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Post-test Calculations of Out-of-pile Single Rod Burst Experiments with Argentine ZRY-4 Tubes Using SSYST Codes System

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POST-TEST CALCULATIONS OF OUT-OF-PILE SINGLE ROD BURST EXPERIMENTS WITH ARGENTINE ZRY-4 TUBES USING SSYST CODE SYSTEM

ABSTRACT

Post-test calculations of out-of-pile single rod burst experiments were performed with SSYST-3 code system. The experiments have been carried out with shortened REBEKA simulators and Argentine Zircaloy tubes.

The main goal of these post-test calculations was to verify whether the model for describing the zircaloy cladding deformation and rupture at high temperatures (NORA2 model) is able to predict the Argentine cladding behaviour under such conditions.

A good agreement between experimental results and model predictions was found in the range of temperatures from 700 to 850 °C (in α phase and first half of $\alpha + \beta$ transition phase). There were some discrepances at higher temperatures, probably due to the strong influence of heating rate on material properties.

According to the results of these post-test calculations, it can be concluded that NORA2 model is able to well describe the Argentine Zircaloy cladding deformation and rupture under LOCA conditions, because there was a good agreement in the range of burst temperatures which are expected in this type of accident. Additional experiments should be performed to investigate the heating rate influence on Argentine material behaviour.

Nachrechnung von out-of-pile Einzelstab-Berstexperimenten mit argentinischen Zircaloy Hüllrohren unter Verwendung des Programmsystems SSYST

Es wurden out-of-pile Einzelstab-Berstexperimente mit dem Programmsystem SSYST-3 nachgerechnet. Die Experimente waren mit verkürzten REBEKA-Simulatoren und argentinischen Zircaloy Hüllrohren durchgeführt worden.

Hauptziel der Nachrechnung war die Prüfung der Frage, ob das in SSYST eingebaute Kriechberstmodell NORA-2 auch das argentinische Hüllrohrmaterial beschreibt.

Zwischen 700 °C und 850 °C (d.h. in der α-phase und in der ersten Hälfte der α-β Übergangsphase) konnte eine gute Übereinstimmung festgestellt werden. Unterschiede zeigten sich bei höheren Temperaturen; sie sind wahrscheinlich auf die hohe Empfindlichkeit des Materialverhaltens in Bezug auf die Aufheizrate zurückzuführen.

Aufgrund dieser Ergebnisse kann man schließen, daß das NORA-2 Modell das Verhalten des argentinischen Hüllrohrmaterials unter LOCA Bedingungen gut beschreibt. Weitere Experimente sollten durchgeführt werden, um die Abhängigkeit des Materialverhaltens von der Aufheizrate bei höheren Temperaturen zu untersuchen.

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1. INTRODUCTION

In order to know the ballooning and burst characteristics of Argentine Zircaloy tubes, under conditions typical for a loss-of-coolant accident (LOCA), several out-of-pile single rod burst experiments were performed with shortened REBEKA simulators (1).
These experiments were intended to simulate the second heatup during the refilling and reflooding phases, in which the Zircaloy fuel rod claddings may reach high temperatures that cause them to balloon and to burst due to the internal overpressure. Such local ballooning reduces the cooling channels cross section in the fuel bundle and may impair the emergency core cooling.
Additionaly, these burst experiments permitted to compare the behaviour of Argentine tubes with the German ones, under similar conditions. A good agreement was found in the range of temperatures between 700 and 1000°C (1).
Starting from recorded data of these burst experiments, post-test calculations were performed using the SSYST code system.
SSYST (2,3,4,5) is a code for analyzing transient behaviour of single fuel rods under off-normal conditions as well as related experimental set-ups. It was developed for Light Water Reactor (LWR) fuel rods but, taking into account its modular structure, it can be adapted to describe the fuel rod behaviour for Pressurized Heavy Water Reactors (PHWR), like the Argentine Reactor ATUCHA I. This adaptation may require some changes in its physical models.
To describe the Zircaloy cladding deformation and rupture under LOCA conditions, SSYST has a model called NORA2 (6), which was built up on the basis of a large computer data bank with tensile, creep and burst test data. All these experiments were performed with Zircaloy produced by a German supplier and with dimensions and geometry corresponding to the German PWR fuel rod claddings.
The main goals of these post-test calculations were:

a) to verify if the NORA2 model is able to predict the Argentine Zircaloy cladding behaviour under similar conditions as the experiments used to set up the model;

b) in case of discrepances, to introduce the necessary modifications into the model for adapting it to the Argentine Zircaloy properties.

This report presents the results of these calculations and a comparative analysis with experimental results.

2. DESCRIPTION OF EXPERIMENTS

2.1. Equipment and specimens

The single rod burst experiments were carried out with shortened REBEKA simulators, in IRB Institut of Kernforschungszentrum Karlsruhe (KfK)(1).

The equipment basically comprises the fuel rod simulator, a gas-handling system to pressurize the specimen, a steam generator and a programmable d.c. power supply for indirect electrical heating of the tube and shroud. Figure 1 shows this schematically.

The fuel rod simulator consists of an electrically insulated heater rod placed inside of an alumina annular pellet stack (Al_2O_3) to simulate the pellet column in fuel elements. The heater is introduced within the specimen to be tested, the gaps between tube, pellets and heater are filled with helium gas at different pressures, and the ends of the specimen are sealed. Figure 2 shows schematically the fuel rod simulator design.

The complete assembly is located in the centre of the test channel, where superheated steam flows at low pressure. To simulate the influence of surrounding rods in a bundle, the shroud is electrically heated during the experiment.

All specimens tested in these experiments were produced by the Argentine supplier (CONUAR S.A.). Their dimensions corresponded to PHWR ATUCHA I Zry cladding design, except the lenght which was of 500 mm, with an internal heated zone of about 325 mm.

2.2. Experimental procedure

The experiments were limited to two controlled independent variables: heating rate and inner pressure.
All tests were performed at the same heating rate ($\sim$1°C/second), while the inner pressure, constant during each experiment, was changed from 6.5 to 94 bar.
The recorded dependent variables were failure temperature, time to rupture, total circumferential strain and the physical appearance of the ruptured specimen.
The experiments began after the complete assembly was equilibrated at initial temperature condition of about 300°C, using the internal and shroud electrical heaters and the superheated steam; also the inner rod pressure was adjusted to the desired value.
The tests ended just after the tube failure by switch-off of the electrical power.
During all experiments, surface temperatures on tube and shroud and inner pressure data were continuosly monitored and recorded in a computer. In some tests, X-ray cinematography with a high-speed camera was used to record the changes of the tube diameter during the test.

2.3. Results

Table 1 summarizes the main results of all experiments performed with Argentine Zircaloy tubes. More details of them may be found in (1).
In Figure 3 the relationship between total circumferential strain at failure and burst temperature is shown.
These results were used for the comparative analysis performed in the present report.

3. POST-TEST CALCULATIONS

3.1. Modelling details

For simulation of these burst experiments, the fuel rod simulator was subdivided into eleven axial segments. In radial direction, eight nodes were considered which corresponded to the different material layers of the heater, the alumina annular pellets, gaps and Zircaloy cladding.

The overall analysis of the transient was resolved into a sequence of up to 1000 integration time steps. The size of each time increment was 1.5 seconds. No numerical instability was found with this value.

At each time step, the following sequence of modules was called:

```
RANDM
  ↓
URGAP
  ↓
ZIRKOX
  ↓
ZET-1D
  ↓
STADEF
  ↓
AZI
  ↓
ZWERG
```

The module RANDM supplied the outer and inner boundary conditions for heat transport calculations in the fuel rod.

URGAP calculated the heat conductance in the gap between heater and Zircaloy cladding.

ZIRKOX determined the cladding oxidation, its contribution to the heat sources and a correction to the clad-to-coolant heat transfer coefficient to simulate the smaller conductivity of the oxide layer.

ZET-1D solved the transient heat transport equation for the fuel rod simulator, neglecting axial heat conduction (1D stands for 1-dimensional).

STADEF modeled the axisymetric deformation of the fuel rod simulator, especially of the Zircaloy cladding and its failure.

To take into account azimuthal asymmetries on the cladding surface, caused by an excentric position of heater or by variations of initial cladding thickness, the module AZI was introduced in the loop. It models heat transport, gap conductance, Zry oxidation, cladding deformation and failure in one selected axial zone, in which the most relevant deformation is expected. It also models radiative heat exchange with the surrounding rods (in this case with the shroud).
In these calculations, the azimuthal analysis was performed in the centre of the rod (sixth axial segment), because it corresponded to the zone with the highest linear power. Twenty azimuthal nodes were considered in this segment.
Finally, the module ZWERG collected several data from different data blocks for plotting.

To calculate the radiative heat exchange between fuel rod simulator and heated shroud with AZI, three different models were built up:

3.1.1. Model A

It was similar to the model used in former post-test calculations of single rod REBEKA experiments with SSYST(7).
In this model, at any time, the shroud temperature was defined by the corresponding azimuthal mean temperature of the cladding surface (temperature of the tenth azimuthal node) plus a constant value of 5 K.
Preliminary calculations performed with this model showed that for reaching the heating rate prescribed during the tests, it was necessary to adjust the clad-to-coolant heat transfer coefficient according to the different inner pressures. A linear adjustment was performed using the extreme values of pressures (6.5 and 94 bar respectively).

3.1.2. Model B

In this model the shroud temperature was defined by the heating rate prescribed during the tests. In this case it was not necessary to adjust the heat transfer coefficient for different pressures.

3.1.3. Model C

All runs performed with models A and B showed that the calculated cladding heating rate was not constant during the transient: at the beginning it was higher than the experimental heating rate and later it dropped to a lower value, even though the average heating rates were the same.
In order to get a constant heating rate on cladding surface, a new model was built up: in it, the prescribed heating rate was imposed to the shroud and the cladding emissivity was changed from its real value (0.8) to an artificial one. With this change, a strong coupling between the rod and shroud was reached and the cladding heating rate was constant too.

In Appendix A a summary of main characteristics of these three diferent models is given.

3.2. Input data

In Appendix B, a complete listing of the input data corresponding to the three selected models is given.

3.3. Sequence of calculations

For each value of rod inner pressure used in the experiments, several computer runs were made with different values of excentricity between heater and cladding (e). The best agreement with the real azimuthal temperature differences, observed during the experiments, was reached with $0.6 \leq e \leq 0.9$. These calculations were repeated for the three selected models.
The analysis of each test was subdivided into two steps:
In the first step, a steady state calculation was performed from cold conditions (at 25 °C) to the initial experimental conditions (at 300 °C). A time vector with 500 integration time steps was defined for this calculation. After it finished, the time was turned

back to zero again.
The second step was the transient calculation of the temperature ramp until cladding failure was reached. The end of calculation was governed by the module AZI: when the cladding failure was detected, the module interrupted the sequence of integration.
After the calculation was finished, all relevant data for comparison with experimental results, were collected from different data blocks and they were stored in a "matrix of results" which was previously defined.

3.4. Results

Tables 2, 3 and 4 summarize the results of post-test calculations, corresponding to models A, B and C, respectively.

4. DISCUSSION OF RESULTS

4.1. Comparison of results from the three selected models

In order to choose the best model for calculating these burst experiments, the results from the three models were first compared in terms of failure temperature, time to rupture and final circumferential strain. They are comprised in Tables 5, 6 and 7 respectively.
From analysis of these results, the following may be concluded:

- There were no significant differences among the three models in predicting failure temperatures and times to burst.

- The model C was not sensitive to excentricity changes. The corresponding values calculated by it were constant for all selected excentricities ($0.6 \leq e \leq 0.9$).

- The circumferential failure strains were best predicted by model B.

For these reasons, the model B was selected for the comparison with the experimental results which is presented in the following paragraph.

4.2. Comparison with experimental results

To verify the predictive capability of NORA2 model, a comparative analysis of post-test calculation results and experimental data was performed.

Figure 4 shows the calculated failure temperatures versus corresponding measured values. As may be seen, the points are enclosed in a scatter band of ± 2 %, except the point corresponding to the lowest rod inner pressure (6.5 bar) which is outside. For this experiment the calculated values were about 6 % higher than the measured ones.

Figure 5 shows a similar plot in terms of burst time. In this case the points are enclosed in a scatter band of ± 4 %. Once more the agreement was not good for the lowest pressure, because the calculated values were about 7 % higher than the experimental ones.

Finally, Figure 6 illustrates the corresponding plot for calculated and measured circumferential strains at failure. In this case, the scattering was greater (± 20 %) and the main differences were found for intermediate pressures. To understand better these discrepances, the calculated and measured failure strains were plotted versus the burst temperatures.

Figure 7 shows this diagram, in which two zones can be distinguished:

a) In α phase and first portion of $\alpha + \beta$ transition, there was a good agreement between predicted and experimental data. Nevertheless, the high circumferential strains found in the experiments between 750 and 850 °C were not reproduced by the calculations. The calculated curve in this zone was flatter, with failure strains smaller than 90 %.

b) In the second half of $\alpha + \beta$ transition and in β phase, the agreement was not good. Two kind of differences were found:

- in $\alpha + \beta$ transition zone, failure strains predicted by the model were different to corresponding experimental values, but there was a good agreement in terms of failure temperature and time to burst. In other words, the specimens failed at expected temperature and time but with different circumferential strain;
- in β phase, the failure strains were well predicted by the model but calculated burst temperatures and times to burst were quite higher than the experimental values. In other words, for these experiments, the specimens failed with the expected circumferential strain, but the failure happened quite earlier.

In order to understand more clearly the nature of these discrepances, two kinds of additional calculations were performed:
In the first one, a concentric arrangement of cladding and heater was used to calculate failure strains in the range of 750 to 850 °C. The goal of these calculations was to estimate the upper scattering predicted by the model.
On the other hand, intermediate pressures between 23 to 6.5 bar were selected to calculate final strains at failure. The goal of these computer runs was to get a more detailed view on the failure strain as a function of the failure temperature, in the upper $\alpha + \beta$ and β phase. The results of these calculations are shown in Figure 8.
In the first case, the calculated failure strains were roughly coincident with experimental values. It means that the model was able to predict the high strains observed in some of those experiments, which probably were performed under concentric conditions.
In the second case, the new results showed that, in the calculated curve, there is a minimum value for the strains in the upper $\alpha + \beta$ phase, and a second maximum in the lower portion of the β phase. In the experimental curve these extreme values are displaced to lower temperatures (the minimum was located in the middle of $\alpha + \beta$ transition phase and the second maximum is at its upper boundary).
These discrepances do not seem to be a consequence of different

properties of Argentine Zircaloy tubes, because there was a good agreement with German tubes tested under similar conditions. They arise from NORA2 development: all tests used to build up the model, except those performed in REBEKA facility, showed this kind of behaviour, as may be seen in Figure 9 (6). According to that, the deformation model was defined in correspondence with those experimental results. Nevertheless, to clarify this point, more experiments with Argentine Zircaloy tubes should be performed in this range of high temperatures, because at the moment, the sample size is not large enough to extract definitive conclusions. Finally, to verify if strain histories were well predicted by the model, calculated and measured strains were compared during the last ten seconds before rupture. The results are plotted in Figure 10 for three different rod inner pressures. The plots show that measured and calculated strain histories matched quite well.

5. CONCLUSIONS

5.1. There was a good agreement between experimental results and model predictions in the range of temperatures from 700 to 850 °C (in α phase and first half of $\alpha + \beta$ transition phase).

5.2. Some discrepances were found for higher temperatures. The strong influence of heating rate on material behaviour in this range of temperatures (see Figure 9), might be the reason for these discrepances.

5.3. To investigate the heating rate dependance of Argentine Zircaloy claddings, some experiments should be performed at different heating rates. They would permit to see whether this dependance is in agreement with the scatter band of Figure 9.

5.4. According to these post-test calculation results, it can be concluded that the NORA2 model is able to well describe the

Argentine Zircaloy cladding deformation and rupture under LOCA conditions, because there was a good agreement in the range of burst temperatures which are expected in this type of accident.

5.5. The influence of input data variations on predicted results, shows that it is not sufficient to perform only one calculation for a single rod analysis. Rather the spectra of uncertainties in the input data have to be taken into account. Also a probabilistic analysis should be performed.

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TABLE 1: Experimental results of single rod burst tests with Argentine tubes

ROD INNER PRESSURE (bar)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
94	982 983 988	341 337 339	67 70 78
80	997 997 1000	348 351 358	74 76 72
67	1031 1037	376 382	107 85
54	1041 1049	398 399	76 99
47	1067	415	102
40	1093 1105 1111	442 450 450	70 84 106
27	1162 1162	496 497	55 52
23	1174	515	45
13.4	1231 1233	545 555	68 56
6.5	1281 1285	604 608	24 26

TABLE 2: Post-test calculation results with MODEL A

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
94	0.6	964	327	71
	0.7	965	327	69
	0.8	965	332	66
	0.9	967	326	64
80	0.6	989	348	75
	0.7	990	348	73
	0.8	990	350	70
	0.9	992	347	67
67	0.6	1016	371	82
	0.7	1017	371	79
	0.8	1017	371	79
	0.9	1019	369	72
54	0.6	1049	399	84
	0.7	1049	398	81
	0.8	1050	401	77
	0.9	1051	396	74
47	0.6	1071	417	84
	0.7	1072	416	82
	0.8	1073	416	78
	0.9	1074	416	75
40	0.6	1097	438	86
	0.7	1098	438	83
	0.8	1098	446	80
	0.9	1099	437	77

TABLE 2 (CONT.)

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
27	0.6	1150	485	72
	0.7	1151	485	67
	0.8	1152	485	65
	0.9	1153	483	61
23	0.6	1171	504	59
	0.7	1172	504	56
	0.8	1172	504	53
	0.9	1173	503	51
13.4	0.6	1235	557	30
	0.7	1235	557	29
	0.8	1236	558	28
	0.9	1236	557	28
6.5	0.6	1357	653	26
	0.7	1358	653	27
	0.8	1357	651	26
	0.9	1356	653	27

TABLE 3: Post-test calculation results with MODEL B

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
94	0.6	967	327	74
	0.7	967	327	72
	0.8	968	329	70
	0.9	968	326	67
80	0.6	991	348	79
	0.7	992	348	77
	0.8	993	350	74
	0.9	993	348	71
67	0.6	1019	372	86
	0.7	1019	372	83
	0.8	1020	372	80
	0.9	1021	372	77
54	0.6	1052	401	88
	0.7	1052	401	85
	0.8	1054	402	83
	0.9	1053	401	79
47	0.6	1075	420	89
	0.7	1075	420	86
	0.8	1075	420	84
	0.9	1076	420	80
40	0.6	1101	443	90
	0.7	1101	443	88
	0.8	1102	444	87
	0.9	1102	443	82

TABLE 3 (CONT.)

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
27	0.6	1154	489	74
	0.7	1154	489	71
	0.8	1155	489	68
	0.9	1155	489	65
23	0.6	1177	509	59
	0.7	1177	509	57
	0.8	1175	507	58
	0.9	1176	507	53
13.4	0.6	1238	558	35
	0.7	1238	558	34
	0.8	1238	558	34
	0.9	1239	558	33
6.5	0.6	1359	654	27
	0.7	1359	654	27
	0.8	1359	654	27
	0.9	1360	656	27

TABLE 4: Post-test calculation results with MODEL C

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
94	0.6	970	332	89
	0.7	970	332	89
	0.8	970	332	88
	0.9	970	332	88
80	0.6	995	353	95
	0.7	995	353	95
	0.8	995	353	95
	0.9	995	353	95
67	0.6	1022	375	103
	0.7	1022	375	103
	0.8	1022	375	103
	0.9	1022	375	102
54	0.6	1054	402	103
	0.7	1054	402	103
	0.8	1054	402	103
	0.9	1054	402	103
47	0.6	1076	420	103
	0.7	1076	420	103
	0.8	1076	420	103
	0.9	1076	420	102
40	0.6	1103	443	106
	0.7	1103	443	106
	0.8	1103	443	106
	0.9	1103	443	105

TABLE 4 (CONT.)

ROD INNER PRESSURE (bar)	EXCENTRIC. (-)	BURST TEMPERATURE (K)*	TIME TO BURST (seconds)	CIRCUMFERENTIAL BURST STRAIN (%)
27	0.6	1157	488	85
	0.7	1157	488	85
	0.8	1157	488	85
	0.9	1157	488	85
23	0.6	1177	504	68
	0.7	1177	504	68
	0.8	1177	504	68
	0.9	1177	504	68
13.4	0.6	1238	555	37
	0.7	1238	555	37
	0.8	1238	555	37
	0.9	1238	555	37
6.5	0.6	1353	651	28
	0.7	1353	651	28
	0.8	1353	651	28
	0.9	1353	651	28

TABLE 5: Comparison between results using the models A-C and experimental values in terms of burst temperatures

ROD INNER PRESSURE (bar)	CALCULATED BURST TEMPERATURES (K) $0.6 \leq e^* \leq 0.9$ (*)			MEASURED BURST TEMPERATURES (K)
	MODEL A	MODEL B	MODEL C	
94	964-967	967-968	970	982-988
80	989-992	991-993	995	997-1000
67	1016-1019	1019-1021	1022	1031-1037
54	1049-1051	1052-1054	1054	1041-1061
47	1071-1074	1075-1076	1076	1067
40	1097-1099	1101-1102	1103	1093-1111
27	1150-1153	1154-1155	1157	1162
23	1171-1173	1175-1177	1177	1174
13.4	1235-1236	1238-1239	1238	1231-1233
6.5	1356-1358	1359-1360	1353	1281-1285

$$(*)\ e = \frac{\text{distance between cladding and heater center}}{\text{transient axisymetric gap width}}$$

TABLE 6: Comparison between results using the models A-C and experimental values in terms of time to burst

ROD INNER PRESSURE (bar)	CALCULATED BURST TIME (seconds) $0.6 \leq e^{*} \leq 0.9$ (*)			MEASURED BURST TIME (seconds)
	MODEL A	MODEL B	MODEL C	
94	326-332	326-329	332	337-341
80	347-350	348-350	353	348-358
67	369-371	372	375	376-382
54	396-401	401-402	402	398-407
47	416-417	420	420	415
40	437-446	443-444	443	442-450
27	483-485	489	488	496-497
23	503-504	507-509	504	515
13.4	557-558	558	555	545-555
6.5	651-653	654-656	651	604-608

(*) See before

TABLE 7: Comparison between results using the models A-C and experimental values in terms of circumferential strain at failure

ROD INNER PRESSURE (bar)	CALCULATED CIRCUMFERENTIAL STRAIN (%) 0.6 ≤ e ≤ 0.9 (*)			MEASURED CIRCUMFERENTIAL STRAIN (%)
	MODEL A	MODEL B	MODEL C	
94	64-71	67-74	88-89	67-78
80	67-75	71-79	95	72-76
67	72-82	77-86	102-103	85-107
54	74-84	79-88	103	76-99
47	75-84	80-89	102-103	102
40	77-86	82-90	105-106	70-106
27	61-72	65-74	85	52-55
23	51-59	53-59	68	45
13.4	28-30	33-35	37	56-68
6.5	26-27	27	28	24-26

(*) See before

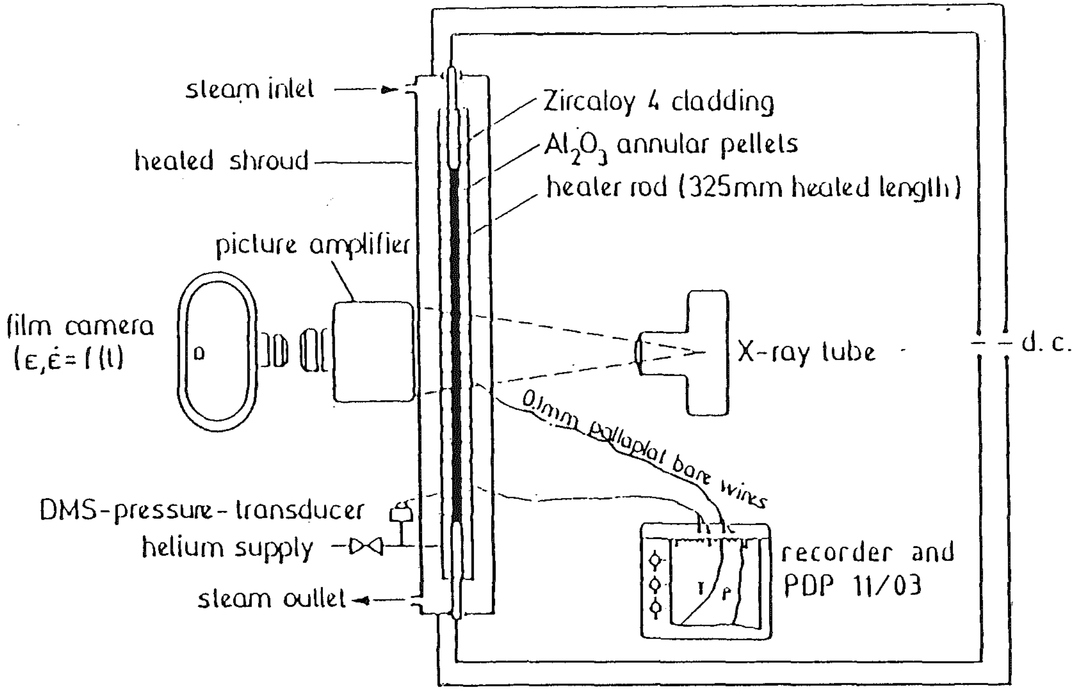


FIGURE 1: Test equipment diagram

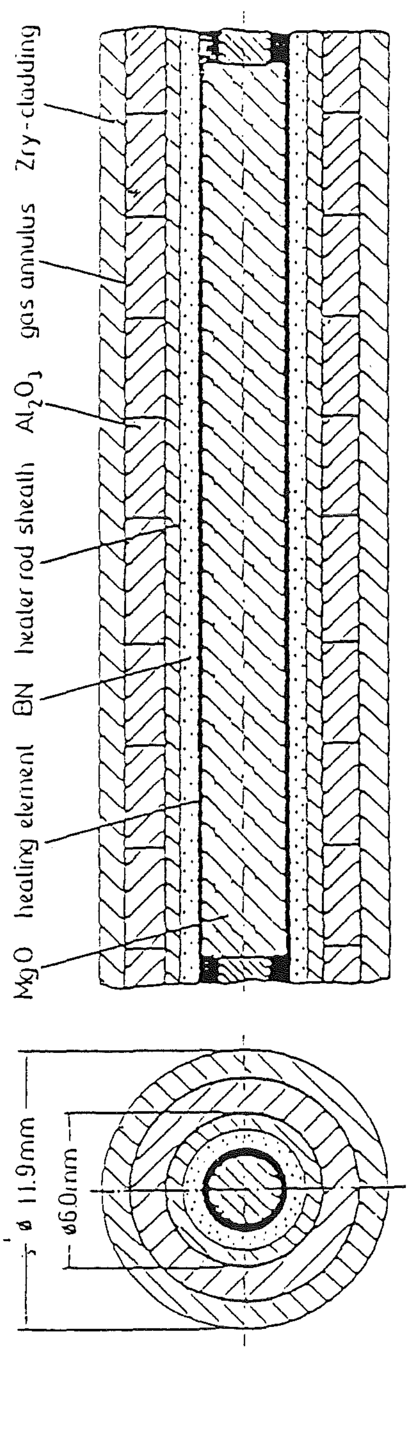


FIGURE 2: Fuel rod simulator design

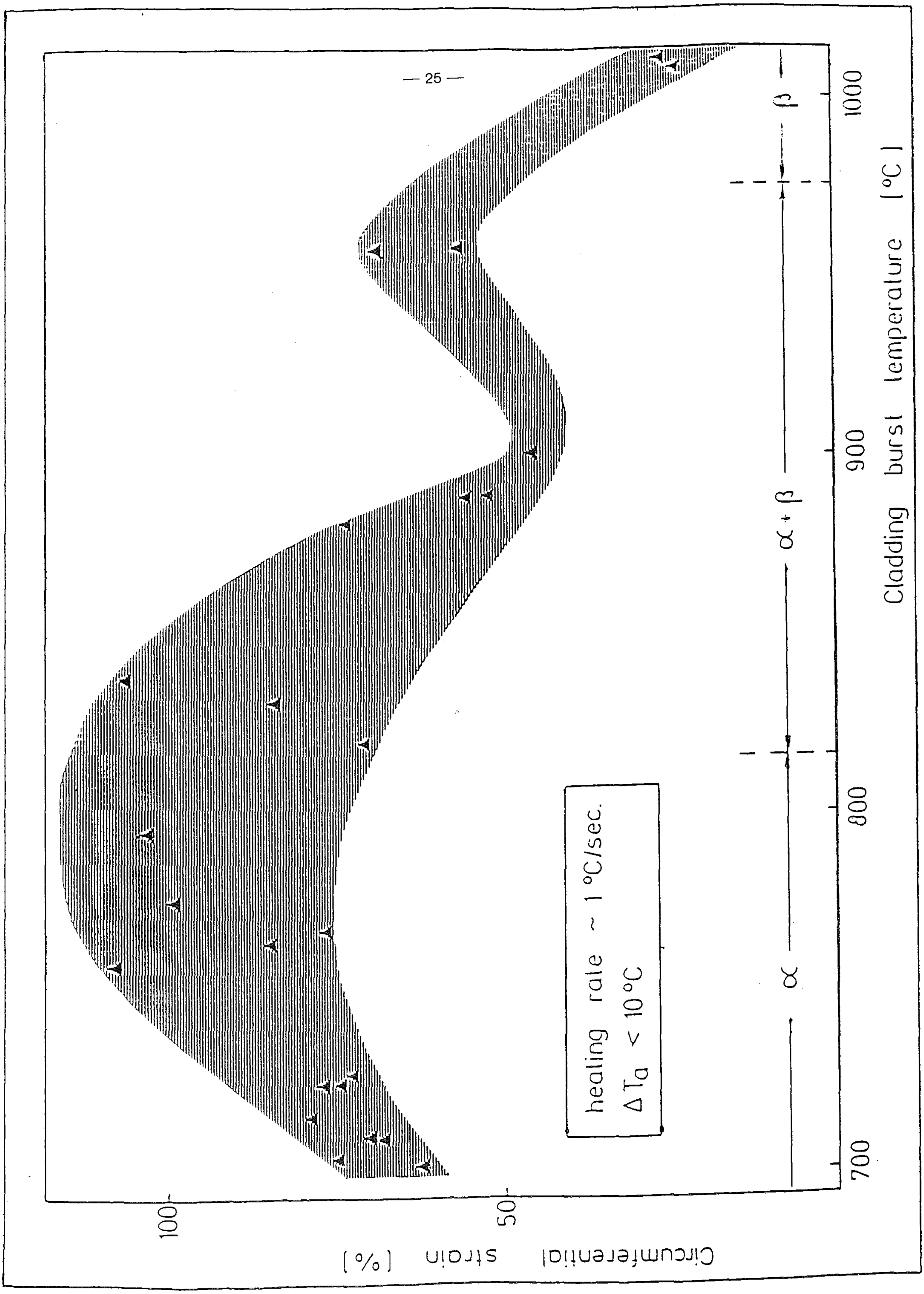


FIGURE 3: Circumferential strain at failure versus burst temperature (measured values)

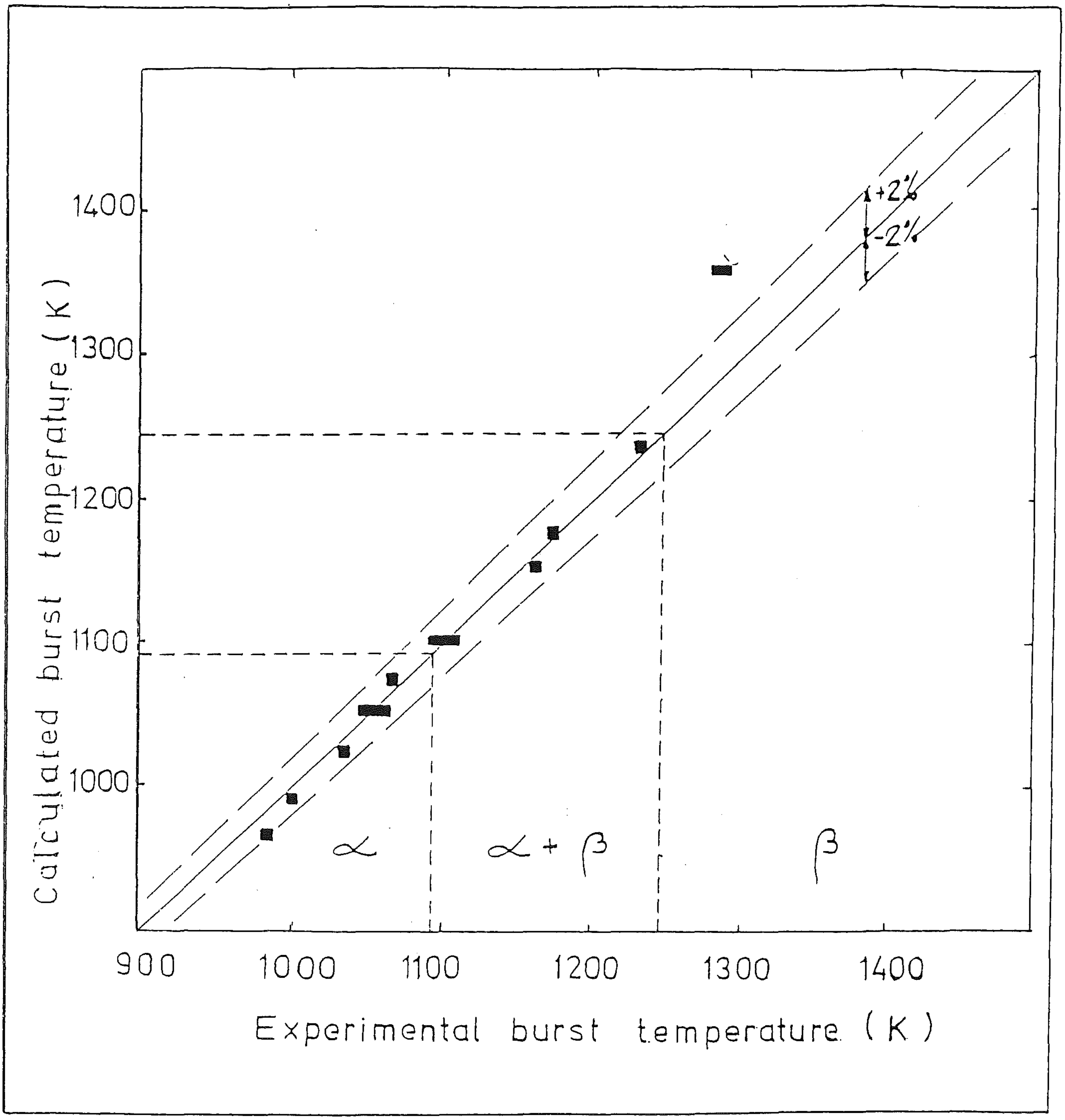


FIGURE 4: Comparison between calculated and measured burst temperatures

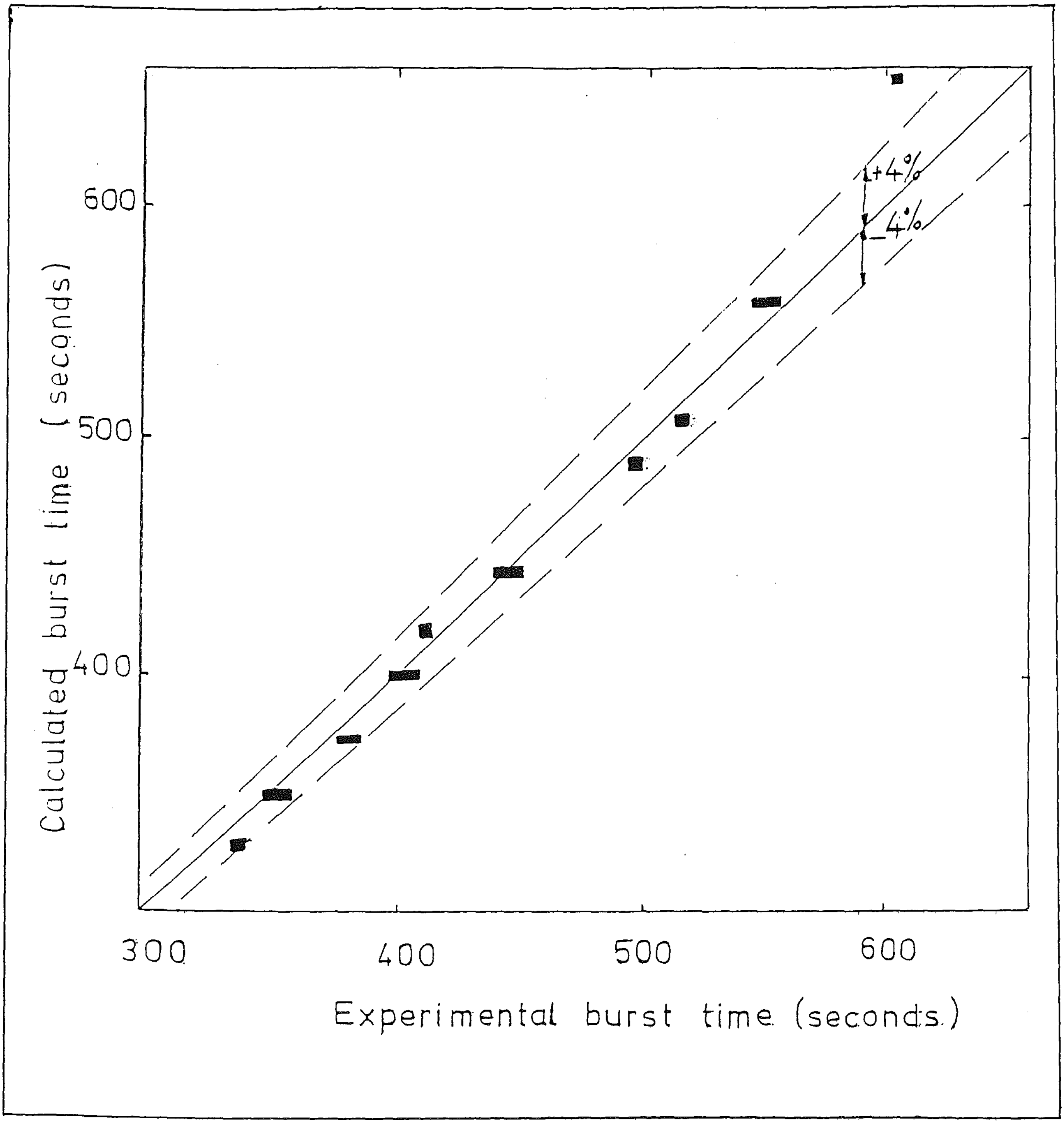


FIGURE 5: Comparison between calculated and measured times to burst

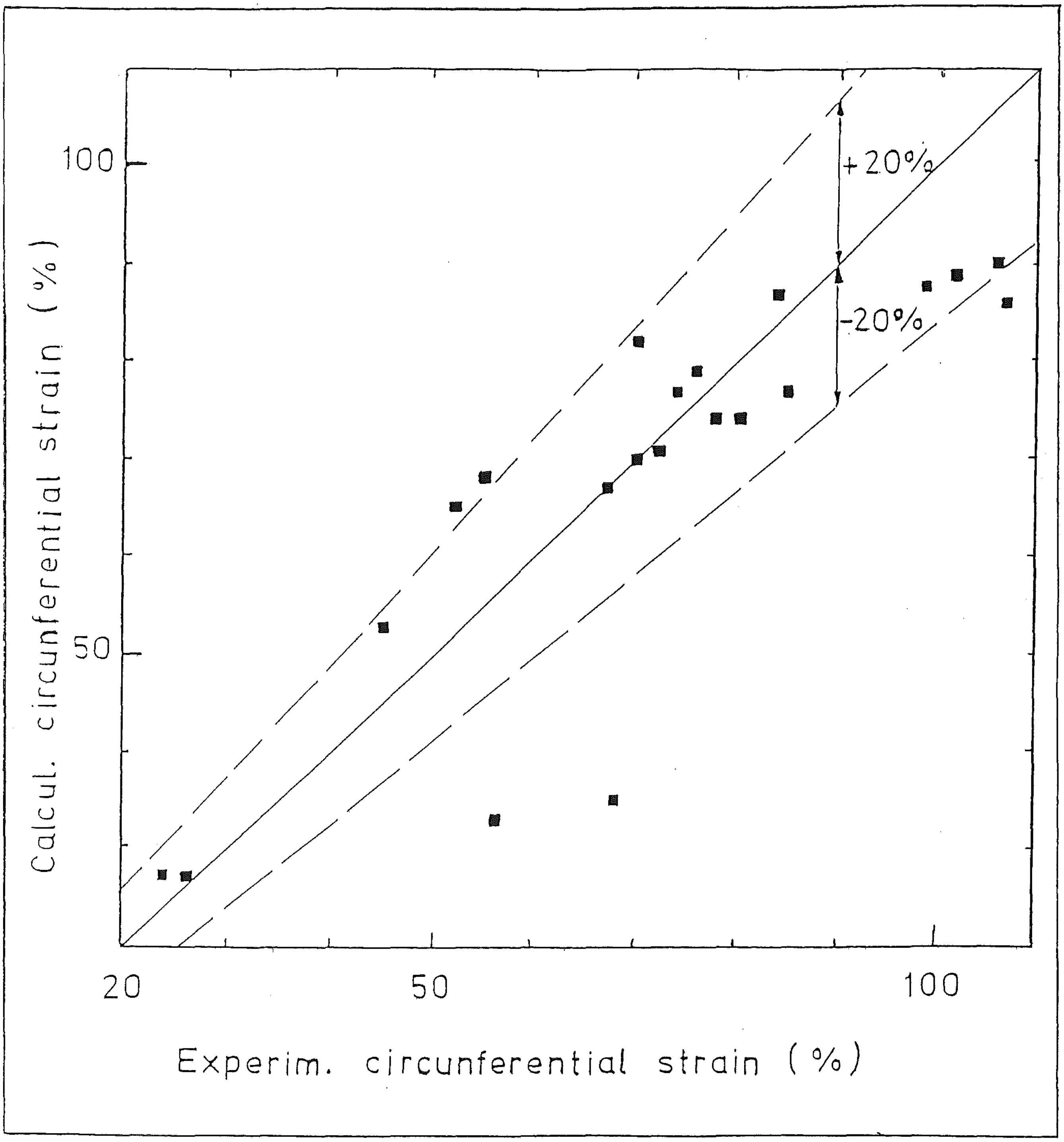


FIGURE 6: Comparison between calculated and measured circumferential strains at failure

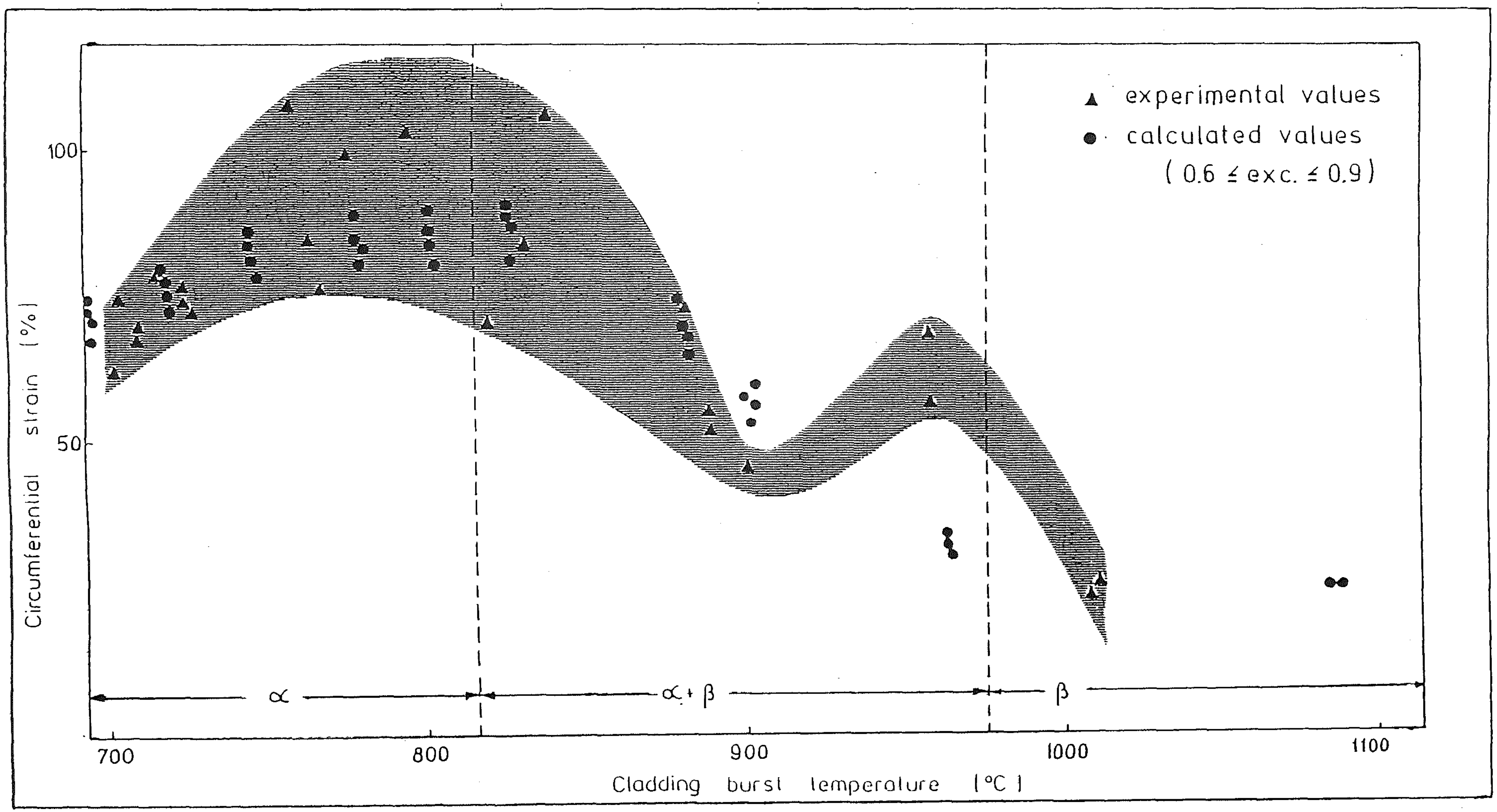


FIGURE 7: Circumferential strain at failure versus burst temperature (measured and calculated values)

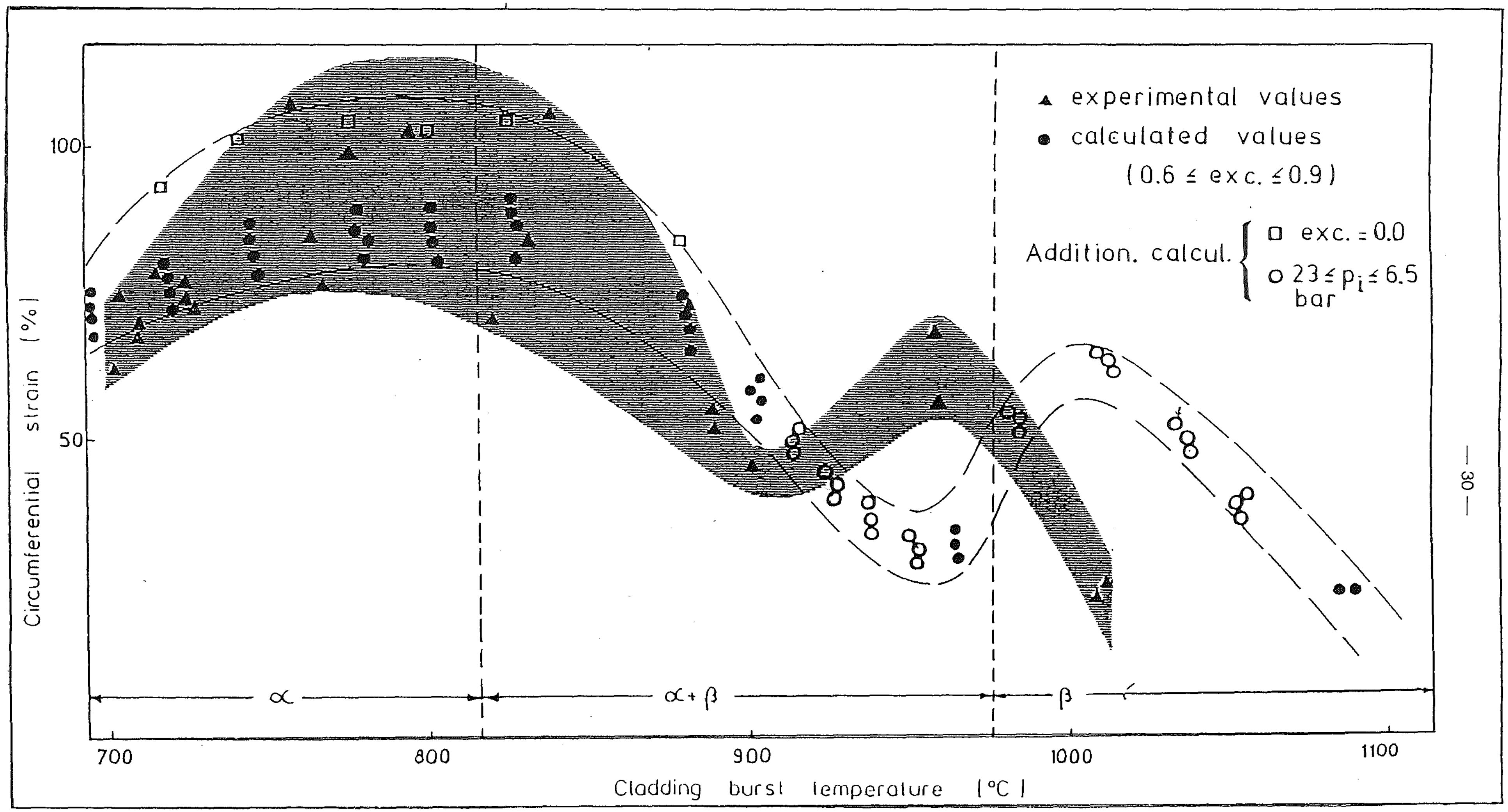


FIGURE 8: Circumferential strain at failure versus burst temperature (measured and additionally calculated values)

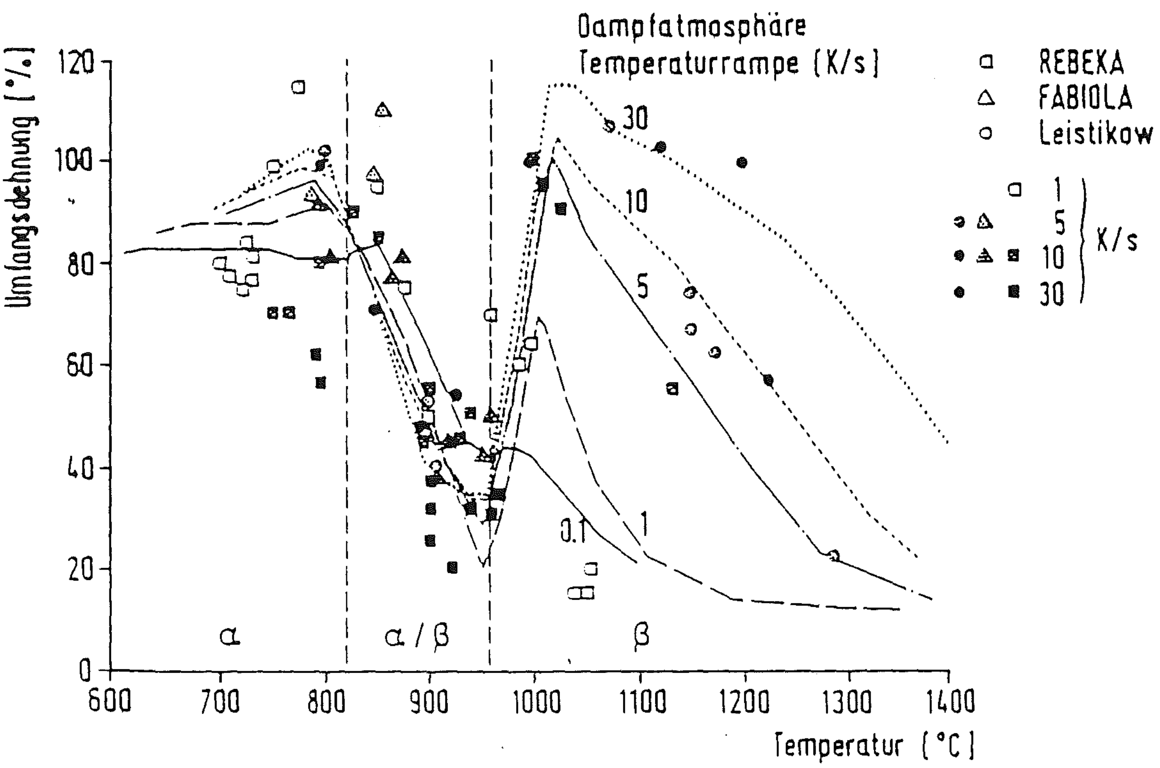
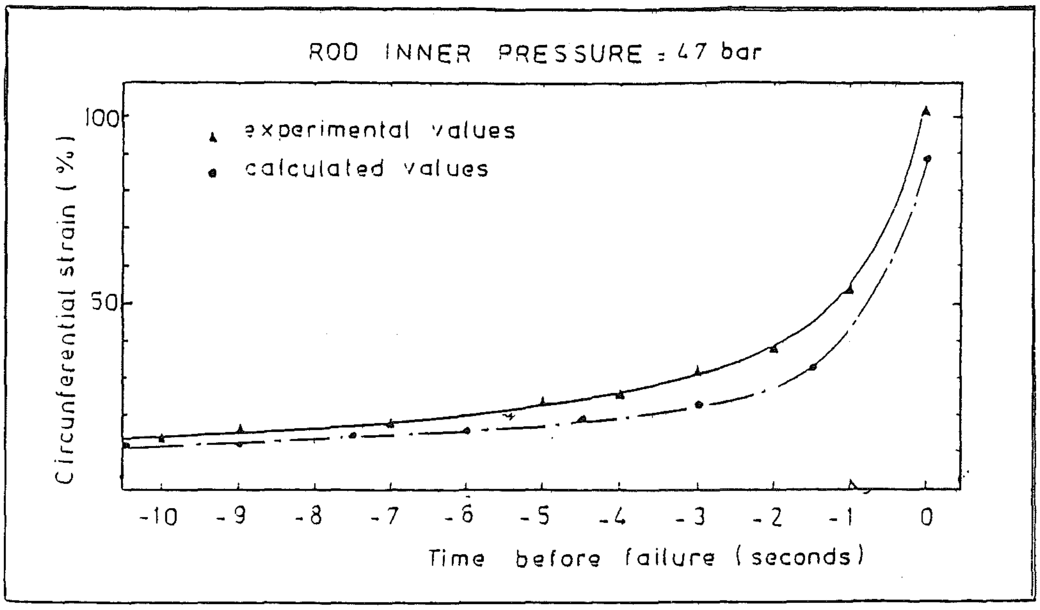
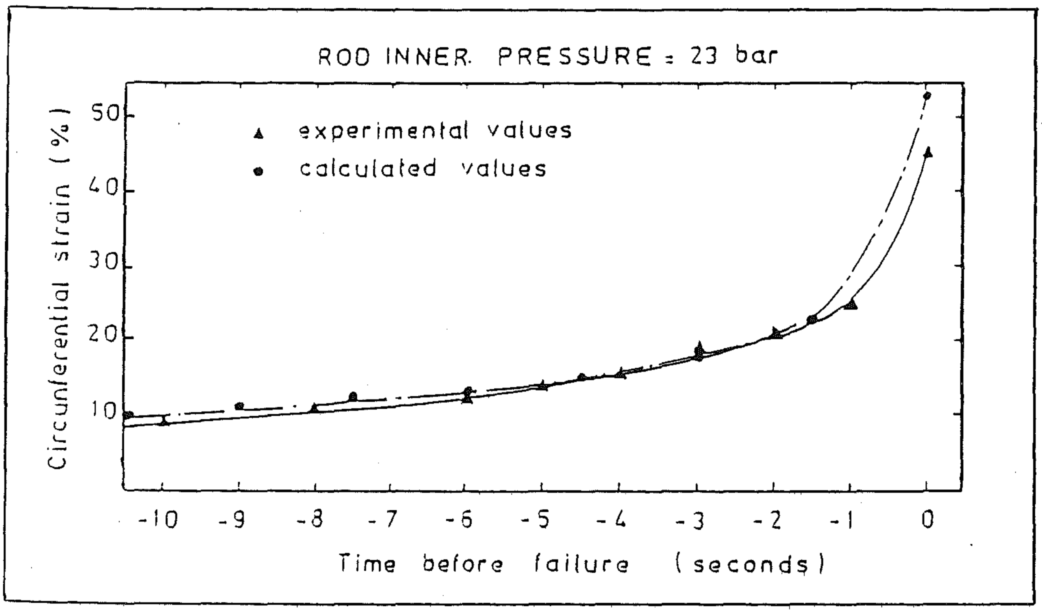


FIGURE 9: Circumferential strain at failure versus burst temperature as a function of the heating rate (measured by different groups).





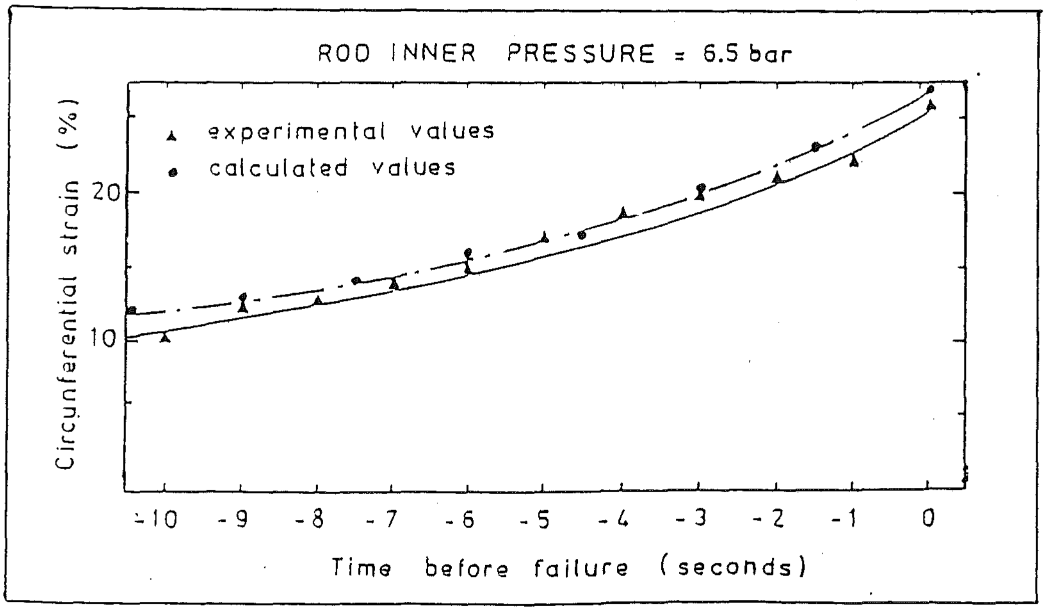


FIGURE 10: Strain histories during the last ten seconds before the rupture (comparison between measured and calculated values)

APPENDIX A:
MAIN CHARACTERISTICS OF TRHEE SELECTED MODELS

A.1. Model A

- T shr (Tau) = $\bar{T}$ clad (Tau) + 5 K

  where:

  T shr= shroud temperature (K)

  $\bar{T}$ clad= average temperature on cladding surface (temperature in tenth azimuthal node) (K)

  Tau= time (s)

- clad-to-coolant heat transfer coefficient (α) is a linnear function of inner pressure, according to the following table:

INNER PRESSURE (bar)	α (W/m**2 K)
94	10.0
80	9.4
67	8.9
54	8.4
47	8.1
40	7.8
27	7.3
23	7.2
13.4	6.8
6.5	6.5

A.2. Model B

- T shr (Tau) = T inic + $\dot{T}$ * Tau

  where:

  T inic= Initial temperature on the shroud (K)

  $\dot{T}$= prescribed heating rate (K/s)

  Tau= time (s)

- Cladding emissivity= 0.8 (real physical value)
- α = 4.0 W/m**2 K (constant for all inner pressures)

A.3. Model C

- T shr (Tau) = T inic + $\dot{T}$ * Tau

  where:

  T inic= Initial temperature on the shroud (K)

  $\dot{T}$= prescribed heating rate (K/s)

  Tau= time (s)

- Cladding emissivity= 1.9999 (artificial value to get a strong coupling between rod and shroud)
- α = 4.0 W/m**2 K (constant for all inner pressures)

APPENDIX B:

POST-TEST CALCULATIONS INPUT DATA

B.1. MODEL A

```
 ARGENTIN      0   100   640     0   200   640                     4000
 MATRIX              1                 1
  1     1    41      5
   9999998T
 MATRIZ CON LOS DATOS EXPERIMENTALES
C      TINI (K)    PINDR (N/M**2) POWER(W/CM)    EXZ        ALKK (W/K*M**2)
        573.        94.E+5          6.0           .6          10.S1
        573.        94.E+5          6.0           .7          10.S2
        573.        94.E+5          6.0           .8          10.S3
        573.        94.E+5          6.0           .9          10.S4
        573.        80.E+5          6.0           .6          9.4S5
        573.        80.E+5          6.0           .7          9.4S6
        573.        80.E+5          6.0           .8          9.4S7
        573.        80.E+5          6.0           .9          9.4S8
        573.        67.E+5          6.0           .6          8.9S9
        573.        67.E+5          6.0           .7          8.9S10
        573.        67.E+5          6.0           .8          8.9S11
        573.        67.E+5          6.0           .9          8.9S12
        573.        54.E+5          6.0           .6          8.4S13
        573.        54.E+5          6.0           .7          8.4S14
        573.        54.E+5          6.0           .8          8.4S15
        573.        54.E+5          6.0           .9          8.4S16
        573.        47.E+5          6.0           .6          8.1S17
        573.        47.E+5          6.0           .7          8.1S18
        573.        47.E+5          6.0           .8          8.1S19
        573.        47.E+5          6.0           .9          8.1S20
        573.        40.E+5          6.0           .6          7.8S21
        573.        40.E+5          6.0           .7          7.8S22
        573.        40.E+5          6.0           .8          7.8S23
        573.        40.E+5          6.0           .9          7.8S24
        573.        27.E+5          6.0           .6          7.3S25
        573.        27.E+5          6.0           .7          7.3S26
        573.        27.E+5          6.0           .8          7.3S27
        573.        27.E+5          6.0           .9          7.3S28
        573.        23.E+5          6.0           .6          7.2S29
        573.        23.E+5          6.0           .7          7.2S30
        573.        23.E+5          6.0           .8          7.2S31
        573.        23.E+5          6.0           .9          7.2S32
        573.      13.4E+5           6.0           .6          6.8S33
        573.      13.4E+5           6.0           .7          6.8S34
        573.      13.4E+5           6.0           .8          6.8S35
        573.      13.4E+5           6.0           .9          6.8S36
        573.       6.5E+5           6.0           .6          6.5S37
        573.       6.5E+5           6.0           .7          6.5S38
        573.       6.5E+5           6.0           .8          6.5S39
        573.       6.5E+5           6.0           .9          6.5S40
        573.       6.5E+5           6.0          1.0          6.5T
  MATRIX
   1      1    100      14
    9999994T
```

```
 MATRIZ PARA ALMACENAR RESULTADOS MARKSIM
F         0.T
C
C CAMPO DE DEFINICION DE LAS VARIABLES
C
  SPEICHER                                1                     4238
  DATOS DE LOS ENSAYOS CON VAINAS ARGENTINAS
&VARIDEF
&IMAGN&=1 &IHEIZ&=1 &IBOR&=1  &INCO&=1  &IALO&=1  &IHUEL&=1 &LEV1&=1
C    &IMAGN& NUMERO DE NODOS EN EL OMG (ZONA INTERIOR DEL CALEFACTOR)
C    &IHEIZ& NUMERO DE NODOS EN EL ELEMENTO CALEFACTOR(NODO RADIAL 2)
C    &IBOR& NUMERO DE NODOS EN EL BN (NODO RADIAL 3)
C    &INCO& NUMERO DE NODOS EN EL REVESTIMIENTO (NODO RADIAL 4)
C    &IALO& NUMERO DE NODOS EN LAS PASTILLAS DE AL2O3 (NODO RADIAL 6)
C    &IHUEL& NUMERO DE NODOS EN EL TUBO DE ZRY (NODO RADIAL 8)
C    &LEV1& NUMERO DE NODOS EN LA ZONA AXIAL 1 DEL CALEFACTOR
&LEV2&=1  &LEV3&=1  &LEV4&=1  &LEV5&=1  &LEV6&=1  &LEV7&=1
C    &LEV2& NUMERO DE NODOS EN LA ZONA 2 DEL CALEFACTOR
C    &LEV3& NUMERO DE NODOS EN LA ZONA 3 DEL CALEFACTOR
C    &LEV4& NUMERO DE NODOS EN LA ZONA CENTRAL (MAXIMA POTENCIA)
C    &LEV5& NUMERO DE NODOS EN LA ZONA 5 DEL CALEFACTOR
C   &LEV6& NUMERO DE NODOS EL LA ZONA 6 DEL CALEFACTOR
C    &LEV7& NUMERO DE NODOS EN LA ZONA 7 DEL CALEFACTOR
&RM1&='1.256' &RM2&='1.372' &RM3&='1.450' &RM4&='1.487' &RME&='1.750'
C    &RM1& RADIO DE LA BARRA INTERIOR DE OMG CORRESPONDIENTE A
C    LAS ZONAS 1 Y 7 DE LA MISMA (EN MM)
C    &RM2& LO MISMO QUE &RM1& PARA LAS ZONAS 2 Y 6
C    &RM3& LO MISMO QUE &RM1& PARA LAS ZONAS 3 Y 5
C    &RM4& LO MISMO QUE &RM1& PARA LA ZON DE MAXIMA POTENCIA (ZONA 4)
C   &RME& RADIO EXTERIOR DEL CALEFACTOR EN MM (CONSTANTE EN LA DIR AXIAL
&RBO&='2.400' &RIN&='3.000' &RALI&='3.0500' &RALA&='5.2500'
C    &RBO& RADIO EXTERIOR DEL BN EN MM
C    &RIN& RADIO EXTERIOR DEL REVESTIMIENTO EN MM
C    &RALI& RADIO INTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
C    &RALA& RADIO EXTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
&RZI&='5.400' &RZA&='5.950' &TKALT&='293.000' &TINI&=(&SP&,1)
C    &RZI& RADIO INTERIOR DEL TUBO DE ZRY EN MM
C    &RZA& RADIO EXTERIOR DEL TUBO DE ZRY EN MM
C    &TKALT& TEMPERATURA DE COMIENZO DEL ENSAYO EN K
C    &TINI& TEMPERATURA DE COMIENZO DE LA RAMPA DE POTENCIA
&STAFA&='      0.'
&DV1&='    .0'
&DV2&='    .0'
&DV3&='    .0'
&DV4&='    .0'
&DV5&='    .0'
&DV6&='    .0'
&DV7&='    .0'
C  &STAFA& FACTOR PARA TENER EN CUENTA O NO LA RESISTENCIA MECANICA DE
C    LA CAPA DE OXIDO (STAFA=0, NO SE TIENE EN CUENTA)
&KKPR&='1.E+5' &IAZ&=20
C    &KKPR& PRESION DEL VAPOR EN EL SUB-CANAL EN N/M**2
C    &IAZ& NUMERO DE NODOS EN LA DIRECCION AZIMUTAL PARA EL MODULO AZI
&AXAZ&=6 &EXZ&=(&SP&,4) &ALFAS&='00000.0' &ALFRE&='000360.'
C    &AXAZ& NODO AXIAL DONDE SE REALIZA EL ANALISIS AZIMUTAL
C    &EXZ& EXCENTRICIDAD ENTRE PASTILLA Y TUBO (VARIA ENTRE 0 Y 1)
C    &ALFAS& CONSTANTE PARA OBTENER EL COEF. DE TRANSFERENCIA TERMICA
C    VARIABLE CON LA POSICION ANGULAR
C    &ALFRE& IDEM &ALFAS&
```

```
&ALAMP&='00000.1' &TNFAS&='0000.0' &TNFRE&='000360.' &TNAMP&='00000.0'
C   &ALAMP& IDEM &ALFRE&
C   &TNFAS& CONSTANTE PARA DETERMINAR LA TEMPERATURA CIRCUNDANTE A LA
C  BARRA EN FUNCION DE LA POSICION ANGULAR (PARA EL CALCULO DE LA TRANS
C   FERENCIA TERMICA POR RADIACION)
C   &TNFRE& IDEM &TNFAS&
C   &TNAMP& IDEM &TNFAS&
&PINDR&=(&SP&,2) &POWER&=(&SP&,3)
C   &PINDR& PRESION INTERIOR DE LA BARRA A &TKALT& (EN N/M**2)
C   &POWER& POTENCIA LINEAL DE LA BARRA (EN WATT/CM)
&GAUO2&='1.08E-5'
&NUO2&='00.316' &GAZRY&='0.60E-5' &NZRY&='0000.4'
&RAUH&='5.E-6'
C   &GAUO2& COEFICIENTE DE DILATACION LINEAL DEL UO2
C   &NUO2& MODULO DE POISSON DEL UO2
C   &GAZRY& COEFICIENTE DE DILATACION LINEAL DEL ZRY
C   &NZRY& MODULO DE POISSON DEL ZRY
C   &RAUH& RUGOSIDAD DE PASTILLA Y VAINA
&IRAD&=&IMAGN&+&IHEIZ& &IRAD&=&IRAD&+&IBOR& &IRAD&=&IRAD&+&INCO&
&IRAD&=&IRAD&+2 &IRAD&=&IRAD&+&IALO& &IRAD&=&IRAD&+&IHUEL&
&IAX&=&LEV1&+&LEV2&  &IAX&=&IAX&+&LEV3&
&IAX&=&IAX&+&LEV4& &IAX&=&IAX&+&LEV5& &IAX&=&IAX&+&LEV6&
&IAX&=&IAX&+&LEV7& &IAX&=&IAX&+4 &ALKK&=(&SP&,5) &IAZM1&=&IAZ&-1
C  &ALKK& COEFICIENTE DE TRANSMISION DE CALOR EN LA INTERFASE BARRA COM
C  BUSTIBLE-VAPOR
&IAM&=&IAX&/2       &IAZMH&=&IAZM1&'2 &IAZH&=&IAZ&/2
&VARIEND
 DR-SETZ
 IVEKTOR              1         1         0        1112          8
VECTOR PARA LA EXPANSION RADIAL
   &IMAGN&   &IHEIZ&    &IBOR&     &INCO&          1       &IALO&
        1    &IHUEL&T
 IVEKTOR              1         1         0        1113         11
VECTOR PARA LA EXPANSION AXIAL
R 2        1     &LEV1&     &LEV2&     &LEV3&     &LEV4&     &LEV5&
    &LEV6&    &LEV7&R 2        1T
 GENSTEU              1         1    1000600
 BLOQUE GENERAL DE CONTROL PARA ANALISIS ARGENTIN
  42     12     1
          0         0     &IRAD&      &IAX&            1          2
   1000700A35      100T
R 8      0.          1.         2.R 2     1000.T
ENSAYOS DE EXPLOSION CON TUBOS ARGENTINOS
 MATRIX               1         1
   1    2    8    11
   1000700T
MATRIZ DE CORRESPONDENCIA PARA ANALISIS ARGENTIN
R 8       3R 7        1         3          4          5           6
          7           9         8         -9         3Q 6         8
R 7       2          3R 8       3T
 UGRID                1         1    1000700    1000700        1113
 UGRID                1         1    1000700    1000700       -1112
 MATRIX               1         1
   1    1    9    11
   1000800T
 CAMPO DE RADIOS INICIALES PARA ANALISIS ARGENTIN
R11      0.R 3&RM1&      &RM2&      &RM3&      &RM4&      &RM3&
     &RM2&R 3    &RM1&S
R11   &RME&S
```

```
R11   &RBO&S
R11   &RIN&S
R11  &RALI&S
R11  &RALA&S
R11   &RZI&S
R11   &RZA&T
 MATMSKAL             1         1    1000800    1000800
 RADIOS PARA ANALISIS ARGENTIN EN METROS
    1.E-3
 UGRID                1         1    1000800    1000800        1113
 UGRID                1         1   -1000800    1000800       -1112
 VEKTOR               1         1          0    1000900          12
 ALTURAS INICIALES PARA ANALISIS ARGENTIN
        0.A 1    0.001A 1    2.001A 1    .001A 1   0.001A 1     0.001
A 1   0.325A 1    0.001A 1    0.001A 1    .001A 1   0.001A 1     0.001
T
 UGRID                1         1   -1000900    1000900        1113
 MATRIX               1         1
   1     0&IRAD& &IAX&
  1001000T
 TEMPERATURAS MEDIAS EN LOS NODOS AL INICIO DEL ENSAYO
F   &TKALT&T
 MATRIX               1         1
   1     0 &IAX&      3
  1001100T
 TEMPERATURAS EN LAS SUPERFICIES AL INICIO DEL ENSAYO
F   &TKALT&T
 NUMKOR               1         1
   4     0
   1000800A 3      100T
  1001500    1001600    1001200    1001300T
 VEKTOR               1         1          0    1001700         501
 VECTOR TIEMPO
        0.A50    0.05A50     .1A50     .15A50      .2A50        .30
A50      .3A50     .3A50     .3A50      .3A50       .3T
 VEKTOR               1         1          0         10           1
 COEFICIENTE DE TRANSFERENCIA TERMICA INTERFASE BARRA-VAPOR
     1.E+5T
 VEKTOR               1         1          0         11           1
 TEMPERATURA DEL VAPOR EN K
    &TINI&T
 MATMAL               1         1         10         11          11
ALFA *&TINI&
 MATRIX               1         1
   2     0     11     3
  1001800     1001900T
 CONDICIONES DE CONTORNO EN EL PLANO CENTRAL (IZQ)
 CONDICIONES DE CONTORNO EN LA SUP. EXTERIOR DE LA BARRA (DER)
R11       0.R11       1.R11       0.T
B         10Q10       1R11        1.B         11Q10        1T
 UGRID                1         1    1001800    1001800       -1113
 UGRID                1         1    1001900    1001900       -1113
 MATRIX               1         1
   2     1     8     11
  1002200     1003201T
 DISTRIBUCION DE LAS FUENTES DE CALOR
 VOLUMENES DE CRACK PARA EL MODULO PIPRE
F          0.T
F          0.T
```

```
  UGRID              1         1    1002200    1002200       1113
  UGRID              1         1    1002200    1002200      -1112
  UGRID              1         1    1003201    1003201       1113
  UGRID              1         1    1003201    1003201      -1112
  MATRIX             1         1
   1    1    8    11
   1003202T
 VOLUMENES DE LOS DISHINGS
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R 2       0.       &DV1&      &DV2&      &DV3&       &DV4&      &DV5&
     &DV6&       &DV7&R 2      0.S
R11       0.S
R11       0.T
  VEKTOR             1         1          0        102          2
  RADIOS DEL ELEMENTO CALEFACTOR EN MM
     &RM4&       &RME&T
  VEKTOR             1         1          0        103          1
  PI/100
  0.0314150T
  VEKTOR             1         1          0        104          1
  MAXIMA POTENCIA LINEAL
    &POWER&T
  MATMSKAL           1         1        102        102
 RADIOS DEL ELEMENTO CALEFACTOR EN M
     1.E-3
  POWER              1         1        102        102          2
  DELTA              1         1        102        102          1
  MATMAL             1         1        102        103        102
  (RME**2-RM4**2)*0.01PI
  MATDIV             1         1        102        102
  1/AREA DEL CALEFACTOR
  MATMAL             1         1        102        104        102
  MAXIMA POTENCIA EN W/M**3
  MATDIV             1         1        104        105
  1/MAXIMA POTENCIA LINEAL
  MATMSKAL           1         1        105        105
    9/MAXIMA POTENCIA LINEAL
      .9E+1
  MATRIX             1         1
   1    1    8    11
   1003001T
DISTRIBUCION DE LAS FUENTES DE CALOR DURANTE EL TRANSIENTE
R11       0.S
R 5       0.B       102R 5      0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.T
  UGRID              1         1    1003001    1003001       1113
  UGRID              1         1    1003001    1003001      -1112
  GENSTEU            1         1    1002300
  BLOQUE DE COMANDOS PARA EL MODULO ZET-1D
```

```
  19      5      0
          9R 2      2301        2306        2302        2303        2304
     2303           2305        2301R 3        1        &IRAD&      &IAM&
R 4       0T
R 2      .5R 3      0.T
  WERBL              1           1           6           3
     2301
  DATOS PARA EL HELIO A 70 BAR DE PRESION
    4      1
           4T
           2T
     250.        750.       1250.       1500.T
     .137        .296        .423       .4810T
    4      1
           4T
           2T
     250.        400.        750.       1500.T
    5283.       5203.       5190.       5192.T
    4      1
           4T
           2T
     250.        800.        900.       1500.T
     13.15       6.712       3.765      2.269T
     2302
  DATOS PARA EL OXIDO DE MAGNESIO CON DENSIDAD 90%
    4      1
           4T
           2T
     250.        673.       1073.       1500.T
       3.        47.5        44.0        40.1T
    4      1
           4T
           2T
     250.        443.        723.       1500.T
     850.       1100.       1210.       1325.T
    2      1
           2T
           2T
     250.       1500.T
    3220.       3220.T
     2303
    DATOS PARA EL INCONEL 600 (ELEMENTO CALEFACTOR)
    3      1
           3T
           2T
     250.        773.       1573.T
      17.        28.3        47.T
    5      1
           5T
           2T
     250.        523.        823.       1000.       1575.T
     425.        500.        553.        612.        645.T
    2      1
           2T
           2T
     250.       1500.T
    8430.       8430.T
     2304
```

```
 DATOS PARA EL NITRITO DE BORO
   2      1
          2T
          2T
      250.        1500.T
       27.          27.T
   6      1
          6T
          2T
      250.         432.       573.       773.      1073.      1373.
T
      600.        1100.      1380.      1620.      1820.      2000.
T
   2      1
          2T
          2T
      250.        1500.T
     1900.        1900.T
      2305
 DATOS PARA LA ALUMINA PURA
   5      1
          5T
          2T
      250.         573.       873.      1173.      1573.T
       34.          16.         9.       6.5        5.5T
   6      1
          6T
          2T
      250.         473.       673.       873.      1173.      1573.
T
      750.        1025.      1140.      1200.      1250.      1280.
T
   2      1
          2T
          2T
      250.        1500.T
     3800.        3800.T
      2306
 DATOS PARA EL ZIRCALOY
   4      1
          4T
          2T
      250.         973.      1373.      1573.T
      12.5        21.5        29.        35.T
   5      1
          5T
          2T
      250.        1073.      1173.      1243.      1573.T
      280.         360.       810.       355.       355.T
   2      1
          2T
          2T
      250.        1500.T
     6570.        6570.T
  VEKTOR              1          1          0     1002400       &IAX&
  PRESION DEL VAPOR EN EL SUB-CANAL
F     &KKPR&T
  MATRIX              1          1
    1      1 &IAX&      6
    1002500T
  DEFORMACION PLASTICA DE LA VAINA EN EL ANALISIS R-Z
F         0.T
  MATRIX              1          1
    1      1 &IAX&      3
    1002600T
  COMPONENTES DE LA DEFORMACION TOTAL ANALISIS R-Z
F         0.T
  GENSTEU             1          1     1002900
  BLOQUE DE COMANDOS PARA EL MODULO AZI
   11     10      0
      &IAZ&      &AXAZ&     1002903A 8        1T
         0.         0.        0.S
         .8         .8S
         0.         0.      8.3E-6        0.          0.T
  MATRIX              1          1
   1      1      2 &IAZ&
   1002903T
  ESPESOR DE LA VAINA 1=INICIAL;2=DURANTE EL ENSAYO
F         0.T
  VEKTOR              1          1          0     1002904       &IAZ&
  SEGMENTOS ANGULARES EN RADIANES
        1.A&IAZMH&  1.T
  VEKTOR              1          1          0          2          1
  NUMERO DE NODOS EN LA DIRECCION AZIMUTAL
      &IAZ&T
  VEKTOR              1          1          0          3          1
  PI
    3.14150T
  MATDIV              1          1          2          2
  1./IAZ
  MATMZ               1          1          2          3          7
  PI/IAZ
  MATMZ               1          1     1002904          7     1002904
  SEGMENTOS ANGULARES EN RADIANES
  MATRIX              1          1
    1      0 &IAZ&      3
    1002905T
TEMPERATURAS EN LAS SUPERFICIES DE VAINA Y PASTILLA
F    &TKALT&T
  MATRIX              1          1
    1      0 &IAZ&      8
    1002906T
  DATOS DE LA OXIDACION AZIMUTAL DE LA VAINA
F         0.T
  MATRIX              1          1
    1      0&IRAD& &IAZ&
    1002907T
  TEMPERATURAS MEDIAS EN LOS NODOS AZIMUTALES
F    &TKALT&T
  MATRIX              1          1
    1      0 &IAZ&      9
    1002908T
1=EPTAN,2=EPRAD,3=EPAX,4=EPEQ,5=VELDE,6=VELOX,7=FUNDA,8=SIGS,9=PARINT
F         0.T
  MATRIX              1          1
    1      0 &IAZ&      3
```

```
    1002909T
DEFORMACION TOTAL 1=TANGENCIAL,2=RADIAL,3=AXIAL
F        0.T
  VEKTOR                1           1           0       1002910           3
  CONDICIONES DE CONTORNO EN LA DIRECCION AZIMUTAL
      &EXZ&       &ALFAS&      &ALFRE&        &ALAMP&       &TNFAS&       &TNFRE&
    &TNAMP&             0.T
  MATRIX                1           1
    1      0 &IAZ&      7
    1002911T
1=ALFAGAP,2=S,3=ALFAKK,4=ALSTR,5=TSTRNACHBAR,6=QOX,7=VERGLSP
F        0.T
  IVEKTOR               1           1           0       1003000           7
  NUMERO DE BLOQUES A SER USADOS POR EL MODULO RANDM
    1003001A 6          1T
  IVEKTOR               1           1           0       1003007          11
  VECTOR CORRESPONDENCIA PARA NODALIZACION AXIAL
R 3        1A 6         1Q 2        1T
  UGRID                 1           1     1003007       1003007        1113
  GENSTEU               1           1     1003200
  BLOQUE DE COMANDOS PARA EL MODULO PIPRE
    3     16       0
    1003201      1003202            0T
R15      0.             1.T
  GENSTEU               1           1     1003300
  PRESIONES PARCIALES DE LOS GASES DE LLENADO
    3      3
           2            36          54T
    &PINDR&             1.          1.T
  VEKTOR                1           1           0       1003400       &IAX&
  PRESION INTERIOR DE LA BARRA COMBUSTIBLE
F   &PINDR&T
  VEKTOR                1           1           0       1003600       &IAX&
  COEFICIENTE DE TRANSMISION DE CALOR DEL GAP
F       0.0T
  GENSTEU               1           1     1003800
  BLOQUE DE COMANDOS PARA EL MODULO STADEF
    7      9       0
    1003801      1003802            0     1003804R 3          0T
    &GAUO2&      &NUO2&      &GAZRY&      &NZRY&R 3           0.S
    &STAFA&      &RAUH&T
  WERBL                 1           1           1             2
    1003802
  TABLAS CON MODULO DE ELASTICIDAD (T) DE PASTILLA Y VAINA
    2      1
           2T
           2T
       250.          2000.T
    0.2E+12      0.14E+11T
    2      1
           2T
           2T
       250.          2000.T
     1.0E+11     0.15E+11T
  VEKTOR                1           1           0       1003804       &IAX&
  TENSION EQUIVALENTE EN LA VAINA (ANALISIS R-Z)
F        0.T
  GENSTEU               1           1     1004000
```

```
  BLOQUE DE COMANDOS PARA EL MODULO ZIRCOX
    3      8
    1004001A 2          1T
   3.966E-5      2.6E+4      5.96E+6        6600.        5800.             2.
F        0.T
  MATRIX                1           1
    1      0 &IAX&      8
    1004001T
1=ESPOX,2=ESPOX+ALFA,3=OXBETA,4=NOLOSE,5=OXTOTAL,6=TRED,7=OXEF,8=PINT
F        0.T
  MATRIX                1           1
    1      0 &IAX&      2
    1004002T
  FACTORES DE OXIDACION INTERNA Y EXTERNA
F       1.0T
  MATRIX                1           1
    1      0 &IAX&      8
    1004003T
1=SZRO2,2=SZRO2+ALFA,3=GEWPROZO2KERN,4=O2TOTAL,5=GEWPROZO2TO,6=TV,O2EFF
F        0.T
  NUMKOR                1           1
    2      0
    1001900      1002400T
    2001900      2002400T
  SPEICHER              1           1           0       2000000
  BLOQUE SPEICHER PARA LOS CALCULOS EN ESTADO ESTACIONARIO
  LSCH-UBI              1
    1001900T
  NUMKOR                1           1
    1      0
    2001900T
    1001900T
  URGAP                 1           1     1000600
  ZIRKOX                1           1     1000600
  ZET-1D                1           1     1000600           500
C PIPRE                 1           1     1000600
  LSCH-UBI              1
    1002400T
  NUMKOR                1           1
    1      0
    1003400T
    1002400T
  STADEF                1           1     1000600
  AZI                   1           1     1000600
  START                 1           1     2000000
***$
  STADEF                1           1     1000600            -1
  AZI                   1           1     1000600            -1
  START                 1           1     2000000
  MODSTEU               1           1     1000600       1000600
  BLOQUE DE COMANDOS COMUNES PARA ANALISIS ARGENTIN
    1      1      1
           0T
    2      1      3
R 3      0.T
999999
  LSCH-UBI              1
    1002400T
```

```
NUMKOR                  1             1
 1    0
 2002400T
 1002400T
SPEICHER                1             1         0       2000010
CORRECTOR PARA LA TEMPERATURA CIRCUNDANTE
LSCH-UBI                1
       20T
BLMOD                   1             1
TEMPERATURA MEDIA DEL NODO AZIMUTAL 1
 1    1    1&IRAD&&IRAD&    1    1
       0T
 1002907T
       20T
MATADD                  1             1         20          30          20
NUEVA TEMPERATURA MEDIA DEL NODO &IAZH&
BLMOD                   1             1
RABAZ(8)=NUEVA TEMP. MEDIA DEL NODO &IAZH&
 1    1    8    1    1    1    1
 1002910T
       20T
 1002910T
***$
VEKTOR                  1             1         0           30          1
VARIACION DE LA TEMPERATURA CIRCUNDANTE
       5.T
START                   1             1     2000010
MATRIX                  1             1
 1    1    6    2
 1103003T
VARIACION DE LA POTENCIA NORMALIZADA EN EL TIEMPO
       0.          1.S
      40.          1.S
      41.          1.0S
     130.          1.0S
     131.          1.0S
     500.          1.0T
LSCH-UBI                1
 1001700T
VEKTOR                  1             1         0       1001700        1001
VECTOR TIEMPO DURANTE EL TRANSIENTE
       0.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.A99       1.S
A 1    1.T
MATMZ                   1             1     1001700         105     1001700
TIEMPO*9/POWER
INTERPOL                1             1     1003003     1001700           1
 1    1    1
 1103003T
       -2T
```

```
 1103003T
      -1T
POTENCIA NORMALIZADA DURANTE EL TRANSIENTE
MATRIX                  1             1
 3    0    7  1000
 1003004      1003006      1003005T
VARIACION AXIAL DE LA TEMPERATURA DEL VAPOR EN EL SUB-CANAL
VARIACION AXIAL DE LA PRESION DEL VAPOR EN EL SUB-CANAL
VARIACION AXIAL DE ALFA EN EL SUB-CANAL
F    &TINI&T
F    &KKPR&T
F    &ALKK&T
ZWERG                   1             1     5000000          -3
BLOQUE DE DATOS PARA EL MODULO ZWERG
       5
 1000600          1      2000600
      -1          1
      TIEMPO
 1002911         20      2002911
       1          6          -19
   CALOR GENERADO EN LA VAINA POR OXIDAĊION(AZI)
 1002906         20      2002906
       1          1          -19
   ESPESOR DE LA CAPA DE OXIDO(AZI)
 1002908         40      2002908
       1          5          -19
       1          6          -19
   STRAIN RATE(AZI)
 1002600         11      2002600
       1          1          -10
   DEFORMACION TANGENCIAL (AZI)
MATRIX                  1             1
 1    3    2    4
 1111111T
1=TIEMPO,2=TEMPERATURA MEDIA NODO &IAZH&
 1000600         -1            1             0S1
 1002907      &IRAD&       &IAZH&            0T2
SPEICHER                1             1         0       2000020
BLOQUE SPEICHER PARA LOS CALCULOS DURANTE EL TRANSIENTE
ZAEHL                   1           500        -1
START                   1             1     2000030
ZAEHL                   2           100        -1
START                   1             1     1111112
RANDM                   1             1     1000600
START                   1             1     2000010
URGAP                   1             1     1000600
ZIRKOX                  1             1     1000600
ZET-1D                  1             1     1000600        1000
C PIPRE                 1             1     1000600
STADEF                  1             1     1000600
AZI                     1             1     1000600
ZWERG                   1             1     5000000           3
START                   1             1     2000020
***$
SPEICHER                1             1         0       2000030
BLOQUE SPEICHER PARA IMPRESION DE RESULTADOS
DR-SETZ                 1
DRUCKE                  1             -         8
```

```
    1000600     1002200     1002911     1004001     1002906S
    1002500     1002908     1002600T
  DR-SETZ
  SZAEHL              1           0
***$
  SPEICHER            1           1           0     1111112
 BLOQUE SPEICHER PARA EXTRAER RESULTADOS
  LSCH-UBI            1
   1111116T
  SAMMEL              1           1     1111111     1111116
  KOMBSP              1           1
          2     1111117
   1111117      1111116T
  SZAEHL              2           0
  ZAEHL               3         100
  ADD                 1           1     1111113     1111113
        1.0
***$
  SPEICHER            1           1           0     1111114
   ERGAENZEN DER TRANSIENTEN STUTZPUNKTE
  KOMBSP              1           1
          2     8888887
   8888887      1111115T
  ZAEHL               3           5
  START               1           1     1111114
***$
  SZAEHL              1           0
  SZAEHL              2          90
  SZAEHL              3           0
  VEKTOR              1           1           0     1111113          1
 VECTOR PARA CONTAR LOS PARES TIEMPO-TEMP EXTRAIDOS
        0.T
  VEKTOR              1           1           0     1111115          2
 COMPLEMENTO PARA LOS PARES DE VALORES TIEMPO-TEMP
F       0.T
  VEKTOR              1           1           0     1111117          1
 TIEMPO-TEMPERATURA MEDIA DE VAINA CADA 100 INTERVALOS
F       0.T
  START               1           1     2000020
  MATMSKAL            1           1     1111113     1111118
  2 VECES EL NUMERO DE EXTRACIONES -1
        2.
  ADD                 1           1     1111118     1111118
      -1.0
  INT                 1           1     1111113     1111113
  INT                 1           1     1111118     1111118
  MATRIX              1           1
   1      3      7    4
   5555555T
1=TMAX,2=TMIN,3=TMED,4=EPST,5=TIEMPO,6=FUDA,7=TAU,8=TEM,...
    1002907     &IRAD&            1          0S1
    1002907     &IRAD&        &IAZ&          0S2
    1002907     &IRAD&       &IAZH&          0S3
    1002600     &AXAZ&            1          0S4
    1000600         -1            1          0S5
    1000600         -1            8          0S6
    1111117          1           2B     1111118T7
  SAMMEL              1           1     5555555     8888887
```

```
  ZAEHL               3           5
  START               1           1     1111114
  BLMOD               1           1
  BLOQUE DE RESULTADOS
   1      1      1      1      1      1     14      0      0
          0T
   8888887T
   8888888T
  BLMOD               2           2
  TRANSFERENCIA DE RESULTADOS A BIB
   1  &SP&    1      1      1      1     14      0      0
   9999994T
   8888888T
   9999994T
  DR-SETZ             1
  DRUCKE              1           1          -1
          1    9999994T
  LSCH-UBI           -2
          1      4237        4239     9999980T
  LSCH-BIB            1
   1111111T
***
  VARIO               1                 4238                9999998
  &SP&=41
&VARIEND
```

APPENDIX B (CONT.)

B.2. MODEL B

```
  ARGENTIN      0   100   640     0   200   640                      4000
  MATRIX              1               1
   1     1    48      5
    9999998T
  MATRIZ CON LOS DATOS EXPERIMENTALES
C      TINI (K)    PINDR (N/M**2)  POWER(W/CM)   EXZ      ALKK (W/K*M**2)
         573.       94.E+5          6.0          .6          4.S1
         573.       94.E+5          6.0          .7          4.S2
         573.       94.E+5          6.0          .8          4.S3
         573.       94.E+5          6.0          .9          4.S4
         573.       80.E+5          6.0          .6          4.S5
         573.       80.E+5          6.0          .7          4.S6
         573.       80.E+5          6.0          .8          4.S7
         573.       80.E+5          6.0          .9          4.S8
         573.       67.E+5          6.0          .6          4.S9
         573.       67.E+5          6.0          .7          4.S10
         573.       67.E+5          6.0          .8          4.S11
         573.       67.E+5          6.0          .9          4.S12
         573.       54.E+5          6.0          .6          4.S13
         573.       54.E+5          6.0          .7          4.S14
         573.       54.E+5          6.0          .8          4.S15
         573.       54.E+5          6.0          .9          4.S16
         573.       47.E+5          6.0          .6          4.S17
         573.       47.E+5          6.0          .7          4.S18
         573.       47.E+5          6.0          .8          4.S19
         573.       47.E+5          6.0          .9          4.S20
         573.       40.E+5          6.0          .6          4.S21
         573.       40.E+5          6.0          .7          4.S22
         573.       40.E+5          6.0          .8          4.S23
         573.       40.E+5          6.0          .9          4.S24
         573.       27.E+5          6.0          .6          4.S25
         573.       27.E+5          6.0          .7          4.S26
         573.       27.E+5          6.0          .8          4.S27
         573.       27.E+5          6.0          .9          4.S28
         573.       23.E+5          6.0          .6          4.S29
         573.       23.E+5          6.0          .7          4.S30
         573.       23.E+5          6.0          .8          4.S31
         573.       23.E+5          6.0          .9          4.S32
         573.      13.4E+5          6.0          .6          4.S33
         573.      13.4E+5          6.0          .7          4.S34
         573.      13.4E+5          6.0          .8          4.S35
         573.      13.4E+5          6.0          .9          4.S36
         573.       6.5E+5          6.0          .6          4.S37
         573.       6.5E+5          6.0          .7          4.S38
         573.       6.5E+5          6.0          .8          4.S39
         573.       6.5E+5          6.0          .9          4.S40
         573.       21.E+5          6.0          .7          4.S41
         573.       19.E+5          6.0          .7          4.S42
         573.       17.E+5          6.0          .7          4.S43
         573.       15.E+5          6.0          .7          4.S44
         573.       11.E+5          6.0          .7          4.S45
         573.        9.E+5          6.0          .7          4.S46
         573.       7.5E+5          6.0          .7          4.S47
```

```
         573.       7.E+5          6.0          .7          4.T
     MATRIX
       1     1    100     14
       9999996T
   MATRIZ PARA ALMACENAR RESULTADOS RADHEAT2
F          0.T
C
C  CAMPO DE DEFINICION DE LAS VARIABLES
C
  SPEICHER                          1                         4238
  DATOS DE LOS ENSAYOS CON VAINAS ARGENTINAS
&VARIDEF
&IMAGN&=1 &IHEIZ&=1 &IBOR&=1  &INCO&=1  &IALO&=1  &IHUEL&=1 &LEV1&=1
C   &IMAGN& NUMERO DE NODOS EN EL OMG (ZONA INTERIOR DEL CALEFACTOR)
C   &IHEIZ& NUMERO DE NODOS EN EL ELEMENTO CALEFACTOR(NODO RADIAL 2)
C   &IBOR& NUMERO DE NODOS EN EL BN (NODO RADIAL 3)
C   &INCO& NUMERO DE NODOS EN EL REVESTIMIENTO (NODO RADIAL 4)
C   &IALO& NUMERO DE NODOS EN LAS PASTILLAS DE AL2O3 (NODO RADIAL 6)
C   &IHUEL& NUMERO DE NODOS EN EL TUBO DE ZRY (NODO RADIAL 8)
C   &LEV1& NUMERO DE NODOS EN LA ZONA AXIAL 1 DEL CALEFACTOR
&LEV2&=1  &LEV3&=1  &LEV4&=1  &LEV5&=1  &LEV6&=1  &LEV7&=1
C   &LEV2& NUMERO DE NODOS EN LA ZONA 2 DEL CALEFACTOR
C   &LEV3& NUMERO DE NODOS EN LA ZONA 3 DEL CALEFACTOR
C   &LEV4& NUMERO DE NODOS EN LA ZONA CENTRAL (MAXIMA POTENCIA)
C   &LEV5& NUMERO DE NODOS EN LA ZONA 5 DEL CALEFACTOR
C   &LEV6& NUMERO DE NODOS EL LA ZONA 6 DEL CALEFACTOR
C   &LEV7& NUMERO DE NODOS EN LA ZONA 7 DEL CALEFACTOR
&RM1&='1.256' &RM2&='1.372' &RM3&='1.450' &RM4&='1.487' &RME&='1.750'
C   &RM1& RADIO DE LA BARRA INTERIOR DE OMG CORRESPONDIENTE A
C   LAS ZONAS 1 Y 7 DE LA MISMA (EN MM)
C   &RM2& LO MISMO QUE &RM1& PARA LAS ZONAS 2 Y 6
C   &RM3& LO MISMO QUE &RM1& PARA LAS ZONAS 3 Y 5
C   &RM4& LO MISMO QUE &RM1& PARA LA ZON DE MAXIMA POTENCIA (ZONA 4)
C  &RME& RADIO EXTERIOR DEL CALEFACTOR EN MM (CONSTANTE EN LA DIR AXIAL
&RBO&='2.400' &RIN&='3.000' &RALI&='3.0500' &RALA&='5.2500'
C   &RBO& RADIO EXTERIOR DEL BN EN MM
C   &RIN& RADIO EXTERIOR DEL REVESTIMIENTO EN MM
C   &RALI& RADIO INTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
C   &RALA& RADIO EXTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
&RZI&='5.400' &RZA&='5.950' &TKALT&='293.000' &TINI&=(&SP&,1)
C   &RZI& RADIO INTERIOR DEL TUBO DE ZRY EN MM
C   &RZA& RADIO EXTERIOR DEL TUBO DE ZRY EN MM
C   &TKALT& TEMPERATURA DE COMIENZO DEL ENSAYO EN K
C   &TINI& TEMPERATURA DE COMIENZO DE LA RAMPA DE POTENCIA
&STAFA&='     0.'
&DV1&='   .0'
&DV2&='   .0'
&DV3&='   .0'
&DV4&='   .0'
&DV5&='   .0'
&DV6&='   .0'
&DV7&='   .0'
C  &STAFA& FACTOR PARA TENER EN CUENTA O NO LA RESISTENCIA MECANICA DE
C   LA CAPA DE OXIDO (STAFA=0, NO SE TIENE EN CUENTA)
&KKPR&='1.E+5' &IAZ&=20
C   &KKPR& PRESION DEL VAPOR EN EL SUB-CANAL EN N/M**2
C   &IAZ& NUMERO DE NODOS EN LA DIRECCION AZIMUTAL PARA EL MODULO AZI
&AXAZ&=6 &EXZ&=(&SP&,4) &ALFAS&='00000.0' &ALFRE&='000360.'
C   &AXAZ& NODO AXIAL DONDE SE REALIZA EL ANALISIS AZIMUTAL
```

```
C   &EXZ& EXCENTRICIDAD ENTRE PASTILLA Y TUBO (VARIA ENTRE 0 Y 1)
C   &ALFAS& CONSTANTE PARA OBTENER EL COEF. DE TRANSFERENCIA TERMICA
C   VARIABLE CON LA POSICION ANGULAR
C   &ALFRE& IDEM &ALFAS&
&ALAMP&='0000.1' &TNFAS&='00000.0' &TNFRE&='000360.' &TNAMP&='00000.0'
C   &ALAMP& IDEM &ALFRE&
C   &TNFAS& CONSTANTE PARA DETERMINAR LA TEMPERATURA CIRCUNDANTE A LA
C   BARRA EN FUNCION DE LA POSICION ANGULAR (PARA EL CALCULO DE LA TRANS
C   FERENCIA TERMICA POR RADIACION)
C   &TNFRE& IDEM &TNFAS&
C   &TNAMP& IDEM &TNFAS&
&PINDR&=(&SP&,2) &POWER&=(&SP&,3)
C   &PINDR& PRESION INTERIOR DE LA BARRA A &TKALT& (EN N/M**2)
C   &POWER& POTENCIA LINEAL DE LA BARRA (EN WATT/CM)
&GAUO2&='1.08E-5'
&NUO2&='00.316' &GAZRY&='0.60E-5' &NZRY&='0000.4'
&RAUH&='5.E-6'
C   &GAUO2& COEFICIENTE DE DILATACION LINEAL DEL UO2
C   &NUO2& MODULO DE POISSON DEL UO2
C   &GAZRY& COEFICIENTE DE DILATACION LINEAL DEL ZRY
C   &NZRY& MODULO DE POISSON DEL ZRY
C   &RAUH& RUGOSIDAD DE PASTILLA Y VAINA
&IRAD&=&IMAGN&+&IHEIZ& &IRAD&=&IRAD&+&IBOR& &IRAD&=&IRAD&+&INCO&
&IRAD&=&IRAD&+2 &IRAD&=&IRAD&+&IALO& &IRAD&=&IRAD&+&IHUEL&
&IAX&=&LEV1&+&LEV2&  &IAX&=&IAX&+&LEV3&
&IAX&=&IAX&+&LEV4& &IAX&=&IAX&+&LEV5& &IAX&=&IAX&+&LEV6&
&IAX&=&IAX&+&LEV7& &IAX&=&IAX&+4 &ALKK&=(&SP&,5) &IAZM1&=&IAZ&-1
C  &ALKK& COEFICIENTE DE TRANSMISION DE CALOR EN LA INTERFASE BARRA COM
C  BUSTIBLE-VAPOR
&IAM&=&IAX&/2      &IAZMH&=&IAZM1&'2 &IAZH&=&IAZ&/2
&VARIEND
  DR-SETZ
  IVEKTOR              1          1          0        1112          8
VECTOR PARA LA EXPANSION RADIAL
    &IMAGN&     &IHEIZ&     &IBOR&     &INCO&          1       &IALO&
         1      &IHUEL&T
  IVEKTOR              1          1          0        1113         11
VECTOR PARA LA EXPANSION AXIAL
R 2        1      &LEV1&     &LEV2&     &LEV3&     &LEV4&      &LEV5&
    &LEV6&      &LEV7&R 2        1T
  GENSTEU              1          1    1000600
 BLOQUE GENERAL DE CONTROL PARA ANALISIS ARGENTIN
   42     12      1
         0          0     &IRAD&      &IAX&           1           2
    1000700A35     100T
R 8      0.         1.        2.R 2     1000.T
ENSAYOS DE EXPLOSION CON TUBOS ARGENTINOS
  MATRIX               1          1
   1     2     8     11
   1000700T
MATRIZ DE CORRESPONDENCIA PARA ANALISIS ARGENTIN
R 8        3R 7        1          3          4          5           6
           7           9          8         -9         3Q 6         8
R 7        2           3R 8       3T
  UGRID                1          1    1000700     1000700       1113
  UGRID                1          1    1000700     1000700      -1112
  MATRIX               1          1
   1     1     9     11
```

```
   1000800T
  CAMPO DE RADIOS INICIALES PARA ANALISIS ARGENTIN
R11       0.R 3&RM1&       &RM2&       &RM3&       &RM4&       &RM3&
     &RM2&R 3     &RM1&S
R11    &RME&S
R11    &RBO&S
R11    &RIN&S
R11   &RALI&S
R11   &RALA&S
R11    &RZI&S
R11    &RZA&T
  MATMSKAL             1          1    1000800     1000800
  RADIOS PARA ANALISIS ARGENTIN EN METROS
     1.E-3
  UGRID                1          1    1000800     1000800       1113
  UGRID                1          1   -1000800     1000800      -1112
  VEKTOR               1          1          0     1000900         12
  ALTURAS INICIALES PARA ANALISIS ARGENTIN
        0.A 1     0.001A 1    2.001A 1     .001A 1     0.001A 1     0.001
A 1   0.325A 1    0.001A 1    0.001A 1     .001A 1     0.001A 1     0.001
T
  UGRID                1          1   -1000900     1000900       1113
  MATRIX               1          1
   1     0&IRAD& &IAX&
   1001000T
  TEMPERATURAS MEDIAS EN LOS NODOS AL INICIO DEL ENSAYO
F   &TKALT&T
  MATRIX               1          1
   1     0 &IAX&       3
   1001100T
  TEMPERATURAS EN LAS SUPERFICIES AL INICIO DEL ENSAYO
F   &TKALT&T
  NUMKOR               1          1
   4     0
   1000800A 3      100T
   1001500     1001600     1001200     1001300T
  VEKTOR               1          1          0     1001700        501
  VECTOR TIEMPO
        0.A50     0.05A50      .1A50      .15A50      .2A50       .30
A50     .3A50      .3A50      .3A50       .3A50       .3T
  VEKTOR               1          1          0          10          1
  COEFICIENTE DE TRANSFERENCIA TERMICA INTERFASE BARRA-VAPOR
     1.E+5T
  VEKTOR               1          1          0          11          1
  TEMPERATURA DEL VAPOR EN K
    &TINI&T
  MATMAL               1          1         10          11         11
 ALFA *&TINI&
  MATRIX               1          1
   2     0     11     3
   1001800     1001900T
  CONDICIONES DE CONTORNO EN EL PLANO CENTRAL (IZQ)
  CONDICIONES DE CONTORNO EN LA SUP. EXTERIOR DE LA BARRA (DER)
R11       0.R11       1.R11       0.T
B        10Q10        1R11       1.B        11Q10        1T
  UGRID                1          1    1001800     1001800      -1113
  UGRID                1          1    1001900     1001900      -1113
  MATRIX               1          1
```

```
   2     1      8     11
   1002200     1003201T
  DISTRIBUCION DE LAS FUENTES DE CALOR
  VOLUMENES DE CRACK PARA EL MODULO PIPRE
F        0.T
F        0.T
  UGRID               1           1      1002200     1002200       1113
  UGRID               1           1      1002200     1002200      -1112
  UGRID               1           1      1003201     1003201       1113
  UGRID               1           1      1003201     1003201      -1112
  MATRIX              1           1
   1     1      8     11
   1003202T
 VOLUMENES DE LOS DISHINGS
R11      0.S
R11      0.S
R11      0.S
R11      0.S
R11      0.S
R 2      0.      &DV1&      &DV2&      &DV3&      &DV4&      &DV5&
    &DV6&        &DV7&R 2    ;  0.S
R11      0.S
R11      0.T
  VEKTOR              1           1            0         102          2
  RADIOS DEL ELEMENTO CALEFACTOR EN MM
      &RM4&        &RME&T
  VEKTOR              1           1            0         103          1
  PI/100
  0.0314150T
  VEKTOR              1           1            0         104          1
  MAXIMA POTENCIA LINEAL
    &POWER&T
  MATMSKAL            1           1          102         102
 RADIOS DEL ELEMENTO CALEFACTOR EN M
      1.E-3
  POWER               1           1          102         102          2
  DELTA               1           1          102         102          1
  MATMAL              1           1          102         103        102
  (RME**2-RM4**2)*0.01PI
  MATDIV              1           1          102         102
  1/AREA DEL CALEFACTOR
  MATMAL              1           1          102         104        102
  MAXIMA POTENCIA EN W/M**3
  MATDIV              1           1          104         105
  1/MAXIMA POTENCIA LINEAL
  MATMSKAL            1           1          105         105
    9/MAXIMA POTENCIA LINEAL
      .9E+1
  MATRIX              1           1
   1     1      8     11
   1003001T
DISTRIBUCION DE LAS FUENTES DE CALOR DURANTE EL TRANSIENTE
R11      0.S
R 5      0.B        102R 5       0.S
R11      0.S
R11      0.S
R11      0.S
R11      0.S
R11      0.S
R11      0.T
```

```
  UGRID               1           1      1003001     1003001       1113
  UGRID               1           1      1003001     1003001      -1112
  GENSTEU             1           1      1002300
  BLOQUE DE COMANDOS PARA EL MODULO ZET-1D
   19      5      0
          9R 2       2301       2306       2302       2303       2304
      2303       2305       2301R 3        1       &IRAD&      &IAM&
R 4       0T
R 2      .5R 3       0.T
  WERBL               1           1            6            3
      2301
  DATOS PARA EL HELIO A 70 BAR DE PRESION
    4      1
           4T
           2T
      250.        750.       1250.       1500.T
      .137        .296        .423       .4810T
    4      1
           4T
           2T
      250.        400.        750.       1500.T
     5283.       5203.       5190.       5192.T
    4      1
           4T
           2T
      250.        800.        900.       1500.T
     13.15       6.712       3.765       2.269T
      2302
  DATOS PARA EL OXIDO DE MAGNESIO CON DENSIDAD 90%
    4      1
           4T
           2T
      250.        673.       1073.       1500.T
        3.        47.5        44.0        40.1T
    4      1
           4T
           2T
      250.        443.        723.       1500.T
      850.       1100.       1210.       1325.T
    2      1
           2T
           2T
      250.       1500.T
     3220.       3220.T
      2303
    DATOS PARA EL INCONEL 600 (ELEMENTO CALEFACTOR)
    3      1
           3T
           2T
      250.        773.       1573.T
       17.        28.3         47.T
    5      1
           5T
           2T
      250.        523.        823.       1000.       1575.T
      425.        500.        553.        612.        645.T
    2      1
           2T
```

```
          2T
      250.        1500.T
     8430.        8430.T
      2304
 DATOS PARA EL NITRITO DE BORO
   2      1
          2T
          2T
      250.        1500.T
       27.          27.T
   6      1
          6T
          2T
      250.         432.        573.        773.       1073.       1373.
T
      600.        1100.       1380.       1620.       1820.       2000.
T
   2      1
          2T
          2T
      250.        1500.T
     1900.        1900.T
      2305
 DATOS PARA LA ALUMINA PURA
   5      1
          5T
          2T
      250.         573.        873.       1173.       1573.T
       34.          16.          9.          6.5         5.5T
   6      1
          6T
          2T
      250.         473.        673.        873.       1173.       1573.
T
      750.        1025.       1140.       1200.       1250.       1280.
T
   2      1
          2T
          2T
      250.        1500.T
     3800.        3800.T
      2306
 DATOS PARA EL ZIRCALOY
   4      1
          4T
          2T
      250.         973.       1373.       1573.T
      12.5         21.5         29.         35.T
   5      1
          5T
          2T
      250.        1073.       1173.       1243.       1573.T
      280.         360.        810.        355.        355.T
   2      1
          2T
          2T
      250.        1500.T
     6570.        6570.T
```

```
  VEKTOR                1           1           0      1002400      &IAX&
  PRESION DEL VAPOR EN EL SUB-CANAL
F    &KKPR&T
  MATRIX                1           1
    1     1 &IAX&      6
    1002500T
 DEFORMACION PLASTICA DE LA VAINA EN EL ANALISIS R-Z
F         0.T
  MATRIX                1           1
    1     1 &IAX&      3
    1002600T
 COMPONENTES DE LA DEFORMACION TOTAL ANALISIS R-Z
F         0.T
  GENSTEU               1           1      1002900
 BLOQUE DE COMANDOS PARA EL MODULO AZI
   11    10     0
      &IAZ&      &AXAZ&      1002903A 8          1T
         0.          0.          0.S
         .8          .8S
         0.          0.       8.3E-6         0.           0.T
  MATRIX                1           1
    1     1      2 &IAZ&
    1002903T
  ESPESOR DE LA VAINA 1=INICIAL;2=DURANTE EL ENSAYO
F         0.T
  VEKTOR                1           1           0      1002904      &IAZ&
  SEGMENTOS ANGULARES EN RADIANES
         1.A&IAZMH&  1.T
  VEKTOR                1           1           0           2           1
  NUMERO DE NODOS EN LA DIRECCION AZIMUTAL
      &IAZ&T
  VEKTOR                1           1           0           3           1
  PI
    3.14150T
  MATDIV                1           1           2           2
  1./IAZ
  MATMZ                 1           1           2           3           7
  PI/IAZ
  MATMZ                 1           1      1002904          7      1002904
  SEGMENTOS ANGULARES EN RADIANES
  MATRIX                1           1
    1     0 &IAZ&      3
    1002905T
TEMPERATURAS EN LAS SUPERFICIES DE VAINA Y PASTILLA
F    &TKALT&T
  MATRIX                1           1
    1     0 &IAZ&      8
    1002906T
  DATOS DE LA OXIDACION AZIMUTAL DE LA VAINA
F         0.T
  MATRIX                1           1
    1     0&IRAD& &IAZ&
    1002907T
  TEMPERATURAS MEDIAS EN LOS NODOS AZIMUTALES
F    &TKALT&T
  MATRIX                1           1
    1     0 &IAZ&      9
    1002908T
1=EPST,2=EPSR,3=EPSAX,4=EPSEQ,5=VEL,6=VELOX,7=FUDA,8=SIGS,9=PARINT
F         0.T
```

```
 MATRIX              1                 1
   1     0 &IAZ&     3
   1002909T
DEFORMACION TOTAL 1=TANGENCIAL,2=RADIAL,3=AXIAL
F        0.T
  VEKTOR             1                 1              0        1002910            8
  VARIACION AZIMUTAL DE LAS CONDICIONES DE CONTORNO
       &EXZ&      &ALFAS&     &ALFRE&       &ALAMP&       &TNFAS&       &TNFRE&
   &TNAMP&              0.T
  MATRIX             1                 1
   1     0 &IAZ&     7
   1002911T
1=ALFAGAP,2=S,3=ALFAKK,4=ALSTR,5=TSTRNACHBAR,6=QOX,7=VERGLSP
F        0.T
  IVEKTOR            1                 1              0        1003000            9
  NUMERO DE BLOQUES A SER USADOS POR EL MODULO RANDM
   1003001A 6        1       1003008       1002910T
  IVEKTOR            1                 1              0        1003007           11
  VECTOR CORRESPONDENCIA PARA NODALIZACION AXIAL
R 3        1A 6          1Q 2            1T
  UGRID              1       ;         1        1003007        1003007         1113
  GENSTEU            1                 1        1003200
  BLOQUE DE COMANDOS PARA EL MODULO PIPRE
    3     16      0
   1003201      1003202              0T
R15      0.           1.T
  GENSTEU            1                 1        1003300
  PRESIONES PARCIALES DE LOS GASES DE LLENADO
    3      3
           2            36             54T
   &PINDR&           1.              1.T
  VEKTOR             1                 1              0        1003400          &IAX&
  PRESION INTERIOR DE LA BARRA COMBUSTIBLE
F   &PINDR&T
  VEKTOR             1                 1              0        1003600          &IAX&
  COEFICIENTE DE TRANSMISION DE CALOR DEL GAP
F       0.0T
  GENSTEU            1                 1        1003800
  BLOQUE DE COMANDOS PARA EL MODULO STADEF
    7      9      0
   1003801      1003802            0        1003804R 3          0T
   &GAUO2&        &NUO2&      &GAZRY&        &NZRY&R 3          0.S
   &STAFA&        &RAUH&T
  WERBL              1                 1              1              2
   1003802
  TABLAS CON MODULO DE ELASTICIDAD (T) DE PASTILLA Y VAINA
    2      1
           2T
           2T
        250.        2000.T
   0.2E+12      0.14E+11T
    2      1
           2T
           2T
        250.        2000.T
   1.0E+11      0.15E+11T
  VEKTOR             1                 1              0        1003804          &IAX&
  TENSION EQUIVALENTE EN LA VAINA (ANALISIS R-Z)
F          0.T
```

```
  GENSTEU                    1                  1        1004000
  BLOQUE DE COMANDOS PARA EL MODULO ZIRCOX
    3      8
    1004001A 2              1T
   3.966E-5        2.6E+4       5.96E+6         6600.          5800.           2.
F        0.T
  MATRIX                     1                  1
    1      0 &IAX&      8
    1004001T
1=ESPOX,2=ESPOX+ALFA,3=OXBETA,4=NOLOSE,5=OXTOTAL,6=TRED,7=OXEF,8=PINT
F        0.T
  MATRIX                     1                  1
    1      0 &IAX&      2
    1004002T
  FACTORES DE OXIDACION INTERNA Y EXTERNA
F        1.T
  MATRIX                     1                  1
    1      0 &IAX&      8
    1004003T
1=SZRO2,2=SZRO2+ALFA,3=GEWPROZO2KERN,4=O2TOTAL,5=GEWPROZO2TO,6=TV,O2EFF
F        0.T
  NUMKOR                     1                  1
    2      0
    1001900        1002400T
    2001900        2002400T
  SPEICHER                   1                  1              0        2000000
  BLOQUE SPEICHER PARA LOS CALCULOS EN ESTADO ESTACIONARIO
  LSCH-UBI                   1
    1001900T
  NUMKOR                     1                  1
    1      0
    2001900T
    1001900T
  URGAP                      1                  1        1000600
  ZIRKOX                     1                  1        1000600
  ZET-1D                     1                  1        1000600          500
C PIPRE                      1                  1        1000600
  LSCH-UBI                   1
    1002400T
  NUMKOR                     1                  1
    1      0
    1003400T
    1002400T
  STADEF                     1                  1        1000600
  AZI                        1                  1        1000600
  START                      1                  1        2000000
***$
  STADEF                     1                  1        1000600            -1
  AZI                        1                  1        1000600            -1
  START                      1                  1        2000000
  MODSTEU                    1                  1        1000600      1000600
  BLOQUE DE COMANDOS COMUNES PARA ANALISIS ARGENTIN
    1      1      1
           0T
    2      1      3
R 3      0.T
999999
  LSCH-UBI                   1
```

```
    1002400T
  NUMKOR               1           1
    1    0
    2002400T
    1002400T
  SPEICHER             1           1           0        2000010
  CORRECTOR PARA LA TEMPERATURA CIRCUNDANTE
  LSCH-UBI             1
          20T
  BLMOD                1           1
  TEMPERATURA MEDIA DEL NODO AZIMUTAL 1
    1     1     1&IRAD&&IRAD&     1     1
          0T
    1002907T
          20T
  MATADD               1           1          20          30          20
  NUEVA TEMPERATURA MEDIA DEL NODO &IAZH&
  BLMOD                1           1
  RABAZ(8)=NUEVA TEMP. MEDIA DEL NODO &IAZH&
    1     1     8     1     1     1     1
    1002910T
          20T                  :
    1002910T
***S
  VEKTOR               1           1           0          30           1
  VARIACION DE LA TEMPERATURA CIRCUNDANTE
          5.T
  START                1           1     2000010
  MATRIX               1           1
    1     1     6     2
    1103003T
VARIACION DE LA POTENCIA NORMALIZADA EN EL TIEMPO
          0.          1.S
         40.          1.S
         41.          1.0S
        130.          1.0S
        131.          1.0S
        500.          1.0T
  LSCH-UBI             1
    1001700T
  VEKTOR               1           1           0        1001700        1001
  VECTOR TIEMPO DURANTE EL TRANSIENTE
          0.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.A99       1.S
A 1       1.T
  MATMZ                1           1     1001700         105     1001700
  TIEMPO*9/POWER
  INTERPOL             1           1     1003003     1001700           1
    1     1     1
    1103003T
```

```
           -2T
    1103003T
           -1T
  POTENCIA NORMALIZADA DURANTE EL TRANSIENTE
  MATRIX               1           1
    3     0     7  1000
    1003004     1003005     1003006T
VARIACION DE LA TEMPERATURA DEL VAPOR EN EL SUB-CANAL EN EL TIEMPO
VARIACION DE ALFA EN EL SUB-CANAL DURANTE EL TRANSIENTE
VARIACION DE LA PRESION DEL VAPOR DURANTE EL TRANSIENTE
F     &TINI&T
F     &ALKK&T
F     &KKPR&T
  MATRIX               1           1
    1     1     8  1000
    1003008T
VARIACION DE LA TEMPERATURA CIRCUNDANTE DURANTE EL TRANSIENTE
R99    &EXZ&S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
R99       0.S
Q90       10S
Q 1        1S
      &TINI&A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A09      1.8T
  ZWERG                1           1     5000000          -3
  BLOQUE DE DATOS PARA EL MODULO ZWERG
           3
    1000600          1     2000600
          -1         1
          TIEMPO
    1002905         20     2002905
          1          1         -19
```

```
        TEMPERATURAS EN LA SUPERFICIE DE LA VAINA(AZI)
   1002600        11     2002600
        1         1         -10
        DEFORMACION TANGENCIAL DE LA VAINA
 MATRIX           1         1
   1    3    2    4
   1111111T
1=TIEMPO,2=TEMPERATURA MEDIA NODO &IAZH&
   1002600       -1         1          0S1
   1002907     &IRAD&     &IAZH&       0T2
 SPEICHER         1         1          0      2000020
 BLOQUE SPEICHER PARA LOS CALCULOS DURANTE EL TRANSIENTE
 ZAEHL            1        500        -1
 START            1         1    2000030
 ZAEHL            2        100        -1
 START            1         1    1111112
 RANDM            1         1    1000600
C START           1         1    2000010
 URGAP            1         1    1000600
 ZIRKOX           1         1    1000600
 ZET-1D           1         1    1000600         1000
C PIPRE           1         1    1000600
 STADEF           1         1    1000600
 AZI              1         1    1000600
 ZWERG            1         1    5000000            3
 START            1         1    2000020
***$
 SPEICHER         1         1          0      2000030
 BLOQUE SPEICHER PARA IMPRESION DE RESULTADOS
 DR-SETZ          1
 DRUCKE           1                    7
   1000600    1001200    1002600    1003400    1001500S
   1002907    1002909T
 DR-SETZ
 SZAEHL           1         0
***$
 SPEICHER         1         1          0      1111112
 BLOQUE SPEICHER PARA EXTRAER RESULTADOS
 LSCH-UBI         1
   1111116T
 SAMMEL           1         1    1111111      1111116
 KOMBSP           1         1
        2     1111117
   1111117    1111116T
 SZAEHL           2         0
 ZAEHL            3        100
 ADD              1         1    1111113      1111113
      1.0
***$
 SPEICHER         1         1          0      1111114
  ERGAENZEN DER TRANSIENTEN STUTZPUNKTE
 KOMBSP           1         1
        2     8888887
   8888887    1111115T
 ZAEHL            3         5
 START            1         1    1111114
***$
 SZAEHL           1         0
 SZAEHL           2        90
 SZAEHL           3         0
 VEKTOR           1         1          0      1111113          1
VECTOR PARA CONTAR LOS PARES TIEMPO-TEMP EXTRAIDOS
      0.T
 VEKTOR           1         1          0      1111115          2
COMPLEMENTO PARA LOS PARES DE VALORES TIEMPO-TEMP
F     0.T
 VEKTOR           1         1          0      1111117          1
TIEMPO-TEMPERATURA MEDIA DE VAINA CADA 100 INTERVALOS
F     0.T
 START            1         1    2000020
 MATMSKAL         1         1    1111113      1111118
 2 VECES EL NUMERO DE EXTRACIONES -1
     2.
 ADD              1         1    1111118      1111118
    -1.0
 INT              1         1    1111113      1111113
 INT              1         1    1111118      1111118
 MATRIX           1         1
   1    3    7    4
   5555555T
1=TMAX,2=TMIN,3=TMED,4=EPST,5=TIEMPO,6=FUDA,7=TAU,8=TEM,...
   1002907     &IRAD&       1          0S1
   1002907     &IRAD&     &IAZ&        0S2
   1002907     &IRAD&     &IAZH&       0S3
   1002600     &AXAZ&       1          0S4
   1000600       -1         1          0S5
   1000600       -1         8          0S6
   1111117        1         2B    1111118T7
 SAMMEL           1         1    5555555      8888887
 ZAEHL            3         5
 START            1         1    1111114
 BLMOD            1         1
 BLOQUE DE RESULTADOS
   1    1    1    1    1    1    14    0    0
        0T
   8888887T
   8888888T
 BLMOD            2         2
 TRANSFERENCIA DE RESULTADOS A BIB
   1  &SP&   1    1    1    1    14    0    0
   9999996T
   8888888T
   9999996T
 DR-SETZ          1
 DRUCKE           1         1         -1
        1    9999996T
 LSCH-UBI        -2
        1      4237       4239     9999980T
 LSCH-BIB         1
   1111111T
 BIB-LIST
***
 VARIO            1                 4238               9999998
 &SP&=37
&VARIEND
```

APPENDIX B (CONT.)

B.3. MODEL C

```
 ARGENTIN      0   100   640     0   200   640                       4000
 MATRIX              1               1
   1    1    40      5
   9999998T
 MATRIZ CON LOS DATOS EXPERIMENTALES
C     TINI (K)    PINDR (N/M**2) POWER(W/CM)   EXZ      ALKK (W/K*M**2)
        573.        94.E+5          6.0         .6         10.S1
        573.        94.E+5          6.0         .7         10.S2
        573.        94.E+5          6.0         .8         10.S3
        573.        94.E+5          6.0         .9         10.S4
        573.        80.E+5          6.0         .6         9.4S5
        573.        80.E+5          6.0         .7         9.4S6
        573.        80.E+5          6.0         .8         9.4S7
        573.        80.E+5          6.0         .9         9.4S8
        573.        67.E+5          6.0         .6         8.9S9
        573.        67.E+5          6.0         .7         8.9S10
        573.        67.E+5          6.0         .8         8.9S11
        573.        67.E+5          6.0         .9         8.9S12
        573.        54.E+5          6.0         .6         8.4S13
        573.        54.E+5          6.0         .7         8.4S14
        573.        54.E+5          6.0         .8         8.4S15
        573.        54.E+5          6.0         .9         8.4S16
        573.        47.E+5          6.0         .6         8.1S17
        573.        47.E+5          6.0         .7         8.1S18
        573.        47.E+5          6.0         .8         8.1S19
        573.        47.E+5          6.0         .9         8.1S20
        573.        40.E+5          6.0         .6         7.8S21
        573.        40.E+5          6.0         .7         7.8S22
        573.        40.E+5          6.0         .8         7.8S23
        573.        40.E+5          6.0         .9         7.8S24
        573.        27.E+5          6.0         .6         7.3S25
        573.        27.E+5          6.0         .7         7.3S26
        573.        27.E+5          6.0         .8         7.3S27
        573.        27.E+5          6.0         .9         7.3S28
        573.        23.E+5          6.0         .6         7.2S29
        573.        23.E+5          6.0         .7         7.2S30
        573.        23.E+5          6.0         .8         7.2S31
        573.        23.E+5          6.0         .9         7.2S32
        573.       13.4E+5          6.0         .6         6.8S33
        573.       13.4E+5          6.0         .7         6.8S34
        573.       13.4E+5          6.0         .8         6.8S35
        573.       13.4E+5          6.0         .8         6.8S36
        573.        6.5E+5          6.0         .6         6.5S37
        573.        6.5E+5          6.0         .7         6.5S38
        573.        6.5E+5          6.0         .8         6.5S39
        573.        6.5E+5          6.0         .9         6.5T
 MATRIX
   1    1   100    14
   9999995T
 MATRIZ PARA ALMACENAR RESULTADOS RADHEAT1
F        0.T
C
C  CAMPO DE DEFINICION DE LAS VARIABLES
C
```

```
  SPEICHER                                   1                    4238
  DATOS DE LOS ENSAYOS CON VAINAS ARGENTINAS
&VARIDEF
&IMAGN&=1 &IHEIZ&=1 &IBOR&=1  &INCO&=1  &IALO&=1  &IHUEL&=1 &LEV1&=1
C   &IMAGN& NUMERO DE NODOS EN EL OMG (ZONA INTERIOR DEL CALEFACTOR)
C   &IHEIZ& NUMERO DE NODOS EN EL ELEMENTO CALEFACTOR(NODO RADIAL 2)
C   &IBOR& NUMERO DE NODOS EN EL BN (NODO RADIAL 3)
C   &INCO& NUMERO DE NODOS EN EL REVESTIMIENTO (NODO RADIAL 4)
C   &IALO& NUMERO DE NODOS EN LAS PASTILLAS DE AL2O3 (NODO RADIAL 6)
C   &IHUEL& NUMERO DE NODOS EN EL TUBO DE ZRY (NODO RADIAL 8)
C   &LEV1& NUMERO DE NODOS EN LA ZONA AXIAL 1 DEL CALEFACTOR
&LEV2&=1  &LEV3&=1  &LEV4&=1  &LEV5&=1  &LEV6&=1  &LEV7&=1
C   &LEV2& NUMERO DE NODOS EN LA ZONA 2 DEL CALEFACTOR
C   &LEV3& NUMERO DE NODOS EN LA ZONA 3 DEL CALEFACTOR
C   &LEV4& NUMERO DE NODOS EN LA ZONA CENTRAL (MAXIMA POTENCIA)
C   &LEV5& NUMERO DE NODOS EN LA ZONA 5 DEL CALEFACTOR
C   &LEV6& NUMERO DE NODOS EL LA ZONA 6 DEL CALEFACTOR
C   &LEV7& NUMERO DE NODOS EN LA ZONA 7 DEL CALEFACTOR
&RM1&='1.256' &RM2&='1.372' &RM3&='1.450' &RM4&='1.487' &RME&='1.750'
C   &RM1& RADIO DE LA BARRA INTERIOR DE OMG CORRESPONDIENTE A
C   LAS ZONAS 1 Y 7 DE LA MISMA (EN MM)
C   &RM2& LO MISMO QUE &RM1& PARA LAS ZONAS 2 Y 6
C   &RM3& LO MISMO QUE &RM1& PARA LAS ZONAS 3 Y 5
C   &RM4& LO MISMO QUE &RM1& PARA LA ZON DE MAXIMA POTENCIA (ZONA 4)
C  &RME& RADIO EXTERIOR DEL CALEFACTOR EN MM (CONSTANTE EN LA DIR AXIAL
&RBO&='2.400' &RIN&='3.000' &RALI&='3.0500' &RALA&='5.2500'
C   &RBO& RADIO EXTERIOR DEL BN EN MM
C   &RIN& RADIO EXTERIOR DEL REVESTIMIENTO EN MM
C   &RALI& RADIO INTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
C   &RALA& RADIO EXTERIOR DE LAS PASTILLAS DE AL2O3 EN MM
&RZI&='5.400' &RZA&='5.950' &TKALT&='293.000' &TINI&=(&SP&,1)
C   &RZI& RADIO INTERIOR DEL TUBO DE ZRY EN MM
C   &RZA& RADIO EXTERIOR DEL TUBO DE ZRY EN MM
C   &TKALT& TEMPERATURA DE COMIENZO DEL ENSAYO EN K
C   &TINI& TEMPERATURA DE COMIENZO DE LA RAMPA DE POTENCIA
&STAFA&='     0.'
&DV1&='    .0'
&DV2&='    .0'
&DV3&='    .0'
&DV4&='    .0'
&DV5&='    .0'
&DV6&='    .0'
&DV7&='    .0'
C  &STAFA& FACTOR PARA TENER EN CUENTA O NO LA RESISTENCIA MECANICA DE
C    LA CAPA DE OXIDO (STAFA=0, NO SE TIENE EN CUENTA)
&KKPR&='1.E+5' &IAZ&=20
C    &KKPR& PRESION DEL VAPOR EN EL SUB-CANAL EN N/M**2
C    &IAZ& NUMERO DE NODOS EN LA DIRECCION AZIMUTAL PARA EL MODULO AZI
&AXAZ&=6 &EXZ&=(&SP&,4) &ALFAS&='00000.0' &ALFRE&='000360.'
C    &AXAZ& NODO AXIAL DONDE SE REALIZA EL ANALISIS AZIMUTAL
C    &EXZ& EXCENTRICIDAD ENTRE PASTILLA Y TUBO (VARIA ENTRE 0 Y 1)
C    &ALFAS& CONSTANTE PARA OBTENER EL COEF. DE TRANSFERENCIA TERMICA
C    VARIABLE CON LA POSICION ANGULAR
C    &ALFRE& IDEM &ALFAS&
&ALAMP&='0000.1' &TNFAS&='00000.0' &TNFRE&='000360.' &TNAMP&='00000.0'
C    &ALAMP& IDEM &ALFRE&
C    &TNFAS& CONSTANTE PARA DETERMINAR LA TEMPERATURA CIRCUNDANTE A LA
C   BARRA EN FUNCION DE LA POSICION ANGULAR (PARA EL CALCULO DE LA TRANS
C    FERENCIA TERMICA POR RADIACION)
```

```
C   &TNFRE& IDEM &TNFAS&
C   &TNAMP& IDEM &TNFAS&
&PINDR&=(&SP&,2) &POWER&=(&SP&,3)
C   &PINDR& PRESION INTERIOR DE LA BARRA A &TKALT& (EN N/M**2)
C   &POWER& POTENCIA LINEAL DE LA BARRA (EN WATT/CM)
&GAUO2&='1.08E-5'
&NUO2&='00.316' &GAZRY&='0.60E-5' &NZRY&='0000.4'
&RAUH&='5.E-6'
C   &GAUO2& COEFICIENTE DE DILATACION LINEAL DEL UO2
C   &NUO2& MODULO DE POISSON DEL UO2
C   &GAZRY& COEFICIENTE DE DILATACION LINEAL DEL ZRY
C   &NZRY& MODULO DE POISSON DEL ZRY
C   &RAUH& RUGOSIDAD DE PASTILLA Y VAINA
&IRAD&=&IMAGN&+&IHEIZ& &IRAD&=&IRAD&+&IBOR& &IRAD&=&IRAD&+&INCO&
&IRAD&=&IRAD&+2 &IRAD&=&IRAD&+&IALO& &IRAD&=&IRAD&+&IHUEL&
&IAX&=&LEV1&+&LEV2&  &IAX&=&IAX&+&LEV3&
&IAX&=&IAX&+&LEV4& &IAX&=&IAX&+&LEV5& &IAX&=&IAX&+&LEV6&
&IAX&=&IAX&+&LEV7& &IAX&=&IAX&+4 &ALKK&=(&SP&,5) &IAZM1&=&IAZ&-1
C &ALKK& COEFICIENTE DE TRANSMISION DE CALOR EN LA INTERFASE BARRA COM
C  BUSTIBLE-VAPOR
&IAM&=&IAX&/2       &IAZMH&=&IAZM1&'2 &IAZH&=&IAZ&/2
&VARIEND
  DR-SETZ
  IVEKTOR              1            1            0         1112          8
VECTOR PARA LA EXPANSION RADIAL
    &IMAGN&      &IHEIZ&      &IBOR&       &INCO&            1        &IALO&
         1       &IHUEL&T
  IVEKTOR              1            1            0         1113         11
VECTOR PARA LA EXPANSION AXIAL
R 2          1      &LEV1&       &LEV2&       &LEV3&       &LEV4&       &LEV5&
     &LEV6&      &LEV7&R 2          1T
  GENSTEU              1            1       1000600
 BLOQUE GENERAL DE CONTROL PARA ANALISIS ARGENTIN
   42     12      1
         0             0      &IRAD&       &IAX&             1            2
    1000700A35       100T
R 8      0.            1.           2.R 2       1000.T
ENSAYOS DE EXPLOSION CON TUBOS ARGENTINOS
  MATRIX               1            1
    1        2      8     11
    1000700T
MATRIZ DE CORRESPONDENCIA PARA ANALISIS ARGENTIN
R 8          3R 7          1            3            4            5            6
             7             9            8           -9         3Q 6            8
R 7          2            3R 8          3T
  UGRID                1            1       1000700      1000700         1113
  UGRID                1            1       1000700      1000700        -1112
  MATRIX               1            1
    1        1      9     11
    1000800T
  CAMPO DE RADIOS INICIALES PARA ANALISIS ARGENTIN
R11      0.R 3&RM1&      &RM2&        &RM3&        &RM4&        &RM3&
     &RM2&R 3      &RM1&S
R11    &RME&S
R11    &RBO&S
R11    &RIN&S
R11   &RALI&S
R11   &RALA&S
R11    &RZI&S
R11    &RZA&T
```

```
  MATMSKAL             1            1       1000800      1000800
  RADIOS PARA ANALISIS ARGENTIN EN METROS
    1.E-3
  UGRID                1            1       1000800      1000800         1113
  UGRID                1            1      -1000800      1000800        -1112
  VEKTOR               1            1             0      1000900           12
  ALTURAS INICIALES PARA ANALISIS ARGENTIN
          0.A 1      0.001A 1     2.001A 1      .001A 1     0.001A 1    0.001
A 1   0.325A 1     0.001A 1     0.001A 1      .001A 1     0.001A 1    0.001
T
  UGRID                1            1      -1000900      1000900         1113
  MATRIX               1            1
    1      0&IRAD& &IAX&
    1001000T
  TEMPERATURAS MEDIAS EN LOS NODOS AL INICIO DEL ENSAYO
F   &TKALT&T
  MATRIX               1            1
    1       0 &IAX&      3
    1001100T
  TEMPERATURAS EN LAS SUPERFICIES AL INICIO DEL ENSAYO
F   &TKALT&T
  NUMKOR               1            1
    4       0
    1000800A 3       100T
    1001500      1001600      1001200      1001300T
  VEKTOR               1            1             0      1001700          501
  VECTOR TIEMPO
          0.A50      0.05A50       .1A50       .15A50       .2A50        .30
A50        .3A50        .3A50       .3A50        .3A50        .3T
  VEKTOR               1            1             0           10            1
  COEFICIENTE DE TRANSFERENCIA TERMICA INTERFASE BARRA-VAPOR
      1.E+5T
  VEKTOR               1            1             0           11            1
  TEMPERATURA DEL VAPOR EN K
      &TINI&T
  MATMAL               1            1            10           11           11
 ALFA *&TINI&
  MATRIX               1            1
    2       0      11      3
    1001800      1001900T
  CONDICIONES DE CONTORNO EN EL PLANO CENTRAL (IZQ)
  CONDICIONES DE CONTORNO EN LA SUP. EXTERIOR DE LA BARRA (DER)
R11         0.R11        1.R11         0.T
B          10Q10         1R11         1.B          11Q10           1T
  UGRID                1            1       1001800      1001800        -1113
  UGRID                1            1       1001900      1001900        -1113
  MATRIX               1            1
    2       1       8     11
    1002200      1003201T
  DISTRIBUCION DE LAS FUENTES DE CALOR
  VOLUMENES DE CRACK PARA EL MODULO PIPRE
F          0.T
F          0.T
  UGRID                1            1       1002200      1002200         1113
  UGRID                1            1       1002200      1002200        -1112
  UGRID                1            1       1003201      1003201         1113
  UGRID                1            1       1003201      1003201        -1112
  MATRIX               1            1
```

```
    1     1      8     11
   1003202T
 VOLUMENES DE LOS DISHINGS
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R 2       0.       &DV1&        &DV2&        &DV3&        &DV4&        &DV5&
     &DV6&       &DV7&R 2       0.S
R11       0.S
R11       0.T
  VEKTOR                1            1            0          102            2
  RADIOS DEL ELEMENTO CALEFACTOR EN MM
      &RM4&        &RME&T
  VEKTOR                1            1            0          103            1
  PI/100
  0.0314150T
  VEKTOR                1            1            0          104            1
  MAXIMA POTENCIA LINEAL
    &POWER&T
  MATMSKAL              1            1          102          102
 RADIOS DEL ELEMENTO CALEFACTOR EN M
     1.E-3
  POWER                 1            1          102          102            2
  DELTA                 1            1          102          102            1
  MATMAL                1            1          102          103          102
  (RME**2-RM4**2)*0.01PI
  MATDIV                1            1          102          102
  1/AREA DEL CALEFACTOR
  MATMAL                1            1          102          104          102
  MAXIMA POTENCIA EN W/M**3
  MATDIV                1            1          104          105
  1/MAXIMA POTENCIA LINEAL
  MATMSKAL              1            1          105          105
    9/MAXIMA POTENCIA LINEAL
     .9E+1
  MATRIX                1            1
    1     1      8     11
   1003001T
DISTRIBUCION DE LAS FUENTES DE CALOR DURANTE EL TRANSIENTE
R11       0.S
R 5       0.B         102R 5        0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.S
R11       0.T
  UGRID                 1            1      1003001      1003001         1113
  UGRID                 1            1      1003001      1003001        -1112
  GENSTEU               1            1      1002300
  BLOQUE DE COMANDOS PARA EL MODULO ZET-1D
   19       5      0
          9R 2        2301         2306         2302         2303         2304
       2303           2305         2301R 3         1         &IRAD&       &IAM&
R 4        0T
R 2       .5R 3        0.T
```

```
WERBL                  1             1             6             3
     2301
DATOS PARA EL HELIO A 70 BAR DE PRESION
  4       1
          4T
          2T
     250.         750.        1250.        1500.T
     .137         .296         .423        .4810T
  4       1
          4T
          2T
     250.         400.         750.        1500.T
    5283.        5203.        5190.        5192.T
  4       1
          4T
          2T
     250.         800.         900.        1500.T
    13.15        6.712        3.765        2.269T
     2302
DATOS PARA EL OXIDO DE MAGNESIO CON DENSIDAD 90%
  4       1
          4T
          2T
     250.         673.        1073.        1500.T
       3.         47.5         44.0         40.1T
  4       1
          4T
          2T
     250.         443.         723.        1500.T
     850.        1100.        1210.        1325.T
  2       1
          2T
          2T
     250.        1500.T
    3220.        3220.T
     2303
  DATOS PARA EL INCONEL 600 (ELEMENTO CALEFACTOR)
  3       1
          3T
          2T
     250.         773.        1573.T
      17.         28.3         47.T
  5       1
          5T
          2T
     250.         523.         823.        1000.        1575.T
     425.         500.         553.         612.         645.T
  2       1
          2T
          2T
     250.        1500.T
    8430.        8430.T
     2304
DATOS PARA EL NITRITO DE BORO
  2       1
          2T
          2T
     250.        1500.T
```

```
      27.          27.T
   6     1
         6T
         2T
      250.         432.          573.          773.          1073.         1373.
T
      600.         1100.         1380.         1620.         1820.         2000.
T
   2     1
         2T
         2T
      250.         1500.T
     1900.         1900.T
      2305
 DATOS PARA LA ALUMINA PURA
   5     1
         5T
         2T
      250.          573.          873.         1173.         1573.T
       34.  -        16.            9.           6.5           5.5T
   6     1
         6T
         2T
      250.          473.          673.          873.         1173.         1573.
T
      750.         1025.         1140.         1200.         1250.         1280.
T
   2     1
         2T
         2T
      250.         1500.T
     3800.         3800.T
      2306
 DATOS PARA EL ZIRCALOY
   4     1
         4T
         2T
      250.          973.         1373.         1573.T
      12.5         21.5           29.           35.T
   5     1
         5T
         2T
      250.         1073.         1173.         1243.         1573.T
      280.          360.          810.          355.          355.T
   2     1
         2T
         2T
      250.         1500.T
     6570.         6570.T
  VEKTOR                 1             1             0      1002400        &IAX&
  PRESION DEL VAPOR EN EL SUB-CANAL
F    &KKPR&T
  MATRIX                 1             1
    1     1 &IAX&      6
    1002500T
 DEFORMACION PLASTICA DE LA VAINA EN EL ANALISIS R-Z
F       0.T
  MATRIX                 1             1
```

```
    1      1 &IAX&      3
    1002600T
 COMPONENTES DE LA DEFORMACION TOTAL ANALISIS R-Z
F         0.T
  GENSTEU                1             1      1002900
 BLOQUE DE COMANDOS PARA EL MODULO AZI
   11    10     0
       &IAZ&       &AXAZ&       1002903A 8          1T
         0.           0.           0.S
         .8       1.99999S
         0.           0.         8.3E-6          0.            0.T
C
C  CLADDING EMISSIVITY CHANGED TO AN ARTIFICIAL VALUE (1.99999) FOR A
C  STRONG COUPLING WITH THE SHROUD
C
  MATRIX                 1             1
    1     1      2 &IAZ&
    1002903T
  ESPESOR DE LA VAINA 1=INICIAL;2=DURANTE EL ENSAYO
F         0.T
  VEKTOR                 1             1             0      1002904        &IAZ&
  SEGMENTOS ANGULARES EN RADIANES
         1.A&IAZMH&  1.T
  VEKTOR                 1             1             0             2             1
  NUMERO DE NODOS EN LA DIRECCION AZIMUTAL
      &IAZ&T
  VEKTOR                 1             1             0             3             1
  PI
    3.14150T
  MATDIV                 1             1             2             2
  1./IAZ
  MATMZ                  1             1             2             3             7
  PI/IAZ
  MATMZ                  1             1      1002904              7      1002904
  SEGMENTOS ANGULARES EN RADIANES
  MATRIX                 1             1
    1     0 &IAZ&      3
    1002905T
TEMPERATURAS EN LAS SUPERFICIES DE VAINA Y PASTILLA
F   &TKALT&T
  MATRIX                 1             1
    1     0 &IAZ&      8
    1002906T
  DATOS DE LA OXIDACION AZIMUTAL DE LA VAINA
F         0.T
  MATRIX                 1             1
    1     0&IRAD& &IAZ&
    1002907T
  TEMPERATURAS MEDIAS EN LOS NODOS AZIMUTALES
F   &TKALT&T
  MATRIX                 1             1
    1     0 &IAZ&      9
    1002908T
1=EPST,2=EPSR,3=EPSAX,4=EPSEQ,5=VEL,6=VELOX,7=FUDA,8=SIGS,9=PARINT
F         0.T
  MATRIX                 1             1
    1     0 &IAZ&      3
    1002909T
DEFORMACION TOTAL 1=TANGENCIAL,2=RADIAL,3=AXIAL
F         0.T
```

```
 VEKTOR                 1            1            0       1002910          8
 VARIACION AZIMUTAL DE LAS CONDICIONES DE CONTORNO
    &EXZ&      &ALFAS&    &ALFRE&      &ALAMP&      &TNFAS&      &TNFRE&
  &TNAMP&          0.T
 MATRIX                 1            1
   1    0 &IAZ&         7
   1002911T
1=ALFAGAP,2=S,3=ALFAKK,4=ALSTR,5=TSTRNACHBAR,6=QOX,7=VERGLSP
F        0.T
 IVEKTOR                1            1            0       1003000          9
 NUMERO DE BLOQUES A SER USADOS POR EL MODULO RANDM
   1003001A 6           1      1003008      1002910T
 IVEKTOR                1            1            0       1003007         11
 VECTOR CORRESPONDENCIA PARA NODALIZACION AXIAL
R 3      1A 6         1Q 2         1T
 UGRID                  1            1      1003007       1003007       1113
 GENSTEU                1            1      1003200
 BLOQUE DE COMANDOS PARA EL MODULO PIPRE
   3   16    0
   1003201     1003202          0T
R15      0.           1.T
 GENSTEU                1            1      1003300
 PRESIONES PARCIALES DE LOS GASES DE LLENADO
   3    3
         2          36           54T
  &PINDR&          1.           1.T
 VEKTOR                 1            1            0       1003400       &IAX&
 PRESION INTERIOR DE LA BARRA COMBUSTIBLE
F   &PINDR&T
 VEKTOR                 1            1            0       1003600       &IAX&
 COEFICIENTE DE TRANSMISION DE CALOR DEL GAP
F       0.0T
 GENSTEU                1            1      1003800
 BLOQUE DE COMANDOS PARA EL MODULO STADEF
   7    9    0
   1003801     1003802          0      1003804R 3         0T
   &GAUO2&     &NUO2&     &GAZRY&      &NZRY&R 3          0.S
   &STAFA&     &RAUH&T
 WERBL                  1            1            1             2
   1003802
 TABLAS CON MODULO DE ELASTICIDAD (T) DE PASTILLA Y VAINA
   2    1
         2T
         2T
      250.        2000.T
   0.2E+12     0.14E+11T
   2    1
         2T
         2T
      250.        2000.T
   1.0E+11     0.15E+11T
 VEKTOR                 1            1            0       1003804       &IAX&
 TENSION EQUIVALENTE EN LA VAINA (ANALISIS R-Z)
F       0.T
 GENSTEU                1            1      1004000
 BLOQUE DE COMANDOS PARA EL MODULO ZIRCOX
   3    8
   1004001A 2          1T
```

```
   3.966E-5      2.6E+4      5.96E+6       6600.       5800.          2.
F       0.T
 MATRIX                 1            1
   1    0 &IAX&      8
   1004001T
1=ESPOX,2=ESPOX+ALFA,3=OXBETA,4=NOLOSE,5=OXTOTAL,6=TRED,7=OXEF,8=PINT
F       0.T
 MATRIX                 1            1
   1    0 &IAX&      2
   1004002T
 FACTORES DE OXIDACION INTERNA Y EXTERNA
F       1.T
 MATRIX                 1            1
   1    0 &IAX&      8
   1004003T
1=SZRO2,2=SZRO2+ALFA,3=GEWPROZO2KERN,4=O2TOTAL,5=GEWPROZO2TO,6=TV,O2EFF
F       0.T
 NUMKOR                 1            1
   2    0
   1001900      1002400T
   2001900      2002400T
 SPEICHER               1            1            0       2000000
 BLOQUE SPEICHER PARA LOS CALCULOS EN ESTADO ESTACIONARIO
 LSCH-UBI               1
   1001900T
 NUMKOR                 1            1
   1    0
   2001900T
   1001900T
 URGAP                  1            1      1000600
 ZIRKOX                 1            1      1000600
 ZET-1D                 1            1      1000600        500
C PIPRE                 1            1      1000600
 LSCH-UBI               1
   1002400T
 NUMKOR                 1            1
   1    0
   1003400T
   1002400T
 STADEF                 1            1      1000600
 AZI                    1            1      1000600
 START                  1            1      2000000
***$
 STADEF                 1            1      1000600         -1
 AZI                    1            1      1000600         -1
 START                  1            1      2000000
 MODSTEU                1            1      1000600    1000600
 BLOQUE DE COMANDOS COMUNES PARA ANALISIS ARGENTIN
   1    1    1
        0T
   2    1    3
R 3     0.T
999999
 LSCH-UBI               1
   1002400T
 NUMKOR                 1            1
   1    0
   2002400T
```

```
  1002400T
SPEICHER                1          1          0      2000010
CORRECTOR PARA LA TEMPERATURA CIRCUNDANTE
LSCH-UBI                1
     20T
BLMOD                   1          1
TEMPERATURA MEDIA DEL NODO AZIMUTAL 1
  1      1      1&IRAD&&IRAD&      1      1
     0T
  1002907T
     20T
MATADD                  1          1          20          30          20
NUEVA TEMPERATURA MEDIA DEL NODO &IAZH&
BLMOD                   1          1
RABAZ(8)=NUEVA TEMP. MEDIA DEL NODO &IAZH&
  1      1      3      1      1      1      1
  1002910T
     20T
  1002910T
***S
VEKTOR                  1          1          0          30          1
VARIACION DE LA TEMPERATURA CIRCUNDANTE
     5.T
START                   1          1      2000010
MATRIX                  1          1
  1      1      6      2
  1103003T
VARIACION DE LA POTENCIA NORMALIZADA EN EL TIEMPO
      0.          1.S
     40.          1.S
     41.          1.0S
    130.          1.0S
    131.          1.0S
    500.          1.0T
LSCH-UBI                1
  1001700T
VEKTOR                  1          1          0      1001700       1001
VECTOR TIEMPO DURANTE EL TRANSIENTE
       0.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.A99      1.S
A 1    1.T
MATMZ                   1          1      1001700       105      1001700
TIEMPO*9/POWER
INTERPOL                1          1      1003003      1001700          1
  1      1      1
  1103003T
     -2T
  1103003T
     -1T
POTENCIA NORMALIZADA DURANTE EL TRANSIENTE
```

```
 MATRIX                 1          1
  3      0      7   1000
  1003004      1003005      1003006T
VARIACION DE LA TEMPERATURA DEL VAPOR EN EL SUB-CANAL EN EL TIEMPO
VARIACION DE ALFA EN EL SUB-CANAL DURANTE EL TRANSIENTE
VARIACION DE LA PRESION DEL VAPOR DURANTE EL TRANSIENTE
F    &TINI&T
F    &ALKK&T
F    &KKPR&T
 MATRIX                 1          1
  1      1      8   1000
  1003008T
VARIACION DE LA TEMPERATURA CIRCUNDANTE DURANTE EL TRANSIENTE
R99    &EXZ&S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
R99      0.S
Q90       10S
Q 1        1S
   &TINI&A90      1.3S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A90      1.8S
A09      1.8T
 ZWERG                  1          1      5000000          -3
 BLOQUE DE DATOS PARA EL MODULO ZWERG
        3
  1000600          1      2000600
       -1          1
     TIEMPO
  1002905         20      2002905
        1          1        -19
     TEMPERATURAS EN LA SUPERFICIE DE LA VAINA(AZI)
  1002600         11      2002600
        1          1        -10
     DEFORMACION TANGENCIAL DE LA VAINA
```

```
 MATRIX              1           1
   1    3    2    4
   1111111T
1=TIEMPO,2=TEMPERATURA MEDIA NODO &IAZH&
   1000600         -1           1            OS1
   1002907      &IRAD&      &IAZH&           OT2
 SPEICHER            1           1           0      2000020
 BLOQUE SPEICHER PARA LOS CALCULOS DURANTE EL TRANSIENTE
 ZAEHL               1         500          -1
 START               1           1     2000030
 ZAEHL               2         100          -1
 START               1           1     1111112
 RANDM               1           1     1000600
C START              1           1     2000010
 URGAP               1           1     1000600
 ZIRKOX              1           1     1000600
 ZET-1D              1           1     1000600          1000
C PIPRE              1           1     1000600
 STADEF              1           1     1000600
 AZI                 1           1     1000600
 ZWERG               1           1     5000000             3
 START               1           1     2000020
***S
 SPEICHER            1           1           0      2000030
 BLOQUE SPEICHER PARA IMPRESION DE RESULTADOS
 DR-SETZ             1
 DRUCKE              1                       7
   1000600     1001200     1002600     1003400     1001500S
   1002907     1002909T
 DR-SETZ
 SZAEHL              1           0
***S
 SPEICHER            1           1           0      1111112
 BLOQUE SPEICHER PARA EXTRAER RESULTADOS
 LSCH-UBI            1
   1111116T
 SAMMEL              1           1     1111111      1111116
 KOMBSP              1           1
        2      1111117
   1111117     1111116T
 SZAEHL              2           0
 ZAEHL               3         100
 ADD                 1           1     1111113      1111113
       1.0
***S
 SPEICHER            1           1           0      1111114
  ERGAENZEN DER TRANSIENTEN STUTZPUNKTE
 KOMBSP              1           1
        2      8888887
   8888887     1111115T
 ZAEHL               3           5
 START               1           1     1111114
***S
 SZAEHL              1           0
 SZAEHL              2          90
 SZAEHL              3           0
 VEKTOR              1           1           0      1111113            1
 VECTOR PARA CONTAR LOS PARES TIEMPO-TEMP EXTRAIDOS
```

```
       0.T
 VEKTOR              1           1           0      1111115            2
 COMPLEMENTO PARA LOS PARES DE VALORES TIEMPO-TEMP
F      0.T
 VEKTOR              1           1           0      1111117            1
 TIEMPO-TEMPERATURA MEDIA DE VAINA CADA 100 INTERVALOS
F      0.T
 START               1           1     2000020
 MATMSKAL            1           1     1111113      1111118
 2 VECES EL NUMERO DE EXTRACIONES -1
       2.
 ADD                 1           1     1111118      1111118
     -1.0
 INT                 1           1     1111113      1111113
 INT                 1           1     1111118      1111118
 MATRIX              1           1
   1    3    7    4
   5555555T
1=TMAX,2=TMIN,3=TMED,4=EPST,5=TIEMPO,6=FUDA,7=TAU,8=TEM,...
   1002907      &IRAD&           1           OS1
   1002907      &IRAD&      &IAZ&            OS2
   1002907      &IRAD&     &IAZH&            OS3
   1002600      &AXAZ&           1           OS4
   1000600          -1           1           OS5
   1000600          -1           8           OS6
   1111117           1          2B     1111118T7
 SAMMEL              1           1     5555555      8888887
 ZAEHL               3           5
 START               1           1     1111114
 BLMOD               1           1
 BLOQUE DE RESULTADOS
   1    1    1    1    1    1   14    0    0
         0T
   8888887T
   8888888T
 BLMOD               2           2
 TRANSFERENCIA DE RESULTADOS A BIB
   1  &SP&    1    1    1    1   14    0    0
   9999995T
   8888888T
   9999995T
 DR-SETZ             1
 DRUCKE              1           1          -1
         1   9999995T
 LSCH-UBI           -2
         1      4237        4239     9999980T
 LSCH-BIB            1
   1111111T
 BIB-LIST
***
 VARIO               1                4238              9999998
 &SP&=40
&VARIEND
```