2

KFKI-1986-86/G

G. ÉZSÖL
L. PERNECZKY
L. SZABADOS
I. TÓTH

IAEA-SPE-1: PRE-TEST CALCULATIONS FOR THE PMK-NVH STANDARD PROBLEM EXERCISE

Hungarian Academy of Sciences

CENTRAL RESEARCH INSTITUTE FOR PHYSICS

BUDAPEST

KFKI-1986-86/G
PREPRINT

IAEA-SPE-1: PRE-TEST CALCULATIONS FOR THE PMK-NVH STANDARD PROBLEM EXERCISE

G. ÉZSÖL, L. PERNECZKY, L. SZABADOS, I. TÓTH

Central Research Institute for Physics
H-1525 Budapest 114, P.O.B. 49, Hungary

HU ISSN 0368 5330

ABSTRACT

Pre-test calculations of the IAEA-PMK-NVH Standard Problem Exercise (IAEA-SPE-1) are presented. The analysis was carried out by the KfK version of RELAP4/mod6 code. Requirements of the Specification Report are strictly followed in presenting the results.

АННОТАЦИЯ

Данный отчет содержит предварительные расчеты эксперимента IAEA-PMK-NVH Standard Problem Exercise. Для анализа был использован вариант вычислительной программы RELAP4/mod6, имеющейся в МАГАТЭ. Результаты расчетов представлены в виде, соответствующем требованиям спецификационного отчета.

KIVONAT

A riport az IAEA-PMK-NVH Standard Problem Exercise (IAEA-SPE-1) kísérletet megelőző számításait tartalmazza. Az elemzéshez a RELAP4/mod6 nukleáris biztonsági rendszerkód KfK változatát használtuk. Az eredményeket a Specifikációs Riport követelményeinek megfelelően közöljük.

1. Introduction

Standard Problem Exercises /SPE/ offer unique possibilities for computer code assessment of participating organizations and for the exchange of informations in a strictly defined field of nuclear safety research.

Therefore, IAEA has deemed it necessary to organize an SPE which is open for all the Member States interested in.

The experimental basis of the SPE is the PMK-NVH integral-type experimental facility located at the Central Research Institute for Physics of the Hungarian Academy of Sciences.

The PMK-NVH facility is a full-pressure 1:2070 scaled model of the Paks Nuclear Power Plant and designed mainly to investigate processes following a small and medium size break in the primary circuit and to study the natural circulation behaviour, but it was conceived in a way that allows simulation of a variety of plant dynamic processes of WWER-type PWRs. [1, 2, 3]

The transient chosen by a Working Group of the IAEA is a 7.4 % break in the cold leg of the Paks Nuclear Power Plant.

The pre-test calculations have been performed by the RELAP4/mod6 code /KfK version/ on the IBM 3081 computer at the IAEA Headquarters in the framework of the Regional Programme on the Computer Aided Safety Analysis.

2. Data for the pre-test analysis

Data for the pre-test analysis are given in [1, 4, 5] . The measured actual initial conditions are slightly different of the nominal initial conditions given in Ref.[1] and they are used as listed below.

2.1 Initial conditions at 0 second

The initial conditions at 0. s for the Standard Problem Test /SPT/ are characterized by the data as follows:

o Primary circuit

- pressure in upper plenum	12.65 MPa
- loop flow	4.73 kg/s
- core inlet temperature	538 K
- core power	654 kW
- coolant level above bottom of pressurizer /collapsed/	1.46 m

o Secondary circuit

- pressure in SG	4.67 MPa
- coolant level above bottom of SG secondary side /collapsed/	2.25 m
- feed water flow	0.353 kg/s

o Position of valves

- MV11, PV12, PV23, MV31, PV31 are closed
- PV11 is throttled, closing current is 11.514 mA
- MV12 is open
- PV21 and PV22 are throttled.

2.2 Transient initiation

The SPT, a 7.4 % cold leg break starting from the above defined conditions was performed with the sequence of events as listed below:

- break valve MV31 starts opening	0.0 s
- PV21, PV22 starts to close /closing time 4 s/	0.0 s
- break valve open	0.1 s
- transient for power is initiated at /power v time, see Table 1./	11.6 MPa
- modelling of the pump coast down is initiated at	9.47 MPa
/closing current v. time of valve PV11, see Table 2./	
- HPIS flow initiated at /flow rate v. time see Table 3./	11.6 MPa
- SG secondary side relief valve PV23	
opening pressure	5.4 MPa
closing pressure	5.0 MPa
the flow rate was limited by an orifice, with a diameter of	6.0 mm

2.3 End of the test

The test was terminated at 997 s

2.4 Other data

The pressure distribution applied to the calculation is given in Table 4.

The flow diagram of the facility and the measurement locations are given in 2.1 and 2.2 respectively.

3. Code information and physical models used

3.1 Problems of nodalization

The nodalization scheme applied to the calculations is given in Fig. 3.1.

The number of nodalization elements applied to the scheme is presented in Table 5. Several schemes of higher number of elements were investigated to obtain the right values for them.

In order to get, however, an acceptable computer time and for the negligation of numerical oscillations, the number of volumes and heat slabs were reduced to 19 and 16, respectively.

The nodalization scheme applied to the calculations is given in Fig. 3.1 and further informations are presented in Table 6.

Slabs S1 - S5 are core heat slabs, while the heat capacity of the steatit is represented by slabs S12 - S14.

3.2 Physical models and options used

For the calculations the standard RELAP4 program option with minimal controls /ISPROG = 0/ was used. For the heat transfer coefficients the HTS2, the new MOD6 blowdown correlation package was chosen.

At the break junction the Henry-Fauske/HEM explicit critical flow model /JCHOKE=5/ with critical flow model dials:

flow rate multipliers: 0.95
transition quality: 0.02

was selected.

The enthalpy transport model was used for the steady state calculation only /until 10 s/.
Vertical slip model was applied for junctions:

J13, J5, J6, J8, J9, J19, J20, J10, J11

In the bubble rise model for volumes /see Table 6./ the used values of bubble density gradient /Alph/ and bubble velocity /Vbub/ are shown in Table 7.

3.3 Computer type and main characteristics of the calculations

The characteristics of caculation and code performance are given in Table 8.

3.4 Remarks on the steady-state calculation

RELAP4/mod6 has no ability to calculate the initial steady-state conditions. Several trial runs have been performed in order to set up the input for the final run, especially the correct amount of heat transferred in the steam generator was difficult to achieve. In the final calculation the break was opened at 10 s that allowed disturbances provoked by incoherent input data to smooth out. /E.g. SG power changed from 718 to 647 kW in this period/. All data were within the error band of measured parameters at break initiation.

4. Results of the calculation

The tesults of the calculation are presented in Figs. 4.1 to 4.46. Figure numbers correspond to plot numbers as required by the Specification Report [1] . Note that Figs. 4.2 and 4.4 are missing since the heated part of the fuel rod simulators was modelled by three heat slabs only. /Figs. 4.1, 4.3 and 4.5/.

Figs. 4.34 to 4.46 present additional information supposed to be important in the assessment.

Section 7 gives a complete list of figures along with the units used for additional plots.

Results of the calculation are discussed in the next section, while major occurances, as required by the Specification Report, are summarized in Table 9.

5. Discussion

The transient process initiated by the break on top of the downcomer is characterized by fast initial depressurization /Figs. 4.14, 4.15/. However, until the pressurizer runs empty it pushes sufficiant water to the system to avoid flashing in any other part of the loop. Afterwards, steam appears in the hot leg, hot collector of the steam generator and the vessel head resulting in continuously sinking mixture levels in these volumes /Figs.4.40, 4.41 and 4.34, respectively/.

In this period primary pressure is dictated by secondary pressure, but the hot leg loop seal plays an important role as well. The loop seal starts to vent steam at 61.5 s, at the same time, when the vessel mixture level drops to the elevation of the hot leg and this results in steam condensation on the steam generator primary side sith a subsequent pressure decrease.

Until the pump is stopped theres isn't much change in the situation discribed above, only at about 85 s the level in the SG cold collector /Fig. 4.39/ starts to decrease. Thus it can be stated that pump operation results in high mixture level in the reactor vessel, while most of the hot leg and the part of the cold leg from SG to pump is voided. Also the neighbourhood of the break remains single phase.

The asymmetric levels brought about by the pump have a great influence on system behaviour after the pump is stopped. There is an immediate flow reversal in the core and the downcomer /Fig. 4.26/ that leads to a fast drop of the mixture level in the vessel. At 185 s the core starts to uncover and this first uncovery is quite violent as it can be seen from Figs. 4.35 to 4.37. This is why dryout occurs practically at the same time, /Figs. 4.3 and 4.5/ due to stagnating flow conditions,steam in the upper part of the core becomes superheated, Fig. 4.7.

At 200 s the cold leg loop seal starts to vent steam that leads to severe oscillation in the downcomer and cold leg flow rates, Figs. 4.26 and 4.27. Soon it also results in two-phase coolant conditions at the break, Fig. 4.28. However, it is only after break uncovery that mixture level in the core increases significantly and this also results in heater rod rewet.

According to the calculation the core level soon starts to decrease again and a second dryout occurs that lasts several hundred seconds. The rest of the transient is characterized by little change in the parameters, only the system pressure decreases continuously. After 600 s the HPIS compensates the slowly decreasing break flow and the core level increases again /Fig..4.37/.This finally leads to a decrease of the heater rod temperatures.

6. References

[1] L. Szabados et al.: Specification for the PMK-NVH Standard Problem Exercise. Budapest, 1985.

[2] L. Szabados: Scaling and Instrumentation of the PMK-NVH Facility. Specialists Meeting on Small Break LOCA Analyses in LWRs. Pisa /1985/ Vol.1.p.527.

[3] L.Szabados, C.Almeida, L.Maróti: The PMK-NVH Facility and Ist Use for an IAEA Standard Problem Excrcise.SPM on SBLOCA Analyses in LWRs. Pisa /1986/

[4] PMK-NVH Standard Problem Exercise. Additional Information to Participants. February 1st, 1986. /Distributed by C.Almeida, 1986/

[5] Measured Initial Conditions for the IAEA - PMK-NVH Standard Problem Test. Budapest-Vienna. May 1986. /Distributed by C.Almeida, 1986./

7. List of figures

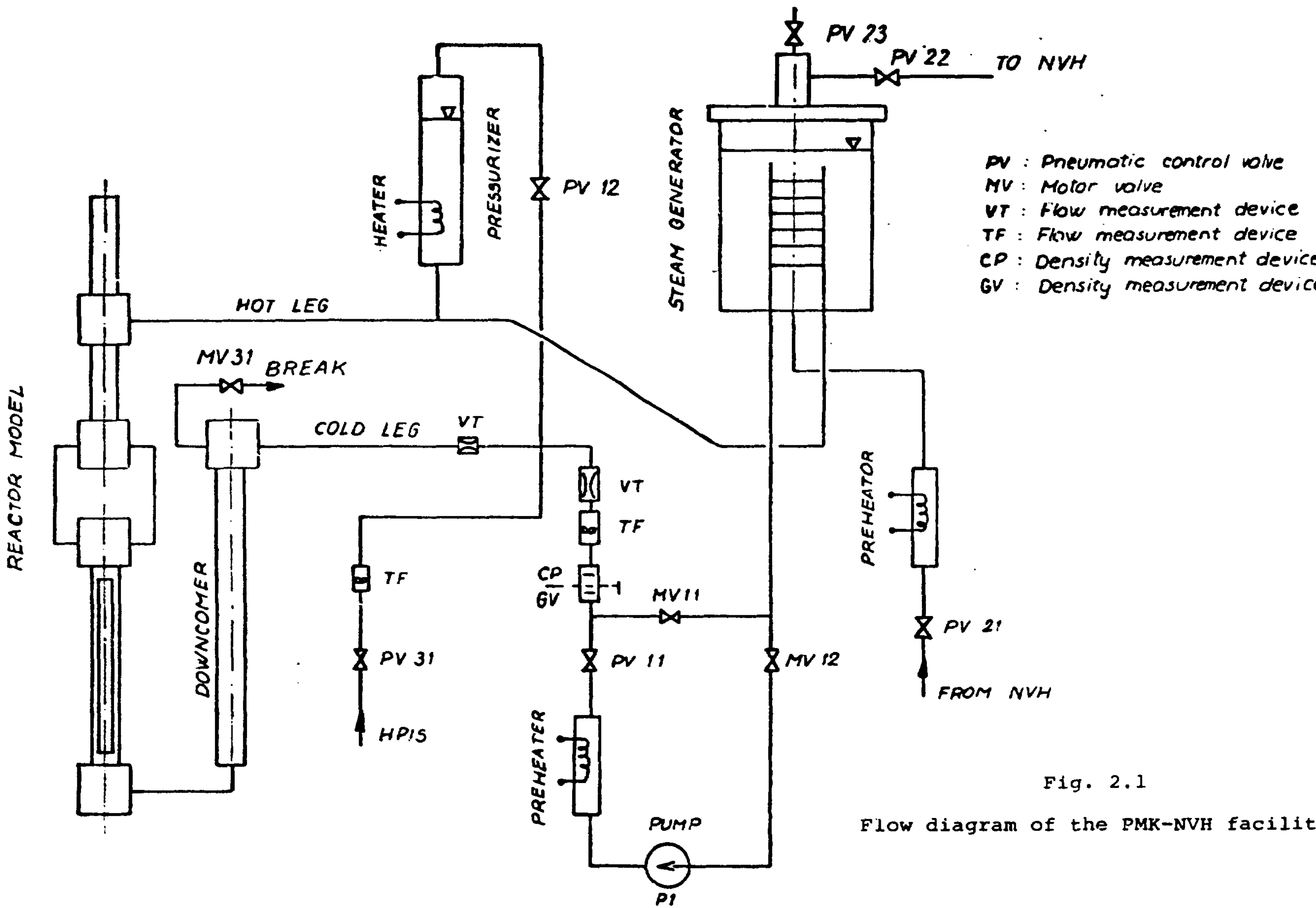
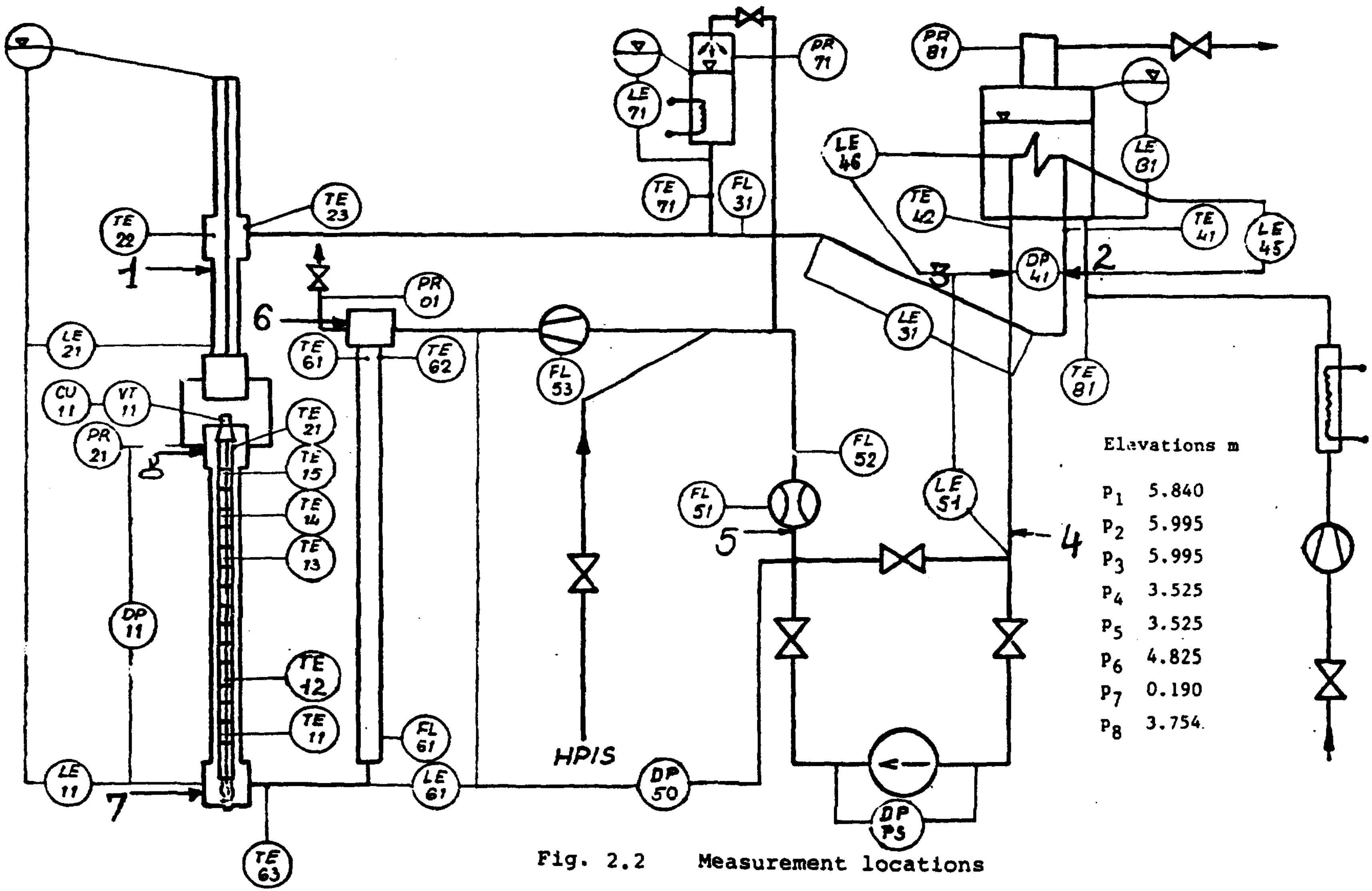


Fig. 2.1

Flow diagram of the PMK-NVH facility



Elevations m

P_1	5.840
P_2	5.995
P_3	5.995
P_4	3.525
P_5	3.525
P_6	4.825
P_7	0.190
P_8	3.754

Fig. 2.2 Measurement locations

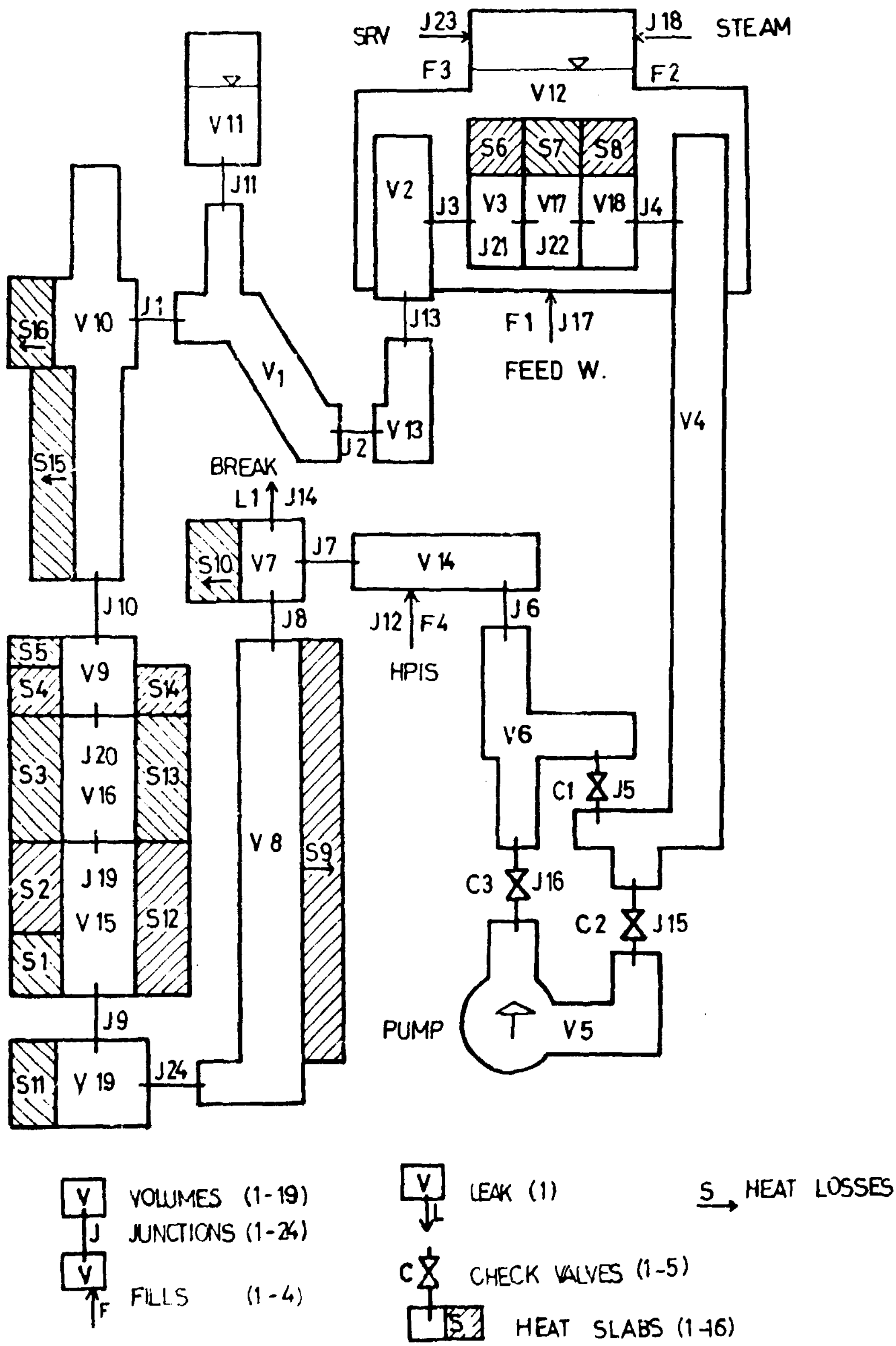

SRV
J23
J18
STEAM
F3
F2
V12
V11
J11
S6
S7
S8
V2
J3
V3
V17
V18
J4
J21
J22
S16
V10
J1
J13
F1
J17
FEED W.
V1
V13
J2
V4
S15
BREAK
L1
J14
S10
V7
J7
V14
J10
J8
J12
F4
J6
HPIS
S5
V9
S4
S14
V6
J20
V16
S3
S13
C1
J5
V8
S9
S2
J19
V15
S12
C3
J16
C2
J15
S1
J9
PUMP
V5
S11
V 19
J24
VOLUMES (1-19)
JUNCTIONS (1-24)
FILLS (1-4)
LEAK (1)
CHECK VALVES (1-5)
HEAT SLABS (1-16)
HEAT LOSSES

Fig. 3.1

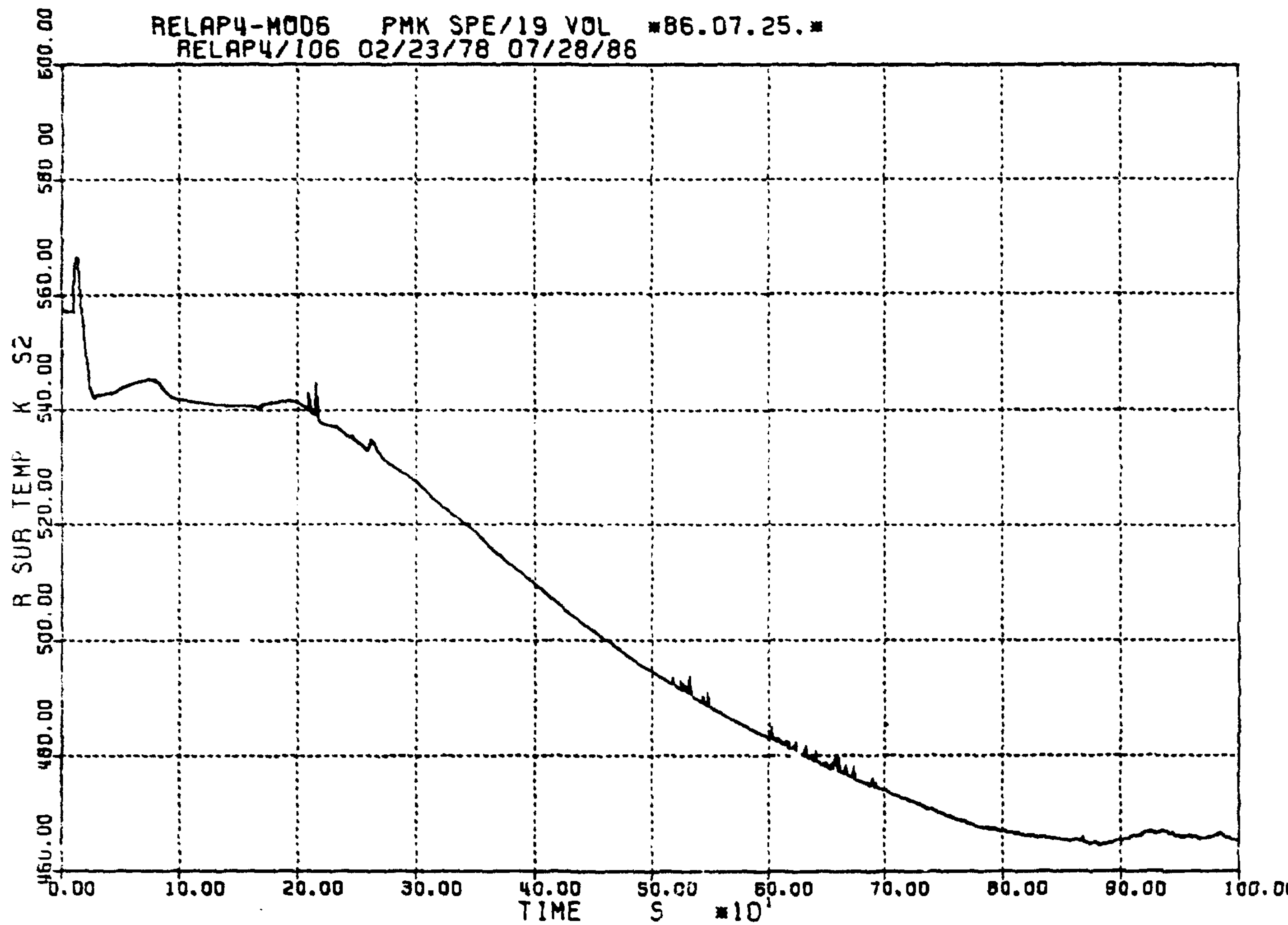

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
R SUR TEMP K S2
460.00
480.00
500.00
520.00
540.00
560.00
580.00
600.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10

Fig. 4.1

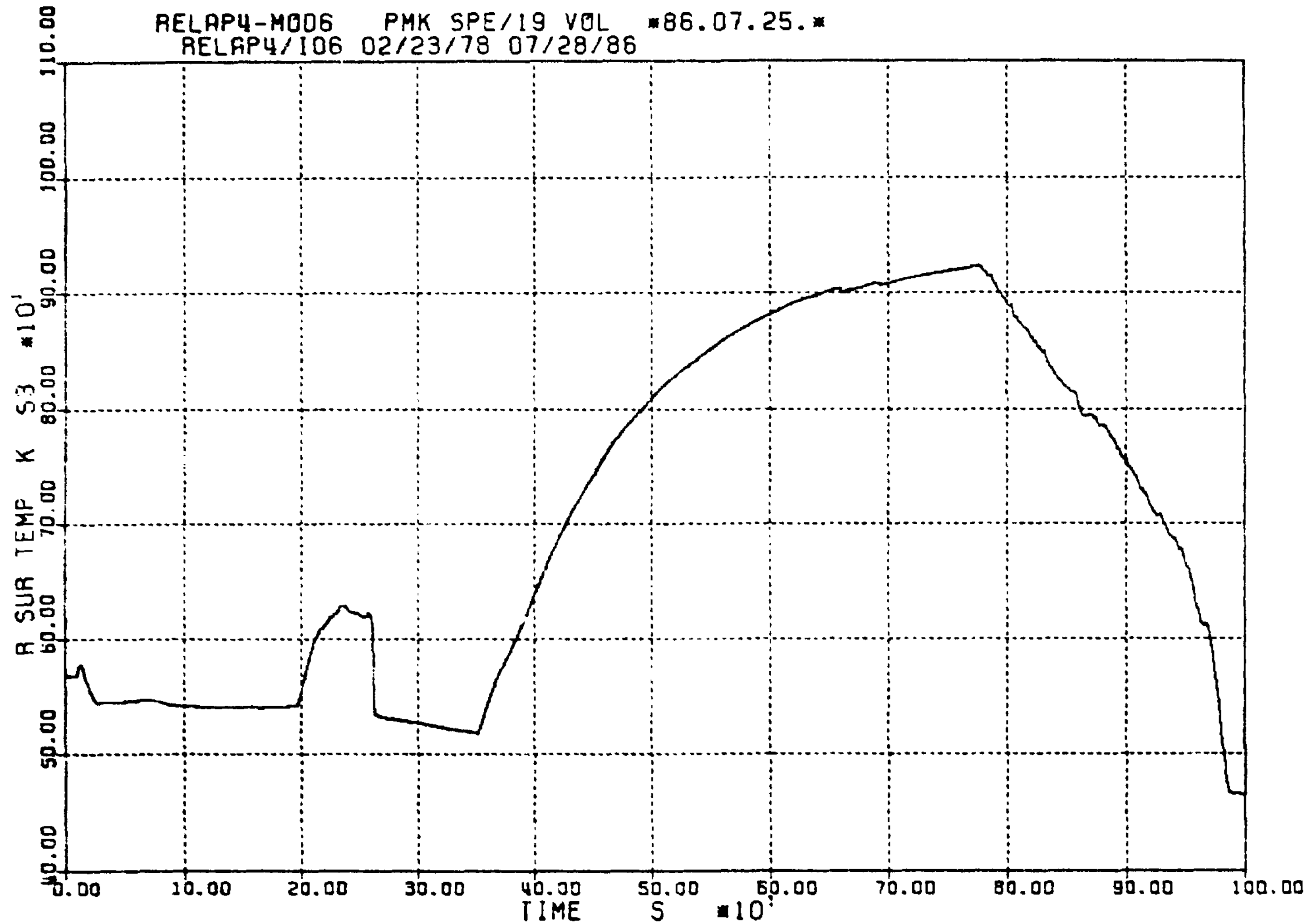

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
R SUR TEMP K 53 *10[1]
TIME S *10[1]
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00

Fig. 4.3

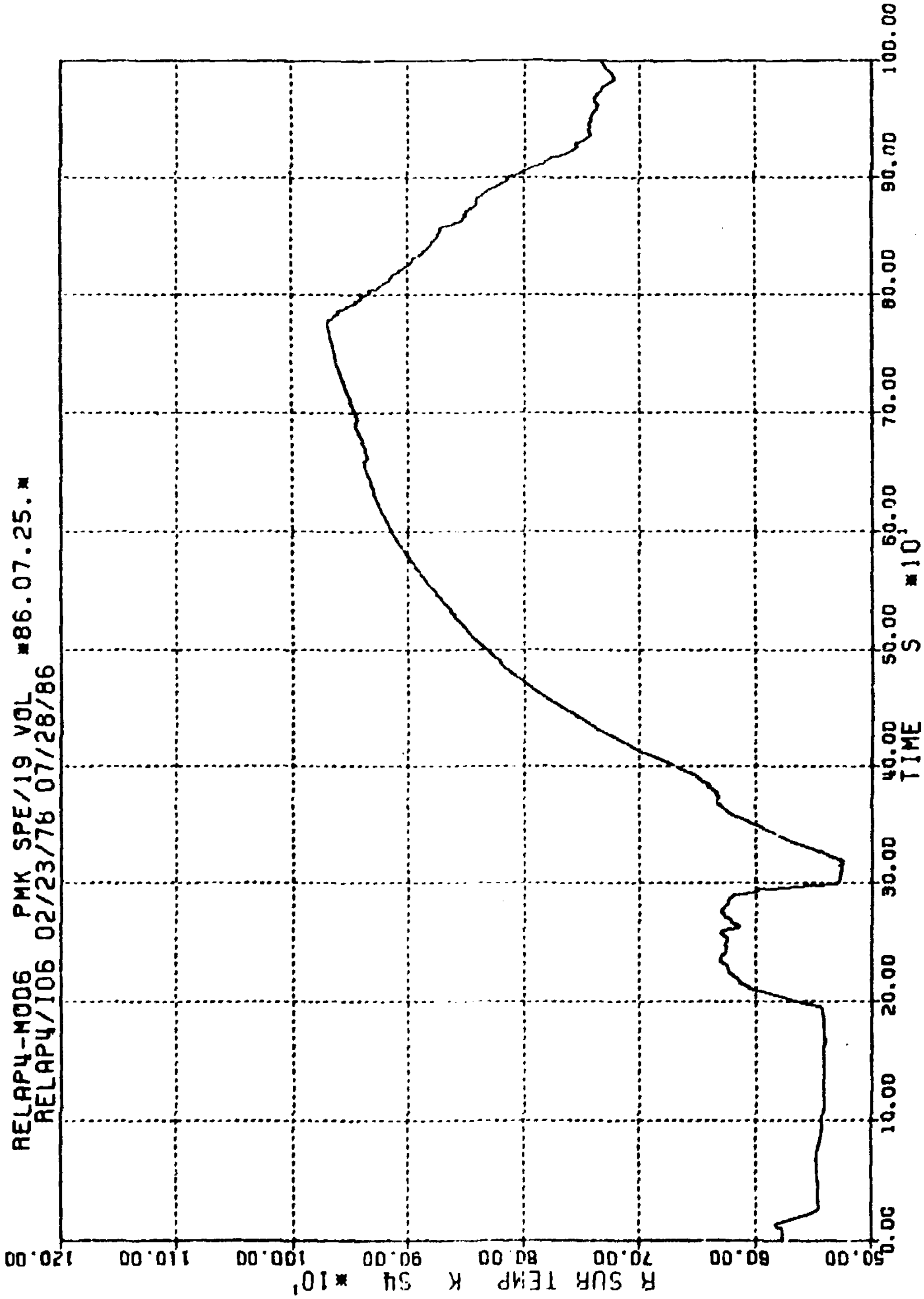

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/IO6 02/23/76 07/28/86
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
R SUR TEMP K S4

Fig. 4.5

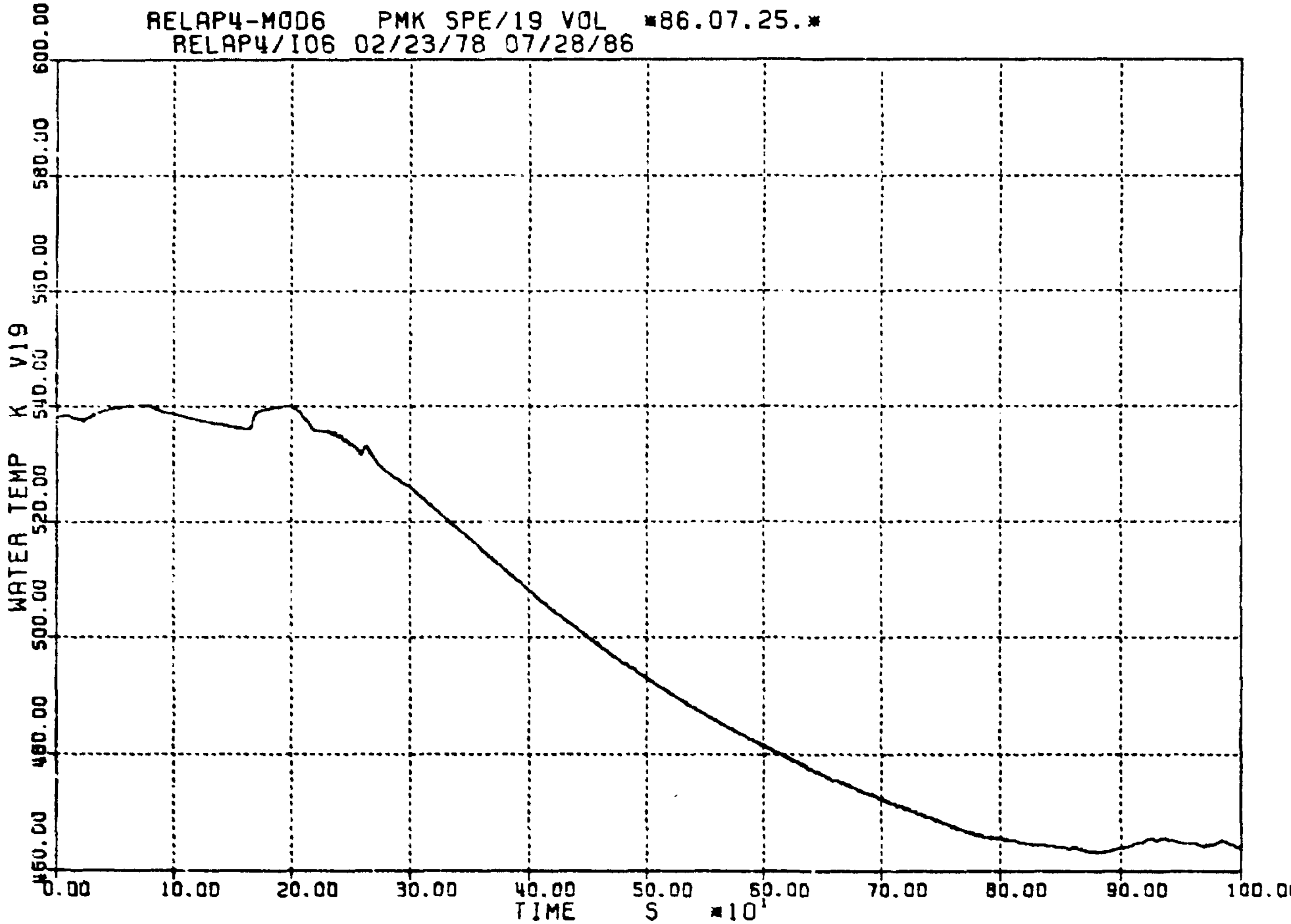

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
WATER TEMP K V19
600.00
580.00
560.00
540.00
520.00
500.00
480.00
460.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10[1]

Fig. 4.6

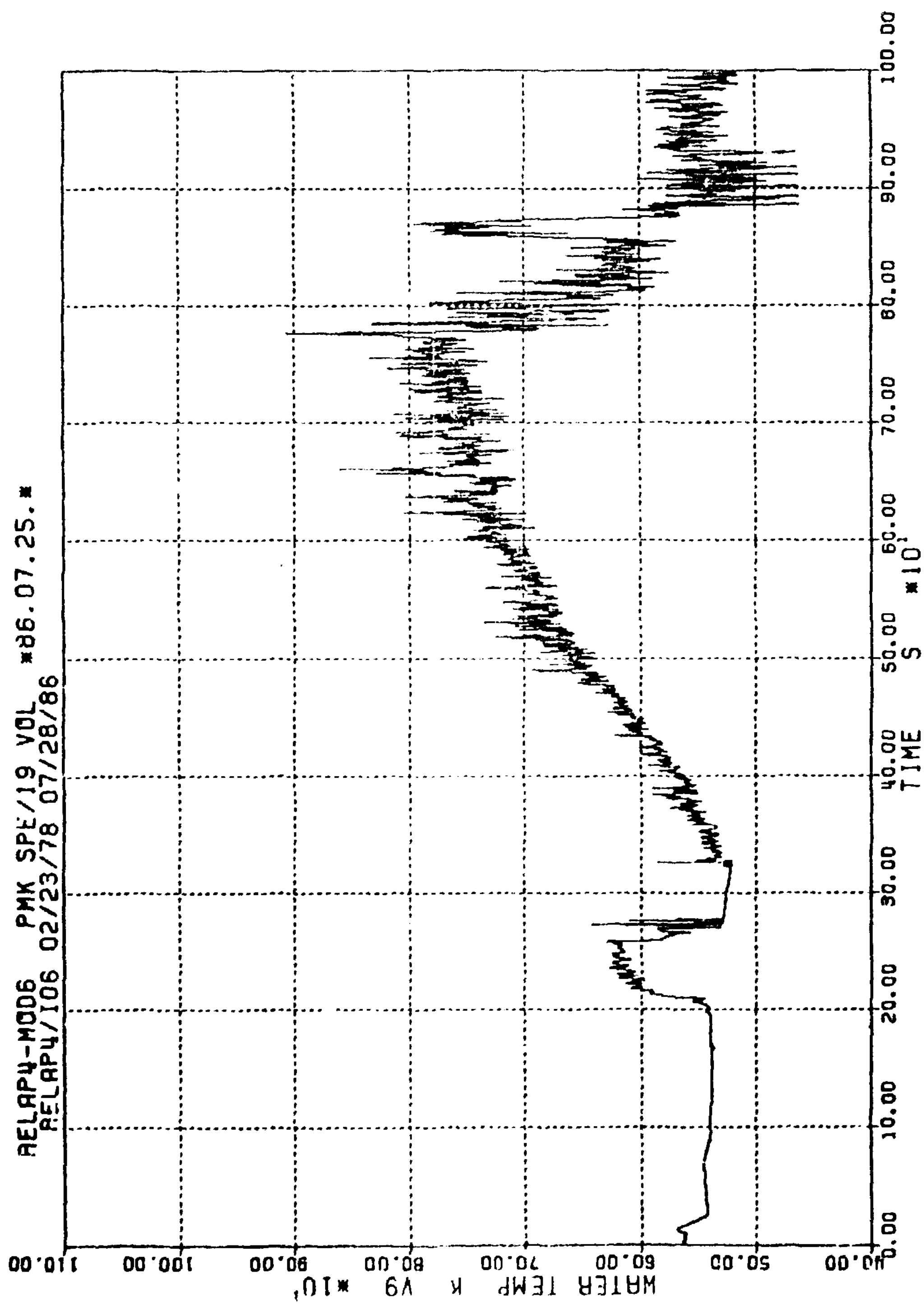

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
WATER TEMP K V9 *10¹
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00

Fig. 4.7

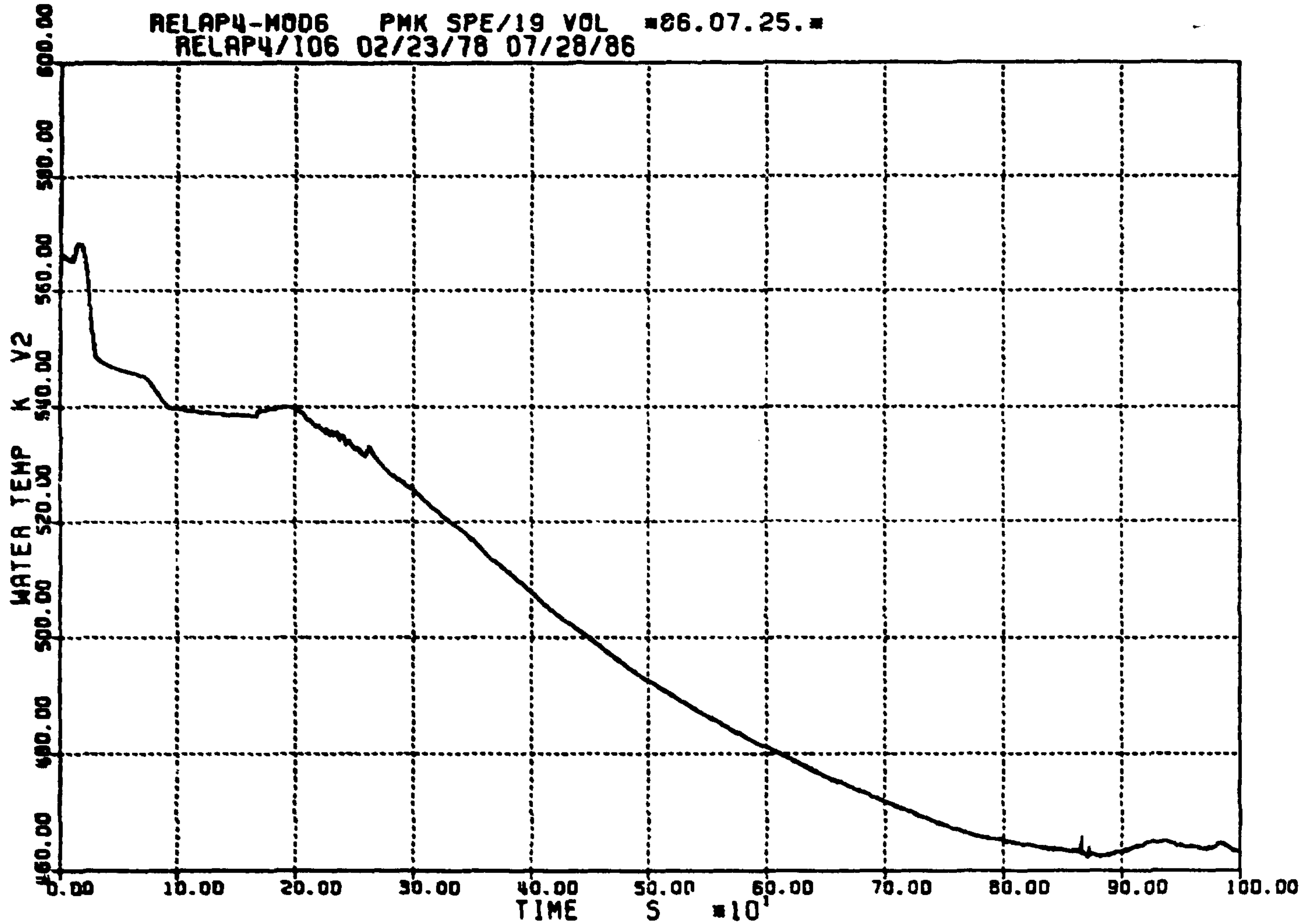

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
WATER TEMP K V2
600.00
580.00
560.00
540.00
520.00
500.00
480.00
460.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10[1]

Fig. 4.8

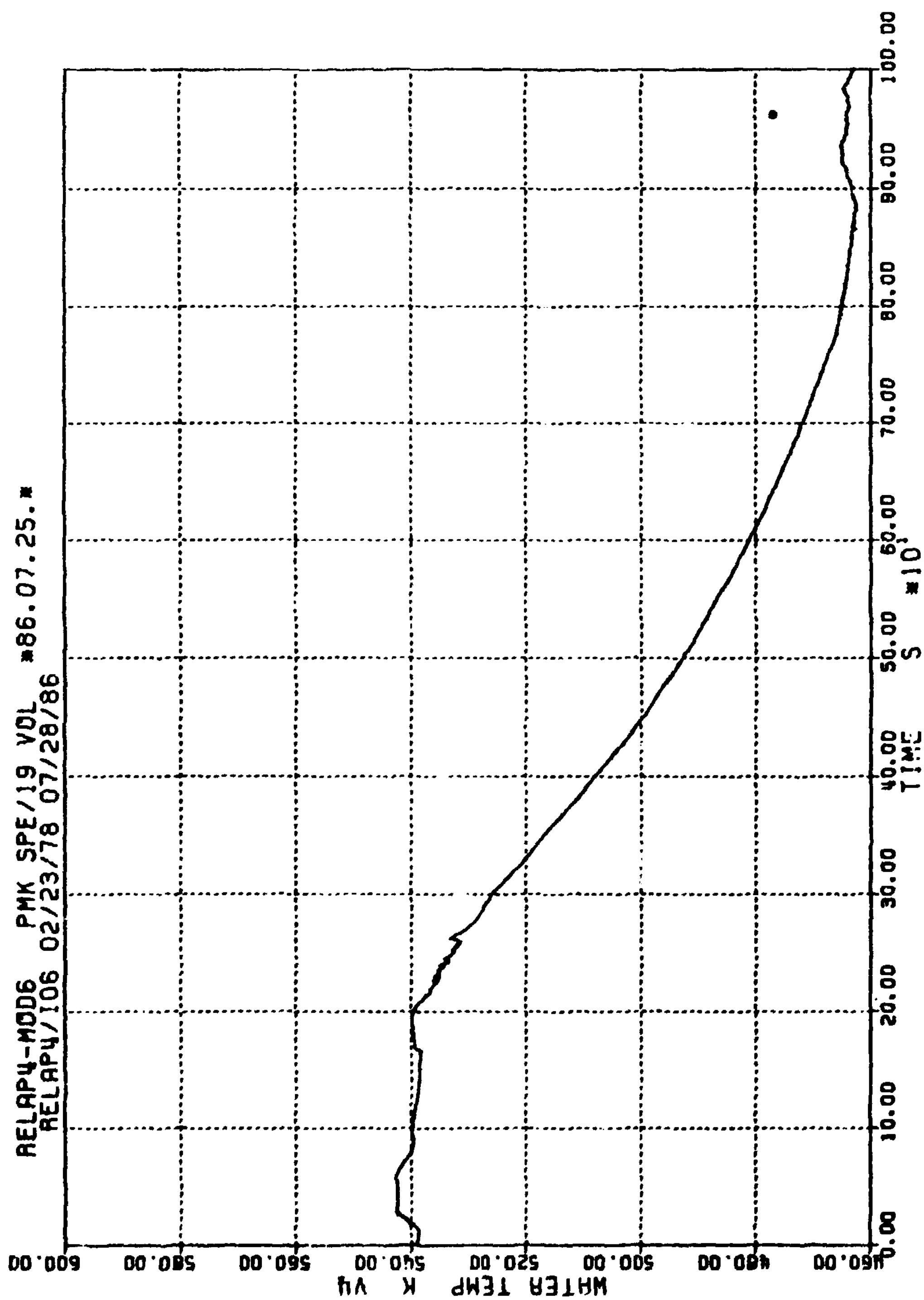

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
WATER TEMP K V4
TIME S *10¹
0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00 100.00
460.00 480.00 500.00 520.00 540.00 560.00 580.00 600.00

Fig. 4.9

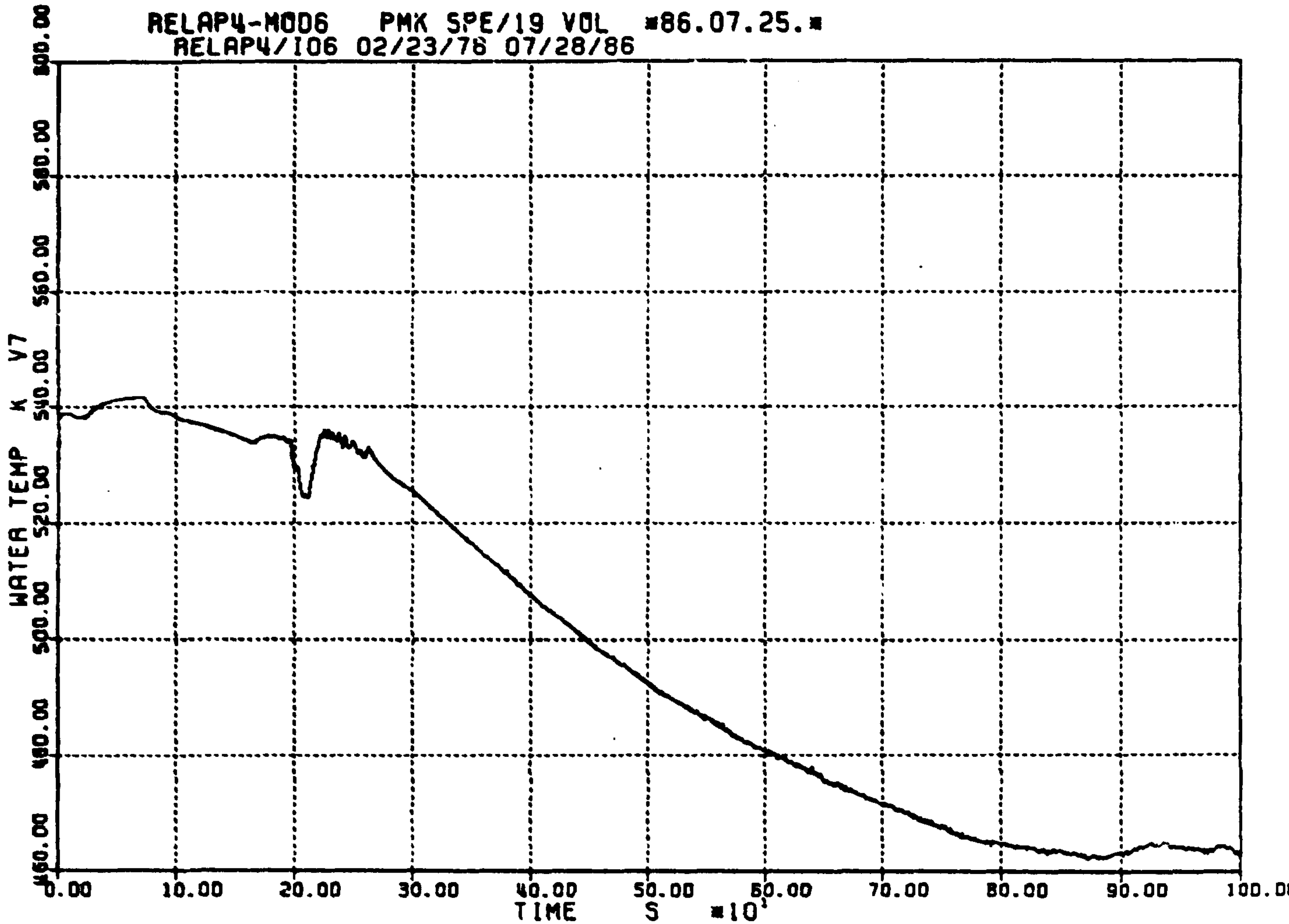

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/76 07/28/86
WATER TEMP K V7
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
460.00
480.00
500.00
520.00
540.00
560.00
580.00
600.00

Fig. 4.10

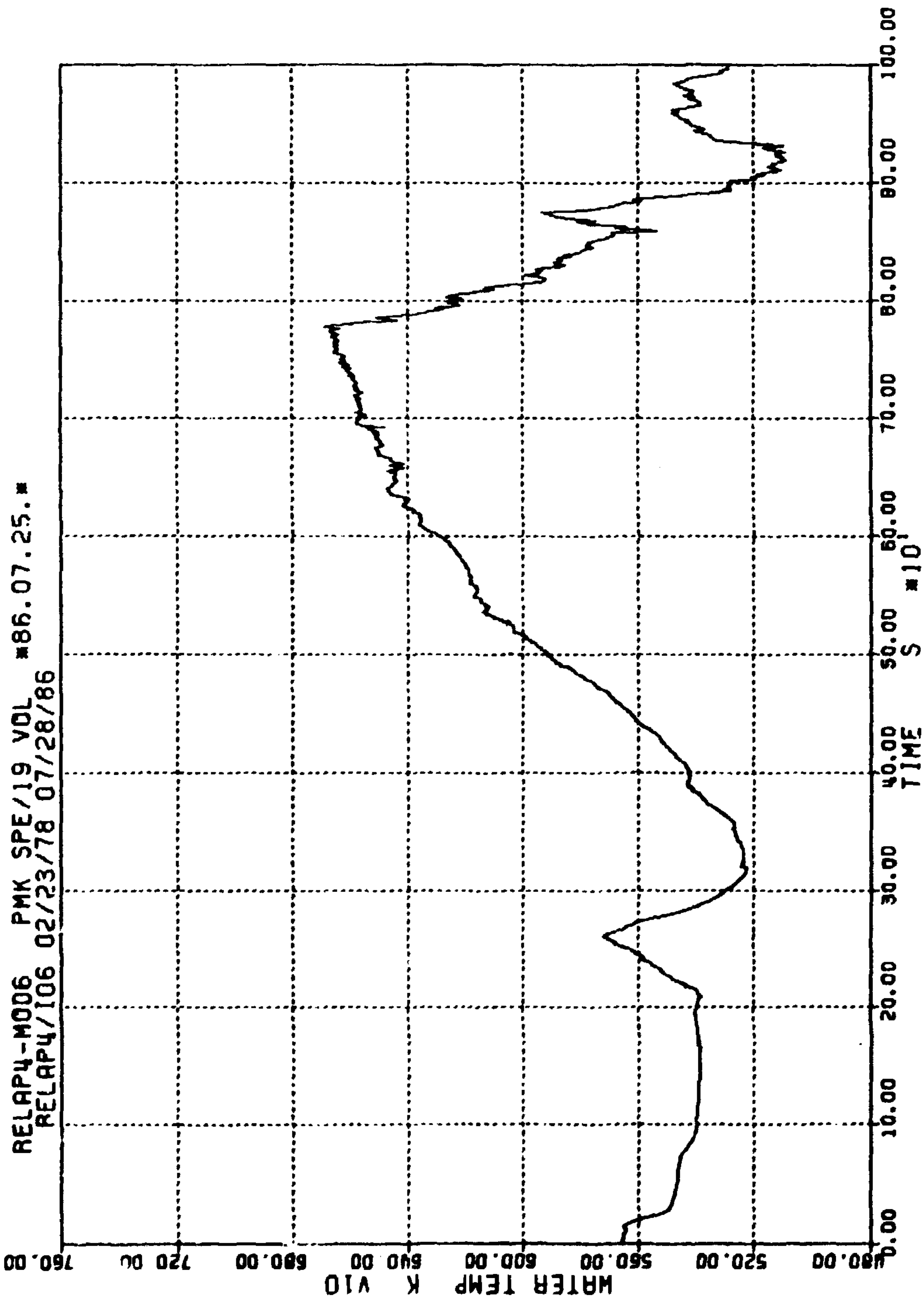

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
WATER TEMP K VIO
480.00
520.00
560.00
600.00
640.00
680.00
720.00
760.00
TIME S *10[1]
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.11

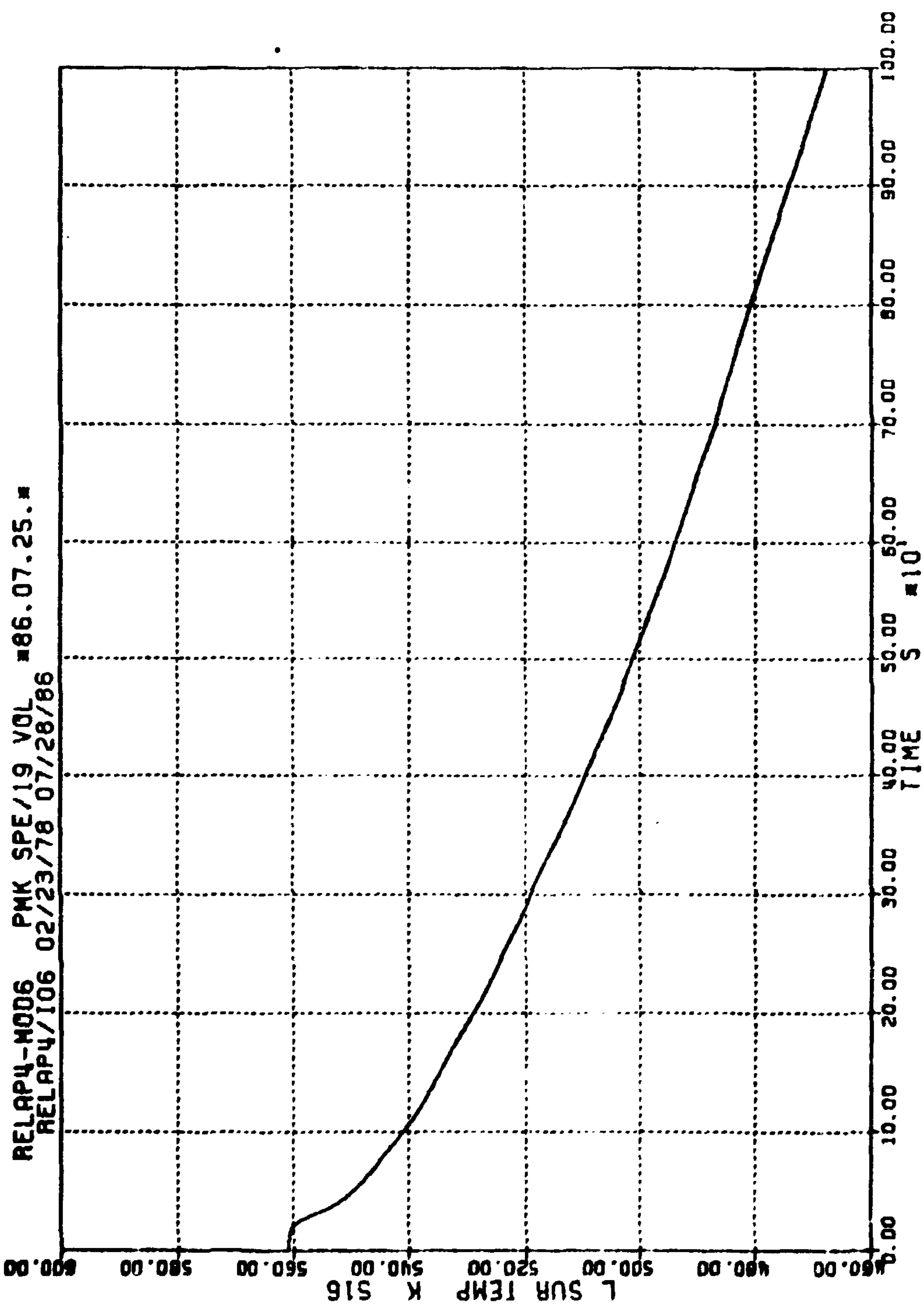

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
L SUR TEMP K S16
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
480.00
500.00
520.00
540.00
560.00
580.00
600.00

Fig. 4.12

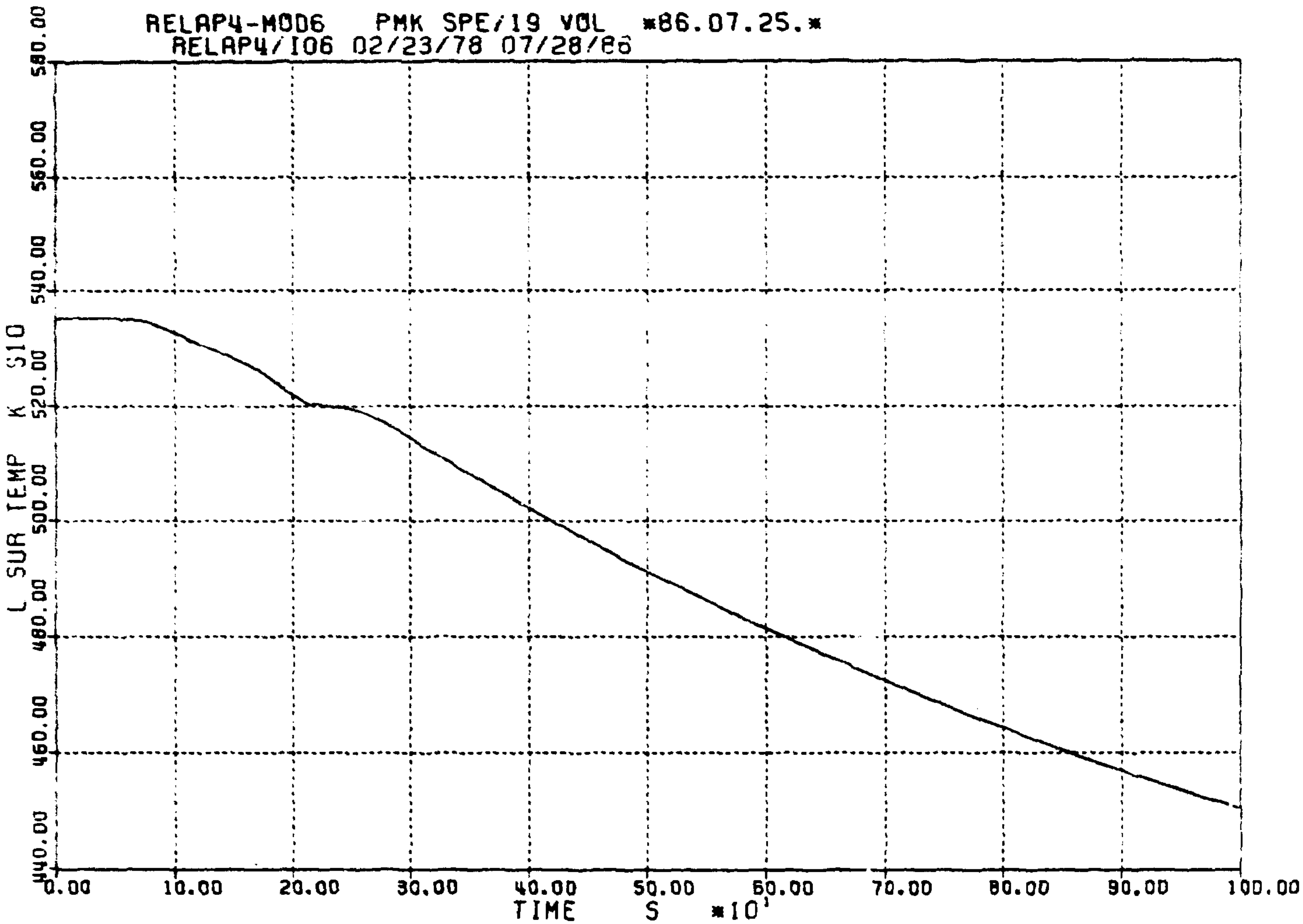

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
L SUR TEMP K 510
580.00
560.00
540.00
520.00
500.00
480.00
460.00
440.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹

Fig. 4.13

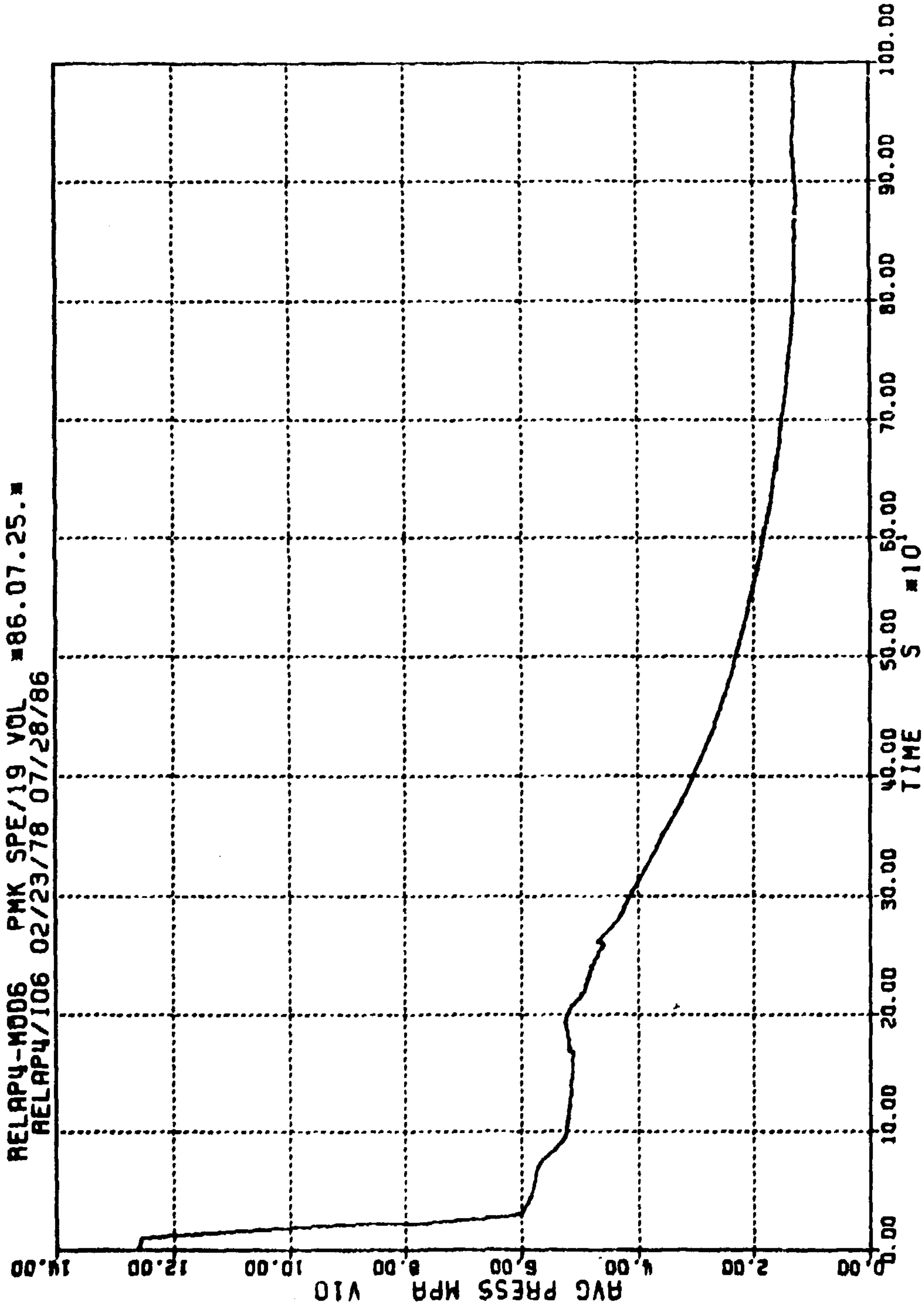

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
AVG PRESS MPA V10
TIME S *10[1]
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Fig. 4.14

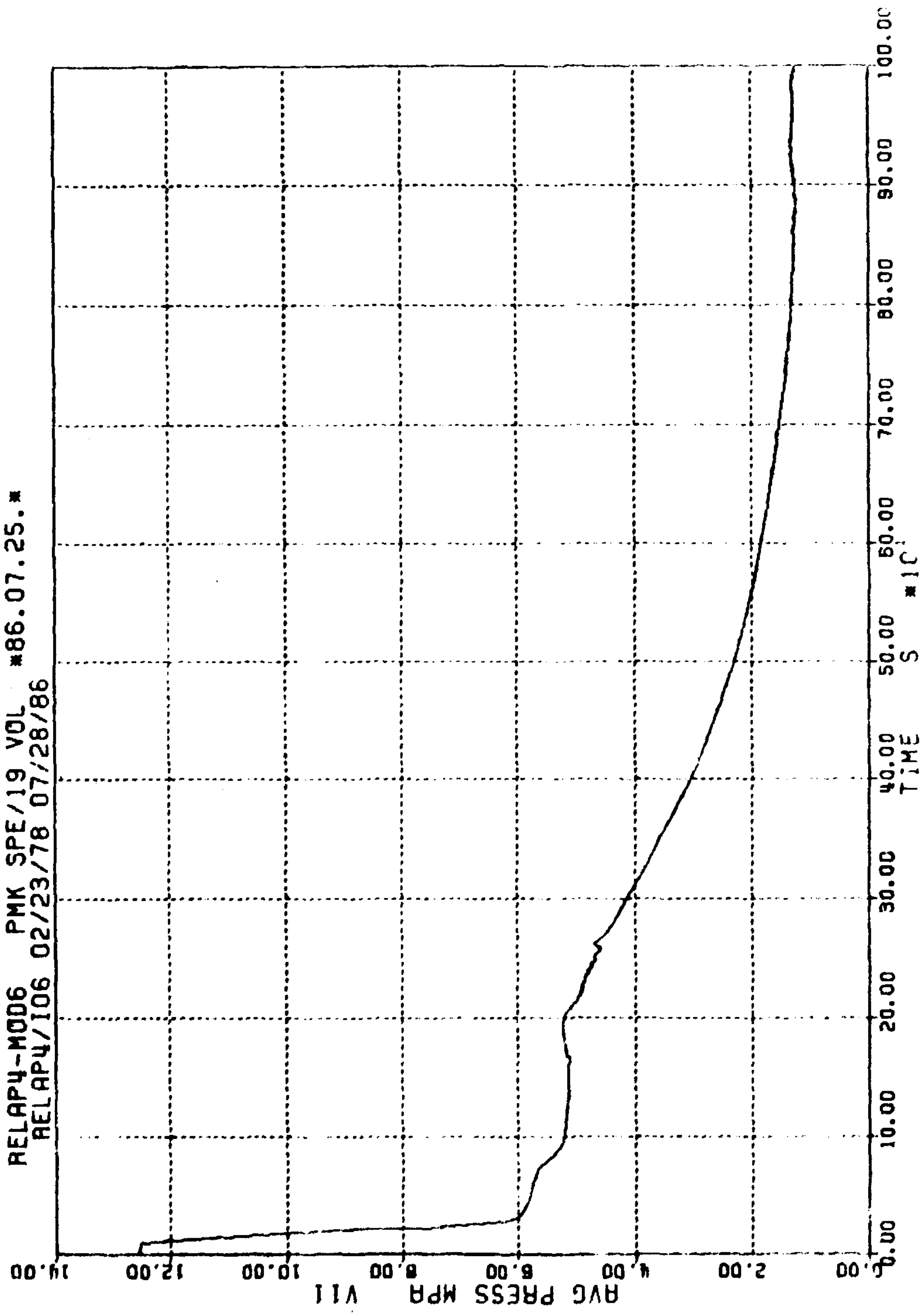

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
AVG PRESS MPA V11
TIME S *10¹
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.15

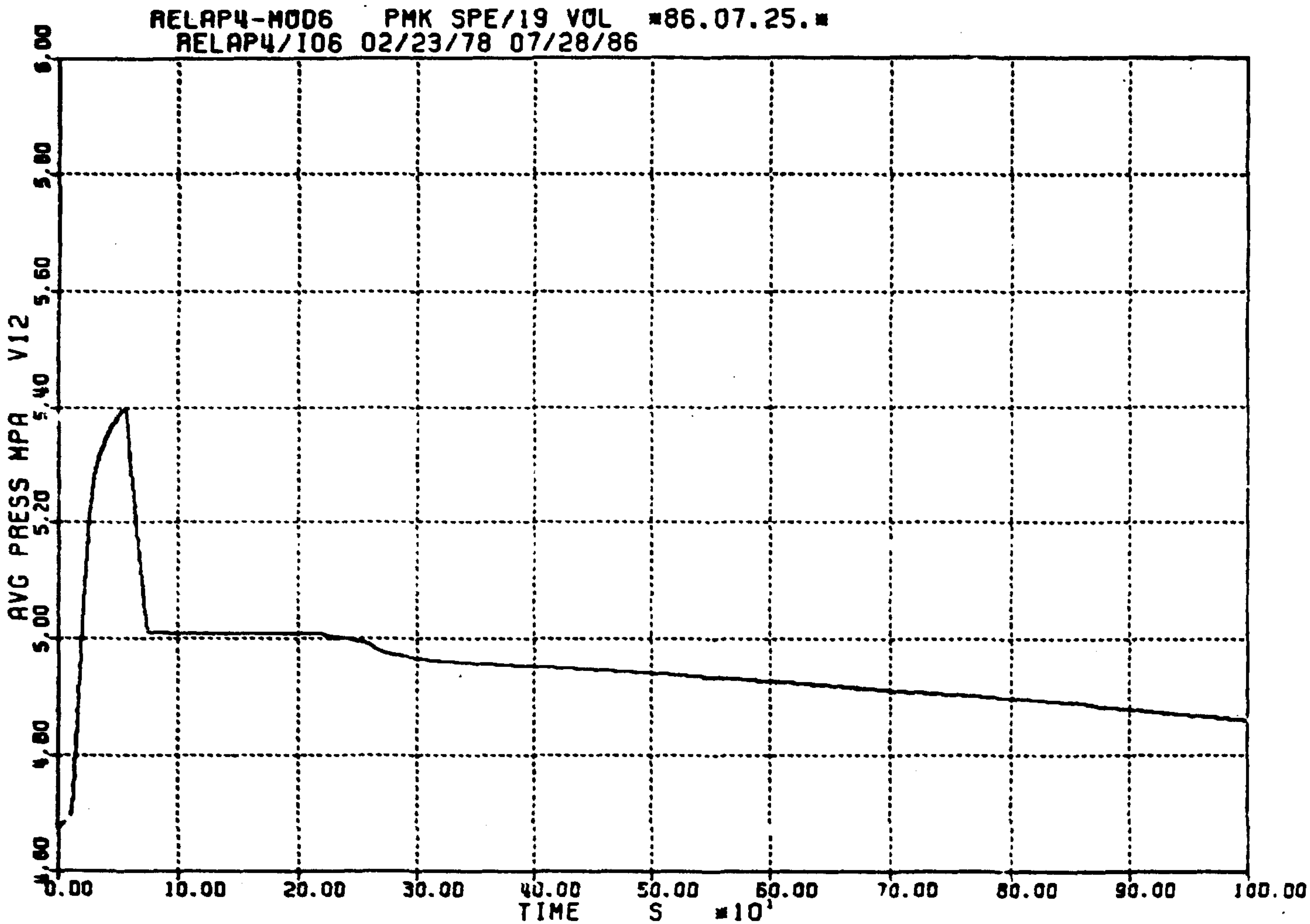
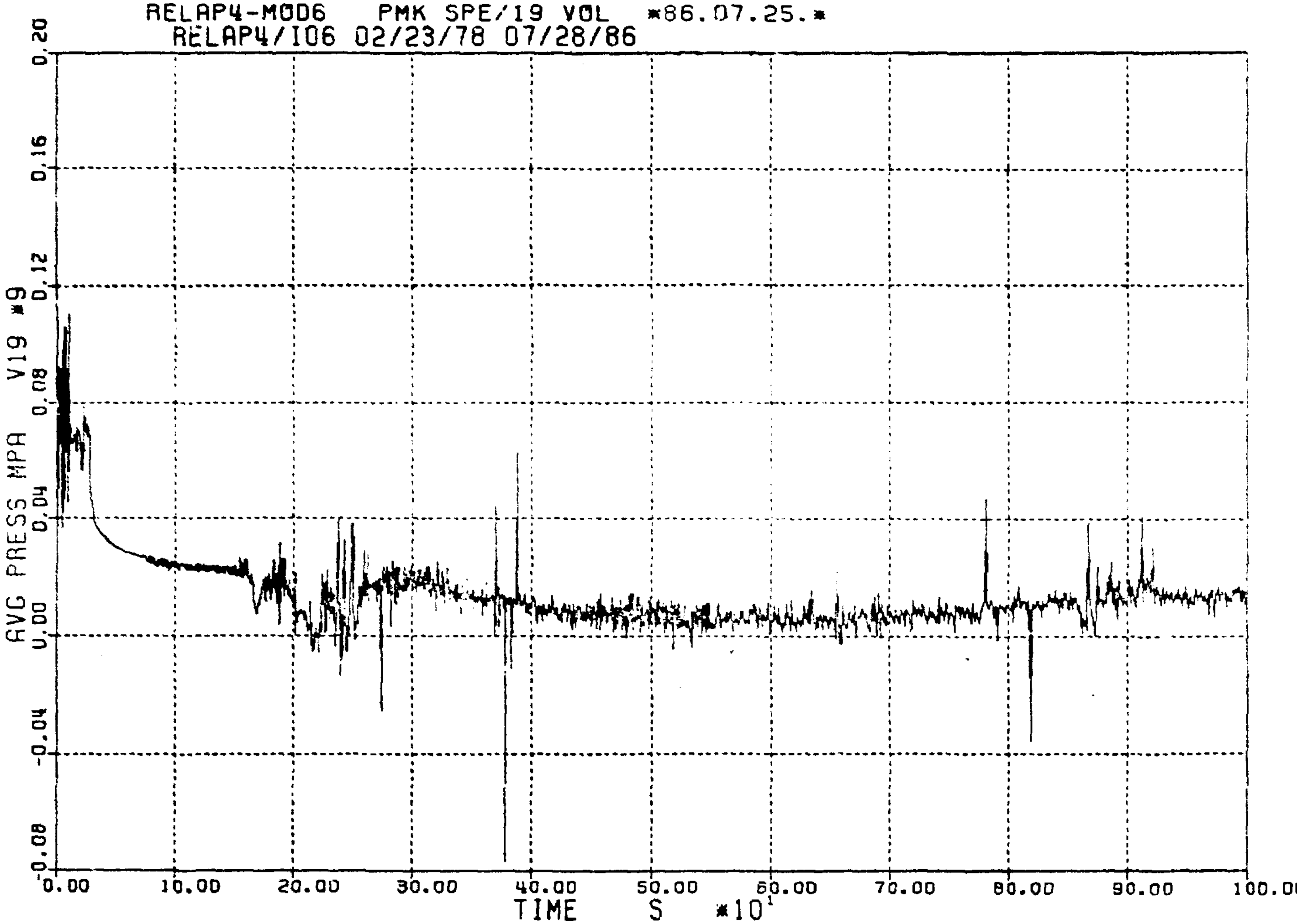

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
AVG PRESS MPA V12
6.00
5.80
5.60
5.40
5.20
5.00
4.80
4.60
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹

Fig. 4.16



RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
AVG PRESS MPA V19 *9
0.20
0.16
0.12
0.08
0.04
0.00
-0.04
-0.08
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10^1

Fig. 4.17

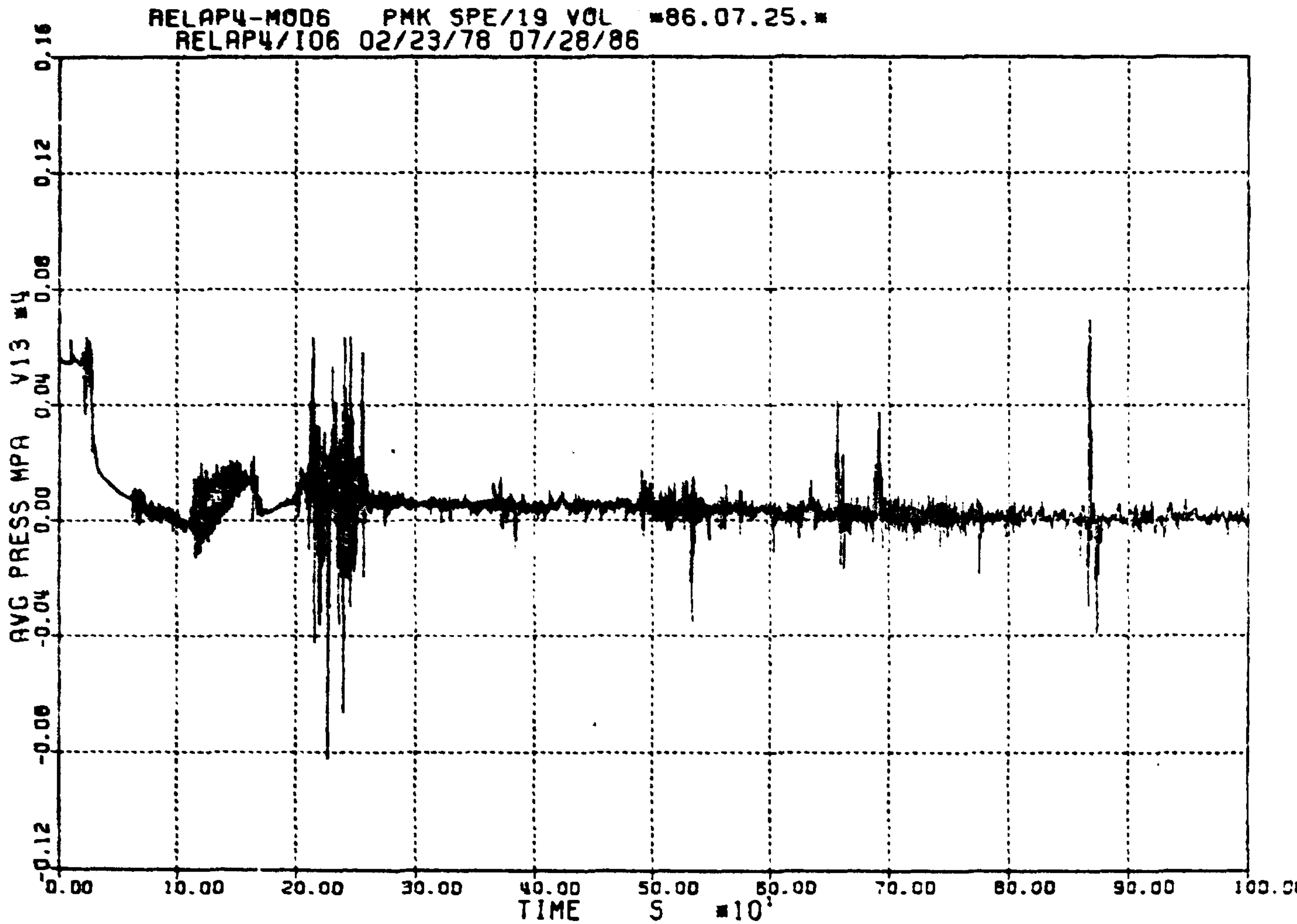

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
AVG PRESS MPA V13 *4
0.16
0.12
0.08
0.04
0.00
-0.04
-0.08
-0.12
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10

Fig. 4.18

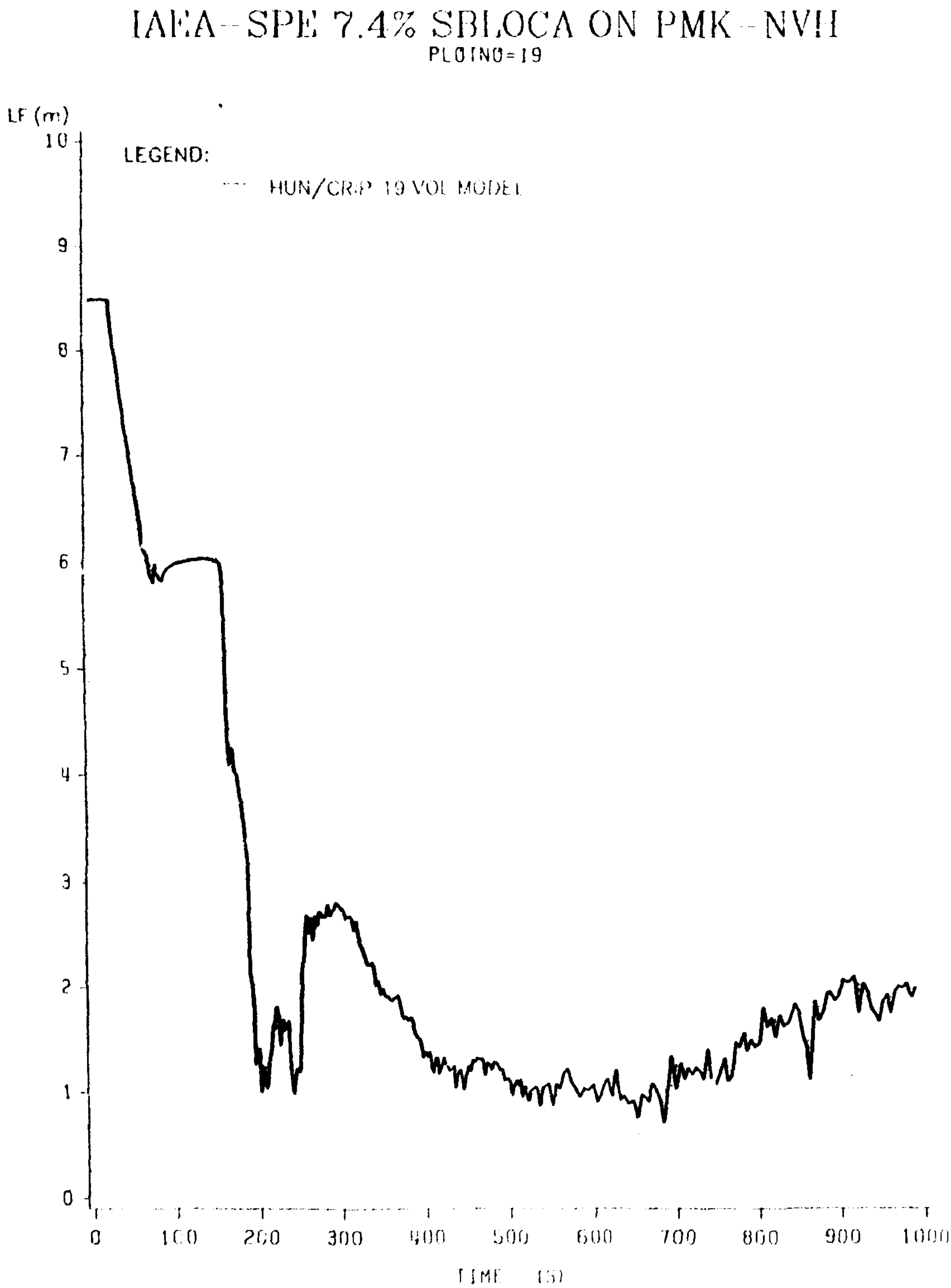

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=19
LF (m)
LEGEND:
HUN/CR-P 19 VOL MODEL
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.19

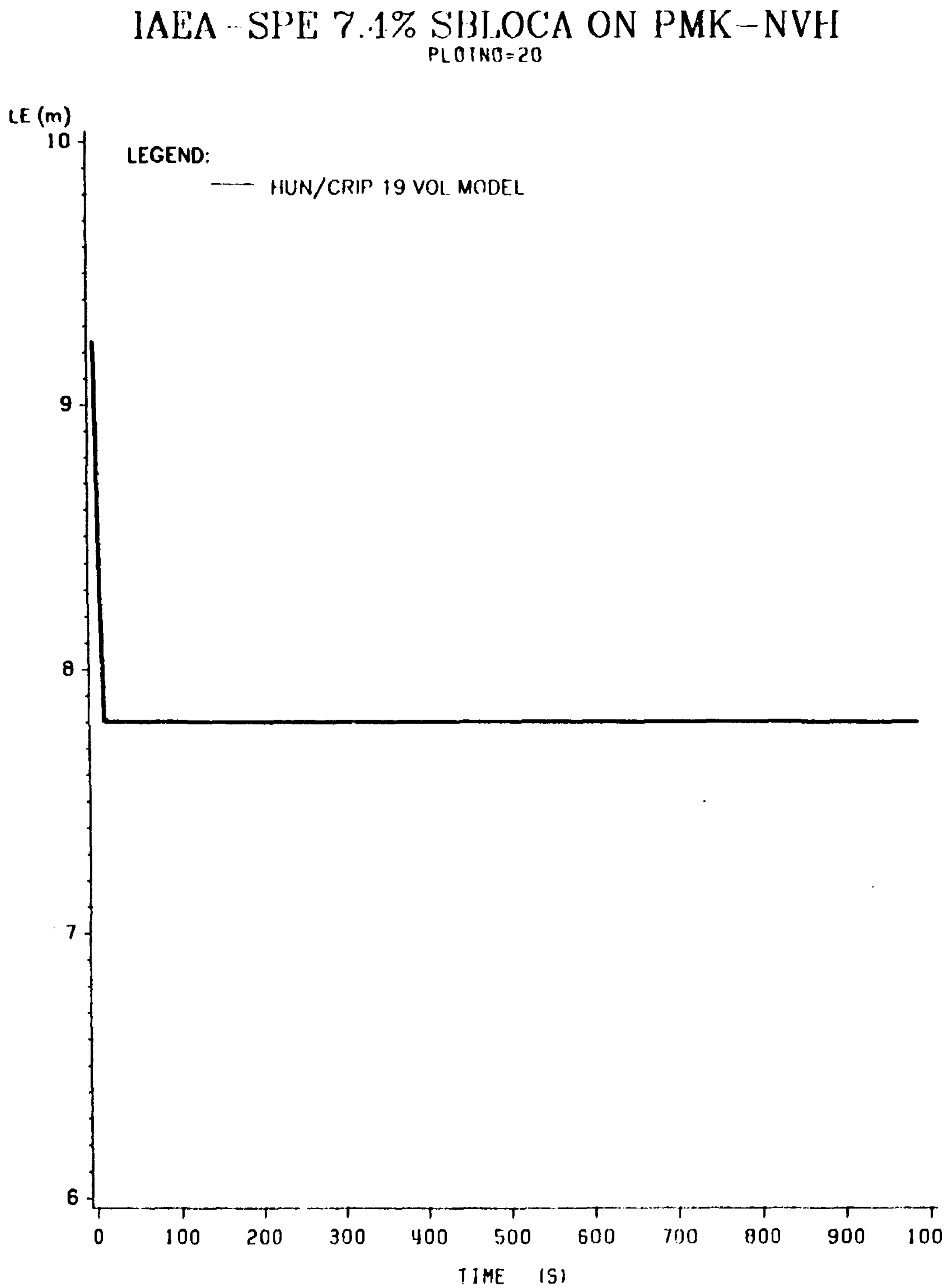

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=20
LE (m)
10
9
8
7
6
LEGEND:
HUN/CRIP 19 VOL MODEL
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.20

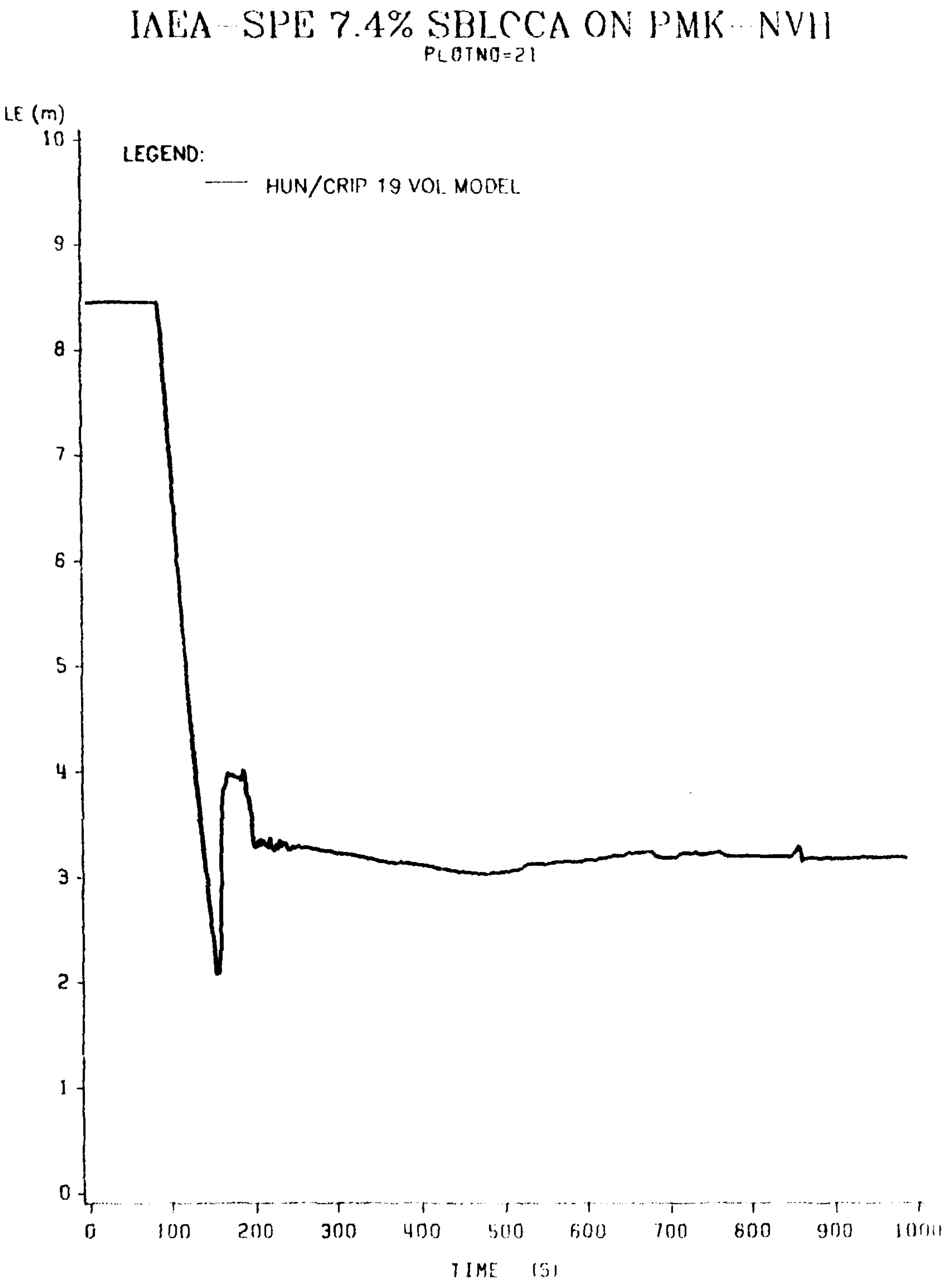

IAEA–SPE 7.4% SBLCCA ON PMK–NVH
PLOTNO=21
LE (m)
LEGEND:
HUN/CRIP 19 VOL MODEL
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.21

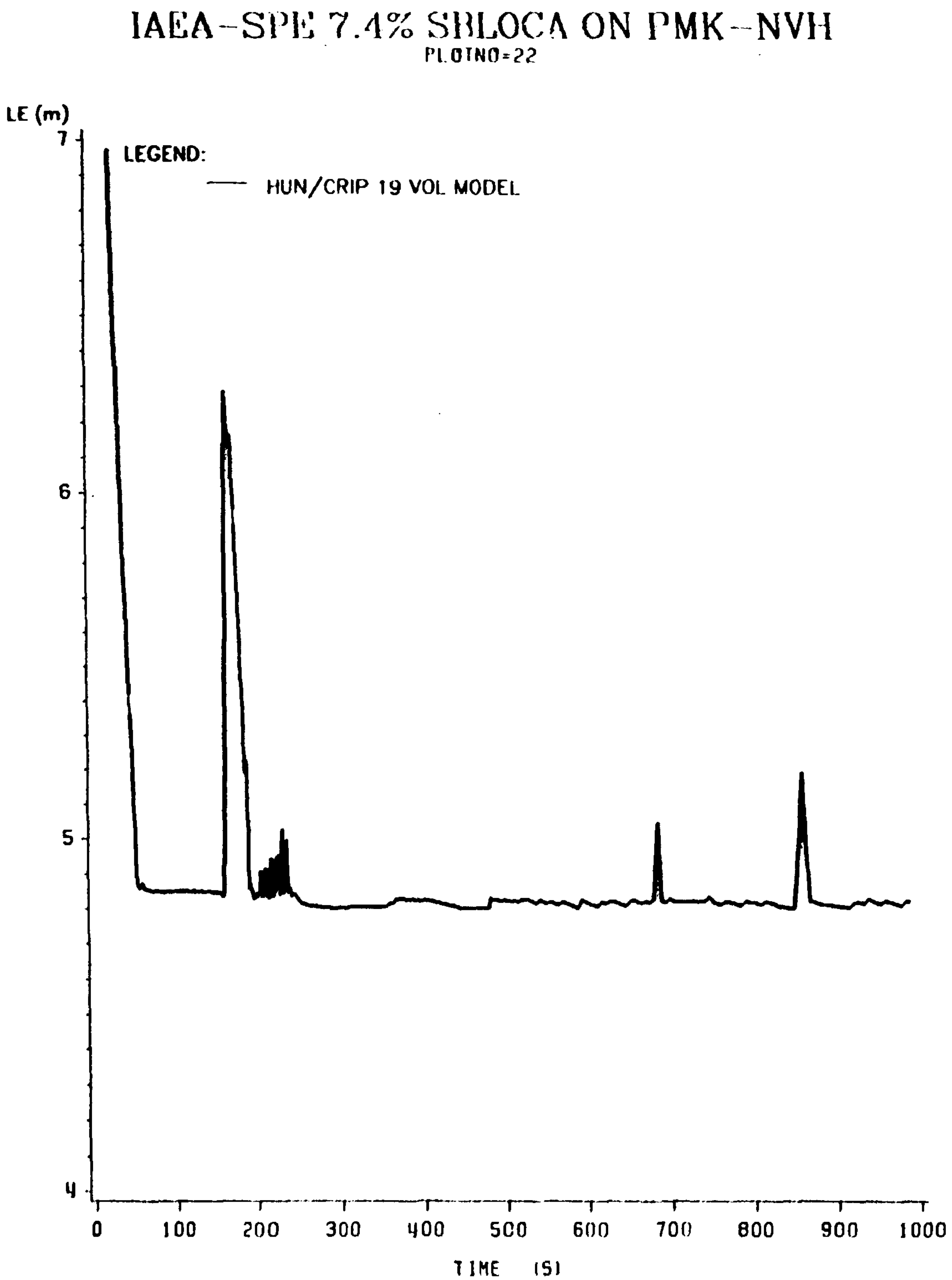

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=22
LE (m)
LEGEND:
HUN/CRIP 19 VOL MODEL
7
6
5
4
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.22

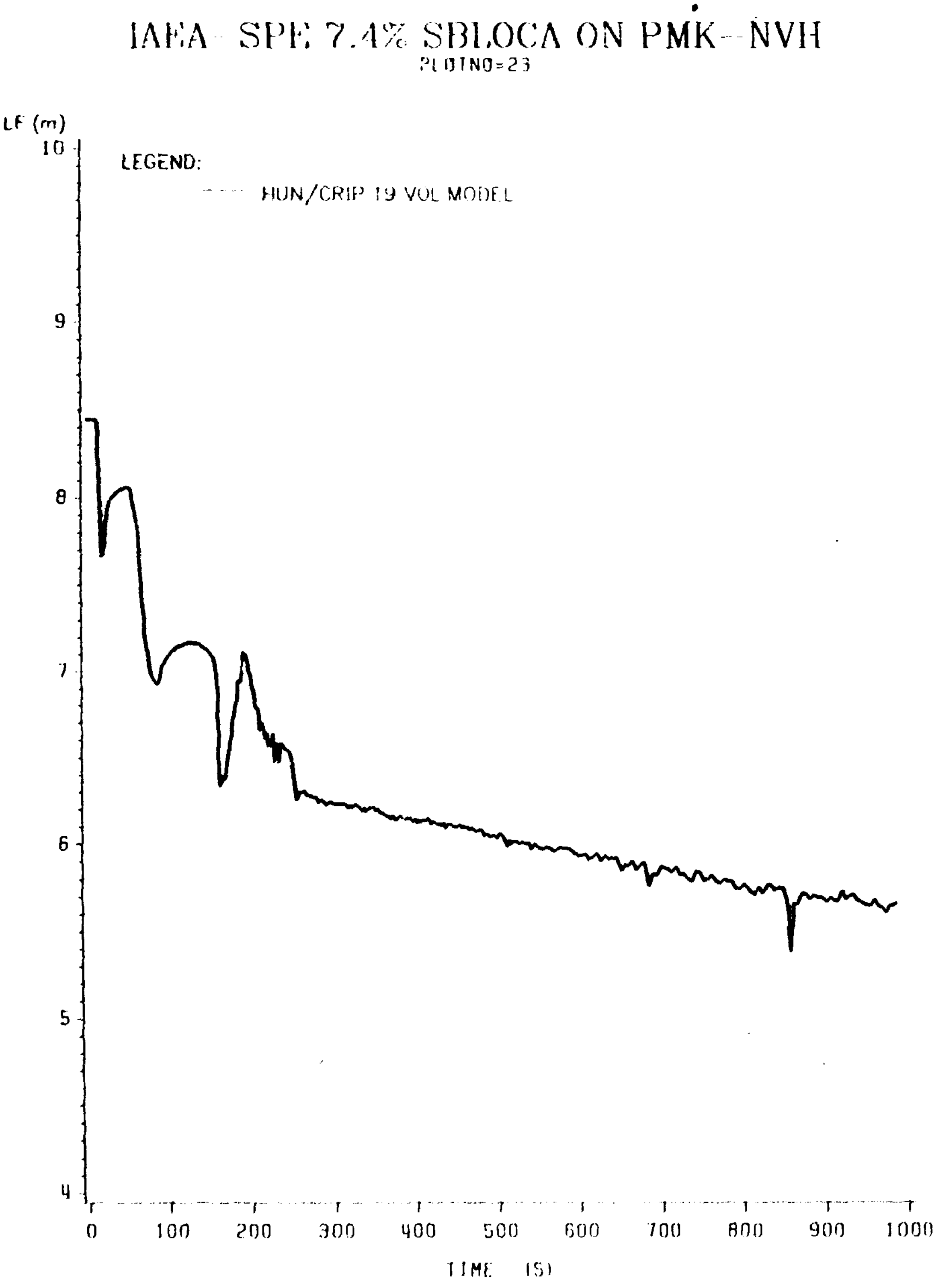

IAEA SPE 7.4% SBLOCA ON PMK--NVH
PLOTNO=23
LF (m)
LEGEND:
HUN/CRIP 19 VOL MODEL
10
9
8
7
6
5
4
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.23

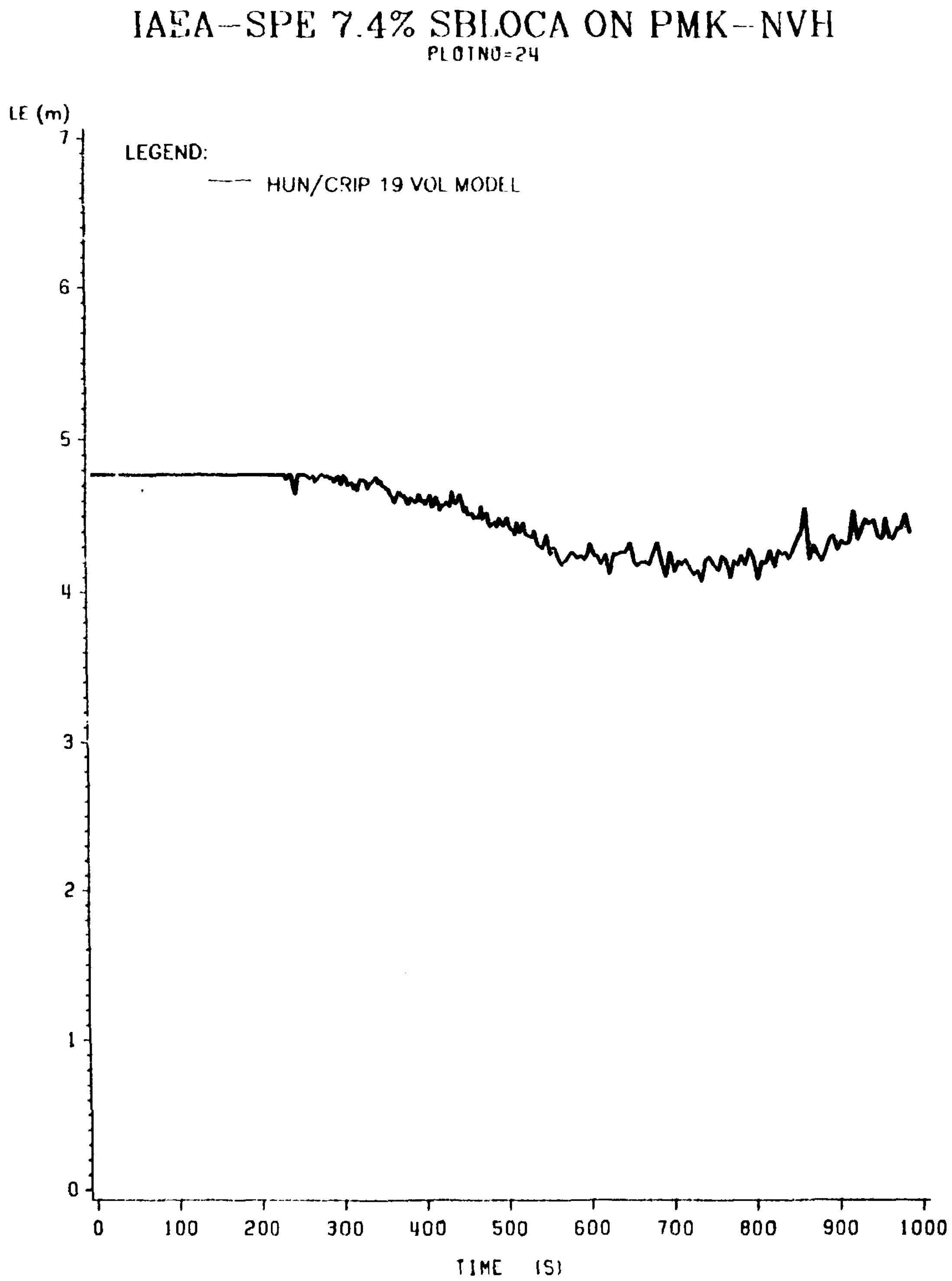

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=24
LE (m)
LEGEND:
HUN/CRIP 19 VOL MODEL
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.24

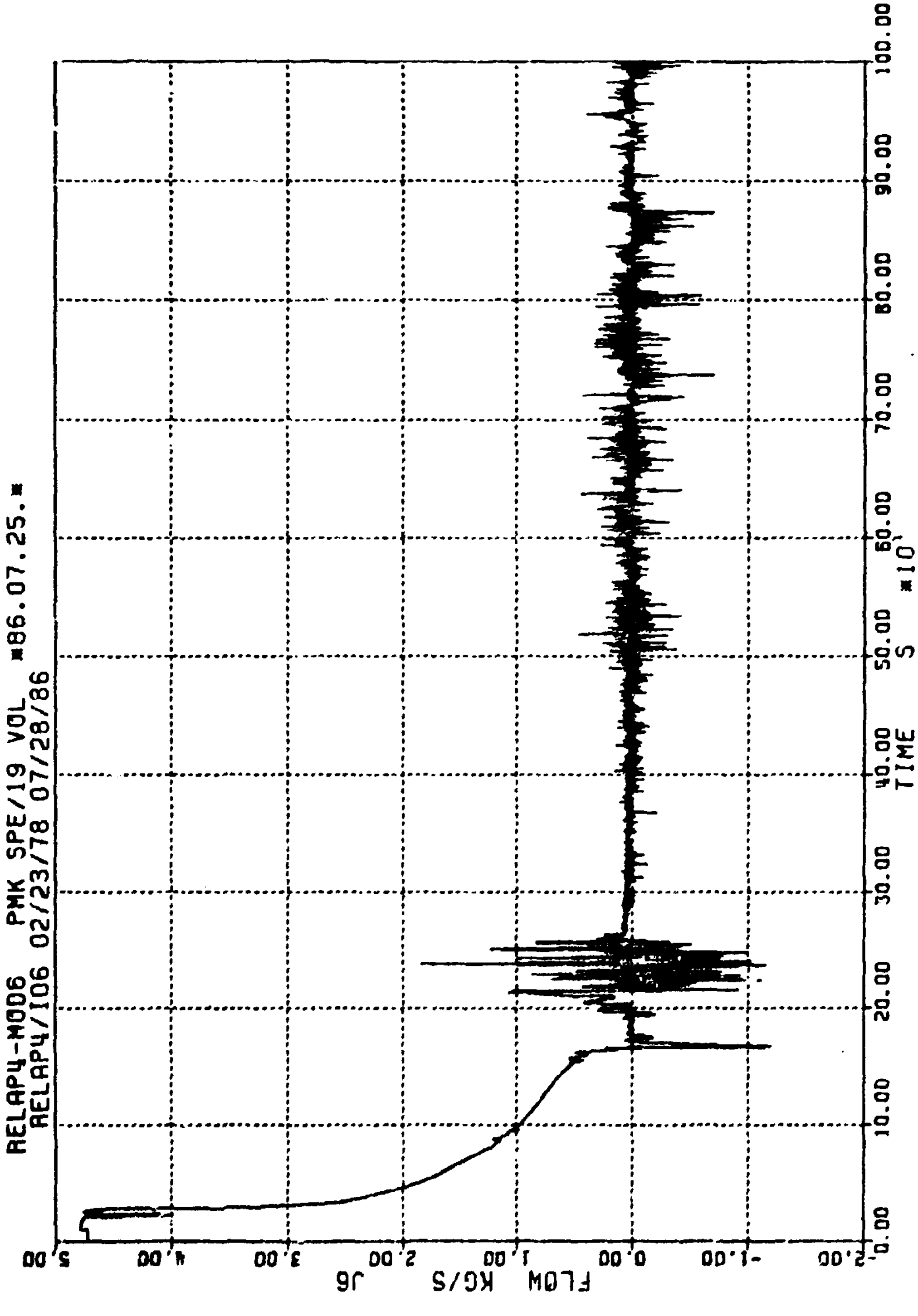

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
FLOW KG/S J6
TIME S *10
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.25

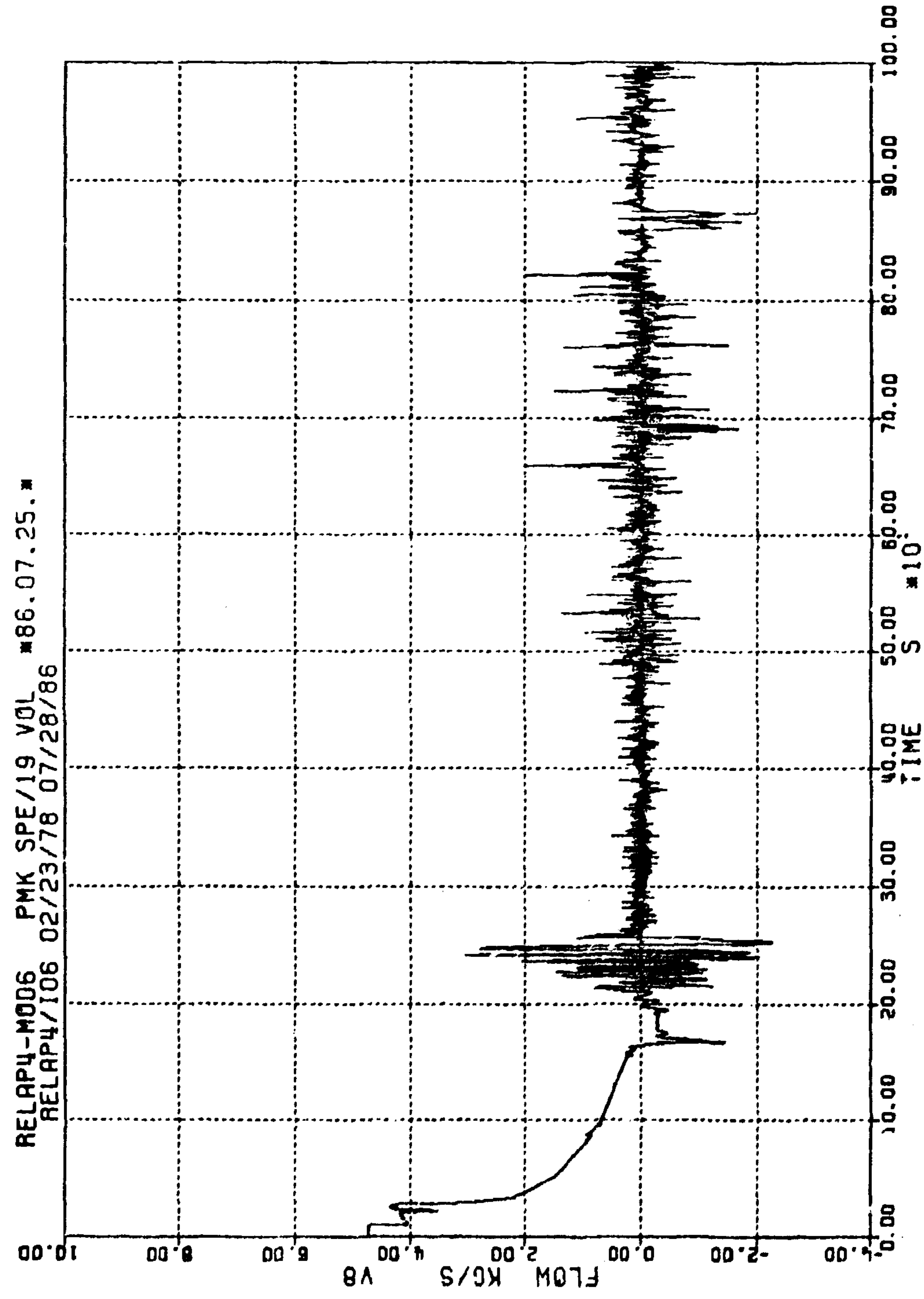
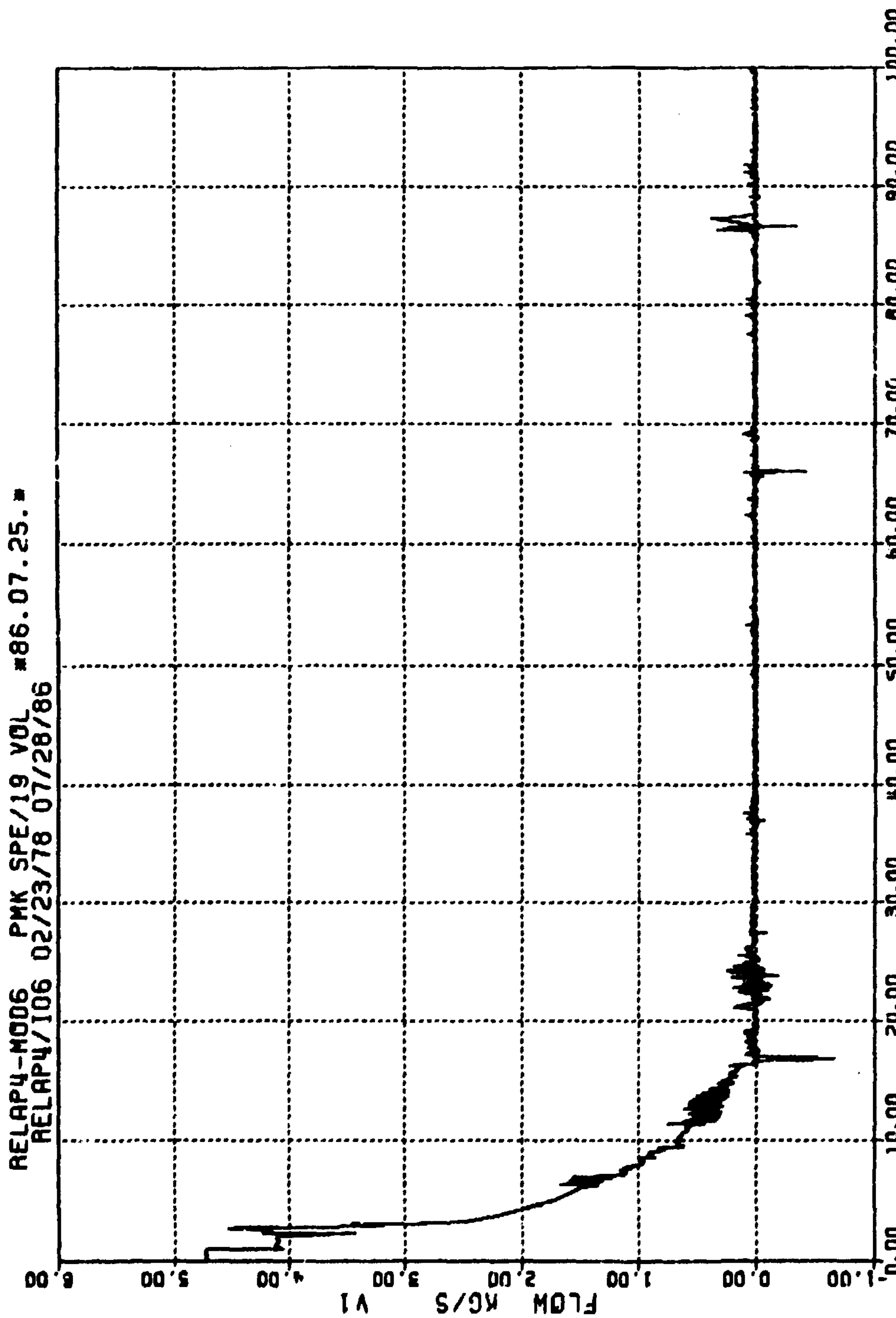

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
FLOW KG/S V8
TIME S *10¹
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.26



RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
FLOW KG/S V1
TIME S *10[1]
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.27

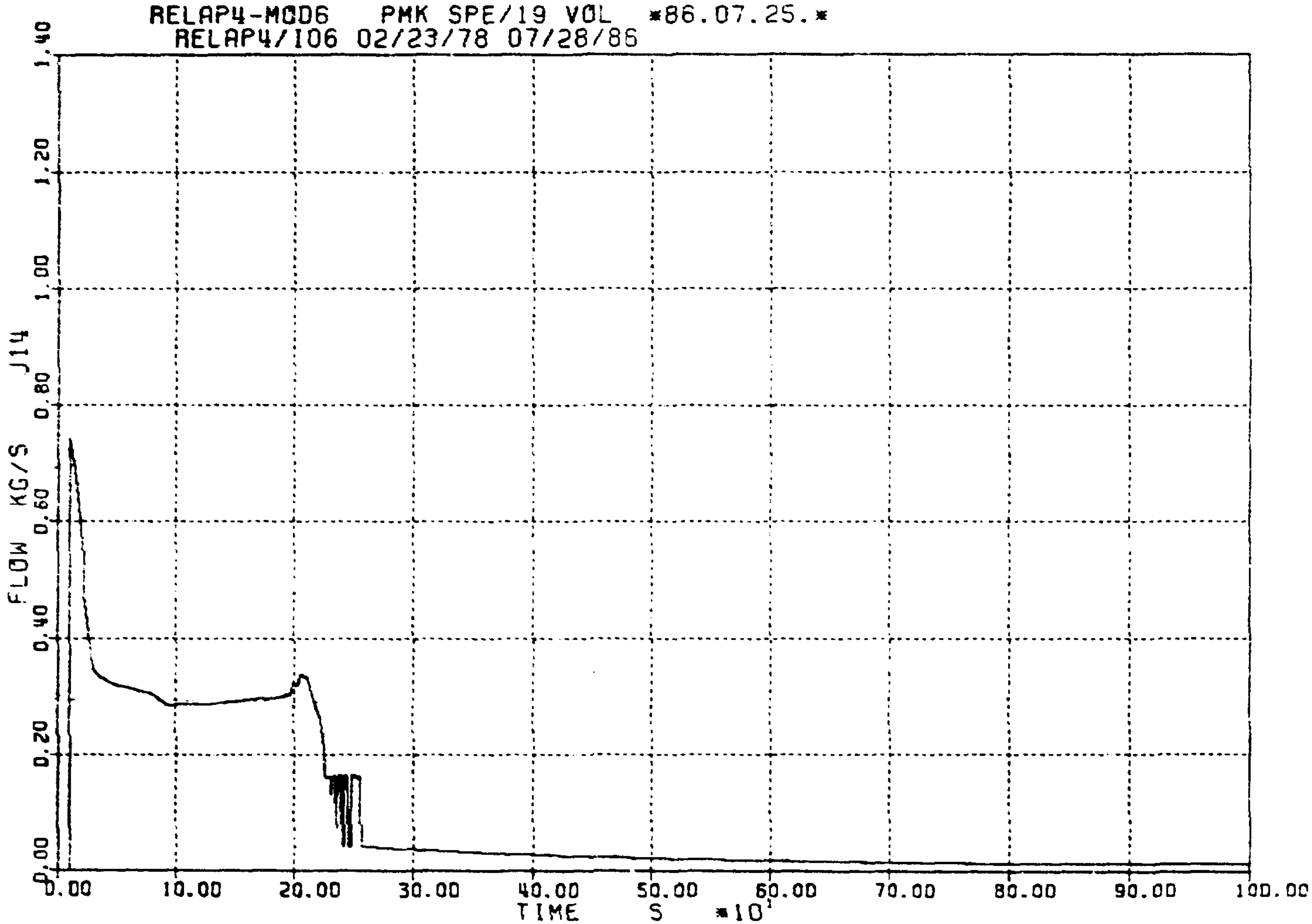

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
FLOW KG/S J14
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹

Fig. 4.28

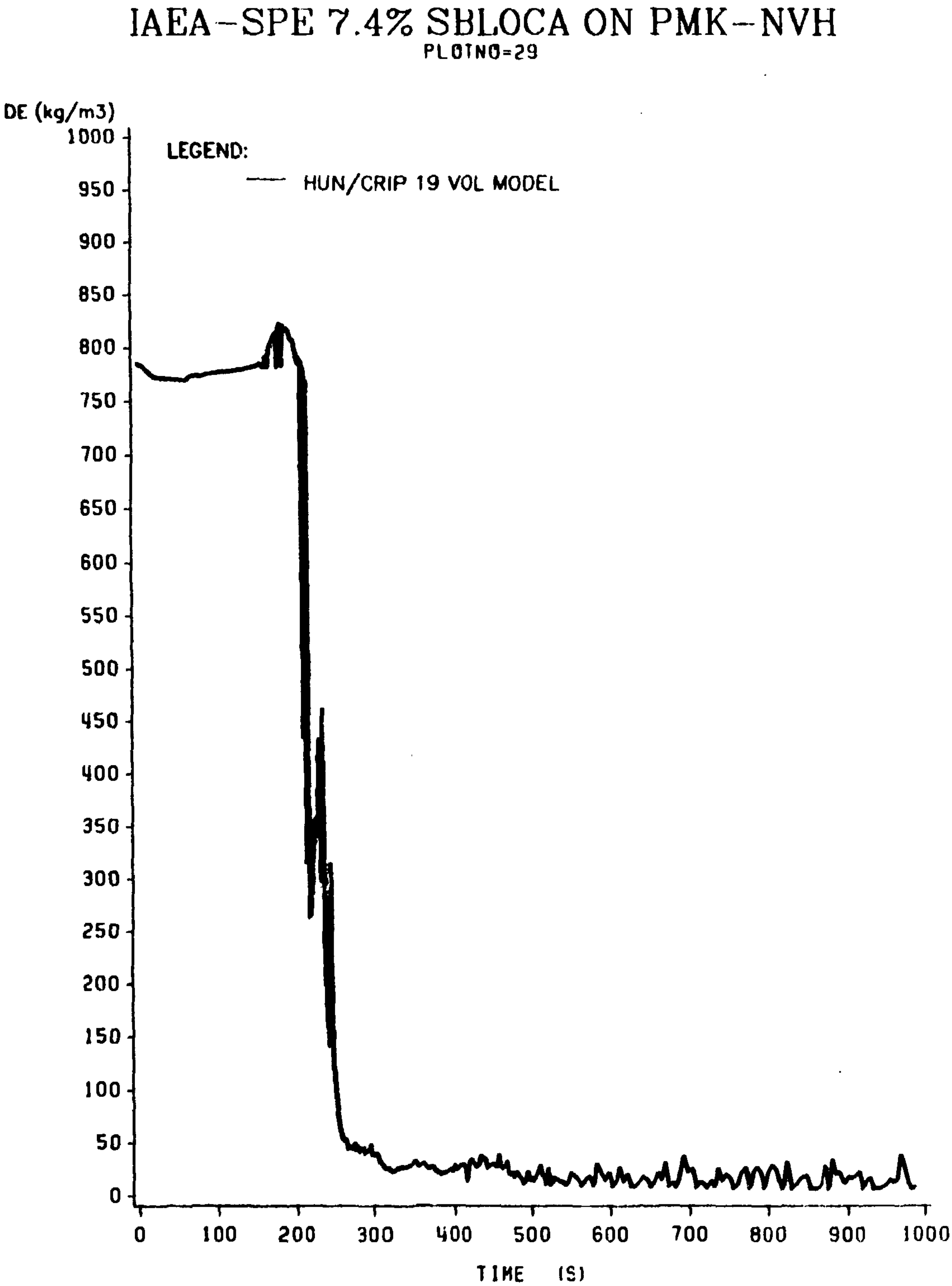

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=29
DE (kg/m3)
LEGEND:
HUN/CRIP 19 VOL MODEL
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.29

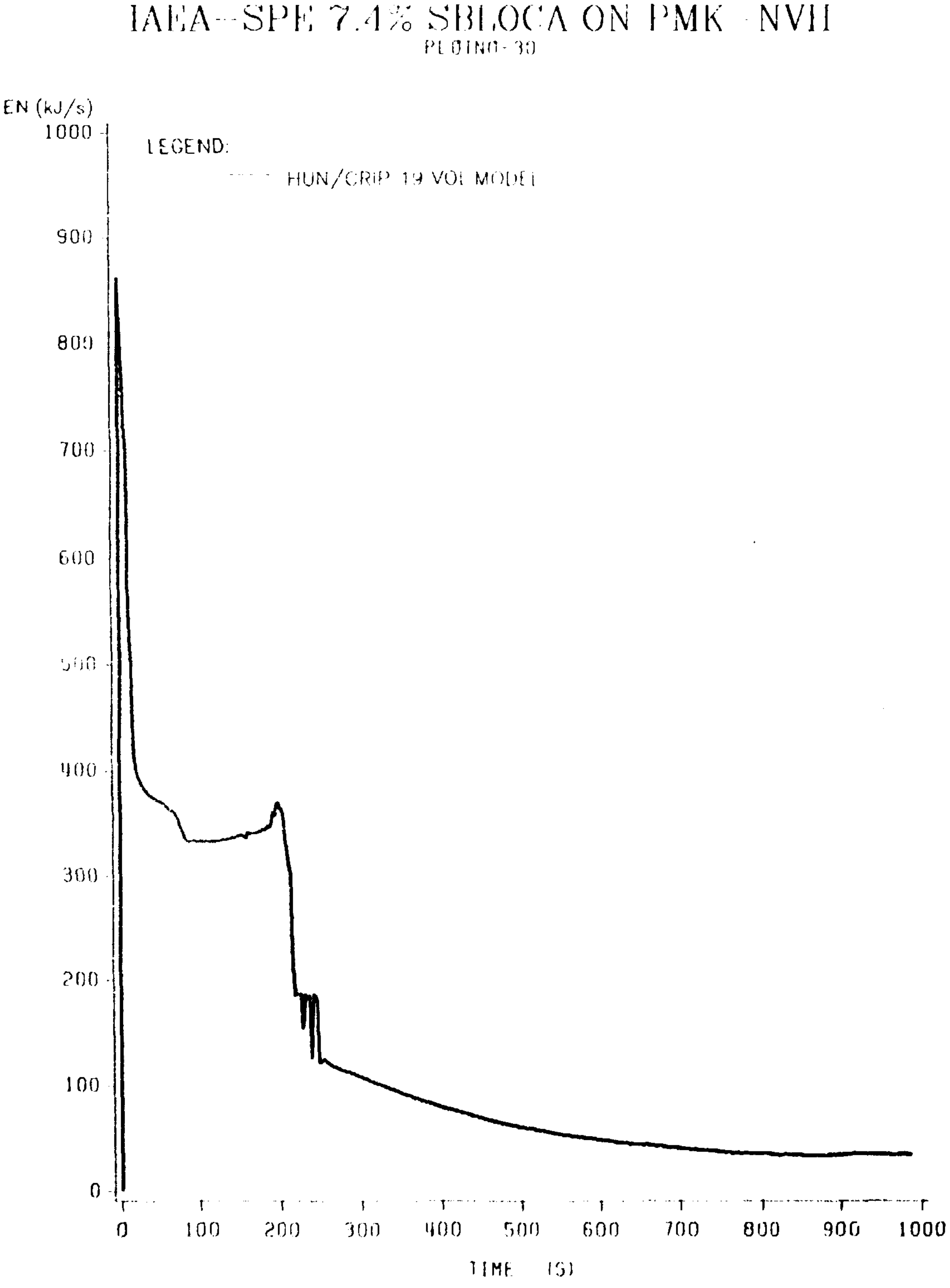

IAEA--SPE 7.4% SBLOCA ON PMK -NVH
EN (kJ/s)
1000
900
800
700
600
500
400
300
200
100
0
LEGEND:
HUN/CRIP 19 VOL MODEL
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.30

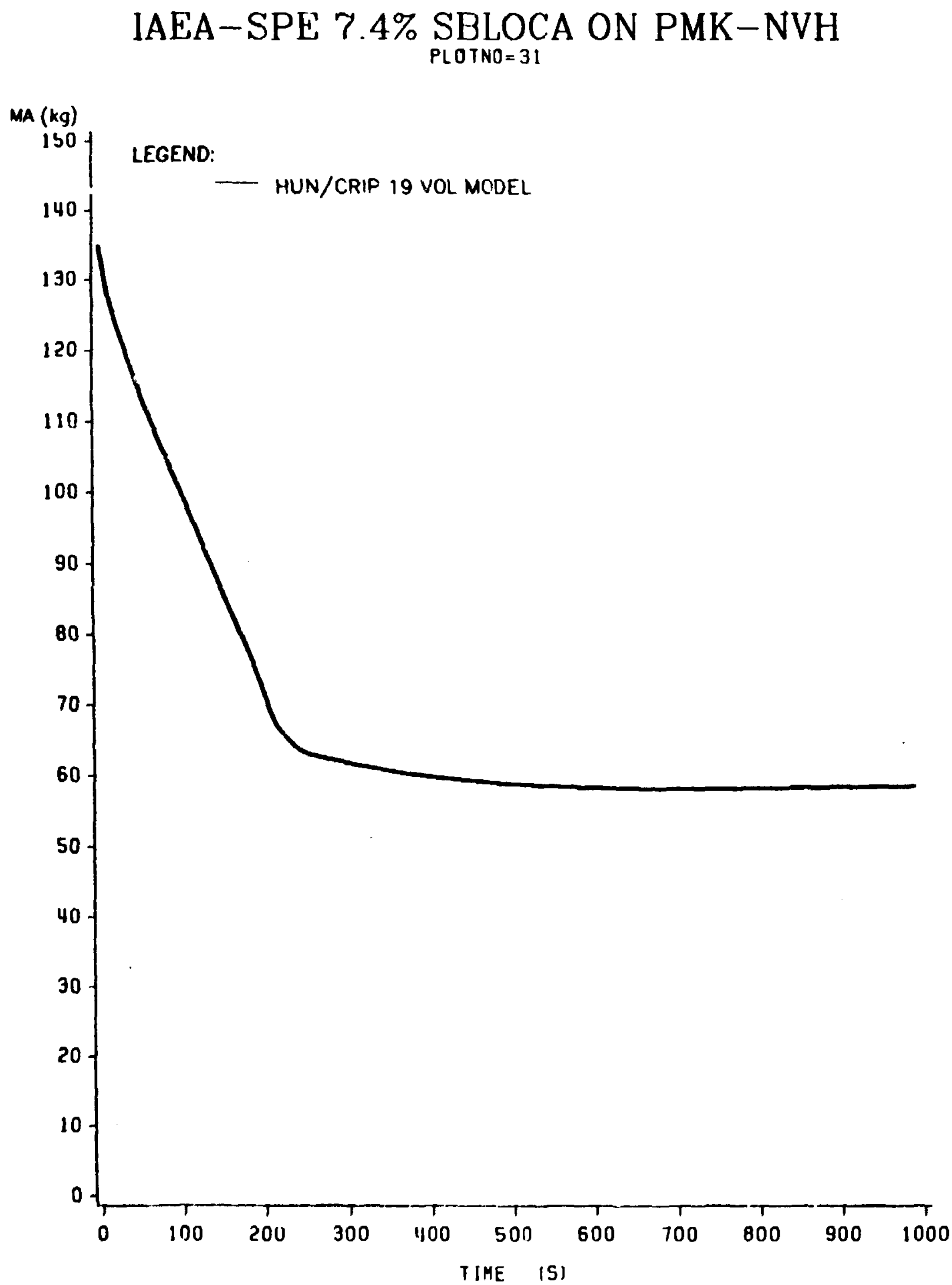

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=31
MA (kg)
LEGEND:
HUN/CRIP 19 VOL MODEL
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.31

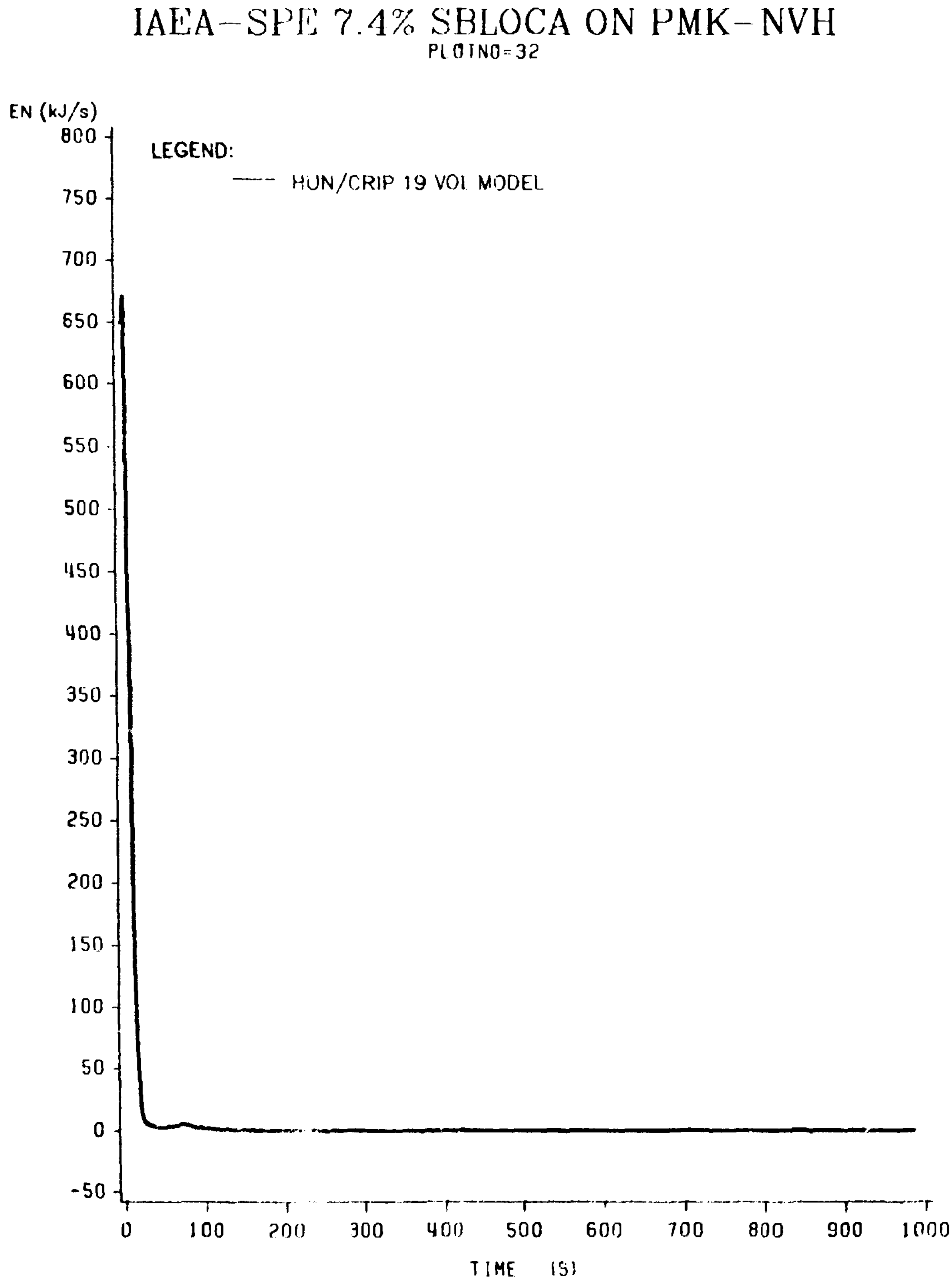

IAEA–SPE 7.4% SBLOCA ON PMK–NVH
PLOTNO=32
EN (kJ/s)
LEGEND:
HUN/CRIP 19 VOL MODEL
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.32

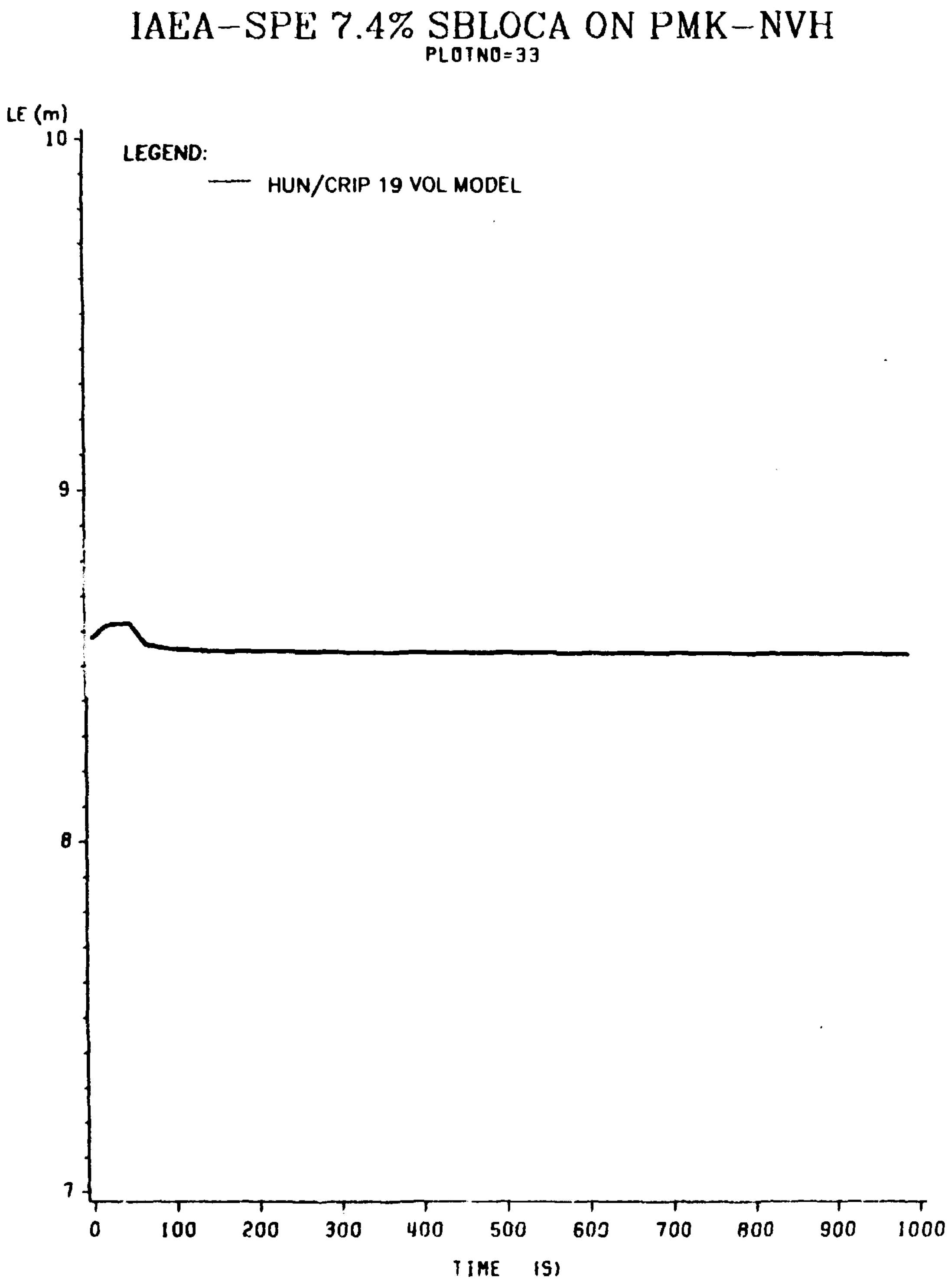

IAEA-SPE 7.4% SBLOCA ON PMK-NVH
PLOTNO=33
LE (m)
10
9
8
7
LEGEND:
HUN/CRIP 19 VOL MODEL
0
100
200
300
400
500
600
700
800
900
1000
TIME (S)

Fig. 4.33

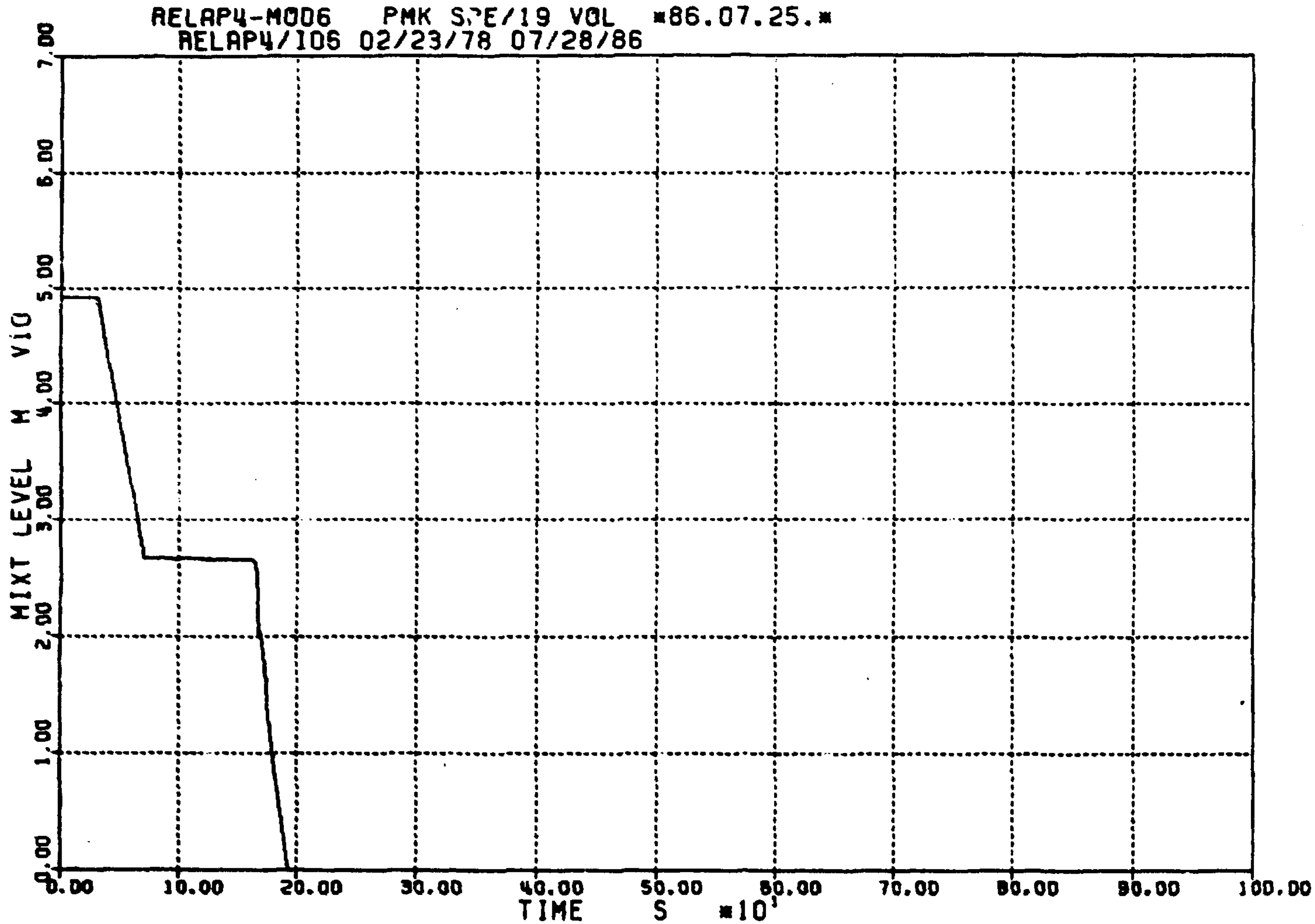

RELAP4-MOD6 PMK S?E/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
MIXT LEVEL M V10
TIME S *10¹
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.34

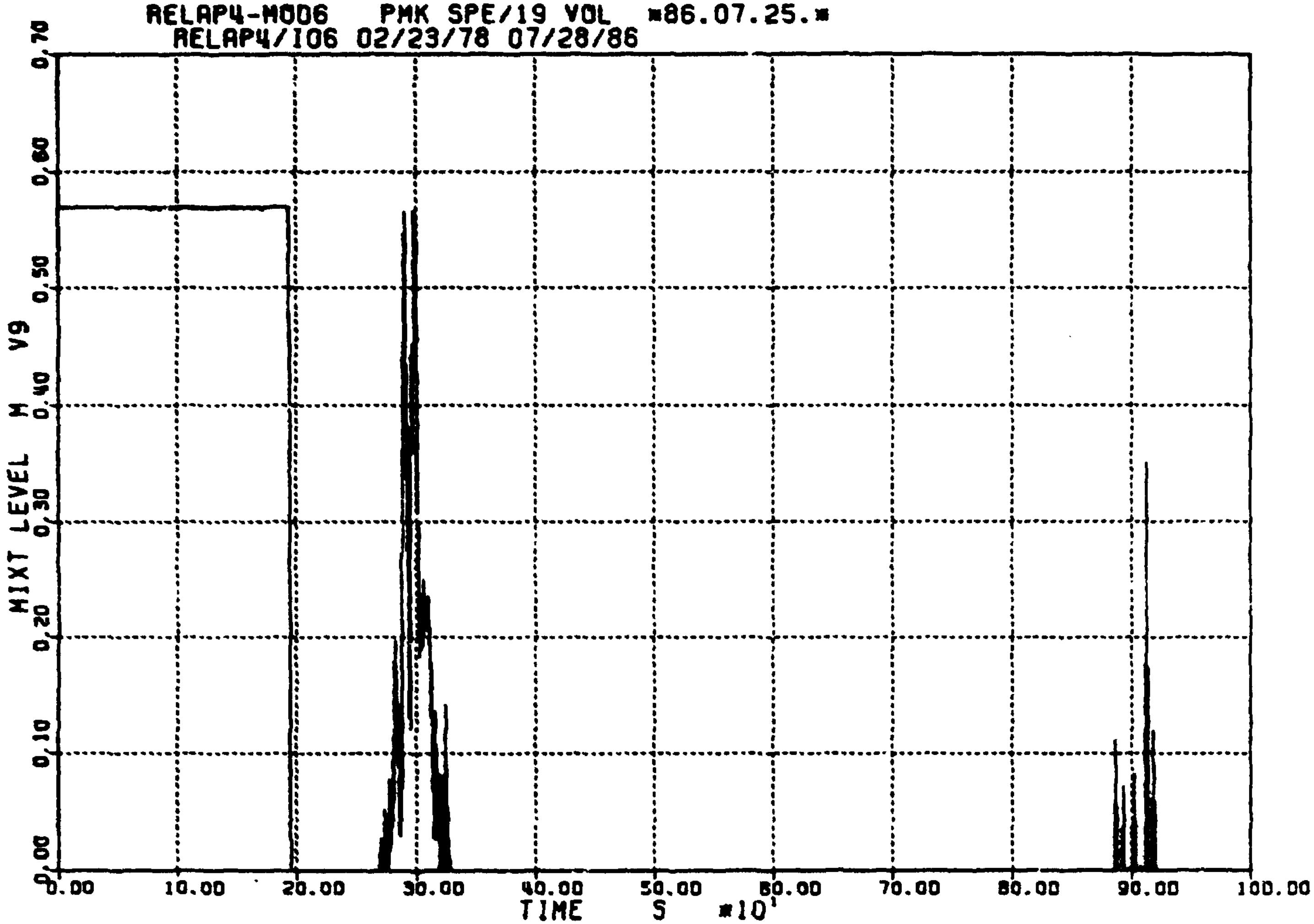

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V9
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10[1]

Fig. 4.35

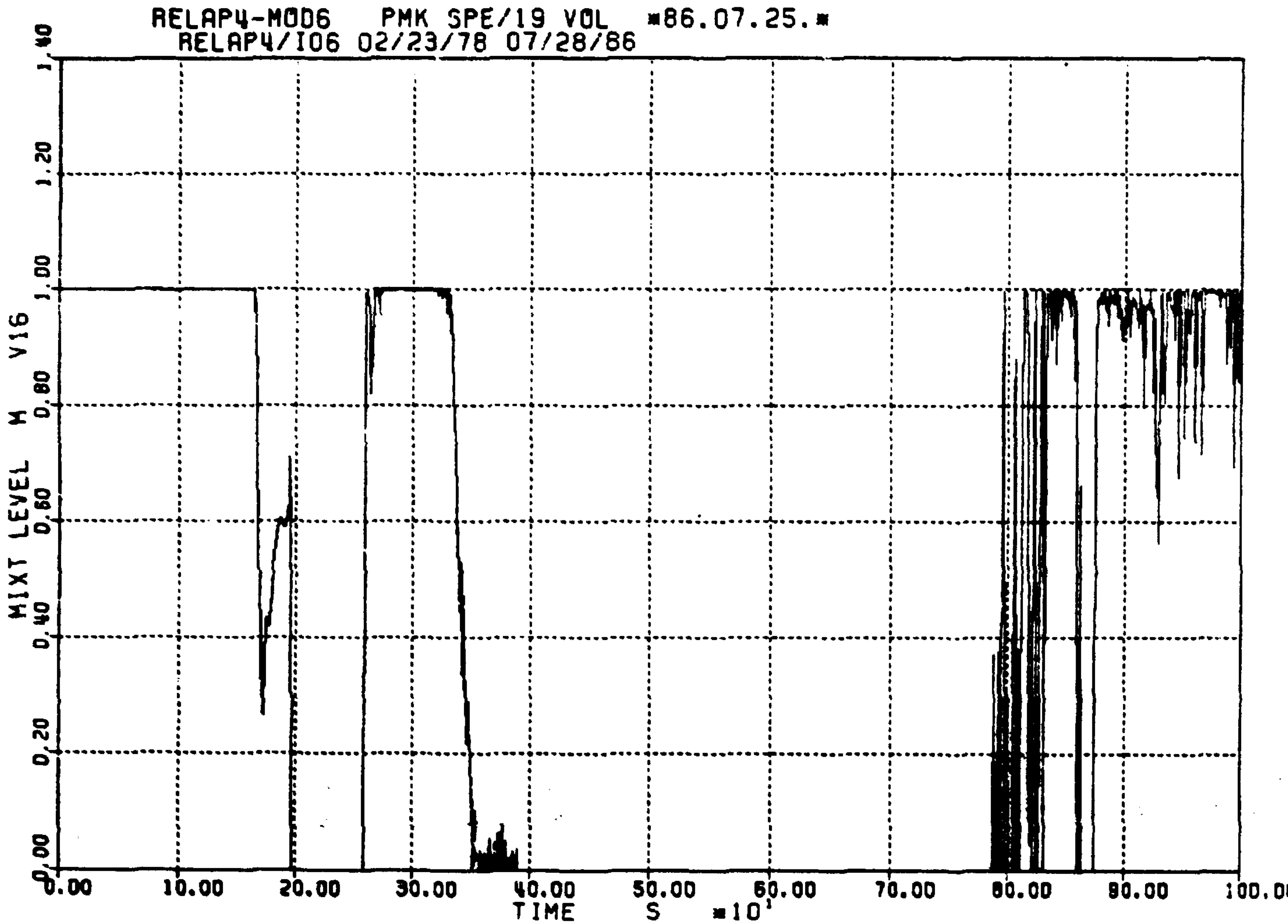

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V16
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹

Fig. 4.36

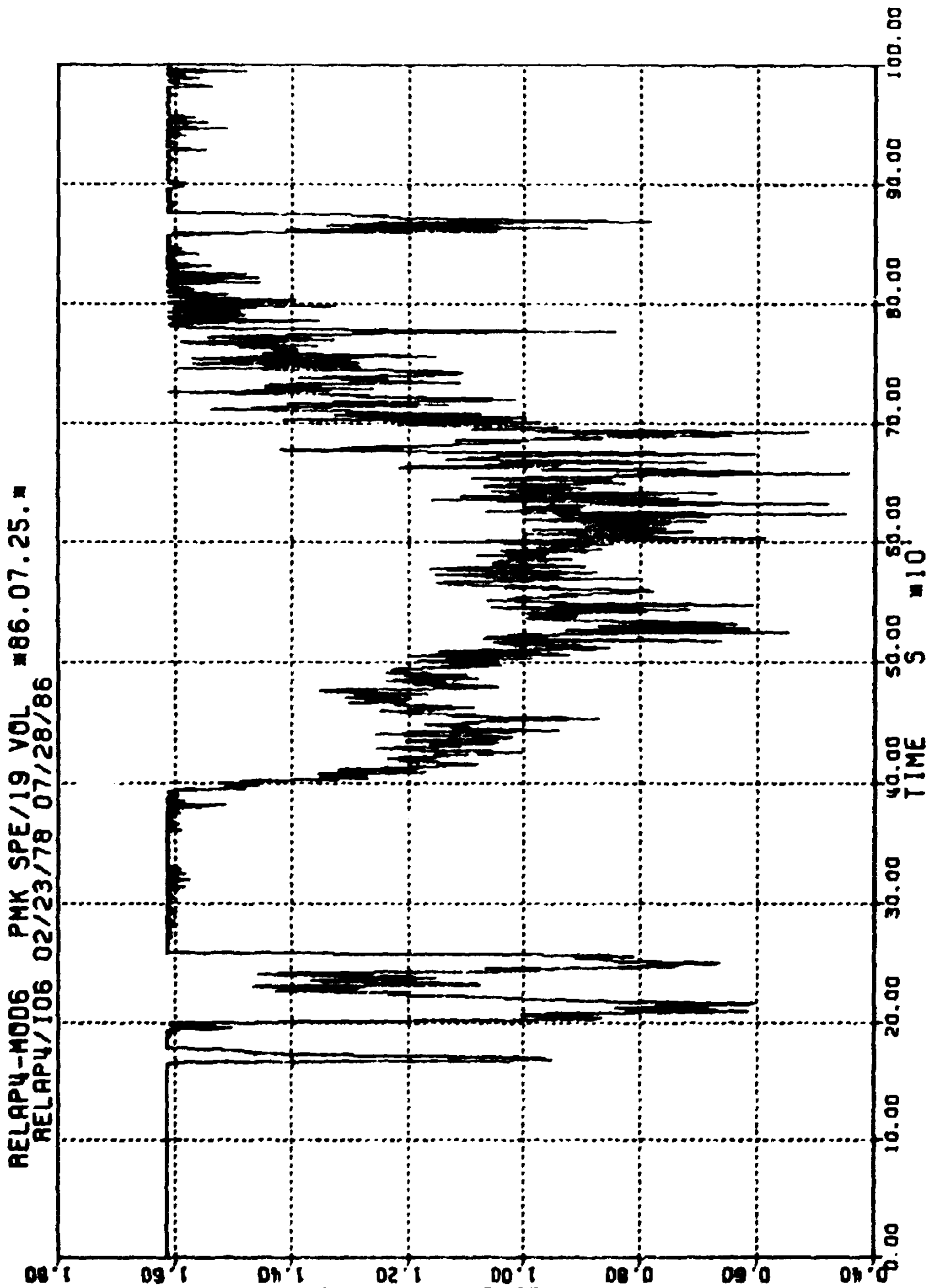

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
MIXT LEVEL M VIS
TIME S *10^1
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80

Fig. 4.37

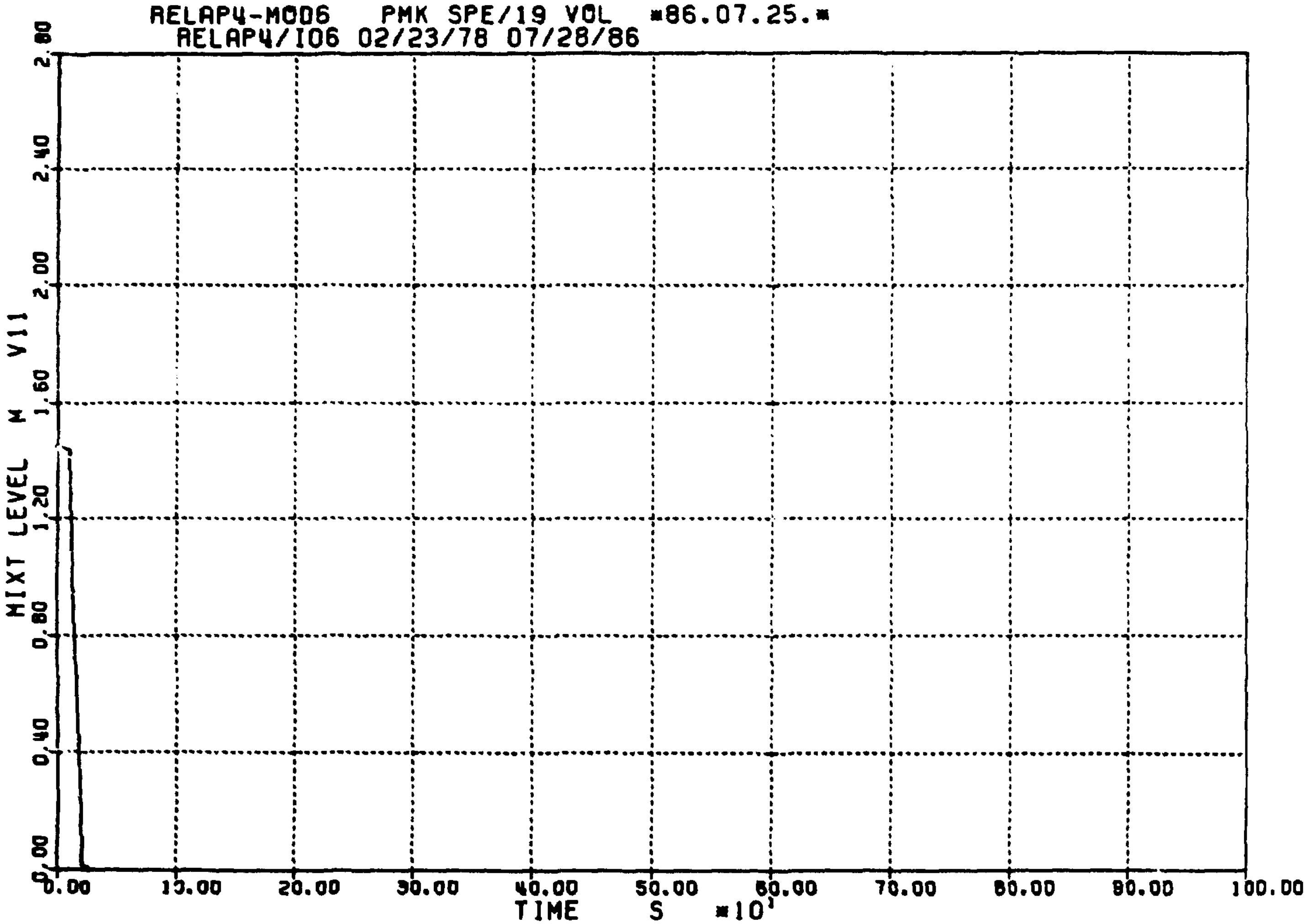

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V11
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10

Fig. 4.38

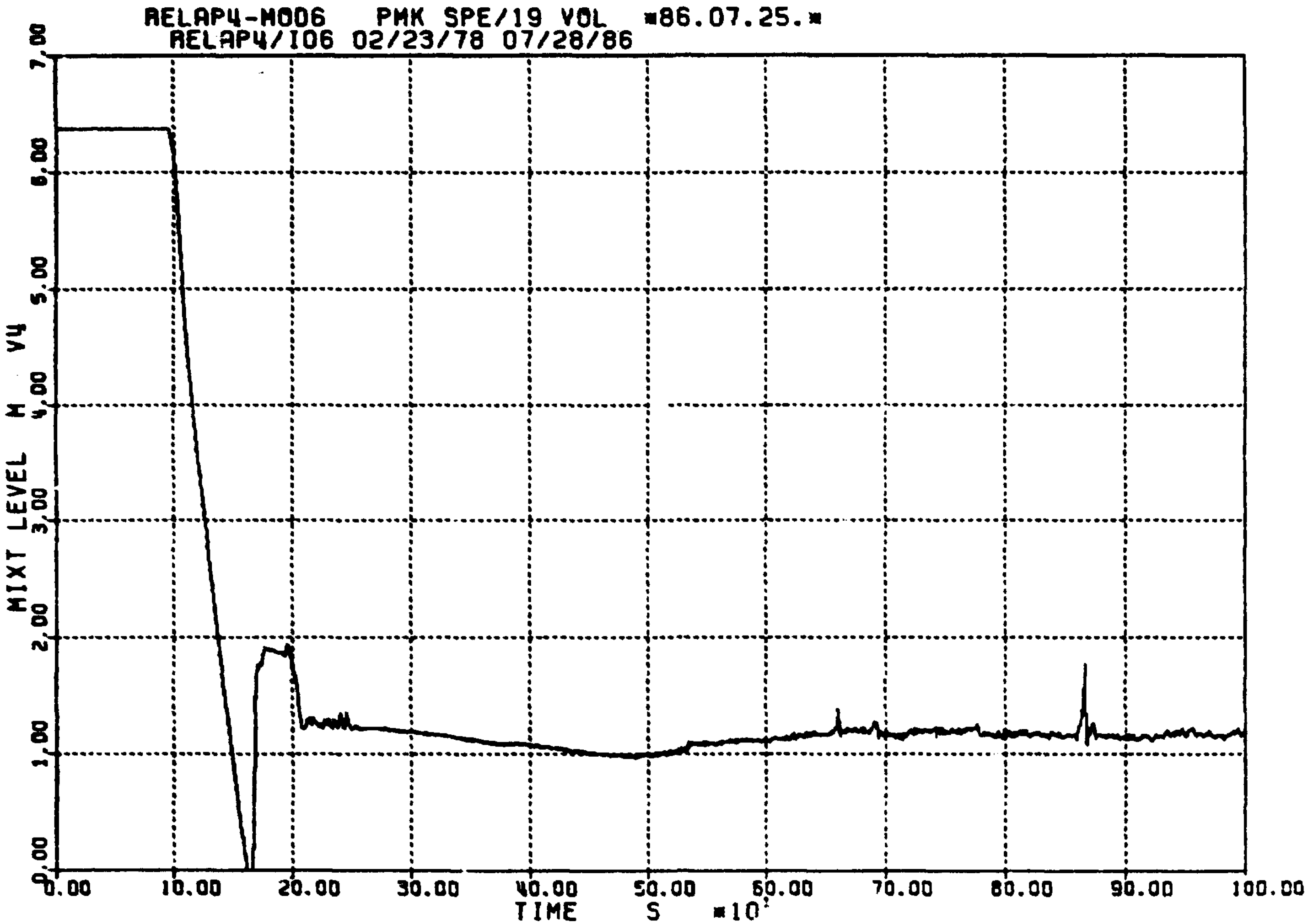

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V4
TIME S *10
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.39

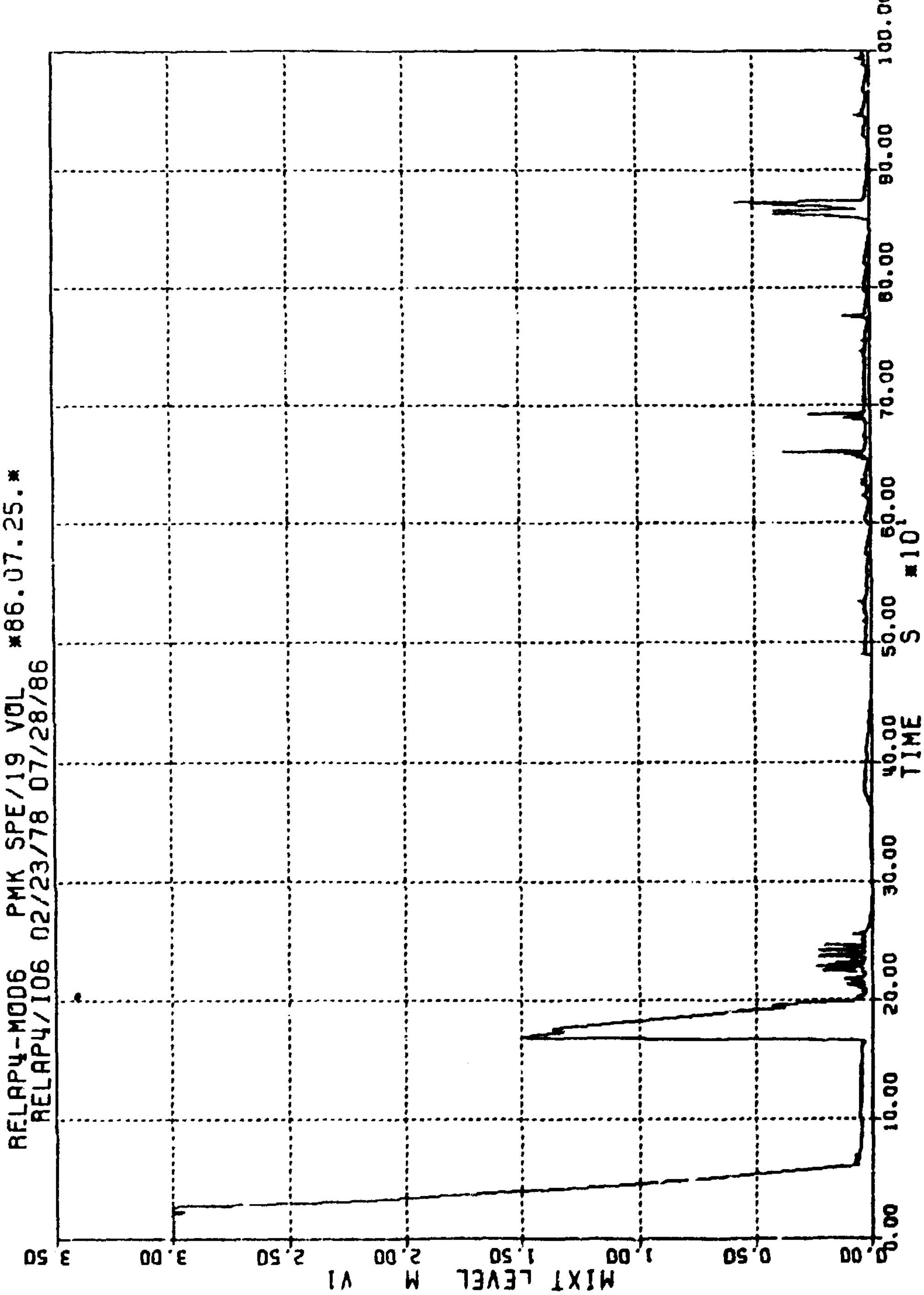

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
MIXT LEVEL M V1
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50

Fig. 4.40

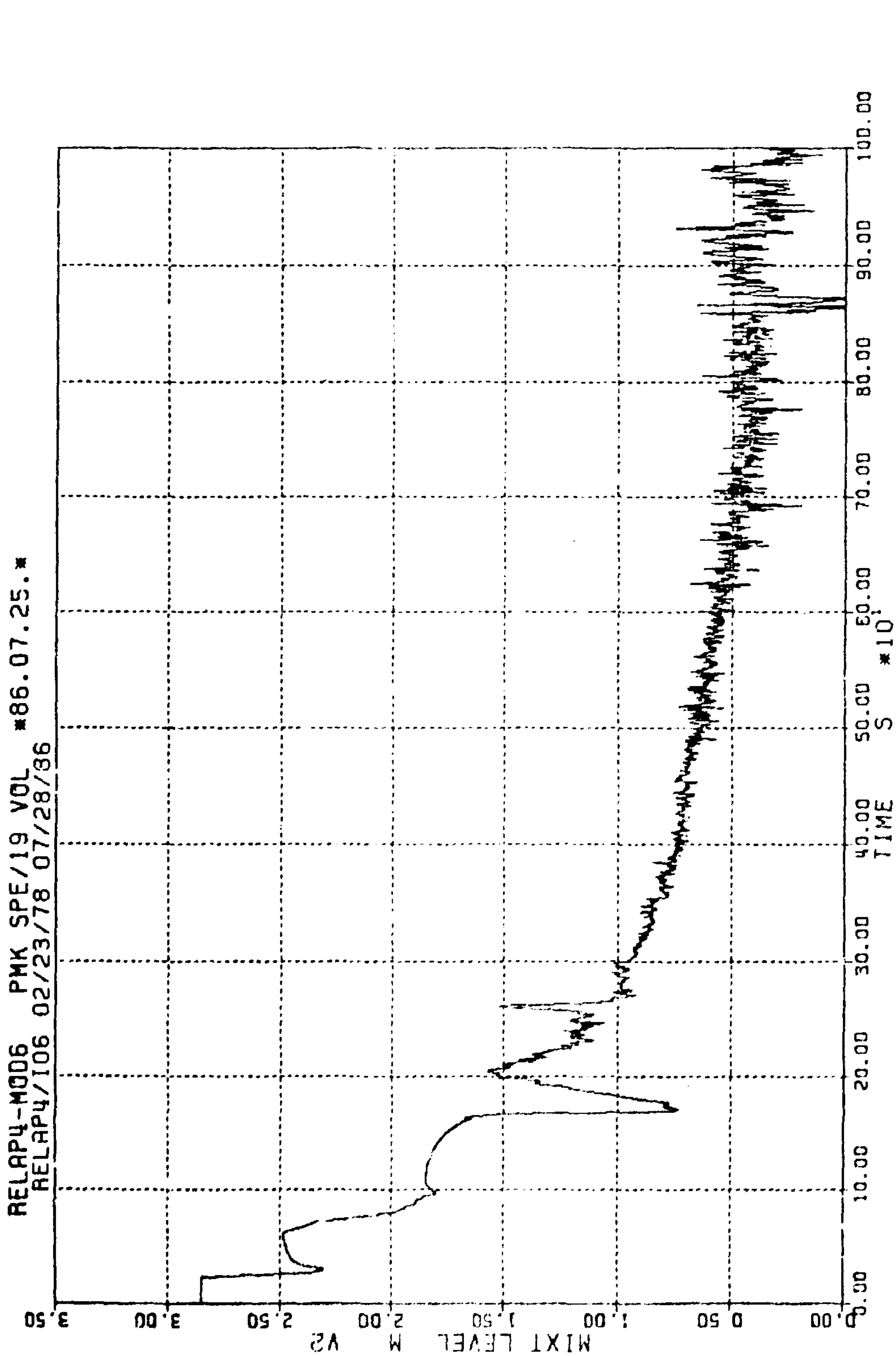

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V2
TIME S *10[1]
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50

Fig. 4.41

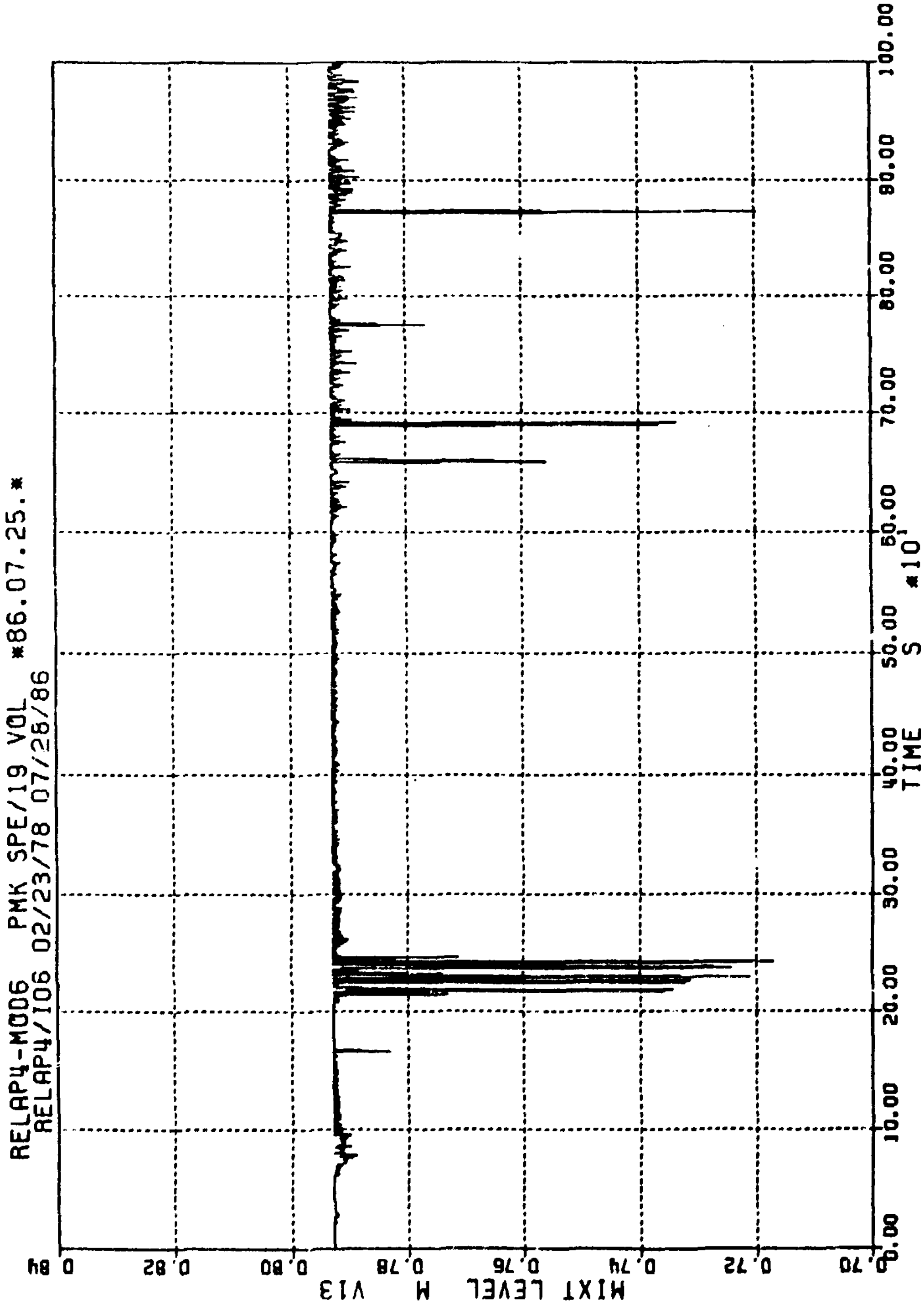

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V13
0.70
0.72
0.74
0.76
0.78
0.80
0.82
0.84
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.42

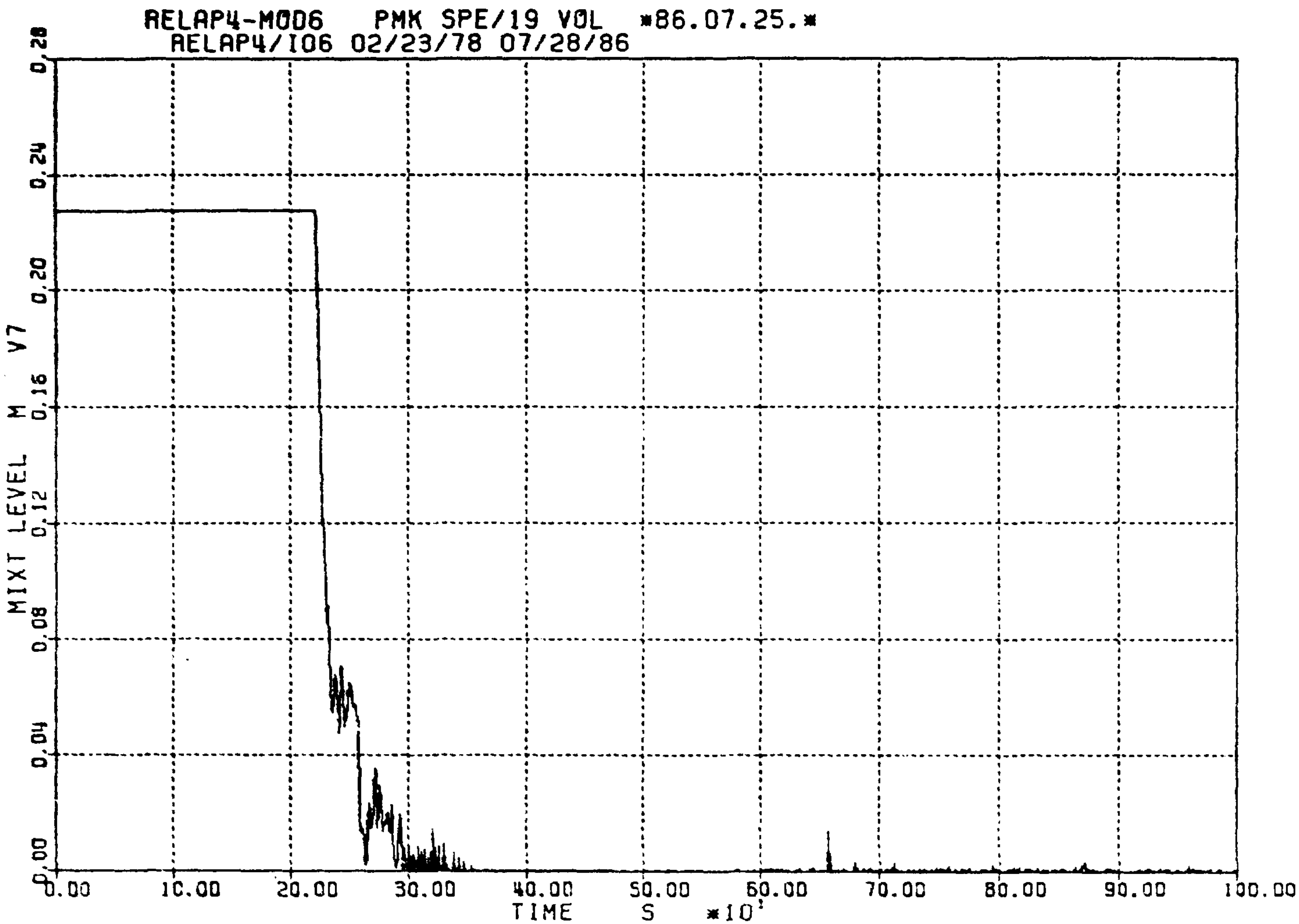

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MIXT LEVEL M V7
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10'

Fig.4.43

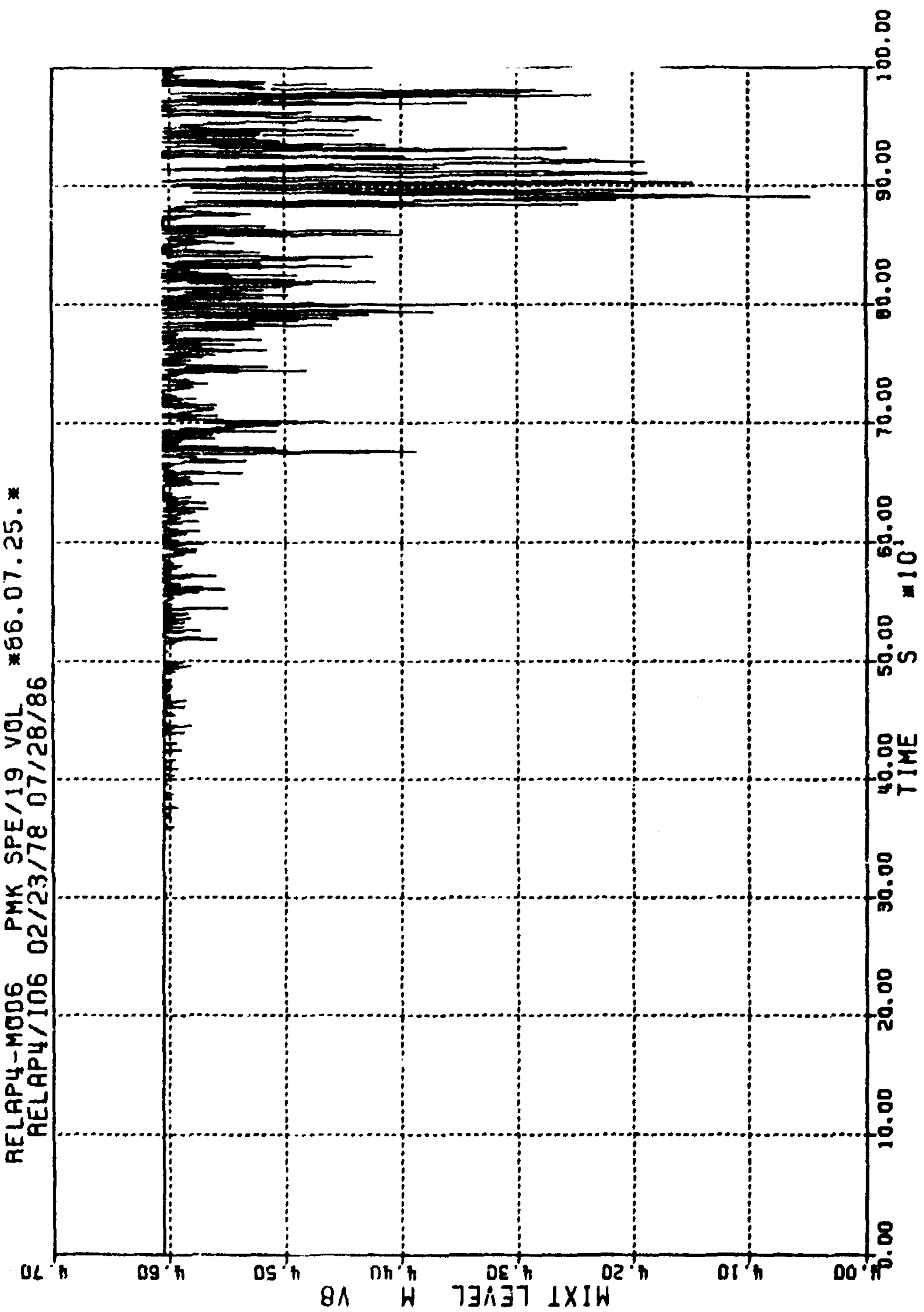

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/IO6 02/23/78 07/28/86
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹
4.00
4.10
4.20
4.30
4.40
4.50
4.60
4.70
MIXT LEVEL M V8

Fig. 4.44

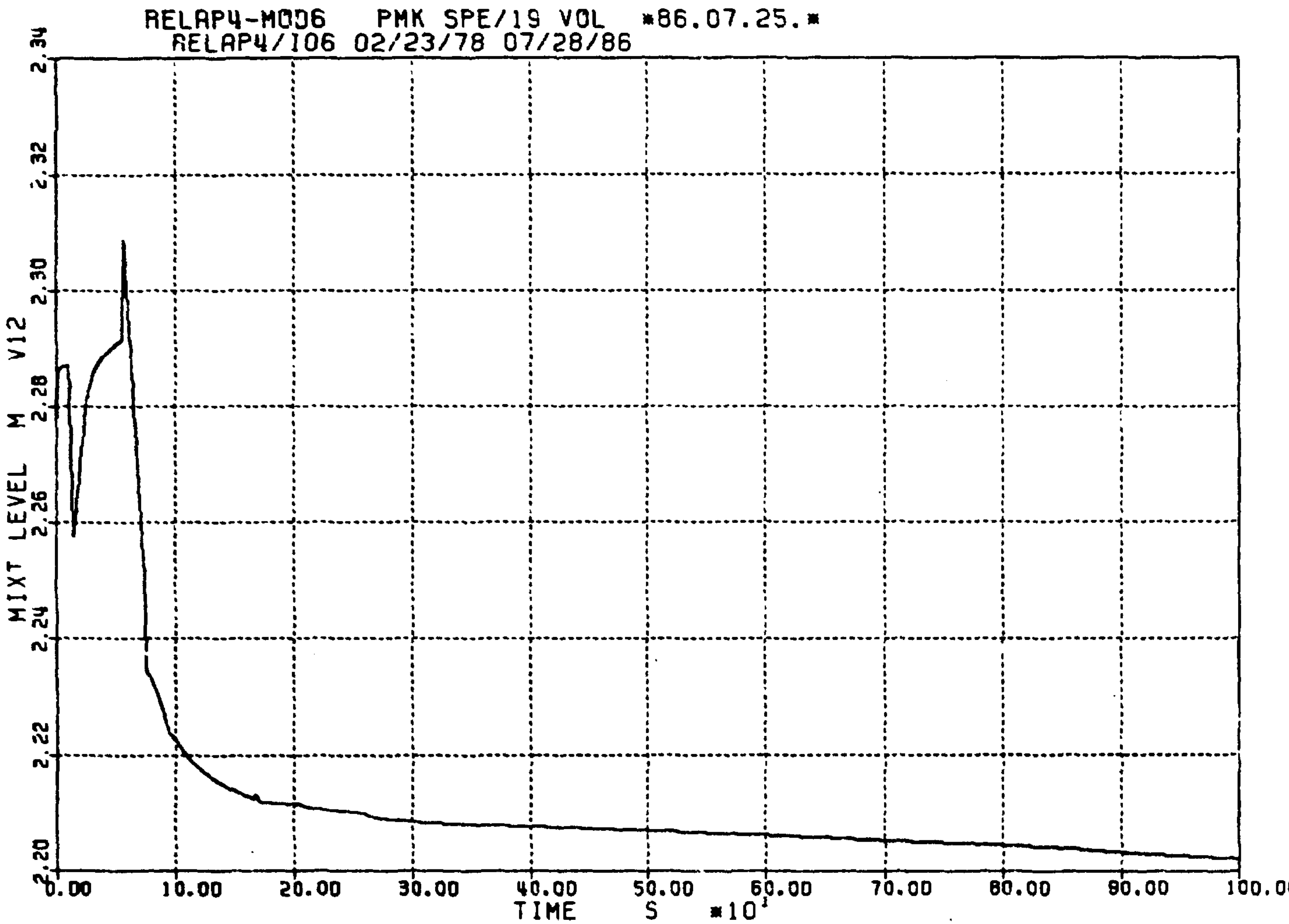
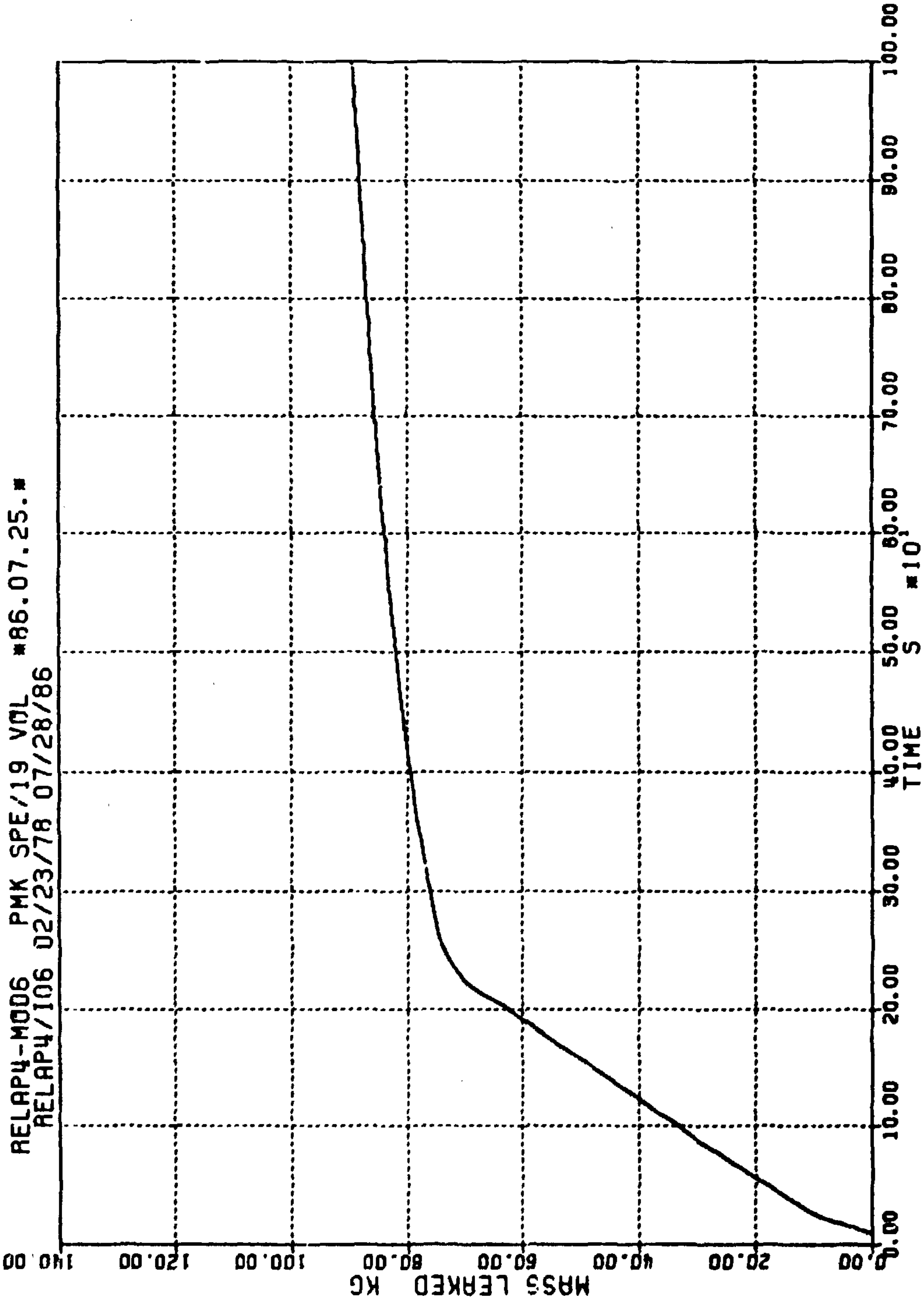

RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/106 02/23/78 07/28/86
MIXT LEVEL M V12
2.20
2.22
2.24
2.26
2.28
2.30
2.32
2.34
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
TIME S *10¹

Fig. 4.45



RELAP4-MOD6 PMK SPE/19 VOL *86.07.25.*
RELAP4/I06 02/23/78 07/28/86
MASS LEAKED KG
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
TIME S *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Fig. 4.46

Table 1.

Time s	Power kW
0	654.0
1	577.2
2	496.6
3	421.3
4	398.4
5	371.5
7	234.0
10	147.6
14	88.0
19	58.5
24	47.5
30	41.4
60	34.6
100	30.3
200	23.2
400	19.3
800	15.0
1000	15.0

Table 2.

Time s	Closing current mA	pump	MV12
0	11.51		
1	11.70		
2-3	12.30		
4-6	12.85		
7-10	13.44		
11-15	13.87		
16÷20	14.21		
21÷26	14.52		
27-32	14.86		
33-40	15.17		
41-48	15.45		
49-56	15.79		
57-66	16.12		
67-76	16.40		
77-86	16.71		
87-96	17.05		
97-106	17.36		
107÷116	17.67		
117-126	18.00		
127-136	18.44		
137-146	18.96		
147-148	19.84	stopped*	
149-150	19.85		begins to close
150-995	19.85		

*At this time MV11 starts to open

Table 3.

s	kg/s	s	kg/s
0	0	61	0.014
60	0	500	0.014
		1000	0.014

Table 4.

Position*	1	2	3	4	5	6	7	8
p MPa	12.629	12.603	12.544	12.552	12.838	12.772	12.730	12.650

* In Reference [4], in Fig.1. /positions 2 and 3 should be changed/

Volume number*	1	2	3	4	5	6	7
p MPa	12.616	12.590	12.579	12.548	13.324	12.838	12.772

Volume number*	8	9	10	11	12	13	14
p MPa	12.750	12.650	12.629	12.607	4.671	12.603	12.790

Volume number*	15	16	17	18	19
p MPa	12.700	12.670	12.568	12.558	12.730

* In Fig. 3.1

Table 5.

Number of control volumes	19
Number of junctions	24
Number of check valves	5
Number of file junctions	4
Number of leak junctions	1
Number of heat slabs	16
Number of core slabs	5
Number of slabs with heat losses	4
Number of pumps	1

Table 6.

Vol. number		Junctions connected	Elevation /m/	Height /m/	Bubble rise
1	hot leg vessel side with surge line	J1,J2,J11	4.802	2.998	2
2	SG hot collector	J13, J3	5.595	2.845	2
3	SG primary tubes 1.part	J3, J21	6.362	1.831	0
4	SG cold collector and cold leg SG side	J4, J5, J15	2.077	6.363	2
5	pump with suction and delivery lines	J15, J16	-0.653	2.933	2
6	cold leg vessel side vertical part	J5, J6, J16	2.234	2.568	2
7	downcomer head	J7, J8, J17	4.770	0.228	2
8	downcomer	J8, J24	0.166	4.604	2
9	core upper part	J20, J9	2.994	0.570	2
10	upper plenum	J10, J1	3.564	4.921	2
11	pressurizer	J11	7.800	2.460	3
12	SG secondary	J17, J18, J23	6.330	2.606	1
13	hot leg SG side	J5, J13	4.802	0.793	2
14	cold leg vessel side horizontal part	J6, J7	4.802	0.046	2
15	core lower part	J9, J19	0.360	1.614	2
16	core middle part	J19, J20	1.994	1.000	2
17	SG primary tubes 2 part	J21, J22	6.362	1.831	0
18	SG primary tubes 3 part	J22, J4	6.362	1.831	0
19	lower plenum	J24, J9	0.0	0.380	2

Table 7.

Bubble rise	Alph	Vbub /ft/s/	
0	0.0	0.0	
1	0.8	12.0	
2	0.8	3.0	
3	0.8	-2.0	/complete separation/

Table 8.

Computer type			IBM 3081 /IAEA Vienna/
Code version			RELAP4/mod6-KfK
Memory region		kbyte	720
Steady state process time		s	10
Steady state CPU time		s	35
CPU time / process time / volumes			0.184
Max. time step		s	0.2
Transient process time		s	990
Transient CPU time		s	27165
CPU time / process time / volumes			1.444
Max. time step	10 - 20s	s	0.01
	20 - 80s	s	0.02
	80 - 600s	s	0.005
	600 - 1000s	s	0.01
Min. time step	10 - 20s	s	0.00005
	20 - 600s	s	0.0001
	600 - 1000s	s	0.0005

Table 9.

Event	Time S
Break valve opens	0.
Pressurizer embty	11.8
First reversal of core inlet flow	154.
Dryout first occurs	186.
Break flow two-phase	212.
Break uncovered	247.
Hot-leg loop seal cleared	61.5
Cold-leg loop seal cleared	200.
Core uncovery starts	185.
Primary pressure equals secondary pressure	206.
Mixture level in UP drops to hot-leg elevation /6.248 m/	61.5
Mixture level in SG hot collector drops to elevation of uppermost SG tubes /8,193 m/	15.2
Scram	3.35
HPIS initiated	63.35
Pump trip simulation starts	9.95
Steam relief valve opens	46.8

The issues of the KFKI preprint/report series are classified as follows:

A. Particle and Nuclear Physics

B. General Relativity and Gravitation

C. Cosmic Rays and Space Research

D. Fusion and Plasma Physics

E. Solid State Physics

F. Semiconductor and Bubble Memory Physics and Technology

G. Nuclear Reactor Physics and Technology

H. Laboratory, Biomedical and Nuclear Reactor Electronics

I. Mechanical, Precision Mechanical and Nuclear Engineering

J. Analytical and Physical Chemistry

K. Health Physics

L. Vibration Analysis, CAD, CAM

M. Hardware and Software Development, Computer Applications, Programming

N. Computer Design, CAMAC, Computer Controlled Measurements

The complete series or issues discussing one or more of the subjects can be ordered; institutions are kindly requested to contact the KFKI Library, individuals the authors.

Title and classification of the issues published this year:

KFKI-1986-01/E J. Kollár et al.	The Kronig-Penney model on a Fibonacci lattice
KFKI-1986-02/C A.J. Somogyi et al.	First results of high energy particle measurements with the TÜNDE-M telescopes on board the S/C VEGA-1 and -2
KFKI-1986-03/C K. Gringauz et al.	The VEGA PLASMAG-1 experiment: description and first experimental results
KFKI-1986-04/A J. Révai	Half-classical three-body problem
KFKI-1986-05/A I. Lovas	Quark degrees of freedom in nuclei
KFKI-1986-06/E Gy. Szabó et al.	Lattice gas model on tetrahedral sites of bcc lattice: anisotropic diffusion in the intermediate phase
KFKI-1986-07/K Pálfalvi J. et al.	Tapasztalatok egy (neutron-alfa) magreakción alapuló szilárdtest nyomdetektorokból felépitett személyi albedo neutron doziméter munkaszintü dozimetriai felhasználásáról
KFKI-1986-08/K Nagy Gy. et al.	Összefoglaló értékelés a paksi környezetellenőrző rendszer GM-csöves és jódtávmérő detektorainak jellemzőiről az 1982-1985-ös mérési adatok feldolgozása alapján. OKKFT-A/11-7.5.9.
KFKI-1986-09/K Nagy Gy. et al.	A paksi atomerőmű hideg- és melegvizcsatornájában üzemelő folyamatos vizaktivitás monitorok paraméatereinek és mérési adatainak összefoglaló értékelése. OKKFT-A/11-7.4.13.
KFKI-1986-10/D S. Zoletnik et al.	Determination of the centre of gravity of the current distribution in the MT-1 tokamak

KFKI-1986-11/G R. Kozma et al.	Studies to the stochastic theory of the coupled reactorkinetic-thermohydraulic systems. Part VI. Analysis of low-frequency noise phenomena
KFKI-1986-12/A A. Frenkel	Canonical quantization of the relativistic theory of the Dirac monopole
KFKI-1986-13/D Gy. Egely	Energy transfer problems of ball lightning
KFKI-1986-14/K Németh I. et al.	Hordozható félvezető gamma-spektrométer üzembe állítása, kalibrálása, számitógépes adatfeldolgozása és tesztelése in situ dózisteljesitmény meghatározás céljából. OKKFT-A/11-7.4.12.
KFKI-1986-15/G M. Makai	In aid of in-core measurement processing
KFKI-1986-16/C K.I. Gringauz et al.	First in situ plasma and neutral gas measurements at comet Halley: initial VEGA results
KFKI-1986-17/C A.J. Somogyi et al.	First spacecraft observationsof energetic particles near comet Halley
KFKI-1986-18/E Z. Kaufmann et al.	Unusual maps and their use to approach usual ones
KFKI-1986-19/A H-W. Barz et al.	Effect of correlations on entropy and hadro-chemical composition in heavy ion reactions
KFKI-1986-20/B A. Horváth et al.	Evidence for a different miocene solar cycle?
KFKI-1986-21/M D. Nicholson	On the humanisation of interfaced systems
KFKI-1986-22/L Novothny F. et al.	Kisérlet mérőváltók meghibásodásának zajdiagnosztikájára 2.
KFKI-1986-23/C T.I. Gombosi et al.	An icy-glue model of cometary nuclei
KFKI-1986-24/A P. Lévai et al.	Should the coupling constants be mass dependent in the relativistic mean field models?
KFKI-1986-25/E G.P. Djotyan et al.	Theory of the nonstationary phase conjugation by four-wave mixing
KFKI-1986-26/E P. Szépfalusy et al.	A new approach to the problem of chaotic repellers
KFKI-1986-27/J A. Vértes et al.	Peak shape determination in laser microprobe mass analysis
KFKI-1986-28/E P. Fazekas	Variational ground state for the periodic Anderson model
KFKI-1986-29/A V.N. Gribov	A new hypothesis on the nature of quark and gluon confinement
KFKI-1986-30/A L. Diósi	A universal master equation for the gravitational violation of quantum mechanics

KFKI-1986-31/D J.S. Bakos	Optically pumped FIR lasers and their application in plasma diagnostics
KFKI-1986-32/B Zs. Bagoly et al.	Monopole abundance from first order gut phase transition of the early universe
KFKI-1986-33/B Z. Perjés	Ernst coordinates
KFKI-1986-34/C R.Z. Sagdeev et al.	Comet Halley: Nucleus and jets (Results of the VEGA mission)
KFKI-1986-35/A K. Szlachányi	Non-local fields in the Z(2) Higgs model: the global gauge symmetry breaking and the confinement problem
KFKI-1986-36/B B. Kämpfer et al.	Entropy production in tepid inflation
KFKI-1986-37/A P. Vecsernyés	Comment to the "Reanalysis of the Eötvös experiment"
KFKI-1986-38/F Gy. Szabó et al.	Influence of temperature oscillation on measured crystal weight during Czochralski growth
KFKI-1986-39/C R.Z. Sagdeev et al.	The spatial distribution of dust jets seen by V-2
KFKI-1986-40/G O. Aguilar	Measurement of reactivity temperature coefficient by noise method in a power reactor
KFKI-1986-41/C G. Benkő et al.	Cosmic ray fluctuations at rigidities 4 to 180 GV
KFKI-1986-42/K Andrási A. et al.	A Központi Fizikai Kutató Intézet Sugárvédelmi Főosztályának mérései a csernobili atomerőmű balesetének következtében létrejött sugárzási helyzetről (1986. április 28 - junius 12). Előzetes beszámoló
KFKI-1986-43/C Dénes E. et al.	A VEGA TV real-time szoftvere
KFKI-1986-44/E É. Hajtó et al.	Submicron resolution amorphous chalcogenide optical grid
KFKI-1986-45/E I. Pócsik et al.	Solitons in chiral liquid crystalline systems I. Cholesteric phase distorted by magnetic field
KFKI-1986-46/E I. Pócsik et al.	Solitons in chiral liquid crystalline systems II. The blue phase
KFKI-1986-47/A L. Földy et al.	External field Dirac equation with separable potential
KFKI-1986-48/A P. Hraskó et al.	Coulomb Pair-creation
KFKI-1986-49/K A. Andrási et al.	Monitoring the radiation consequences due to the disaster at the Chernobyl nuclear facility From April 28 to June 12, 1986. Preliminary report
KFKI-1986-50/E K. Itai	Theory of one-dimensional hopping motion of a heavy particle interacting with a degenerate electron gas or phonons by different couplings

KFKI-1986-51/B J. Bičák et al.	Asymptotic behaviour of Robinson-Trautman pure radiation solutions
KFKI-1986-52/A P. Hraskó	Magnetism of the electric quadrupoles
KFKI-1986-53/A I. Lovas et al.	Heavy ion collisions and anisotropic hydrodinamics
KFKI-1986-54/E P. Szépfalusy et al.	Calculation of the fractal dimension in the one-dimensional random field Ising model
KFKI-1986-55/A L. Diósi	Quantum Stochastic Processes as Models for State Vector Reduction
KFKI-1986-56/G,J H. Illy	Recent bibliography on analytical and sampling problems of a PWR primary coolant. Supplement IV
KFKI-1986-57/D J.S. Bakos et al.	Measuring laser blow-off of thin sodium films
KFKI-1986-58/E P. Jani	Interferometry applied to ceramics
KFKI-1986-59/D P. Apai et al.	D.C. helium and helium - krypton discharges in aluminium hollow cathode discharge tubes for blue $He-Kr^+$ laser operation
KFKI-1986-60/E P. Fazekas	Concentration dependence of the Kondo exponent in heavy fermion alloys
KFKI-1986-61/E B. Sas et al.	The influence of magnetic scattering to the transport properties of Ni-based amorphous alloys
KFKI-1986-62/E B. Sas et al.	Magnetic contribution to the thermopower of iron based amorphous alloys
KFKI-1986-63/G O. Aguilar	Measurement of reactivity temperature coefficient by noise method in power reactors. Theory
KFKI-1986-64/A M.N. Kobrinsky et al.	Inclusive reactions in the quasi-nuclear quark model: numerical results for hadron-hadron collisions
KFKI-1986-65/E E. Tóth-Kádár et al.	Preparation and characterization of electrodeposited amorphous Ni-P alloys
KFKI-1986-66/M J. Bóta et al.	Data presentation in the WWER-440 basic principle simulator
KFKI-1986-67/E A. Jánossy et al.	Linear current-field relation of charge-density-waves near the depenning threshold in alkali-metal blue bronzes $A_{0.3}MoO_3$
KFKI-1986-68/E G. Gévay	Growth and characterization of $Bi_4Ge_3O_{12}$ single crystals: a survey from discovery to application
KFKI-1986-69/A K. Szlachányi et al.	θ-sectors in the OS-construction
KFKI-1986-70/E P. Fazekas et al.	Application of the Gutzwiller method to the periodic Anderson model
KFKI-1986-71/J P. Jani et al.	Development of optical system for a laser ionization mass spectrometer

KFKI-1986-72/E
J. Gazsó et al.
Field-effect problems with I-V measurements on gap-type a-Si:H specimens

KFKI-1986-73/A
G. Perneczki
Bias of poisson distributed data decomposition

KFKI-1986-74/A
A. Tóth et al.
Two-center Dirac equation with separable potentials

KFKI-1986-75/M
G. Bóna et al.
Fault tolerance

KFKI-1986-76/G
I. Vidovszky et al.
Non-destructive fuel burn-up study on WWR-SM type fuel assemblies. (Gamma spectrometric method)

KFKI-1986-77/E
L. Malkinski et al.
Influence of magnetic annealing on shear modulus and internal friction of $Fe_{78}Si_{10}B_{12}$ metallic glass

KFKI-1986-78/E
L. Malkinski et al.
Density of Fe-Si-B metallic glasses

KFKI-1986-79/A
L. Diósi
Exact solution for particle trajectories in modified quantum mechanics

KFKI-1986-80/A
B. Lukács et al.
Thermodynamical considerations for the rehadronization of a quark-gluon plasma

KFKI-1986-81/G
O. Glöckler et al.
Results and interpretation of noise measurements using in-core self powered neutron detector strings at Unit 2 of the Paks Nuclear Power Plant

KFKI-1986-82/G
G. Pór et al.
Sophysticated systems for analysing standard signals of a PWR NPP for diagnostic purposes

KFKI-1986-83/J
J. Szőke et al.
How to build up an up-to-date decay time spectrometer for the nanosecond region

KFKI-1986-84/E
A. Czitrovszky et al.
On selection of active material for acousto-optic mode-lockers

KFKI-1986-85/G
Perneczky L. et al.
Baleseti helyzetek előbecslését szolgáló számítások. A térfogatkompenzátor biztonsági szelepének fennakadását követő folyamatok számítógépes analizise

KFKI-1986-86/G
G. Ézsöl et al.
IAEA-SPE-1: Pre-test calculations for the PMK-NVH Standard Problem Exercise

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Gyimesi Zoltán
Szakmai lektor: Vigassy József
Nyelvi lektor: Vigassy József
Példányszám: 175 Törzsszám: 86-644
Készült a KFKI sokszorosító üzemében
Felelős vezető: Töreki Béláné
Budapest, 1986. november hó