------------------------------

Temperature     :   21.00  deg.C      Fg load      : 1000.00   kHz
Velocity Vo     :    5.52  m/s        E dial       :   81.80   J
Avail. energy   :  300.02  J          E corr.      :   79.57   J
Fall. height h  : 1554.56  mm         E incr.      :   80.77   J
Fall. angle  α  :  160.60  deg.       E comp.      :   76.99   J
Time            :   16.00  ms         SFA          :  100.00   %
Comment         : SPECIMEN BROKEN     Lat. exp.    :    0.888  mm

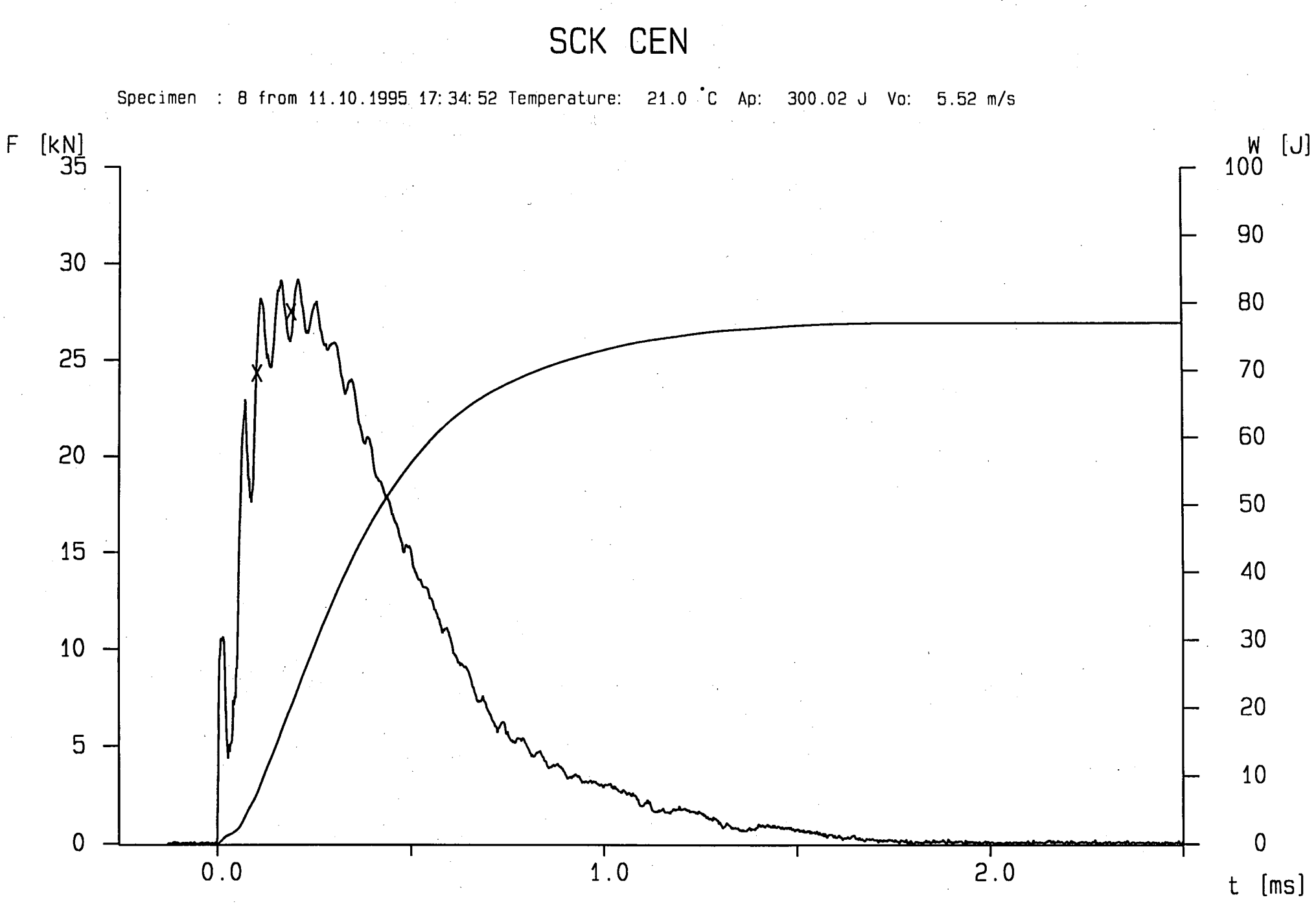
--------------------------------------------------------------------------------

Time                  Load                  Energy                Displacement

t_gy=  0.104 ms    F_gy= 24.34 kN    W_gy=   7.50 J    s_gy=  0.561 mm
t_m =  0.192 ms    F_m = 27.50 kN    W_m =  20.26 J    s_m =  1.035 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

--------------------------------------------------------------------------------
```

Annex 3: Table 9



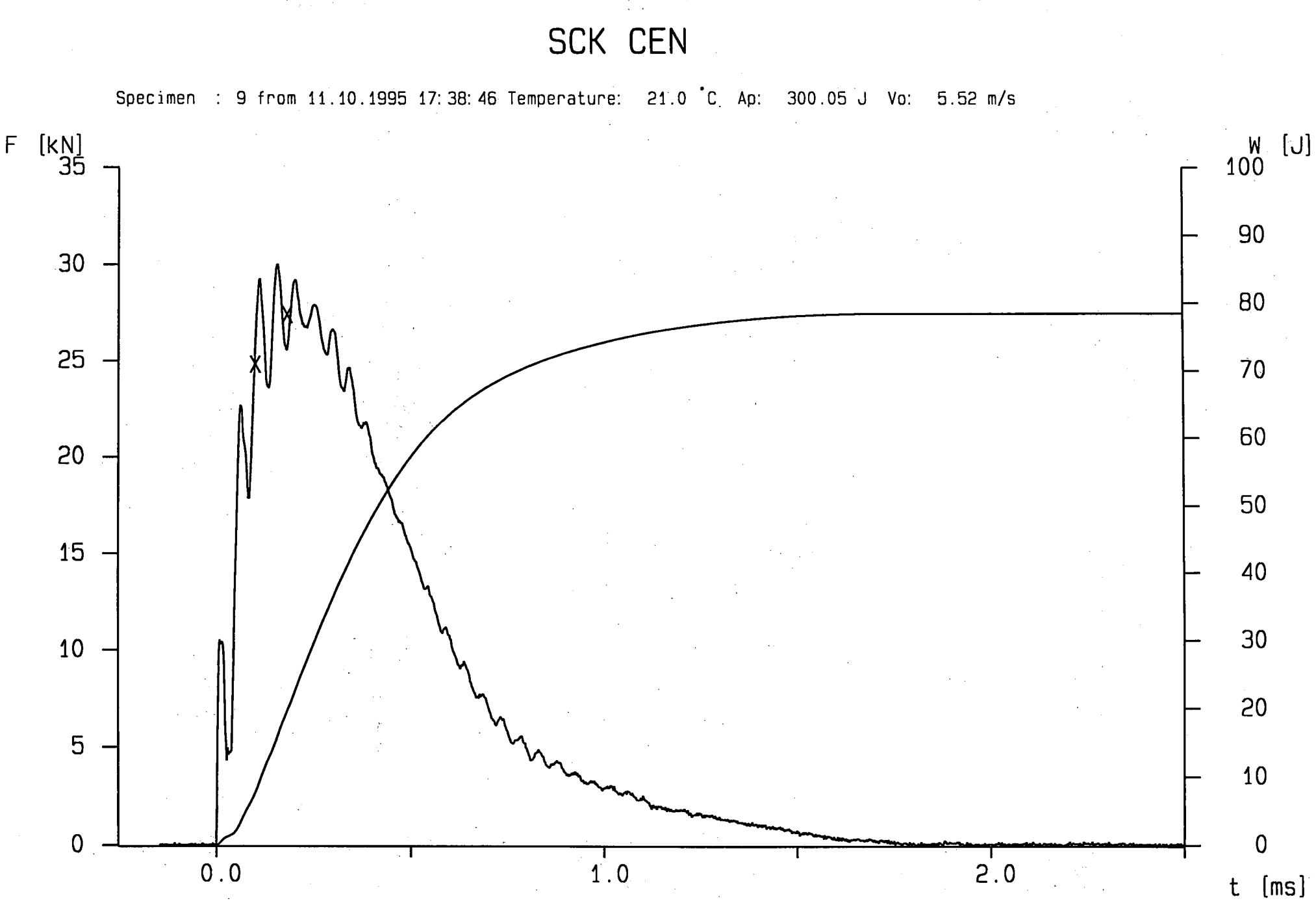
Annex 3: Figure 8 BCR MAT. - 80 J LEVEL - N° 3 - DIN TUP

Date : 11.10.1995 Operator: R. VOSCH Budget : B032050
Tup : DIN-2970 Material: BCR 1-80-G Nr. : 9
Hammer: Charpy 300J Force,fr Specimen: 04

Temperature	21.00	deg.C	Fg load	1000.00	kHz
Velocity Vo	5.52	m/s	E dial	82.20	J
Avail. energy	300.05	J	E corr.	80.37	J
Fall. height h	1554.73	mm	E incr.	81.59	J
Fall. angle α	160.63	deg.	E comp.	78.45	J
Time	16.00	ms	SFA	100.00	%
Comment	SPECIMEN BROKEN		Lat. exp.	0.925	mm

Time	Load	Energy	Displacement
t_gy= 0.102 ms	F_gy= 24.82 kN	W_gy= 7.78 J	s_gy= 0.561 mm
t_m = 0.184 ms	F_m = 27.40 kN	W_m = 19.74 J	s_m = 1.003 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

Annex 3: Table 10



Annex 3: Figure 9 BCR MAT. - 80 J LEVEL - N°4 - DIN TUP

```
================================================================================

Date   : 11.10.1995          Operator: R. VOSCH          Budget  : B032050
Tup    : DIN-2970            Material: BCR 1-80-G        Nr.     :    10
Hammer: Charpy 300J Force,fr                             Specimen: 05

--------------------------------------------------------------------------------

Temperature     :   21.00  deg.C      Fg load      : 1000.00   kHz
Velocity Vo     :    5.52  m/s        E dial       :   85.00   J
Avail. energy   :  300.05  J          E corr.      :   82.76   J
Fall. height h  : 1554.73  mm         E incr.      :   83.98   J
Fall. angle  α  :  160.63  deg.       E comp.      :   80.90   J
Time            :   16.00  ms         SFA          :  100.00   %
Comment         : SPECIMEN BROKEN     Lat. exp.    :    1.061  mm

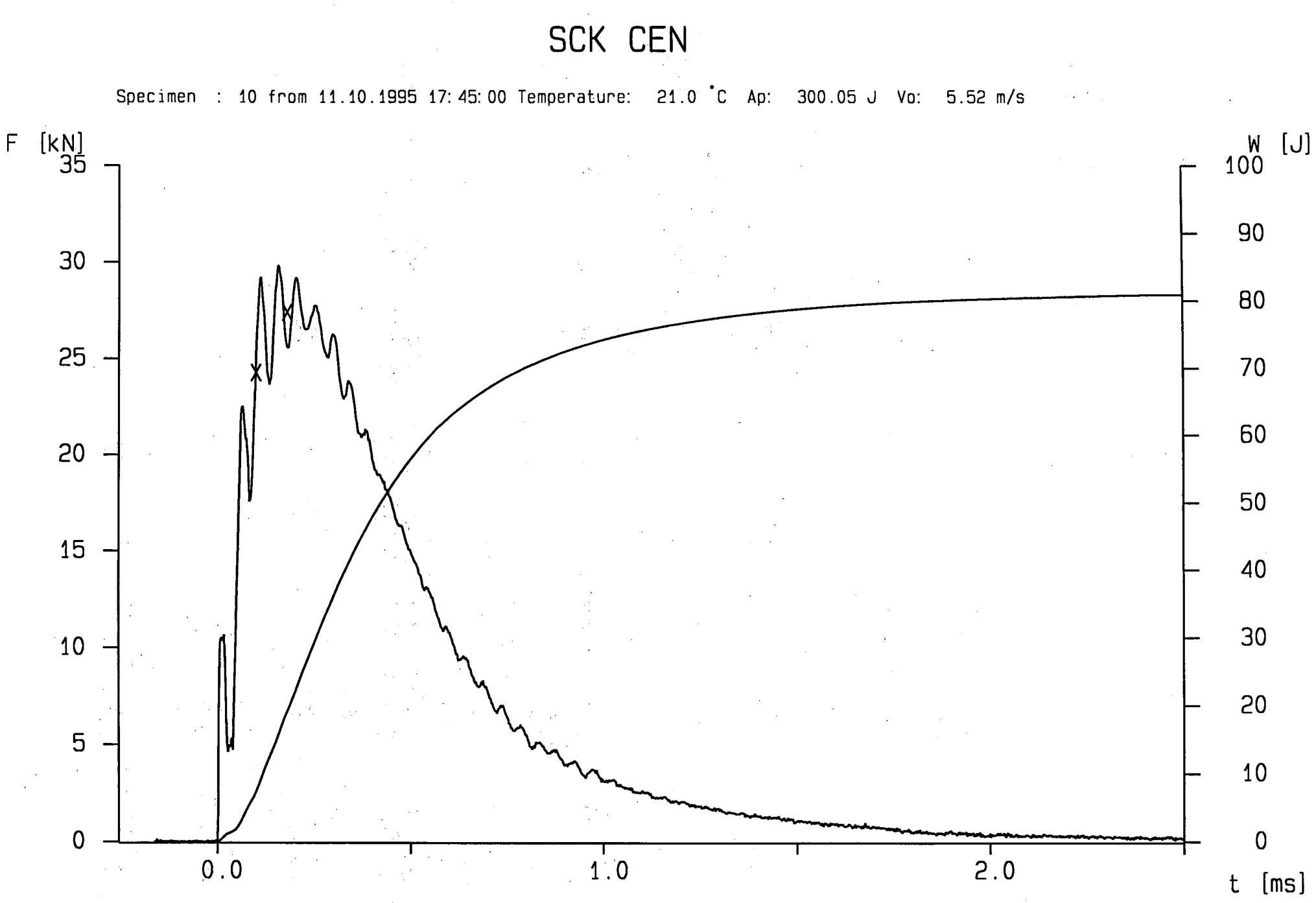
--------------------------------------------------------------------------------

Time                  Load                  Energy                Displacement

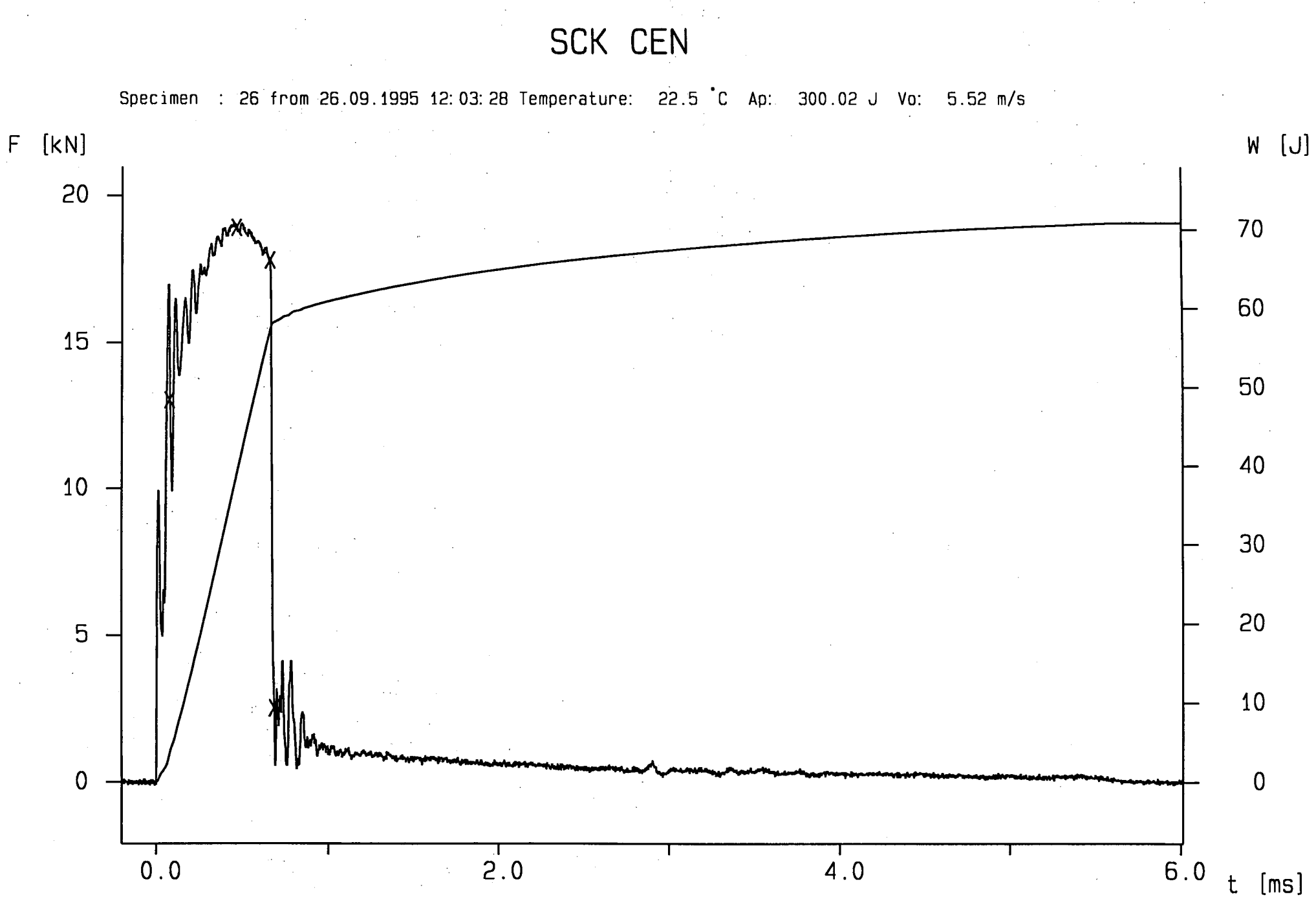
t_gy=  0.103 ms    F_gy= 24.12 kN    W_gy=   7.68 J    s_gy=  0.550 mm
t_m =  0.182 ms    F_m = 27.40 kN    W_m =  19.36 J    s_m =  0.982 mm
t_u = --     ms    F_u = --    kN    W_u = --     J    s_u = --     mm
t_a = --     ms    F_a = --    kN    W_a = --     J    s_a = --     mm

--------------------------------------------------------------------------------
```

Annex 3: Table 11



Annex 3: Figure 10 BCR MAT. - 80 J LEVEL - N°5 - DIN TUP



Annex 3: Figure 11 18MND5 MAT. - DIN TUP - 70 J