FRAMATOME COGEMA FUELS

January 14, 2000
GR00-004.doc

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

References:

1. Stuart A. Richards, NRC to T. A. Coleman, FCF Acceptance for Referencing of Topical Report BAW-10227P: "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel" (TAC No. M99903), December 14, 1999.

2. T. A. Coleman (FCF) to NRC Document Control Desk, Response to Request for Additional Information on Topical Report BAW-10227P, April 23, 1999.

Gentlemen:

Reference 1 transmitted the safety evaluation (SE) for Framatome Cogema Fuels (FCF) topical report BAW-10227P. The last sentence of section 7.0 of the SE states, "The limitations and conditions identified in past SEs for the Framatome SBLOCA and LBLOCA models continue to apply." FCF requests that this statement be extended to include the phrase ".....except as modified in this SE." FCF also requests that the following statement be added. "In particular, Appendix I (reference 2) and the attachment to the letter provided to the NRC on January 14, 2000 justify extending the limitation on 20% cladding swell to 56% cladding swell before additional justification is required."

Please revise the SE for BAW-10227P to provide relief to the limitation on the BEACH topical report. Framatome Technologies will use this revised limitation in BEACH and all other RELAP based methodologies where it appears. In order to meet our customers' fuel shipping dates, the revised SE is needed by January 31, 2000.

Very truly yours,

L. Dean Lindeman
for T. A. Coleman, Vice President
Government Relations

Attachment
cc:
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R. Caruso, NRC
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non-prop encl. per J. rrr. 1/27/00

FRAMATOME TECHNOLOGIES

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ATTACHMENT

Discussion of Cladding Cooling Characteristics Under Pre-Rupture Swelling Conditions Including Potential Flow Diversion Effects

Although fuel pin cladding within a fuel assembly can swell prior to rupture creating a bulge that interferes with the local coolant passage, the Framatome LOCA evaluation models do not include flow diversion around this swelling until after a rupture has been calculated. For the Zircaloy evaluation models the justification that not including a pre-rupture flow diversion model was conservative comprised:

1. Fuel pin swelling prior to rupture generates continuously curved surfaces that are efficient in passing fluid and do not generate large pressure drops to induce flow diversion.

2. The maximum swelling of the individual fuel pins was limited in the approved Zircaloy swelling models to 20 % strain limiting channel blockages to less than 34 %.

3. Analytical evaluations indicated that cladding swelling of 20 % will decrease flow around the swelling slightly, increase the cladding heat transfer area, and increase the local fluid velocity. These effects combine to produce a net improvement in heat transfer through the swelling zone. These studies also indicated that the flow would recover rapidly downstream of the swelling such that downstream cooling is unaffected by the cladding swelling

4. Experiments modeling swelled fuel pins showed that net heat transfer from the cladding was increased for assembly blockages up to 62 %.

Because the pre-rupture swelling possible with Zircaloy was limited to 20 % strain, 34 % channel blockage, no consideration was given to larger pin strains or blockages and the EMs applicability was limited to cladding strains of 20 % or less pending additional justification. The approved M5 alloy pre-rupture swelling curves allow substantially higher pre-rupture swelling and blockages. Strains up to 56 %, blockages of 88 %, occur at the extremes of the calculations. However, even for strains and blockages this high, a more complete consideration of the available experimental and analytical results supports the conclusion that pre-rupture swelling enhances rather than degrades the heat transfer process within the affected assembly. Therefore, not including a pre-rupture flow diversion model in the LOCA evaluation models remains a neutral to conservative approach. The revised justification for not including a pre-rupture flow diversion model consists of:

1. Fuel pin swelling prior to rupture generates continuously curved surfaces that are efficient in passing fluid and do not generate large pressure drops to induce flow diversion.

2. The axial position of swelling bulges on individual fuel pins is randomly distributed within the immediate grid span such that diversion is primarily between sub-channels and not fuel assemblies.

3. Fuel assemblies adjacent to the hot assembly, to which assembly flow could be diverted, experience similar swelling providing a buffer to impede any diversion.

4. Analytical evaluations indicated that cladding swelling will decrease flow around the swelling, increase the cladding heat transfer area, increase local fluid velocities, promote turbulence, and possibly liquid droplet vaporization to reduce vapor temperatures. These effects combine to produce a net increase in heat transfer through the swelling zone.

5. Experiments, the FEBA program, directly modeling systems of partially blocked coolant channels, swelled fuel pins, adjacent to normal unblocked coolant channels, unswelled pins, indicated that the heat transfer process is more efficient in both the blocked and the adjacent unblocked channels for swelling-induced blockages up to 90 %, Reference 1.

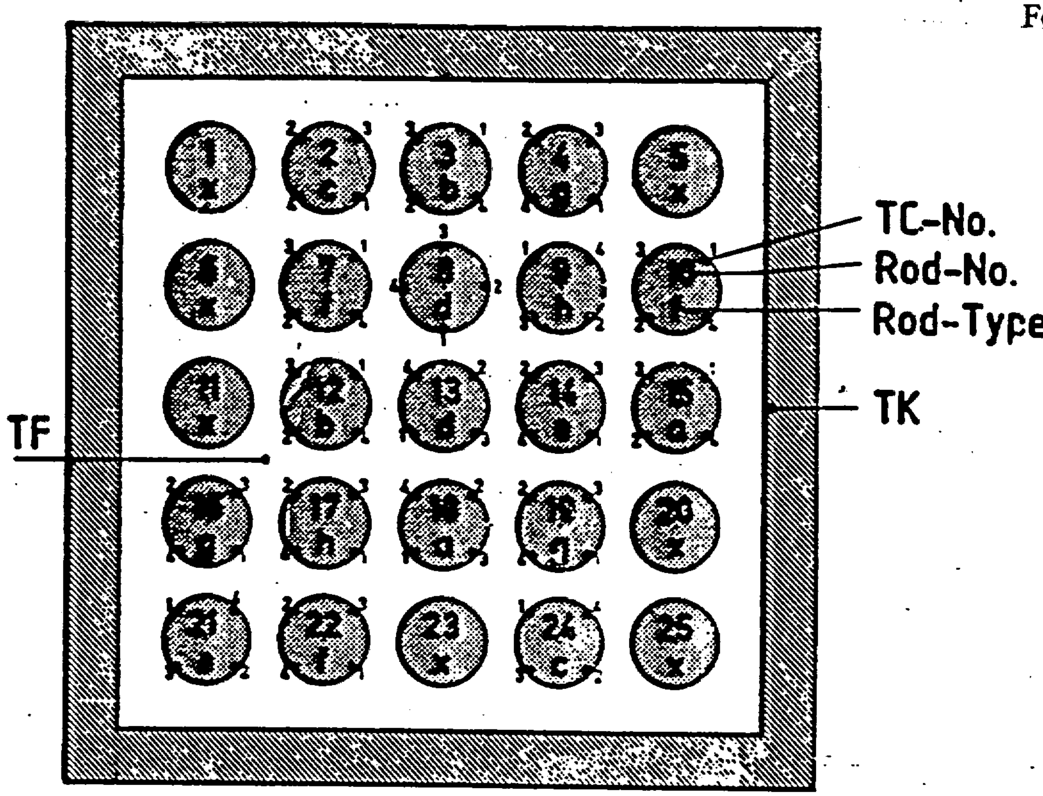
The most significant of these factors is the FEBA program results. The FEBA simulation directly addresses flow diversion effects. Both obstructed and normal flow channels were simulated. The blockage simulators were of a conical geometry characteristic of pre-rupture swelling. An additional flow bypass around the normal channels was provided to simulate a larger test assembly. Yet no adverse impact on fuel pin cooling in either the obstructed or the unobstructed regions of the fuel was observed. Cooling in both the blocked region and the unblocked region was slightly improved for a 62 % obstruction simulation. For the 90 % blockage simulation, cooling may have been improved slightly but is essentially the same as for the completely unobstructed base line assembly until after the time of peak cladding temperature. Some delay in long term cooldown (post PCT) was indicated for the 90 % blockage case. No such effect was evident in the 62 % blockage case. The judgement as to pre-rupture cooling effects should be based on fluid conditions of low flow and high quality. Thus, the early periods of these experiments are the most representative of the conditions under which pre-rupture flow diversion would occur.

A slightly different interpretation of the FEBA results, Reference 2, was presented at the 1983 Water Reactor Safety Research Information Meeting. In a figure on page 204 of the WRSM report, the temperature rise, peak cladding temperature minus the initial temperature, for the blocked channels downstream of the blockage was compared to the temperature rise at the same elevation for reference unblocked tests. Only 3 of the 54 comparisons showed blocked cladding experiencing higher temperature rises than the base line unblocked tests. One of these had an increased rise of less than 10 C and the other two were under 25 C. One of the conclusions from Reference 1 provides a good summary, "For subchannel blockage ratios of 90 %, the mass flux reduction dominates slightly leading to a moderate increase of cladding temperatures (50K) just downstream of the blockage compared with the same axial position in the bypass {*unblocked section of same test*}. However, compared with unblocked bundle conditions {*base line test*} there is no increase of the maximum cladding temperatures for 90 % blockages for 65 mm axial length."

With the exception of droplet interactions, the arguments provided apply equally to large break simulations and to small break simulations above the core mixture height. These results verify that the Framatome approach of not including a simulation of pre-rupture flow diversion is conservative for coolant channel obstructions up to 90 %. Therefore, the additional justification for strains in excess of 20 % has been provided and the M5 LOCA evaluations need not directly consider pre-rupture induced flow diversion effects for cladding strains up to 56 %.

Reference 1: P. Ihle and K. Rust, FEBA - Flooding Experiments with Blocked Arrays, Evaluation Report, KFK3657, March 1984.

Reference 2: Donald M. Ogden, "Review of FEBA Blockage Data," NUREG/CR-0048 Vol 1, 11th Water Reactor Safety Research Meeting, USNRC, 1983.

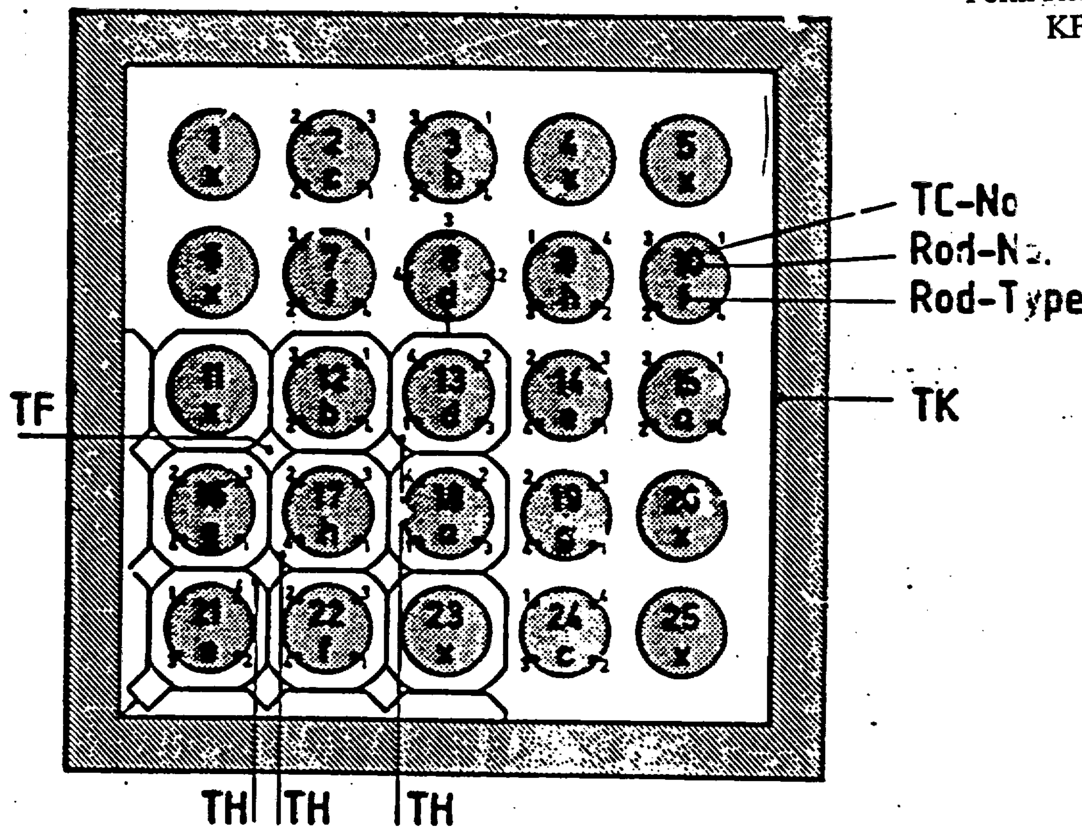


Rod Type	TC No.	Axial Level mm
a	1	2225
	2	2770
	3	3315
	4	3860
b	1	45
	2	590
	3	1135
	4	1680
c	1	3725
	2	3825
	3	3925
	4	4025
d	1	2025
	2	2025
	3	2025
	4	2025

Rod Type	TC No.	Axial Level mm
e	1	2075
	2	2125
	3	2175
	4	2225
f	1	2125
	2	2225
	3	2325
	4	2425
g	1	1625
	2	1725
	3	1825
	4	1925
h	1	1925
	2	2025
	3	2125
	4	2225

Rod Type	TC No.	Axial Level mm
x	without TC's	

Fig. 24 5x5 rod bundle: Radial and axial location of cladding, fluid and housing TC's for test series II

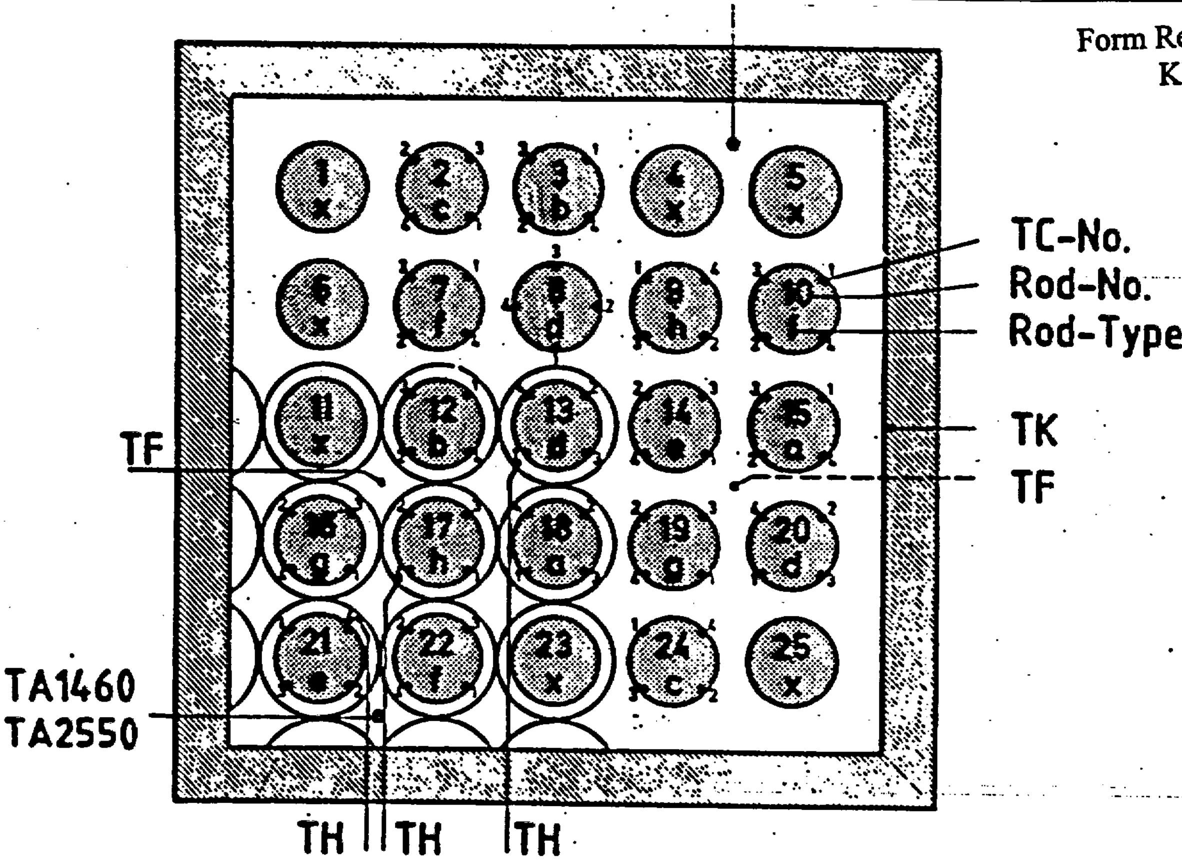


Rod Type	TC No.	Axial Level mm
a	1	2225
	2	2770
	3	3315
	4	3860
b	1	45
	2	590
	3	1135
	4	1680
c	1	3725
	2	3825
	3	3925
	4	4025
d	1	2025
	2	2025
	3	2025
	4	2025

Rod Type	TC No.	Axial Level mm
e	1	2075
	2	2125
	3	2175
	4	2225
f	1	2125
	2	2225
	3	2325
	4	2425
g	1	1625
	2	1725
	3	1825
	4	1925
h	1	1925
	2	2025
	3	2125
	4	2225

Rod Type	TC No.	Axial Level mm
x	without TC's	

Fig. 25 5x5 rod bundle: Radial and axial loca= tion of cladding, sleeve, fluid and hou= sing TC's for test series III



Rod Type	TC No.	Axial Level mm
a	1	2225
	2	2770
	3	3315
	4	3860
b	1	45
	2	590
	3	1135
	4	1680
c	1	3725
	2	3825
	3	3925
	4	4025
d	1	2025
	2	2025
	3	2025
	4	2025

Rod Type	TC No.	Axial Level mm
e	1	2075
	2	2125
	3	2175
	4	2225
f	1	2125
	2	2225
	3	2325
	4	2425
g	1	1625
	2	1725
	3	1825
	4	1925
h	1	1925
	2	2025
	3	2125
	4	2225

Rod Type	TC No.	Axial Level mm
x	without TC's	

Fig. 26 5x5 rod bundle: Radial and axial location of cladding, sleeve, spacer, fluid and housing TC's for test series IV

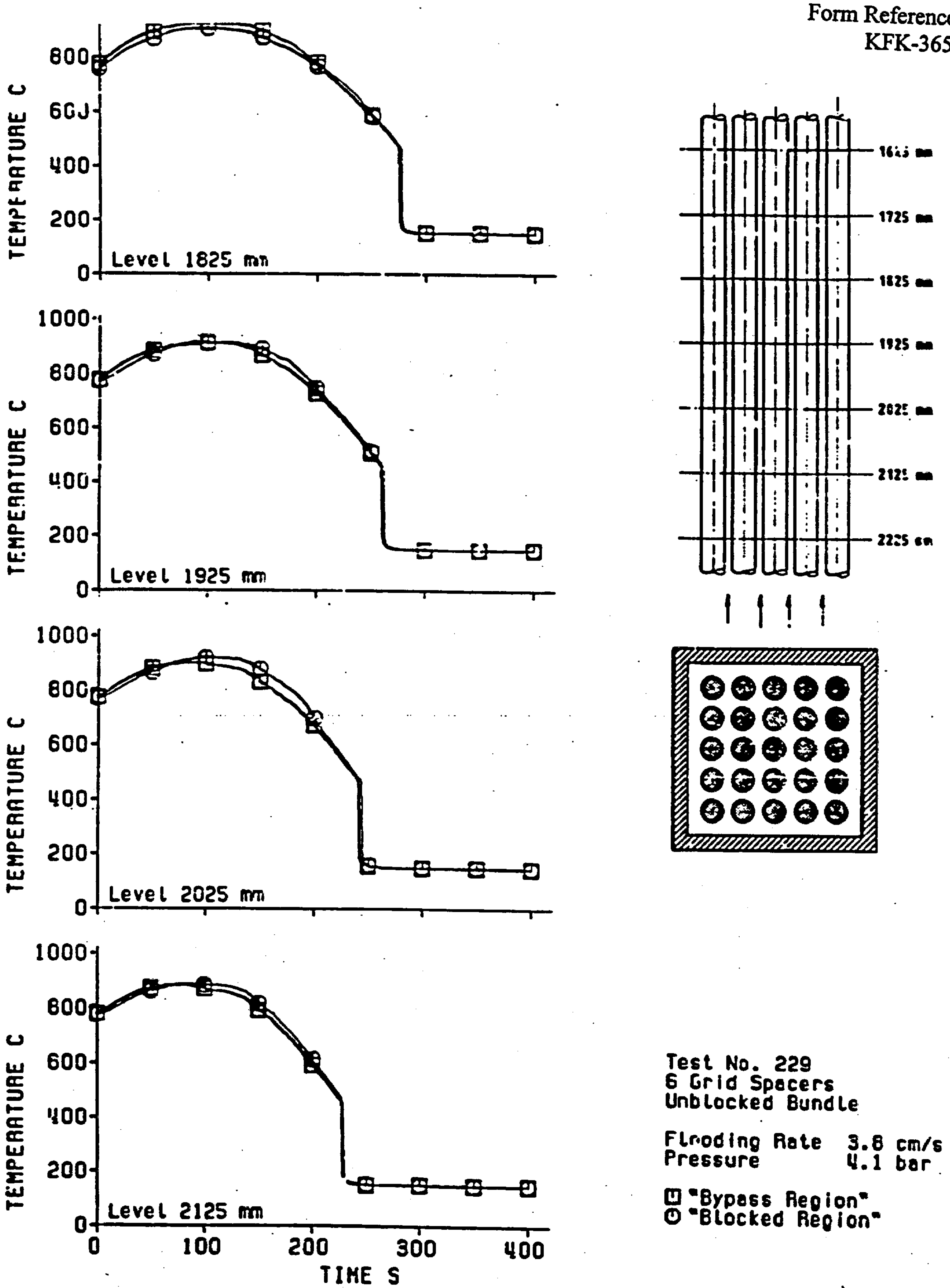


Fig. 42 5x5 rod bundle: Test series II, cladding temperatures

Form Reference 1
KFK-3657

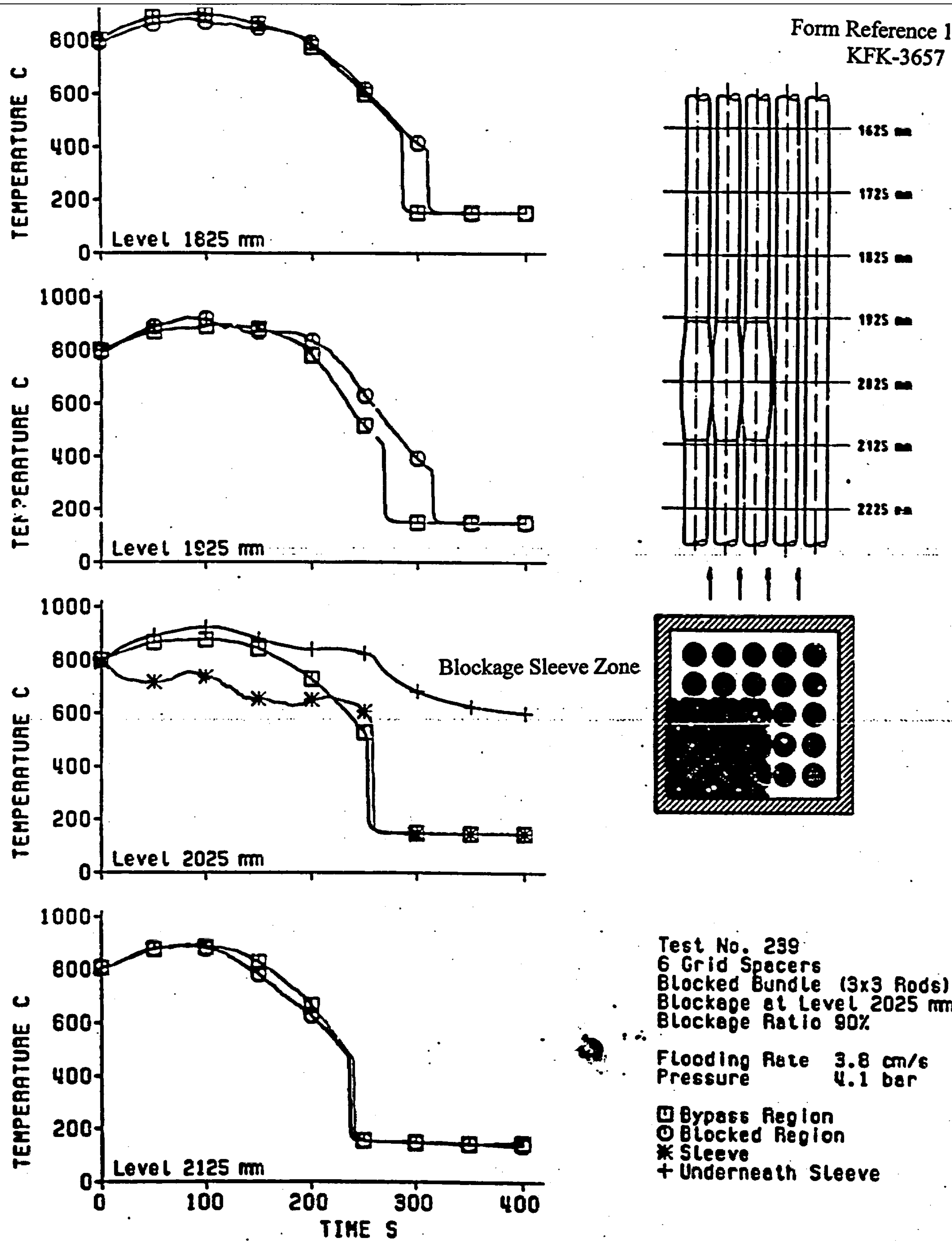


Fig. 44 5x5 rod bundle: Test series III, cladding temperatures

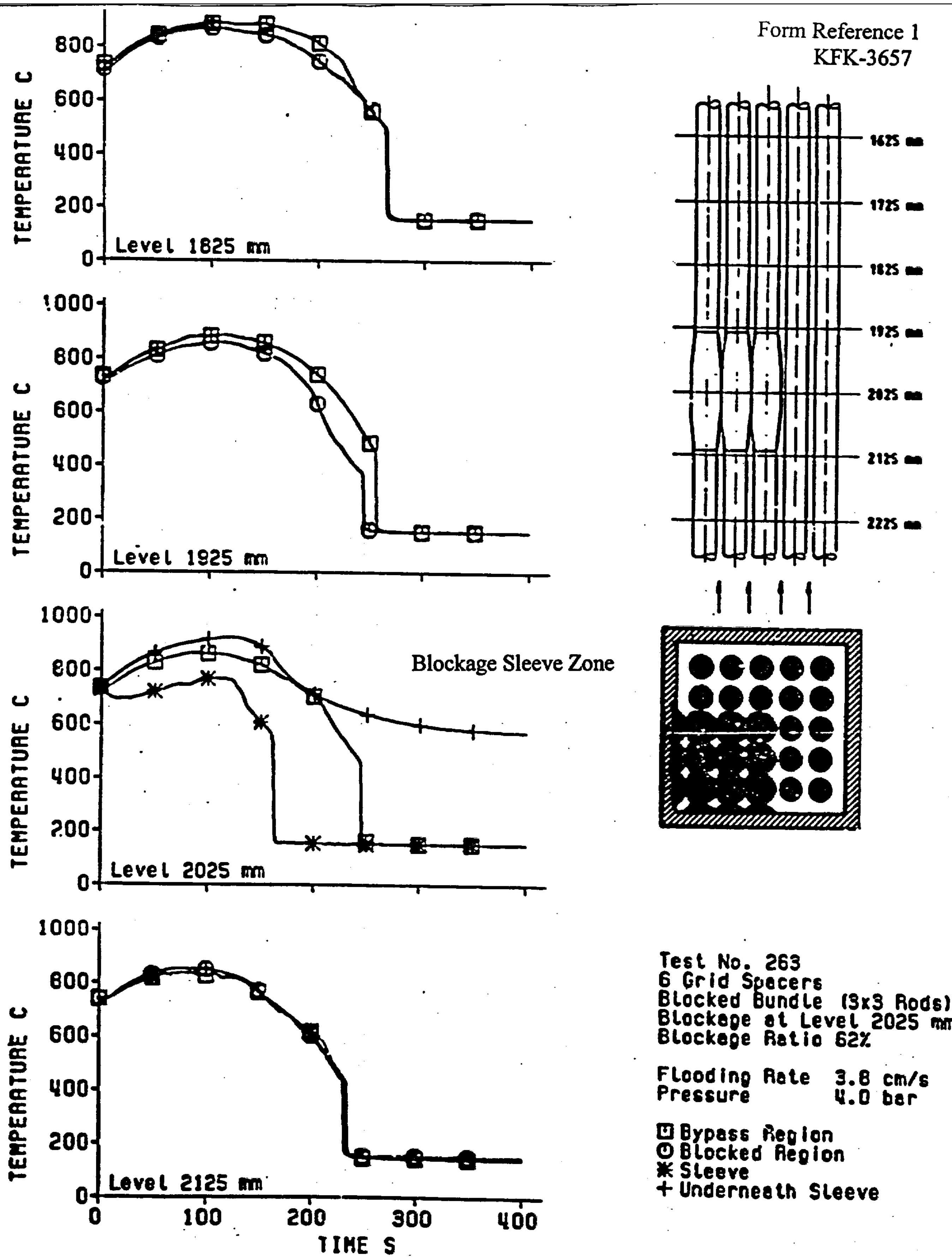


Fig. 45 5x5 rod bundle: Test series IV, cladding temperatures

Form Reference 1
KFK-3657

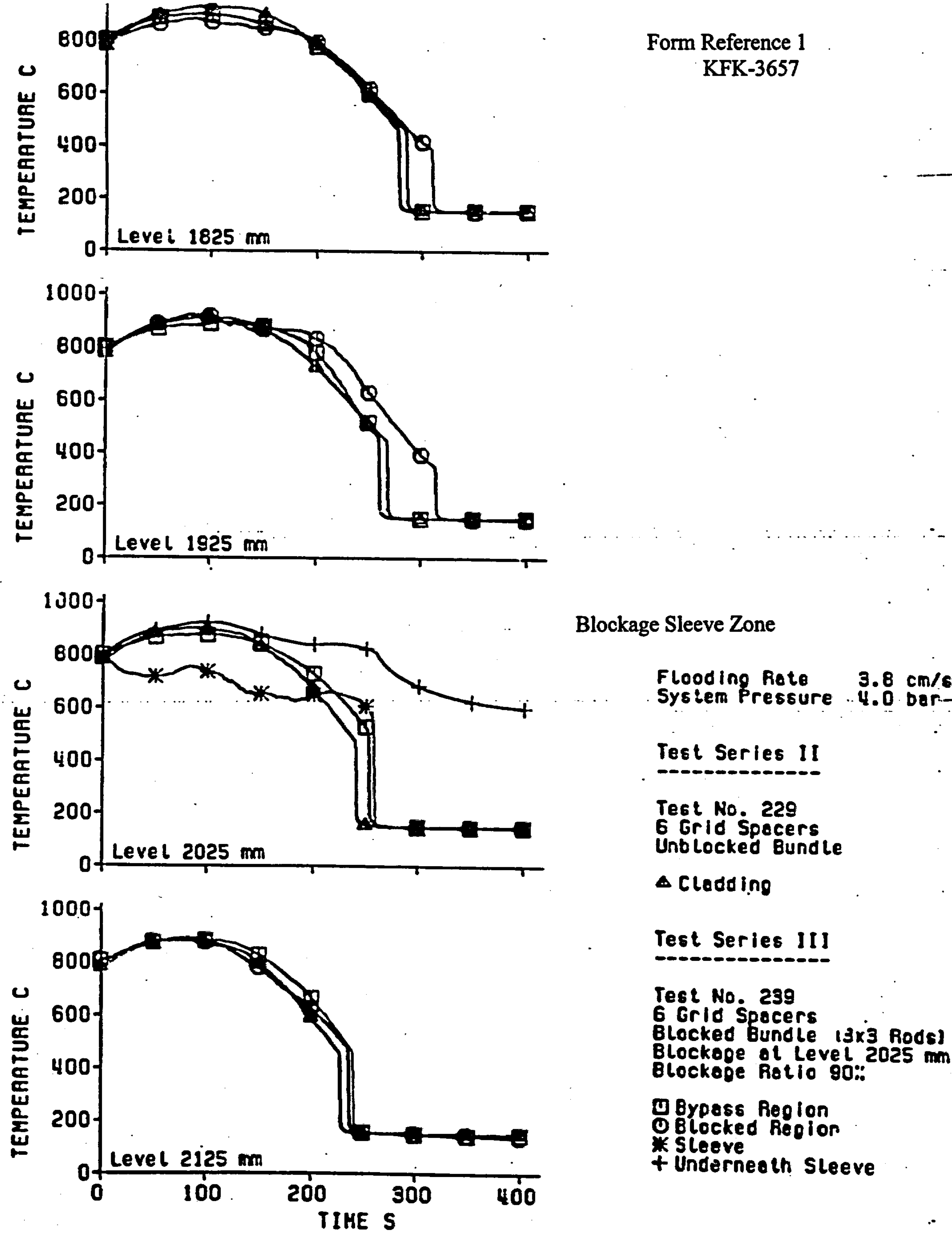


Fig. 57 5x5 rod bundle: Test series II + III, cladding temperatures

FEBA Comparison Tests

Blockage/ Grid Test	Test Type	Unblocked Test	Pressure (MPa)	Flooding Rate (cm/s)
241	90%	234	0.20	3.8
242	90%	234	0.20	3.8
243	90%	234	0.20	3.8
261	62%	233	0.20	5.7
262	62%	234	0.20	3.8
263	62%	229	0.39	3.8
264	62%	228	0.39	5.8
268	62%	231	0.59	3.8
269	62%	230	0.59	5.7

FEBA 25 Rod Blockage Data