PNC ~~S~~TN 941 85—67

NOT FOR PUBLICATION

登録区分
'98. 3. 26
変更表示

COMPARISON OF SOFIRE-MII PREDICTIONS WITH THE RESULTS OF GERMAN FAUNA F5 AND F6 TESTS

区 分 変 更	
変更後資料番号	PNCTN941 85-67
決裁年月日	平成10年 3 月26日

March 1985

OARAI ENGINEERING CENTER

POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION

〒３１９−１１８４　茨城県那珂郡東海村村松４番地４９
核燃料サイクル開発機構
技術展開部　技術協力課

Technical Cooperation Section
Technology Management Division,
Japan Nuclear Cycle Development Institute
4-49 Muramatsu, Tokai-mura, Naka-gun, Ibaraki 319-1184,
Japan

Ⓦ

NOT FOR PUBLICATION
PNC T~~S~~N941 85-67
March 1985

COMPARISON OF SOFIRE-MII PREDICTIONS WITH THE RESULTS OF GERMAN FAUNA F5 AND F6 TESTS

Osamu Miyake*, Ryuhei Kawabe*,
Yoshiaki Himeno*, and Kimihide Miyaguchi*

Abstract

The SOFIRE-MII code, which was developed based on the U.S. SOFIRE-II code, analyzes a sodium pool fire accident in the LMFBR plant to predict the pressure and temperature of atmosphere as well as the structural temperatures within a reactor building. To date, the code has been validated by test data at low oxygen concentrations. However, the code validation at high oxygen concentration has been incomplete. To complete this validation, the calculations of pool fire test results that were obtained with an air-filled closed vessel, are conducted. The test results used for this purpose are those taken from the FAUNA F5 and F6 tests. FAUNA is a large sodium fire test facility installed in Kernforschungszentrum Karlsruhe (KfK), Federal Republic of Germany. The calculations include sensitivity studies on the important input parameters in SOFIRE-MII; the burning ratio, S (weight ratio of sodium/oxygen consumed by a the radiation heat exchange coefficient, F between a pool and the atmospheric gas, and the heat removal rate from the external surface of the test vessel. Enhancement of sodium combustion at the initial stage of the test due to sodium filling by a columnar high-speed sodium flow from an open nozzle over the pan is also evaluated. The result indicates that, as a whole, the test results are predicted fairly well by SOFIRE-MII with the S value

---

* Plant Safety Section, FBR Safety Division,
O-arai Engineering Center, PNC

of 1.44 that represents the sodium combustion generating 100% sodium peroxide as its reaction products and with F=0.65. The sensitivity studies of these parameters indicate that the S value has a significant effect, while the F value does not. The heat removal rate from the external surface of the vessel has also a little effect on the gas pressure and temperature, although the vessel wall temperature is significantly affected by this. Contribution of a columnar combustion during the sodium fill at the initial stage of the test is found to be significant to the initial gas temperature and pressure spikes.

CONTENTS

1 Introduction 1

2 FAUNA Facility and Test Conditions of F5 and F6 3

3 Analysis of F5 and F6 Test Data Using SOFIRE-MII 5

  3.1 Model Description 5
  3.2 Comparison of SOFIRE-MII Predictions with Test Data 8
  3.3 Parameter Studies 10

4 Conclusion 15

Acknowledgments 17

References 18

1. Introduction

The SOFIRE-MII code (Reference 1) has been developed, based on the SOFIRE-II code (Reference 2), to analyze a sodium pool fire accident in LMFBR plants. The code calculates the pressure and temperature transients of a containment atmosphere in the event of a sodium pool fire at the floor of a containment. The major extended features of SOFIRE-MII in comparison with SOFIRE-II are as follows:

- The maximum number of cell is three, and the gas exchanges between these cells can be taken into account.

- For each cell, structures that contain six heat conduction components, i.e., a floor, ceiling, and four walls, can be considered.

- A columnar sodium fire is modeled. This is to simulate a sodium spill in the form of columnar flow from a pipe opening at the upper part of the cell.

- Improvement is made in the catch pan model so that heat transfer from/to the side wall of the pan can be considered.

- For the numerical solution method, the predictor-corrector method is applied to improve the numerical precision and to reduce the computational time.

The capabilities of the code, including the above extended features, have been tested. Furthermore, the code has been validated by experimental data (Reference 3). The results of the validation indicated that the code calculated the temperature and pressure transients accurately in all the major respects. However, these tests were limited with the conditions at low oxygen concentration (i.e., about 3 vol%) that simulated the containment atmosphere. The another test, therefore, under a high oxygen concentration condition (air-filled condition) has been required to complete the code validation. The validation study presented in this report is conducted to meet the above requirement.

The test data used for this purpose are those from the German sodium fire test facility that was named FAUNA. With FAUNA, six pool fire tests had been performed by KfK since 1979.
Among these, results of the F5 and F6 tests have been transmitted to PNC (References 4 and 5) under the agreement of information exchange between KfK and PNC, and these results were used for the present SOFIRE-MII code validation study.

The F5 and F6 tests have following features:

- The tests had been performed under the completely closed containment conditions. This indicates that the measurements of oxygen concentration change can be compared with the code predictions in regard to the oxygen consumption rate that is directly related to the sodium combustion rate.

- The test conditions of F5 and F6 are almost identical except for the pool burning area. This indicates that, although the difference in the pool burning area is not considered in the code, the effect due to the difference in the pool area can be studied, if it actually exists.

In the present report, Section 2 covers the brief description of the FAUNA facility together with the experimental conditions of F5 and F6. Section 3 presents the comparison of the code predictions with the FAUNA test data. The heat transfer model that are used for the calculation by SOFIRE-MII is also explained in this section. Section 4 gives the conclusion of this work.

2. FAUNA Facility and Test Conditions of F5 and F6

According to the KfK reports (References 4 and 5), the FAUNA facility was designed to study the sodium fires and the nuclear aerosols behavior. The facility consists of an operation building, a test vessel, and an offgas system. The test vessel (Figure 2.1) is a gastight cylindrical steel container of 220 m^3 in volume, and its cylindrical part is 6 m in height and 6 m in diameter. The vessel wall thickness is 16 mm. The test vessel is equipped with the external water cooling system.

The burning pan made of 3 mm thickness steel is installed at the bottom part of the vessel. Its area was 2 m^2 for F5 and 5 m^2 for F6 (Figures 2.2 and 2.3). The pan was placed on a 10 cm thickness thermal insulator that was made of mineral wool. In the tests, the burning pan was pre-heated electrically up to the temperature of the sodium (480°C) to be filled.

Sodium filling was performed through a 7 mm diameter nozzle, which was located above 1 m from the burning pan. The filling was continued for 20 minutes with the flow rate of 17.5 kg/min., then total sodium of 350 kg was filled in the both F5 and F6 tests.

In the F5 and F6 tests, a whole sodium burning time can be divided into three distinct stages due to the experimental procedures. The burning behavior during the initial 20 minutes was significantly affected by the sodium filling through the nozzle. During this stage, a combined fire of pool and columnar combustion has been occurred in the vessel. In addition, the surface of the sodium pool was perturbed by the high flow rate of sodium filling. For these reasons, the burning rate and convective heat transfer were increased distinctly during this first stage. The second stage followed the termination of the sodium filling. During this stage, the pool combustion continued by itself. Through the first and the second stages, the tests F5 and F6 had been conducted by enclosing the vessel completely for 60 minutes in F5 and for 120 minutes in F6. The final stage of tests was to allow the air to re-enter the vessel. This procedure was for the purpose to burn the residual sodium completely for easier sodium removal operations after the tests. For the present code validation study, the test data obtained during the first and the second stages are utilized.

Details of the FAUNA facility, the test conditions, the test procedures, and the measurement techniques are presented in the KfK reports (References 4 and 5).

3. Analysis of FAUNA F5 and F6 Data Using SOFIRE-MII

3.1 Model Description

A schematic diagram of the SOFIRE-MII heat transfer model for the present calculations is shown in Figure 3.1. System dimensions, conditions, and parameters used for the calculation are summarized in Tables 3.1 and 3.2.

For a base case calculation (called Case 'A01' in this report), parameters and assumptions are selected in the following manners:

- The burning ration is assumed to be 1.44, which is equivalent to the assumption that the sodium combustion produces only sodium peroxide (Na_2O_2). (For the SOFIRE-MII input data, a parameter S which represents the ratio of kg-sodium/kg-oxygen consumed is used. S=1.44 is equivalent to 100% peroxide formation.)

- The radiation heat exchange coefficient between sodium and gas is 0.65.

- The effect of sodium filling during the early combustion period is ignored.

- The effect of the vessel water cooling is also ignored.

Firstly, the assumption of 100% peroxide formation is based on the following reason: In the event of a sodium fire, sodium may react with oxygen to form not only sodium peroxide Na_2O_2 but also sodium monoxide Na_2O. In addition, the formation of super oxide NaO_2 is reported from the FAUNA tests (Reference 5). The fraction of those reaction products may vary depending on the oxygen concentration and the other factors relating to sodium surface conditions. However, it is generally agreed that the reaction of 100% peroxide formation is the most probable one under the high oxygen concentration condition. Hence the reaction of 100% peroxide formation is assumed in the base case calculation.

Secondary, in regard to the radiation heat transfer between sodium surface and atmosphere, the following simple correlation is used in SOFIRE-MII:

$$Q = \sigma F A (Ts^4 - Ta^4)$$

where, Q = heat transfer rate in kcal/hr,
σ = Stefan-Boltzmann constant ($=4.88\ 10^{-8}$ kcal/m^2/hr/K^4),
F = radiation heat exchange coefficient given as the SOFIRE-MII input,
A = pool surface area in m^2,
Ts = pool surface temperature in K, and
Ta = atmospheric temperature in K.

With high oxygen concentration atmosphere, the aerosol concentration increases rapidly and reaches several tens of g/m^3 within a minute. In this instance, the aerosol containing atmosphere can be regarded as a gray body which absorbs thermal radiation heat from the pool, and whose emissivity can be approximated to be unity. Therefore, the emissivity of sodium surface becomes more important than that of the aerosol containing atmosphere. Few experimental data are available for emissivity of high temperature (oxidized) sodium. Here we used the value of 0.65 which was reported in Reference 6.

Thirdly, the effect of sodium filling in the early combustion stage can be analyzed with the columnar combustion model in

SOFIRE-MII. However, this effect is ignored in the base case due to the following two reasons: One reason is the very large sodium filling rate (17.5 kg/min = 9 m/sec at the nozzle outlet), which significantly perturbs the sodium surface state. Such perturbation cannot be analyzed by SOFIRE-MII. Another reason is that, by ignoring this effect, one can obtain much clear and simpler results of calculation to be discussed.

Finally, the reason of ignoring the vessel outer cooling is that enough information is not available.

Above four items the burning ratio, the radiation exchange coefficient, the effect of sodium fill, and the effect of vessel cooling, will be discussed later in the sensitivity studies of the code.

3.2 Comparison of SOFIRE-MII Predictions with Test Data

In this subsection, the results of the base case calculation by SOFIRE-MII are discussed in comparison with the FAUNA F5 and F6 tests data. Figures 3.2(a) through 3.2(f) show the comparisons for the F5 test, and Figures 3.3(a) through 3.3(f) show those for the F6 test.

The code predictions of the gas temperature, which are given in Figures 3.2(a) and 3.3(a) for F5 and F6, respectively, show good agreement with the test data except for the early combustion stage (20 minutes). As described in the previous section, a columnar combustion as well as perturbation of the sodium surface should enhance the combustion and heat transfer. It is seen that the enhancement was remarkable in the F6 test. The reason for this may be that the larger perturbation occurred in the large burning pan which made the increase of sodium depth slower.

The gas pressures are shown in Figures 3.2(b) and 3.3(b). The pressure prediction of F5 (Figure 3.2(b)) shows a reasonable agreement with the test result. However, the agreement for F6 (Figure 3.3(b)) is very poor. The code prediction shows the over estimation even after the termination of sodium filling, i.e., after 20 minutes. This disagreement is inconsistent with the fact that the comparison of gas temperature shows good agreement. The discrepancy is presumably attributed to the errors in the measured data. Temperature measurement by use of thermocouples tends to be affected by thermal radiation from a combustion flame whose temperature sometimes exceeds 1000°C. If that is the case, the actual gas temperature should be lower than the test results plotted in Figure 3.3(a). In return, this suggests that both the predicted gas temperature and pressure might be over estimated.

The sodium temperatures are shown in Figures 3.2(c) and 3.3(c).

In general, the agreement between predictions and measurements is good. It is noteworthy that the effect of sodium filling on the sodium temperature is comparatively small, probably due to a large heat capacity of the pool sodium and the burning pan.

The oxygen concentration changes are shown in Figures 3.2(d) and 3.3(d). The agreement is reasonably good. However, the prediction for F5 shows a faster decreasing rate than observed in the measurements. This indicates that the burning rate is over-estimated by the code.

Although no measurements have been available from KfK, the predictions of wall temperature are given in Figures 3.2(e) and 3.3(e).

Finally, the burning rate predictions are shown in Figures 3.2(f) and 3.3(f). The burning rates that had been determined from the oxygen concentration changes during the tests are reported in Reference 5. The reported values are 18.4 kg-Na/m^2/hr for the F5 test and 28.0 kg-Na/m^2/hr for the F6 test. These different burning rates suggest that the rate might depend on the burning area. On the contrary, the SOFIRE-MII model assumes that the combustion is governed only by the oxygen supply from gas phase to sodium surface. Therefore, the calculated burning rates do not depend on the burning area, and the predictions for F5 and F6 provide the same initial burning rate (28 kg-Na/m^2/hr) as shown in Figures 3.2(f) and 3.3(f). From the results of the base case calculation, one can conclude that, although the effect of burning area on the burning rate is not considered in the code, the calculated temperatures have reasonable accuracy.

3.3 Parameter Studies

Parameters used in the sensitivity studies are summarized in Table 3.3. The exactly same parameter sets are used for both the F5 and F6 test calculations.

Cases 'A01' to 'A03' are for the sensitivity study of the burning ratio S. The formation of 100% Na_2O_2 formation is assumed in 'A01' (S=1.44), the reaction of 100% Na_2O formation is assumed in 'A02' (S=2.88), and the reaction of 40% Na_2O_2 formation is assumed in 'A03' (S=2.3).

Cases 'B01' and 'B02' are for the sensitivity study of the radiation exchange coefficient (F), where F=0.5 is assumed in 'B01' and F=0.35 is assumed in 'B02'.

Cases 'X01' to 'X03' and 'Y01' to 'Y03' are for the studies to simulate the experimental procedures whose information was not sufficiently available for the detailed calculations. The parameters used for these studies are determined in an arbitrary way.

The cases 'X01' to 'X03' are to study the effect of the external water cooling system that was equipped to FAUNA to remove excess heat generated during the test. The only available information was the water flow rate (60 m^3/hr) of the system.
Therefore, the heat transfer coefficient at the outer surface of the FAUNA vessel was roughly estimated assuming that the water flowed in the form of an ideal film along the vessel wall (Reference 7). The water film thickness in this case was calculated to be 0.5 mm with its flow velocity at 1.7 m/sec. From these values, the heat transfer coefficient was estimated to be about 3000 kcal/m^2/hr/deg. Since these values are based on the assumption of an ideal flow, the actual (i.e., apparent) heat

transfer coefficient may be smaller than this value. In the present sensitivity study, the heat transfer coefficient was taken as a parameter with the values of 2000 kcal/m^2/hr/deg for 'X01', 200 kcal/m^2/hr/deg for 'X02', and 20 kcal/m^2/hr/deg for 'X03'. Temperature of water is assumed to be 25°C.

The cases 'Y01' to 'Y03' are to study the effect of sodium filling. As described, the columnar sodium combustion can be modeled in SOFIRE-MII in addition to the pool combustion. For the columnar combustion, the burning rate is calculated by;

$$Xcl = \left(0.037 \frac{Dg}{Lcl} Re^{0.8} Sc^{0.333} \right) \rho \, Co_2 \, S$$

where , Xcl = burning rate in kg-Na/m^2/hr,
ρ = gas density in kg/m^3,
Co_2 = oxygen concentration,
S = reaction ratio in kg-Na/kg-O_2,
Dg = diffusion coefficient of gas in m^2/hr,
Lcl = length of column in m,
Re = Reynolds number, and
Sc = Schmidt number.

In the calculation, the column is assumed to be 7 mm in diameter (equal to the nozzle diameter), and 1 m in height with sodium velocity at 9 m/sec. The burning area is taken as a parameter because it was not clearly measured in the test. In the test, the effective pool surface area was increased to some extent by perturbation given to the pool surface during the sodium filling. This effect might be included by taking the burning area as a parameter. For case 'Y01', the burning area is selected to be 0.022 m^2, which is equivalent to the ideal column surface area. The area of 0.22 m^2 and 2.2 m^2 is used for the cases 'Y02' and

'Y03', respectively. It should be noted that the total burning area of 'Y03' is approximately double the F5 pool burning area.

Results and discussions of the sensitivity studies are summarized as follows:

(1) Burning Ratio

Results of the sensitivity study of the burning ratio are shown in Figures 3.4 and 3.5. It is seen that the different burning ratio gives largely different results. The chemical reactions used in the SOFIRE-MII model are;

$$2\mathrm{Na} + 1/2\ \mathrm{O_2} \rightarrow \mathrm{Na_2O}, \quad E = 2261\ \mathrm{kcal/kg\text{-}Na}, \text{ and}$$
$$2\mathrm{Na} + \mathrm{O_2} \rightarrow \mathrm{Na_2O_2}, \quad E = 2696\ \mathrm{kcal/kg\text{-}Na}.$$

These reactions indicate that, if the oxygen supply rate is given and governs the reaction, the monoxide reaction produces greater reaction heat than that of the peroxide reaction by the factor of 1.68. Therefore, the calculation with the assumption of 100% monoxide formation (A02) provides the highest temperature and pressure predictions. As described in the previous section, it has been suggested that the peroxide reaction is most likely under the air filled conditions. The results of the present sensitivity studies assure this suggestion.

(2) Radiation Heat Exchange

The sensitivity of the radiation heat exchange coefficient used in the SOFIRE-MII model is shown in Figures 3.6 and 3.7.
It is seen in these figures that the gas temperatures and the gas pressures are not sensitive to the heat transfer coefficient.

However, the pool temperatures are comparatively sensitive to the coefficient. In regard to the pool temperatures, the base case (F=0.65) described provides a reasonable agreement with the test results. In contrast, the code predictions with the smaller coefficient (i.e., F=0.5 and 0.35) give the larger temperatures than the test results.

(3) Effect of Vessel Cooling

The results of the sensitivity study for the heat transfer coefficient of the external water cooling system are shown in Figures 3.8 and 3.9. Although there is no appreciable differences in the sodium pool temperatures due to the difference in the heat transfer coefficient, the predictions of gas temperatures and gas pressures are affected significantly by the difference in the coefficient. In the case 'X01', the heat transfer coefficient under the assumption of the ideal water flow of a thin film was used. In this case, the predicted vessel temperature is kept constant during the test due to the very high heat removal rate from the wall. However, since no information is available regarding the wall temperature, we can not make any further discussion.

(4) Effect of Sodium Filling

Figures 3.10 and 3.11 show the results of the calculations to which a columnar sodium combustion, during the first stage of the test, is taken into account. It is clearly shown in these figures, particularly in Figure 3.11, that the agreement between the code predictions and the test results improved by considering a columnar combustion (Case 'Y01'). However, the calculation (Case 'Y03') being attempted to take into account of the perturbation of the pool surface does not improve the agreement. This attempt rather results in the higher oxygen consumption rate than the test results as seen in the lower graph in the right side of Figures 3.10 and 3.11. Hence, it is suggested that, although the perturbation may enhance the heat transfer between the sodium surface and the atmospheric gas to some extent during the test, it dose not increase the combustion rate so significantly.

4. Conclusion

An assessment of the validity of SOFIRE-MII for a sodium pool fire with air filled atmospheric conditions has been completed using the test results from the German FAUNA F5 and F6 tests.

In the present study, the SOFIRE-MII code predictions have been compared with measurements with respect to the primary areas of concern; the gas temperature and pressure histories in the test vessel, the sodium temperature, and the change of oxygen concentration.

Agreement of the code predictions with measurements is found to be reasonably good as a whole.

Major conclusions from the present work are;

- Overall agreement of the code calculations, using the code parameters assuming the 100% sodium peroxide formation and the sodium-gas radiation coefficient of 0.65, is good. The adopted set of parameters can be utilized for the sodium fire analyses under the air filled condition.

- Anomalous temperature and pressure increases observed in the measurements of the early combustion stage are due to the effects of the rapid sodium filling. Parameter studies being attempted to simulate this effect indicate that, by taking into account of a columnar combustion, an agreement between the code predictions and the test results was improved to some extent. However, the further attempting to improve the agreement by taking into account of the perturbation of the sodium surface was not fruitful.

- The consistency of the SOFIRE-MII calculations is accomplished; the code can be used to predict the temperature and pressure transients conservatively in the air filled containment condition.

Acknowledgments

This work was performed in accordance with the information exchange agreement between Kernforschungszentrum Karlsruhe (KfK) and Power Reactor and Nuclear Fuel Development Corporation (PNC). The authors would like to thank Dr. S. Jordan and Mr. W. Cherdron of KfK, who supplied detailed answers to our questions.

References

1. "Sodium Fire Analysis Code SOFIRE-MII User's Report," PNC Report SJ206 82-01 (1981) (in Japanese)

2. P. Beiriger, et al., "SOFIRE-II User Report," AI-AEC-13055 (1973)

3. T. Yagi, T. Naganuma, "Integrity Test on Primary Containment System (II) - Part 2, Verification of a Code for Sodium Fire Analysis in LMFBRs -," PNC Report SJ222 72-01(2) (1978) (in Japanese)

4. W. Cherdron, S. Jordan, "Die Natrium-Brandversuche in der FAUNA-Anlage auf Brandflächen bis 12 m^2," KfK 3041 (1983)

5. W. Cherdron, Ch. Hosemann, "The Sodium Fire Tests FAUNA 5 and FAUNA 6," KfK PSB-Bericht Nr. 1667 (Kl. II) (1982)

6. H.Takasu, et al., "Heat Transfer to Rotating Plug Through Cover Gas in LMFBR Reactor Vessel - Measurement of emissivity (2)," PNC Report SN941 81-146 (1981) (in Japanese)

7. R. Bird, et al., "Transport Phenomena," John Wiley & Sons, Inc. (1960)

TABLE 3.1

SYSTEM DIMENSIONS AND CONDITIONS USED FOR FAUNA F5 AND F6 CALCULATIONS

		F5	F6
Vessel Volume [m^3]		220	220
Vessel Wall Area [m^2]		176	176
Vessel Wall Thickness [mm]		16	16
Burning Pan Area [m^2]		2.0	4.9
Burning Pan Thickness [mm]		3	3
Amount of Sodium [kg]		350	350
Gas Pressure [kg/cm^2 abs]	(init.)	1.03	1.03
Gas/Wall Temperature [c.deg]	(init.)	25	25
Sodium/Pan Temperature [c.deg]	(init.)	480	480
O_2 Concentration [vol %]	(init.)	21	21
Duration of Sodium Filling [min]		20	20
Duration of Fire [min]	(closed cond.)	110	60

TABLE 3.2

PHYSICAL PROPERTIES USED FOR FAUNA F5 AND F6 CALCULATIONS

Sodium	Specific Weight	[kg/m^3]	837
	Conductivity	[kcal/m/hr/deg]	58.27
	Specific Heat	[kcal/kg/deg]	0.302
Steel*1)	Specific Weight	[kg/m^3]	7830
	Conductivity	[kcal/m/hr/deg]	46
	Specific Heat	[kcal/kg/deg]	0.11
Insulation	Specific Weight	[kg/m^3]	100
	Conductivity	[kcal/m/hr/deg]	0.05
	Specific Heat	[kcal/kg/deg]	0.15
Radiation Exchange Coefficient (F)*2)		(Na to Gas)	0.35-0.65
Radiation Exchange Coefficient (F)*2)		(Gas to Wall)	0.5

*1) used for the material properties of the vessel and the pan.
*2) used in the equation, $Q = \sigma FA(Ta^4 - Tb^4)$.

TABLE 3.3

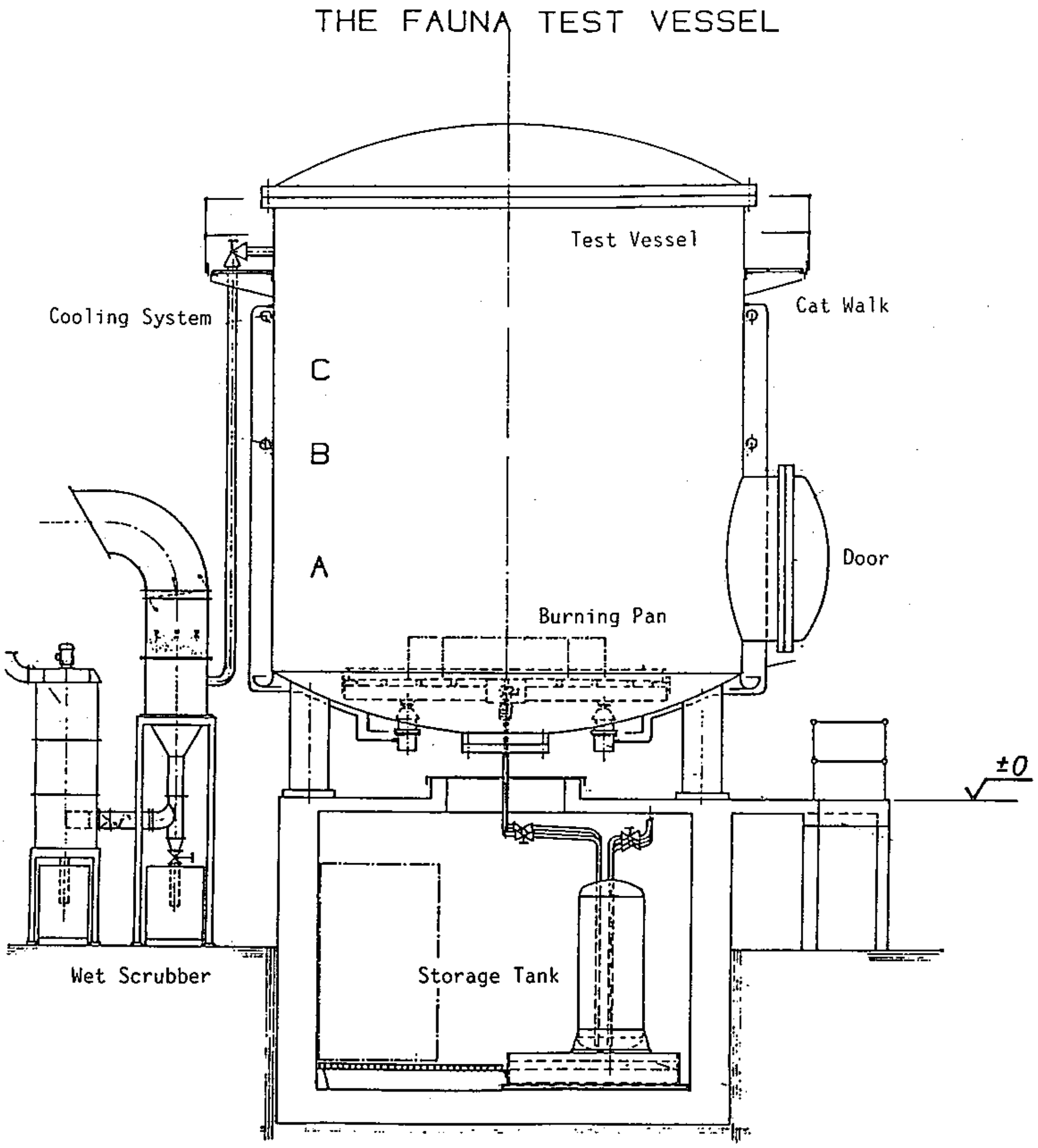
PARAMETERS USED FOR SENSITIVITY STUDIES

Case Identification	Burning Ratio (S) [kg-Na/ kg-O_2]	Na-Gas Rad.Ex. Coef.(F) [-]	Cooling H.T.C. [kcal/m^2 /hr/deg]	Column Burning Area [m^2]
A01[a]	1.44	0.65	-(b)	-(c)
A02	2.88	0.65	-(b)	-(c)
A03	2.30	0.65	-(b)	-(c)
B01	1.44	0.5	-(b)	-(c)
B02	1.44	0.35	-(b)	-(c)
X01	1.44	0.65	2000	-(c)
X02	1.44	0.65	200	-(c)
X03	1.44	0.65	20	-(c)
Y01	1.44	0.65	-(b)	0.022
Y02	1.44	0.65	-(b)	0.22
Y03	1.44	0.65	-(b)	2.2

(a) base case

(b) not considered, i.e., the adiabatic condition is assumed.

(c) not considered, i.e., all sodium spills at time zero.



A : Location of oxygen measurement
B : Location of pressure measurement
C : Position (in height) of Thermocouples

Figure 2.1 General Arrangement of FAUNA Test Vessel

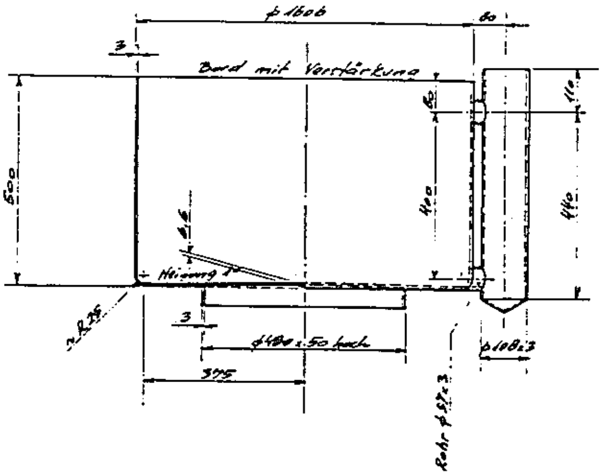


Figure 2.2 Burning Pan of FAUNA F5

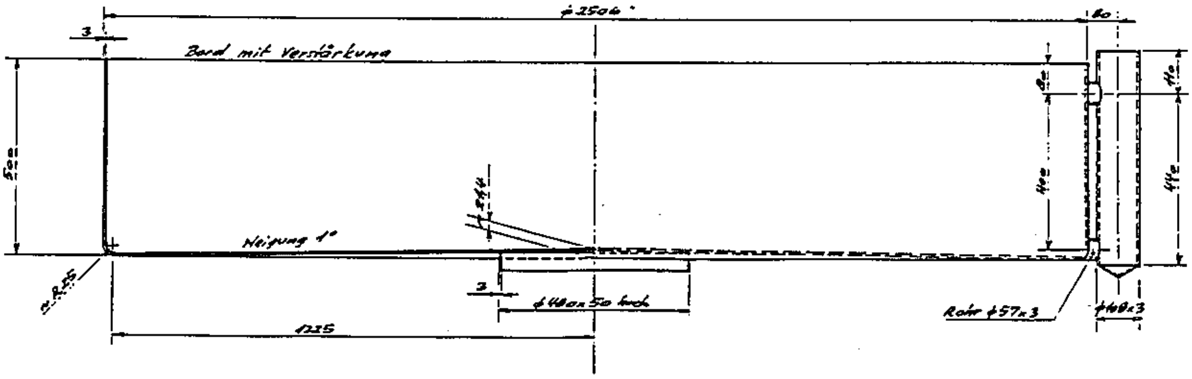


Figure 2.3 Burning Pan of FAUNA F6

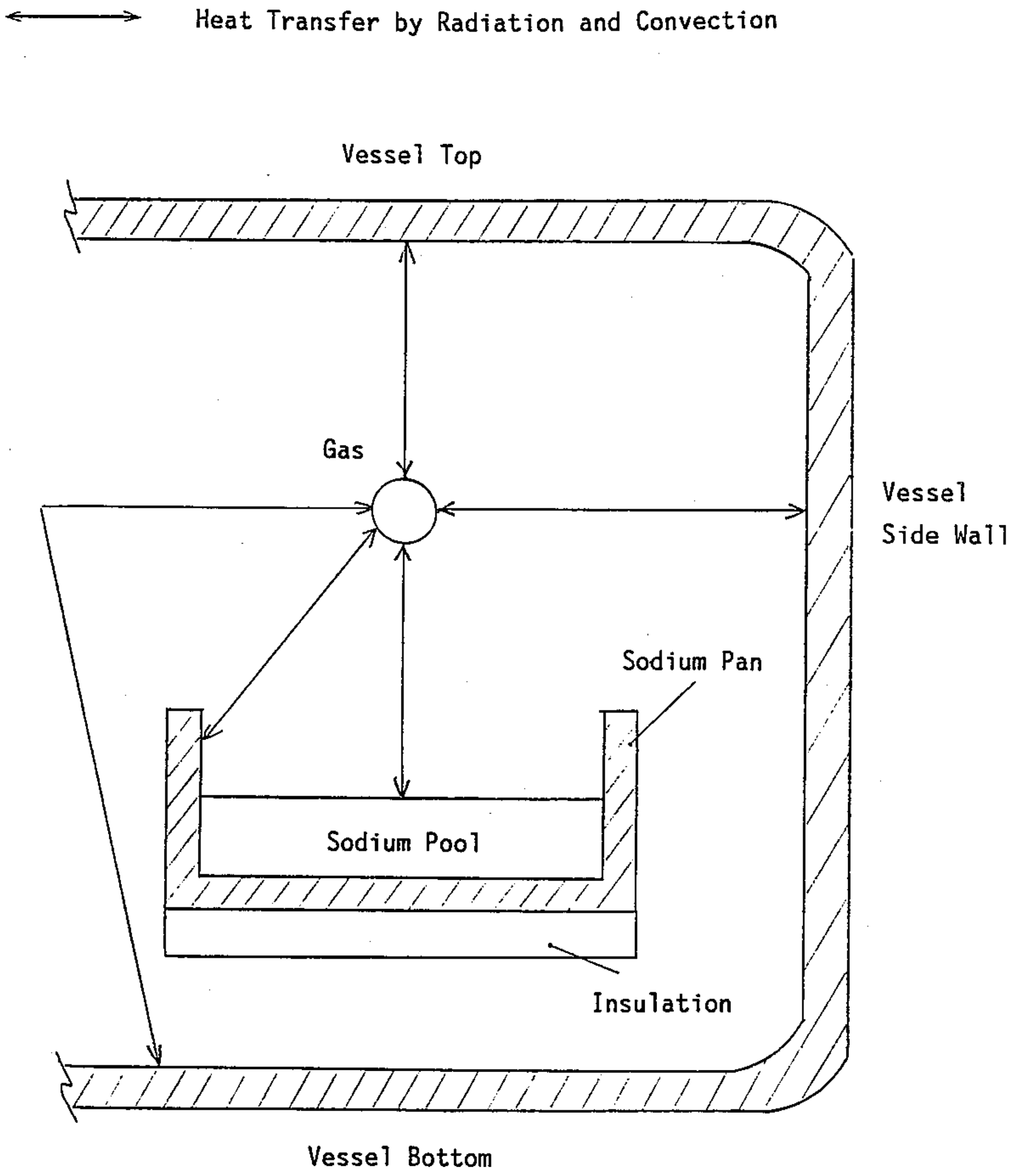


Figure 3.1 SOFIRE-MII Heat Transfer Model for FAUNA Calculation

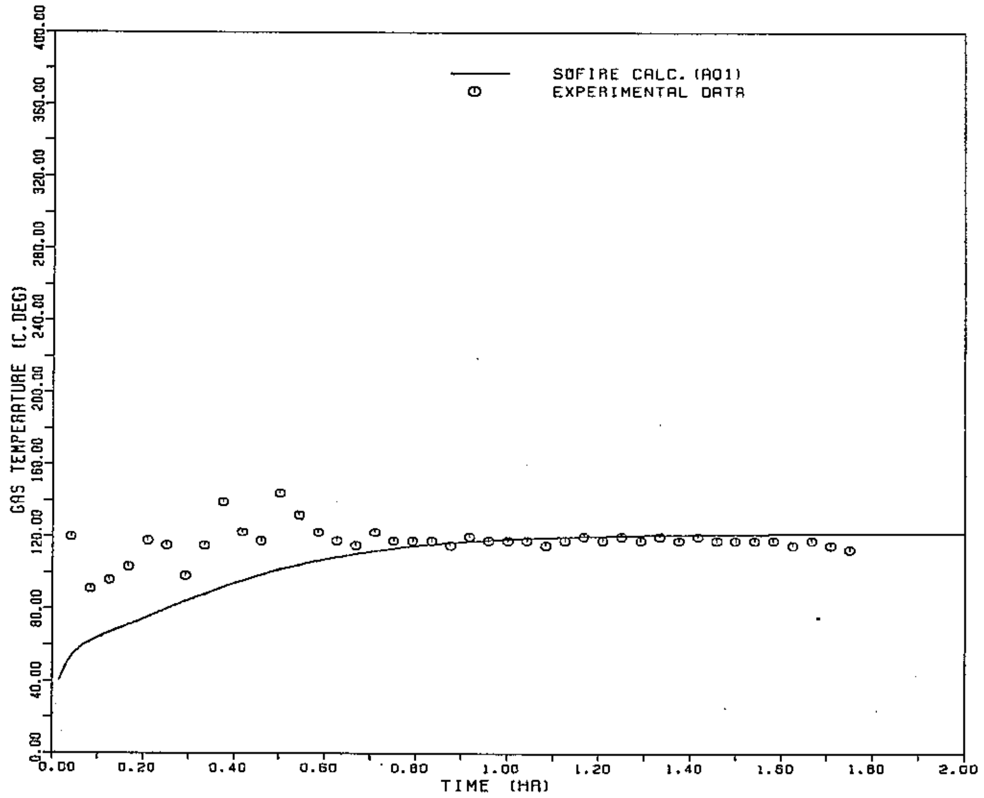


Fig. 3.2 (a) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

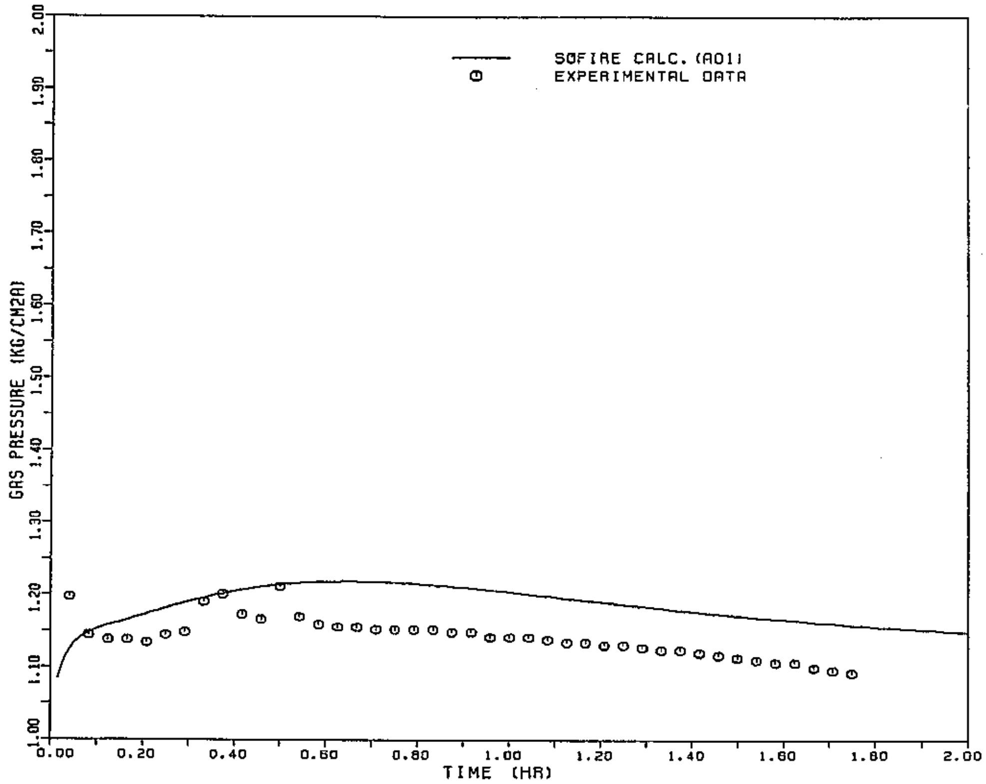


Fig. 3.2 (b) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

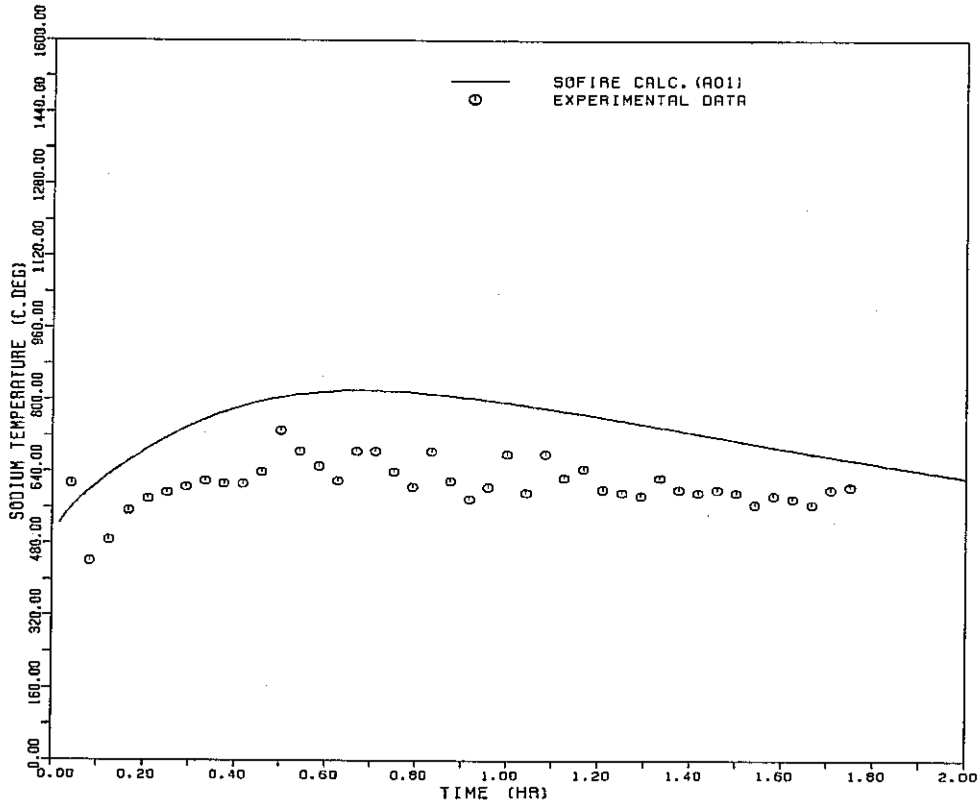


Fig. 3.2 (c) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

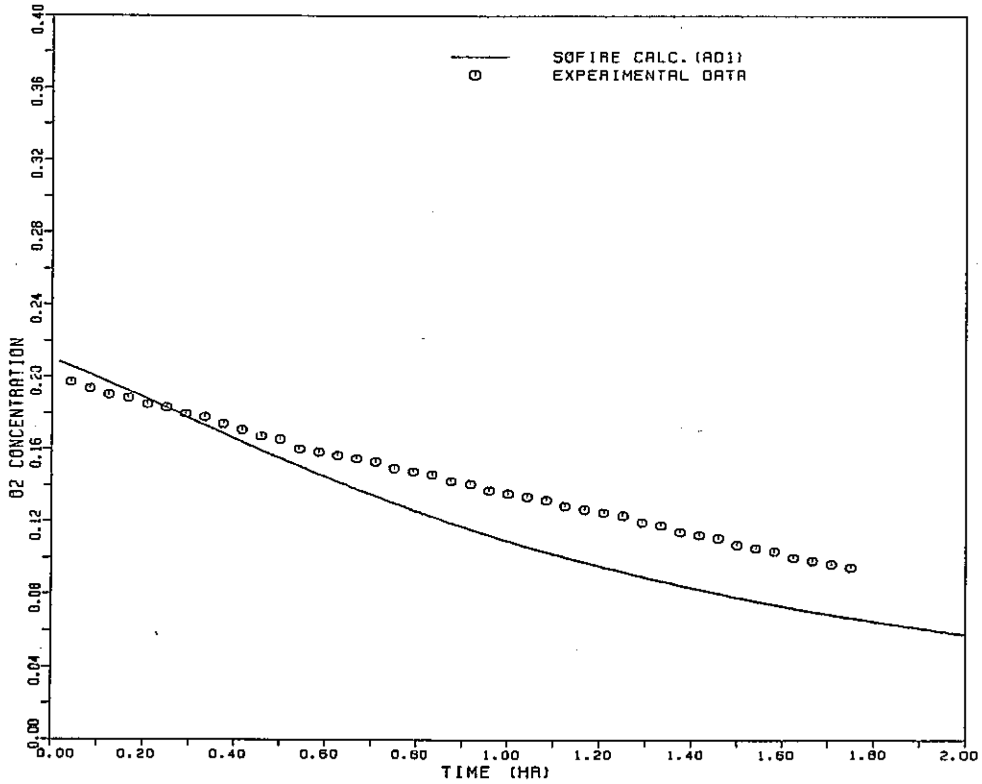


Fig. 3.2 (d) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

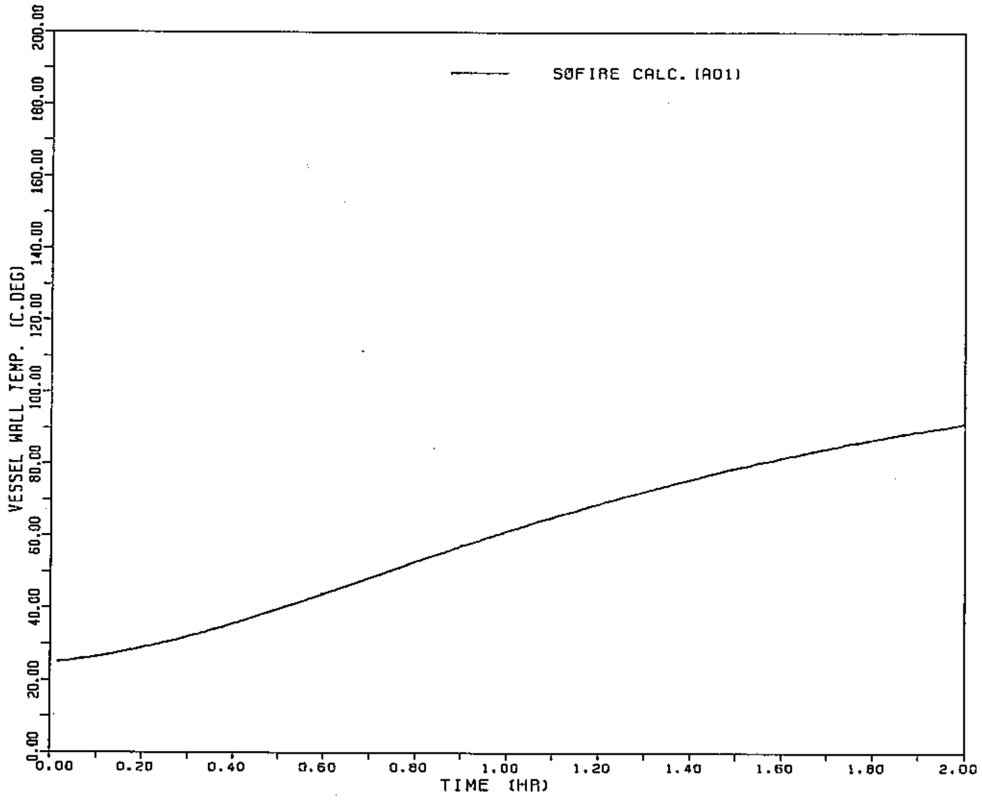


Fig. 3.2 (e) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

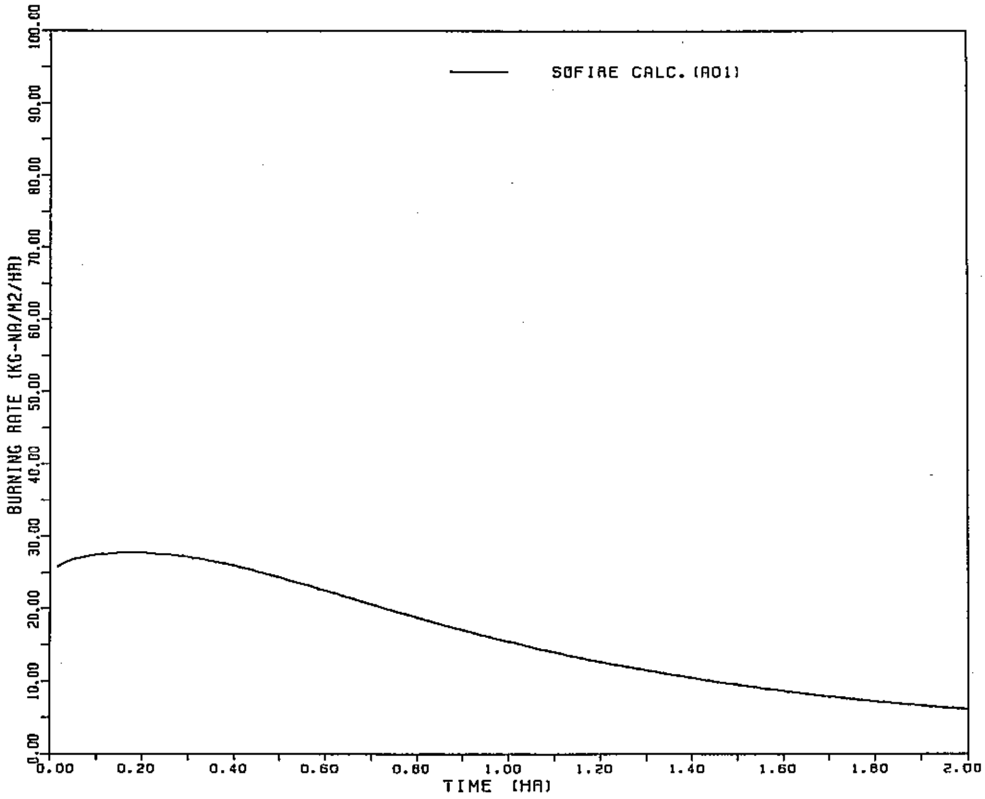


Fig. 3.2 (f) Comparison of SOFIRE Calculations with FAUNA F5 Data (Results of Base Case Calculation)

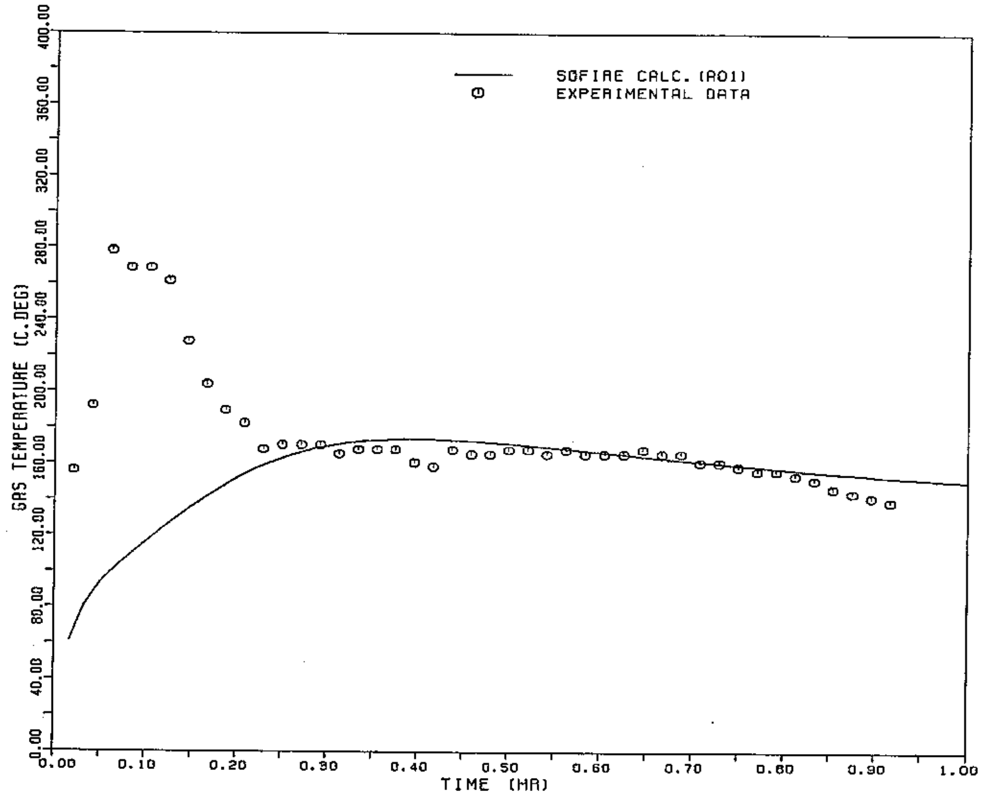


Fig. 3.3 (a) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

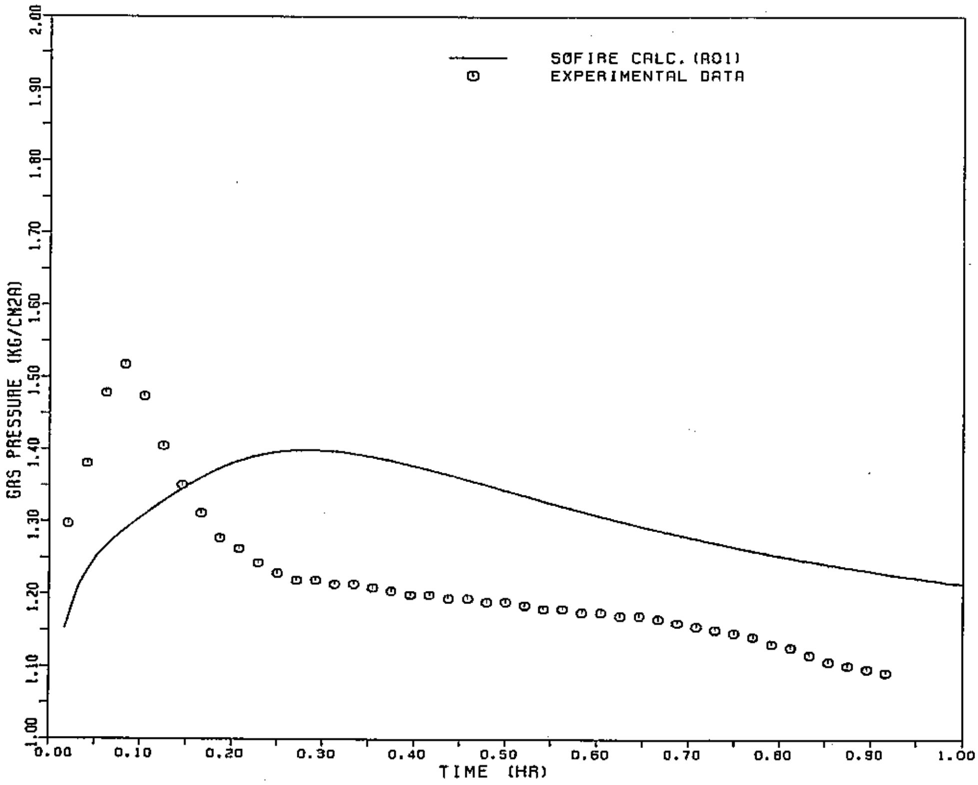


Fig. 3.3 (b) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

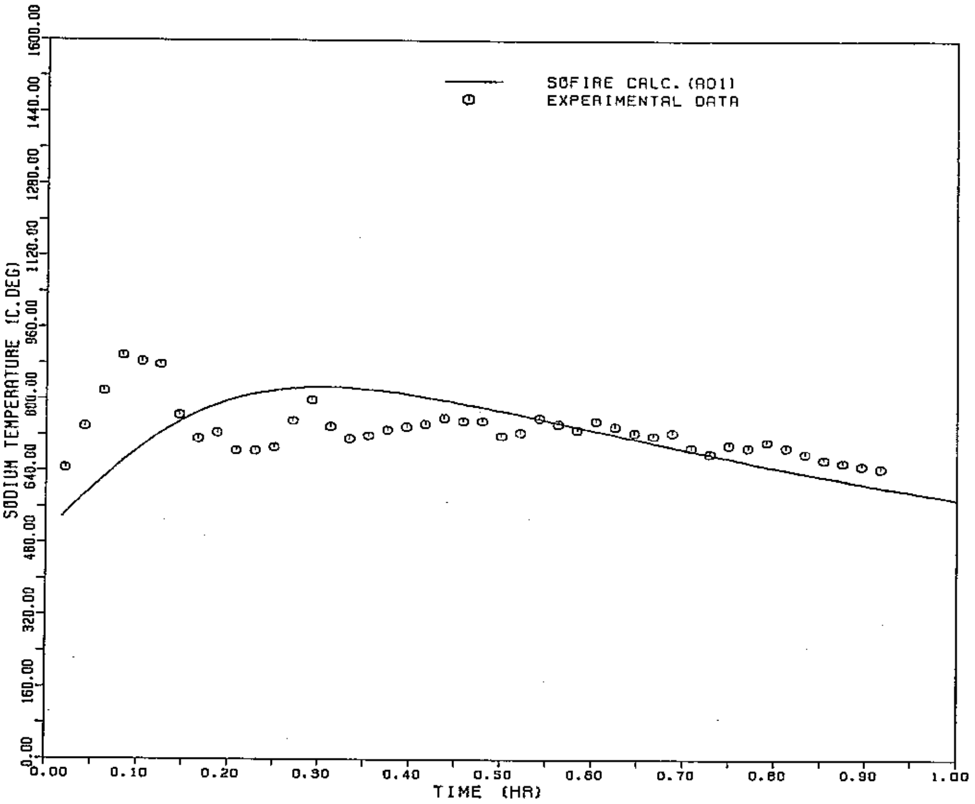


Fig. 3.3 (c) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

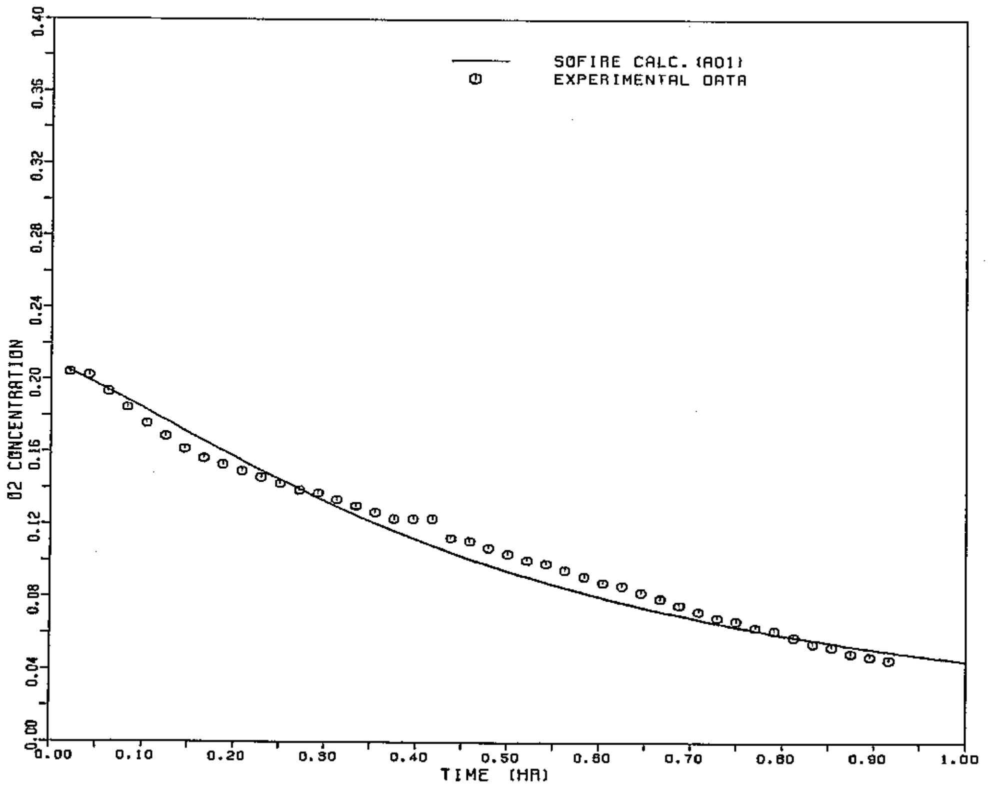


Fig. 3.3 (d) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

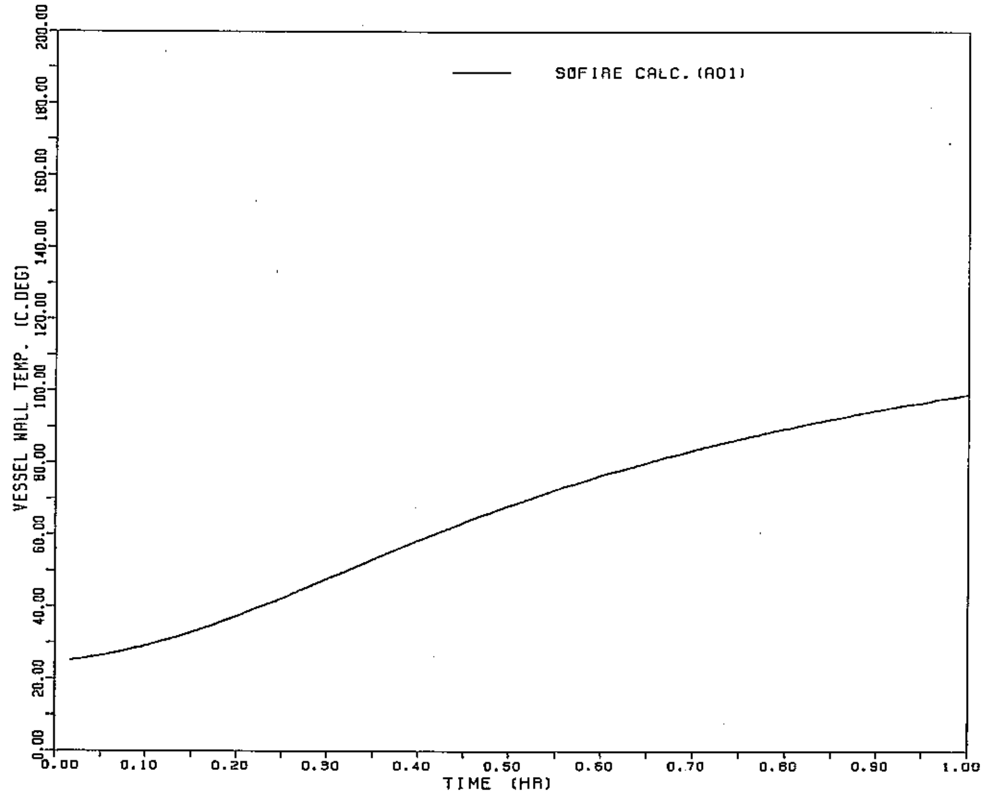


Fig. 3.3 (e) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

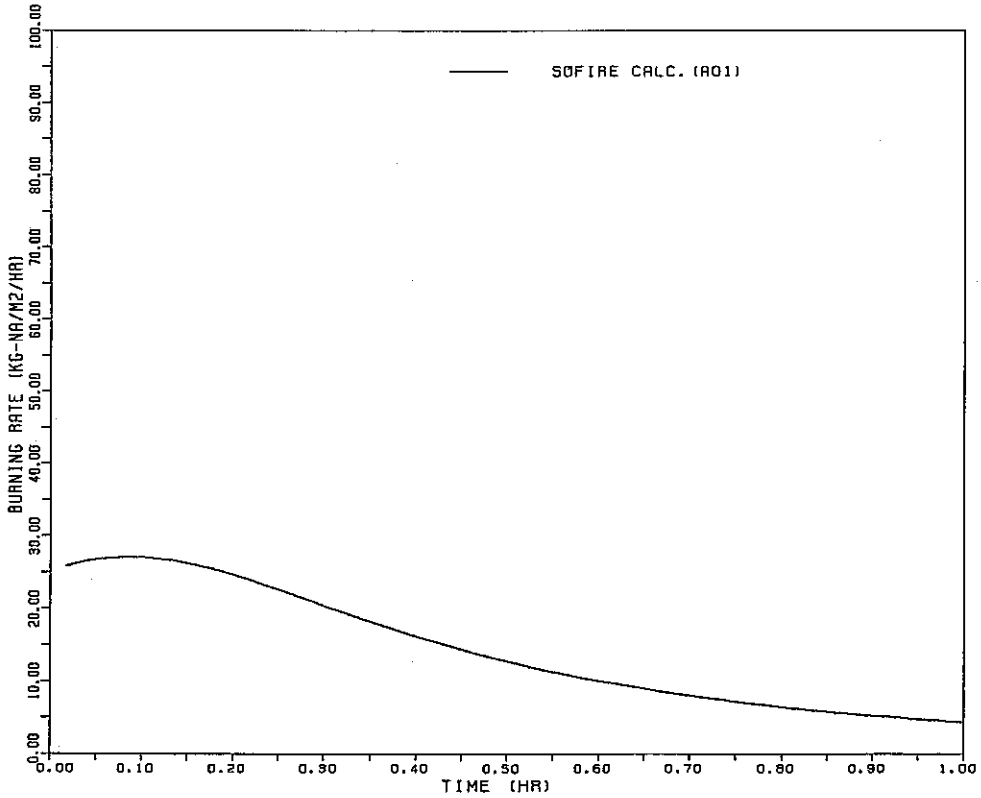


Fig. 3.3.(f) Comparison of SOFIRE Calculations with FAUNA F6 Data (Results of Base Case Calculation)

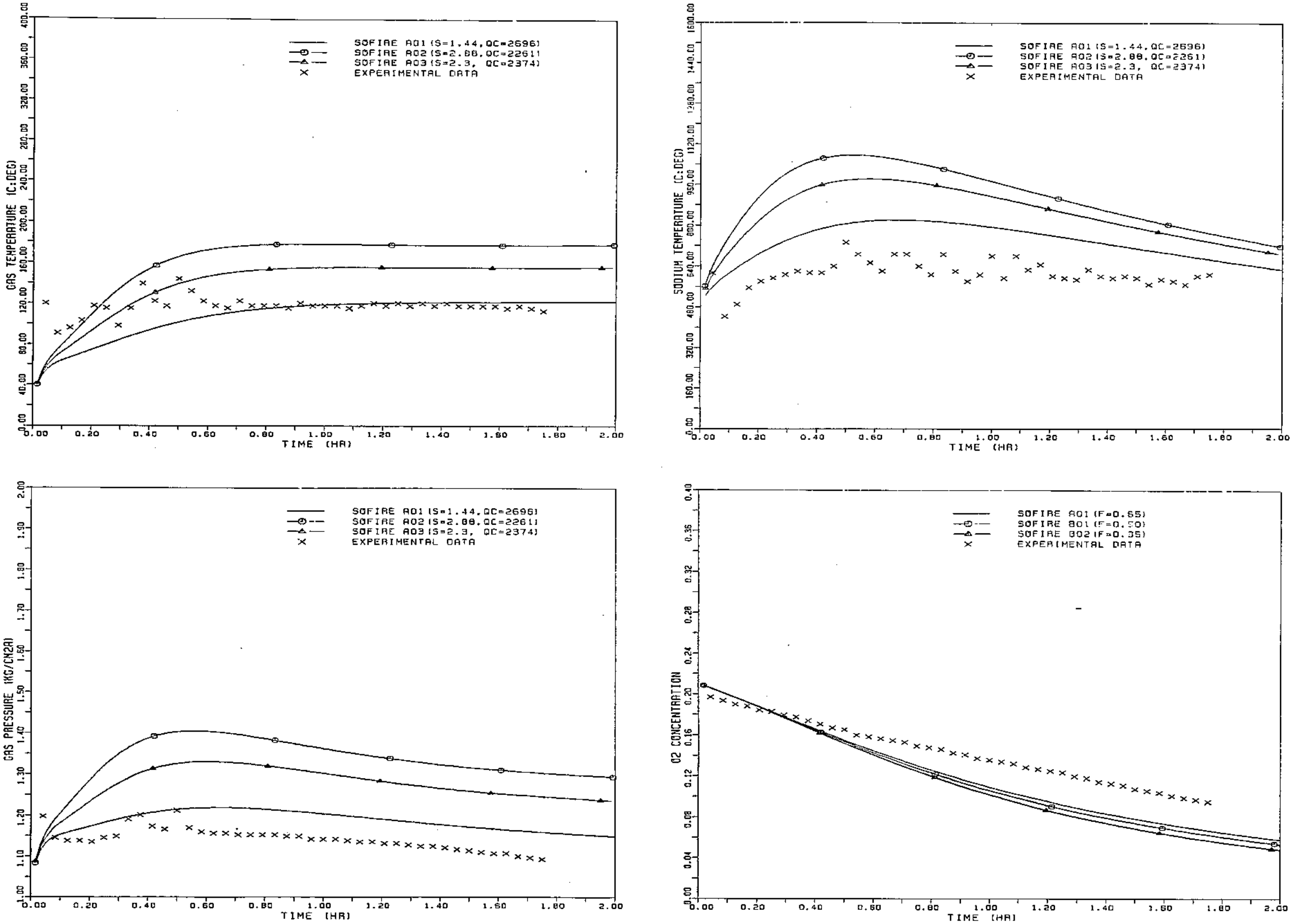


Fig. 3.4 Comparison of SOFIRE Calculations with FAUNA F5 Data
(Effect of Sodium Burning Ratio)

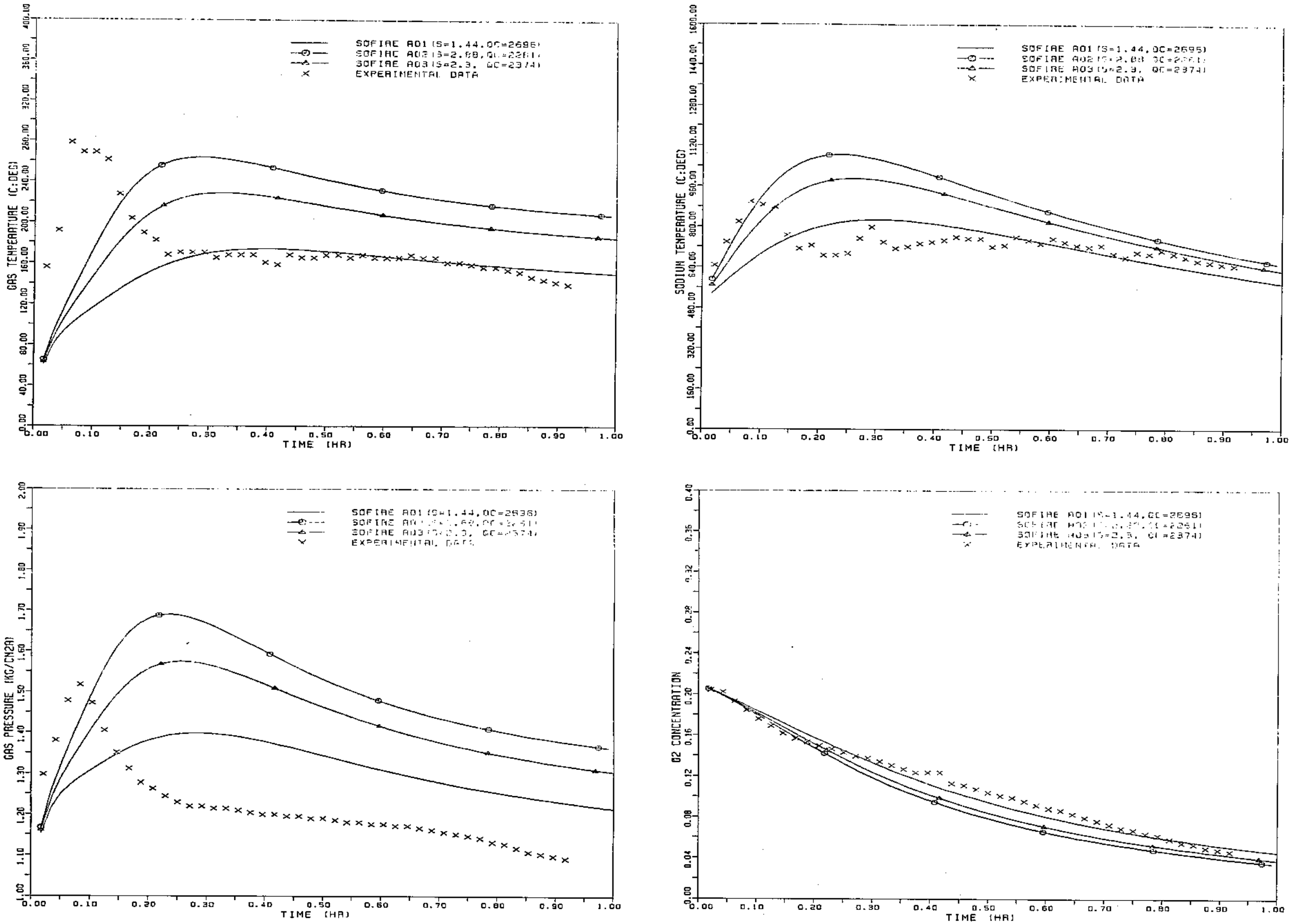


Fig. 3.5 Comparison of SOFIRE Calculations with FAUNA F6 Data
(Effect of Sodium Burning Ratio)

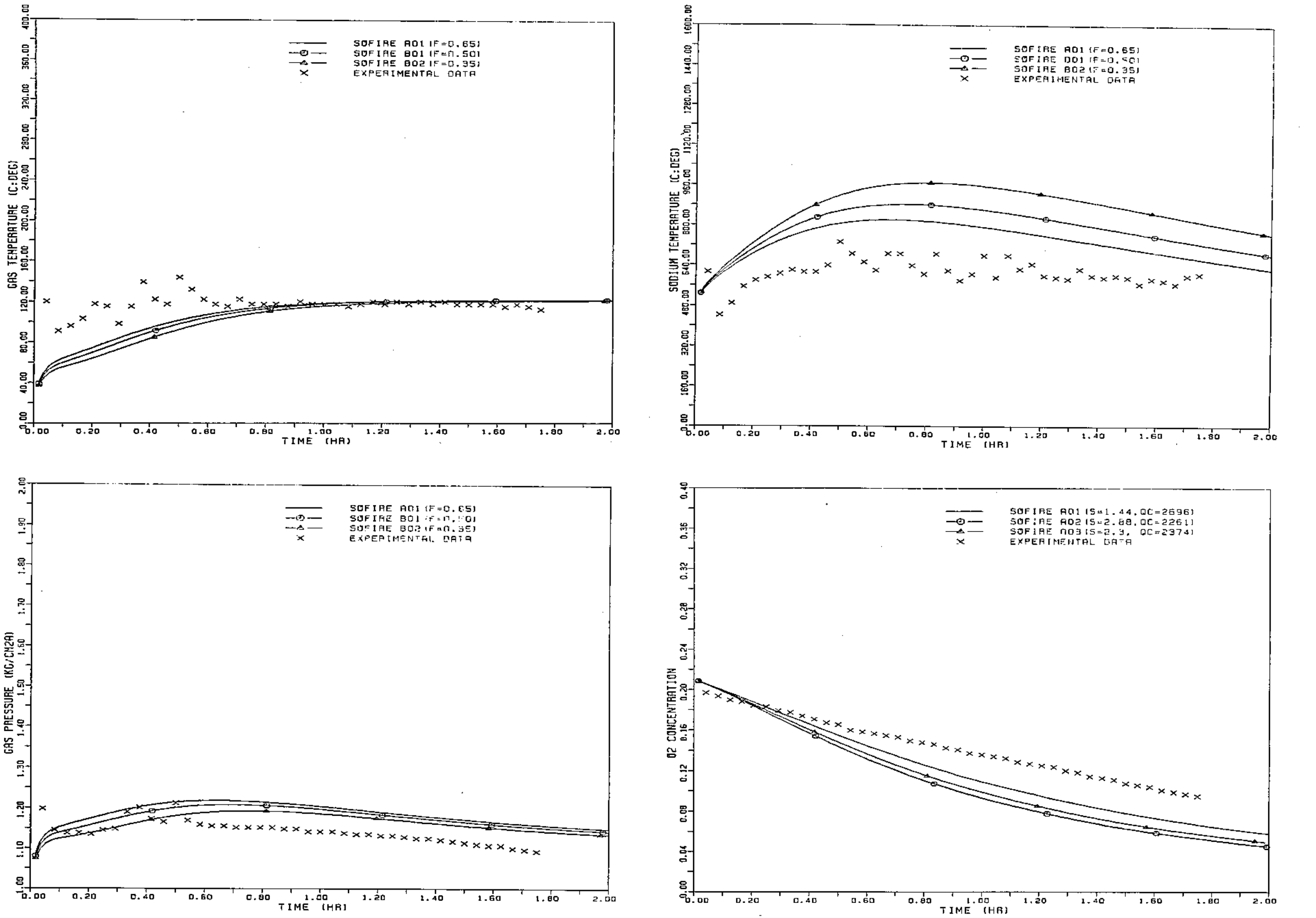


Fig. 3.6 Comparison of SOFIRE Calculations with FAUNA F5 Data (Effect of Na Surface Rad. Coef.)

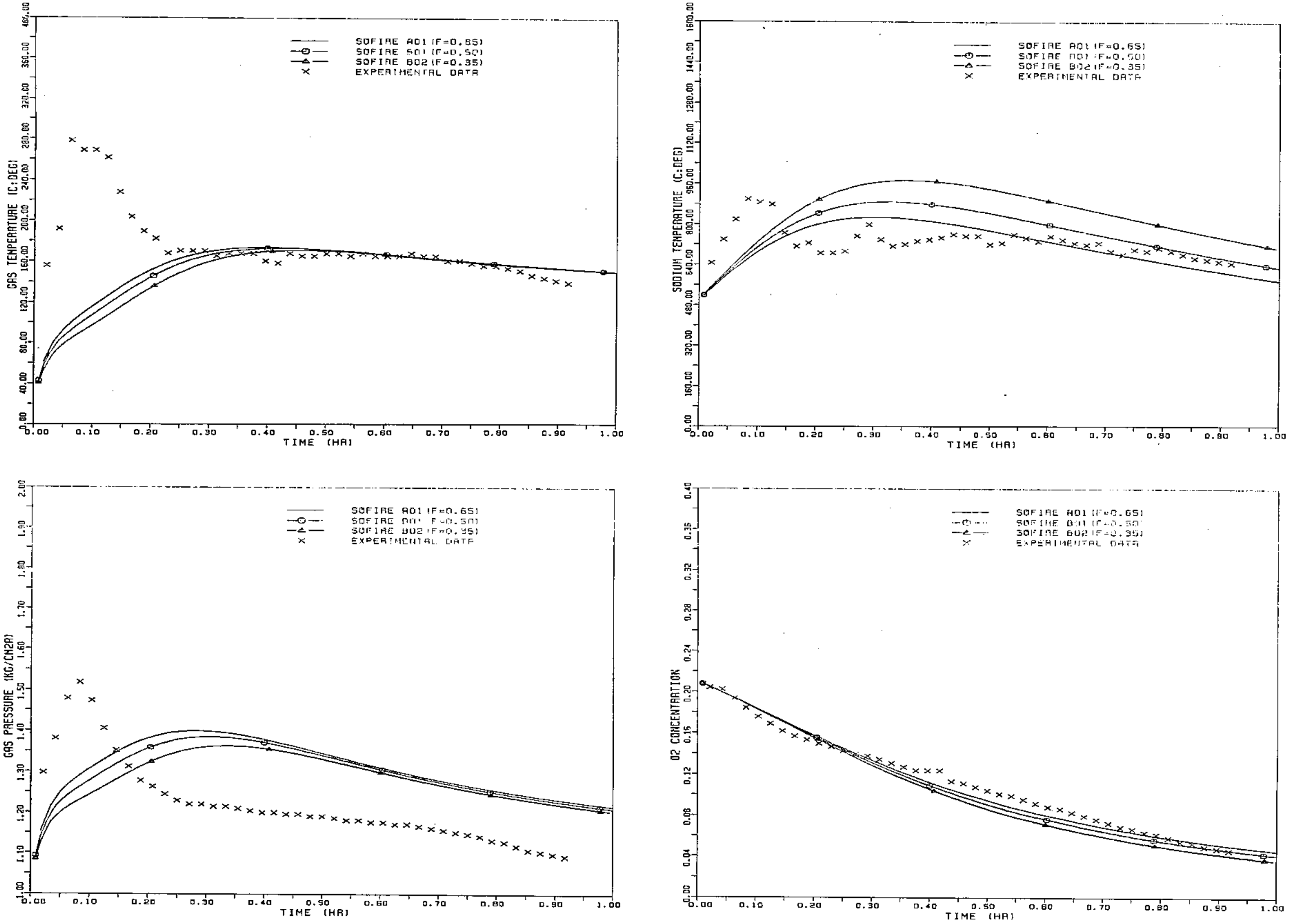


Fig. 3.7 Comparison of SOFIRE Calculations with FAUNA F6 Data
(Effect of Na Surface Rad. Coef.)

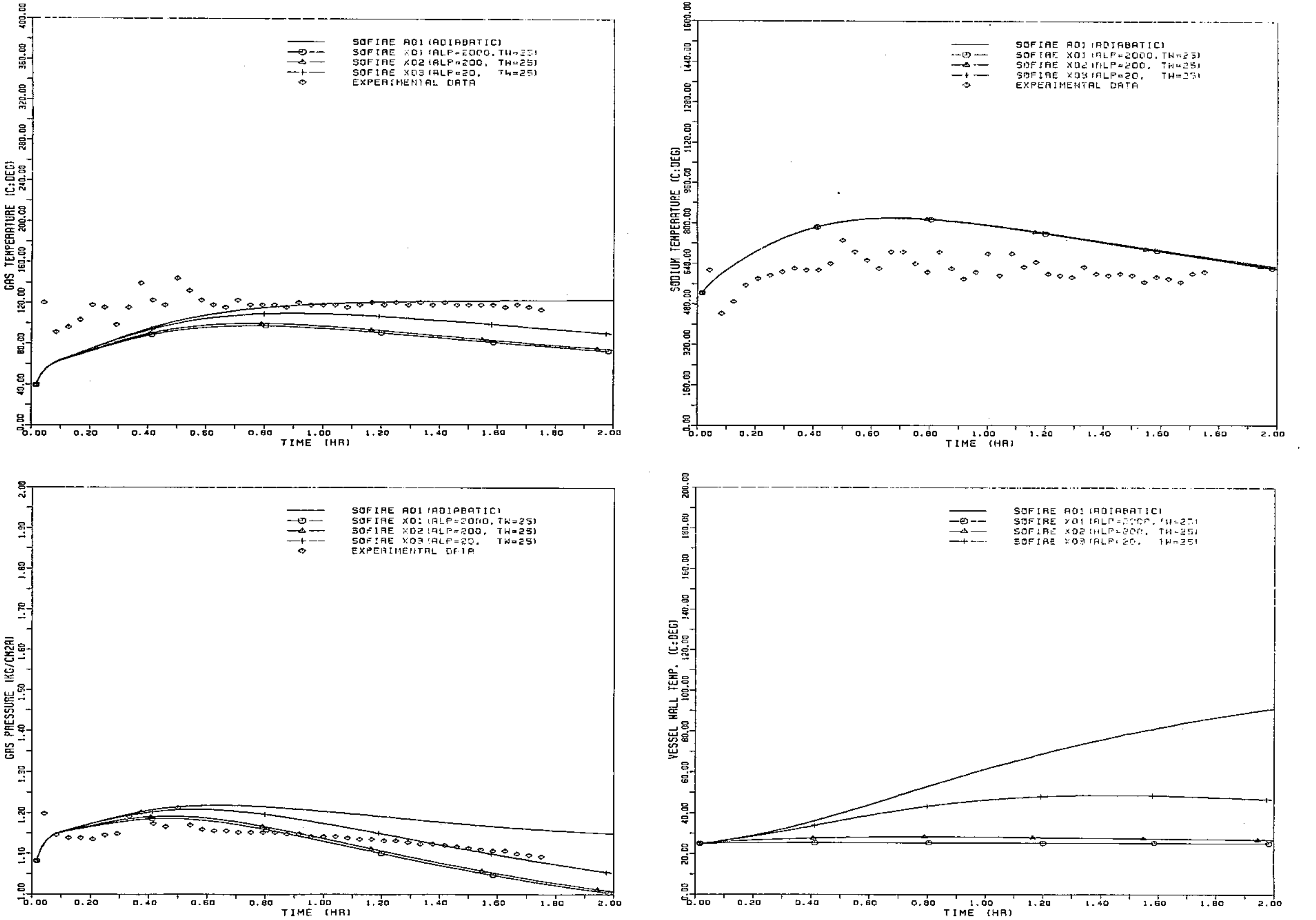


Fig. 3.8 Comparison of SOFIRE Calculations with FAUNA F5 Data
(Effect of Vessel-Outer Cooling)

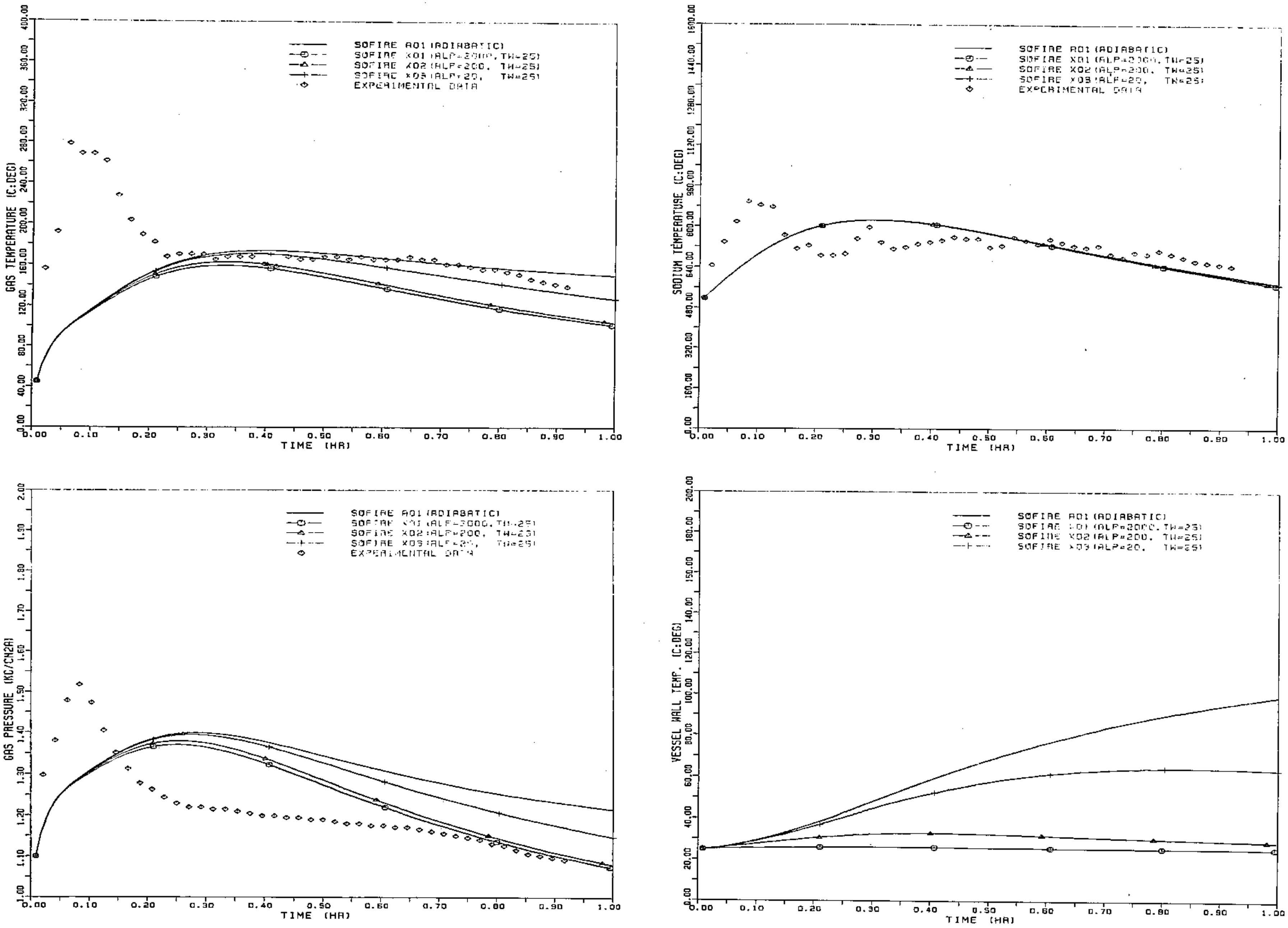


Fig. 3.9 Comparison of SOFIRE Calculations with FAUNA F6 Data
(Effect of Vessel-Outer Cooling)

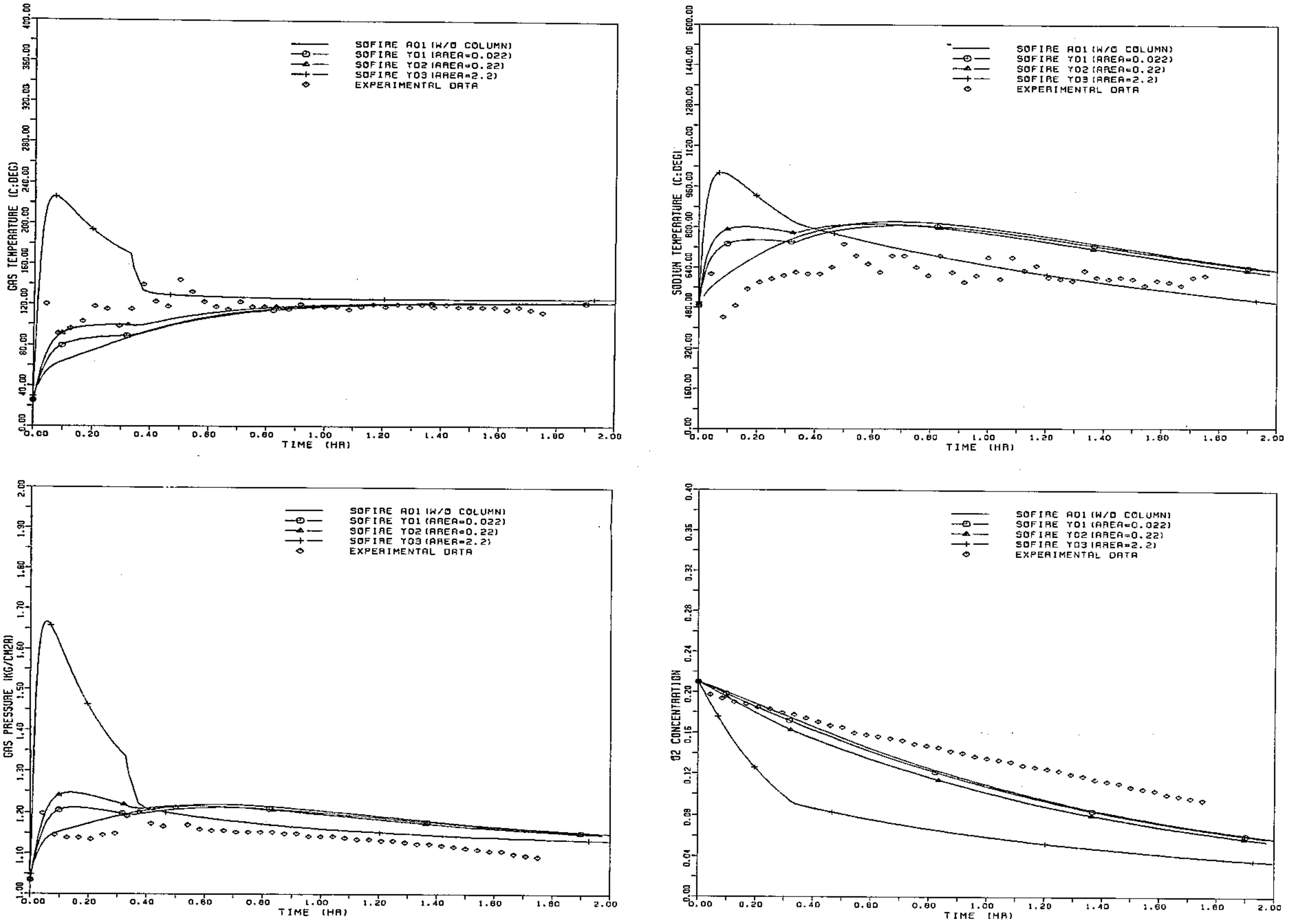


Fig. 3.10 Comparison of SOFIRE Calculations with FAUNA F5 Data
(Effect of Initial Columnar Burning)

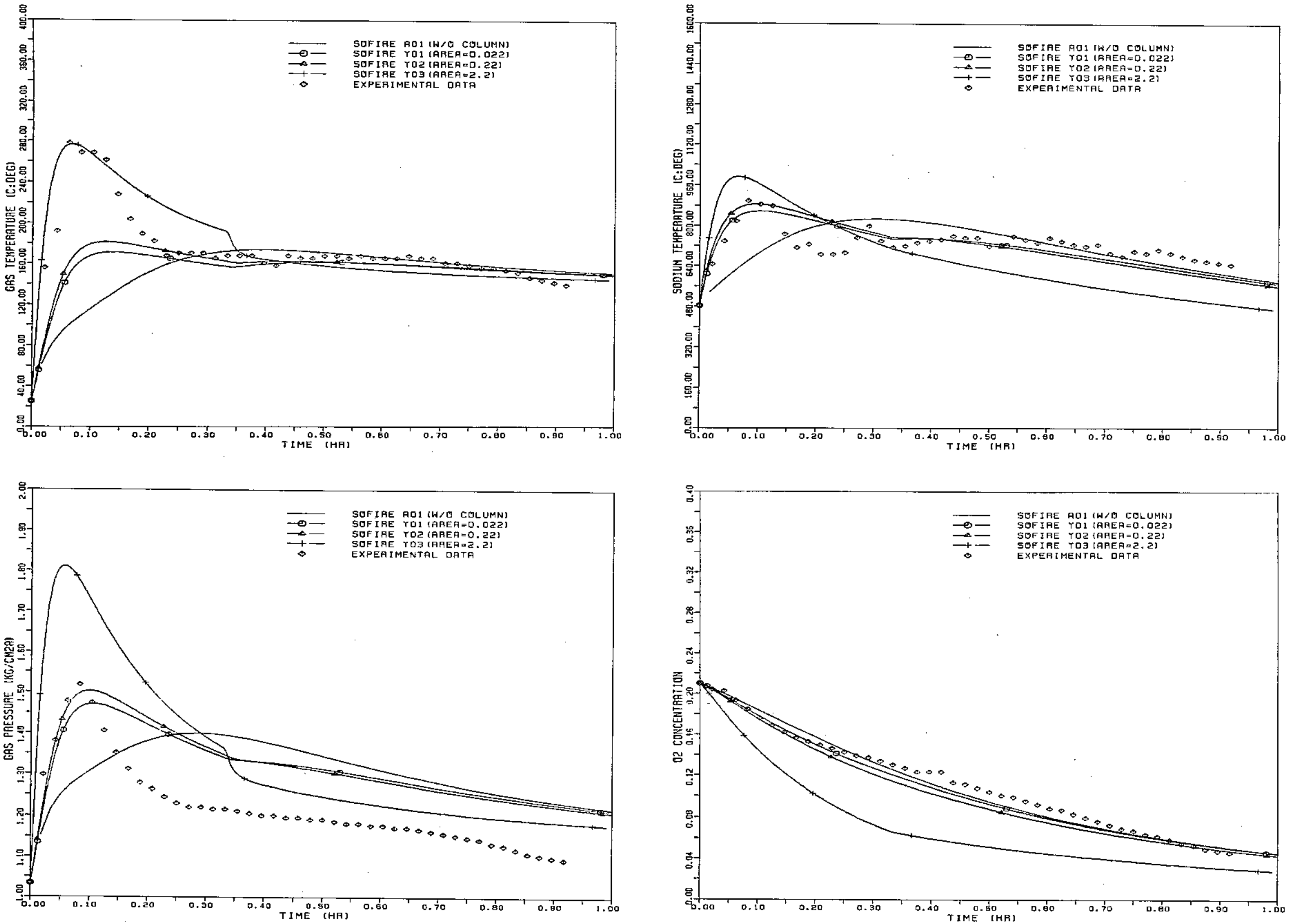


Fig. 3.11 Comparison of SOFIRE Calculations with FAUNA F6 Data
(Effect of Initial Columnar Burning)