PP&L

POOR ORIGINAL

# GKM II M TESTS

# TEST PHILOSOPHY AND MATRIX

OCTOBER 10 - 1979

ADAPTED FROM KWU WORKING REPORT R 141/136/79

1237 247

## 1.0 INTRODUCTION

In order to investigate the Condensation Oscillation (C. O.) loading phenomena occurring during a postulated Loss-of-Coolant Accident (LOCA) and thereby:

A) Resolve NRC concerns on the differences in vent configuration between the 4T facility and a prototypical Mark II containment

B) Verify the C. O. design load specification used on the Susquehanna containment (Section 4.2.2.1 of Susquehanna Design Assessment Report)

it was decided by PP&L to conduct a series of transient steam blowdown tests in a modified GKM-II test tank in Mannheim, Germany. This report and Kraftwerk Union Working Report R 541/10/79 are submitted to respond to the NRC's request for formal documentation of the test description, purpose, matrix and instrumentation.

## 2.0 FIXED PARAMETERS

A single cell corresponding to the Susquehanna Steam Electric Station (SSES) is simulated at actual scale in the GKM-IIM test stand. The single cell consists of a vent pipe with proportionate drywell and suppression chamber. A comparison of the plant and test parameters is given in Table 1.

### 2.1 Drywell

The volume of the drywell part of the test tank corresponds to the proportionate volume of the drywell in the plant. The drywell walls are preheated to temperatures of about 143°C (corresponding to 4 bar saturated steam) in order to avoid steam condensation. As a result, the mass flow values in the test are higher than in the plant, where condensation on dry well internals and walls is possible. Since the drywell of the test stand consists of a volume without any major internals, the air is flushed over just as fast, and probably even somewhat faster than in the plant.

### 2.2 Suppression Chamber (Wetwell)

Like the drywell volume, the free air volume of the suppression chamber also corresponds to the proportionate value in the plant. As a result, the pressure build-ups in the test tank and in the SSES containment are equal.

The ratio of surrounding water surface to the cross-sectional area of the vent pipe varies in the plant as a function of the pipe's position. Theoretical and experimental investigations /1,2/ show that the condensation loads decrease with increasing area ratio. Therefore, the single cell with the smallest area ratio at the containment wall was simulated in the test stand. Its area of 3.66 $m^2$ (39.4 $ft.^2$) /3/ is clearly less than the mean value in the SSES (5.64 $m^2$); 60.7 $ft.^2$ /3/).

1237 248

Due to the decreased volume of water relative to the mean value in the plant, there is a greater heating of the water in the suppression chamber during the tests than would be expected in the plant.

The volume flexibility of the suppression chamber walls is less than or equal to the plant value of $0.6 \times 10^{-3}\ m^3/bar$ ($37.2\ in^3/bar$/11/) relative to the single cell.

### 2.3 Vent Pipe

The vent pipe has practically the same dimensions and the same distance from the bottom as in the plant. Previous test series /4/ and also theoretical considerations /10/ have shown that the condensation loads vary somewhat with the submergence depth of the pipe.

For small submergence depths, the loads first increase rapidly with increasing depth and then approach a limiting value asymptotically. Therefore, the tests are performed at the highest value of submergence depth, 3.66 m (12 ft./5/), occurring in the plant.

The vent pipe braces have a stiffness greater than or equal to the maximum value of $770 \times 10^6$ N/m (4386 kips/in/6/) occurring in the plant and are located at the same position as in the plant.

### 2.4 Internals in the Water Region

To measure the condensation loads on internals in the water region of the suppression chamber, a dummy quencher arm of the SSES pressure relief system and an I-beam are installed in the test stand.

## 3.0 VARIABLE PARAMETERS

The Test Matrix (Table 2) provides for twenty tests with ten different parameter combinations. Earlier test series indicate that the strength of condensation events is very highly stochastic and can differ for tests with identical boundary conditions. In order to largely rule out any erroneous correlation of measurement values with the parameters, each test is repeated once.

### 3.1 Break Size

Four different line breaks are investigated:

- the complete break of a recirculation loop (RCL break)

- the complete break of a main-steam line (MSL break)

- two other steam-line breaks corresponding to 1/3 and 1/6 of the MSL break area.

1237 249

The data (discharge rate, enthalpy and pressure build-up in the drywell) for the RCL and MSL breaks came from the SSES Final Safety Analysis Report /7/. The steam and water fractions of the relevant transients were calculated from it (under the assumption of thermodynamic equilibrium) /8/.

In the planned tests, only the steam fraction is considered. The decision to proceed with tests which considered only the steam fraction of the various LOCA blowdowns was made upon our evaluation that, at a specified steam mass flux, the addition of more mass in the form of saturated liquid would have no effect on either the amplitude or frequency of the condensation oscillation in a MK II containment. This evaluation was further confirmed by 1/4 scale single vent tests performed by Creare, Inc. In these tests, condensation oscillation was established at a constant steam mass flux. Then additional mass, in the form of saturated water, was either sprayed into the vent or dumped into the drywell. The test data showed no significant change in either pressure amplitude or frequency between the two cases.

The plant transients relative to one vent pipe (steam fraction only) are shown in Figures 1 and 2. For comparison, the planned test transients are also indicated.

The range of small mass flow densities is traversed very rapidly during a transient in the event of large line breaks. For smaller breaks, in contrast, distinctly longer blowdown times result. Accordingly, such breaks are also to be investigated. The associated transients were so chosen that a comparison of the results with data known from earlier test series is possible.

Figure 3 summarizes the four GKM-IIM test transients once again in one graph. For each of the considered line breaks, Figures 4 to 7 show the mass flow transient, the pressure build-up in the drywell and suppression chamber, the air fraction of the mass flow through the vent pipe, and the heating of the water in the suppression chamber.

### 3.2 Water Temperatures in the Suppression Chamber

The test matrix provides for tests at 24°C, 32°C and 55°C (75°F, 90°F and 130°F). The value 32°C corresponds to the mean temperature that is maintained by the cooling system of the suppression chamber during normal operation. The emphasis on the tests at 32°C is explained by the fact that no clear dependence of the condensation loads on the water temperature was observed in previous test series /2,4/. The temperatures 24°C and 55°C were taken from the limits of the operation field of the pressure relief system in the plant /9/.

### 3.3 Drywell Air Content

The amount of air flushed over from the drywell influences the back-pressure in the suppression chamber and also the composition of the

1237 250

air-steam mixture flowing through the vent pipe. Since the SSES drywell consists of a single space, it can be assumed that all the air contained in the drywell is flushed over during the accident. Furthermore, the drywell internals will lead to diffuse distribution of the steam jet and thus to a good mixing of steam and air. Therefore, most of the tests are performed with the same (proportionate) amount of air as in the plant. The steam is introduced in such a manner that it can mix in a mostly homogeneous manner with the air. By exchanging the air just before test start, the drywell air temperature is brought to a value $T_0$ corresponding to that in the plant. To investigate the effect of a possible incomplete steam-air mixing, individual tests are performed with reduced air content in the drywell. In those tests, the drywell air is not exchanged. The air temperature then corresponds to the temperature $T_1$ of the drywell walls, which, as already mentioned, are heated in order to prevent steam condensation. Thus, the density $\varrho(T_1)$ $(= \varrho(T_0) \cdot T_0/T_1)$ and therefore the amount of air are decreased by about 15%. The values of $T_0$ and $T_1$ are fixed in the individual test specifications.

An implicit variation of the air content already results from the different break sizes. For the planned RCL transient, all the air (99%/8/) is flushed over within approximately 9 seconds (Figure 4). That means that there is air-free condensation during the major portion of the phase of constant mass flow and the subsequent monotonic decrease.

A highly simplified representation of two transients from steam line breaks is shown in Figure 8. Since (for homogeneous steam-air mixing) the air fraction of the mass flow through the vent pipe at a particular instant depends only on the amount of steam that has flowed over until then (shaded areas in Figure 8), the points of equal mass flow density lying on the horizontal line correspond to different air contents.

1237 251

REFERENCES


/1/ Technical Report R 14/48/76 16 August 1976
Calculation of the spatial pressure distribution when several condensation events are superimposed.

/2/ Technical Report R 14/187/77 24 November 1977
Results of the continuing GKM-II tests on the influence of parameters on the pressure amplitudes in the phase of air-poor condensation.

/3/ Working Report R 141/122/78 30 November 1978
GKM-II M Tests
Information for modification of the condensation test stand in the GKM.

/4/ Technical Report R 52/R 14/45/76 24 September 1976
Results of the GKM-II tests on the pressure suppression system.

/5/ Letter from Bechtel to KWU, 24 May 1978 087187
Attachment 3, response to question 2.1.11.

/6/ Letter from Bechtel to KWU, 2 June 1978 087613
Attachment 1.

/7/ SSES Final Safety Analysis Report, Rev. 0
Tables 6.2-9 and 6.2-10
Figures 6.2-11 and 6.2.2.

/8/ Working Report R 141/135/79 22 August 1979
Partial stipulation of the GKM-IIM test parameters.

/9/ Telex from Bechtel to KWU, 22 December 1977 080215.

/10/ Working Report R 141/33/78 19 June 1978
Parameter study of the dynamic loading of water-filled elastic tank by a collapsing steam bubble.

/11/ Letter from Bechtel to KWU, 2 June 1978 087613
Attachment 6.

/12/ Creare, Inc. Technical Memorandum, TM-646 - May, 1979
Effects of Saturated Liquid on Condensation Oscillation.




1237 252

Comparisicn of Fixed Parameters
data taken from /3/

| | SSES Single Cell | GKM II M Test Vessel (Design Values) |
|---|---|---|
| Drywell Free Volume, $m^3$ | 75 | 75 |
| (including Vent Pipe) | 78 | 78 |
| Wetwell Free Air Volume, $m^3$ (normal water level) | 50 | 50 |
| Drywell/Wetwell Air Volume Ratio | 1.5 | 1.5 |
| Free Pool Area, $m^2$ | | |
| Small Cell at Containment Wall | 3.66 | 3.66 |
| Mean Value | 5.64 | |
| Vent Pipe Dimensions | | |
| Length, m | 13.86 | 13.86 |
| Outer Diameter, mm | 610 | 610 |
| Wall Thicknes, mm | 9,5 | 9,5 |
| Vent Pipe Submergence, m (high water level) | 3.66 | 3.66 |
| Vent Pipe Clearence, m | 3.66 | 3.66 |
| Distance between Bracing and Vent Opening, m | 2.44 | 2.44 |
| Volume Flexibility of Wet Containment Walls, $dm^3$/bar | 0.6 | 0.6 |

Table 1

1237 253



Kraftwerk Union

KWU 0018 Textedit 50000 1.79 985

| GKM II M Test Matrix | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Number | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Break Size (mm) | Ø 210 (RCL) | * | * | | | | | | | | | | | | | | | | | | |
| | Ø 190 (MSL) | | | * | * | * | * | * | * | * | * | | | | | | | | | | |
| | Ø 110 (1/3 MSL) | | | | | | | | | | | * | * | | | | | | | | |
| | Ø 80 (1/6 MSL) | | | | | | | | | | | | | * | * | * | * | * | * | * | * |
| Pool Temperature | 24°C (75 F) | | | * | * | | | | | | | | | * | * | | | | | | |
| | 32°C (90 F) | * | * | | | * | * | * | * | | | * | * | | | * | * | * | * | | |
| | 55°C (130 F) | | | | | | | | | * | * | | | | | | | | | * | * |
| Drywell Air Content | 100 % | * | * | * | * | * | * | | | * | * | * | * | * | * | * | * | | | * | * |
| | 85 % | | | | | | | * | * | | | | | | | | | * | * | | |
| Repeat Test | | | * | | * | | * | | * | | * | | * | | * | | * | | * | | * |

Table 2

1237 254



AD R 141/136/79

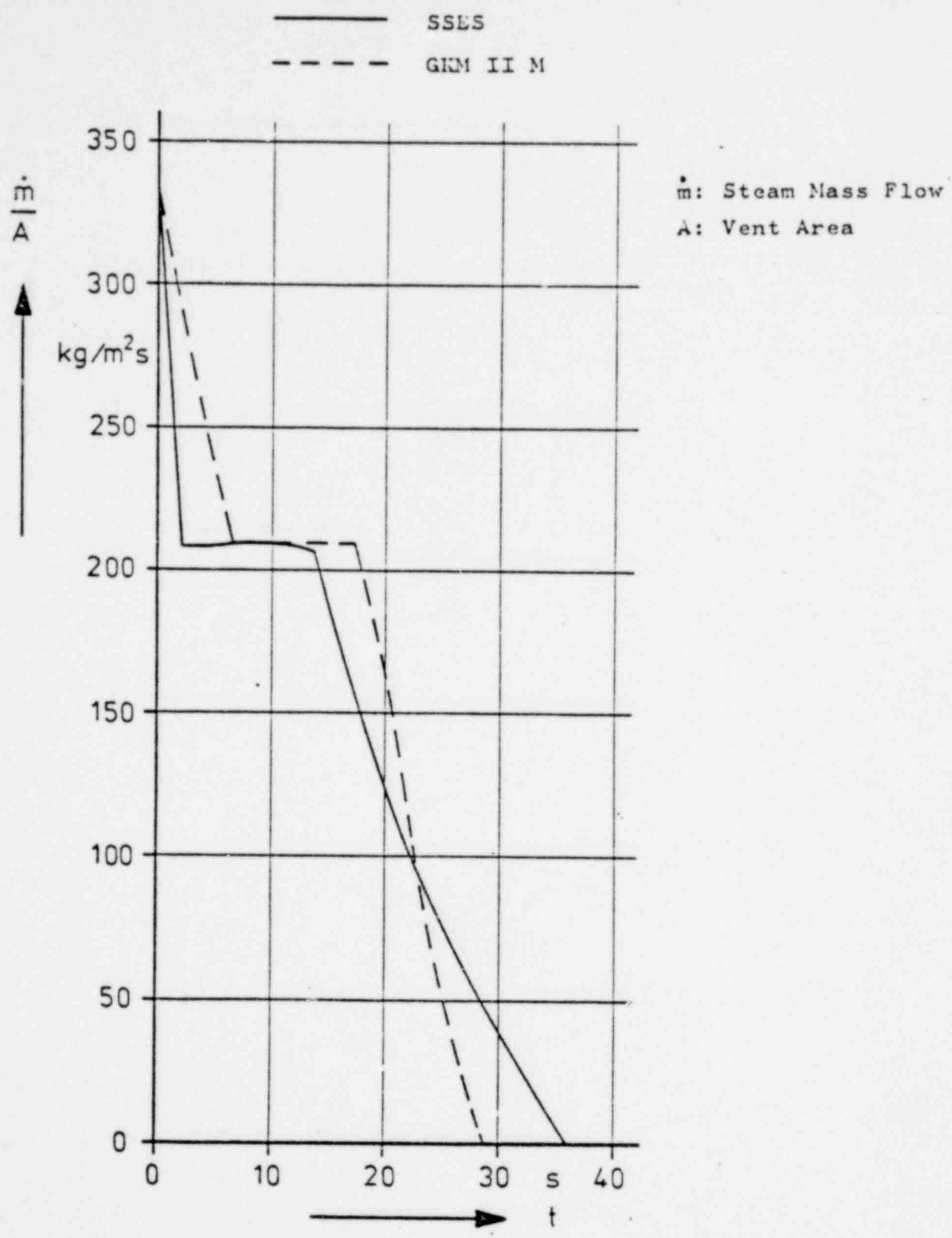



Figure 1: Steam Mass Flux Transients
RCL Break



1237 255

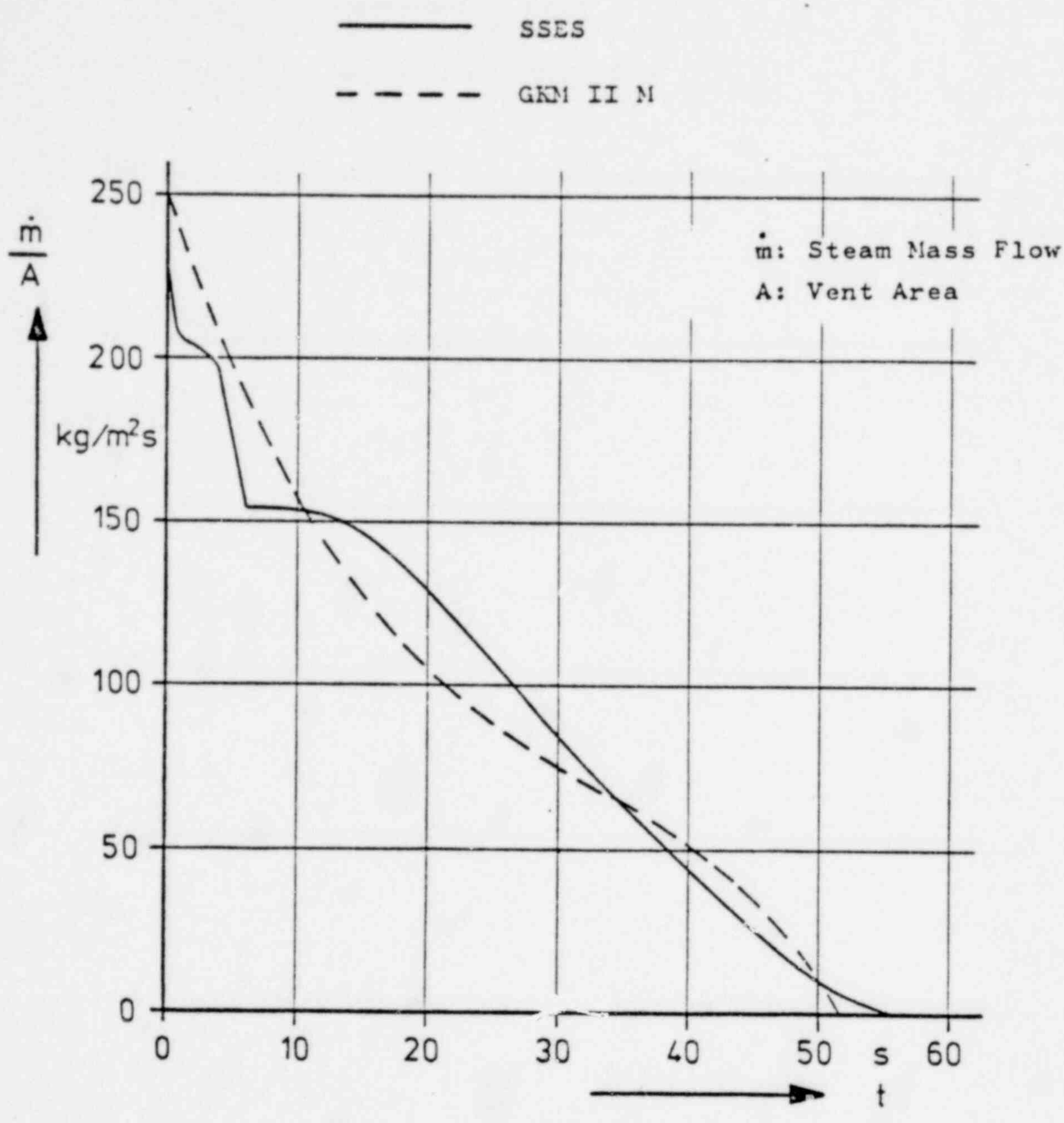



Figure 2: Steam Mass Flux Transients
MSL Break

1237 256

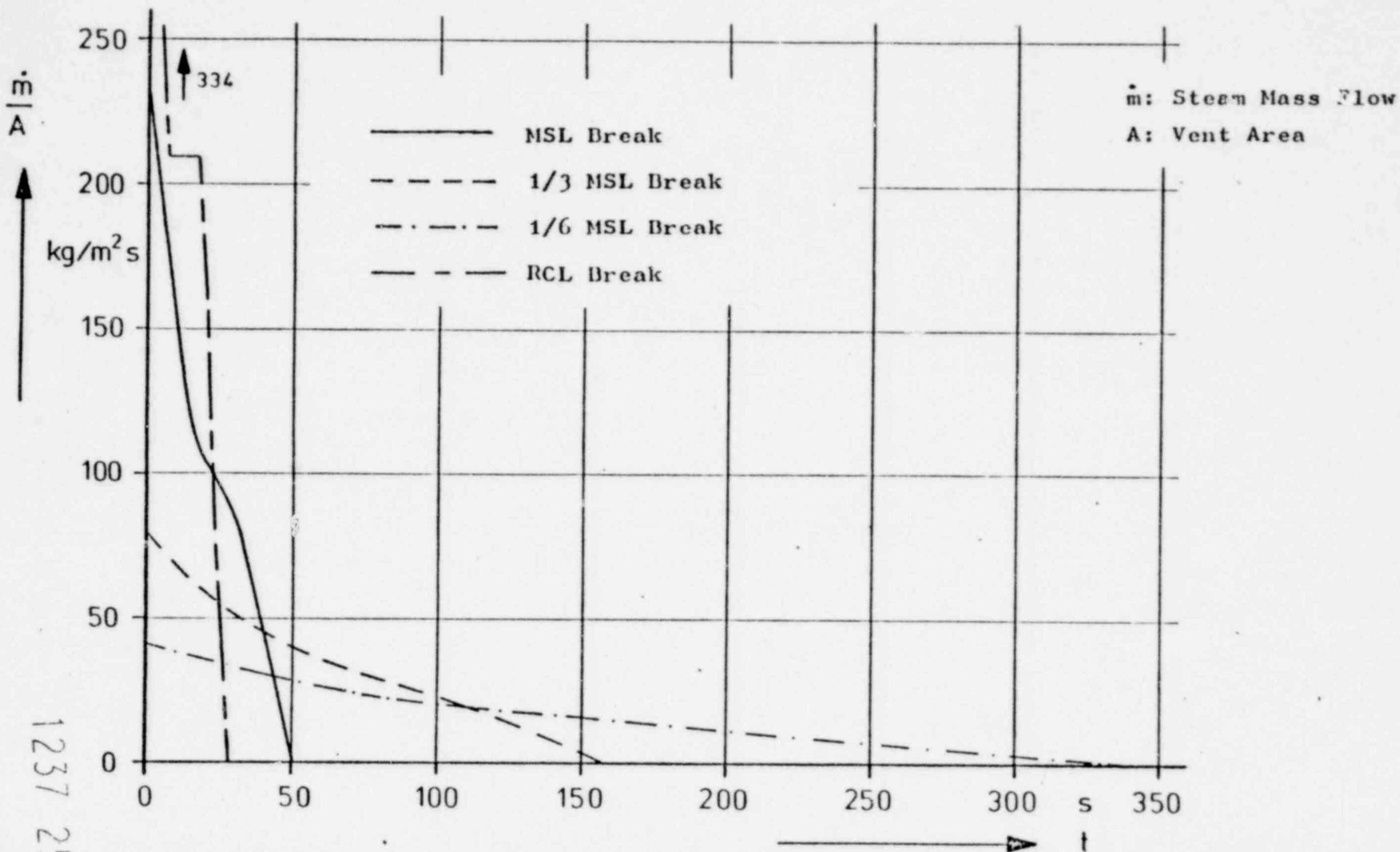



Figure 3: GKM II M Tests
Steam Mass Flux Transients

1237 257

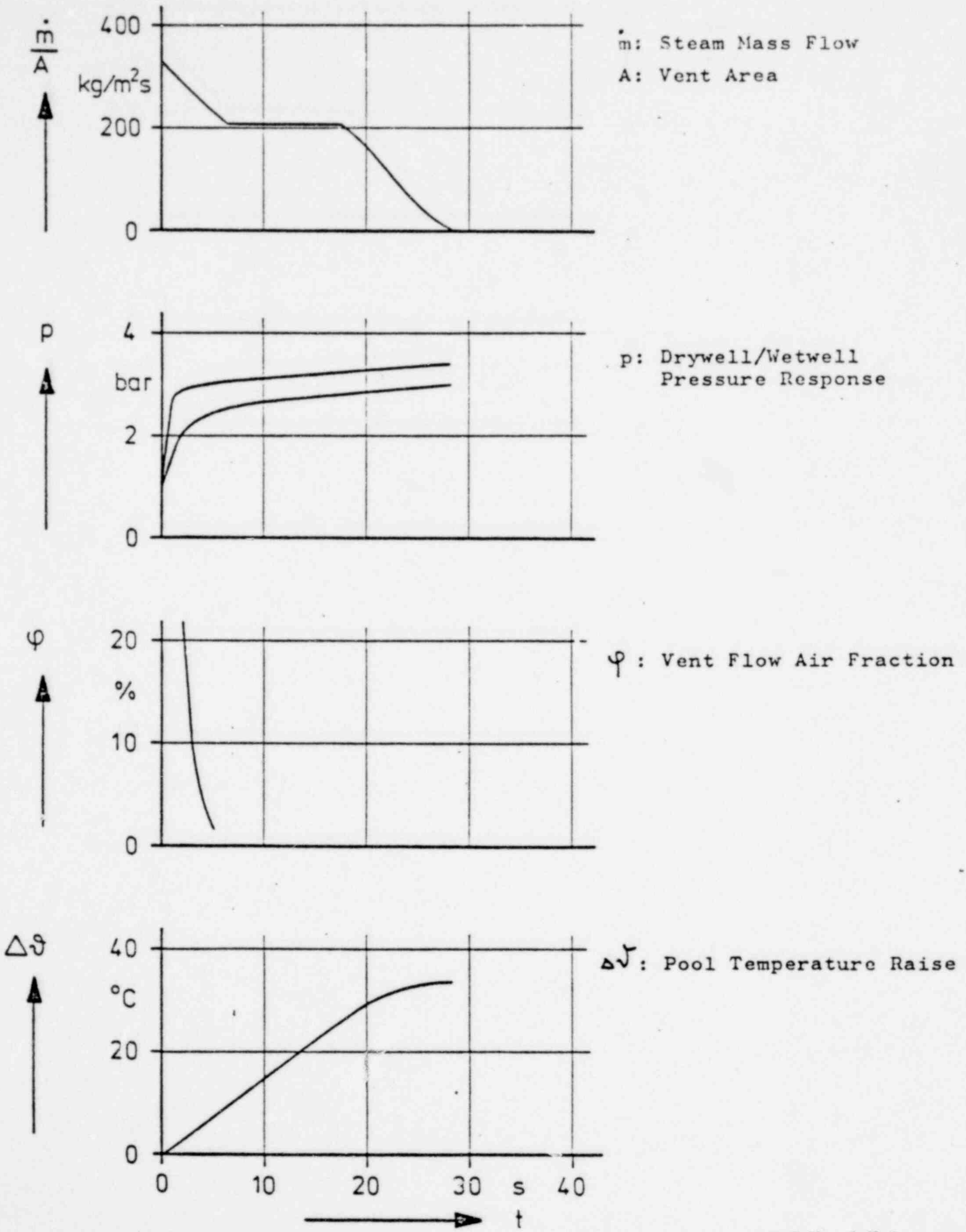



Figure 4: GKM II M Test Transients
RCL Break



1237 258

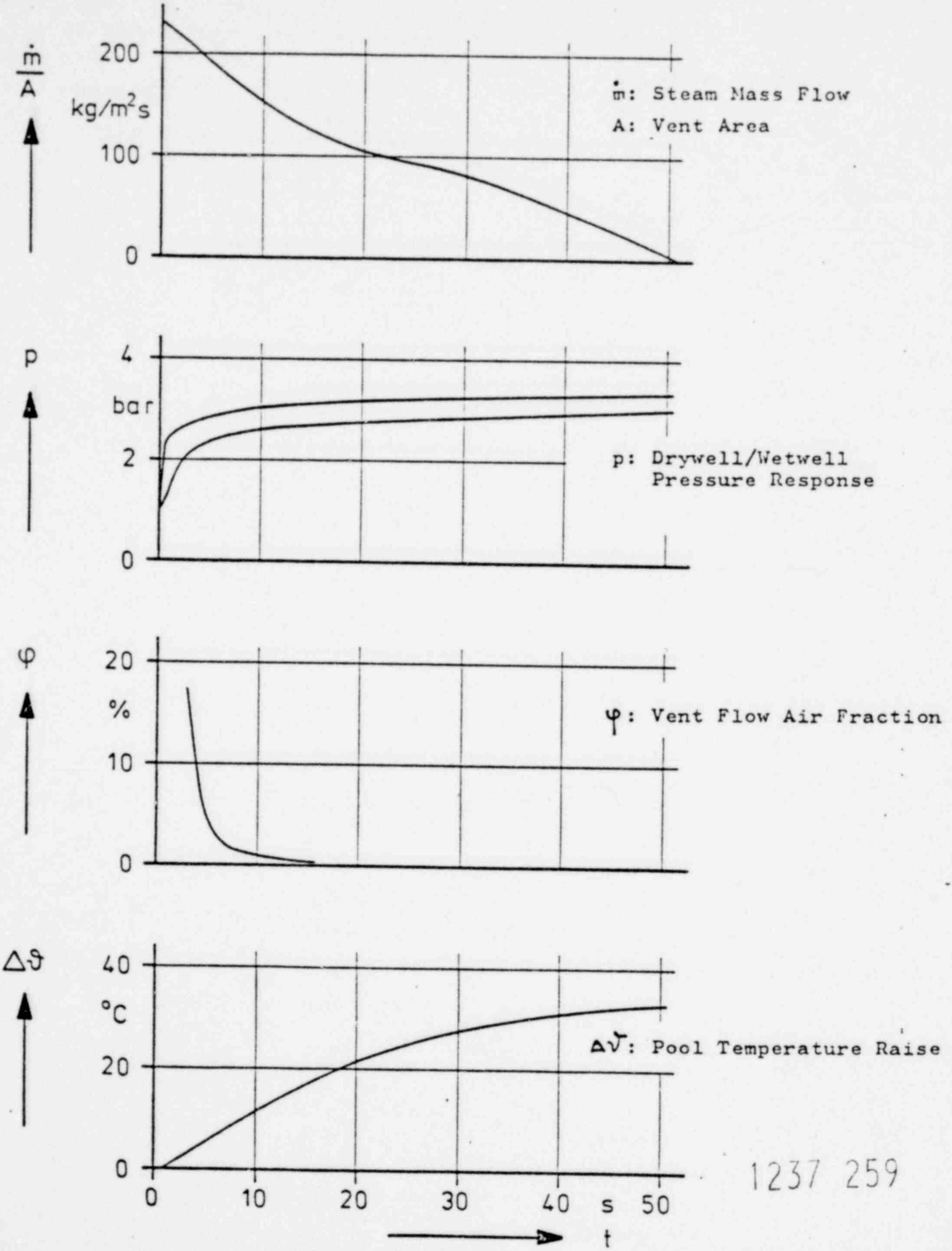
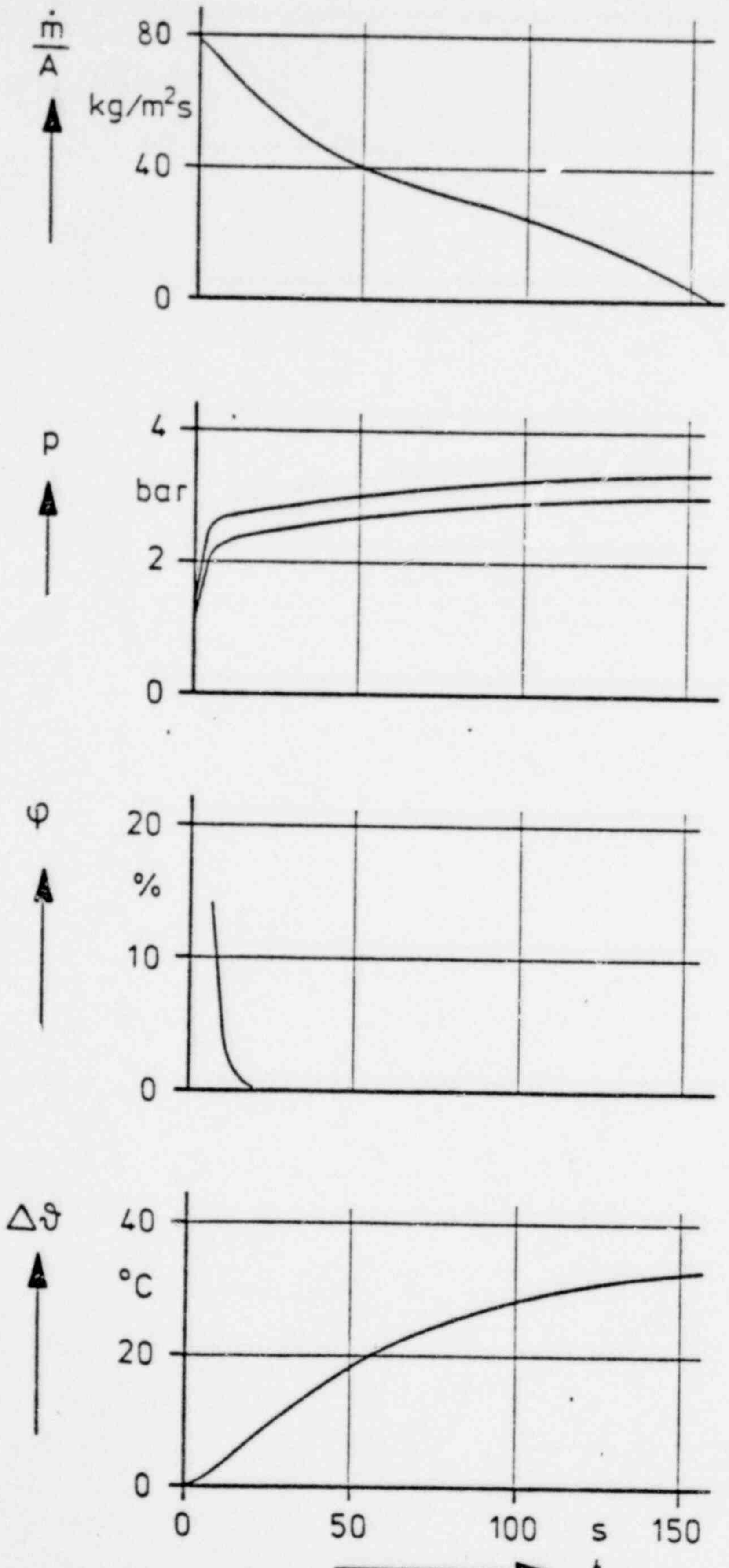



Figure 5: GKM II M Test Transients
MSL Break



1237 259




ṁ: Steam Mass Flow

A: Vent Area

p: Drywell/Wetwell Pressure Response

φ : Vent Flow Air Fraction

Δϑ : Pool Temperature Raise

Figure 6: GKM II M Test Transients
1/3 MSL Break



1237 260

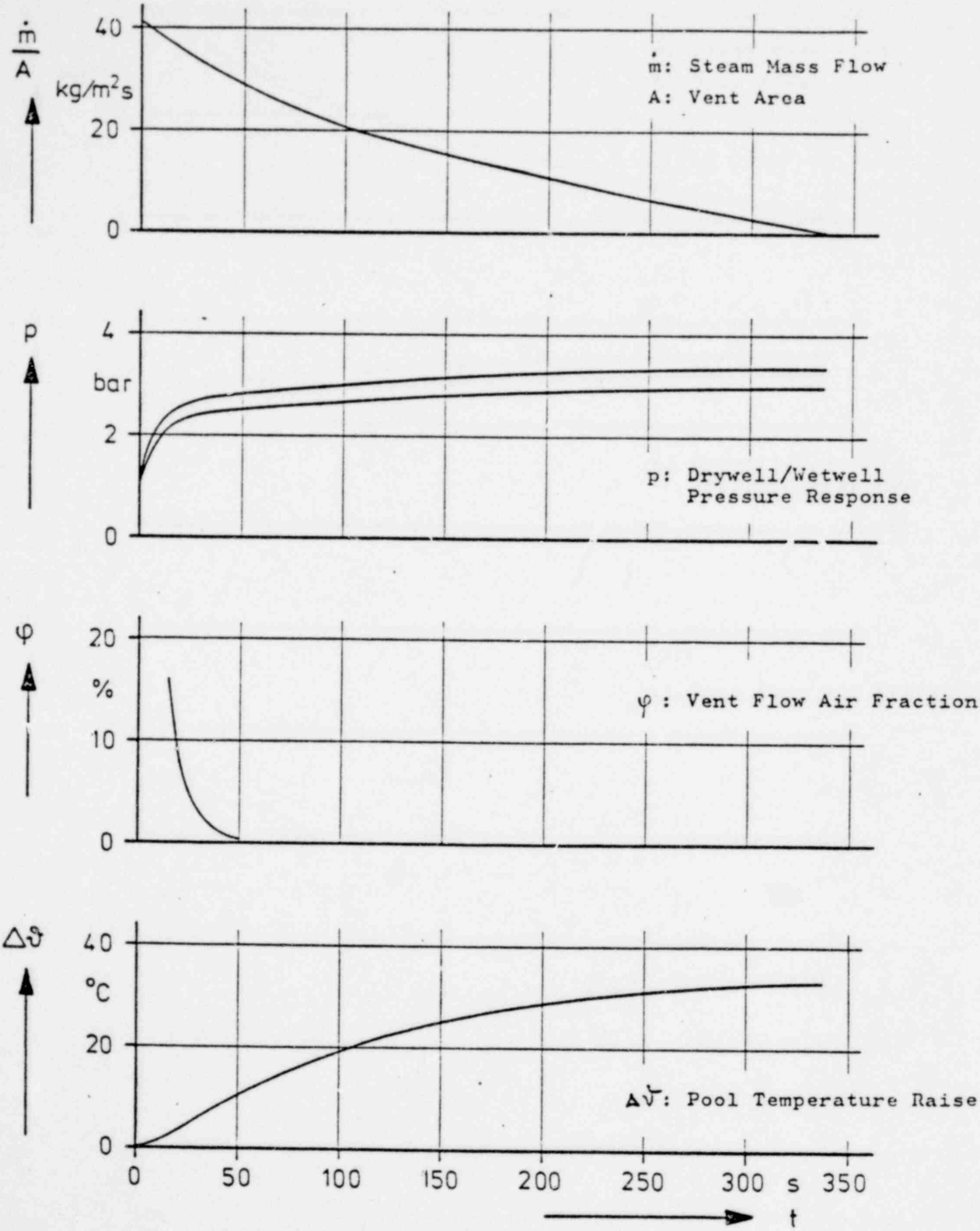



Figure 7: GKM II M Test Transients
1/6 MSL Break



1237 261

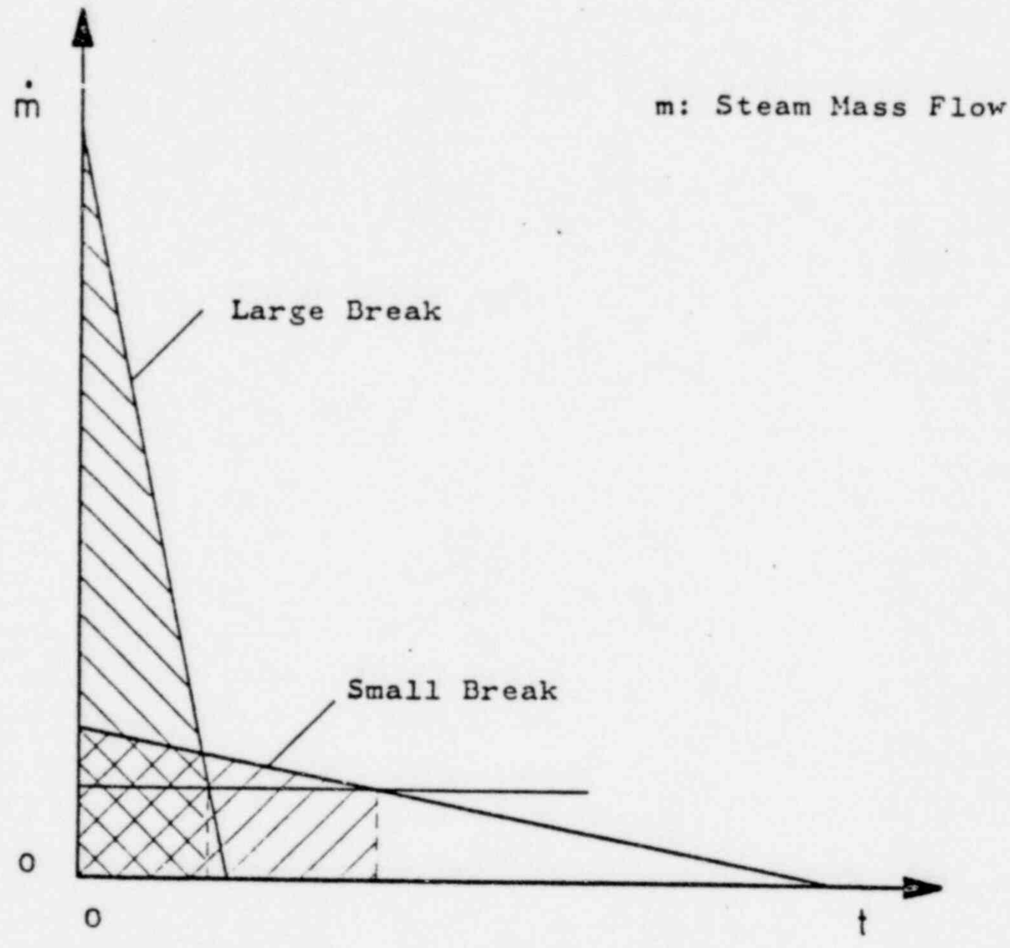



Figure 8: Implicit Variation of the Drywell Air Content by Variation of the Break Size. Purged Drywell Air Mass is a Function of shaded Areas.

1237 262