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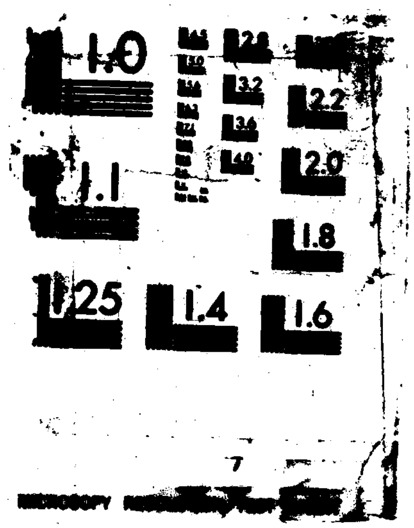
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APPLICATION OF SYSTEM IDENTIFICATION TECHNIQUES TO COMBUSTOR POSTSTALL DYNAMICS

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Final Report for Period December 1984 to September 1986

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This technical report has been reviewed and is approved for publication.

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The combustor (main burner) of gas turbine engines has been identified ~~to be~~ as a significant contributor to the degree of recoverability of engine surge events. Whether or not the combustor blows out and if so, whether it rapidly relights, can determine whether or not rotating (nonrecoverable) stall will occur. Component stall investigations have traditionally concentrated on the compression system and experience has shown that traditional methods of obtaining data are generally inadequate in identifying poststall characteristics. The use of system identification to obtain poststall compressor characteristics has been pursued with promising results. The objective of ~~the present~~ this program is to apply system identification techniques to design experiments which will be suitable for extracting combustor poststall characteristics.

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The program was entirely analytical in nature, and divided into five technical tasks:

1. Combustor Model Survey
2. Test Configuration Definition
3. System Identification
4. Test Evaluation
5. Test Methodology

During task 1, many models, modeling approaches, and combustion physics were examined. The objective was to provide an improved combustor dynamic model. The model derived under the Air Force Nonrecoverable Stall Investigation (F33615-79-C-2087) was selected as a starting point since it represented state of the art. Physics improvements were incorporated, including characteristic time approaches for ignition and stability.

During task 2, the planned United Technologies Research Center Transient Combustion Facility was selected as the only cost-effective, flexible test vehicle of all candidates screened. The facility will be operational in 1987.

The system identification expertise of Systems Control Technology, Inc. was employed to perform the majority of the analysis in tasks 3 through 5 with Pratt & Whitney supporting. The results of these analyses indicate that with currently available instrumentation and model confidence, valuable testing allowing the identification of combustor poststall characteristics can be performed. The results of this contract will also provide the guidance to design such tests to obtain the most meaningful results.

FOREWORD

Personnel of United Technologies Corporation, Pratt & Whitney, Florida Operations, prepared this final report under contract F33615-84-C-2432. The program was conducted under the sponsorship of the United States Air Force, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. This report documents work conducted during the period from December 1984 to September 1986. S. Przybylko was the Air Force Project Engineer and L. Steele was the P&W Program Manager.

The author wishes to acknowledge the contributions of R. Anex and S. Rock (Principal Engineer and Program Manager for the Subcontractor, Systems Control Technology, Inc.) for their system identification expertise, analysis, pertinent recommendations, and significant contributions to this written report. Also, the author is grateful for the guidance and technical contributions of J. Grant, Senior Analytical Engineer, D. Harrold, Technology Manager, J. Erhart, Analytical Engineer, and T. Roadinger, Senior Analytical Engineer.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

2788C

GLOSSARY OF TERMS

ALP	Air loading parameter
B	Mass transfer number
$Ce_{1\text{-}12}$	Combustor model diddle factors
Cp	Specific heat, constant pressure
d_q	Spark kernal diameter
E	Ignitor spark energy
E_G	Global activation energy for fuel type
FPLX	Fuel loading parameter
H	Heat of combustion
K	Thermal conductivity
L_s	Latent heat of vaporization at droplet surface temperature
L_o	Latent heat of vaporization at T_o
M_{ox}	Fractional mass concentration of O_2
PC_B	Percent of combustor annulus burning
Pr	Prandtl number = Cp μ/k
Q_{av}	Energy available to vaporize the fuel
Q_r	Energy required to vaporize the fuel
Q_{burn}	Burner heat release
r	Stoichiometric ratio
R	Universal gas constant
Re	Reynolds number
S_L	Laminar flame speed
S_T	Turbulent flame speed
SMD	Sauter mean diameter = D_{32}
T	Temperature
T_o	Initial liquid fuel temperature
T_s	Initial fuel boiling temperature
ΔT	Temperature rise = function of (fuel, local f/a, T, P)
Δt	Transient time step
V	Velocity
Wa	Airflow
u'	RMS turbulent intensity = 0.75 $\bar{u}$
VOL	Burner volume
α	Thermal diffusivity = $k/(\rho C\rho)$
η	Combustion efficiency
μ	Viscosity
φ	Equivalence ratio
ρ	Density
τ	Characteristic time

Subscripts

a	Air
b	Burner
c	Reaction
e	Evaporation
f	Fuel
id	Ignition delay
ideal	Calculated from ideal temperature rise
L	Liquid
lag	Lagging in time during transients
pz	Primary zone

Subscripts

q	Quench
st	Stoichiometric
V	Vapor
vhr	Volumetric hot residence

SUMMARY

This report describes a computer model of combustor transient performance, emphasizing recent improvements in the model's descriptions of heat release rate, autoignition, stability, and fuel injector performance. Also included is an independent analysis of the model identifying five parameters: combustor volume, liner pressure drop, combustion efficiency, turbine inlet flow parameter, and prediffuser exit area, which strongly affect the model's calculations of combustor exit temperature and flowrate. Finally, a unique, nearly complete, transient combustion facility is described along with the instrumentation which will be used in the first test, planned for 1987. Data from this test will be used to validate and further refine the model. Ultimately, the transient combustion model will become a tool used to promote stall recovery in future gas turbine engines.

SECTION I

INTRODUCTION

In current aircraft gas turbines, compressors must be designed to meet the contradictory demands of high pressure ratio (to optimize engine performance) and stall-free operation (to minimize aircraft vulnerability). In practice, compressor stall margin may be consumed by inlet distortion, pilot requested transients, and engine-to-engine manufacturing variations. Most stalls are self-recovering, with only a momentary loss of engine power. However, some stalls are nonrecoverable; they cause the engine to operate at low power and high turbine inlet temperature, and they can only be cleared by an in-flight shutdown and restart. While there has been considerable effort to simulate and control compressor stalls, little attention has been paid to the combustor's role in the engine post-stall scenario, even though combustor response to a compressor stall can determine whether or not the engine recovers.

This report summarizes Pratt & Whitney's efforts to model and understand transient operating conditions in a gas turbine combustor, with an ultimate goal of designing future combustors to promote stall recovery. Toward this end, Pratt & Whitney (P&W) has created a lumped-parameter computer model of a gas turbine combustor, and has subjected the model to independent analysis designed to identify model parameters which have the greatest impact on model predictions of combustor exit temperature and flowrate. This analysis has also resulted in a prediction of model accuracy when test sensor (e.g., pressure, temperature) accuracies are within specified limits. In 1987, these efforts will culminate in noncontractual validation of the model with test data from a transient combustion facility under construction at United Technologies Research Center (UTRC).

SECTION II

BACKGROUND DISCUSSION

1. COMBUSTOR CONTRIBUTIONS TO ENGINE STALL BEHAVIOR

a. Normal Combustor Operation

The combustor is located at the heart of the gas turbine engine. From a thermodynamic cycle standpoint, the role of the combustor is simply to convert the chemical potential energy in the fuel to thermal energy by combustion. This thermal energy is then converted to kinetic energy in the turbines to drive the compression system and create thrust. In the combustion process, high efficiency at low pressure drop is desired. The design and performance of a combustor is much more complex than the blackbox thermodynamic description suggests.

A typical gas turbine combustor during normal (i.e., unstalled) operation is shown schematically in Figure 1. The compressor exit air Mach number is gradually reduced in the diffuser in a manner which limits total pressure loss. A dump section is provided for consistent flow behavior at the diffuser exit.

Combustor stability during normal operation is typically considered to be defined by conditions in the primary zone. Stoichiometry and swirler/fuel nozzle induced swirl strength are prime contributors in this regard.

Primary zone stoichiometry is controlled by the combustor fuel and front end/primary air flowrates and distributions. Fuel distribution is determined by the spray cone structure and the degree of atomization, and can vary significantly between nozzles of different designs, such as pressure atomizing or airblast. A pressure atomizing fuel nozzle design relies upon large fuel pressure drops to atomize. A pure airblast design uses the shearing effect of high velocity air on a fuel film for atomization.

Reverse flow in the primary zone occurs when a nondimensional ratio of tangential momentum to axial momentum (called the swirl number) exceeds a value of 0.6. The static pressure in the central core of the swirler then becomes sufficiently low and recirculation results. With increased swirl number, the recirculated mass flow is increased and, for very strong swirl levels, it can actually exceed the swirler flow.

Primary zone reverse flow creates stable combustion by recirculating hot reacting gases and fresh fuel and air which perpetuates combustion. Since only fuel in the vapor phase can burn, some of the heat release is used to help vaporize the injected fuel. The resulting overall fuel/air ratio in this zone must be within lean and rich limits and, in general, exceeds stoichiometric level.

The gases exiting the primary zone enter the intermediate zone. The intermediate zone provides time, at elevated temperature, for the recombination of the dissociated products, such as CO and H_2. This recombination process helps to reduce engine smoke emissions and prevent low combustion efficiency at reduced power conditions.

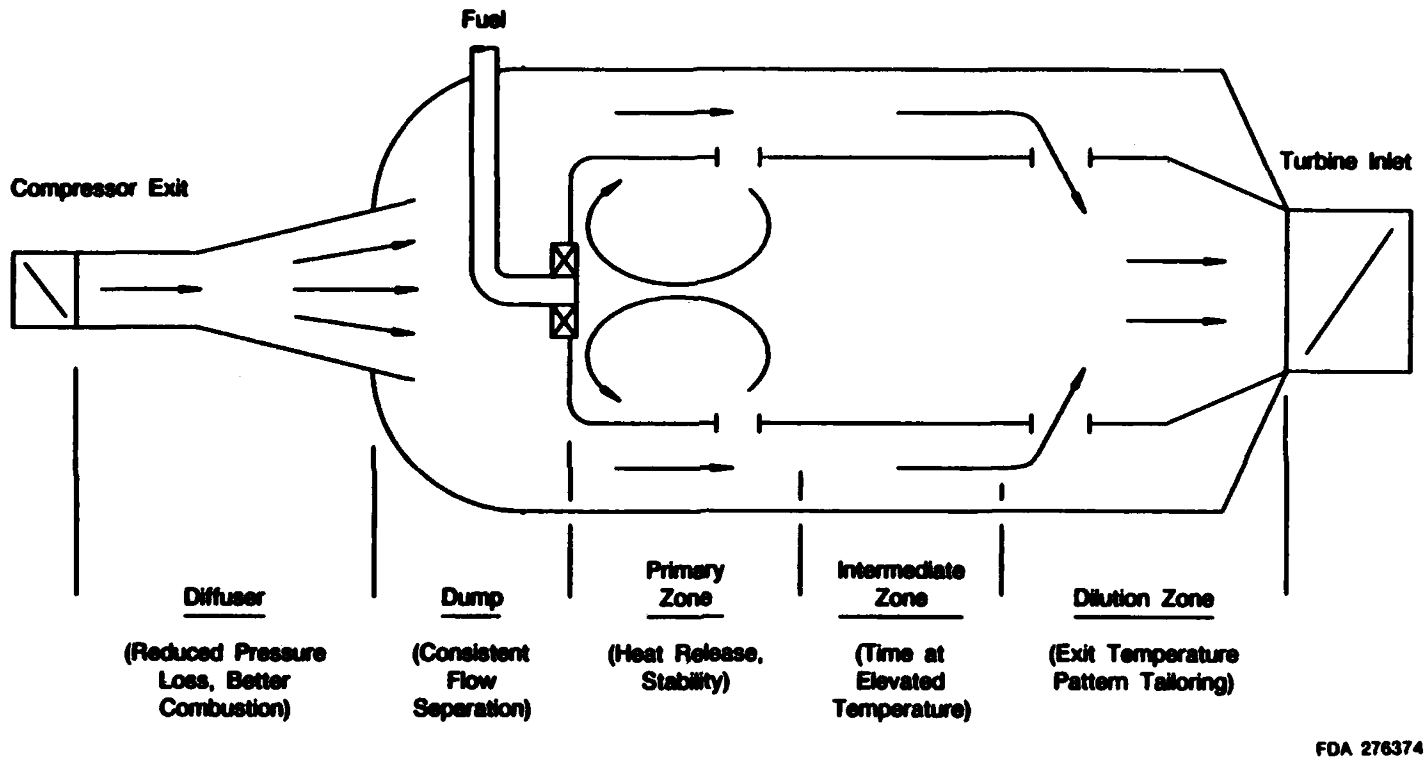

Figure 1. — *Combustors Are Typically Designed for Normal Flow Conditions*

The gases exiting the intermediate zone enter the dilution zone. In the dilution zone, the hot gases are mixed with cooler compressor exit air to reduce temperature levels and produce temperature patterns compatible with the turbine. Typically at high power, most of the combustion is complete before the hot gases enter the dilution zone.

Combustors are presently designed for these conditions of normal operation and are required to provide the following at acceptable levels:

- Durability
- Exit temperature patterns (hot spot and average profile)
- Starting capability at sea level and altitude
- Smoke and emissions (including efficiency).

There are presently very few accepted guidelines for the design of "stall resistant combustor systems." Two of these are elevated fuel nozzle passage pressures to limit boiling potential, and increased combustor section volume. Conventional "normal operation" design guidelines must not be severely impacted by stall resistance design considerations, however.

b. Combustor During Stall

During normal combustor operation, the distribution of airflow is bookkept in the interests of providing desired exit temperature patterns, durability, starting, and smoke and emissions. These airflow distributions are determined by measured steady-state pressures. Figure 2 illustrates in a simple manner what is believed to happen to combustor air flow during an engine surge. For pre-surge conditions, the airflow distribution is normal. During the early stage of the surge cycle, the airflow into the combustor is retarded as the compressor discharge flow is reduced. As the engine approaches the trough of the surge cycle, it is speculated that deep reverse flow within the combustor section occurs. Hot reactants and products are drawn forward out of the liner. Primary zone recirculation patterns and, therefore, stability in the conventional sense may vanish from the primary zone. On the repressurization side of the surge cycle, forward flow is reestablished and some of the reactants and products are drawn back through the combustor liner. During these last two steps, it is considered crucial whether or not the combustor blows out and, if so, does it relight (if normal terminology can be applied).

In the case of a rotating stall, the amplitude of the combustor pressure variations is decreased while the frequency is increased. Local combustor response to a passing stalled cell might be visualized as being somewhat similar to surge response, but of reduced severity. The passing stall cell induces a local reverse flow of reduced strength relative to a surge induced reverse flow. The cell must affect local combustion to some extent as it passes, but complete blowout is not likely.

Combustor poststall dynamic effects have a significant impact on engine system stall recovery. Possibly the most important of these is the tendency for repeated combustor blowout/relight during surge cycling to reduce engine power level far into the sub-idle region. Once in the far sub-idle (or starting) region, it can be easy for the engine to fall into rotating stall (stagnation). As shown in Figure 3, repeated combustor relight/blowouts on the surge cycles drive average combustor pressure well below idle level. The end result of this transient was rotating stall.

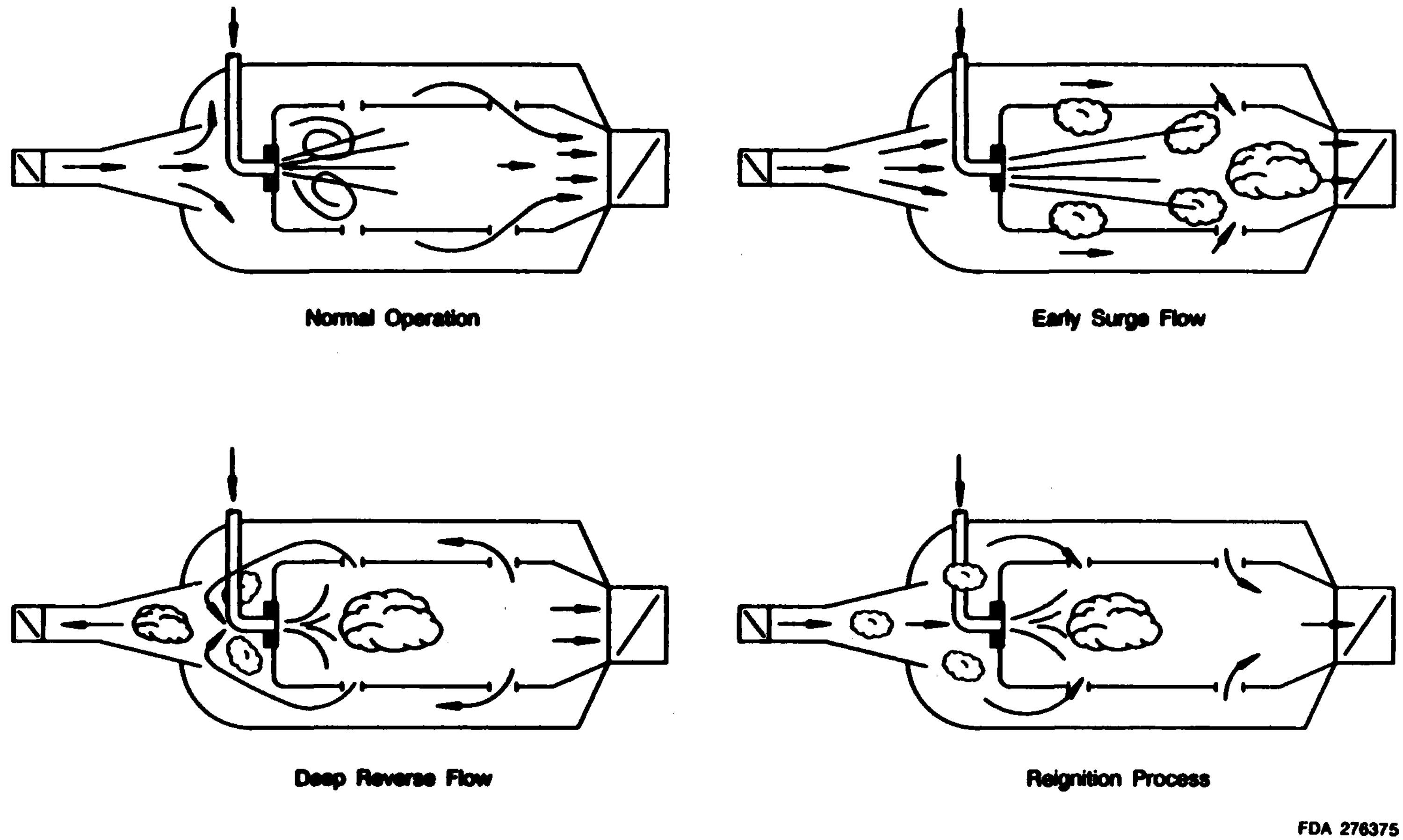

Figure 2. — Combustor Reignition Following Surge Can Be Crucial to Engine Stall Recovery

A study was conducted to determine the feasibility of using either existing rigs or engine configurations to conduct timely yet relatively inexpensive transient tests. No suitable facility presently exists at P&W to accomplish this goal. However, the United Technologies Research Center Transient Combustion Facility (planned to be operational in 1987) has this objective and was selected under this study.

The combustor model was integrated into the Systems Control Technologies (SCT) parameter estimation code and subjected to system identification analysis. This analysis determined the feasibility of identifying combustor model characteristics from rig test data with the goal of including the identified model in a full-scale engine poststall model.

SCT and Pratt & Whitney defined sensor sets which are currently practical for poststall combustor testing and sensors which are not currently available but could be developed in the near future. Accuracy levels for all sensors were then defined, and estimates of combustor model parameter uncertainties were made.

Using these uncertainty estimates, the optimum set of parameters to identify was defined for each combination of input, sensor set, and uncertainties. These estimation sets are optimum in the sense that they will minimize combustor model output error due to estimation error.

Estimation accuracy analysis was then performed in an iterative fashion for each estimation set. The final result of this analysis is a specification of the test instrumentation, inputs, and model uncertainty required to determine combustor model characteristics from test data.

A test input which drives the combustor into its different modes of operation, is desirable and has been selected as an input to the transient rig. It is essential that the state of the burner be determined through proper instrumentation of the facility and rig, and that the computer model be flexible enough to react to and simulate that change. The JETAS computer system installed in the transient facility's control room is capable of accessing data at as high a rate as 500 cuts/sec. This is more than adequate for the type of instrumentation and resolution desired.

3. SUMMARY OF FINDINGS

a. Combustor Model Survey

During the literature search, most of the technical papers on combustor modeling reviewed were concerned with steady-state operation, but the lumped volume approaches taken,lends them to transient analysis as well. No papers were identified which specifically presented poststall combustor models. However, many papers were assembled which concentrate on the important physical mechanisms which occur during poststall combustor operation, namely mixing, evaporation and chemical reaction. These mechanisms along with gas dynamic effects such as residence time and turbulence intensity help to control combustor ignition, stability, flame propagation and efficiency. A bibliography of the important publications which were used in the formulation of the poststall combustor model under this program are listed in the reference section.

(1) Existing Digital Computer Model

A review and critique of the existing state-of-the-art P&W poststall combustor dynamic computer model developed under the AF contract F33615-79-C-2087 was also performed. The model is shown schematically in Figure 4 and in flow chart form in Figure 5. It consists of two lumped-parameter volumes, one representing the region surrounding the combustor liner and the other representing the region inside the liner. Flow into the outside liner is calculated based on the "dump loss" associated with sudden expansion at the diffuser exit and likewise, flow through the liner is based on the liner pressure drop. Combustor exit flow is calculated by assuming a choked high turbine since the turbine is not modeled.

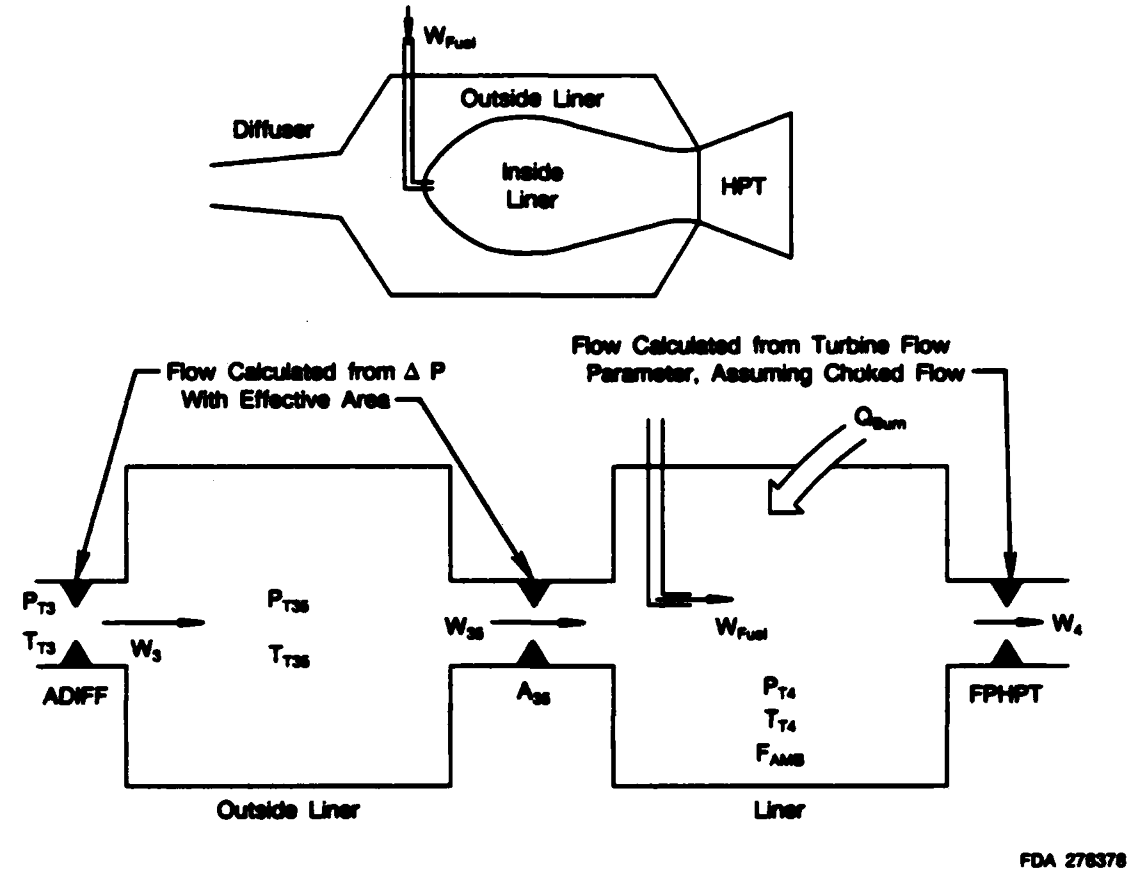

Figure 4. — Existing Combustor Model Represents Outside and Inside Liner Regions as Separate Lumped Volumes

Each of the two volumes incorporates dynamic equations for conservation of mass and conservation of energy. The liner volume also includes conservation of fuel so that fuel/air ratio can be taken as the ratio of the mass of fuel within the volume to the mass of air as shown in Figure 6.

The heat release due to combustion is obtained by reading steady-state temperature rise curves with fuel/air ratio and applying a first-order lag intended to account for transient residence time effects as shown in Figure 7. This provides a somewhat realistic transient temperature rise with minimal computational complexity.

The model also includes other important physical processes using empirical correlations. Blowout limits are checked and, if exceeded, the temperature rise is zero. Following blowout, the combustor does not immediately relight once stability limits are no longer violated. Rather, some time elapses before the relight. This autoignition delay time has been correlated with entering air temperature and pressure. Once the relight is initiated, the flame must propagate around the annulus; it is assumed that the propagation is a linear function of time.

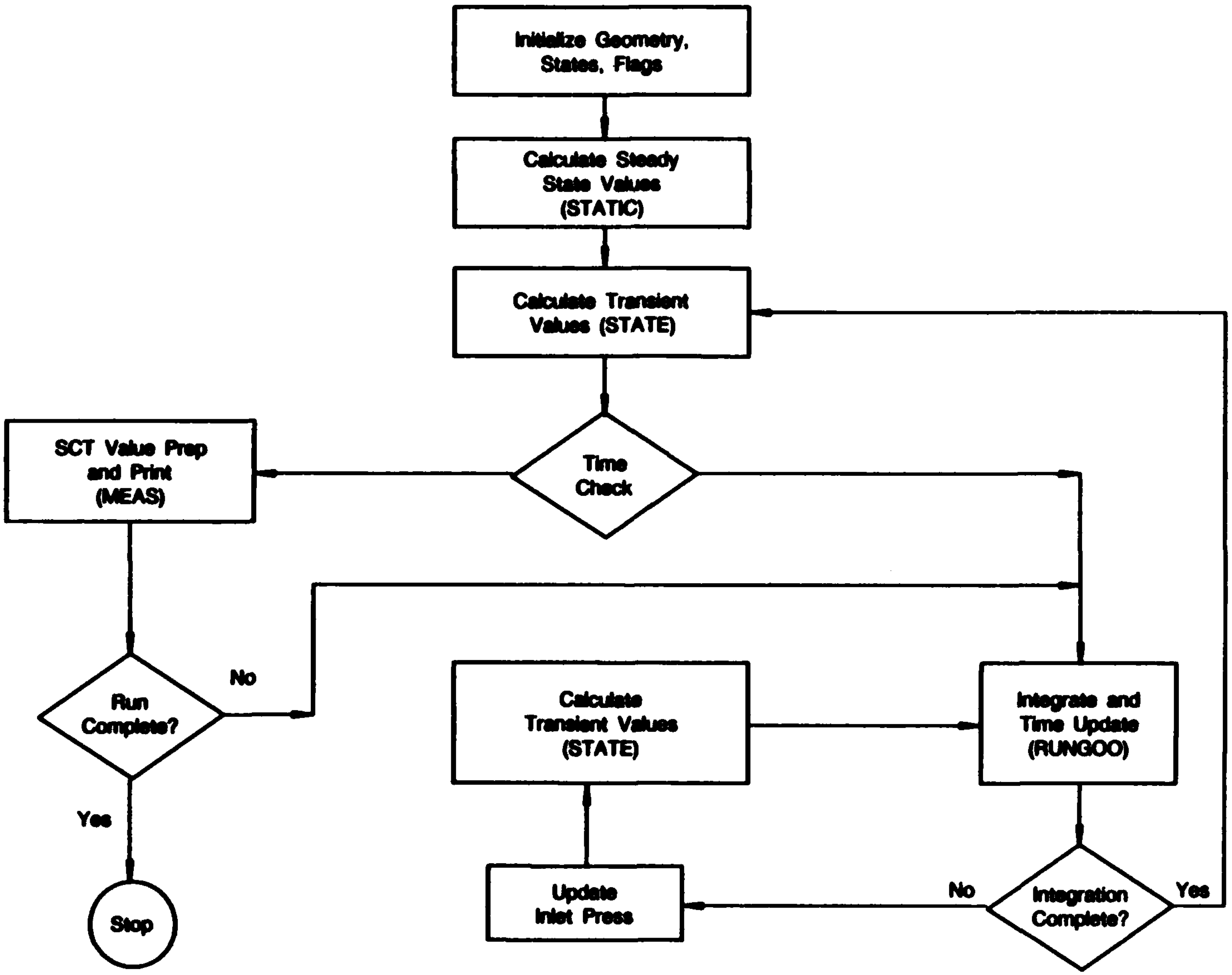

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Figure 5. — Main Program of Existing Poststall Combustor Model

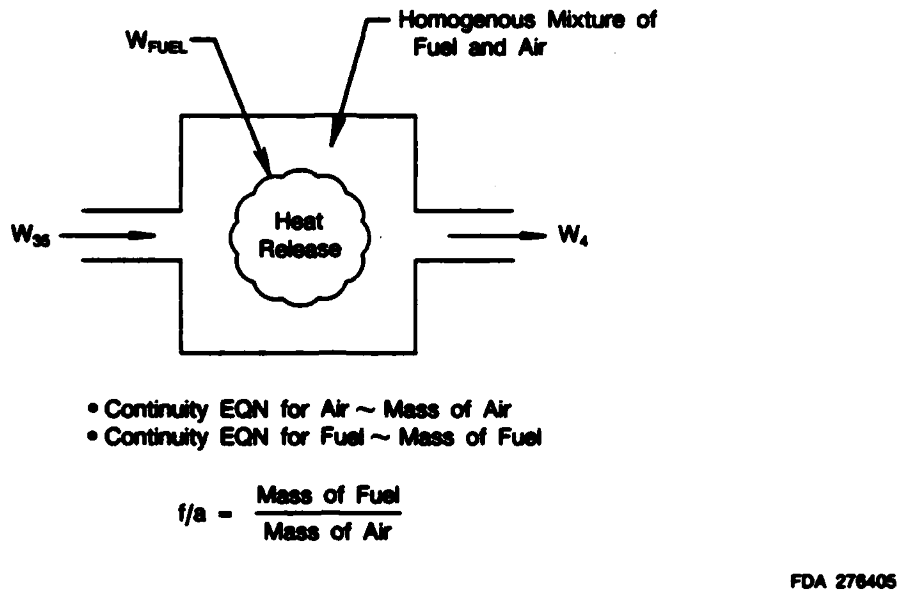

Figure 6. — Model Simulates Masses of Air and Fuel Separately for Transient Fuel/Air Ratio Calculation

(2) Shortcomings

An analysis of the function of the various subroutines and how they interact as well as the overall methodology of the model was undertaken in the review. The weaknesses in the model and the methods of dealing with the weaknesses will be discussed in this section.

(a) Heat Release

The efficiency values which are applied to the ideal temperature rise are based upon a simple functional form involving only two variables. The literature search indicated that steady-state combustor efficiencies are dependent on mixing, evaporation, and reaction effects which involve many variables. Also, the application of a first order time lag may be appropriate, but the time constant involves more physical effects than only residence time.

(b) Combustion Zones

The "inside liner" volume was previously one lumped volume. This was divided into a primary and a secondary zone because the primary zone is most influential in terms of ignition and stability and is separable from the secondary zone in this regard.

(c) Ignition Model

Autoignition delay time was previously the only criterion used for a combustor "on/off" decision. Using the characteristic time approach, a spark ignition criterion was added for better modeling and completeness.

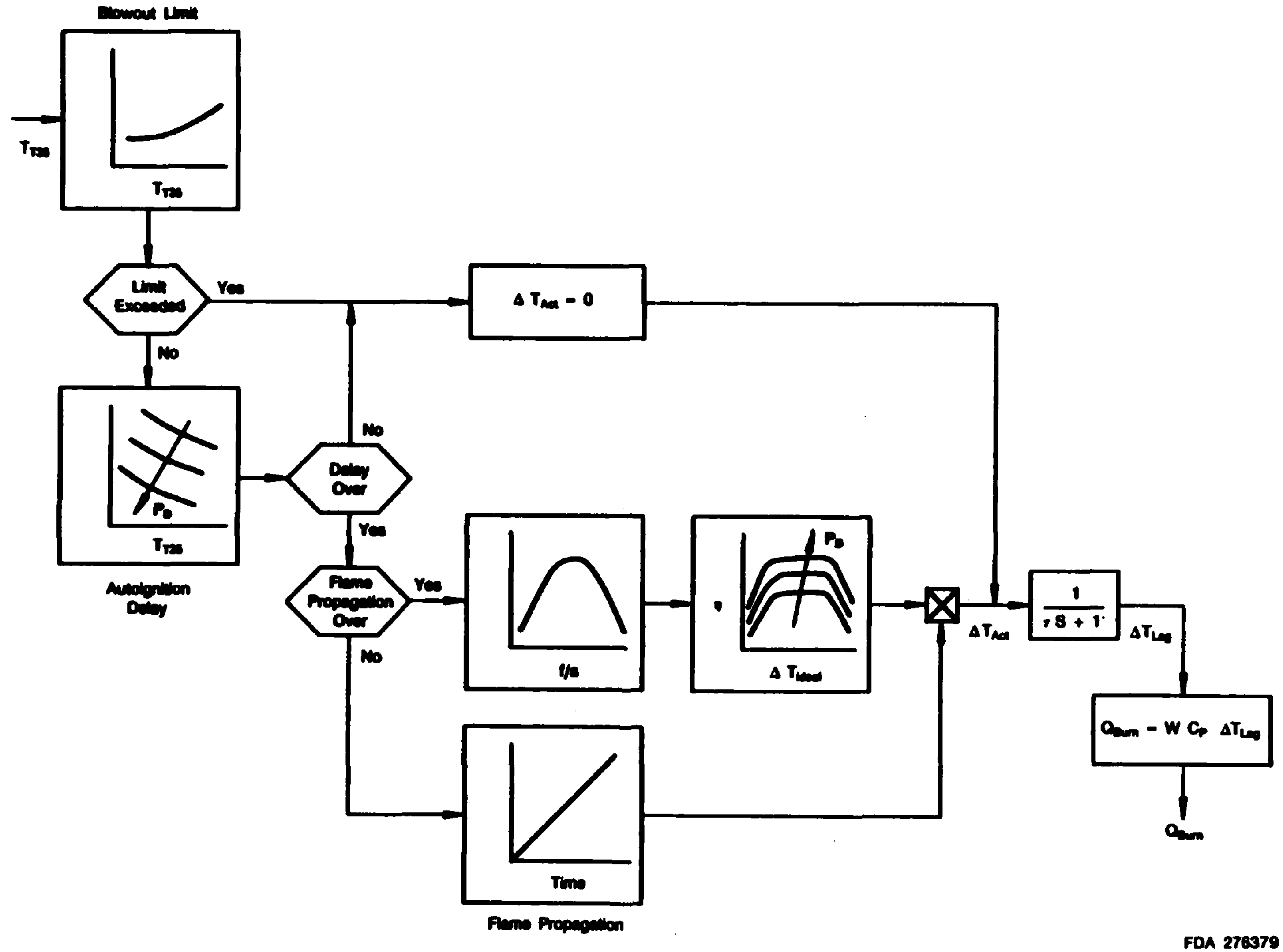

Figure 7. — Heat Release Calculation for Nonrecoverable Stall Investigation Combustor Dynamic Model

(d) Stability

The original blowout characteristic did not allow the inclusion of all the important variables revealed in the literature search, and was based upon steady state rig data. A stability calculation, better than the original, was required to determine if blowout limits are exceeded. A characteristic time approach was adopted.

(e) Fuel injector

An improved fuel injector model was incorporated to allow calculation of droplet size. Fuel nozzle design and fuel type are strong drivers on spray droplet size (typically identified by the Sauter mean diameter or SMD) which is involved in the physics of evaporation, flame propagation, and efficiency.

(3) Approach

A combustor modeling approach which has been given much attention in the literature is that of characteristic times. Characteristic times can be formulated for mixing, evaporation, chemical reaction, residence, and quenching. Relationships between these characteristic times can be developed to form criteria for spark induced ignition and stability. The previous model used a first order lag approach but the time constant is now represented as the sum of the residence, evaporation, and reaction characteristic times.

b. Test Configuration Definition

A survey of possible test configurations indicated that no appropriate rigs existed for simulating combustor transient operation. It was also apparent that engine testing was far too late in the development cycle and a very expensive operability test vehicle. Early in this program effort, a capital appropriation for the construction of the Transient Combustion Facility at the United Technologies Research Center in East Hartford was approved. The purpose of this facility is to provide a less expensive approach to operability testing which can be performed much earlier in the engine development cycle. It will also serve as an excellent poststall combustor dynamic test vehicle for the refinement of the poststall combustor computer model. The facility will be capable of simulating compressor surge and rotating stall, spooldown relight conditions and lean deceleration conditions. Flow capabilities for this facility are summarized in Table 1 and a schematic of the facility itself is shown in Figure 8. The different possible airflow transients are illustrated in Figure 9.

c. System Identification

Optimal parameter estimation sets have been identified for a range of possible instrumentation sets and levels of model confidence. These results indicate that, with current instrumentation and model confidence, estimation of four model parameters will produce the best results. These parameters include a constant bias on combustor efficiency, the resistive areas, and volumes. Parameter estimation techniques require the coefficients in the combustor stability equation to be identified separately, after other model parameters have been identified. These terms may be estimated accurately from test data after initial identification efforts. As with all estimation results, identified model accuracy is dependent on the model structure.

TABLE 1.

LIMITING CONDITIONS FOR TRANSIENT COMBUSTION FACILITY

Airflow

- Steady State Operation — Continuous
  - Flowrate: 10 pps
  - Pressure: 230 psia
  - Temperature: 1000°F
- Transient or Short Duration Steady State (30 sec) Operation
  - Flowrate: 0-20 pps
  - Pressure: 280 psia max
  - Temperature: 1000°F max
  - Cycling Frequency: 10 Hz
  - Rise/Decay Time: 1-5 sec

Fuel Flow

- Steady State or Transient Operation
  - Flowrate: 0-0.5 pps
  - Pressure: 1000 psia max
  - Temperature: Ambient — 320°F
  - Cycling Frequency: 30 Hz
  - Rise/Decay Time: Instantaneous

Data Acquisition — Fast Response (>1000 Hz)

- 24 Channels
- Expect UTRC Capacity to Increase

d. Test Evaluation

The result of the test evaluations can be summarized as follows: Non-estimated model parameters must be known on the average to within 5 percent of the true values. Systematic measurement errors must be known extremely well (sensor bias within ±0.5 percent and sensor time constraints to within ±0.25 percent). With this knowledge and currently available instrumentation, a poststall combustor model could be identified such that predicted combustor exit temperature and flow would be accurate to within 5 percent of the true values (combined total error).

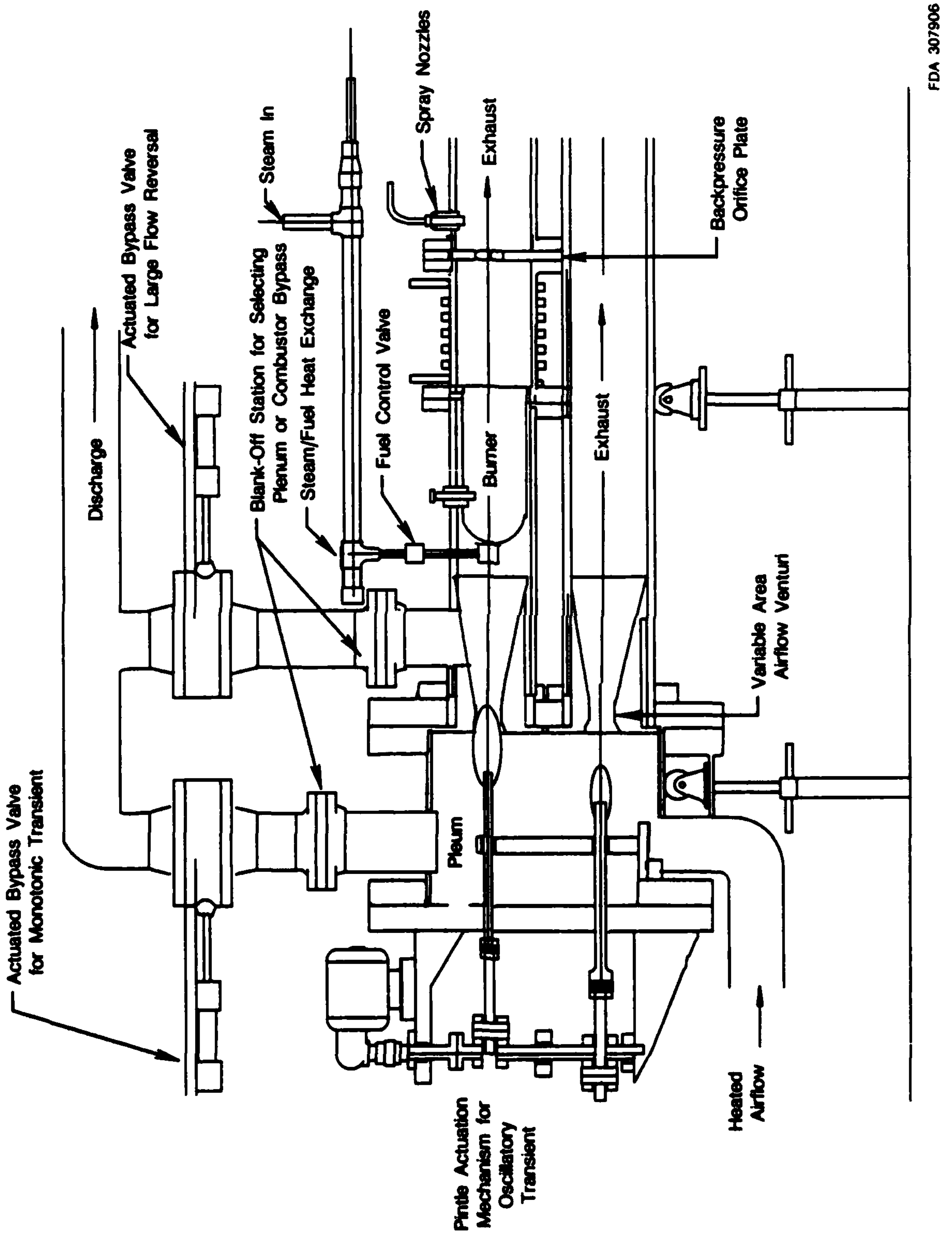

Figure 8. — UTRC Transient Combustion Facility

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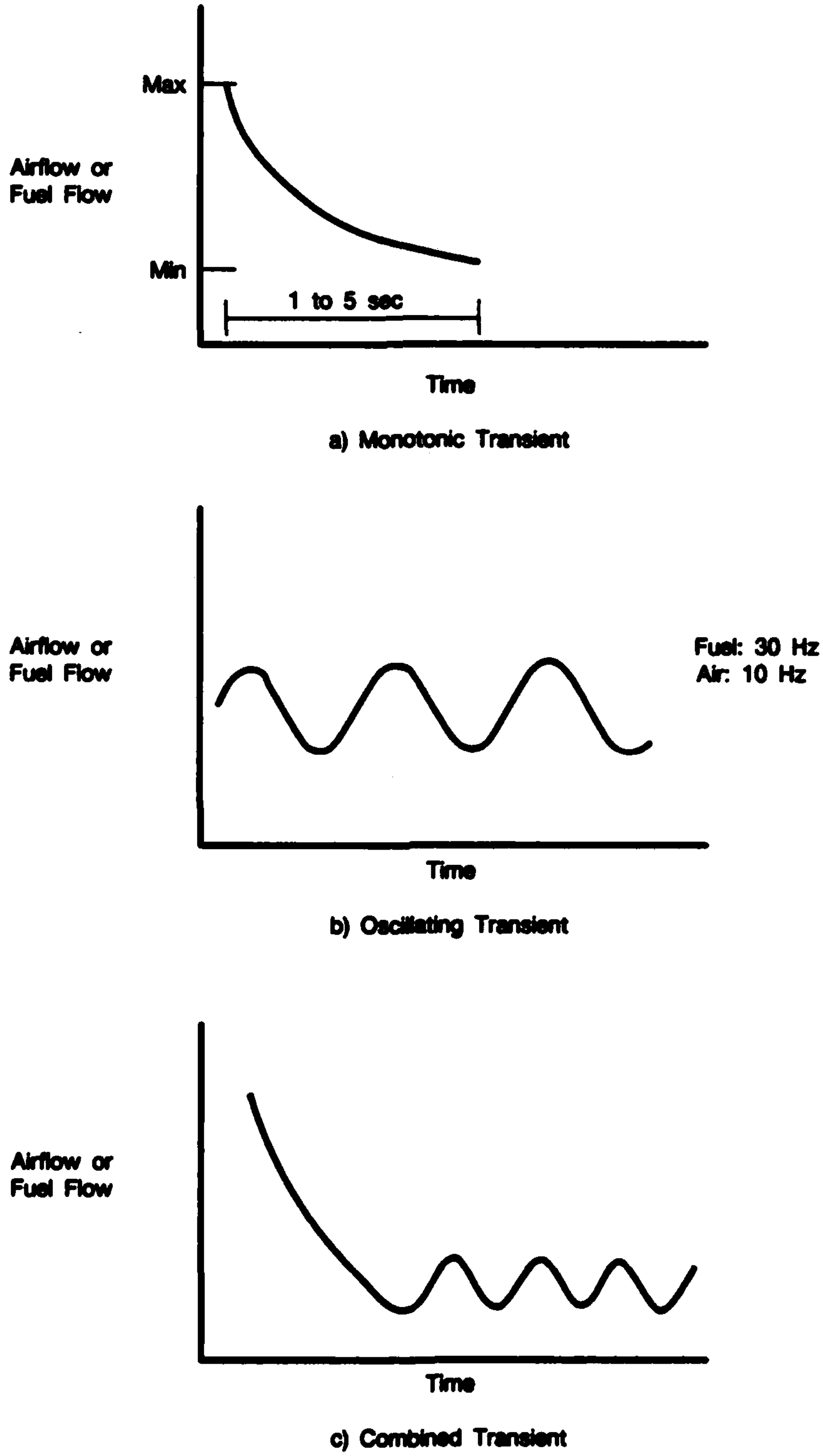

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Figure 9. — Combustor Transients

SECTION III

TEST CONFIGURATION DEFINITION

1. TEST INPUTS

The combustor transient model was exercised at SCT using two input test cases. The first test case simulates the compressor exit pressure during multiple planar surge. This consists of a 20 Hz signal imposed on an inlet pressure varying from 50 to 250 psia. The second test case is a slow increase in fuel flow, from 0.0 to 2.0 pps with combustor inlet pressure constant at 14.7 psia.

2. INSTRUMENTATION

It is important to state at this time that the rig and facility instrumentation must be capable of indicating at what time during the transient the burner is in the lit and unlit modes.

The selection of combustor and rig instrumentation will be determined by such factors as their frequency response, accuracy, durability, and nonobtrusiveness. Adequate but not excessive redundancy is important to allow for instrumentation failure without incurring excessive cost or influencing the flowpath because of large instrumentation bundles. Selection of instrumentation based upon frequency response, however, is likely to be the most important factor for a dynamic combustor test. A typical rule of thumb for the measurement of transient phenomena is that data should be sampled at twice (2X) the event frequency for frequency information and 10X for amplitude and phase information.

Facility transient capabilities must be considered as well as the dynamics of engine stall events when selecting instrumentation based upon frequency response. For the measurement of pressure at high frequencies there are at least three possibilities: Statham, Kulite, or Kistler sensors. Statham pressure sensors can sample at rates up to approximately 1000 Hz, but Kulites or Kistlers have much higher maximum sampling rates at nearly 20,000 and 50,000 Hz, respectively. These sampling rates assume flush mounting with no leads which detract from the response levels. If leads of any substantial length are required, Kulites and Kistlers might be left as the only adequate pressure sensors, since Stathams display limited response margin. Accuracy levels for these devices are typically about 1 percent of full scale.

Given the importance of burner state, an optical viewing probe will be used as a data gathering device and the signal will be recorded on video tape. This video recording will have a time signal superimposed on the signal from the host computer so that during data analysis, plots may be compared to the video transmission.

With a test input of 20 Hz, it is necessary to have a minimum of 40 Hz frequency response for frequency definition, and 200 Hz for amplitude information. For the transient combustor test rig, the minimum line length for burner pressure instrumentation will be about 6 inches. With these line lengths required to route the instrumentation to an accessible location the best Statham sensor frequency response would be 23 Hz. The more capable Kulite sensor for the same conditions will provide 65 Hz frequency response. Given SCT's conclusion that 50 Hz is adequate, the pressure data should allow accurate examination.

Air temperature response will be limited to 5 Hz at best, and for the majority of the transient testing will be on the order of 1 Hz. Conventional platinum-iridium thermocouples with wire diameters ranging from 15 mils to 3 mils will provide durability during the checkout phase (15 mils) and somewhat better response time (3 mils at 5 Hz) during crucial transient data gathering.

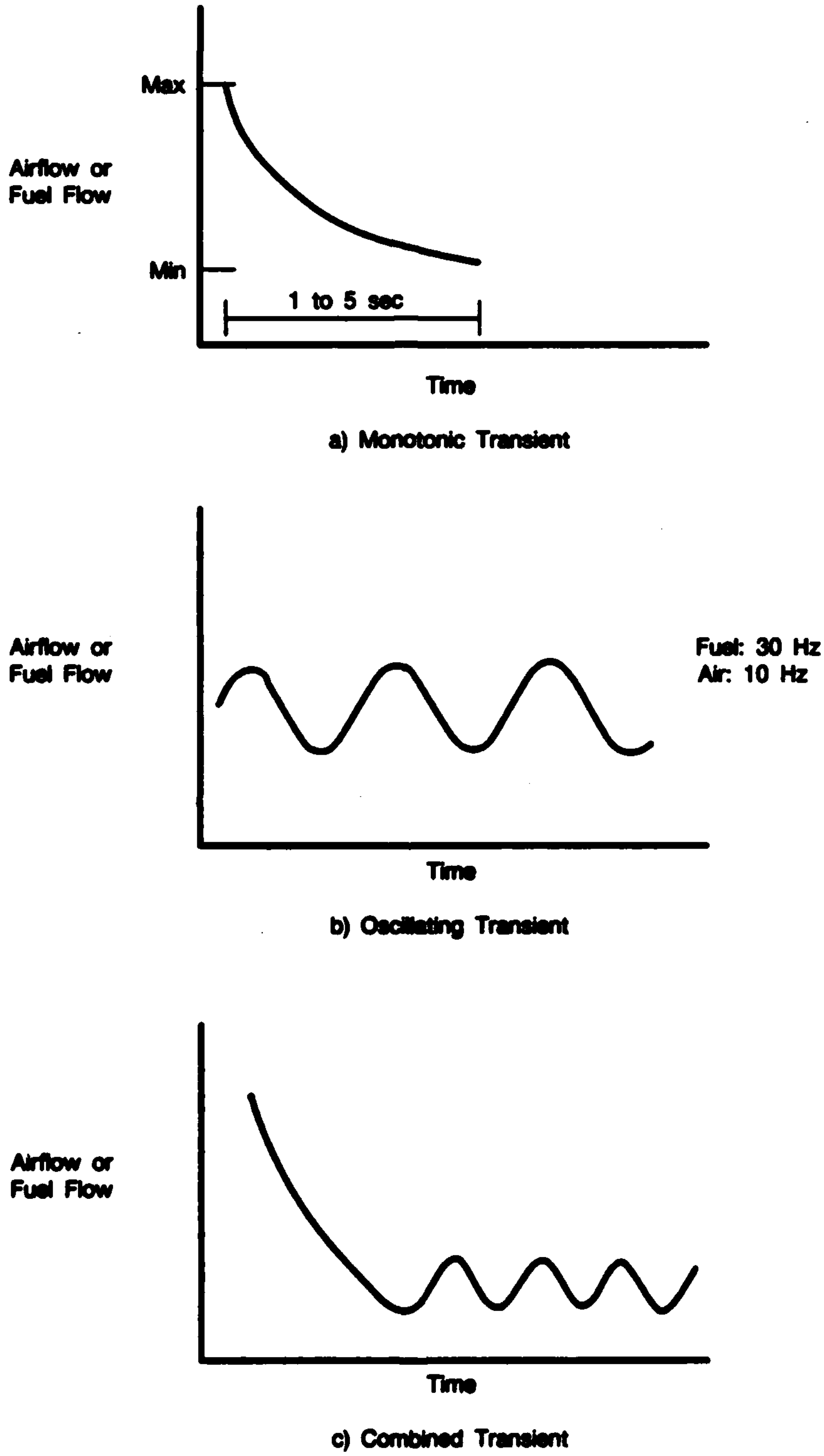

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Figure 9. — Combustor Transients

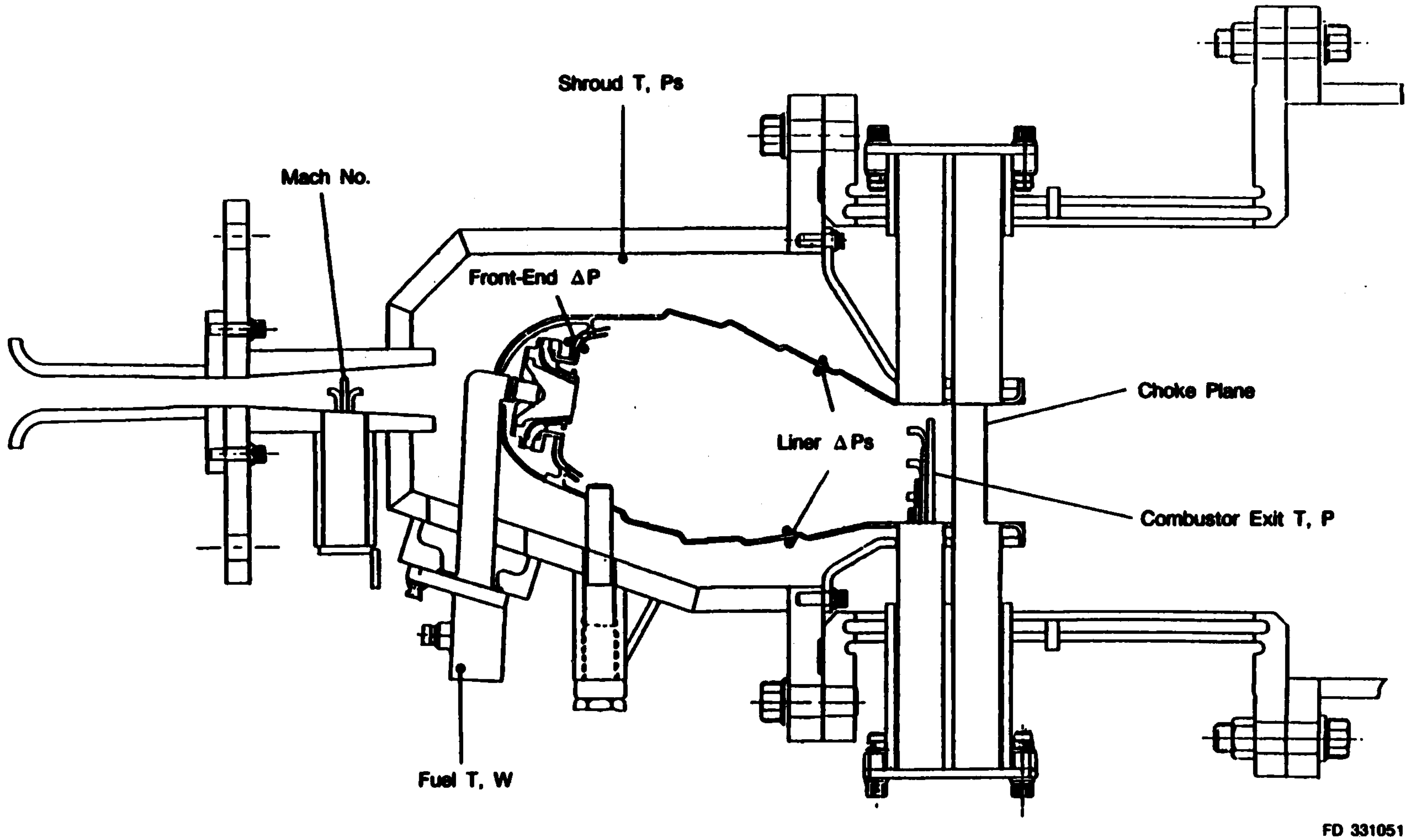

Figure 11. — Extensive Transient Instrumentation Is Required for Dynamic Model Validation Tests

Two 14 track FM tape systems can be used to record up to 26 critical, high response pressures (one each for time). These FM recorders are capable of recording frequencies well above the range of Kulite sensor response expected from this data.

The use of the video recorder is made necessary by the distinct modes of combustor operation (on or off). The optical viewing probe is capable of sending a signal to the computer as a digital representation of the optical data, but the ability to see with the eye the front end of the burner, will be irreplaceable.

With a data acquisition system as capable as what has been described here, and the knowledge that the instrumentation is adequate to perform its required task, the data accumulated should provide the proper information to verify the digital computer model.

SECTION IV

COMBUSTOR MODELING

1. MODEL DESCRIPTION

The burner physics coded into the original digital computer combustor model inadequately described the burner process for the scope of this program. As listed in the Summary of Findings there were several weaknesses that were recognized and more accurately modeled in the improved computer code. This section will describe the improvements and explain how each was incorporated into the computer code.

Flexibility has been designed into the computer program so that data may be matched by changing constants in equations or by modifying the physical makeup of the burner itself. The input, output, and burner geometry parameters are listed in Table 2, and a description of these parameters is given in Table 3. An example of combustor model predictions for specified inlet conditions are provided in Appendix A.

TABLE 2.

SUMMARY OF ARRAY PARAMETERS

States	*Output*	*Diddle Factors*
X(1) = P_{T35}	Y(1) = P_{T3}	P(1) = FPHPT
X(2) = T_{T35}	Y(2) = T_{T3}	P(2) = ADIFF
X(3) = P_{T4}	Y(3) = W_3	P(3) = ALINR
X(4) = T_{T4}	Y(4) = P_{T3M}	P(4) = VOL35
X(5) = F_{AMB}	Y(5) = T_{T3M}	P(5) = VOL4
	Y(6) = W_{3M}	P(6) = AP3
Inputs	Y(7) = P_{T35}	P(7) = BP3
	Y(8) = T_{T35}	P(8) = AP35
u(1) = P_{T3}	Y(9) = W_{35}	P(9) = BP35
u(2) = T_{T3}	Y(10) = P_{T35M}	P(10) = AP4
u(3) = W_{FMB}	Y(11) = T_{T35M}	P(11) = BP4
	Y(12) = W_{T35M}	P(12) = AT3
	Y(13) = P_{T4}	P(13) = BT3
	Y(14) = T_{T4}	P(14) = τ_{T3}
	Y(15) = W_4	P(15) = A_{T35}
	Y(16) = P_{T4M}	P(16) = B_{T35}
	Y(17) = T_{T4M}	P(17) = τ_{T35}
	Y(18) = W_{4M}	P(18) = A_{T4}
	Y(19) = W_{FMB}	P(19) = B_{T4}
	Y(20) = W_{FMBM}	P(20) = τ_{T4}
	Y(21) = Q_{BURN}	P(21) = AWF
	Y(22) = Q_{BURNM}	P(22) = BWF

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a. Airflow Management

The improved heat release calculation "BURN 02" more accurately models the burner physics. The burner airflow is split into several components, illustrated in Figure 1. These include swirler (or fuel nozzle) airflow, primary (or recirculation) zone airflow and intermediate and dilution zone airflows. The swirler airflow is primarily responsible for fuel atomization which, in turn, impacts combustor ignition and stability. The recirculation airflow, a portion of the air entering through the primary holes, is specified to calculate primary zone stoichiometry, which impacts combustor stability, ignition, chemical efficiency, and circumferential flame propagation.

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TABLE 3.

POSTSTALL COMBUSTOR MODEL CANDIDATE PARAMETER SET DIVISIONS

Parameter Name	*Description*
Mode Change Parameters	
CSTAB	Bias on Characteristic Fuel Evaporations/Reaction Times in Stability Equation
CIG	Bias on Steady State Fuel Evaporation/Reaction Times in Ignition Criterion Equation
CIGE	Scale Factor on Evaporation Time in Ignition Criterion
CIGC	Scale Factor on Reaction Time in Ignition Criterion
Combustor Physical Parameters	
FPHPT	Resistive Area at Exit
ADIFF	Resistive Area at Inlet (Diffuser Dump Loss)
ALINR	Burner Liner Loss
VOL 35	Outer Case Volume
VOL 4	Liner Volume
CPROP	Scale Factor on Flame Propagation (Percent Burning)
CIGDLY	Ignition Delay for Autoignition
CSTABE	Scale Factor on Fuel Evaporation Time (Heat Release)
CSTABC	Scale Factor on Fuel Reaction Time (Heat Release)
CTAU	Bias on Heat Release Lag
CTAUM	Scale Factor on Mining Time (Heat Release)
CEFFA	Quadratic Combustion Efficiency Correlation Term
CEFFB	Linear Combustion Efficiency Correlation Term
DELEFF	*Bias on Combustor Efficiency*
BOTIME	Time of Blowout
Sensor Model Parameters	
AP3	Diffuser Total Pressure Measurement Scale Factor
BP3	Diffuser Total Pressure Measurement Bias Factor
TAUP3	Diffuser Total Pressure Measurement Time Constant
AP35	Outercase Total Pressure Measurement Scale Factor
BP35	Outercase Total Pressure Measurement Bias Factor
TAUP35	Outercase Total Pressure Measurement Time Constant
AP4	Linear Total Pressure Measurement Scale Factor
BP4	Linear Total Pressure Measurement Bias Factor
TAUP4	Linear Total Pressure Measurement Time Constant
AT3	Diffuser Total Temperature Measurement Scale Factor
BT3	Diffuser Total Temperature Measurement Bias Factor
TAUT3	Diffuser Total Temperature Measurement Time Constant
AT35	Outercase Total Temperature Measurement Scale Factor
BT35	Outercase Total Temperature Measurement Bias Factor
TAU35	Outercase Total Temperature Measurement Time Constant
AT4	Linear Total Temperature Measurement Scale Factor
BT4	Linear Total Temperature Measurement Bias Factor
TAUT4	Linear Total Temperature Measurement Time Constant
AWF	Fuel Flow Measurement Scale Factor
BWF	Fuel Flow Measurement Bias Factor

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b. Heat Release Routine Logic

The basic combustor physical processes that are modeled are contained in the program's heat release routine. Figure 12 shows how the improved heat release calculation fits into routine "STATIC" of the main program. STATIC is used to calculate steady-state combustor parameters. The heat release routine is employed to evaluate the state of the combustor (lit or

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unlit) and combustor heat release at each time step. Referring to Figure 13, supporting variables for the various combustor correlations are first calculated, after which the state of the combustor at the previous time step is checked.

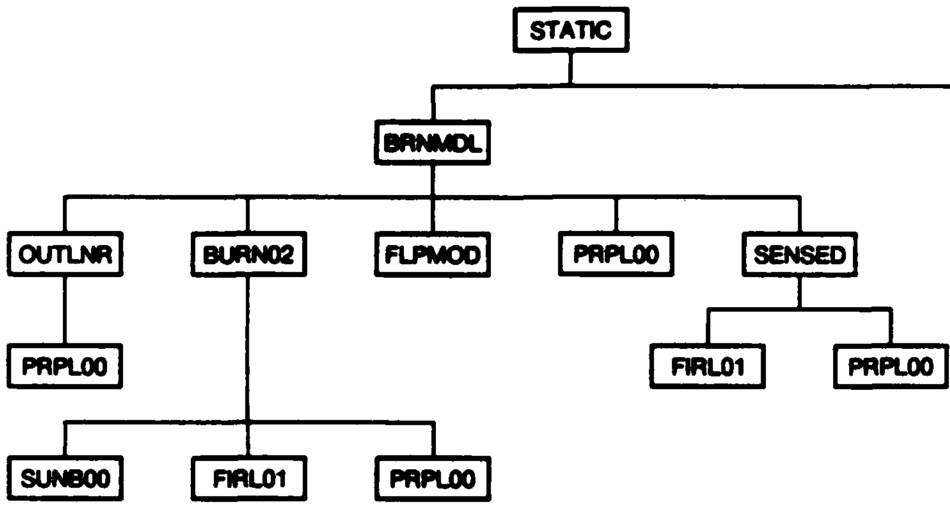

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Figure 12. — Revised Routine STATIC Including Improved Heat Release Subroutine BURN02

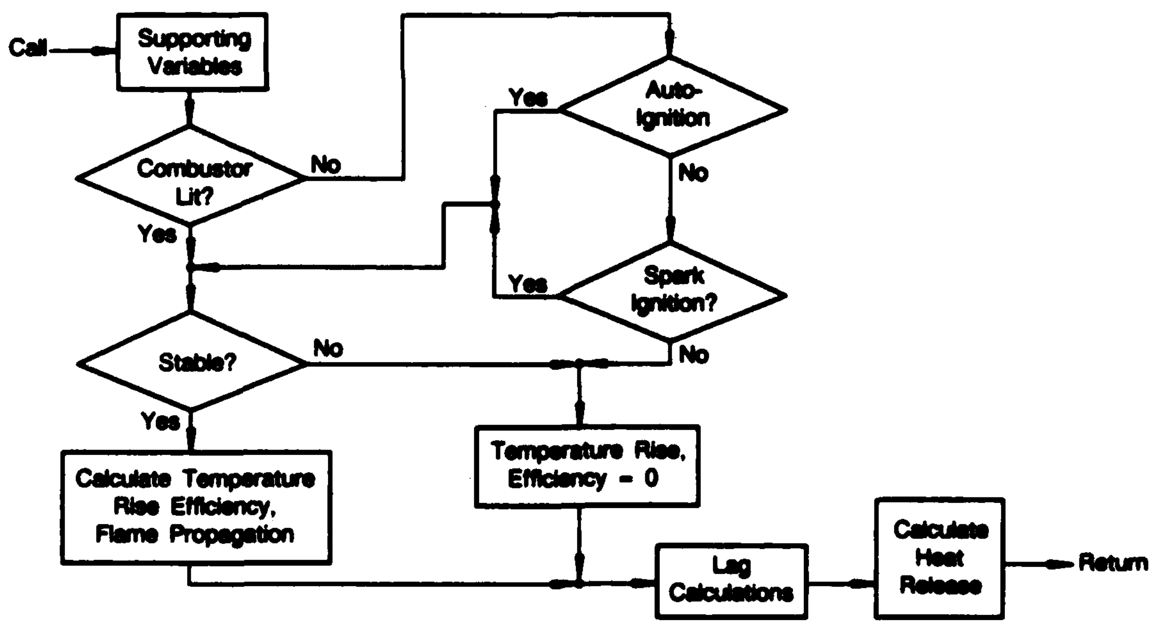

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Figure 13. — Simplified Flow Diagram for Heat Release Routine

If the burner is not lit, conditions in the primary zone are examined to determine if they are favorable for autoignition. If not, the potential for spark ignition is checked. Since the ignitor does not operate continuously, an evaluation of the occurrence of spark ignition includes an

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assessment of whether or not the ignitor has fired between the previous and present time steps, as well as an examination of primary zone conditions. Should it be determined that autoignition and spark ignition do not occur, temperature rise and efficiency are equated to zero, and time lag calculations are made.

If the combustor is found to be lit at the previous time step or if autoignition or spark ignition occurs, conditions in the primary zone are examined to determine if stable operation is possible at the present time step. If not, combustor blowout occurs, efficiency and temperature rise are equated to zero, and time lag is calculated. If stable combustion is possible, chemical efficiency, combustor temperature rise, and the extent of flame propagation around the combustor annulus are determined prior to the time lag/heat release calculations. The flame propagation calculation does not apply when the combustor has been lit as a result of autoignition. In this case, it is assumed that conditions are favorable for autoignition at multiple locations around the circumference of the burner, and propagation is instantaneous. If the combustor lights via spark ignition, however, the time required for the flame front to propagate around the annulus is taken into account.

A description of the correlations used to evaluate the various physical processes referred to above is provided in the following section.

c. Heat Release Routine Correlations

The heat release routine first calculates a number of supporting variables which include:

- Inlet air properties
- Atomization characteristics (Sauter mean diameter)
- Turbulent intensities within the combustor
- Fuel droplet Reynolds number
- Mass transfer numbers
- Effective primary zone fuel-air ratio (based on the fraction of vaporized fuel).

These parameters are necessary to evaluate the various combustor physical processes discussed in the following paragraphs.

(1) Spark Ignition

The ignition and stability models use the characteristic time approach presented by Ballal and Lefebvre and correlated to many P&W commercial and military aircraft gas turbine engine data by Andreadis. This approach was viewed as being the simplest to incorporate while exhibiting the important physics with flexibility. The spark ignition model states that for ignition to occur, the passage of the spark must create a small, roughly spherical volume of air (spark kernel) with a sufficiently high temperature to initiate evaporation and chemical reaction. If the rate of heat release by combustion exceeds the rate of heat loss by thermal conduction and turbulent diffusion, then the kernel grows to a size capable of flame propagation. The ignition is successful when the time required for the fuel to evaporate (τ_e) and chemically react (τ_c) is less than (on an order basis) the time required for the cold mixture to quench the spark kernel (τ_q) by thermal conduction turbulent diffusion. In equation form:

$$\tau_q > C_1 + C_2\tau_c + C_3\tau_e \text{ (msec)} \quad (1)$$

where C_1, C_2, and C_3 are constants of proportionality or "free variables" which were determined by Andreadis to be:

$$C_1 = 0.0$$
$$C_2 = 0.1$$
$$C_3 = 1.0$$

The spark kernel quench time (τ_q) was defined as the ratio of the heat capacity of the spark kernel divided by the average rate of heat loss from the kernel by thermal conduction and turbulent diffusion, i.e.:

For moderate turbulence:

$$\tau_q = \frac{d_q^2}{8(\alpha + 0.08\, u' d_q)} \text{(msec)} \tag{2}$$

For high turbulence, this reduces to:

$$\tau_q = \frac{d_q}{0.64u'} \text{(msec)} \tag{3}$$

where:

$$d_q = \left[\frac{6E}{\pi Cp_a \rho_a \Delta T_{st}}\right]^{1/3} \tag{4}$$

and

$$u' = 0.75\bar{u} \tag{5}$$

The droplet evaporation time (τ_e) is defined as the ratio of the mass of fuel present to the average rate of fuel evaporation for polydisperse spray. Thus according to Ballal and Lefebvre, the droplet evaporation time is given:

$$\tau_e = \frac{Ce_3^2\, \rho_f\, Cp_a\, (SMD)^2}{8Ce_1 K_a \varphi \log(1 + B)(1 + 0.25\, Ce_2^{0.25}\, Re^{0.5})} \text{(msec)} \tag{6}$$

where the mass transfer number (B) is defined as the available vaporization energy divided by the energy required to vaporize the fuel. In equation form:

$$B = \frac{Q_{av}}{Q_r} \tag{7}$$

The energy required to vaporize the fuel is stated as:

$$Q_r = L_s + Cp_L(T_3 - T_0) = L_0 + Cp_v(T_3 - T_0) \tag{8}$$

The energy available to vaporize the fuel is calculated by:

$$Q_{av} = (M_{st}\, H/r) + Cp_L(T_3 - T_s) \tag{9}$$

The constants used in the evaporation equation, Ce_1, Ce_2, and Ce_3 are:

$Ce_1 = 0.31$
$Ce_2 = 0.21$
$Ce_3 = 0.46$

The characteristic reaction time calculation is dependent upon the relative value of the root mean square of the fluctuation velocity and the laminar and turbulent flame speeds.

$$\tau_c = \frac{12.5\alpha}{(S_L - 0.16u')^2} \quad \text{for } u'<2S_L \tag{10}$$

or

$$= \frac{15.6\alpha}{u'(S_T - 0.63u')} \quad \text{for } u'>2S_L \tag{11}$$

where the laminar flame speed is determined from a P&W relationship:

$$S_L = S_{L0}\left(\frac{T_3}{T_{30}}\right)^{1.4}\left(\frac{T_{fl} - T_3}{T_{fl0} - T_{30}}\right)^{-1.4} \exp\left(-2\times10^4/T_{fl} + 2\times10^4/T_{fl0}\right) \tag{12}$$

From propane and ethane data

S_{L0} = 38 cm/sec
T_{fl0} = 4114°R
T_{30} = 540°R

and the flame speed correlated for combustor turbulent intensity using the Shchelkim model as follows:

$$S_T = S_L\left[1 + \left(\frac{u'}{S_L}\right)^2\right]^{0.5} \tag{13}$$

(2) Stability

For the combustion stability model, the stabilization process is viewed as occurring in the shear layer surrounding the combustor recirculation zone by way of turbulent mixing of fresh reactants and hot products and partially oxidized fuel. The stability criterion is met when the volumetric residence time (τ_{vhr}) of the hot turbulent eddies present in the shear-layer region is greater then the evaporation time (τ_e) plus chemical reaction time (τ_c) (on an order basis). In equation form:

$$\tau_{vhr} > C_4 + C_5\tau_c + C_6\tau_e (\text{msec}) \tag{14}$$

where C_4, C_5, and C_6 were found experimentally by Andreadis to be:

$C_4 = 0.0$
$C_5 = 5.0$
$C_6 = 5.0$

The volumetric hot residence time (τ_{vhr}) is defined as the ratio of the primary zone volume divided by the airflow through the primary zone times the gas density. In equation form:

$$\tau_{vhr} = \frac{V_{pz}\rho_g}{Wa_{pz}} \text{(msec)} \tag{15}$$

(3) Autoignition

The autoignition correlation employed in the current model is based on the work of Spadaccini and TeVelde. In this correlation, the residence time of the unreacting fuel-air mixture (τ_{vhr}) is compared with the ignition delay time (τ_{id}). When (τ_{vhr}) is equal to or greater than (τ_{id}), autoignition occurs. In equation form:

$$\tau_{vhr} > \tau_{id} \text{(msec)} \tag{16}$$

Ignition delay time is defined as:

$$\tau_{id} = \frac{A}{p^2} \exp\left(\frac{E_G}{RT}\right) \text{(msec)} \tag{17}$$

where:

$$A = 2.527\ E - 10 \text{ for JP-4}$$

$$\frac{E_G}{R} = 3.9E + 4$$

(4) Combustion Efficiency

The correlation used for calculating combustion efficiency was developed by P&W and has been successfully applied to several commercial engine combustors. In this correlation, combustion or chemical efficiency (η) is dependent on air loading parameter (ALP) as follows:

$$1/\eta = 0.9943 + C_7(\text{FLPX}) + C_8(\text{FLPX})^2 \tag{18}$$

$$\text{FLPX} = \text{ALP}\varphi_{pz}\, 10^{(-0.00079\ \eta\ \Delta T_g)} \tag{19}$$

$$\text{ALP} = \frac{3.72\ Wa_b}{P_{T3}^{1.8}(\text{VOL})\, 10^{(0.000794\ T_{T3})}} \tag{20}$$

where the constants C_7 and C_8 are for the PW2037 and were adopted here because the F100(3) system is being modeled and also has an airblast fuel nozzle system.

$C_7 = -1.963$
$C_8 = 2.501$

(5) Flame Propagation

The time required for flame propagation around the combustor annulus following spark ignition is calculated from combustor geometry and turbulent flame speed. The percent of the annulus lit is a linear function of time and flame speed.

(6) Combustor Heat Release

The current model calculates heat release due to combustion (Q_{burn}) by employing steady-state ideal temperature rise data and correcting for chemical efficiency and the extent of flame propagation around the annulus. Furthermore, a first order lag is applied to account for transient effects. This method provides a realistic transient temperature rise with minimal computational complexity. An approach requiring a transient solution of the chemical composition equations would be too complex for a system type model. Heat release is calculated as follows:

$$Q_{burn} = W_g C_{pg} PC_B \Delta T_{lag} \tag{20}$$

where:

$$\Delta T_{lag} = \eta \, \Delta T_{ideal} \left(1 - \exp \frac{-t}{\tau_e + \tau_c + \tau_q}\right)(PC_B) \tag{21}$$

The lag time (τ_{lag}) is a function of evaporation, chemical reaction, and combustor residence times as follows:

$$\tau_{lag} = C_9 + C_{10}\,\tau_{res} + C_{11}\,\tau_e + C_{12}\,\tau_c \tag{22}$$

where:

$C_9 = 0.0$
$C_{10} = 5.0$
$C_{11} = 5.0$
$C_{12} = 1.0$

2. LIMITATIONS OF THE MODEL

While much progress is being made regarding the development of the P&W combustor dynamic model, there are a number of model aspects which require further efforts. First, the model does not include the required physics for assessing the impact of fuel boiling on combustor transient behavior. The model is currently configured only for constant (liquid) fuel flowrates. Second, the model does not have the capability of handling multiple fuels. Although most of the correlations employed are dependent upon fuel properties, the model fuel property library contains only a single propellant (JP-4) at present. Third, the model does not have the capabililty to simulate multiple combustor configurations. With the exception of the efficiency correlation, the model uses variables rather than empirical constants to account for the influence of combustor geometry. However, the combustor/fuel nozzle swirler geometry, inside/outside liner volumes, and airlfow splits libraries are currently limited to one configuration — the F100(3).

SECTION V

SYSTEM IDENTIFICATION BACKGROUND

1. INTRODUCTION

System identification is a powerful technique used to validate and enhance computerized models of dynamic systems. Techniques have been developed which allow definition of system test procedures, identification of model structures and parameters which simulate the dynamic system, and evaluation of the uncertainty and sensitivity of the identified model. The system identification procedure represents an integrated approach to the problem of modeling and understanding uncertain dynamic phenomena. State-of-the-art system identification procedures and theory are discussed in this section.

2. SYSTEM IDENTIFICATION PROCEDURE

Figure 14 illustrates the integrated system identification procedure which is applicable to a wide variety of dynamic systems. The system identification process consists of an iterative loop of test planning, actual testing, and data processing. There are two feedback loops in the process which may be vital to the success of the system identification. An inner loop, closed during data collection, checks the quality of the data produced in the tests. This checking is done in real or nearly real time. If the quality of the data is determined to be poor, then corrections to the testing procedure can be made while the test crew and facilities are still available.

An outer loop around the entire identification process is also closed. For the first pass through the identification process, a model structure is chosen. Given an initial model structure, test input and sensor specifications may be generated. As the model structure and parameter values are iterated upon, the characteristics of the model which result may indicate that different input signals or sensors are required for complete model identification. If this is the case, then additional tests are required.

A key component of the identification process is the estimation of system parameters. The theory of parameter estimation is presented in the following section.

3. PARAMETER ESTIMATION THEORY

The techniques used to identify model parameters from transient data are drawn directly from parameter estimation theory developed at SCT. This section briefly summarizes the concepts of parameter estimation and identification sensitivity. Sensitivity tools are used to determine the effects of instrumentation (e.g., noise, sample rates, lags) and model structure (e.g., tri-modal models, nuisance parameters) on the identification process.

The basic idea in system parameter identification is to find model parameters that make the model results match the actual data as closely as possible. Parameters identified by SCT's parameter estimation algorithm, SCIDNT, represent maximum likelihood values of the estimated parameters. That is, the identified parameters that make the model best follow the unknown system are, most likely, the actual parameters of the plant.

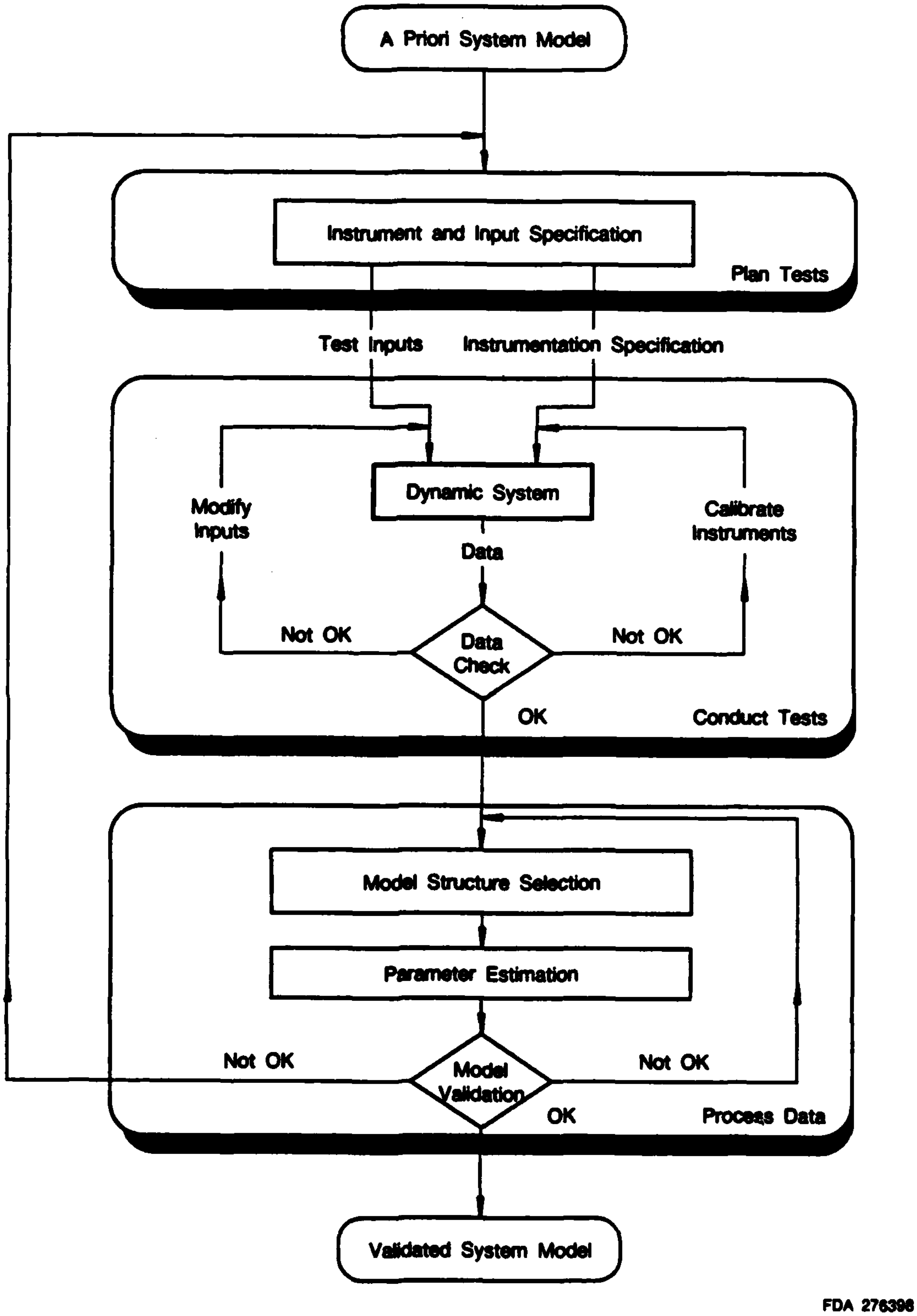

Figure 14. — Integrated System Identification Procedure

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Stated mathematically, the problem is equivalent to minimizing a performance index, the error between measured plant outputs and corresponding model outputs:

$$L_s(\theta) = \sum_{1}^{N} (y - \hat{y}) \qquad (23)$$

where $\dot{x} = f(x, u, \omega, t, \theta)$

and $\hat{y} = h(x, u, t, \theta) + \upsilon$

N = Number of data points
x = nx states
y = ny outputs
u = nu inputs
θ = np $\times$ 1 parameter vector
t = Time
ω = nx $\times$ 1 process noise vector
υ = ny $\times$ 1 output noise vector

$E(\omega) = 0 \qquad E(\omega\ \omega') = Q$
$E(\upsilon) = 0 \qquad E(\upsilon\ \upsilon') = R$

where E is the expected value

and $E[x\ x']$ is the covariance matrix.

The estimated plant outputs are determined by using both state equations and output measurements.

If ω and υ are Gaussian, then the performance index in Equation 23, can be expressed as a likelihood function (Equation 24). This likelihood function is Gaussian and indicates the likelihood (probability) that a certain parameter set, θ, has produced the measured data, y. Since θ is the random variable here, the likelihood function covers np-space, and instead of a single normal curve, the function is actually an np-space surface.

$$L(\theta) = N \frac{\exp(-\upsilon^2/2\sigma^2)}{2\pi\sigma} \qquad (24)$$

To find an optimal set of parameters, the likelihood function in Equation 24 must be maximized, i.e., a θ must be found which gives the largest value of L. Equation 24 can be maximized as is, but a simpler approach considers the negative log of Equation 24. Finding the minimum of the negative log likelihood function is equivalent to finding the maximum of the likelihood function:

$$J(\theta) = -\ln L(\theta)$$

$$\min J(\theta) = \max L(\theta)$$

where:

$$J(\theta) = \sum_{1}^{N} (\upsilon \upsilon R^{-1} + 2 \ln R^{1/2}) \tag{25}$$

J = Negative log likelihood (cost function)
υ = $Y - Y(\theta)$
$Y(\theta)$ = Model outputs
θ = Model parameters
Y = Plant measured outputs
R = $E(\upsilon\ \upsilon)$ = Covariance of measurement noise.

Minimizing the negative log likelihood is a least squares problem, very similar in form to Equation 23, the general optimization problem. Because υ and ω are Gaussian, the relationship in Equation 25 still produces maximum likelihood parameter estimates.

The maximum likelihood parameters occur where J is at a minimum. Finding this minimum requires the use of the gradient of J since the minimum of J occurs where the gradient (slope) of J is zero. The parameter identification algorithm is based upon finding where the gradient of J is zero:

$$\frac{\partial J}{\partial \theta_{final}} = 0 \tag{26}$$

SCIDNT, the SCT algorithm, uses a Gauss-Newton method to converge to gradient zeros. The convergence follows a first-order iterative algorithm. Consider some initial parameter guess, θ_i, the gradient of J at θ_i, and the Hessian (i.e., the gradient of the gradient, or second partial of J) at θ_i. A first-order guess of where the gradient is zero is

$$\theta_{i+1} = \theta_i - pM^{-1} \times g \tag{27}$$

where: θ = np $\times$ 1 parameter vector
g = Gradient of J
M = Gradient of g and second partial of J
p = a user defined scalar (< 1) used to control the rate of convergence.

Convergence occurs by iterating through the algorithm until the gradient drops below a minimal threshold (e.g., 0.001 percent). The critical problem at this point is, how are the gradient and Hessian determined for a nonlinear model. Differentiating Equation 25 with respect to θ yields the following relationships for the gradient and Hessian (written in matrix form for the jth parameter):

$$g(j) = \sum_{t=0}^{N} \left(\upsilon' R^{-1} \frac{\partial \upsilon}{\partial \theta(j)} - (1/2)\, \upsilon' R^{-1} \frac{\partial R}{\partial \theta(j)} R^{-1} \upsilon + 1/2\, \mathrm{Tr}\, R^{-1} \frac{\partial R}{\partial \theta(j)} \right) \tag{28}$$

$$M = \sum_{t=0}^{N} \left(\frac{\partial \upsilon}{\partial \theta} R^{-1} \frac{\partial \upsilon}{\partial \theta} + \mathrm{Tr} \left(R^{-1} \frac{\partial R}{\partial \theta} R^{-1} \frac{\partial R}{\partial \theta} \right) \right) \tag{29}$$

$$M = \sum_{t=0}^{N} \left(\frac{\partial \upsilon}{\partial \theta} R^{-1} \frac{\partial \upsilon}{\partial \theta} \right) \tag{30}$$

2897C

SCIDNT approximates the gradient and Hessian values by forming estimates of the ν and R partials using a perturbational technique for each parameter θ(j):

$$\frac{\partial \upsilon}{\partial \theta(j)} = \frac{(y(\theta + \Delta\theta) - y) - (y(\theta) - y)}{\Delta\theta(j)} \quad (31)$$

$$= \frac{(y(\theta + \Delta\theta)) - y(\theta)}{\Delta\theta(j)} \quad (32)$$

In effect, SCIDNT propagates two output models, one at θ + Δθ and one at θ. The partial of R is found in a manner similar to that used above. From these approximations and the stepping algorithm, SCIDNT produces maximum likelihood parameter estimates.

The key points regarding identifiability and sensitivity lie in the Hessian. The Hessian is also known as the Fisher information matrix. Its name derives from a unique property where its inverse is the covariance matrix of the estimated parameters. As a result, the square root of M inverse is a measure of the uncertainty of the parameter estimates.

$$M^{-1} = E(\theta\, \theta') \quad (33)$$

$$\text{diag}\, M^{-1/2} = E(\theta) \quad (34)$$

This property is the basis for the identifiability formulae developed in the following subsections.

The uncertainty relationship in Equation 33 is an ideal, i.e., the uncertainty predicted by the information matrix is a minimal value based upon exact model and plant agreement. Any disagreement between model and plant in form or parameter values will be reflected as an increase in uncertainty. However, once the model and plant disagree, the inverse square root of M is no longer a mathematically correct prediction of uncertainty and the values predicted by M will be less than actual uncertainties. More information and background on parameter estimation and applicable algorithms can be found in References 24 through 31.

a. Identifiability

This discussion focuses on the use of the Hessian for developing identification relationships. These relationships relate uncertainty to sample rates, noise levels, and limited sensor sets.

Identifiability is defined as a measure of the likelihood that any estimated parameter is within a specific range of the actual parameter value. Identifiability can also be thought of as a measure of confidence (or uncertainty) in a parameter estimate. This is a more quantitative view of identifiability. Mathematically, uncertainty is expressed as a standard deviation, where a single standard deviation width indicates a 68 percent probability that the actual parameter value is within that width.

2897C

Factors affecting M (and uncertainty) may be understood by expressing M in a different form. The information matrix relationship in Equation 30 equates M to a sum of partial innovation vector products normalized by the measurement noise covariance matrix, R. If R is considered to be diagonal, then Equation 30 can be expanded to a scalar relation where each measurement (or innovation) contribution is seen separately:

$$M = \sum_{j=1}^{m} \frac{1}{\sigma(y)^2} \left(\sum_{i=1}^{N} \left(\frac{\partial \upsilon}{\partial \theta} \right)^2 \right) \tag{35}$$

In this form, the relationships between parameter uncertainty, number of data points (N), number of measurements (m), and measurement noise level (σ(y)) are more clearly visible. Generally speaking, parameter uncertainty decreases with 1/ (N), i.e., the ability of the parameter estimation algorithm to identify a parameter accurately will improve with the square root of N. One simple way to increase the number of data points is to use a higher sample rate. The number of points can also be increased by making several runs under the same conditions. In this approach, even though sample rate has not changed, the number of data points for the same type of information has increased. Other conditions impinge upon the selection of sample rate minimums, but generally, identification can be improved without increasing sample rates by using multiple identification runs (i.e., multiple maneuvers).

Equation 34 indicates that uncertainty decreases as the number of outputs is increased — not a very surprising result. Equally predictable is the fact that uncertainty increases with measurement noise. In fact, uncertainty increases in direct proportion to overall increases in measurement noise levels.

The term within the highest level brackets in Equation 34 has a unique characteristic. From Equations 31 and 34 it is apparent that this term is only dependent on the model output and the number of data points. Thus, if θ is near the actual θ, *then the values for each output* j are constant. This is illustrated by rewriting Equation 34:

$$\sigma(\theta) = \sum_{j=1}^{m} \frac{m(\upsilon,\theta)}{\sigma(y)} \tag{36}$$

where m(υ, θ) is the contribution of the jth innovation over the entire measurement period (N points) and σ(y) is the noise level associated with the jth measurement.

Since m(υ, θ) is constant near θ actual, it is possible to relate uncertainty changes to various combinations of sensor noise levels. In fact by making σ (y) very large, it is possible to see how uncertainty will change without the contributions of a sensor, i.e., what happens to uncertainty under limited sensor sets.

This completes the development of identifiability formulae. These results are used later in this report to explain how uncertainty is quantified. The following section uses the information matrix to show how modeling errors affect identification. Together, these identifiability and sensitivity tools explain a great deal about how successful an identification will be and how identification can be improved.

b. Sensitivity

The effect of an error in a parameter that is assumed known on the identification of another is called parameter sensitivity. For in-stall engine parameters, the effects of biased or incorrect parameters are substantial. Parameters being identified (affected) are customarily called "estimate parameters" θ; remaining (affecting) parameters are called "nuisance parameters" (φ). As with identifiability, answers to the sensitivity problem are found within the Fisher information matrix.

The information matrix defined in Equation 30 is an np × np matrix, for np model parameters. If only ne parameters are being estimated, M can be rearranged and partitioned as follows:

$$M_{12} = \begin{array}{c} \\ ne \\ nn \end{array} \begin{array}{c} \begin{array}{cc} ne & nn \end{array} \\ \left[\begin{array}{c|c} M_{11} & M_{12} \\ \hline M_{21} & M_{22} \end{array}\right] \end{array} \tag{37}$$

where:
- ne = Number of estimate parameters
- nn = Number of nuisance parameters
- np = ne + nn

M_{11} is the Fisher information matrix that relates the changes in J due to changes in only the estimate parameters, θ. During parameter identification, only M_{11} (the portion of the information matrix which pertains to the parameters being identified) is used.

A relationship between θ and σ can be found by using other portions of the information matrix (namely M_{12}) in conjunction with M_{11}. M_{12} can be expressed as:

$$M_{12} = E\left(\frac{\partial J}{\partial \theta}\frac{\partial J'}{\partial \varphi}\right) \tag{38}$$

Combining the information in M_{11} and M_{12} yields

$$X_b = M_{11}^{-1} M_{12} = E\left(\frac{\partial \theta'}{\partial J}\frac{\partial \theta}{\partial J}\frac{\partial J}{\partial \theta}\frac{\partial J'}{\partial \varphi}\right)$$

$$= E\left(\frac{\partial \theta}{\partial \varphi}\right) \tag{39}$$

where X_b = bias matrix.

The bias matrix indicates how much the estimate parameters change for a unit change in the nuisance parameters. Equation 38 is the exact solution for the scalar case (J, θ, and σ scalars) and has similar interpretations in the general matrix case. Equation 38 can now be used to estimate the effects of biased parameters on the estimation of other parameters. For the worst case results, the absolute value of each element in the product of X_b and σ is taken. The worst case estimate parameter (θ) errors are:

$$\text{Worst Error} = |M_{11}^{-1} M_{12}|\ |\Delta\varphi| \tag{40}$$

where Δφ is the change in off nominal.

Equation 39 is the primary means used in analyzing potential effects of nuisance parameter errors. A typical application would be the effect of a change in a sensor time constant. For example, assume T_{T4} has a modeled time lag constant of 100 milliseconds, but the actual sensor time constant is 120 milliseconds. How might this nuisance parameter error bias estimates of poststall combustor parameters? Questions of this type are addressed in a subsequent section of this report.

4. SUMMARY

In the past ten years, system analysis tools have been developed and implemented which are directed toward system identification. The tools include algorithms for mathematical model structure determination, parameter estimation, and test planning. A unified approach to the problem of understanding uncertain dynamic phenomena has been formulated using these analysis techniques. Application of system identification to combustor poststall operation is discussed in the remainder of this report.

SECTION VI

APPLICATION OF SYSTEM IDENTIFICATION PROCEDURES

1. INTRODUCTION

The application of system identification techniques to the poststall combustor model required extensions of the system identification procedure. Because the combustor can operate in different discrete modes such as blown out or ignited from spark or autoignition, special care is required to ensure the success and validity of system identification analysis. The system identification techniques developed in this program to accommodate the complicated nature of the combustor model are detailed in this chapter. Included are discussions of model parameterization, separation of the discrete combustor modes of operation, and classification of model parameters by function in the model. Inclusion of the combustor model into SCIDNT is the first topic presented.

2. LOADING THE MODEL INTO SCIDNT

Prior to inserting the Generic Poststall Combustor model into SCIDNT, the simulation was run on the VAX 11/785 to verify correct operation and to generate test cases to verify the output of the SCIDNT resident simulation. This initial evaluation was completely successful. The simulation matched test case results provided by P&W exactly.

Following simulation installation and testing on the VAX 11/785, the combustor model was loaded into SCIDNT. Out of foresight and necessity, SCIDNT was designed with modularity in mind. SCIDNT subroutines are modular and generic so that dynamic simulations such as the combustor poststall model are easily incorporated.

SCIDNT requires three subroutines as inputs:

(1) STATE
(2) STATIC
(3) MEAS.

Inputs and outputs of these three required SCIDNT subroutines are shown in Table 4. STATE calculates the state derivatives (XDOT). Inputs to STATE include the past states (X), the vector of model parameters (P), and the input control vector (U). STATIC is the SCIDNT initial condition module called at the beginning of each propagation to determine the system initial states. Inputs to STATIC are the input control vector and the model parameter vector. MEAS, the third required SCIDNT module, takes the current state, state derivatives (XDOT), the control input vector, and the vector of model parameters as inputs. The measurement vector (Y) is the MEAS output. Note that any parameter in the P vector can be identified, and SCIDNT is capable of identifying up to 50 parameters simultaneously.

TABLE 4.

INPUTS AND OUTPUTS OF THE REQUIRED SCIDNT SUBROUTINES

Subroutine	*Input*	*Output*
STATE	X, P, U	XDOT
STATIC	U, P	XINITIAL
MEAS	X, XDOT, U, P	Y

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A sample of the STATE, STATIC, and MEAS subroutines from the combustor simulation can be found in Appendix B of this report. These subroutines demonstrate the organizational complexity resulting from dividing the highly modular and flexible code across its many designed boundaries.

The Generic Poststall Combustor model was created expressly for use in the SCIDNT identification code. The model was written with the STATE, STATIC, and MEAS routines in the code. This greatly simplified the installation of the combustor model in SCIDNT. There were, however, a number of changes which were required to ensure proper operation of simulation within the parameter estimation code.

The modifications made to the combustor simulation are conceptually simple but required a good deal of effort to implement and test. The simplest change was to convert all real variables and FORTRAN functions to double precision. This is done as a matter of course in parameter estimation work at SCT to allow maximum numerical accuracy.

The major area of modification of the combustor simulation was to eliminate all reliance of the code on memory between subroutine calls. That is, any code which assumes that on the next pass through that piece of code the variables will still have the values they had on the previous pass. This is characteristic of first order lag approximations and flags which control discrete mode changes. The reason that this is required is that SCIDNT calls the simulation $N\theta$ times at each time step. Once for each perturbed model corresponding to each perturbed parameter to be identified. SCIDNT was written in this way to conserve memory usage. The SCIDNT code computes the $N\theta \times NX$ state derivatives at each time step and integrates $N\theta$ models together. Thus, the code must have all dependence on "memory" in variables (that values will not change between time steps) replaced by vector variables which are indexed by the perturbed model number.

As an example, the combustor ignition condition is stored in the flag MBLITE. If MBLITE equals 0, the combustor is blown out. If MBLITE equals 1, the combustor was ignited by a spark, and if equal to 2, the combustor was ignited by autoignition. SCIDNT will call the simulation with the nominal parameter values and then call it repeatedly using the parameter set with one value perturbed at a time. Then one time step will be integrated over. If on a given call the perturbed parameter value makes the combustor blow out, then MBLITE equals 0. If there isn't a separate MBLITE for each model, on the next call the combustor will be out by virtue of the previous call, which is not correct for the next model.

The combustor model was carefully examined to determine all occurrences of this type of assumed "memory" and, where found, scalar variables were replaced by vectors indexed by the propagation number. The total number of such terms was 18. The SCIDNT code was modified to pass a flag (IPROP), corresponding to the current propagation number, to the STATE, STATIC, and MEAS routines. This flag is used to index the vectors of memory variables.

A related change was required to assure that the correct outputs would be produced for each perturbed model. The simulation was written so that outputs were not computed at the end of a time step, but rather the subroutines were called just to pass the output values to the output routine. This is equivalent to saying that all outputs of the simulation require memory. Model states were already stored for each propagation by SCIDNT, but all non-state outputs were made vectors indexed by propagation number.

In addition to modifying the combustor simulation to account for "memory" variables, the SCIDNT code was modified to use the fourth order Runge-Kutta integration routine which came in the simulation. This was done because the simulation was written so that first order lag approximation would not be updated during intermediate integration time steps based on flags from this integration routine. By using the simulation integration routine, this work was not repeated and debugged for the SCIDNT integration routine. Also, the performance of the simulation using this type of integration and the corresponding integration step site were known to be good.

The operation of the combustor simulation was verified against the stand-alone simulation which was mounted and tested on SCT's VAX 11/785. The outputs of the stand-alone and SCIDNT simulations were found to correspond exactly. SCIDNT simulation response to a 20 Hz, 250 lb/in.^{2} amplitude sinusoid in inlet total pressure, with inlet total temperature and fuel flow fixed at 1000°R and 2.78 lbm/sec respectively is shown in Figure 15. Comparison of exit total temperature, T_{T4}, between the stand-alone and SCIDNT simulations is presented in Figure 16. The outputs overplot each other exactly.

3. MODEL PARAMETERIZATION

In order to be able to perform identification, the model of interest must be described in a set of constant parameters which can be identified from test data. The combustor simulation was written so that most combustor dynamic characteristics are computed as a function of constant parameters which are usable in parameter estimation.

The choice of which model terms to make the candidates for parameter estimation is made at the highest level based on the purpose of the model and a knowledge of the physics of the system. In this program, the initial choice of parameters was made by Pratt & Whitney after consultation with SCT. This is a large set of all likely parameters of interest.

The process of choosing which model parameters to make the identified parameters in the estimation effort is discussed in Section VII.4a of this report.

Many parameters which comprise a dynamic engine simulation, especially one formed from test data, are scheduled or stored for data table lookup. (An example in the poststall combustor model is the fuel to air ratio for a given operating condition.) These characteristics must be described by a fitted equation in constant parameters to be identifiable through parameter estimation. Characteristics of this type would probably be generated from combustor rig testing and would require this type of formulation to allow identification.

4. COMBUSTOR MODES

Based on experience with identification of poststall compressor models and from observed poststall test data, the discrete modes of combustor operation have been separated for analysis. The model parameter identifiabilities have been evaluated in each mode of operation separately, assuming that the combustor could be tested in this manner. The discrete modes of operation are: blown out, ignited by spark, and ignited by autoignition.

The change of operating mode in the combustor, e.g., blowout, has very dramatic effects on virtually all outputs. This is very similar to the effect of stall occurring in the compressor. SCT has found that a parameter which describes a discrete and dramatic event such as combustor blowout or compressor stall must be identified after the parameters which describe the continuous, nominal system operation are identified. This is because a small error in a parameter which controls the discrete change can create very large output errors. If the outputs are very much in error, the partial derivatives used for parameter estimation will be in error and the parameter estimation algorithm will be unable to converge to the correct parameter values. In addition, if there is any significant model structure error in the equations which control the discrete mode change, the true parameter values for each mode change will be different. The parameter estimation algorithm will be unable to hit this "moving target," and each incorrect mode change will disrupt the estimation process of the parameters.

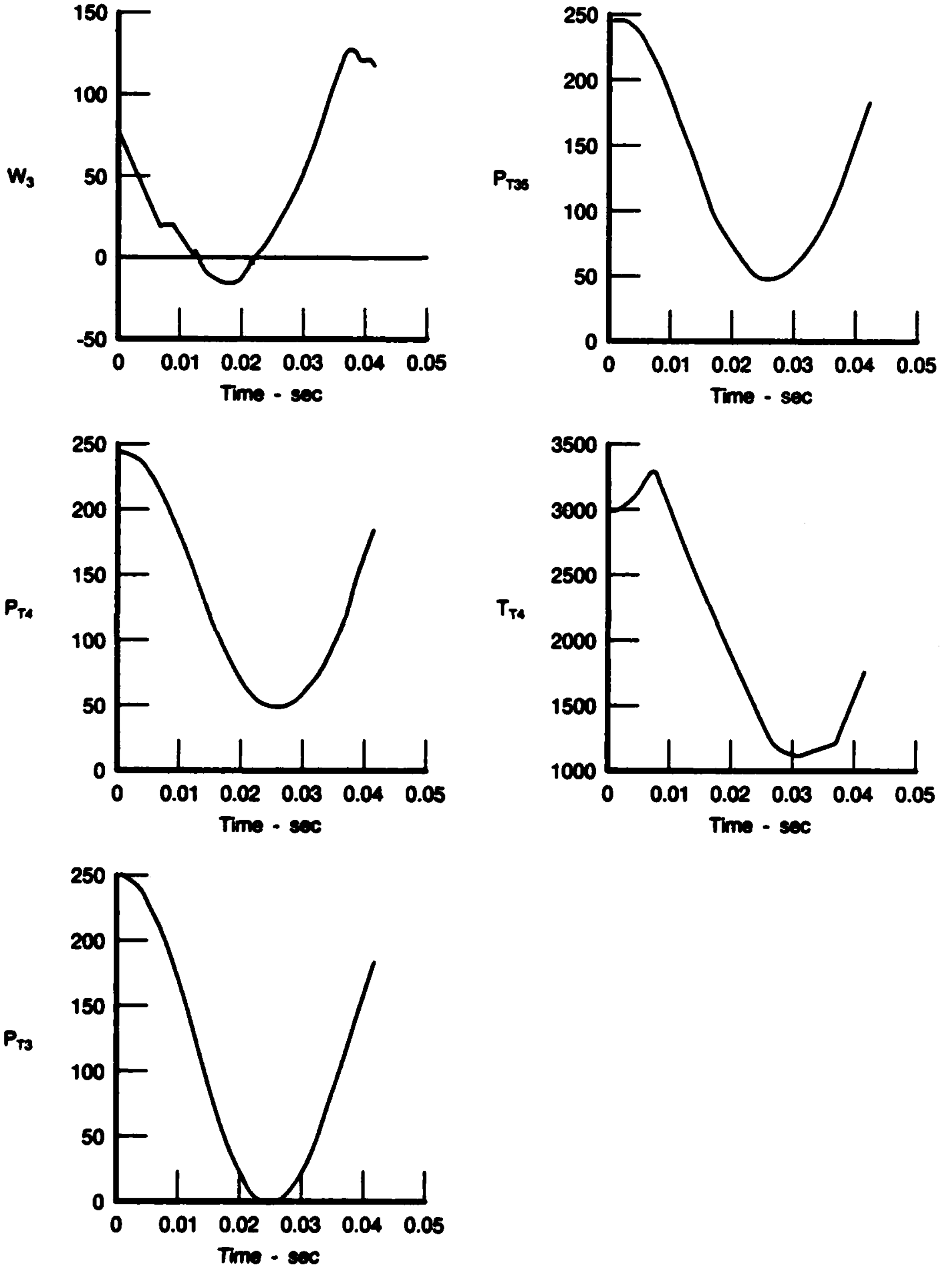

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Figure 15. — Poststall Combustor Simulation Outputs for 20 Hz, 250 psia P_{T3} Sinusoid

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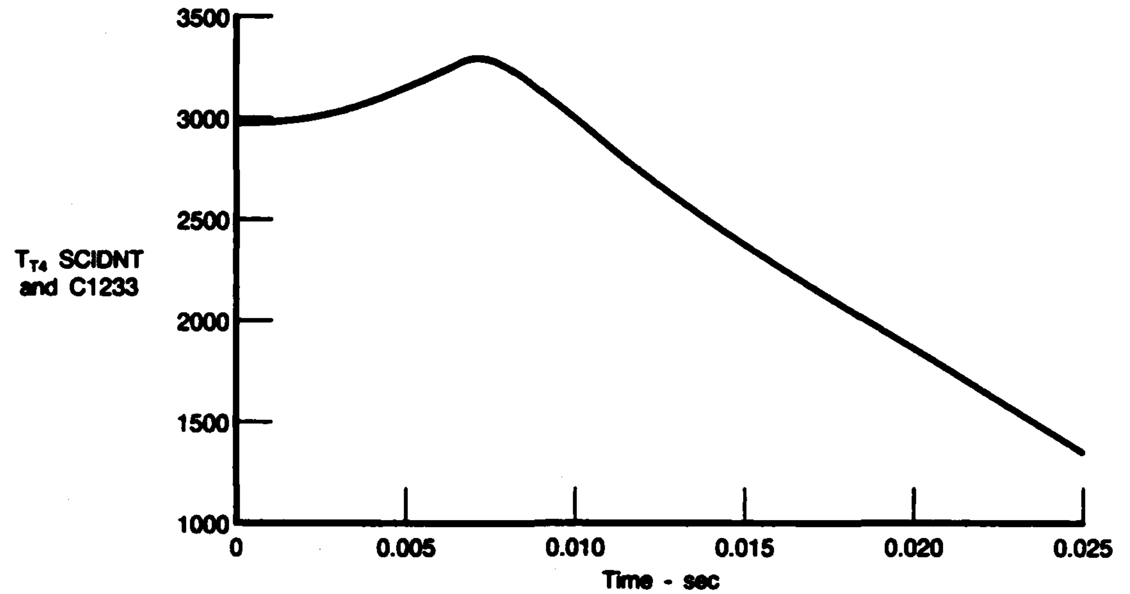

Figure 16. — Overplot of SCIDNT and Stand-Alone Combustor Simulation T_{T4} Output

The poststall combustor model parameters which affect only off mode change equations are few. These are CSTAB, a constant bias term in th. test for combustor stability, and CIG, CIGE, and CIGC constants in the spark ignition criteria equation.

For this program, it was assumed that the combustor could be tested separately in blownout, ignited by spark, and ignited by autoignition modes, or, alternately, that mode could be detected through use of an UV probe and then fixed in the model to match test data during estimation. All parameters but those listed above could be identified in the appropriate modes, and then the "pre-tuned" model could be used to estimate the mode change parameters separately. This is justifiable because no error in the mode change variables will bias the remaining parameter estimates. This is evident if no mode change occurs during the test, but, even if a mode change does occur, it will be forced in the model at the same time. This requires a measurement of the time of mode change. An accuracy requirement for this measurement is discussed in Section VII. It is important to realize, however, that this is really unnecessary since estimation of all but the mode controling parameters can be done without a mode change occurring during testing.

5. PARAMETER CLASSIFICATION

One further subdivision is made in parameter types for this program. This is to divide the non-mode controlling parameters into the physical combustor parameters such as volumes, areas, and reaction times and into sensor model parameters such as sensor bias, scale factor, and time constant. This is done for clarity since these three divisions of parameters are treated differently in the test evaluation process. A summary of the poststall combustor model candidate parameter set division is presented in Table 3.

A comment should be made regarding the importance of modeling the sensors used in testing. Sensors are subject to a variety of errors that degrade both state and parameter estimation accuracies. Reference 35 presents an analytical technique to determine the effect of sensor errors on estimation accuracies. Both random (e.g., additive uncorrelated noise in

2270C

measurements) and systematic (e.g., instrument bias or scale factor) errors are treated. One important conclusion is that systematic errors of relatively small magnitude in comparison with random errors can cause significant parameter estimation bias. If such systematic errors are unavoidable, then parameters modeling them can be added to the set of total parameters to be estimated. This technique can reduce overall parameter estimation uncertainty. For this reason, detailed sensor models have been included in the poststall combustor model.

Sensor lags, particularly in temperature probes, are an inevitable nuisance in parameter identification. Unless sensor dynamics are explicitly modeled, the error between estimated and measured combustor response will hamper identification efforts. The type of sensor model used depends on the measurement dynamics in question. First-order lags, scale, and bias errors are modeled for all of the sensors in the combustor model used in this program.

6. SUMMARY

This program required several procedural extensions to accommodate the combustor model in the system identification process. The topics discussed exemplify those procedures required to apply SCIDNT and the overall system identification process to highly complicated nonlinear system models. These modifications also require a very good understanding of the parameter estimation process and the physics and model structure of the poststall combustor — and therefore close teamwork between the engine modeling, parameter estimation, and testing personnel.

SECTION VII

TEST EVALUATION

1. INTRODUCTION

In this chapter the method of test evaluation procedure used in this program is presented. The final result of the procedure is a specification of the inputs, sensor accuracy, and nonidentified model parameter value accuracy required in order to identify a model with a given accuracy of combustor output response prediction. In summary,this testing is of value with current instrumentation and can be very useful if modest improvements can be made in the state of the art of combustor instrumentation.

2. TEST EVALUATION PROCEDURE

Given a model of a physical system and the purpose for which the model is intended, the test evaluation procedure is used to analyze possible testing methods and to evaluate achievable model output accuracy. Used in an iterative fashion, the procedure can specify the a priori model parameter accuracy and sensor calibration required to achieve desired model fidelity. The test evaluation procedure is a many step process which requires a good deal of insight into the physics of the system and the practical considerations of the testing procedure.

In this program, the poststall combustor rig under consideration does not actually exist at this time. Because of this fact, a large number of assumptions have been required as to possible inputs, sensors, sensor quality, etc., in order to perform this test evaluation. Obviously, all combinations of sensors, inputs, and other test variables could not be analyzed in this effort. A select set of most probable test configurations have been evaluated. If a poststall combustor rig became available and facility capabilities and instrumentation were more definite, additional analysis would provide more specific and definite prediction of testing quality.

The test evaluation procedure applied in this program is shown in Figure 17. The evaluation is begun by selecting the important model outputs. Usually a parameter identification study is undertaken with a goal of increasing model fidelity for certain model outputs of interest so these outputs are predefined. In this program, the goal is to model combustor outputs which affect poststall engine operation, so the outputs of interest are those which drive the upstream and downstream engine components.

The next step was to define the discrete modes of operation of the combustor. This was done as an initial step in selecting the set of model parameters to identify. The reasoning behind this mode distinction and the selection of the candidate model parameters is discussed in Section VI.4 of this report. The result was a set of candidate model parameters from which a specific subset will be chosen for parameter estimation. A distinction is made between the parameters in this set which control change of combustor operating mode and those that do not. This distinction is made because the groups of parameters will be identified separately.

Step four in the procedure is to evaluate the inputs to the combustor. In this program, inputs which are characteristic of engine poststall operation and realizable in rig test were provided by Pratt & Whitney. SCT evaluated these inputs and selected those best suited for parameter estimation.

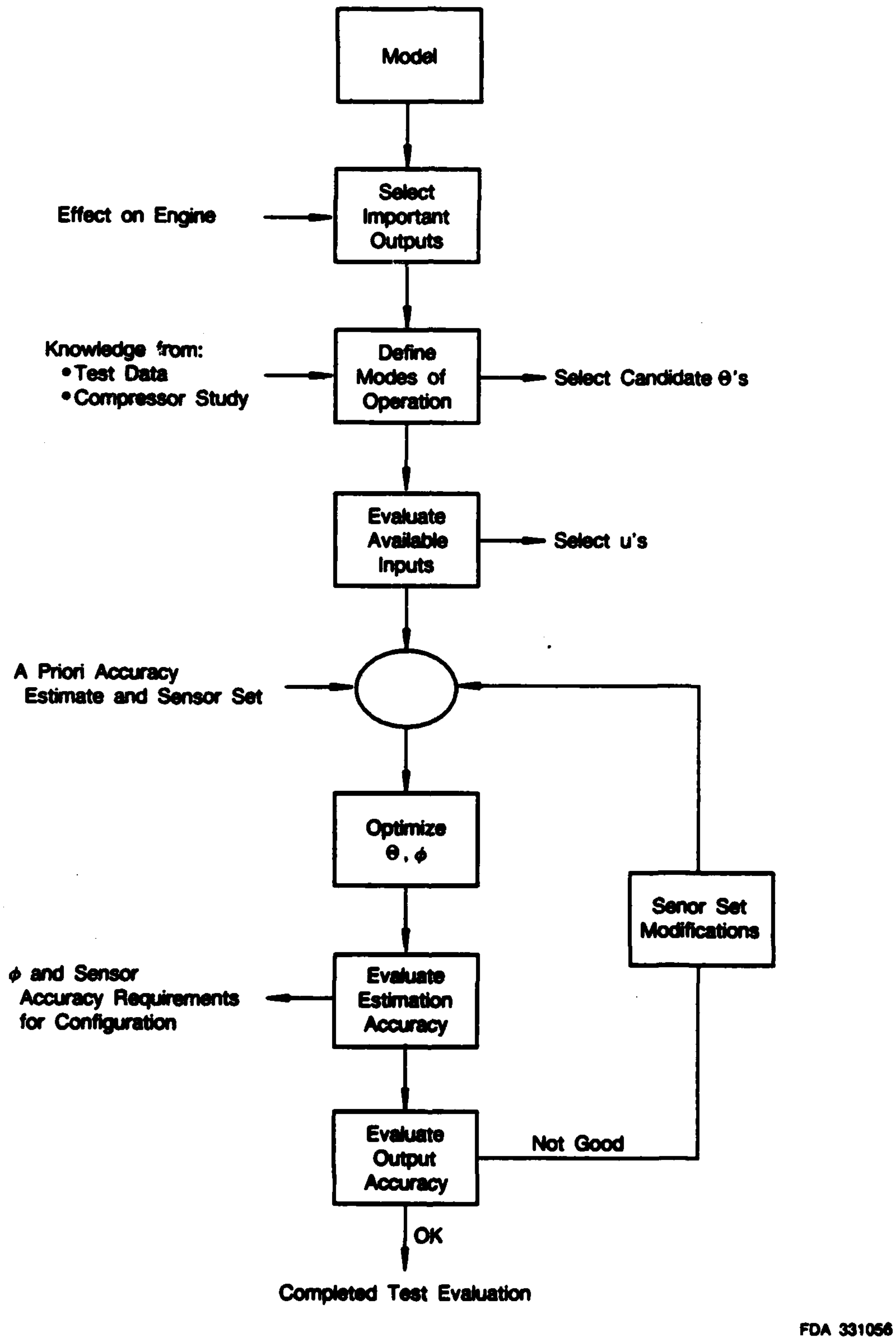

Figure 17. — Combustor Test Evaluation Procedure

2978C

The next stage in the procedure enters an iterative evaluation process. The a priori values of the model parameter values and sensor characteristics were estimated. Using this information, the candidate estimation set was systematically evaluated to determine the optimum set of parameters to identify.

The assumed sensor and parameter accuracies were then used to determine how accurately the optimum set of parameters could be estimated. This accuracy was then used to evaluate how accurately the identified model could predict the desired outputs. Iteration was then performed, if necessary, to determine how much better the sensor set and knowledge of the nonestimated parameter values needed to be to achieve acceptable model output accuracy.

If acceptable model fidelity could not be achieved with reasonable sensor and model parameter knowledge, additional sensors were added to the sensor set. When this was necessary or if an alternate sensor set was to be investigated, the procedure was reentered at the stage of defining the sensor accuracy and reoptimizing the split between identified and nonidentified parameters.

3. PARAMETER AND SENSOR BIAS DETERMINATION

In order to perform test evaluation, a priori estimates of model parameter accuracy and sensor quality must be made. These estimates are used to select the parameters to identify and to begin the estimation accuracy iteration which produces the final specification of required sensor quality and parameter bias levels. Pratt & Whitney and SCT worked together to identify a reasonable set of these values, representative of realizable instrumentation and reflecting current modeling technique. The development of these values is discussed in this section.

a. Physical Parameters

Through discussion with Pratt & Whitney, allowable bias levels were estimated for the candidate model parameters. The bias levels are the probable errors in the model parameters. For example, the resistive exit area is 18 in.^{2}, and its bias is estimated to be ± 1.8 in.^{2}. Parameters for which good bias estimates were not available were assumed to be accurate to 10 percent. For example, CTAU, a direct bias on the heat release time constant was assumed to be correct to within ± 10 percent of the nominal time constant value, or 0.0006 second. A list of the a priori bias level estimates for the model physical parameters is presented in Table 5.

b. Sensor Model Parameter Biases

The overall sensor accuracies were estimated by Pratt & Whitney test engineers. The sensor inaccuracy was then divided evenly among the sources of sensor error. The sources of sensor error were modeled as shown in Equation 1.

$$P_{T3_M} = AP3 \times P_{T3_L} + BP3 \tag{41}$$

where P_{T3_M} is the measured output, P_{T3_L} is the model variable after a first order lag and AP3 and BP3 are scale and bias factors. The three sources of sensor error are then the scale, bias, and lag time constant errors.

2270C

TABLE 5.

A PRIORI PARAMETER BIAS ESTIMATES

*Parameter Name**	*Bias Level (±)*
FPHPT	1.8
ADIFF	7.0
ALINR	10.0
VOL 35	250.0
VOL 4	260.0
CPROP	0.1
CIGDLY	0.1
CSTABE	0.1
CSTABC	0.1
CTAU	0.0006
CTAUM	0.1
CEFFA	4×10^{-6}
CEFFB	4×10^{-4}
DELEFF	2.0
BOTIME	0.001

*Parameters Are Described in Table 3

2261C

As an example, Pratt & Whitney estimates that PT43, the diffuser total pressure, can be measured to within ± 1.5 psia. Dividing this accuracy between three error sources means that each can contribute ± 0.5 psia error. This then is the estimated error for the bias factor BP3. The scale factor can contribute ± 0.5 psia also, so if P_{T3} is nominally 250 psia, AP3 is found to be 0.002. If P_{T3} is a 50 Hz signal, a 50 msec lag time constant error will produce ± 0.5 psia error in P_{T3_L}. This type of analysis was done for all of the sensor models. The biases generated are shown in Table 6.

4. ANALYSIS TOOLS

a. Choosing the Parameters to Identify

The poststall combustor model used in this program is far more complicated than a standard combustor component model. The combustor simulation contains a very large number of physical parameters which could be identified. Selection of the set of parameters to identify is performed on two levels in the test evaluation procedure as shown in Figure 17. A number of analysis methods drawn from the theory described in Section IV.3 and a knowledge of combustor physics allow a useful set of identification parameters to be chosen. This section describes these methods and their application to the combustor simulation.

TABLE 6.

A PRIORI SENSOR MODEL BIAS ESTIMATES

*Parameter Name**	*Bias Level (±)*
AP3	2×10^{-3}
BP3	5×10^{-1}
TAUP3	5×10^{-5}
AP35	2×10^{-3}
BP35	5×10^{-1}
TAUP35	5×10^{-5}
AP4	2×10^{-3}
BP4	5×10^{-1}
TAUP4	5×10^{-5}
AT3	3×10^{-3}
BT3	3.0
TAUT3	5×10^{-5}
AT35	3×10^{-3}
BT35	3.0
TAU35	5×10^{-5}
AT4	3×10^{-3}
BT4	3.0
TAUT4	5×10^{-5}
AWF	2.5×10^{-2}
BWF	7×10^{-2}

*Parameters Are Described in Table 3

2261C

The first stage at which parameters are selected is in choosing a set of candidate parameters to subject to the quantitative analysis tools. This is done by applying available knowledge of the physical system. Parameters which are known to a high degree of certainty are not included in the list of candidate parameters (e.g., accurately measured geometry, gas density). Additionally, knowledge of the phenomena of interest can be used to select all parameters known to be important. This step is aided by a simple sensitivity analysis where parameters are perturbed and the model propagated so that a qualitative measure of the parameters' influence is found (e.g., which parameters directly affect combustor blowout). The goal of this process is to choose a large set of candidate parameters including all parameters which may be of importance.

In this program, Pratt & Whitney and SCT worked together to select the set of candidate model parameters shown on Table 5.

The purpose of the combustor model in this program is to correctly model performance in poststall engine operation. Because the phenomena of interest are outputs of the simulation, an output sensitivity study is used to choose the optimal parameter set to be identified. Parameter selection through output sensitivity is described in the following section.

b. Output Sensitivity

SCIDNT identifies selected model parameters to minimize the model output error. The model parameters to be identified are chosen so as to maximize the fidelity of the model outputs of interest in a given study. This section describes the process of selecting the optimum set of parameters to be identified. A computer code has been written at SCT which automates the parameter-selection process.

2370C

When a parameter identification study is undertaken, there is usually a primary goal of increasing model fidelity for certain model outputs of interest (e.g., output flow, component efficiency). Therefore, the parameters to be identified are chosen to minimize error in a weighted sum of these outputs. Specifically, the output error to be minimized can be expressed as

$$\Delta Y_{pred} = \frac{\partial y}{\partial \theta} \Delta \theta - \frac{\partial y}{\partial \varphi} \Delta \varphi \qquad (42)$$

where θ is a vector of identified parameters and φ is a vector of nonidentified parameters, also known as nuisance parameters. If too many parameters are identified, the overall parameter identifiability decreases, and ΔY_{pred} becomes large due to the $\Delta\theta$ term. Conversely, if too few parameters are selected for identification, ΔY_{pred} increases due to the biasing effects of the $\Delta\varphi$ (errors in important parameters which are not identified). An optimal choice of parameters to be identified (set of θs and φs) will minimize the output error due to the parameter estimate errors and the errors in the nonestimated parameter values.

Selection of the correct parameter set is a very difficult step in the identification process and one which is very difficult to perform by intuition. For instance, parameters which have relatively certain values and do not directly affect the outputs of interest appear to be likely candidates for nuisance parameters (φs) but may in fact bias the parameter estimates and so require identification. Since,

$$\Delta \theta = M_{11}^{-1} + M_{11}^{-1} M_{12} \Delta \varphi \qquad (43)$$

as discussed in Section V.3a, a nuisance parameter error may indirectly affect the output of interest by biasing the parameter values estimated.

The computer code developed by SCT to select the identified parameters requires the user to define a priori estimates of the uncertainty in all parameters ($\Delta\varphi$ values). The code then works through all combinations of θs and φs, evaluating for each set the weighted sum of model output errors defined by the user as the performance parameter (ΔY_{pred}). The code then returns the optimal choice of θ parameters to minimize uncertainty for the outputs selected (subject to the weighting and $\Delta\varphi$ values chosen).

c. Prediction of Estimation Accuracy

Once the set of parameters to be identified has been chosen, the task is to determine how accurately those parameters' values can be estimated. Alternately, the task is to determine through iteration how good the sensors and knowledge of the plant must be in order for the model to adequately predict combustor response. This is done using a combination of identifiability and sensitivity analyses. The theoretical basis for, and generic application of, these analysis methods are described in Sections V.3a and V.3b of this report.

As described in Section V, the error in estimated parameters comes from two sources. The first is estimation inaccuracy due to sensor noise; the second is estimation bins due to incorrect nuisance parameter values. Given an estimate of the sensor quality and the accuracy of model parameter values, estimation accuracy, can be predicted prior to test. Working backwards in an iterative fashion, the needed sensor set and nuisance bias levels can be found for a desired level of estimation accuracy.

In this program, a desired model output accuracy has been chosen (i.e., 5 percent combined output error in exit total temperature and flow, T_{T4} and W_4). From the output sensitivity matrix, the estimated parameter accuracies required to achieve this are determined. Working backward from these values in the identifiability/sensitivity analysis, a possible sensor quality and nuisance bias level mix is found to meet these requirements.

SECTION VIII

TEST EVALUATION RESULTS

1. INTRODUCTION

This section reports on the results of the 63 test evaluations performed in this program. The result of each evaluation is a specification of sensor quality and model parameter knowledge required in order for a certain fidelity of model to be produced through testing and identification. Each result is dependent upon the sensor set evaluated, the input used, and the set of parameters chosen for identification. In addition, there are an infinite number of tradeoffs possible between model parameter uncertainty and sensor quality. In other words, for a given input, parameter, and sensor set, if the model is known better the sensors can be worse. Because a huge volume of output has been generated in this program, this section will describe in detail the evaluation of one input, sensor, parameter set, and then summarize the results of the other evaluations.

There are two extremes of possible test evaluation results: 1) If the plant model parameters are completely unknown, then testing will require many sensors of extreme accuracy, and 2) If the plant model is completely known, then testing is practically unnecessary, and evaluations will show the sensor set can be small and of low quality. Reality lies somewhere between the two extremes. The test evaluation results follow this general trend but provide a quantitative measure of just how good the model knowledge and sensor quality must be to achieve required model identification accuracy.

The sensor and parameter bias levels which were used to begin the evaluation process were chosen to be reasonable combustor rig instrumentation and model parameter uncertainties. As iteration toward a final uncertainty specification progresses, there are an immense number of possible combinations of bias levels. In this program, a very large number of these possible combinations have been evaluated. While details vary, valuable generalizations about the results can be made. These results are summarized at the end of this section.

2. PARAMETER SEARCH STRATEGY

The variable terms in a test evaluation include combustor operating mode, sensor set, parameter set, sensor noise level, and sensor and nuisance parameter bias levels. In order to produce meaningful results, a logical strategy for selecting sets of these variables is required. The strategy used to select a search path through this variable space is described in this section.

As described in Section VI.4, the combustor operation has been divided into three modes: blown-out, lit by ignitor, and lit by autoignition. The normal mode of operation is the latter, and effort has been concentrated on this mode in this program. In the blown-out mode the combustor is simply flow resistance and volume and, as such, is a subset of normal operation. The lit by ignition case is important because it allows the three parameters which determine if the combustor will light from spark to be identified. However, once lit, this mode is identical to the autoignition mode in terms of model parameter identifiability. Analysis of all modes has been performed; however, effort has concentrated on the autoignition mode of operation.

The strategy used to choose both sensor sets, sensor quality, and bias levels for evaluation has been to define the best of a realizable, probable system description and to make small excursions from this system. For example, the sensor set defined by P&W for a combustor rig test included the first four sensors listed in Table 7. This was the nominal sensor set from which SCT began. Because W_3 may not be measurable in the reverse direction, the set of sensors 2 through 4 was evaluated. Also, if turbine flow were measurable and a choked turbine is assumed, a measurement of W_4 could be created. Therefore, a sensor set including all of the sensors in Table 7 was evaluated.

TABLE 7.

SENSED COMBUSTOR OUTPUTS/INPUTS

Output	*Description*
1. W_3	Mass Flowrate Into Outside Liner
2. P_{T35}	Total Pressure at Burner Shroud
3. P_{T4}	Combustor Total Pressure
4. T_{T4}	Combustor Total Temperature
5. W_4	Combustor Exit Mass Flowrate
Input	
1. P_{T3}	Diffuser Total Pressure
2. T_{T3}	Diffuser Total Temperature
3. W_{FMB}	Fuel Mass Flowrate

2281C

3. EXAMPLE TEST EVALUATION

This section presents the detailed result and interpretation of one test evaluation analysis. The sensor set used includes sensors 1 through 5 on Table 7. The input is a 250 psia amplitude, 20 Hz sinusoid in diffuser total pressure with diffuser total temperature and fuel mass flowrate constant at 1000°R and 2.78 lbm/sec respectively. (Sample poststall combustor model responses to this input were presented in Figure 16.) This input forces the combustor to blowout and relight repeatedly. Figure 18 is a plot of P_{T3} and burner condition through one cycle of the P_{T3} input sinusoid. A burner state of 2 indicates ignition by autoignition; 0 indicates blowout. Only the output data where burner state equals 2 is used for this evaluation.

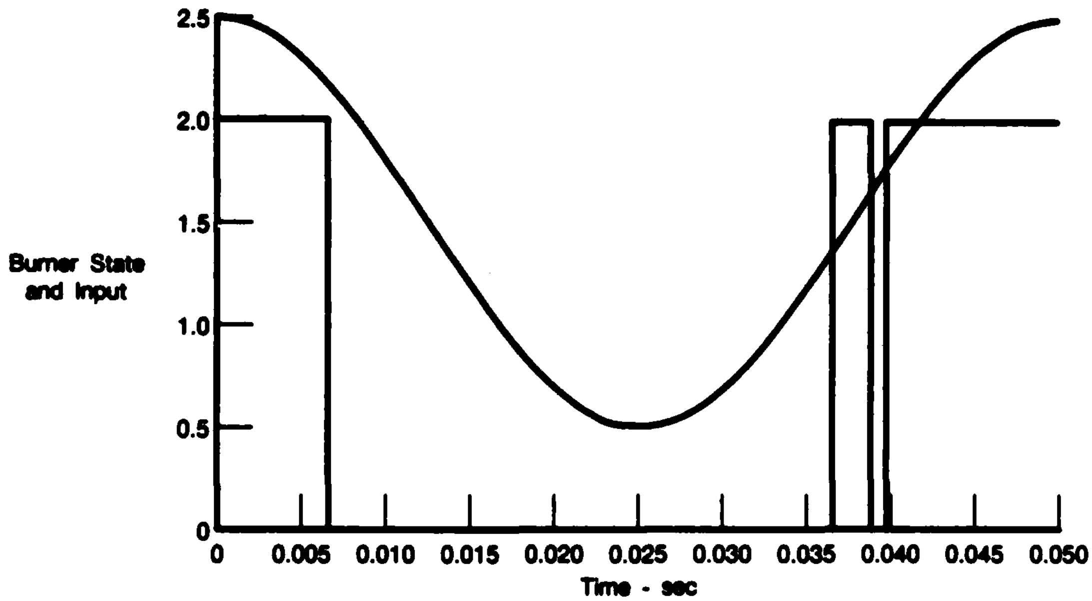

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Figure 18. — Burner Ignition State and Input P_{T3} for Example Case

2370C

The sensor bias and parameter bias levels used for this evaluation are those on Tables 5 and 6. Note that a number of these bias terms need not be considered for this input. TAUT3 is not of interest since the T_{T3} input is a constant value. AT35, BT35, and TAUT35 are not needed because T_{T35} is not a measurement. CPROP and CIGDLY are used only if the burner ignites from an ignitor spark, which it does not for this input.

The important outputs of this model were selected based on the goal of predicting poststall combustor performance as it influences poststall engine operation. Because a combustor is normally modeled as a gas temperature rise and flow resistance, the outputs selected as measures of model performance were T_{T4} and W_4, the combustor exit temperature and flow. Figure 19 contains the output sensitivity matrix for all outputs with respect to the model physical parameters. The matrix is not normalized, so interpretation requires some care. Initial evaluation of Figure 19 indicates that the parameters FPHPT, CTAU, DELEFF, and BOTIME have the largest influence on the outputs T_{T4} and W_4. This does not mean that these are the best parameters to identify, however. As discussed in Section VII.4, the influences of the sensor noise and nuisance parameter bias must be considered also.

OUTPUT SENSITIVITY MATRIX =

Starting at row 1 columns 1 thru 6

	FPHPT	ADIFF	ALINR	VOL35	VOL4	CSTABE
W3	1.41700+00	-3.06080-02	-3.85940-02	-2.22290-01	-2.50150-01	-2.57560-02
PT35	-3.04650-02	1.45280-02	6.74060-04	3.90300-03	4.52610-03	4.04680-04
PT4	-5.30280-02	1.48030-02	1.41700-02	3.82290-03	8.61480-03	8.71940-04
TT4	-8.18550-01	-9.78810-03	1.62750-02	-3.36080-03	1.24560-01	9.92950-03
W4	1.23980+00	1.93980-02	7.13230-03	5.33410-03	-4.62830-02	-3.50530-03

Starting at row 1 columns 7 thru 12

	CSTABC	CTAU	CTAUM	CEFFA	CEFFB	DELEFF
W3	-4.53160-04	-3.55430+00	-3.14770-02	-7.61620-05	8.76800-03	-3.52060-01
PT35	7.88930-06	4.56680-02	4.87500-04	3.12430-06	-1.63490-04	8.04000-03
PT4	1.79710-05	1.04410-01	1.06280-03	5.10080-06	-2.95980-04	1.35890-02
TT4	1.73970-04	1.35650+00	1.11590-02	1.04080-04	-1.84980-02	9.09440-01
W4	-5.88300-05	-4.59800-01	-3.85870-03	-4.14770-05	8.10620-03	-3.99160-01

Starting at row 1 columns 13 thru 13

	BOTIME
W3	-2.32760-01
PT35	3.93230-03
PT4	7.66980-03
TT4	1.71020-01
W4	-6.66540-02

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Figure 19. — Output Sensitivity Matrix

Estimation parameters are selected by use of the SCT developed code PARSEL. This code evaluates output error for all combinations of θs and φs to determine the optimal set of parameters to identify. This is a very large task which is well suited to computer automation. In general, if very few parameters are estimated, error will be high due to the bias effects. Conversely, if too many parameters are estimated, insufficient information will be available from the sensors and errors will again be large. A typical plot of the output performance index versus the number of parameters estimated as determined by the PARSEL code for this program is shown in Figure 20.

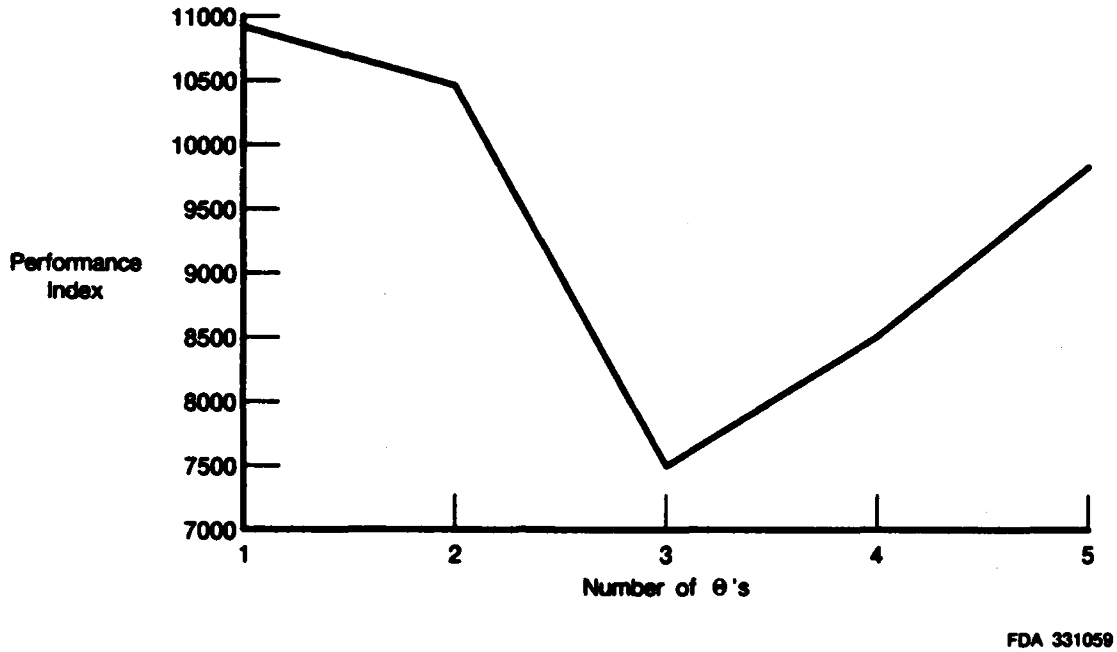

Figure 20. — Typical Plot of Output Error Vs Number of Estimation Parameters

a. Parameter Selection Output

The parameter selection code was run for this case to determine the optimum mix of θs and φs. The program output is included in Appendix C of this report. The first output page lists the a priori uncertainty and bias levels used for all parameters. If any parameters are declared to always be nuisance terms, they are listed with their bias levels, as are the measurements and their assumed noise levels. For this run, CTAU and CTUAM are defined to be nuisance parameters.

The second page describes the performance index to be evaluated and minimized. The description lists J, the performance index, as a sum of terms, while in fact it is a root sum square of the terms listed.

Page 3 is the start of the actual code output. The code examines all combinations of N parameters where N goes from 1 to a user specified limit. For example, page three describes the three best sets of 7 parameters to identify. The code has formed, evaluated, and ordered all possible combinations and lists the p best sets, where p is specified by the user.

In this case, page 3 shows that, if only one parameter is identified, the best is parameter 1, FPHPT. Only slightly worse, the second choice is 41, DELEFF. The root sum square of the estimation and bias error terms for estimated FPHPT is 349.22 while for DELEFF is 350.48. For each, the nuisance parameter set is listed.

The PARSEL code output continues in this manner for the best three combinations of two estimated parameters up to the best three sets of five parameters. The best set of parameters to identify is that which minimizes the performance index overall. Figure 21 is a plot of the lowest

The parameter estimation accuracy is evaluated through the use of an SCT developed computer code called SENSIT. This code evaluates the parameter estimation error for a given set of sensor noise levels and nuisance parameter biases. These two error sources are termed parameter identifiability and sensitivity. The theory used to evaluate these is presented separately in Sections V.3a and V.3b of this report.

The parameter estimation accuracy predicted by SENSIT will produce an error in the model outputs. The output error is computed by multiplying the output sensitivity matrix with the predicted parameter estimation errors. If the resulting output errors are within acceptable limits, then the sensor quality and bias levels assumed will produce sufficiently good test and estimation results, which in turn translate into the required quality of model.

(1) SENSIT Output Discussion

Appendix D contains the SENSIT output for the first estimation accuracy iteration in the example test evaluation. This run evaluates the estimation accuracy which can be achieved with the a priori sensor set and model knowledge. The first page lists all of the parameters for which sensitivity data were generated and the nominal parameter values to be used in normalization. Also, the measurements used when the sensitivity data were generated are listed.

The second page presents the estimation parameter set and corresponding a priori uncertainty, the nuisance parameter set, and the measurement set to be evaluated with the assumed measurement noise levels. In this output, pages 3 and 4 contain optional output of the M_{11} and M_{12} portions of the information matrix and the bias matrix. (A detailed description of these matrices is presented in Section V.) Page 5 of the SENSIT output contains the measurement contributions to the second derivative of the cost function. This matrix shows which measurements are important in the identification of the various parameters. For example, only Y04 and Y05 which are T_{T4} and W_4 provide information about AT4, BT4, and TAUT4, the sensor model parameters for the T_{T4} measurement. This is quite logical since these parameters directly scale the T_{T4} measurement which is in turn used to compute W_4. Similarly, AP4 and BP4 are only reflected in the P_{T4} and W_4 measurements. The reasoning here is identical. From these values, it can also be seen that the flow measurements are very important for the estimation of all parameters. The next most critical measurement is the exit temperature, followed by the pressures. Note that for estimation of the combustor efficiency bias, the temperature measurement provides more information than the flow measurements.

The final page of the output contains the run summary information. Each parameter in the estimation set is presented along with the computed standard estimation errors and estimation bias errors. In this case, the estimation bias on the second and third parameters, ADIFF and VOL 35, are exceedingly large. The two error values for each parameter are combined and multiplied by the output sensitivity matrix described in Section VIII.3. This gives the output error created by the estimation error, if too large iteration or sensor quality and bias levels are required. For this run, it is evident from the bias errors in ADIFF and VOL 35 and the output sensitivity matrix of Table 8 that iteration is required.

The nuisance bias values to use for the next iteration are a function of how the investigator has chosen to search the sensor/bias space. In this case, the goal is to minimize excursions from the a priori estimates which reflect current rig test capabilities and modeling confidence.

TABLE 8.

SUMMARY OF PARAMETER SELECTION RUNS

Run No.	*Combustor Mode*	*Sensor Set*	*Noise Level*	*Bias Level*	*Optimum Estimation Set*
1	2	5	Nom	Nom	1,4,41
2	2	5	Low	Nom	1,2,4,41
3	2	5	Nom	Low	4
4	2	5	Low	Low	4
5	2	5	Nom	High	1,4,41
6	2	5	Low	High	1,2,4,41
7	2	4	Nom	Nom	1,41
8	2	4	Low	Nom	1,41
9	2	4	Nom	Low	4
10	2	4	Low	Low	4
11	2	4	Nom	High	1,41
12	2	4	Low	High	1,3,41
13	2	3	Nom	Nom	41
14	2	3	Low	Nom	1,41
15	2	3	Nom	High	1,3
16	2	3	Low	High	1,3
17	1	5	Nom	Nom	1
18	1	4	Nom	Nom	1
19	1	3	Nom	Nom	1
20	0	5	Nom	Nom	1
21	0	4	Nom	Nom	1
22	0	3	Nom	Nom	1

2381C

From the bias matrix on pages 3 nd 4, the biases which have the largest effect on each parameter estimation bias can be determined. Lowering each of these parameters' bias levels slightly forms a first iteration. The bias level assumed must be included in this process. If the bias matrix has a large entry corresponding to a nuisance parameter but its bias level is small, obviously this parameter is not a large contributor to the estimation bias.

The nuisance bias levels assumed for the run are listed on the final page of the SENSIT output.

Iteration on the bias terms continues in the above manner until acceptable output error levels are achieved. In Appendices D and E, an intermediate run and the final SENSIT run for this evaluation are presented. The final run estimation errors result in errors of 3.62 percent in T_{T4} and 1.39 percent in W_4. These levels are considered to be good enough. (For this study, a combined error of 5 percent was an arbitrarily assumed acceptable output error limit.)

The acceptable nuisance bias levels found for this case are small but achievable. The sensor models must be known very well, particularly sensor time constants and any scale factors. This result comes as no surprise, since these terms have a very large effect on the outputs. The required model physical parameter biases range from 0.1 percent to 3 percent of the nominal values. These levels can certainly be achieved for the physically measurable parameters such as the combustor volumes.

The final bias (or uncertainty) levels found for the nuisance parameters in this example are only one of many possible sets which will produce an acceptable level of output error. Many more performance function for each page of output (best sets of N parameters). The result for this case is that the best set of 3 parameters is optimal; however; the best sets of 2 and 4 parameters are not significantly worse.

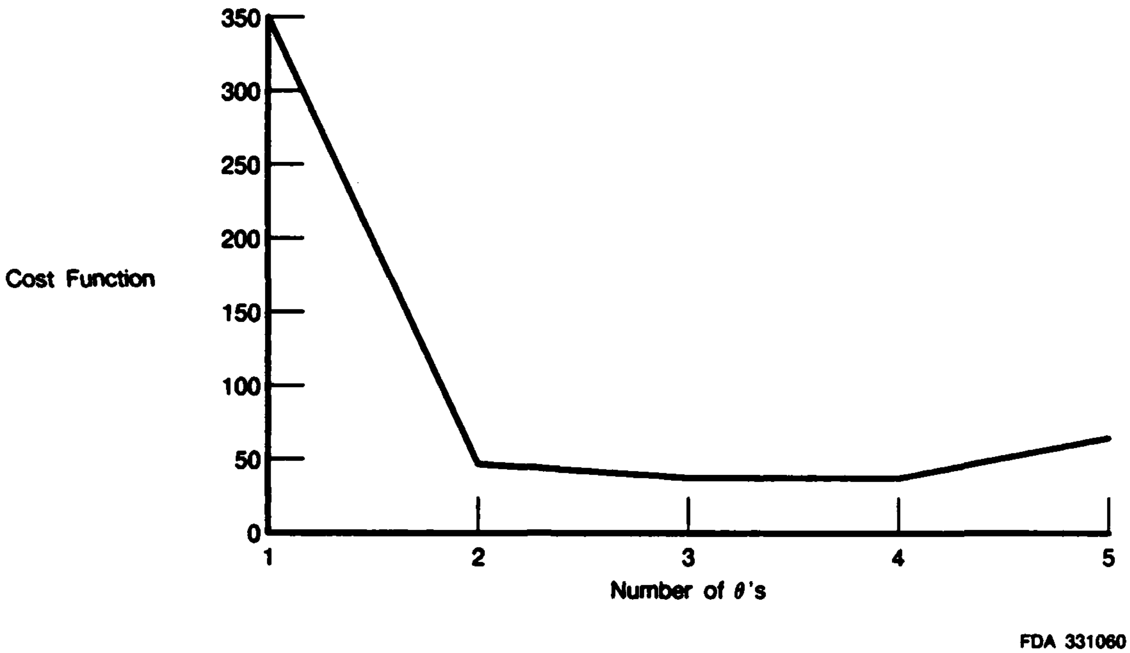

Figure 21. — Output Cost Function Vs Number of Estimated Parameters

The PARSEL output shows that the optimal set contains parameters 1, 4, and 41. However, the second and third best sets of three are nearly equal to the first choice. If the best three sets for each number of parameters are examined, it can be seen that the difference between the three best sets is always the exchange of one variable. For example, the difference between the first and second best set of five parameters is whether parameter 4 or 5 is estimated. The cost function values for these sets are nearly equal. This shows that parameters 4 and 5 have a significant effect on the system. However, the two are not identifiable at the same time. This indicates that parameters 4 and 5 probably have the same effect on the system. This is quite logical since these parameters are the two volumes of the combustor.

The other parameters selected for estimation are the resistive area at the exit and DELEFF, a bias on combustor efficiency. These are quite logical since the outputs in which error is to be minimized are exit flow and exit total temperature. If a fourth parameter is added to the estimation set,the PARSEL code indicates that it should be the inlet resistive area, ADIFF.

This output shows that for the assumed sensor set and bias levels there are a few sets of estimate parameters which will yield approximately the same result in terms of model fidelity in the selected outputs. For this example, we will examine the set containing parameter numbers 1, 2, 4, and 41.

b. Estimation Accuracy

Once the estimation set has been chosen, an estimate of the achievable identification accuracy for this set is produced. More importantly, a specification of the sensor quality and plant model knowledge required to achieve a desired fidelity of identified model can be produced.

iterations must be made, studying tradeoffs between various parameter bias levels. This process is performed repeatedly for various sensor sets, estimation sets, and combustor operating modes to complete the test evaluation process.

4. SUMMARY OF EVALUATIONS

This section describes the test evaluations that were performed in this program. The parameter selection analyses made are summarized in Table 9. The sensor set numbers correspond to the number of sensors used in the analysis; the specific sensors are described in Section VIII.2. Standard noise and bias levels were defined. These are described as High, Low, or Nominal, where high is twice the nominal and low is one half of nominal bias levels defined in Tables 5 and 6.

TABLE 9.

SUMMARY OF TEST EVALUATIONS

Evaluation Set No.	*Combustor Mode*	*Sensor Set*	*Noise Level*	*Estimation Set*	*Approximate No. of SENSIT Estimation Accuracy Evaluations*
1	2	5	Nom	1,4,41	4
2	2	5	Nom	1,2,4,41	11
3	2	4	Nom	1,2,4,41	4
4	2	4	Nom	1,41	5
5	2	4	Nom	1,41	4
6	2	4	Nom	1,3,41	6
7	2	3	Nom	1,2,4,41	1
8	2	3	Nom	1,41	5
9	2	3	Low	1,3	2
10	1	4	Nom	1	3
11	0	4	Nom	1	3

2281C

Table 9 reflects the general trends which are expected in parameter selection: when sensor noise is low, more parameters may be identified because more information is available about the system. Similarly, when fewer sensors are available, fewer model parameters can be identified. When bias levels are high (the model is less certain), more parameters are identified to minimize bias errors.

The parameters which have been selected as the optimal estimation sets are consistent and logical. When the five measurements: W_3, P_{T35}, P_{T4}, T_{T4}, and W_4 are available, the largest estimation set contains parameters 1, 2, 4, and 41, the exit resistive area, inlet resistive area, outer case volume, and efficiency bias respectively. Physical intuition supports this set as those most likely to minimize errors in exit flow and temperature. As was discussed in Section VIII.3.a, the volumes of the combustor are both important parameters; however, because they have the same effects on the available measurements, they cannot be identified at the same time.

If exit flow is dropped from the measurement set, less information is available for estimation. Table 9 indicates that, with nominal bias levels, the inlet resistive area and outer case volume should be dropped from the estimation set. If model confidence is high (low bias), then the volume is the only parameter to be identified.

If both of the flow measurements are dropped, no volumes are selected for estimation, and parameter 3, the burner liner loss, appears in the estimation sets. This is physically understandable since the remaining sensors (the combustor pressure and temperature and the pressure at the burner shroud) are in the center of the combustor, so parameters which can best be identified are in this area, directly driving these measurements. For example, the inlet resistive area a priori value is more accurate than the area can be identified with these measurements, so to minimize model error, this area is not estimated. The parameters which are estimated are the exit resistive area, delta efficiency, and liner loss.

From the results of the parameter selection analyses, test evaluation sets were formed. The test evaluation sets are the sensors, noise levels, and estimation sets to be carefully analyzed in the estimation accuracy analyses. The evaluation sets formed and processed in this program are listed on Table 10, along with the approximate number of estimation accuracy iterations which were performed for each.

TABLE 10.

ESTIMATION ERROR VARIATION WITH MEASUREMENT NOISE

	Percent Increase in Estimation Error			
Parameter	*FPHPT*	*ADIFF*	*VOL 35*	*DELEFF*
10 Percent Noise Increase in Measurement				
W_3 and W_4	8.39	7.12	8.98	4.93
P_{T35} and P_{T4}	0.13	1.82	0.21	0.19
T_{T4}	1.47	0.50	0.61	5.18

2261C

a. Generalization of Evaluation Results

In this section, selected results from the broad range of test evaluations are presented.

- Combustor identification must be performed in two stages. In the first stage the combustor operating mode (e.g., blown out, lit) is fixed in the model and parameters affecting gross transient behavior are identified. In the second stage the mode change functions are identified. This program has addressed Stage 1.

    - Parameters which affect the stability functions are very important in that they drastically effect the combustor transient, however their effect is limited to a very small portion of the total transient time. From a practical point of view the parameters are divided into those which control and do not control mode change based on frequency separation.

    - The important combustor model parameters which are only identifiable during combustor mode transition are the time constants in the stability equation and the coefficients in the combustor efficiency correlation equation.

- Change of combustor operating mode (e.g., blowout) must be measurable in order to perform accurate parameter estimation.

2376C

- If identification must be performed using data from a transient during which the combustor mode changes, the mode change must be forced in the model so that model and data are consistent.

- If operating mode is sensed and forced in the model, the time of mode change must be sensed to within ±0.001 sec.

- Efficiency is a very important term in combustor models. The delta combustor efficiency used in this program is indistinguishable from the heat value of fuel in steady state, but is separable from transient data. The importance of DELEFF identified simply means that efficiency must be computed very accurately.

- Overall combustor efficiency was found to be very important while the coefficients of the combustor efficiency correlation equation were not. This is due to the very brief drop in efficiency prior to blowout. As shown in Figure 22, the combustor efficiency is virtually constant until blowout. Since the efficiency correlation coefficients contribute almost nothing to the overall efficiency value until blowout (and then the terms are relatively small), the coefficients were not of primary importance in predicting transient behavior which has few or no mode changes.

- Estimation accuracy decreases rapidly if flow measurements are not available, however acceptable results can still be obtained using only pressure and temperature probes.

  - If sensors which measure W_3, P_{T35}, P_{T4}, T_{T4}, and W_4 are available and the RMS noise levels on these sensors are 0.5, 1.5, 1.5, 10.0, and 0.5 respectively, then four model parameters can be successfully identified. The optimal set of these to minimize model error in outputs T_{T4} and W_4 is FPHPT, ADIFF, VOL 35, and DELEFF. (Once this identification has been performed, other important parameters such as VOL 4 can be substituted into the estimation set, based on the knowledge that certain parameters such as VOL 4 and VOL 35 cannot be identified at the same time.) To perform this identification, the model nuisance parameters must be known within an average of 6 percent of their true values. Additionally, any sensor scale factors must be known to within $\pm 4 \times 10^{-3}$ of their true values, on the average. Sensor bias errors must be below ±1/2 percent on the average, and sensor time constants must be known with ±1/4 percent of their true values, on the average.

  - If the sensor noise and bias levels reported in Appendix E (which meet the above requirements) are used to estimate FPHPT, ADIFF, VOL 35, and DELEFF, the resulting output accuracy is 3.62 percent error in T_{T4} and 1.39 percent in W_4.

  - If the above noise and bias levels are used to identify the same four parameters but only the W_3, P_{T35}, P_{T4}, and T_{T4} measurements are available, the achievable output accuracy is 4.21 percent error in T_{T4} and 2.23 percent error in W_4. This error results from a 44.7 percent average increase in the parameter estimation errors.

  - If the above noise and bias levels are used to identify the same four parameters but only the P_{T35}, P_{T4} and T_{T4} measurements are available, the achievable output accuracy is 5.97 percent error in T_{T4} and 4.16 percent error in W_4. This error results from a 76.5 percent average increase in the parameter estimation errors.

- If a W_4 sensor is not available, with the nominal sensor and model uncertainties, the optimal set of three estimation parameters is FPHPT, ALINR, and DELEFF. Similarly, if the W_3 sensor is not present in the measurement set, only two parameters should be identified, the optimal set of which is FPHPT and DELEFF.

- Measurement noise is not the major cause of estimation error. Systematic measurement errors such as sensor biases re much more significant sources of estimation error than is measurement noise.

  - Estimation accuracy variation with sensor noise. Using the nominal sensor and parameter bias values, estimation accuracy of parameters 1, 2, 4, and 41 has been evaluated for a 10 percent increase in sensor noises levels. Table 10 summarizes these evaluations. It is evident that flow measurements are very important, particularly in estimation of the volume. The temperature measurement is the second most important and is particularly valuable in the estimation of combustor efficiency. The estimated combustor measurement noise levels have been shown to be acceptable, and Table 10 indicates that estimation accuracy is not overly sensitive to random measurement noise. Obviously, measurement noise should be minimized, particularly in the flow measurements; but, in comparison to systematic errors such as sensor bias and scale, measurement noise is not a critical source of estimation error for poststall combustor model identification.

- Inputs which represent poststall engine behavior and drive the combustor into its operating modes are sufficient for initial parameter estimation efforts. Specifically, inputs which are characteristic of engine surge sufficiently excite all modeled combustor dynamics.

- Estimation results are dependent upon the operating point where estimation is performed, and limited by the model structure used. For example, if a combustor characteristic is strongly correlated with flow, however this dependency is unmodeled, estimation results will vary significantly with operating point, and cannot explicitly reflect the flow dependence.

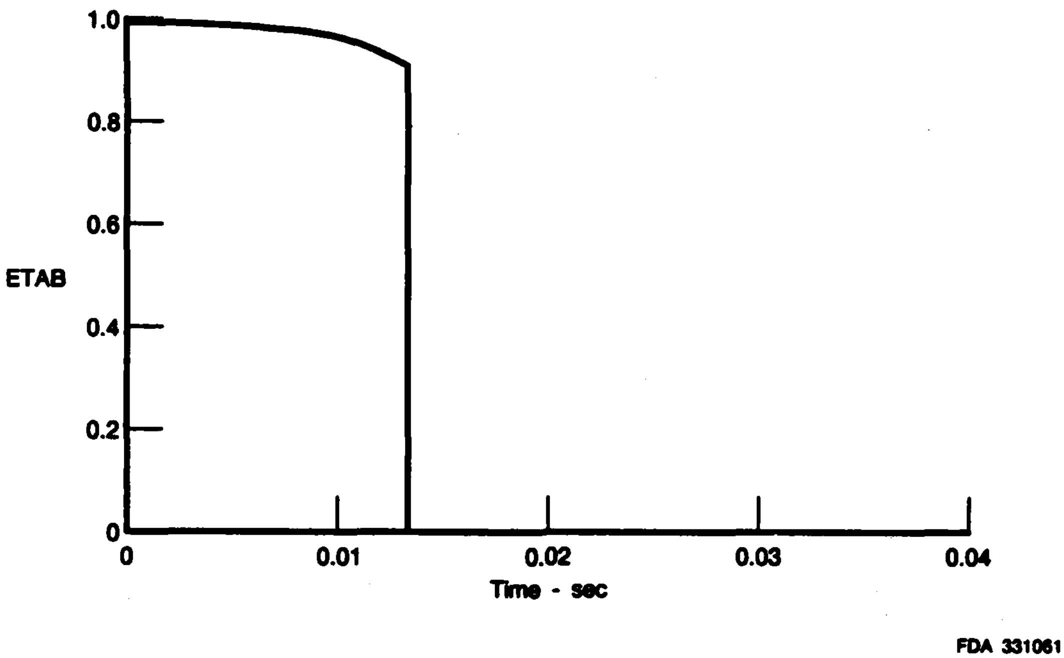

Figure 22. — Combustor Efficiency During Mode Change

2370C

SECTION IX

TEST METHODOLOGY

The data reduction will consist primarily of processing and compiling data into tabular, graphical, and video form for eventual comparison to model predictions. However, some intermediate computations will be required to determine pressure losses and combustion efficiency.

Combustion system percent pressure losses will be calculated in the usual manner for the system (diffuser inlet to combustor exit), combustor dome, and combustor liner:

$$\Delta P_{loss} = \frac{P_{up} - P_{down}}{P_{up}} \times 100 \quad (44)$$

Upstream pressure (P_{up}) and downstream pressure (P_{down}) will be defined according to the normal flow direction.

A temperature-based combustion efficiency will be calculated from the data using the following equation:

$$\eta = \frac{\Delta T_{act}}{\Delta T_{ideal}} \quad (45)$$

The actual temperature rise can be calculated from the diffuser inlet temperature and either a measured or a calculated combustor exit temperature. The measured combustor exit temperature will be determined using the combustor exit temperature instrumentation. The calculated exit temperature will be based on the choked flow conditions at the simulated turbine using the flow parameter (FP). Flow parameter is defined as:

$$FP = \frac{W_a (T_3)^{0.5}}{PA} = f(Mn, \gamma) \quad (46)$$

Since Mach number, flowrate, pressure, and flow area will be known at the choke plane, this equation can be solved iteratively for temperature and gamma.

SECTION X

SUMMARY AND FUTURE EFFORTS

1. SUMMARY

A lumped-parameter computer model for combustor transient behavior during compressor stall events has been described. Recent improvements to the model include a characteristic time approach to stability, the addition of spark ignition and flame propagation, droplet size calculation, and the division of the combustor into primary and secondary zones. This model has undergone a type of analysis called Systems Identification, which has subjected the model to various transient boundary conditions that highlight the input parameters which most affect the model's calculated results. Those parameters are: prediffuser exit area, combustor volume, liner flow area, combustion efficiency, and turbine inlet flow parameter. Systems Identification also specifies the accuracy of pressure and temperature data, from transient combustion experiments, needed to improve the model's accuracy. Finally, this report reviews a transient combustion facility being built at United Technologies Research Center (UTRC) and scheduled to become operational in early 1987.

2. FUTURE EFFORTS (NONCONTRACTUAL)

In the fourth quarter of 1987, testing of a four-nozzle combustor sector, currently under construction, will begin at the new UTRC facility. Data from these transient combustion tests will be used to validate and upgrade the computer model. Eventually, the model will be incorporated into the design system, allowing combustors to be designed for stall recovery along with the more traditional features of operability, pattern factor, and combustion efficiency. The model will also be absorbed into the engine simulation computer program, complementing the existing compressor stall model, and increasing the realism with which engine cycles are calculated.

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APPENDIX A

SAMPLE COMPUTER MODEL PREDICTION

FILE: FILE   OUTPUT   A   P R A T T   A N D   W H I T N E Y   A I R C R A F T   PAGE 00001

SLOW FUEL DECEL (10,000 PPH TO 0 PPH) IN TEN SECONDS AT CONSTANT
INLET TEMPERATURE AND PRESSURE

SMITE HAS CONVERGED IN 25 ATTEMPTS
** STATISTICS ** 31 TOTAL PASSES,
1 JACOBIAN EVALUATIONS,   16 BROYDEN UPDATES

****

BRNMDL

1 TIME	.0	.1004965	.2009892	.3014819	.4019746	.5024673	.6029601
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-.6013601E-03	-3.257597	-3.221265	-3.185199	-3.149009	-3.113031	-3.076905
5 DPT35	-1.832967	-102043.5	-101718.9	-101395.4	-101073.2	-100753.0	-100431.7
6 DPT4	-1.778266	129299.2	128769.4	128239.2	127710.2	127181.2	126652.1
7 DTT35	-2.116904	-742109.3	-733254.7	-724457.6	-715760.6	-707122.6	-698595.2
8 DTT4	-71.06857	332406.1	329354.8	326295.4	323288.6	320292.6	317337.1
9 FAMB	.3584334E-01	.1563948E-01	.1547930E-01	.1531936E-01	.1515944E-01	.1499978E-01	.1484017E-01
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.016828	1.124823	1.124230	1.123631	1.123032	1.122427	1.121828
18 PRLINR	1.008378	1.336489	1.334885	1.333286	1.331697	1.330113	1.328534
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	245.8627	222.2572	222.3742	222.4929	222.6116	222.7315	222.8505
21 PT4	243.8199	166.2993	166.5867	166.8755	167.1637	167.4530	167.7416
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	999.9998	2050.314	2041.967	2033.617	2025.309	2017.008	2008.752
27 TT4	2988.941	2501.069	2489.303	2477.562	2465.833	2454.122	2442.442
28 WFMB	2.777778	2.749859	2.721943	2.694026	2.666109	2.638192	2.610275
29 W3	77.49799	190.0780	189.7281	189.3754	189.0214	188.6614	188.3045
30 W35	77.50311	231.2261	231.5576	231.8920	232.2257	232.5613	232.8942
31 W4	80.27542	59.85492	60.09993	60.34659	60.59441	60.84395	61.09436

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-1.832967	-102043.5	-101718.9	-101395.4	-101073.2	-100753.0	-100431.7
34 DTT35	-2.116904	-742109.3	-733254.7	-724457.6	-715760.6	-707122.6	-698595.2
35 FAMB	.3584334E-01	.1563948E-01	.1547930E-01	.1531936E-01	.1515944E-01	.1499978E-01	.1484017E-01
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	239.9999	492.0752	490.0718	488.0681	486.0740	484.0818	482.1003
38 H4	717.3457	600.2566	597.4326	594.6147	591.7998	588.9890	586.1860
39 PT35	245.8627	222.2572	222.3742	222.4929	222.6116	222.7315	222.8505
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0

41 RHO35	.3841606E-03	.1693774E-03	.1701594E-03	.1709492E-03	.1717421E-03	.1725419E-03	.1733434E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	999.9998	2050.314	2041.967	2033.617	2025.309	2017.008	2008.752
45 TT4	2988.941	2501.069	2489.303	2477.562	2465.833	2454.122	2442.442
46 U35	171.0000	350.6035	349.1763	347.7485	346.3276	344.9082	343.4966
47 M3	77.49799	190.0780	189.7281	189.3754	189.0214	188.6614	188.3045
48 M35	77.50311	231.2261	231.5576	231.8920	232.2257	232.5613	232.8942

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-.6013601E-03	-3.257597	-3.221265	-3.185199	-3.149009	-3.113031	-3.076905
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	.5447388E-02	172.2928	172.3738	172.4559	172.5361	172.6165	172.6932
55 DMFUEL	.2861023E-05	1.828174	1.805819	1.783503	1.761248	1.739033	1.716882
56 DPT4	-1.778266	129299.2	128769.4	128239.2	127710.2	127181.2	126652.1
57 DTBIDL	2010.774	735.4402	727.5566	719.6875	711.8423	704.0149	696.2170
58 DTBLAG	1988.809	739.0916	731.1750	723.2769	715.3984	707.5430	699.7102
59 DTBURN	1988.809	739.0515	731.1375	723.2371	715.3608	707.5027	699.6736
60 DTT4	-71.06857	332406.1	329354.8	326295.4	323288.6	320292.6	317337.1
61 ETAB	.9890761	1.004910	1.004922	1.004932	1.004943	1.004954	1.004965
62 FAO	.3584085E-01	.1189251E-01	.1175493E-01	.1161759E-01	.1148068E-01	.1134407E-01	.1120799E-01
63 FAP	.1433634	.4757005E-01	.4701971E-01	.4647036E-01	.4592271E-01	.4537629E-01	.4483195E-01
64 FAPA	.1433634	.4757005E-01	.4701971E-01	.4647036E-01	.4592271E-01	.4537629E-01	.4483195E-01
65 H35	239.9999	492.0752	490.0718	488.0681	486.0740	484.0818	482.1003
66 H4	717.3457	600.2566	597.4326	594.6147	591.7998	588.9890	586.1860
67 H4SS	717.3140	669.4573	665.5540	661.6545	657.7695	653.8921	650.0308
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	243.8199	166.2993	166.5867	166.8755	167.1637	167.4530	167.7416
72 QBURN	38316.58	10617.19	10546.46	10475.35	10403.79	10331.93	10259.60
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3313944	.2701208	.2718668	.2736286	.2754049	.2771983	.2790037
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	.0	.1004965	.2009892	.3014819	.4019746	.5024673	.6029601
78 TLITE	.0	.1004965	.2009892	.3014819	.4019746	.5024673	.6029601
79 TT35	999.9998	2050.314	2041.967	2033.617	2025.309	2017.008	2008.752
80 TT4	2988.941	2501.069	2489.303	2477.562	2465.833	2454.122	2442.442
81 U4	511.1089	427.6829	425.6707	423.6631	421.6575	419.6548	417.6575
82 MFMB	2.777778	2.749859	2.721943	2.694026	2.666109	2.638192	2.610275
83 M35	77.50311	231.2261	231.5576	231.8920	232.2257	232.5613	232.8942
84 M4	80.27542	59.85492	60.09993	60.34659	60.59441	60.84395	61.09436

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	245.8627	222.2572	222.3742	222.4929	222.6116	222.7315	222.8505
87 PT4M	243.8199	166.2993	166.5867	166.8755	167.1637	167.4530	167.7416
88 QBURNM	38320.61	-4961.098	-4770.422	-4797.633	-4826.730	-4855.754	-4885.977
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000

90 TT35M	999.9998	2050.314	2041.967	2033.617	2025.309	2017.008	2008.752
91 TT4M	2988.941	2501.069	2489.303	2477.562	2465.833	2454.122	2442.442
92 WFMBM	2.777778	2.749859	2.721943	2.694026	2.666109	2.638192	2.610275
93 W3M	77.49799	190.0780	189.7281	189.3754	189.0214	188.6614	188.3045
94 W35M	77.50311	231.2261	231.5576	231.8920	232.2257	232.5613	232.8942
95 W4M	80.27542	59.85492	60.09993	60.34659	60.59441	60.84395	61.09436

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BRNMDL

1 TIME	.7034528	.8039455	.9044382	1.004929	1.105373	1.205818	1.306263
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-3.041101	-3.005198	-2.969367	-2.933508	-2.897903	-2.862359	-2.826691
5 DPT35	-100115.1	-99796.81	-99480.31	-99166.44	-98853.50	-98541.31	-98228.31
6 DPT4	126124.8	125594.0	125065.1	124537.4	124008.9	123481.0	122950.8
7 DTT35	-690125.5	-681710.1	-673389.5	-665191.3	-657024.6	-648928.6	-640899.5
8 DTT4	314394.5	311452.2	308556.6	305689.1	302814.9	299983.7	297171.9
9 FAMB	.1468078E-01	.1452154E-01	.1436243E-01	.1420347E-01	.1404473E-01	.1388612E-01	.1372762E-01
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.121219	1.120609	1.119995	1.119386	1.118767	1.118148	1.117526
18 PRLINR	1.326965	1.325389	1.323829	1.322270	1.320724	1.319179	1.317632
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	222.9716	223.0928	223.2151	223.3367	223.4602	223.5840	223.7083
21 PT4	168.0312	168.3225	168.6132	168.9039	169.1951	169.4873	169.7805
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	2000.502	1992.256	1984.048	1975.909	1967.748	1959.598	1951.467
27 TT4	2430.777	2419.127	2407.495	2395.946	2384.392	2372.818	2361.258
28 WFMB	2.582358	2.554441	2.526525	2.498608	2.470704	2.442801	2.414897
29 W3	187.9398	187.5708	187.2012	186.8292	186.4519	186.0729	185.6901
30 W35	233.2319	233.5672	233.9033	234.2362	234.5735	234.9124	235.2486
31 W4	61.34650	61.60065	61.85593	62.11171	62.36938	62.62926	62.89102

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-100115.1	-99796.81	-99480.31	-99166.44	-98853.50	-98541.31	-98228.31
34 DTT35	-690125.5	-681710.1	-673389.5	-665191.3	-657024.6	-648928.6	-640899.5
35 FAMB	.1468078E-01	.1452154E-01	.1436243E-01	.1420347E-01	.1404473E-01	.1388612E-01	.1372762E-01
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	480.1204	478.1414	476.1714	474.2183	472.2593	470.3032	468.3518
38 H4	583.3862	580.5906	577.7988	575.0271	572.2539	569.4761	566.7017
39 PT35	222.9716	223.0928	223.2151	223.3367	223.4602	223.5840	223.7083
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.1741529E-03	.1749689E-03	.1757890E-03	.1766091E-03	.1774397E-03	.1782765E-03	.1791188E-03

42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	2000.502	1992.256	1984.048	1975.909	1967.748	1959.598	1951.467
45 TT4	2430.777	2419.127	2407.495	2395.946	2384.392	2372.818	2361.258
46 U35	342.0857	340.6755	339.2722	337.8804	336.4846	335.0911	333.7007
47 W3	187.9398	187.5708	187.2012	186.8292	186.4519	186.0729	185.6901
48 W35	233.2319	233.5672	233.9033	234.2362	234.5735	234.9124	235.2486

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-3.041101	-3.005198	-2.969367	-2.933508	-2.897903	-2.862359	-2.826691
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	172.7729	172.8483	172.9232	172.9943	173.0679	173.1409	173.2092
55 DMFUEL	1.694774	1.672708	1.650702	1.628760	1.606874	1.585033	1.563243
56 DPT4	126124.8	125594.0	125065.1	124537.4	124008.9	123481.0	122950.8
57 DTBIDL	688.4287	680.6689	672.9297	665.2209	657.5259	649.8491	642.2009
58 DTBLAG	691.8955	684.1033	676.3325	668.5918	660.8657	653.1597	645.4771
59 DTBURN	691.8538	684.0625	676.2917	668.5515	660.8247	653.1162	645.4363
60 DTT4	314394.5	311452.2	308556.6	305689.1	302814.9	299983.7	297171.9
61 ETAB	1.004975	1.004986	1.004996	1.005007	1.005017	1.005028	1.005038
62 FAO	.1107206E-01	.1093664E-01	.1080158E-01	.1066704E-01	.1053275E-01	.1039877E-01	.1026530E-01
63 FAP	.4428825E-01	.4374656E-01	.4320630E-01	.4266816E-01	.4213099E-01	.4159509E-01	.4106119E-01
64 FAPA	.4428825E-01	.4374656E-01	.4320630E-01	.4266816E-01	.4213099E-01	.4159509E-01	.4106119E-01
65 H35	480.1204	478.1414	476.1714	474.2183	472.2593	470.3032	468.3518
66 H4	583.3862	580.5906	577.7988	575.0271	572.2539	569.4761	566.7017
67 H4SS	646.1753	642.3259	638.4912	634.6802	630.8672	627.0618	623.2664
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	168.0312	168.3225	168.6132	168.9039	169.1951	169.4873	169.7805
72 QBURN	10186.89	10113.87	10040.44	9966.562	9892.277	9817.668	9742.734
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.2808265	.2826682	.2845244	.2863888	.2882728	.2901791	.2921042
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	.7034528	.8039455	.9044382	1.004929	1.105373	1.205818	1.306263
78 TLITE	.7034528	.8039455	.9044382	1.004929	1.105373	1.205818	1.306263
79 TT35	2000.502	1992.256	1984.048	1975.909	1967.748	1959.598	1951.467
80 TT4	2430.777	2419.127	2407.495	2395.946	2384.392	2372.818	2361.258
81 U4	415.6628	413.6707	411.6816	409.7068	407.7310	405.7517	403.7749
82 WFMB	2.582358	2.554441	2.526525	2.498608	2.470704	2.442801	2.414897
83 W35	233.2319	233.5672	233.9033	234.2362	234.5735	234.9124	235.2486
84 W4	61.34650	61.60065	61.85593	62.11171	62.36938	62.62926	62.89102

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	222.9716	223.0928	223.2151	223.3367	223.4602	223.5840	223.7083
87 PT4M	168.0312	168.3225	168.6132	168.9039	169.1951	169.4873	169.7805
88 QBURNM	-4916.328	-4946.152	-4977.594	-5009.410	-5040.543	-5073.414	-5106.684
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	2000.502	1992.256	1984.048	1975.909	1967.748	1959.598	1951.467

91 TT4M	2430.777	2419.127	2407.495	2395.946	2384.392	2372.818	2361.258
92 WFMBM	2.582358	2.554441	2.526525	2.498608	2.470704	2.442801	2.414897
93 W3M	187.9398	187.5708	187.2012	186.8292	186.4519	186.0729	185.6901
94 W35M	233.2319	233.5672	233.9033	234.2362	234.5735	234.9124	235.2486
95 W4M	61.34650	61.60065	61.85593	62.11171	62.36938	62.62926	62.89102

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BRNMDL

1 TIME	1.406708	1.507153	1.607597	1.708042	1.808487	1.908932	2.009377
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-2.791181	-2.755801	-2.720138	-2.684515	-2.649103	-2.613697	-2.578246
5 DPT35	-97916.56	-97610.94	-97277.12	-96944.69	-96615.12	-96285.31	-95956.25
6 DPT4	122420.3	121893.9	121317.9	120742.4	120167.1	119589.2	119011.2
7 DTT35	-632929.4	-625094.1	-616658.7	-608296.4	-600005.9	-591767.3	-583623.6
8 DTT4	294362.1	291599.9	288577.1	285600.8	282635.7	279681.3	276768.7
9 FAMB	.1356928E-01	.1341109E-01	.1325310E-01	.1309523E-01	.1293755E-01	.1278001E-01	.1262254E-01
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.116899	1.116272	1.115591	1.114905	1.114211	1.113511	1.112814
18 PRLINR	1.316088	1.314567	1.312903	1.311245	1.309597	1.307942	1.306292
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	223.8339	223.9596	224.0963	224.2343	224.3740	224.5149	224.6557
21 PT4	170.0751	170.3676	170.6875	171.0086	171.3305	171.6550	171.9796
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1943.338	1935.299	1926.584	1917.880	1909.186	1900.487	1891.820
27 TT4	2349.715	2338.264	2325.841	2313.391	2300.964	2288.529	2276.104
28 WFMB	2.386993	2.359090	2.331186	2.303283	2.275379	2.247476	2.219572
29 W3	185.3037	184.9130	184.4867	184.0565	183.6198	183.1765	182.7306
30 W35	235.5872	235.9244	236.2881	236.6538	237.0221	237.3910	237.7588
31 W4	63.15469	63.41800	63.70654	63.99789	64.29129	64.58781	64.88637

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-97916.56	-97610.94	-97277.12	-96944.69	-96615.12	-96285.31	-95956.25
34 DTT35	-632929.4	-625094.1	-616658.7	-608296.4	-600005.9	-591767.3	-583623.6
35 FAMB	.1356928E-01	.1341109E-01	.1325310E-01	.1309523E-01	.1293755E-01	.1278001E-01	.1262254E-01
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	466.4011	464.4717	462.3801	460.2910	458.2046	456.1167	454.0366
38 H4	563.9316	561.1833	558.2019	555.2139	552.2314	549.2468	546.2649
39 PT35	223.8339	223.9596	224.0963	224.2343	224.3740	224.5149	224.6557
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.1799690E-03	.1808181E-03	.1817469E-03	.1826842E-03	.1836303E-03	.1845868E-03	.1855487E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000

43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1943.338	1935.299	1926.584	1917.880	1909.186	1900.487	1891.820
45 TT4	2349.715	2338.264	2325.841	2313.391	2300.964	2288.529	2276.104
46 U35	332.3108	330.9360	329.4458	327.9573	326.4707	324.9832	323.5010
47 M3	185.3037	184.9130	184.4867	184.0565	183.6198	183.1765	182.7306
48 M35	235.5872	235.9244	236.2881	236.6538	237.0221	237.3910	237.7588

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-2.791181	-2.755801	-2.720138	-2.684515	-2.649103	-2.613697	-2.578246
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	173.2780	173.3456	173.4148	173.4832	173.5520	173.6181	173.6812
55 DMFUEL	1.541502	1.519840	1.497919	1.476048	1.454231	1.432458	1.410749
56 DPT4	122420.3	121893.9	121317.9	120742.4	120167.1	119589.2	119011.2
57 DTBIDL	634.5686	626.9583	618.5891	610.2402	601.9106	593.6055	585.3289
58 DTBLAG	637.8120	630.1704	621.7585	613.3662	604.9973	596.6504	588.3291
59 DTBURN	637.7717	630.1252	621.7139	613.3228	604.9507	596.6035	588.2849
60 DTT4	294362.1	291599.9	288577.1	285600.8	282635.7	279681.3	276768.7
61 ETAB	1.005048	1.005052	1.005052	1.005052	1.005051	1.005051	1.005051
62 FAO	.1013210E-01	.9999342E-02	.9865861E-02	.9732708E-02	.9599857E-02	.9467401E-02	.9335395E-02
63 FAP	.4052839E-01	.3999737E-01	.3946345E-01	.3893083E-01	.3839943E-01	.3786960E-01	.3734158E-01
64 FAPA	.4052839E-01	.3999737E-01	.3946345E-01	.3893083E-01	.3839943E-01	.3786960E-01	.3734158E-01
65 H35	466.4011	464.4717	462.3801	460.2910	458.2046	456.1167	454.0366
66 H4	563.9316	561.1833	558.2019	555.2139	552.2314	549.2468	546.2649
67 H4SS	619.4761	615.7124	611.6021	607.4990	603.4038	599.3127	595.2356
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	170.0751	170.3676	170.6875	171.0086	171.3305	171.6550	171.9796
72 QBURN	9667.398	9591.383	9506.410	9421.000	9335.043	9248.719	9161.887
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.2940485	.2959965	.2981364	.3003048	.3024949	.3047147	.3069575
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	1.406708	1.507153	1.607597	1.708042	1.808487	1.908932	2.009377
78 TLITE	1.406708	1.507153	1.607597	1.708042	1.808487	1.908932	2.009377
79 TT35	1943.338	1935.299	1926.584	1917.880	1909.186	1900.487	1891.820
80 TT4	2349.715	2338.264	2325.841	2313.391	2300.964	2288.529	2276.104
81 U4	401.8013	399.8430	397.7187	395.5898	393.4648	391.3384	389.2136
82 WFMB	2.386993	2.359090	2.331186	2.303283	2.275379	2.247476	2.219572
83 M35	235.5872	235.9244	236.2881	236.6538	237.0221	237.3910	237.7588
84 M4	63.15469	63.41800	63.70654	63.99789	64.29129	64.58781	64.88637

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	223.8339	223.9596	224.0963	224.2343	224.3740	224.5149	224.6557
87 PT4M	170.0751	170.3676	170.6875	171.0086	171.3305	171.6550	171.9796
88 QBURNM	-5139.582	-5173.828	-5211.930	-5251.566	-5291.145	-5330.859	-5372.121
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1943.338	1935.299	1926.584	1917.880	1909.186	1900.487	1891.820
91 TT4M	2349.715	2338.264	2325.841	2313.391	2300.964	2288.529	2276.104

92	NFMBM	2.386993	2.359090	2.331186	2.303283	2.275379	2.247476	2.219572
93	W3M	185.3037	184.9130	184.4867	184.0565	183.6198	183.1765	182.7306
94	W35M	235.5872	235.9244	236.2881	236.6538	237.0221	237.3910	237.7588
95	W4M	63.15469	63.41800	63.70654	63.99789	64.29129	64.58781	64.88637

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BRNMDL

1	TIME	2.109821	2.210266	2.310711	2.411156	2.511600	2.612045	2.712490
2	ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3	ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4	DFAMB	-2.543099	-2.507834	-2.472662	-2.437656	-2.402614	-2.367666	-2.332793
5	DPT35	-95632.31	-95306.00	-94980.81	-94658.62	-94336.37	-94015.62	-93695.12
6	DPT4	118434.1	117855.0	117274.2	116693.1	116112.0	115528.9	114944.2
7	DTT35	-575535.1	-567530.1	-559584.0	-551696.9	-543905.5	-536167.2	-528489.1
8	DTT4	273865.4	270995.8	268133.7	265287.2	262485.1	259690.9	256908.4
9	FAMB	.1246531E-01	.1230815E-01	.1215115E-01	.1199432E-01	.1183755E-01	.1168095E-01	.1152448E-01
10	FA3	.0	.0	.0	.0	.0	.0	.0
11	FA35	.0	.0	.0	.0	.0	.0	.0
12	FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13	GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14	GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15	GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16	IUPDAT	.0	.0	.0	.0	.0	.0	.0
17	PRDIFF	1.112102	1.111391	1.110676	1.109949	1.109225	1.108493	1.107755
18	PRLINR	1.304652	1.303013	1.301366	1.299729	1.298093	1.296460	1.294820
19	PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20	PT35	224.7995	224.9433	225.0881	225.2355	225.3824	225.5314	225.6817
21	PT4	172.3060	172.6331	172.9629	173.2941	173.6257	173.9593	174.2957
22	R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24	R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26	TT35	1883.152	1874.506	1865.858	1857.212	1848.597	1839.981	1831.363
27	TT4	2263.688	2251.273	2238.859	2226.449	2214.040	2201.636	2189.225
28	NFMB	2.191669	2.163765	2.135861	2.107958	2.080054	2.052151	2.024247
29	W3	182.2735	181.8166	181.3526	180.8794	180.4062	179.9234	179.4360
30	W35	238.1315	238.5017	238.8735	239.2478	239.6215	239.9960	240.3721
31	W4	65.18753	65.49113	65.79790	66.10735	66.41920	66.73405	67.05235

OUTLNR

32	CV35P	.1709999	.1709999	.1709999	.1709998	.1709999	.1709999	.1709999
33	DPT35	-95632.31	-95306.00	-94980.81	-94658.62	-94336.37	-94015.62	-93695.12
34	DTT35	-575535.1	-567530.1	-559584.0	-551696.9	-543905.5	-536167.2	-528489.1
35	FAMB	.1246531E-01	.1230815E-01	.1215115E-01	.1199432E-01	.1183755E-01	.1168095E-01	.1152448E-01
36	W3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37	W35	451.9563	449.8813	447.8057	445.7307	443.6633	441.5955	439.5271
38	W4	543.2849	540.3054	537.3262	534.3477	531.3696	528.3926	525.4138
39	PT35	224.7995	224.9433	225.0881	225.2355	225.3824	225.5314	225.6817
40	QDBNCS	.0	.0	.0	.0	.0	.0	.0
41	RHO35	.1865220E-03	.1875023E-03	.1884926E-03	.1894941E-03	.1905012E-03	.1915198E-03	.1925493E-03
42	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000

44 TT35	1883.152	1874.506	1865.858	1857.212	1848.597	1839.981	1831.363
45 TT4	2263.688	2251.273	2238.859	2226.449	2214.040	2201.636	2189.225
46 U35	322.0188	320.5405	319.0615	317.5830	316.1101	314.6367	313.1631
47 W3	182.2735	181.8166	181.3526	180.8794	180.4062	179.9234	179.4360
48 W35	238.1315	238.5017	238.8735	239.2478	239.6215	239.9960	240.3721

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-2.543099	-2.507834	-2.472662	-2.437656	-2.402614	-2.367666	-2.332793
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	173.7465	173.8068	173.8655	173.9239	173.9793	174.0325	174.0837
55 DMFUEL	1.389090	1.367491	1.345940	1.324442	1.303011	1.281633	1.260307
56 DPT4	118434.1	117855.0	117274.2	116693.1	116112.0	115528.9	114944.2
57 DTBIDL	577.0657	568.8345	560.6248	552.4348	544.2720	536.1326	528.0151
58 DTBLAG	580.0300	571.7556	563.5039	555.2759	547.0708	538.8909	530.7317
59 DTBURN	579.9807	571.7078	563.4568	555.2258	547.0225	538.8423	530.6843
60 DTT4	273865.4	270995.8	268133.7	265287.2	262485.1	259690.9	256908.4
61 ETAB	1.005052	1.005052	1.005052	1.005053	1.005054	1.005054	1.005055
62 FAO	.9203605E-02	.9072326E-02	.8941390E-02	.8810770E-02	.8680582E-02	.8550767E-02	.8421302E-02
63 FAP	.3681442E-01	.3628930E-01	.3576556E-01	.3524308E-01	.3472233E-01	.3420307E-01	.3368521E-01
64 FAPA	.3681442E-01	.3628930E-01	.3576556E-01	.3524308E-01	.3472233E-01	.3420307E-01	.3368521E-01
65 H35	451.9563	449.8813	447.8057	445.7307	443.6633	441.5955	439.5271
66 H4	543.2849	540.3054	537.3262	534.3477	531.3696	528.3926	525.4138
67 H4SS	591.1636	587.1028	583.0466	578.9971	574.9602	570.9292	566.9026
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	172.3060	172.6331	172.9629	173.2941	173.6257	173.9593	174.2957
72 QBURN	9074.578	8986.785	8898.570	8809.883	8720.633	8630.965	8540.824
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3092268	.3115225	.3138483	.3162018	.3185825	.3209932	.3234373
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	2.109821	2.210266	2.310711	2.411156	2.511600	2.612045	2.712490
78 TLITE	2.109821	2.210266	2.310711	2.411156	2.511600	2.612045	2.712490
79 TT35	1883.152	1874.506	1865.858	1857.212	1848.597	1839.981	1831.363
80 TT4	2263.688	2251.273	2238.859	2226.449	2214.040	2201.636	2189.225
81 U4	387.0906	384.9675	382.8447	380.7227	378.6008	376.4795	374.3574
82 WFMB	2.191669	2.163765	2.135861	2.107958	2.080054	2.052151	2.024247
83 W35	238.1315	238.5017	238.8735	239.2478	239.6215	239.9960	240.3721
84 W4	65.18753	65.49113	65.79790	66.10735	66.41920	66.73405	67.05235

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	224.7995	224.9433	225.0881	225.2355	225.3824	225.5314	225.6817
87 PT4M	172.3060	172.6331	172.9629	173.2941	173.6257	173.9593	174.2957
88 QBURNM	-5413.348	-5455.836	-5498.266	-5541.004	-5585.652	-5630.199	-5675.039
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1883.152	1874.506	1865.858	1857.212	1848.597	1839.981	1831.363
91 TT4M	2263.688	2251.273	2238.859	2226.449	2214.040	2201.636	2189.225
92 WFMBM	2.191669	2.163765	2.135861	2.107958	2.080054	2.052151	2.024247

93 W3M	182.2735	181.8166	181.3526	180.8794	180.4062	179.9234	179.4360
94 W35M	238.1315	238.5017	238.8735	239.2478	239.6215	239.9960	240.3721
95 W4M	65.18753	65.49113	65.79790	66.10735	66.41920	66.73405	67.05235

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BRNMDL

1 TIME	2.812935	2.913380	3.013824	3.114269	3.214714	3.315159	3.415604
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-2.298051	-2.263397	-2.228763	-2.194085	-2.159644	-2.125183	-2.090957
5 DPT35	-93379.25	-93063.94	-92749.19	-92433.81	-92122.44	-91810.00	-91503.25
6 DPT4	114358.7	113772.9	113186.1	112596.6	112006.4	111412.9	110819.9
7 DTT35	-520858.0	-513310.1	-505831.9	-498421.4	-491054.4	-483747.4	-476489.1
8 DTT4	254148.8	251406.4	248697.2	246008.6	243324.2	240652.7	238002.4
9 FAMB	.1136815E-01	.1121194E-01	.1105582E-01	.1089980E-01	.1074396E-01	.1058820E-01	.1043263E-01
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.107004	1.106249	1.105493	1.104733	1.103958	1.103182	1.102387
18 PRLINR	1.293181	1.291553	1.289921	1.288285	1.286651	1.285007	1.283371
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	225.8346	225.9888	226.1434	226.2987	226.4577	226.6171	226.7803
21 PT4	174.6348	174.9744	175.3157	175.6588	176.0054	176.3547	176.7067
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1822.737	1814.133	1805.539	1796.954	1788.352	1779.749	1771.137
27 TT4	2176.790	2164.382	2151.956	2139.528	2127.086	2114.637	2102.165
28 WFMB	1.996344	1.968440	1.940536	1.912633	1.884729	1.856826	1.828922
29 W3	178.9333	178.4287	177.9186	177.4030	176.8753	176.3419	175.7931
30 W35	240.7516	241.1315	241.5118	241.8901	242.2738	242.6566	243.0447
31 W4	67.37440	67.69867	68.02626	68.35704	68.69197	69.03059	69.37326

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709998
33 DPT35	-93379.25	-93063.94	-92749.19	-92433.81	-92122.44	-91810.00	-91503.25
34 DTT35	-520858.0	-513310.1	-505831.9	-498421.4	-491054.4	-483747.4	-476489.1
35 FAMB	.1136815E-01	.1121194E-01	.1105582E-01	.1089980E-01	.1074396E-01	.1058820E-01	.1043263E-01
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	437.4568	435.3918	433.3291	431.2688	429.2043	427.1396	425.0728
38 H4	522.4294	519.4514	516.4692	513.4866	510.5007	507.5127	504.5193
39 PT35	225.8346	225.9888	226.1434	226.2987	226.4577	226.6171	226.7803
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.1935917E-03	.1946426E-03	.1957029E-03	.1967729E-03	.1978582E-03	.1989546E-03	.2000661E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1822.737	1814.133	1805.539	1796.954	1788.352	1779.749	1771.137

45 TT4	2176.790	2164.382	2151.956	2139.528	2127.086	2114.637	2102.165
46 U35	311.6880	310.2166	308.7471	307.2791	305.8081	304.3369	302.8643
47 W3	178.9333	178.4287	177.9186	177.4030	176.8753	176.3419	175.7931
48 W35	240.7516	241.1315	241.5118	241.8901	242.2738	242.6566	243.0447
BURNER							
49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-2.298051	-2.263397	-2.228763	-2.194085	-2.159644	-2.125183	-2.090957
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	174.1345	174.1834	174.2294	174.2701	174.3120	174.3492	174.3876
55 DMFUEL	1.239030	1.217822	1.196673	1.175588	1.154550	1.133574	1.112649
56 DPT4	114358.7	113772.9	113186.1	112596.6	112006.4	111412.9	110819.9
57 DTBIDL	519.9160	511.8416	503.7910	495.7703	487.7637	479.7844	471.8198
58 DTBLAG	522.5952	514.4819	506.3928	498.3286	490.2847	482.2634	474.2642
59 DTBURN	522.5447	514.4299	506.3396	498.2788	490.2327	482.2139	474.2100
60 DTT4	254148.8	251406.4	248697.2	246008.6	243324.2	240652.7	238002.4
61 ETAB	1.005056	1.005057	1.005059	1.005060	1.005062	1.005064	1.005066
62 FAO	.8292127E-02	.8163348E-02	.8034952E-02	.7907029E-02	.7779334E-02	.7652070E-02	.7525045E-02
63 FAP	.3316851E-01	.3265339E-01	.3213981E-01	.3162812E-01	.3111733E-01	.3060828E-01	.3010018E-01
64 FAPA	.3316851E-01	.3265339E-01	.3213981E-01	.3162812E-01	.3111733E-01	.3060828E-01	.3010018E-01
65 H35	437.4568	435.3918	433.3291	431.2688	429.2043	427.1396	425.0728
66 H4	522.4294	519.4514	516.4692	513.4866	510.5007	507.5127	504.5193
67 H4SS	562.8796	558.8674	554.8635	550.8677	546.8726	542.8828	538.8962
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	174.6348	174.9744	175.3157	175.6588	176.0054	176.3547	176.7067
72 QBURN	8450.289	8359.133	8267.531	8175.422	8082.859	7989.816	7896.305
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3259175	.3284234	.3309641	.3335381	.3361509	.3388011	.3414913
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	2.812935	2.913380	3.013824	3.114269	3.214714	3.315159	3.415604
78 TLITE	2.812935	2.913380	3.013824	3.114269	3.214714	3.315159	3.415604
79 TT35	1822.737	1814.133	1805.539	1796.954	1788.352	1779.749	1771.137
80 TT4	2176.790	2164.382	2151.956	2139.528	2127.086	2114.637	2102.165
81 U4	372.2310	370.1091	367.9844	365.8591	363.7317	361.6028	359.4700
82 WFMB	1.996344	1.968440	1.940536	1.912633	1.884729	1.856826	1.828922
83 W35	240.7516	241.1315	241.5118	241.8901	242.2738	242.6566	243.0447
84 W4	67.37440	67.69867	68.02626	68.35704	68.69197	69.03059	69.37326
SENSED PARAMETERS							
85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	225.8346	225.9888	226.1434	226.2987	226.4577	226.6171	226.7803
87 PT4M	174.6348	174.9744	175.3157	175.6588	176.0054	176.3547	176.7067
88 QBURNM	-5720.801	-5766.879	-5814.453	-5862.734	-5910.969	-5959.570	-6009.094
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1822.737	1814.133	1805.539	1796.954	1788.352	1779.749	1771.137
91 TT4M	2176.790	2164.382	2151.956	2139.528	2127.086	2114.637	2102.165
92 WFMBM	1.996344	1.968440	1.940536	1.912633	1.884729	1.856826	1.828922
93 W3M	178.9333	178.4287	177.9186	177.4030	176.8753	176.3419	175.7931

94	M35M	240.7516	241.1315	241.5118	241.8901	242.2738	242.6566	243.0447
95	M4M	67.37440	67.69867	68.02626	68.35704	68.69197	69.03059	69.37326

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BRNMDL

1	TIME	3.516048	3.616493	3.716938	3.817383	3.917828	4.018272	4.118717
2	ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3	ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4	DFAMB	-2.056669	-2.022459	-1.988378	-1.954441	-1.920522	-1.886525	-1.852839
5	DPT35	-91194.75	-90888.31	-90583.62	-90282.31	-89982.19	-89678.75	-89383.87
6	DPT4	110223.9	109626.9	109025.5	108425.7	107821.7	107214.6	106606.6
7	DTT35	-469302.0	-462179.1	-455080.0	-448064.4	-441090.7	-434186.1	-427312.1
8	DTT4	235367.7	232761.9	230142.4	227561.8	224983.9	222445.2	219894.6
9	FAMB	.1027709E-01	.1012167E-01	.9966418E-02	.9811245E-02	.9656172E-02	.9501159E-02	.9346325E-02
10	FA3	.0	.0	.0	.0	.0	.0	.0
11	FA35	.0	.0	.0	.0	.0	.0	.0
12	FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13	GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14	GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15	GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16	IUPDAT	.0	.0	.0	.0	.0	.0	.0
17	PRDIFF	1.101593	1.100792	1.099975	1.099150	1.098315	1.097485	1.096624
18	PRLINR	1.281730	1.280088	1.278432	1.276789	1.275133	1.273468	1.271809
19	PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20	PT35	226.9440	227.1092	227.2779	227.4484	227.6213	227.7936	227.9722
21	PT4	177.0606	177.4168	177.7786	178.1409	178.5078	178.8765	179.2503
22	R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24	R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26	TT35	1762.537	1753.940	1745.305	1736.692	1728.062	1719.437	1710.782
27	TT4	2089.697	2077.208	2064.694	2052.177	2039.639	2027.061	2014.475
28	WFMB	1.801019	1.773116	1.745213	1.717309	1.689405	1.661502	1.633598
29	W3	175.2413	174.6812	174.1048	173.5232	172.9271	172.3298	171.7084
30	W35	243.4305	243.8180	244.2081	244.6015	244.9947	245.3851	245.7835
31	W4	69.71924	70.06920	70.42456	70.78299	71.14639	71.51422	71.88716

OUTLNR

32	CV35P	.1709999	.1709999	.1709999	.1709999	.1709998	.1709999	.1709999
33	DPT35	-91194.75	-90888.31	-90583.62	-90282.31	-89982.19	-89678.75	-89383.87
34	DTT35	-469302.0	-462179.1	-455080.0	-448064.4	-441090.7	-434186.1	-427312.1
35	FAMB	.1027709E-01	.1012167E-01	.9966418E-02	.9811245E-02	.9656172E-02	.9501159E-02	.9346325E-02
36	H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37	H35	423.0088	420.9453	418.8730	416.8059	414.7346	412.6648	410.5876
38	H4	501.5273	498.5298	495.5266	492.5222	489.5132	486.4944	483.4739
39	PT35	226.9440	227.1092	227.2779	227.4484	227.6213	227.7936	227.9722
40	QDBNCS	.0	.0	.0	.0	.0	.0	.0
41	RHO35	.2011874E-03	.2023207E-03	.2034726E-03	.2046353E-03	.2058135E-03	.2070025E-03	.2082128E-03
42	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44	TT35	1762.537	1753.940	1745.305	1736.692	1728.062	1719.437	1710.782
45	TT4	2089.697	2077.208	2064.694	2052.177	2039.639	2027.061	2014.475

46 U35	301.3938	299.9236	298.4470	296.9741	295.4983	294.0237	292.5437
47 M3	175.2413	174.6812	174.1048	173.5232	172.9271	172.3298	171.7084
48 M35	243.4305	243.8180	244.2081	244.6015	244.9947	245.3851	245.7835

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-2.056669	-2.022459	-1.988378	-1.954441	-1.920522	-1.886525	-1.852839
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	174.4205	174.4509	174.4785	174.5062	174.5287	174.5439	174.5620
55 DMFUEL	1.091796	1.071005	1.050258	1.029586	1.008973	.9884285	.9679389
56 DPT4	110223.9	109626.9	109025.5	108425.7	107821.7	107214.6	106606.6
57 DTBIDL	463.8848	455.9722	448.0798	440.2063	432.3586	424.5413	416.7346
58 DTBLAG	466.2888	458.3369	450.4060	442.4978	434.6118	426.7517	418.9114
59 DTBURN	466.2361	458.2842	450.3530	442.4409	434.5547	426.6987	418.8535
60 DTT4	235367.7	232761.9	230142.4	227561.8	224983.9	222445.2	219894.6
61 ETAB	1.005069	1.005071	1.005074	1.005076	1.005079	1.005082	1.005085
62 FAO	.7398490E-02	.7272292E-02	.7146414E-02	.7020842E-02	.6895680E-02	.6770998E-02	.6646492E-02
63 FAP	.2959396E-01	.2908917E-01	.2858566E-01	.2808337E-01	.2758272E-01	.2708399E-01	.2658597E-01
64 FAPA	.2959396E-01	.2908917E-01	.2858566E-01	.2808337E-01	.2758272E-01	.2708399E-01	.2658597E-01
65 H35	423.0088	420.9453	418.8730	416.8059	414.7346	412.6648	410.5876
66 H4	501.5273	498.5298	495.5266	492.5222	489.5132	486.4944	483.4739
67 H4SS	534.9182	530.9463	526.9705	523.0054	519.0415	515.0852	511.1262
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	177.0606	177.4168	177.7786	178.1409	178.5078	178.8765	179.2503
72 QBURN	7802.238	7707.680	7612.711	7517.113	7421.059	7324.516	7227.430
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3442167	.3469832	.3497979	.3526490	.3555471	.3584926	.3614858
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	3.516048	3.616493	3.716938	3.817383	3.917828	4.018272	4.118717
78 TLITE	3.516048	3.616493	3.716938	3.817383	3.917828	4.018272	4.118717
79 TT35	1762.537	1753.940	1745.305	1736.692	1728.062	1719.437	1710.782
80 TT4	2089.697	2077.208	2064.694	2052.177	2039.639	2027.061	2014.475
81 U4	357.3381	355.2024	353.0625	350.9221	348.7781	346.6272	344.4751
82 WFMB	1.801019	1.773116	1.745213	1.717309	1.689405	1.661502	1.633598
83 W35	243.4305	243.8180	244.2081	244.6015	244.9947	245.3851	245.7835
84 W4	69.71924	70.06920	70.42456	70.78299	71.14639	71.51422	71.88716

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	226.9440	227.1092	227.2779	227.4484	227.6213	227.7936	227.9722
87 PT4M	177.0606	177.4168	177.7786	178.1409	178.5078	178.8765	179.2503
88 QBURNM	-6059.055	-6110.414	-6160.797	-6213.051	-6265.219	-6319.539	-6372.891
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1762.537	1753.940	1745.305	1736.692	1728.062	1719.437	1710.782
91 TT4M	2089.697	2077.208	2064.694	2052.177	2039.639	2027.061	2014.475
92 WFMBM	1.801019	1.773116	1.745213	1.717309	1.689405	1.661502	1.633598
93 W3M	175.2413	174.6812	174.1048	173.5232	172.9271	172.3298	171.7084
94 W35M	243.4305	243.8180	244.2081	244.6015	244.9947	245.3851	245.7835

95 MAM	69.71924	70.06920	70.42456	70.78299	71.14639	71.51422	71.88716

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BRNMDL

1 TIME	4.219162	4.319607	4.420052	4.520496	4.620941	4.721386	4.821831
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-1.819263	-1.785377	-1.751880	-1.718612	-1.685014	-1.651942	-1.618705
5 DPT35	-89092.25	-88788.94	-88497.12	-88212.94	-87916.00	-87636.06	-87351.50
6 DPT4	105994.0	105377.4	104758.2	104139.1	103511.2	102882.7	102252.1
7 DTT35	-420463.4	-413719.5	-406976.2	-400281.3	-393655.9	-387023.3	-380483.3
8 DTT4	217336.3	214847.7	212323.7	209815.6	207341.6	204836.4	202399.7
9 FAMB	.9191632E-02	.9036873E-02	.8882359E-02	.8727949E-02	.8573510E-02	.8419357E-02	.8265138E-02
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.095746	1.094894	1.094001	1.093085	1.092190	1.091239	1.090302
18 PRLINR	1.270135	1.268445	1.266755	1.265069	1.263350	1.261637	1.259920
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	228.1549	228.3324	228.5190	228.7103	228.8979	229.0973	229.2941
21 PT4	179.6303	180.0096	180.3971	180.7887	181.1832	181.5873	181.9909
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1702.088	1693.432	1684.713	1675.974	1667.239	1658.421	1649.634
27 TT4	2001.852	1989.184	1976.494	1963.771	1950.994	1938.169	1925.291
28 WFMB	1.605695	1.577791	1.549888	1.521984	1.494081	1.466177	1.438273
29 W3	171.0669	170.4422	169.7818	169.1009	168.4284	167.7112	166.9960
30 W35	246.1852	246.5762	246.9782	247.3878	247.7850	248.2000	248.6086
31 W4	72.26634	72.64917	73.03889	73.43420	73.83501	74.24413	74.65758

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709998	.1709999
33 DPT35	-89092.25	-88788.94	-88497.12	-88212.94	-87916.00	-87636.06	-87351.50
34 DTT35	-420463.4	-413719.5	-406976.2	-400281.3	-393655.9	-387023.3	-380483.3
35 FAMB	.9191632E-02	.9036873E-02	.8882359E-02	.8727949E-02	.8573510E-02	.8419357E-02	.8265138E-02
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	408.5010	406.4236	404.3308	402.2336	400.1372	398.0210	395.9121
38 H4	480.4443	477.4041	474.3584	471.3049	468.2385	465.1604	462.0698
39 PT35	228.1549	228.3324	228.5190	228.7103	228.8979	229.0973	229.2941
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2094440E-03	.2106783E-03	.2119417E-03	.2132252E-03	.2145183E-03	.2158467E-03	.2171829E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1702.088	1693.432	1684.713	1675.974	1667.239	1658.421	1649.634
45 TT4	2001.852	1989.184	1976.494	1963.771	1950.994	1938.169	1925.291
46 U35	291.0569	289.5767	288.0857	286.5913	285.0977	283.5898	282.0874

47 M3	171.0669	170.4422	169.7818	169.1009	168.4284	167.7112	166.9960
48 M35	246.1852	246.5762	246.9782	247.3878	247.7850	248.2000	248.6086

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-1.819263	-1.785377	-1.751880	-1.718612	-1.685014	-1.651942	-1.618705
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	174.5770	174.5776	174.5823	174.5889	174.5776	174.5758	174.5630
55 DMFUEL	.9474990	.9271492	.9068413	.8865992	.8664360	.8463079	.8262762
56 DPT4	105994.0	105377.4	104758.2	104139.1	103511.2	102882.7	102252.1
57 DTBIDL	408.9480	401.2041	393.4673	385.7434	378.0645	370.3833	362.7373
58 DTBLAG	411.0908	403.2991	395.5251	387.7708	380.0444	372.3337	364.6506
59 DTBURN	411.0291	403.2468	395.4722	387.7107	379.9939	372.2751	364.5918
60 DTT4	217336.3	214847.7	212323.7	209815.6	207341.6	204836.4	202399.7
61 ETAB	1.005089	1.005092	1.005095	1.005100	1.005104	1.005108	1.005113
62 FAO	.6522305E-02	.6398797E-02	.6275401E-02	.6152216E-02	.6029744E-02	.5907238E-02	.5785290E-02
63 FAP	.2608922E-01	.2559519E-01	.2510160E-01	.2460887E-01	.2411897E-01	.2362895E-01	.2314116E-01
64 FAPA	.2608922E-01	.2559519E-01	.2510160E-01	.2460887E-01	.2411897E-01	.2362895E-01	.2314116E-01
65 H35	408.5010	406.4236	404.3308	402.2336	400.1372	398.0210	395.9121
66 H4	480.4443	477.4041	474.3584	471.3049	468.2385	465.1604	462.0698
67 H4SS	507.1628	503.2153	499.2571	495.2986	491.3479	487.3811	483.4282
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	179.6303	180.0096	180.3971	180.7887	181.1832	181.5873	181.9909
72 QBURN	7129.930	7031.840	6933.309	6834.148	6734.539	6634.461	6533.738
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3645365	.3676329	.3707898	.3740020	.3772726	.3806165	.3840137
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	4.219162	4.319607	4.420052	4.520496	4.620941	4.721386	4.821831
78 TLITE	4.219162	4.319607	4.420052	4.520496	4.620941	4.721386	4.821831
79 TT35	1702.088	1693.432	1684.713	1675.974	1667.239	1658.421	1649.634
80 TT4	2001.852	1989.184	1976.494	1963.771	1950.994	1938.169	1925.291
81 U4	342.3167	340.1504	337.9802	335.8047	333.6199	331.4268	329.2246
82 WFMB	1.605695	1.577791	1.549888	1.521984	1.494081	1.466177	1.438273
83 W35	246.1852	246.5762	246.9782	247.3878	247.7850	248.2000	248.6086
84 W4	72.26634	72.64917	73.03889	73.43420	73.83501	74.24413	74.65758

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	228.1549	228.3324	228.5190	228.7103	228.8979	229.0973	229.2941
87 PT4M	179.6303	180.0096	180.3971	180.7887	181.1832	181.5873	181.9909
88 QBURNM	-6425.719	-6482.516	-6537.082	-6592.559	-6650.012	-6705.703	-6765.516
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1702.088	1693.432	1684.713	1675.974	1667.239	1658.421	1649.634
91 TT4M	2001.852	1989.184	1976.494	1963.771	1950.994	1938.169	1925.291
92 WFMBM	1.605695	1.577791	1.549888	1.521984	1.494081	1.466177	1.438273
93 W3M	171.0669	170.4422	169.7818	169.1009	168.4284	167.7112	166.9960
94 W35M	246.1852	246.5762	246.9782	247.3878	247.7850	248.2000	248.6086
95 W4M	72.26634	72.64917	73.03889	73.43420	73.83501	74.24413	74.65758

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BRNMDL

1 TIME	4.922276	5.022720	5.123165	5.223610	5.324055	5.424500	5.524944
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-1.586156	-1.550808	-1.606487	-1.401346	-1.365279	-1.334426	-1.303105
5 DPT35	-87091.75	-86712.69	-92199.25	-87201.19	-87174.06	-87167.56	-87042.06
6 DPT4	101621.0	100932.4	103465.6	102262.9	102252.5	102096.3	101751.6
7 DTT35	-373910.5	-367483.7	-367802.0	-396737.5	-401642.7	-402835.9	-400810.8
8 DTT4	199899.1	197443.0	200107.7	206742.1	206365.4	204999.1	203194.2
9 FAMB	.8111261E-02	.7956814E-02	.7779449E-02	.7520188E-02	.7359661E-02	.7202473E-02	.7045541E-02
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.089293	1.088490	1.079644	1.093829	1.094801	1.095008	1.094771
18 PRLINR	1.258202	1.256267	1.266750	1.261795	1.262229	1.262239	1.261585
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	229.5067	229.6758	231.5576	228.5548	228.3519	228.3089	228.3582
21 PT4	182.4084	182.8241	182.7964	181.1345	180.9116	180.8762	181.0088
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1640.727	1631.930	1632.614	1671.681	1678.313	1679.984	1677.391
27 TT4	1912.364	1899.375	1899.676	1937.168	1944.337	1945.771	1941.380
28 WFMB	1.410370	1.382466	1.354563	1.326659	1.298756	1.270852	1.242949
29 W3	166.2181	165.5969	158.4385	169.6550	170.3741	170.5261	170.3533
30 W35	249.0434	249.3588	254.2231	246.6703	246.0790	245.9139	245.9827
31 W4	75.08134	75.50929	75.49193	74.07814	73.85043	73.80875	73.94635

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-87091.75	-86712.69	-92199.25	-87201.19	-87174.06	-87167.56	-87042.06
34 DTT35	-373910.5	-367483.7	-367802.0	-396737.5	-401642.7	-402835.9	-400810.8
35 FAMB	.8111261E-02	.7956814E-02	.7779449E-02	.7520188E-02	.7359661E-02	.7202473E-02	.7045541E-02
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	393.7744	391.6631	391.8271	401.2034	402.7949	403.1960	402.5737
38 H4	458.9670	455.8499	455.9221	464.9202	466.6409	466.9851	465.9312
39 PT35	229.5067	229.6758	231.5576	228.5548	228.3519	228.3089	228.3582
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2185643E-03	.2199043E-03	.2216131E-03	.2136276E-03	.2125944E-03	.2123430E-03	.2127171E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1640.727	1631.930	1632.614	1671.681	1678.313	1679.984	1677.391
45 TT4	1912.364	1899.375	1899.676	1937.168	1944.337	1945.771	1941.380
46 U35	280.5642	279.0601	279.1770	285.8574	286.9915	287.2771	286.8337
47 W3	166.2181	165.5969	158.4385	169.6550	170.3741	170.5261	170.3533

48 M35	249.0434	249.3588	254.2231	246.6703	246.0790	245.9139	245.9827
BURNER							
49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-1.586156	-1.550808	-1.606487	-1.401346	-1.365279	-1.334426	-1.303105
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	174.5661	174.4456	179.3139	173.1450	172.7681	172.6329	172.5537
55 DMFUEL	.8062655	.7863956	.7718105	.7737356	.7592123	.7430480	.7256012
56 DPT4	101621.0	100932.4	103465.6	102262.9	102252.5	102096.3	101751.6
57 DTBIDL	355.0791	347.6135	334.0803	337.2170	330.9175	324.0251	316.8218
58 DTBLAG	356.9761	349.3689	339.5776	336.5862	330.2100	323.4019	316.2712
59 DTBURN	356.8960	349.3940	335.7959	338.9631	332.6367	325.7129	318.4751
60 DTT4	199899.1	197443.0	200107.7	206742.1	206365.4	204999.1	203194.2
61 ETAB	1.005117	1.005122	1.005136	1.005178	1.005196	1.005209	1.005219
62 FAO	.5663149E-02	.5544081E-02	.5328242E-02	.5378269E-02	.5277798E-02	.5167872E-02	.5052987E-02
63 FAP	.2265260E-01	.2217633E-01	.2131297E-01	.2151307E-01	.2111119E-01	.2067149E-01	.2021195E-01
64 FAPA	.2265260E-01	.2217633E-01	.2131297E-01	.2151307E-01	.2111119E-01	.2067149E-01	.2021195E-01
65 H35	393.7744	391.6631	391.8271	401.2034	402.7949	403.1960	402.5737
66 H4	458.9670	455.8499	455.9221	464.9202	466.6409	466.9851	465.9312
67 H4SS	479.4487	475.5117	473.3259	481.9839	482.0454	480.8125	478.4790
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	182.4084	182.8241	182.7964	181.1345	180.9116	180.8762	181.0088
72 QBURN	6432.539	6331.348	6152.496	5984.070	5852.680	5728.770	5612.914
73 QOBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3874967	.3910356	.3909145	.3798634	.3779970	.3776444	.3787760
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	4.922276	5.022720	5.123165	5.223610	5.324055	5.424500	5.524944
78 TLITE	4.922276	5.022720	5.123165	5.223610	5.324055	5.424500	5.524944
79 TT35	1640.727	1631.930	1632.614	1671.681	1678.313	1679.984	1677.391
80 TT4	1912.364	1899.375	1899.676	1937.168	1944.337	1945.771	1941.380
81 U4	327.0142	324.7930	324.8445	331.2556	332.4814	332.7268	331.9758
82 WFMB	1.410370	1.382466	1.354563	1.326659	1.298756	1.270852	1.242949
83 W35	249.0434	249.3588	254.2231	246.6703	246.0790	245.9139	245.9827
84 W4	75.08134	75.50929	75.49193	74.07814	73.85043	73.80875	73.94635
SENSED PARAMETERS							
85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	229.5067	229.6758	231.5576	228.5548	228.3519	228.3089	228.3582
87 PT4M	182.4084	182.8241	182.7964	181.1345	180.9116	180.8762	181.0088
88 QBURNM	-6821.684	-6879.730	-7223.762	-7420.953	-7481.641	-7508.555	-7550.934
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1640.727	1631.930	1632.614	1671.681	1678.313	1679.984	1677.391
91 TT4M	1912.364	1899.375	1899.676	1937.168	1944.337	1945.771	1941.380
92 WFMBM	1.410370	1.382466	1.354563	1.326659	1.298756	1.270852	1.242949
93 W3M	166.2181	165.5969	158.4385	169.6550	170.3741	170.5261	170.3533
94 W35M	249.0434	249.3588	254.2231	246.6703	246.0790	245.9139	245.9827
95 W4M	75.08134	75.50929	75.49193	74.07814	73.85043	73.80875	73.94635

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BRNMDL

1 TIME	5.625389	5.725834	5.826279	5.926723	6.027168	6.127613	6.228058
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-1.272296	-1.242477	-1.214748	-1.189550	-1.168675	-1.249304	-1.056209
5 DPT35	-86835.25	-86600.75	-86455.69	-86485.12	-86836.31	-96109.00	-86581.56
6 DPT4	101233.9	100585.0	99928.19	99362.44	98994.19	99746.75	98440.87
7 DTT35	-395616.6	-387810.4	-379263.2	-371348.2	-364943.2	-344842.2	-374545.2
8 DTT4	200811.2	197971.9	194913.4	191965.1	189283.9	156988.2	186066.4
9 FAMB	.6889030E-02	.6733090E-02	.6578166E-02	.6424200E-02	.6271511E-02	.6128050E-02	.5905557E-02
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.094038	1.092805	1.091221	1.089428	1.087365	1.065169	1.088809
18 PRLINR	1.260353	1.258679	1.256983	1.255606	1.254912	1.256051	1.252738
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	228.5112	228.7690	229.1011	229.4782	229.9134	234.7043	229.6086
21 PT4	181.3072	181.7532	182.2626	182.7629	183.2106	186.8588	183.2854
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1670.557	1660.155	1648.658	1637.927	1629.245	1609.161	1645.032
27 TT4	1931.501	1917.010	1901.341	1886.832	1875.308	1897.937	1893.842
28 WFMB	1.215045	1.187141	1.159238	1.131334	1.103431	1.075527	1.047624
29 W3	169.8112	168.8905	167.6976	166.3254	164.7190	145.3435	165.8449
30 W35	246.3199	246.9156	247.6692	248.5039	249.4419	256.5525	247.3016
31 W4	74.25745	74.72095	75.23849	75.73451	76.15295	77.20493	75.81035

OUTLNR

32 CV35P	.1709999	.1709998	.1709999	.1709999	.1709999	.1709998	.1709998
33 DPT35	-86835.25	-86600.75	-86455.69	-86485.12	-86836.31	-96109.00	-86581.56
34 DTT35	-395616.6	-387810.4	-379263.2	-371348.2	-364943.2	-344842.2	-374545.2
35 FAMB	.6889030E-02	.6733090E-02	.6578166E-02	.6424200E-02	.6271511E-02	.6128050E-02	.5905557E-02
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	400.9336	398.4370	395.6777	393.1023	391.0188	386.1985	394.8076
38 H4	463.5603	460.0823	456.3215	452.8396	450.0737	455.5049	454.5220
39 PT35	228.5112	228.7690	229.1011	229.4782	229.9134	234.7043	229.6086
40 QOBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2137304E-03	.2153122E-03	.2171286E-03	.2189107E-03	.2204945E-03	.2278987E-03	.2180891E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1670.557	1660.155	1648.658	1637.927	1629.245	1609.161	1645.032
45 TT4	1931.501	1917.010	1901.341	1886.832	1875.308	1897.937	1893.842
46 U35	285.6650	283.8862	281.9204	280.0854	278.6008	275.1663	281.3003
47 W3	169.8112	168.8905	167.6976	166.3254	164.7190	145.3435	165.8449
48 W35	246.3199	246.9156	247.6692	248.5039	249.4419	256.5525	247.3016

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	.0	.0	.0
51 DFAMB	-1.272296	-1.242477	-1.214748	-1.189550	-1.168675	-1.249304	-1.056209
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	172.5704	172.6944	172.9223	173.2528	173.7636	179.8177	171.9363
55 DMFUEL	.7069830	.6874033	.6675407	.6479062	.6288132	.6052929	.6025496
56 DPT4	101233.9	100585.0	99928.19	99362.44	98994.19	99746.75	98440.87
57 DTBIDL	309.2856	301.4539	293.4724	285.4463	277.3591	262.8523	265.6104
58 DTBLAG	308.8213	301.1035	293.2922	285.4978	277.7642	267.9343	263.4338
59 DTBURN	310.9016	303.0303	295.0083	286.9414	278.8137	264.2341	267.0134
60 DTT4	200811.2	197971.9	194913.4	191965.1	189283.9	156988.2	186066.4
61 ETAB	1.005225	1.005230	1.005234	1.005239	1.005245	1.005258	1.005283
62 FAO	.4932791E-02	.4807882E-02	.4680589E-02	.4552580E-02	.4423596E-02	.4192229E-02	.4236218E-02
63 FAP	.1973116E-01	.1923153E-01	.1872236E-01	.1821032E-01	.1769438E-01	.1676892E-01	.1694487E-01
64 FAPA	.1973116E-01	.1923153E-01	.1872236E-01	.1821032E-01	.1769438E-01	.1676892E-01	.1694487E-01
65 H35	400.9336	398.4370	395.6777	393.1023	391.0188	386.1985	394.8076
66 H4	463.5603	460.0823	456.3215	452.8396	450.0737	455.5049	454.5220
67 H4SS	475.0505	470.7019	466.0679	461.6218	457.6821	450.5027	458.0317
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
70 PCBURN	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
71 PT4	181.3072	181.7532	182.2626	182.7629	183.2106	186.8588	183.2854
72 QBURN	5503.734	5399.699	5296.047	5189.293	5076.609	4964.598	4793.039
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3813412	.3851687	.3894318	.3935032	.3968915	.3999680	.3931677
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	5.625389	5.725834	5.826279	5.926723	6.027168	6.127613	6.228058
78 TLITE	5.625389	5.725834	5.826279	5.926723	6.027168	6.127613	6.228058
79 TT35	1670.557	1660.155	1648.658	1637.927	1629.245	1609.161	1645.032
80 TT4	1931.501	1917.010	1901.341	1886.832	1875.308	1897.937	1893.842
81 U4	330.2866	327.8086	325.1292	322.6482	320.6775	324.5471	323.8469
82 WFMB	1.215045	1.187141	1.159238	1.131334	1.103431	1.075527	1.047624
83 W35	246.3199	246.9156	247.6692	248.5039	249.4419	256.5525	247.3016
84 W4	74.25745	74.72095	75.23849	75.73451	76.15295	77.20493	75.81035

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	228.5112	228.7690	229.1011	229.4782	229.9134	234.7043	229.6086
87 PT4M	181.3072	181.7532	182.2626	182.7629	183.2106	186.8588	183.2854
88 QBURNM	-7597.434	-7648.984	-7694.160	-7737.562	-7777.566	-5757.121	-7719.246
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1670.557	1660.155	1648.658	1637.927	1629.245	1609.161	1645.032
91 TT4M	1931.501	1917.010	1901.341	1886.832	1875.308	1897.937	1893.842
92 WFMBM	1.215045	1.187141	1.159238	1.131334	1.103431	1.075527	1.047624
93 W3M	169.8112	168.8905	167.6976	166.3254	164.7190	145.3435	165.8449
94 W35M	246.3199	246.9156	247.6692	248.5039	249.4419	256.5525	247.3016
95 W4M	74.25745	74.72095	75.23849	75.73451	76.15295	77.20493	75.81035

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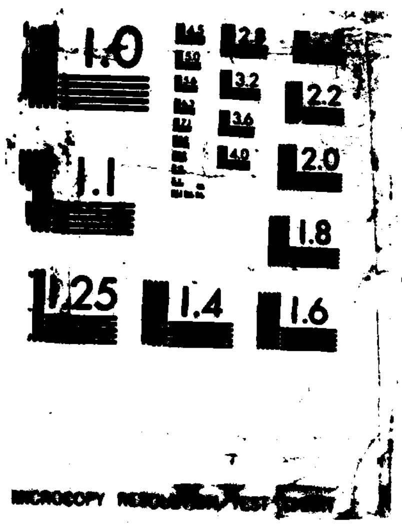
BRNMDL

1	TIME	6.328503	6.428947	6.529392	6.629837	6.730282	6.830727	6.931171
2	ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3	ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4	DFAMB	-1.184372	-.9903963	-1.092928	-.8852664	-.9145156	-.6517332	-.7166873
5	DPT35	-96591.00	-86023.87	-95392.06	-82122.00	-87532.50	-71043.25	-81655.62
6	DPT4	99917.19	97502.94	98100.06	90286.87	87480.62	72554.81	76851.56
7	DTT35	-351933.9	-366694.2	-329628.4	-302804.2	-232102.4	-170485.0	-176609.7
8	DTT4	155188.2	183135.4	155668.9	161394.7	151101.1	121070.9	126757.3
9	FAMB	.5807512E-02	.5585570E-02	.5467780E-02	.5258802E-02	.5113740E-02	.4840378E-02	.4695535E-02
10	FA3	.0	.0	.0	.0	.0	.0	.0
11	FA35	.0	.0	.0	.0	.0	.0	.0
12	FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13	GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14	GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15	GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16	IUPDAT	.0	.0	.0	.0	.0	.0	.0
17	PRDIFF	1.065784	1.088166	1.063315	1.080568	1.053871	1.061248	1.046179
18	PRLINR	1.257651	1.250793	1.253084	1.234638	1.228345	1.191024	1.205562
19	PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20	PT35	234.5690	229.7442	235.1135	231.3597	237.2206	235.5716	238.9647
21	PT4	186.5135	183.6787	187.6277	187.3906	193.1221	197.7891	198.2185
22	R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24	R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26	TT35	1620.363	1633.863	1584.658	1538.175	1407.729	1293.435	1289.746
27	TT4	1911.145	1875.123	1851.989	1720.134	1544.273	1339.479	1339.222
28	WFMB	1.019720	.9918165	.9639130	.9360094	.9081059	.8802023	.8522987
29	W3	145.9400	165.3459	143.5216	159.2133	133.6158	141.4453	124.6556
30	W35	255.9749	247.7367	258.1106	252.1011	267.9753	262.2268	272.8599
31	W4	76.79552	76.35130	78.47842	81.32782	88.45906	97.27625	97.49681

OUTLNR

32	CV35P	.1709998	.1709999	.1709998	.1709999	.1709999	.1709999	.1709999
33	DPT35	-96591.00	-86023.87	-95392.06	-82122.00	-87532.50	-71043.25	-81655.62
34	DTT35	-351933.9	-366694.2	-329628.4	-302804.2	-232102.4	-170485.0	-176609.7
35	FAMB	.5807512E-02	.5585570E-02	.5467780E-02	.5258802E-02	.5113740E-02	.4840378E-02	.4695535E-02
36	H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37	H35	388.8870	392.1270	380.3179	369.1619	337.8550	310.4243	309.5391
38	H4	458.6746	450.0295	444.4773	412.8320	370.6255	321.4749	321.4133
39	PT35	234.5690	229.7442	235.1135	231.3597	237.2206	235.5716	238.9647
40	QDBNCS	.0	.0	.0	.0	.0	.0	.0
41	RHO35	.2261927E-03	.2197096E-03	.2318259E-03	.2350185E-03	.2633014E-03	.2845759E-03	.2895005E-03
42	R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43	TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44	TT35	1620.363	1633.863	1584.658	1538.175	1407.729	1293.435	1289.746
45	TT4	1911.145	1875.123	1851.989	1720.134	1544.273	1339.479	1339.222
46	U35	277.0818	279.3904	270.9763	263.0278	240.7217	221.1774	220.5466
47	W3	145.9400	165.3459	143.5216	159.2133	133.6158	141.4453	124.6556
48	W35	255.9749	247.7367	258.1106	252.1011	267.9753	262.2268	272.8599

AD-A187 898 APPLICATION OF SYSTEM IDENTIFICATION TECHNIQUES TO 2/2
COMBUSTOR POSTSTALL DV (U) PRATT AND WHITNEY WEST PALM
BEACH FL GOVERNMENT PRODUCTS DIV L L STEELE ET AL.
UNCLASSIFIED SEP 87 P/W/GPD-FR-18829-REV F/G 21/2 NL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MICROCOPY

BURNER

49 CV4P	.1709999	.1709999	.1709998	.1709999	.1709999	.1709999	.1709999
50 DELAY	.0	.0	.0	.0	72.72433	1938.204	5256.492
51 DFAMB	-1.184372	-.9903963	-1.092928	-.8852664	-.9145156	-.6517332	-.7166873
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	179.6228	171.8094	180.0589	171.1987	179.9663	165.4191	175.8187
55 DMFUEL	.5763042	.5677195	.5371436	.5105598	.4580507	.4116165	.3966385
56 DPT4	99917.19	97502.94	98100.06	90286.87	87480.62	72554.81	76851.56
57 DTBIDL	249.7759	251.0199	234.1528	.0	212.4756	.0	.0
58 DTBLAG	254.6574	248.9236	238.9252	147.7718	127.8050	.3258623E-15	.1161379E-48
59 DTBURN	251.0973	252.3505	235.3917	.0	213.5777	.0	.0
60 DTT4	155188.2	183135.4	155668.9	161394.7	151101.1	121070.9	126757.3
61 ETAB	1.005290	1.005301	1.005291	.0	1.005187	.0	.0
62 FAO	.3983669E-02	.4003510E-02	.3734496E-02	.2739897E-02	.3388766E-02	.2704959E-02	.2704959E-02
63 FAP	.1593468E-01	.1601404E-01	.1493798E-01	.1485133E-01	.1355506E-01	.1342658E-01	.1249431E-01
64 FAPA	.1593468E-01	.1601404E-01	.1493798E-01	.1485133E-01	.1355506E-01	.1342658E-01	.1249431E-01
65 H35	388.8870	392.1270	380.3179	369.1619	337.8550	310.4243	309.5391
66 H4	458.6746	450.0295	444.4773	412.8320	370.6255	321.4749	321.4133
67 H4SS	450.0046	451.8684	437.6599	404.6272	368.5281	310.4243	309.5391
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	2.000000	2.000000	2.000000	.0	2.000000	.0	.0
70 PCBURN	1.000000	1.000000	1.000000	.0	1.000000	.0	.0
71 PT4	186.5135	183.6787	187.6277	187.3906	193.1221	197.7891	198.2185
72 QBURN	4693.562	4561.336	4500.109	2884.318	2713.313	.0	.0
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.3964699	.3979447	.4115778	.4425671	.5080438	.5998735	.6012913
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	6.328503	6.428947	6.529392	6.629837	6.730282	6.830727	6.931171
78 TLITE	6.328503	6.428947	6.529392	6.629337	6.730282	6.778255	6.778255
79 TT35	1620.363	1633.863	1584.658	1538.175	1407.729	1293.435	1289.746
80 TT4	1911.145	1875.123	1851.989	1720.134	1544.273	1339.479	1339.222
81 U4	326.8057	320.6460	316.6899	294.1428	264.0706	229.0509	229.0070
82 WFMB	1.019720	.9918165	.9639130	.9360094	.9081059	.8802023	.8522987
83 W35	255.9749	247.7367	258.1106	252.1011	267.9753	262.2268	272.8599
84 W4	76.79552	76.35130	78.47842	81.32782	88.45906	97.27625	97.49681

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	234.5690	229.7442	235.1135	231.3597	237.2206	235.5716	238.9647
87 PT4M	186.5135	183.6787	187.6277	187.3906	193.1221	197.7891	198.2185
88 QBURNM	-5815.941	-7925.152	-6472.027	-9429.203	-10565.76	-12628.39	-13033.55
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1620.363	1633.863	1584.658	1538.175	1407.729	1293.435	1289.746
91 TT4M	1911.145	1875.123	1851.989	1720.134	1544.273	1339.479	1339.222
92 WFMBM	1.019720	.9918165	.9639130	.9360094	.9081059	.8802023	.8522987
93 W3M	145.9400	165.3459	143.5216	159.2133	133.6158	141.4453	124.6556
94 W35M	255.9749	247.7367	258.1106	252.1011	267.9753	262.2268	272.8599
95 W4M	76.79552	76.35130	78.47842	81.32782	88.45906	97.27625	97.49681

0IHO208I IBCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FFE4000DA2022D12 . REGISTER CONTAINED FFEA6603
0TRACEBACK ROUTINE CALLED FROM ISN REG. 14 REG. 15 REG. 0 REG. 1
0 FIRL01 0198 420400C0 00022BE0 00000000 0003EF8C

```
0          BURN02         0041   4202173E   0003EBD8   00000000   0002115C
0          BRNMDL         0005   62020C7E   00020F08   00000000   00020BF4
0          STATE          0094   620206FE   00020B80   52A72C1C   00020100
0          MAIN                  00F6137E   00020000   00000048   0000DD20
0ENTRY POINT=  00020000
0STANDARD FIXUP TAKEN , EXECUTION CONTINUING
0IHO208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFE4000DA2022D12 . REGISTER CONTAINED   FFEA6603
0TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1
0          FIRL01         0198   420400C0   00022BE0   00000000   0003EF8C
0          BURN02         0041   4202173E   0003EBD8   00000000   0002115C
0          BRNMDL         0005   62020C7E   00020F08   00000000   00020BF4
0          STATE          0094   620206FE   00020B80   0E6C2C06   00020100
0          MAIN                  00F6137E   00020000   00000048   0D00DD20
0ENTRY POINT=  00020000
0STANDARD FIXUP TAKEN , EXECUTION CONTINUING
0IHO208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFE4000DA2022D12 . REGISTER CONTAINED   FFC187F4
0TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1
0          FIRL01         0198   420400C0   00022BE0   00000000   0003EF8C
0          BURN02         0041   4202173E   0003EBD8   00000000   0002115C
0          BRNMDL         0005   62020C7E   00020F08   00000000   00020BF4
0          STATE          0094   620206FE   00020B80   0E6C2C06   00020100
0          MAIN                  00F6137E   00020000   00000048   0D00DD20
0ENTRY POINT=  00020000
0STANDARD FIXUP TAKEN , EXECUTION CONTINUING
0IHO208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFE4000DA2022D12 . REGISTER CONTAINED   FFC187F4
0TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1
0          FIRL01         0198   420400C0   00022BE0   00000000   0003EF8C
0          BURN02         0041   4202173E   0003EBD8   00000000   0002115C
0          BRNMDL         0005   62020C7E   00020F08   00000000   00020BF4
0          STATE          0098   52020732   00020B80   00000000   00020134
0          MAIN                  00F6137E   00020000   00000048   0D00DD20
0ENTRY POINT=  00020000
0STANDARD FIXUP TAKEN , EXECUTION CONTINUING

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 BRNMDL

   1 TIME     7.031616      7.132061      7.232506      7.332951      7.433395      7.533840      7.634285
   2 ADIFF    70.00000      70.00000      70.00000      70.00000      70.00000      70.00000      70.00000
   3 ALINR    100.0000      100.0000      100.0000      100.0000      100.0000      100.0000      100.0000
   4 DFAMB   -.6100439     -.6691682     -.5685361     -.6217711     -.5270974     -.5744733     -.4856772
   5 DPT35   -71042.00     -81630.69     -71050.69     -81603.19     -71062.19     -81577.31     -71068.31
   6 DPT4     72512.81      76800.75      72478.69      76750.69      72445.75      76700.81      72410.44
   7 DTT35   -170247.7     -176404.0     -170051.2     -176199.6     -169860.1     -175997.9     -169665.1
   8 DTT4     120984.1      126643.1      120894.2      126530.4      120805.4      126420.4      120716.1
   9 FAMB     .4532907E-02  .4387487E-02  .4225552E-02  .4079584E-02  .3918316E-02  .3771816E-02  .3611222E-02
  10 FA3      .0            .0            .0            .0            .0            .0            .0
  11 FA35     .0            .0            .0            .0            .0            .0            .0
  12 FPHPT    18.00000      18.00000      18.00000      18.00000      18.00000      18.00000      18.00000
  13 GAM3     1.400000      1.400000      1.400000      1.400000      1.400000      1.400000      1.400000
  14 GAM35    1.400000      1.400000      1.400000      1.400000      1.400000      1.400000      1.400000
  15 GAM4     1.400000      1.400000      1.400000      1.400000      1.400000      1.400000      1.400000
  16 IUPDAT   .0            .0            .0            .0            .0            .0            .0
  17 PRDIFF   1.061181      1.046161      1.061110      1.046144      1.061037      1.046129      1.060971
```

18 PRLINR	1.190996	1.205500	1.190992	1.205441	1.190989	1.205386	1.190984
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	235.5865	238.9688	235.6024	238.9725	235.6185	238.9762	235.6330
21 PT4	197.8062	198.2321	197.8202	198.2447	197.8342	198.2569	197.8472
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1292.844	1289.249	1292.331	1288.756	1291.824	1288.268	1291.318
27 TT4	1338.718	1338.619	1338.111	1338.022	1337.517	1337.428	1336.915
28 WFMB	.8243952	.7964916	.7685881	.7406845	.7127810	.6848774	.6569738
29 W3	141.3742	124.6299	141.3034	124.6133	141.2290	124.5919	141.1616
30 W35	262.2891	272.8914	262.3572	272.9236	262.4272	272.9543	262.4910
31 W4	97.31236	97.52542	97.34128	97.55342	97.36975	97.58105	97.39813

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-71042.00	-81630.69	-71050.69	-81603.19	-71062.19	-81577.31	-71068.31
34 DTT35	-170247.7	-176404.0	-170051.2	-176199.6	-169860.1	-175997.9	-169665.1
35 FAMB	.4532907E-02	.4387487E-02	.4225552E-02	.4079584E-02	.3918316E-02	.3771816E-02	.3611222E-02
36 W3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 W35	310.2825	309.4197	310.1592	309.3013	310.0376	309.1843	309.9163
38 W4	321.2922	321.2686	321.1465	321.1252	321.0039	320.9827	320.8594
39 PT35	235.5865	238.9688	235.6024	238.9725	235.6185	238.9762	235.6330
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2847242E-03	.2896171E-03	.2848564E-03	.2897324E-03	.2849877E-03	.2898467E-03	.2851170E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1292.844	1289.249	1292.331	1288.756	1291.824	1288.268	1291.318
45 TT4	1338.718	1338.619	1338.111	1338.022	1337.517	1337.428	1336.915
46 U35	221.0763	220.4616	220.9886	220.3773	220.9019	220.2939	220.8154
47 W3	141.3742	124.6299	141.3034	124.6133	141.2290	124.5919	141.1616
48 W35	262.2891	272.8914	262.3572	272.9236	262.4272	272.9543	262.4910

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	8562.953	11859.78	15145.45	18421.70	21687.00	24942.86	28187.85
51 DFAMB	-.6100439	-.6691682	-.5685361	-.6217711	-.5270974	-.5744733	-.4856772
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	165.4158	175.7919	165.4254	175.7665	165.4375	175.7400	165.4432
55 DMFUEL	.3852778	.3704692	.3589979	.3443239	.3327444	.3182027	.3065130
56 DPT4	72512.81	76800.75	72478.69	76750.69	72445.75	76700.81	72410.44
57 DTBIDL	.0	.0	.0	.0	.0	.0	.0
58 DTBLAG	.0	.0	.0	.0	.0	.0	.0
59 DTBURN	.0	.0	.0	.0	.0	.0	.0
60 DTT4	120984.1	126643.1	120894.2	126530.4	120805.4	126420.4	120716.1
61 ETAB	.0	.0	.0	.0	.0	.0	.0
62 FAO	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02
63 FAP	.1257231E-01	.1167485E-01	.1171819E-01	.1085556E-01	.1086443E-01	.1003651E-01	.1001137E-01
64 FAPA	.1257231E-01	.1167485E-01	.1171819E-01	.1085556E-01	.1086443E-01	.1003651E-01	.1001137E-01
65 W35	310.2825	309.4197	310.1592	309.3013	310.0376	309.1843	309.9163
66 W4	321.2922	321.2686	321.1465	321.1252	321.0039	320.9827	320.8594

67 MASS	310.2825	309.4197	310.1592	309.3013	310.0376	309.1843	309.9163
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	.0	.0	.0	.0	.0	.0	.0
70 PCBURN	.0	.0	.0	.0	.0	.0	.0
71 PT4	197.8062	198.2321	197.8202	198.2447	197.8342	198.2569	197.8472
72 QBURN	.0	.0	.0	.0	.0	.0	.0
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.6002668	.6016033	.6005814	.6019102	.6008906	.6022145	.6012009
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	7.031616	7.132061	7.232506	7.332951	7.433395	7.533840	7.634285
78 TLITE	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255
79 TT35	1292.844	1289.249	1292.331	1288.756	1291.824	1288.268	1291.318
80 TT4	1338.718	1338.619	1338.111	1338.022	1337.517	1337.428	1336.915
81 U4	228.9207	228.9039	228.8170	228.8018	228.7154	228.7001	228.6124
82 WFMB	.8243952	.7964916	.7685881	.7406845	.7127810	.6848774	.6569738
83 W35	262.2891	272.8914	262.3572	272.9236	262.4272	272.9543	262.4910
84 W4	97.31236	97.52542	97.34128	97.55342	97.36975	97.58105	97.39813

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	235.5865	238.9688	235.6024	238.9725	235.6185	238.9762	235.6330
87 PT4M	197.8062	198.2321	197.8202	198.2447	197.8342	198.2569	197.8472
88 QBURNM	-12418.99	-13028.39	-12416.28	-13023.45	-12413.54	-13018.70	-12410.78
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1292.844	1289.249	1292.331	1288.756	1291.824	1288.268	1291.318
91 TT4M	1338.718	1338.619	1338.111	1338.022	1337.517	1337.428	1336.915
92 WFMBM	.8243952	.7964916	.7685881	.7406845	.7127810	.6848774	.6569738
93 W3M	141.3742	124.6299	141.3034	124.6133	141.2290	124.5919	141.1616
94 W35M	262.2891	272.8914	262.3572	272.9236	262.4272	272.9543	262.4910
95 W4M	97.31236	97.52542	97.34128	97.55342	97.36975	97.58105	97.39813

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BRNMDL

1 TIME	7.734730	7.835175	7.935619	8.036064	8.136509	8.236954	8.337399
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-.5272769	-.4443207	-.4801826	-.4030405	-.4331827	-.3617926	-.3862958
5 DPT35	-81551.87	-71077.31	-81526.12	-71089.81	-81498.12	-71098.94	-81472.69
6 DPT4	76651.12	72376.50	76601.25	72344.56	76550.56	72310.75	76500.87
7 DTT35	-175796.2	-169472.7	-175594.7	-169287.6	-175392.6	-169097.2	-175192.6
8 DTT4	126309.7	120627.1	126196.7	120542.0	126083.2	120453.4	125971.2
9 FAMB	.3464161E-02	.3304226E-02	.3156638E-02	.2997362E-02	.2849246E-02	.2690621E-02	.2541982E-02
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.046111	1.060901	1.046095	1.060829	1.046080	1.060758	1.046062
18 PRLINR	1.205329	1.190980	1.205270	1.190983	1.205211	1.190981	1.205153

19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	238.9803	235.6487	238.9839	235.6646	238.9875	235.6804	238.9914
21 PT4	198.2697	197.8610	198.2825	197.8741	198.2951	197.8875	198.3080
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1287.779	1290.814	1287.291	1290.318	1286.806	1289.818	1286.320
27 TT4	1336.833	1336.318	1336.244	1335.735	1335.658	1335.145	1335.073
28 WFMB	.6290703	.6011667	.5732632	.5453596	.5174561	.4895525	.4616489
29 W3	124.5708	141.0905	124.5497	141.0157	124.5329	140.9448	124.5117
30 W35	272.9866	262.5579	273.0181	262.6277	273.0474	262.6943	273.0789
31 W4	97.60909	97.42667	97.63690	97.45432	97.66454	97.48251	97.69225

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-81551.87	-71077.31	-81526.12	-71089.81	-81498.12	-71098.94	-81472.69
34 DTT35	-175796.2	-169472.7	-175594.7	-169287.6	-175392.6	-169097.2	-175192.6
35 FAMB	.3464161E-02	.3304226E-02	.3156638E-02	.2997362E-02	.2849246E-02	.2690621E-02	.2541982E-02
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	309.0669	309.7952	308.9497	309.6763	308.8333	309.5562	308.7168
38 H4	320.8398	320.7163	320.6985	320.5762	320.5579	320.4346	320.4172
39 PT35	238.9803	235.6487	238.9839	235.6646	238.9875	235.6804	238.9914
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2899617E-03	.2852471E-03	.2900760E-03	.2853761E-03	.2901896E-03	.2855058E-03	.2903040E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1287.779	1290.814	1287.291	1290.318	1286.806	1289.818	1286.320
45 TT4	1336.833	1336.318	1336.244	1335.735	1335.658	1335.145	1335.073
46 U35	220.2102	220.7291	220.1268	220.6443	220.0438	220.5589	219.9608
47 W3	124.5708	141.0905	124.5497	141.0157	124.5329	140.9448	124.5117
48 W35	272.9866	262.5579	273.0181	262.6277	273.0474	262.6943	273.0789

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	31423.61	34648.51	37864.27	41069.38	44265.44	47450.96	50627.45
51 DFAMB	-.5272769	-.4443207	-.4801826	-.4030405	-.4331827	-.3617926	-.3862958
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	175.7144	165.4520	175.6883	165.4645	175.6602	165.4734	175.6343
55 DMFUEL	.2921039	.2803070	.2660284	.2541264	.2399763	.2279678	.2139466
56 DPT4	76651.12	72376.50	76601.25	72344.56	76550.56	72310.75	76500.87
57 DTBIDL	.0	.0	.0	.0	.0	.0	.0
58 DTBLAG	.0	.0	.0	.0	.0	.0	.0
59 DTBURN	.0	.0	.0	.0	.0	.0	.0
60 DTT4	126309.7	120627.1	126196.7	120542.0	126083.2	120453.4	125971.2
61 ETAB	.0	.0	.0	.0	.0	.0	.0
62 FAO	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02
63 FAP	.9217598E-02	.9158615E-02	.8398902E-02	.8306198E-02	.7580455E-02	.7454328E-02	.6762132E-02
64 FAPA	.9217598E-02	.9158615E-02	.8398902E-02	.8306198E-02	.7580455E-02	.7454328E-02	.6762132E-02
65 H35	309.0669	309.7952	308.9497	309.6763	308.8333	309.5562	308.7168
66 H4	320.8398	320.7163	320.6985	320.5762	320.5579	320.4346	320.4172
67 H4SS	309.0669	309.7952	308.9497	309.6763	308.8333	309.5562	308.7168

68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	.0	.0	.0	.0	.0	.0	.0
70 PCBURN	.0	.0	.0	.0	.0	.0	.0
71 PT4	198.2697	197.8610	198.2825	197.8741	198.2951	197.8875	198.3080
72 QBURN	.0	.0	.0	.0	.0	.0	.0
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.6025215	.6015111	.6028261	.6018135	.6031289	.6021205	.6034324
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	7.734730	7.835175	7.935619	8.036064	8.136509	8.236954	8.337399
78 TLITE	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255
79 TT35	1287.779	1290.814	1287.291	1290.318	1286.806	1289.818	1286.320
80 TT4	1336.833	1336.318	1336.244	1335.735	1335.658	1335.145	1335.073
81 U4	228.5984	228.5104	228.4977	228.4107	228.3975	228.3097	228.2974
82 MFMB	.6290703	.6011667	.5732632	.5453596	.5174561	.4895525	.4616489
83 M35	272.9866	262.5579	273.0181	262.6277	273.0474	262.6943	273.0789
84 M4	97.60909	97.42667	97.63690	97.45432	97.66454	97.48251	97.69225

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	238.9803	235.6487	238.9839	235.6646	238.9875	235.6804	238.9914
87 PT4M	198.2697	197.8610	198.2825	197.8741	198.2951	197.8875	198.3080
88 QBURNM	-13013.91	-12408.03	-13008.84	-12405.51	-13003.68	-12402.71	-12998.64
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1287.779	1290.814	1287.291	1290.318	1286.806	1289.818	1286.320
91 TT4M	1336.833	1336.318	1336.244	1335.735	1335.658	1335.145	1335.073
92 MFMBM	.6290703	.6011667	.5732632	.5453596	.5174561	.4895525	.4616489
93 M3M	124.5708	141.0905	124.5497	141.0157	124.5329	140.9448	124.5117
94 M35M	272.9866	262.5579	273.0181	262.6277	273.0474	262.6943	273.0789
95 M4M	97.60909	97.42667	97.63690	97.45432	97.66454	97.48251	97.69225

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BRNMDL

1 TIME	8.437843	8.538288	8.638733	8.739178	8.839622	8.940067	9.040512
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-.3206045	-.3395109	-.2794820	-.2928271	-.2383928	-.2462428	-.1973640
5 DPT35	-71107.81	-81446.44	-71123.62	-81421.06	-71132.44	-81396.06	-71145.31
6 DPT4	72277.81	76452.19	72246.37	76402.56	72213.50	76353.19	72181.94
7 DTT35	-168909.9	-174996.9	-168726.6	-174797.9	-168542.3	-174601.6	-168359.7
8 DTT4	120366.9	125864.7	120279.8	125753.0	120195.6	125640.9	120111.2
9 FAMB	.2384005E-02	.2234844E-02	.2077514E-02	.1927837E-02	.1771147E-02	.1620955E-02	.1464903E-02
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.060691	1.046048	1.060613	1.046031	1.060547	1.046014	1.060473
18 PRLINR	1.190978	1.205099	1.190982	1.205042	1.190982	1.204986	1.190986
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000

20 PT35	235.6954	238.9946	235.7128	238.9986	235.7273	239.0025	235.7437
21 PT4	197.9007	198.3194	197.9146	198.3320	197.9267	198.3447	197.9398
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1289.322	1285.845	1288.826	1285.362	1288.336	1284.886	1287.846
27 TT4	1334.558	1334.491	1333.981	1333.908	1333.401	1333.337	1332.823
28 WFMB	.4337454	.4058418	.3779383	.3500347	.3221312	.2942276	.2663240
29 W3	140.8773	124.4949	140.7952	124.4737	140.7274	124.4524	140.6525
30 W35	262.7622	273.1099	262.8337	273.1411	262.8999	273.1716	262.9700
31 W4	97.51042	97.71919	97.53836	97.74677	97.56557	97.77390	97.59319

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-71107.81	-81446.44	-71123.62	-81421.06	-71132.44	-81396.06	-71145.31
34 DTT35	-168909.9	-174996.9	-168726.6	-174797.9	-168542.3	-174601.6	-168359.7
35 FAMB	.2384005E-02	.2234844E-02	.2077514E-02	.1927837E-02	.1771147E-02	.1620955E-02	.1464903E-02
36 W3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 W35	309.4370	308.6028	309.3181	308.4868	309.2007	308.3726	309.0828
38 W4	320.2939	320.2778	320.1555	320.1379	320.0161	320.0007	319.8774
39 PT35	235.6954	238.9946	235.7128	238.9986	235.7273	239.0025	235.7437
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2856338E-03	.2904152E-03	.2857649E-03	.2905291E-03	.2858911E-03	.2906416E-03	.2860196E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1289.322	1285.845	1288.826	1285.362	1288.336	1284.886	1287.846
45 TT4	1334.558	1334.491	1333.981	1333.908	1333.401	1333.337	1332.823
46 U35	220.4740	219.8795	220.3892	219.7969	220.3055	219.7156	220.2216
47 W3	140.8773	124.4949	140.7952	124.4737	140.7274	124.4524	140.6525
48 W35	262.7622	273.1099	262.8337	273.1411	262.8999	273.1716	262.9700

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	53793.50	56950.63	60097.43	63235.39	66362.37	69474.62	72577.75
51 DFAMB	-.3206045	-.3395109	-.2794820	-.2928271	-.2383928	-.2462428	-.1973640
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DWAIR	165.4836	175.6085	165.4976	175.5824	165.5068	175.5559	165.5195
55 DWFUEL	.2018328	.1879416	.1757210	.1619574	.1496337	.1359970	.1235687
56 DPT4	72277.81	76452.19	72246.37	76402.56	72213.50	76353.19	72181.94
57 DTBIDL	.0	.0	.0	.0	.0	.0	.0
58 DTBLAG	.0	.0	.0	.0	.0	.0	.0
59 DTBURN	.0	.0	.0	.0	.0	.0	.0
60 DTT4	120366.9	125864.7	120279.8	125753.0	120195.6	125640.9	120111.2
61 ETAB	.0	.0	.0	.0	.0	.0	.0
62 FAO	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02
63 FAP	.6602857E-02	.5944006E-02	.5751744E-02	.5126063E-02	.4901197E-02	.4308317E-02	.4051015E-02
64 FAPA	.6602857E-02	.5944006E-02	.5751744E-02	.5126063E-02	.4901197E-02	.4308317E-02	.4051015E-02
65 W35	309.4370	308.6028	309.3181	308.4868	309.2007	308.3726	309.0828
66 W4	320.2939	320.2778	320.1555	320.1379	320.0161	320.0007	319.8774
67 W4SS	309.4370	308.6028	309.3181	308.4868	309.2007	308.3726	309.0828
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0

69 MBLITE	.0	.0	.0	.0	.0	.0	.0
70 PCBURN	.0	.0	.0	.0	.0	.0	.0
71 PT4	197.9007	198.3194	197.9146	198.3320	197.9267	198.3447	197.9398
72 QBURN	.0	.0	.0	.0	.0	.0	.0
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.6024250	.6037300	.6027281	.6040324	.6030272	.6043296	.6033288
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	8.437843	8.538288	8.638733	8.739178	8.839622	8.940067	9.040512
78 TLITE	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255
79 TT35	1289.322	1285.845	1288.826	1285.362	1288.336	1284.886	1287.846
80 TT4	1334.558	1334.491	1333.981	1333.908	1333.401	1333.337	1332.823
81 U4	228.2095	228.1980	228.1108	228.0983	228.0116	228.0006	227.9127
82 WFMB	.4337454	.4058418	.3779383	.3500347	.3221312	.2942276	.2663240
83 W35	262.7622	273.1099	262.8337	273.1411	262.8999	273.1716	262.9700
84 W4	97.51042	97.71919	97.53836	97.74677	97.56557	97.77390	97.59319

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	235.6954	238.9946	235.7128	238.9986	235.7273	239.0025	235.7437
87 PT4M	197.9007	198.3194	197.9146	198.3320	197.9267	198.3447	197.9398
88 QBURNM	-12400.09	-12994.06	-12397.34	-12989.04	-12394.80	-12983.84	-12392.30
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1289.322	1285.845	1288.826	1285.362	1288.336	1284.886	1287.846
91 TT4M	1334.558	1334.491	1333.981	1333.908	1333.401	1333.337	1332.823
92 WFMBM	.4337454	.4058418	.3779383	.3500347	.3221312	.2942276	.2663240
93 W3M	140.8773	124.4949	140.7952	124.4737	140.7274	124.4524	140.6525
94 W35M	262.7622	273.1099	262.8337	273.1411	262.8999	273.1716	262.9700
95 W4M	97.51042	97.71919	97.53836	97.74677	97.56557	97.77390	97.59319

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BRNMDL

1 TIME	9.140957	9.241402	9.341846	9.442291	9.542736	9.643181	9.743626
2 ADIFF	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000
3 ALINR	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
4 DFAMB	-.1997693	-.1563779	-.1533871	-.1154514	-.1071100	-.7457274E-01	-.6093108E-01
5 DPT35	-81372.75	-71155.75	-81346.19	-71170.06	-81321.25	-71184.56	-81297.50
6 DPT4	76305.56	72149.25	76256.25	72118.87	76208.75	72088.75	76160.56
7 DTT35	-174410.2	-168177.6	-174215.2	-167999.8	-174025.2	-167824.1	-173834.8
8 DTT4	125535.4	120025.9	125423.8	119943.5	125319.4	119862.0	125212.1
9 FAMB	.1314207E-02	.1158783E-02	.1007585E-02	.8527846E-03	.7010929E-03	.5469141E-03	.3947297E-03
10 FA3	.0	.0	.0	.0	.0	.0	.0
11 FA35	.0	.0	.0	.0	.0	.0	.0
12 FPHPT	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000
13 GAM3	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
14 GAM35	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
15 GAM4	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000	1.400000
16 IUPDAT	.0	.0	.0	.0	.0	.0	.0
17 PRDIFF	1.046000	1.060404	1.045983	1.060329	1.045970	1.060257	1.045954
18 PRLINR	1.204933	1.190989	1.204876	1.190994	1.204826	1.191001	1.204773
19 PT3	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
20 PT35	239.0058	235.7592	239.0093	235.7757	239.0125	235.7919	239.0162

21 PT4	198.3560	197.9525	198.3683	197.9654	198.3792	197.9778	198.3910
22 R3	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
23 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
24 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
25 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
26 TT35	1284.415	1287.360	1283.943	1286.876	1283.479	1286.395	1283.012
27 TT4	1332.765	1332.250	1332.198	1331.682	1331.633	1331.119	1331.069
28 MFMB	.2384205	.2105169	.1826134	.1547098	.1268063	.9890270E-01	.7099915E-01
29 M3	124.4309	140.5811	124.4143	140.5063	124.3973	140.4310	124.3759
30 M35	273.2046	263.0361	273.2344	263.1079	273.2661	263.1790	273.2971
31 M4	97.80051	97.62038	97.82733	97.64760	97.85350	97.67435	97.88002

OUTLNR

32 CV35P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
33 DPT35	-81372.75	-71155.75	-81346.19	-71170.06	-81321.25	-71184.56	-81297.50
34 DTT35	-174410.2	-168177.6	-174215.2	-167999.8	-174025.2	-167824.1	-173834.8
35 FAMB	.1314207E-02	.1158783E-02	.1007585E-02	.8527846E-03	.7010929E-03	.5469141E-03	.3947297E-03
36 H3	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000
37 H35	308.2595	308.9663	308.1462	308.8501	308.0347	308.7349	307.9229
38 H4	319.8635	319.7400	319.7275	319.6038	319.5918	319.4685	319.4565
39 PT35	239.0058	235.7592	239.0093	235.7757	239.0125	235.7919	239.0162
40 QDBNCS	.0	.0	.0	.0	.0	.0	.0
41 RHO35	.2907522E-03	.2861465E-03	.2908632E-03	.2862741E-03	.2909724E-03	.2864008E-03	.2910828E-03
42 R35	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
43 TT3	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
44 TT35	1284.415	1287.360	1283.943	1286.876	1283.479	1286.395	1283.012
45 TT4	1332.765	1332.250	1332.198	1331.682	1331.633	1331.119	1331.069
46 U35	219.6350	220.1385	219.5543	220.0558	219.4748	219.9736	219.3951
47 M3	124.4309	140.5811	124.4143	140.5063	124.3973	140.4310	124.3759
48 M35	273.2046	263.0361	273.2344	263.1079	273.2661	263.1790	273.2971

BURNER

49 CV4P	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999	.1709999
50 DELAY	75673.37	78757.12	81832.12	84898.44	87957.12	91003.75	94042.81
51 DFAMB	-.1997693	-.1563779	-.1533871	-.1154514	-.1071100	-.7457274E-01	-.6093108E-01
52 DLYP	.0	.0	.0	.0	.0	.0	.0
53 DLYPRP	.0	.0	.0	.0	.0	.0	.0
54 DMAIR	175.5325	165.5287	175.5055	165.5435	175.4812	165.5580	175.4556
55 DMFUEL	.1100591	.9752715E-01	.8414328E-01	.7150847E-01	.5825001E-01	.4551241E-01	.3237822E-01
56 DPT4	76305.56	72149.25	76256.25	72118.87	76208.75	72088.75	76160.56
57 DTBIDL	.0	.0	.0	.0	.0	.0	.0
58 DTBLAG	.0	.0	.0	.0	.0	.0	.0
59 DTBURN	.0	.0	.0	.0	.0	.0	.0
60 DTT4	125535.4	120025.9	125423.8	119943.5	125319.4	119862.0	125212.1
61 ETAB	.0	.0	.0	.0	.0	.0	.0
62 FAO	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02	.2704959E-02
63 FAP	.3490724E-02	.3201338E-02	.2673359E-02	.2352036E-02	.1856158E-02	.1503200E-02	.1039149E-02
64 FAPA	.3490724E-02	.3201338E-02	.2673359E-02	.2352036E-02	.1856158E-02	.1503200E-02	.1039149E-02
65 H35	308.2595	308.9663	308.1462	308.8501	308.0347	308.7349	307.9229
66 H4	319.8635	319.7400	319.7275	319.6038	319.5918	319.4685	319.4565
67 H4SS	308.2595	308.9663	308.1462	308.8501	308.0347	308.7349	307.9229
68 IUPDAT	.0	.0	.0	.0	.0	.0	.0
69 MBLITE	.0	.0	.0	.0	.0	.0	.0

70 PCBURN	.0	.0	.0	.0	.0	.0	.0
71 PT4	198.3560	197.9525	198.3683	197.9654	198.3792	197.9778	198.3910
72 QBURN	.0	.0	.0	.0	.0	.0	.0
73 QDBNLP	.0	.0	.0	.0	.0	.0	.0
74 RMASS	.6046237	.6036265	.6049182	.6039237	.6052086	.6042170	.6055006
75 R4	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000	640.0000
76 TEND	.0	.0	.0	.0	.0	.0	.0
77 TIME	9.140957	9.241402	9.341846	9.442291	9.542736	9.643181	9.743626
78 TLITE	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255	6.778255
79 TT35	1284.415	1287.360	1283.943	1286.876	1283.479	1286.395	1283.012
80 TT4	1332.765	1332.250	1332.198	1331.682	1331.633	1331.119	1331.069
81 U4	227.9028	227.8148	227.8059	227.7177	227.7092	227.6214	227.6129
82 WFMB	.2384205	.2105169	.1826134	.1547098	.1268063	.9890270E-01	.7099915E-01
83 W35	273.2046	263.0361	273.2344	263.1079	273.2661	263.1790	273.2971
84 W4	97.80051	97.62038	97.82733	97.64760	97.85350	97.67435	97.88002

SENSED PARAMETERS

85 PT3M	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000	250.0000
86 PT35M	239.0058	235.7592	239.0093	235.7757	239.0125	235.7919	239.0162
87 PT4M	198.3560	197.9525	198.3683	197.9654	198.3792	197.9778	198.3910
88 QBURNM	-12979.23	-12389.61	-12974.01	-12387.20	-12969.43	-12384.80	-12964.58
89 TT3M	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000	1000.000
90 TT35M	1284.415	1287.360	1283.943	1286.876	1283.479	1286.395	1283.012
91 TT4M	1332.765	1332.250	1332.198	1331.682	1331.633	1331.119	1331.069
92 WFMBM	.2384205	.2105169	.1826134	.1547098	.1268063	.9890270E-01	.7099915E-01
93 W3M	124.4309	140.5811	124.4143	140.5063	124.3973	140.4310	124.3759
94 W35M	273.2046	263.0361	273.2344	263.1079	273.2661	263.1790	273.2971
95 W4M	97.80051	97.62038	97.82733	97.64760	97.85350	97.67435	97.88002

FUEL/AIR RATIO IN DELTAT LESS THAN ZERO
FUEL/AIR RATIO IN DELTAT LESS THAN ZERO
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FUEL/AIR RATIO IN DELTAT LESS THAN ZERO

**********************************************

BRNMDL

   1 TIME       9.844070       9.944515       10.04496
   2 ADIFF      70.00000       70.00000       70.00000
   3 ALINR      100.0000       100.0000       100.0000
   4 DFAMB     -.3373873E-01  -.1485227E-01   .7044759E-02
   5 DPT35     -71194.87      -81271.87      -71213.37
   6 DPT4       72057.19       76112.31       72028.19
   7 DTT35     -167647.8      -173644.3      -167475.2
   8 DTT4       119781.0       125104.7       119700.1
   9 FAMB       .2411665E-03   .8849695E-04  -.6445586E-04
  10 FA3        .0             .0             .0
  11 FA35       .0             .0             .0
  12 FPHPT      18.00000       18.00000       18.00000
  13 GAM3       1.400000       1.400000       1.400000
  14 GAM35      1.400000       1.400000       1.400000
  15 GAM4       1.400000       1.400000       1.400000
  16 IUPDAT     .0             .0             .0
  17 PRDIFF     1.060192       1.045938       1.060111
  18 PRLINR     1.191004       1.204721       1.191015
  19 PT3        250.0000       250.0000       250.0000
  20 PT35       235.8062       239.0198       235.8242
  21 PT4        197.9894       198.4026       198.0026
  22 R3         640.0000       640.0000       640.0000
  23 R35        640.0000       640.0000       640.0000
  24 R4         640.0000       640.0000       640.0000
  25 TT3        1000.000       1000.000       1000.000
  26 TT35       1285.920       1282.549       1285.443
  27 TT4        1330.556       1330.510       1329.999
  28 WFMB       .4309559E-01   .1519203E-01  -.1271152E-01
  29 W3         140.3630       124.3592       140.2807
  30 W35        263.2456       273.3271       263.3196
  31 W4         97.70074       97.90631       97.72772

OUTLNR

  32 CV35P      .1709999       .1709999       .1709999
  33 DPT35     -71194.87      -81271.87      -71213.37
  34 DTT35     -167647.8      -173644.3      -167475.2
  35 FAMB       .2411665E-03   .8849695E-04  -.6445586E-04
  36 H3         240.0000       240.0000       240.0000
  37 H35        308.6208       307.8118       308.5061
  38 H4         319.3333       319.3223       319.1995
```

39	PT35	235.8062	239.0198	235.8242
40	QDBNCS	.0	.0	.0
41	RHO35	.2865240E-03	.2911922E-03	.2866525E-03
42	R35	640.0000	640.0000	640.0000
43	TT3	1000.000	1000.000	1000.000
44	TT35	1285.920	1282.549	1285.443
45	TT4	1330.556	1330.510	1329.999
46	U35	219.8923	219.3159	219.8107
47	W3	140.3630	124.3592	140.2807
48	W35	263.2456	273.3271	263.3196

BURNER

49	CV4P	.1709999	.1709999	.1709999
50	DELAY	97073.62	100094.7	101744.1
51	DFAMB	-.3373873E-01	-.1485227E-01	.7044759E-02
52	DLYP	.0	.0	.0
53	DLYPRP	.0	.0	.0
54	DMAIR	165.5683	175.4294	165.5856
55	DMFUEL	.1953910E-01	.6528389E-02	-.6411999E-02
56	DPT4	72057.19	76112.31	72028.19
57	DTBIDL	.0	.0	.0
58	DTBLAG	.0	.0	.0
59	DTBURN	.0	.0	.0
60	DTT4	119781.0	125104.7	119700.1
61	ETAB	.0	.0	1.007519
62	FAO	.2704959E-02	.2704959E-02	-.4827413E-04
63	FAP	.6548346E-03	.2223274E-03	-.1930965E-03
64	FAPA	.6548346E-03	.2223274E-03	-.1930965E-03
65	H35	308.6208	307.8118	308.5061
66	H4	319.3333	319.3223	319.1995
67	H4SS	308.6208	307.8118	308.5061
68	IUPDAT	.0	.0	.0
69	MBLITE	.0	.0	2.000000
70	PCBURN	.0	.0	1.000000
71	PT4	197.9894	198.4026	198.0026
72	QBURN	.0	.0	.0
73	QDBNLP	.0	.0	.0
74	RMASS	.6045081	.6057906	.6048019
75	R4	640.0000	640.0000	640.0000
76	TEND	.0	.0	.0
77	TIME	9.844070	9.944515	10.04496
78	TLITE	6.778255	6.778255	10.04496
79	TT35	1285.920	1282.549	1285.443
80	TT4	1330.556	1330.510	1329.999
81	U4	227.5251	227.5172	227.4297
82	WFMB	.4309559E-01	.1519203E-01	-.1271152E-01
83	W35	263.2456	273.3271	263.3196
84	W4	97.70074	97.90631	97.72772

SENSED PARAMETERS

85	PT3M	250.0000	250.0000	250.0000
86	PT35M	235.8062	239.0198	235.8242
87	PT4M	197.9894	198.4026	198.0026

```
   88 QBURNM     -12382.39      -12959.66      -12380.04
   89 TT3M        1000.000       1000.000       1000.000
   90 TT35M       1285.920       1282.549       1285.443
   91 TT4M        1330.556       1330.510       1329.999
   92 WFMBM      .4309559E-01   .1519203E-01  -.1271152E-01
   93 W3M         140.3630       124.3592       140.2807
   94 W35M        263.2456       273.3271       263.3196
   95 W4M         97.70074       97.90631       97.72772
1

        ***  STATISTICS IN WRIT04  ***

 TEMPORARY FILE FOR CREATING CAPAFILE CAPAFILE     HAS BEEN WRITTEN
 WITH  71 VARIABLES AND  101 DATA POINTS.

 THE MENU FOR THE CAPA DATA SET IS:

  TIME      ADIFF     ALINR     CV35P     CV4P      DELAY     DFAMB     DLYP      DLYPRP    DMAIR
  DMFUEL    DPT35     DPT4      DTBIDL    DTBLAG    DTBURN    DTT35     DTT4      ETAB      FAMB
  FAO       FAP       FAPA      FA3       FA35      FPHPT     GAM3      GAM35     GAM4      H3
  H35       H4        H4SS      IUPDAT    MBLITE    PCBURN    PRDIFF    PRLINR    PT3       PT3M
  PT35      PT35M     PT4       PT4M      QBURN     QBURNM    QDBNCS    QDBNLP    RHO35     RMASS
  R3        R35       R4        TEND      TLITE     TT3       TT3M      TT35      TT35M     TT4
  TT4M      U35       U4        WFMB      WFMBM     W3        W3M       W35       W35M      W4
  W4M
1
1SUMMARY OF ERRORS FOR THIS JOB    ERROR NUMBER    NUMBER OF ERRORS
0                                      208               4
```

APPENDIX B

SAMPLES OF STATE, STATIC, AND MEAS SUBROUTINES

```
      SUBROUTINE STATIC(X,P,Y,U)
C***********************************************************************
C SUBPROGRAM STATIC  --  STEADY STATE BALANCE FOR SIMPLE BURNER MODEL
C
C INPUTS:  U = ARRAY OF INPUTS
C          P = ARRAY OF TWIDDLE FACTORS
C
C OUTPUT:  X = ARRAY OF STATES
C
C COMMENTS:  NONE
C***********************************************************************
      implicit double precision (a-h)
      implicit double precision (o-z)
      DIMENSION X(1),U(1),P(1)
      DIMENSION YSTATE(5),DYDX(5)
      DOUBLE PRECISION NAME(5)
      DIMENSION DELTAX(5), DXALOW(5), TOL(5)
      EQUIVALENCE (YSTATE(1), PT35),(YSTATE(2), TT35),(YSTATE(3), PT4),
     *            (YSTATE(4),  TT4),(YSTATE(5), FAMB)
      EQUIVALENCE (  DYDX(1),DPT35),(  DYDX(2),DTT35),(  DYDX(3),DPT4),
     *            (  DYDX(4), DTT4),(  DYDX(5),DFAMB)
      DATA NAME /
     1 'PT35    ','TT35    ','PT4     ','TT4     ','FAMB    '/
C*******************************
C EXTRACT INPUTS FROM ARRAY    *
C*******************************
      PT3U =U(1)
      TT3U =U(2)
      WFMBU=U(3)
C
      AP3   =P(6)
      BP3   =P(7)
      AT3   =P(12)
      BT3   =P(13)
      AWF   =P(21)
      BWF   =P(22)
C
C  SENSOR MODELS FOR INPUTS ARE MOVED HERE SO THAT THE ERROR EFFECTS
C  DRIVE THE MODEL - AS THEY WILL IN TESTING.
C
      PT3   = AP3   * PT3U  + BP3
      TT3   = AT3   * TT3U + BT3
C***************************
C MEASURED FUEL FLOW       *
C***************************
      WFMB = AWF*WFMBU+BWF
C
C*************************************
C INITIALIZATION FOR STATE VARIABLES *
C*************************************
      PT35=.97*PT3
      TT35=TT3
      PT4 =.94*PT3
      TT4 =TT3+1500.
      if( p(39) .eq. 0.0) tt4 = tt3
      FAMB=.02
C**********************
C MISCELANIOUS FLAGS  *
C**********************
      TIME=0.
```

```
      IWAY=0
      NEQ=5
      TOLE=.10
      PCTDX=.001
      XBOUND=.1
      MXPASS=100
      ISSPNT=0
      dt = p(38)
C*****************************
C  STEADY STATE BALANCE      *
C*****************************
 10   CALL BRNMDL(0    ,-1     ,TIME,YSTATE,U,P,DYDX,Y,DT)
      CALL SSBL01(NEQ    , ISSPNT, YSTATE, DYDX   , IWAY   , TOLE   ,
     *              PCTDX , XBOUND, MXPASS, NAME   , XBOUND, MXPASS,
     *              NAME   , NPASS )
      GO TO (10,10,15,11,13),IWAY
 11   WRITE(6,12)
 12   FORMAT(1X,' STEADY STATE BALANCE FAILED --- '/
     *       1X,' SINGULAR JACOBIAN' )
      STOP
 13   WRITE(6,14)
 14   FORMAT(1X,'STEADY STATE BALANCE FAILED WITH MAX. PASSES')
      STOP
 15   CONTINUE
C*******************************
C  PUT STATES INTO X ARRAY     *
C*******************************
      DO 20 I=1,NEQ
 20   X(I)=YSTATE(I)
      RETURN
      END
```

```
      SUBROUTINE STATE(X,U,P,XDOT,TIME)
C***********************************************************************
C SUBPROGRAM STATE  --  CALCULATED DERIVITIVES OF STATE VARIABLES
C
C INPUTS: IUPDAT = LAG/MODE UPDATE FLAG
C                  -1 DURING STEADY STATE BALANCE OR ON FIRST CALL
C                   0 DURING CONVERGENCE ATTEMPTS
C                   1 AFTER COMPLETED DT
C           TIME = TIME
C              X = ARRAY OF STATES
C              U = ARRAY OF INPUTS
C              P = ARRAY OF DIDDLE FACTORS
C
C OUTPUTS:  XDOT = ARRAY OF DERIVITIVES
C************************************************************************
      implicit double precision (a-h)
      implicit double precision (o-z)
      COMMON /dLAG/ iupdat
      COMMON /CLAG/ IPROP
      DIMENSION X(1),U(1),P(1),XDOT(1)
      IPRPL=0
      dt = p(38)
      CALL BRNMDL(IPRPL,IUPDAT,TIME,X,U,P,XDOT,Y,DT)
      RETURN
      END
```

```
      SUBROUTINE MEAS(X,U,P,XDOT,Y)
C**********************************************************************
C SUBPROGRAM MEAS  --  LOADS OUTPUTS INTO Y ARRAY
C
C INPUTS:  TIME = TIME
C                 X = ARRAY OF STATES
C                 U = ARRAY OF INPUTS
C                 P = ARRAY OF DIDDLE FACTORS
C
C OUTPUTS:        Y = OUTPUT ARRAY
C
C COMMENTS:
C   1.  ANY AVAILIABLE PARAMETER CAN BE OUTPUT BE CALLING HEADLD
C       WITH THE PARAMETER.
C   2.  ANY SYNTHESISED PARAMETER SHOULD BE CALCULATED IN THE
C       APPROPRIATE SUBROUTINE AND PASSED TO PRPL.
C   3.  PARAMETERS ARE ARRANGED IN THE Y ARRAY IN THE SAME ORDER
C       AS THE CALLS TO HEADLD.
C**********************************************************************
      implicit double precision (a-h)
      implicit double precision (o-z)
      DOUBLE PRECISION HEADER
      INCLUDE 'DUA2:[UTPWA.SCIDNT.SPL]NLMCOM.INC'
      COMMON/CLAG/ IPROP
      COMMON/PRPLBS/HEADER(100),VAROUT(100),NLOAD
      DIMENSION X(1),XDOT(1),U(1),P(1),Y(1)
C     DATA IFIRST/0/
C
C LOAD NAMES OF OUTPUT VARIABLES
      IF(IFIRST.EQ.1)GO TO 1
      IFIRST=1
      CALL HEADLD('W3M      ')
      CALL HEADLD('PT35M    ')
      CALL HEADLD('PT4M     ')
      CALL HEADLD('TT4M     ')
      CALL HEADLD('W4M      ')
C
C LOAD Y ARRAY
 1    CONTINUE
      CALL BRNMDL(1,0,TIME,X,U,P,XDOT,Y,DT)
C**********************************************************************
C********  REMOVE WRITE LOOP BEFORE RUNNING TRANSIENTLY  ***************
C**********************************************************************
c      WRITE(6,*)IPROP,Y(3)
C %END SCT
      RETURN
      END
```

APPENDIX C

SAMPLE PARSEL OUTPUT

FOLLOWING PARAMETERS WILL BE USED AS ESTIMATE PARAMETERS

PARAMETER NO.	1	2	3	4	5	29	30	33	34	41
LABEL	FPHPT	ADIFF	ALINR	VOL35	VOL4	CSTABE	CSTABC	CEFFA	CEFFB	deleff
APRIORI UNCERT	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06	1.000E+06
UNCERTAINTY	1.000E+00	7.000E+00	1.000E+01	2.500E+02	2.600E+02	1.000E-01	1.000E-01	4.000E-06	4.000E-04	2.000E+00

FOLLOWING PARAMETERS WILL BE CONSIDERED NUISANCE PARAMETERS

PARAMETER NO.	31	32
LABEL	CTAU	CTAUM
UNCERTAINTY	6.000E-04	1.000E-01

FOLLOWING MEASUREMENT SET WILL BE USED IN THIS STUDY

MEAS NO.	1	2	3	4	5
LABEL	Y01	Y02	Y03	Y04	Y05
NOISE	5.00000E-01	1.50000E+00	1.50000E+00	1.00000E+01	5.00000E-01

PERFORMANCE INDEX :

$$J = w_1 J_1 + w_2 J_2 + w_3 J_3 + \ldots\ldots\ldots\ldots + w_n J_n$$

where w_i = weighting on ith component performance index, J_i

J_i = ith component of performance index given by:

$$J_i = \frac{d\,T_i}{d(\text{theta})} * \text{delta (theta)} + \frac{d\,T_i}{d(\text{phi})} * \text{delta (phi)}$$

where T (theta,phi) = vector of performance measure variables of the system

theta = set of estimate parameters

phi = set of nuisance parameters

delta (theta) = error in estimate parameters given by:

delta (theta) = covariance (theta) + nuisance error
= sqrt <diag [inv (M11)] > + inv (M11) * M12 * delta (phi)

delta (phi) = error in nuisance parameters (nuisance level)

SUMMARY OF RUN
OPTIMUM PERFORMANCE INDEX FOR 1 ESTIMATE PARAMETERS

	performance index	number of estimate parameters	estimate parameters	number of nuisance parameters	nuisance parameters
1	349.22	1	1	11	2 3 4 5 29 30 33 34 41 31 32
2	350.48	1	41	11	1 2 3 4 5 29 30 33 34 31 32
3	376.22	1	4	11	1 2 3 5 29 30 33 34 41 31 32

SUMMARY OF RUN
OPTIMUM PERFORMANCE INDEX FOR 2 ESTIMATE PARAMETERS

	performance index	number of estimate parameters	estimate parameters	number of nuisance parameters	nuisance parameters
1	47.864	2	1 41	10	2 3 4 5 29 30 33 34 31 32
2	295.46	2	5 41	10	1 2 3 4 29 30 33 34 31 32
3	339.53	2	1 2	10	3 4 5 29 30 33 34 41 31 32

SUMMARY OF RUN
OPTIMUM PERFORMANCE INDEX FOR 3 ESTIMATE PARAMETERS

	performance index	number of estimate parameters	estimate parameters	number of nuisance parameters	nuisance parameters
1	37.923	3	1 4 41	9	2 3 5 29 30 33 34 31 32
2	40.260	3	1 30 41	9	2 3 4 5 29 33 34 31 32
3	42.389	3	1 5 41	9	2 3 4 29 30 33 34 31 32

SUMMARY OF RUN

OPTIMUM PERFORMANCE INDEX FOR 4 ESTIMATE PARAMETERS

	performance index	number of estimate parameters	estimate parameters	number of nuisance parameters	nuisance parameters
1	40.960	4	1 2 4 41	8	3 5 29 30 33 34 31 32
2	43.010	4	1 2 30 41	8	3 4 5 29 33 - 34 31 32
3	47.934	4	1 2 5 41	8	3 4 29 30 33 34 31 32

SUMMARY OF RUN
OPTIMUM PERFORMANCE INDEX FOR 5 ESTIMATE PARAMETERS

	performance index	number of estimate parameters	estimate parameters	number of nuisance parameters	nuisance parameters
1	67.902	5	1 2 3 4 41	7	5 29 30 33 34 31 32
2	69.087	5	1 2 3 5 41	7	4 29 30 33 34 31 32
3	70.178	5	1 2 3 30 41	7	4 5 29 33 34 31 32

MEASUREMENT CONTRIBUTION TO SECOND DERIVATIVE OF THE COST FUNCTION

PARAMETER	NO.	Y01	Y02	Y03	Y04	Y05
FPHPT	1	7.3229E+01	3.7852E-02	1.0716E-01	1.4445E+02	1.0766E+02
ADIFF	2	5.1634E-04	7.9444E-04	8.2057E-04	2.0979E-03	1.5240E-03
ALINR	3	6.1555E-04	1.0386E-08	2.4087E-04	2.4166E-03	6.1204E-04
VOL35	4	1.3690E-04	2.1886E-08	2.1997E-08	9.3003E-08	4.2605E-08
VOL4	5	9.5445E-05	2.2472E-08	9.3318E-08	4.3797E-05	1.1092E-06
CSTABE	29	3.1758E-02	1.7336E-05	8.0234E-05	5.6230E-01	1.8480E-02
CSTABC	30	2.0059E-02	1.7295E-07	2.1834E-10	2.7359E-04	1.0989E-05
CTAU	31	5.4074E+04	1.3066E+01	4.9269E+01	2.9699E+05	1.0179E+04
CTAUN	32	1.6025E+00	8.8088E-04	3.7097E-03	2.5727E+01	8.6243E-01
CEFFA	33	2.8509E-08	5.1032E-08	1.2208E-06	4.1700E-03	1.1363E-04
CEFFB	34	1.5851E-01	7.0117E-05	4.4653E-04	9.3366E+00	3.8362E-01
deleff	41	1.8835E+03	1.1407E+00	2.9907E+00	8.7057E+04	4.0703E+03

APPENDIX D

SENSIT OUTPUT

SENSITIVITY DATA FOR THE FOLLOWING PARAMETERS
WAS GENERATED BY THE SCIDNT PROGRAM

PARAMETER NO.	1	2	3	4	5	6	7	8	9	10
LABEL	FPHPT	ADIFF	ALINR	VOL35	VOL4	AP3	BP3	AP35	BP35	AP4
NORMALIZATION	1.800E+01	7.000E+01	1.000E+02	2.500E+03	2.600E+03	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

PARAMETER NO.	11	12	13	18	19	20	21	22	29	30
LABEL	BP4	AT3	BT3	AT4	BT4	TAUT4	AWF	BWF	CSTABE	CSTABC
NORMALIZATION	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	5.000E+00	5.000E+00

PARAMETER NO.	31	32	33	34	35	36	37	41	42
LABEL	CTAU	CTAUN	CEFFA	CEFFB	TAUP3	TAUP35	TAUP4	deloff	betime
NORMALIZATION	1.000E+00	1.000E+00	1.963E+00	2.501E+00	1.000E+00	1.000E+00	1.600E+00	1.000E+00	5.000E-03

FOLLOWING MEASUREMENTS WERE USED BY THE SCIDNT PROGRAM

1 : Y01 2 : Y02 3 : Y03 4 : Y04 5 : Y05

ESTINATION PARAMETER SET

PARAMETER NO.	1	2	4	41
LABEL	FPHPT	ADIFF	VOL35	deleff
APRIORI UNCERT	1.000E+06	1.000E+06	1.000E+06	1.000E+06

NUISANCE PARAMETER SET

3 : ALINR	5 : VOL4	6 : AP3	7 : BP3	8 : AP35	9 : BP35	10 : AP4	11 : BP4
12 : AT3	13 : BT3	18 : AT4	19 : BT4	20 : TAUT4	21 : AWF	22 : BWF	29 : CSTABE
30 : CSTABC	31 : CTAU	32 : CTAUM	33 : CEFFA	34 : CEFFB	35 : TAUP3	36 : TAUP35	37 : TAUP4
42 : betime							

MEASUREMENT SET

MEAS NO.	1	2	3	4	5
LABEL	Y01	Y02	Y03	Y04	Y05
NOISE	5.00000E-01	1.50000E+00	1.50000E+00	1.00000E+01	5.00000E-01

W11 MATRIX

	1	2	3	4
1	9.1631E+04	3.5264E+01	-3.2614E+01	-1.0055E+06
2	3.5264E+01	4.0579E+00	1.6827E-01	-2.0101E+03
3	-3.2614E+01	1.6827E-01	5.2885E-02	1.0087E+02
4	-1.0055E+06	-2.0101E+03	1.0087E+02	1.6310E+07

W12 MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-3.0711E+02	-8.7089E+01	-2.9588E+07	-7.2677E+04	-3.0796E+07	-7.7964E+04	3.0922E+05	1.3885E+03	-1.8870E+05	-3.3539E+02
2	1.0042E+00	1.0306E-01	1.8517E+05	4.3557E+02	1.8235E+05	4.2483E+02	2.4198E+03	1.0386E+01	-2.0890E+03	-1.8004E+00
3	2.5867E-01	5.3152E-02	3.8809E+04	9.9226E+01	3.9010E+04	1.0113E+02	1.6639E+01	7.8243E-02	-2.0006E+02	-1.8282E-01
4	2.7139E+03	9.0712E+02	1.1507E+08	2.6795E+05	1.3023E+08	3.2484E+05	-1.8137E+06	-8.1075E+03	5.4254E+06	7.4964E+03

W12 MATRIX

	11	12	13	14	15	16	17	18	19	20
1	-9.6952E+05	-3.2584E+02	-8.5477E+05	-7.8280E+05	-2.9328E+05	-4.4636E+03	-8.1359E+01	-3.0813E+06	-2.6473E+04	-6.7191E+01
2	-3.2063E+03	-1.0609E+00	2.9097E+03	-1.5363E+03	-5.5615E+02	3.7934E+00	6.5774E-02	2.6664E+03	2.2390E+01	-7.4770E-02
3	-2.8607E+01	-9.6552E-03	-4.2285E+01	7.9431E+01	3.1195E+01	3.8495E+00	7.6628E-02	2.6887E+03	2.4036E+01	5.5742E-03
4	1.7247E+07	5.7483E+03	2.4288E+06	1.2686E+07	4.7289E+06	3.5256E+04	5.8409E+02	2.3798E+07	1.9689E+05	9.8007E+02

W12 MATRIX

	21	22	23	24	25
1	8.5293E+03	-6.3902E+07	-7.4098E+07	2.3372E+06	-5.3720E+07
2	1.4695E+01	3.8360E+05	3.7452E+05	9.1888E+03	-3.8148E+04
3	-1.5759E+00	1.0764E+05	1.1151E+05	1.9287E+02	2.7688E+04
4	-1.3188E+05	1.6929E+08	2.7646E+08	-1.3065E+07	6.0769E+08

BIAS MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-1.1103E-03	-4.4117E-04	-2.0037E+02	-4.2839E-01	-2.1621E+02	-4.8087E-01	1.2865E+01	5.8029E-02	1.7351E+00	6.7981E-04
2	1.8371E-01	1.6209E-02	2.1307E+04	4.1553E+01	2.0992E+04	3.8741E+01	6.4874E+02	2.7601E+00	-1.9373E+02	-2.6958E-02
3	3.4325E+00	6.3082E-01	5.5563E+05	1.5069E+03	5.4924E+05	1.5159E+03	4.7876E+03	2.2222E+01	-2.9240E+03	-3.9487E+00
4	9.9361E-05	2.6516E-05	-6.1079E+00	-1.4180E-02	-6.1549E+00	-1.4823E-02	7.3227E-01	3.2832E-03	4.3382E-01	5.2263E-04

BIAS MATRIX

	11	12	13	14	15	16	17	18	19	20
1	1.5920E+00	3.6073E-04	-4.5187E+01	-1.1748E-02	-4.7358E-02	-2.7734E-02	-5.1375E-04	-2.0112E+01	-1.7072E-01	-4.3259E-04
2	-1.9374E+02	-6.1882E-02	1.1066E+03	7.5055E+00	6.2910E+00	-1.3641E+00	-3.5588E-02	-9.8448E+02	-9.9818E+00	1.5329E-02
3	-1.1143E+03	-4.6881E-01	-2.7745E+04	-1.3232E+01	-8.3479E+00	6.0195E+01	1.2607E+00	4.1878E+04	3.8490E+02	-2.0081E-01
4	1.1386E+00	3.6996E-04	-2.3290E+00	7.7812E-01	2.8705E-01	-8.8588E-05	-8.0437E-06	-1.6112E-01	-2.0639E-03	3.7046E-05

BIAS MATRIX

	21	22	23	24	25
1	8.4109E-04	2.1114E+01	-9.9421E+01	1.0209E+02	-2.5385E+02
2	3.3510E-01	1.1253E+04	9.1713E+03	1.9987E+03	-1.4231E+04
3	-1.5201E+01	2.0114E+06	2.0190E+06	4.9887E+04	3.7887E+05
4	-7.8963E-03	6.2920E-01	-5.3498E-01	5.4304E+00	1.7512E+01

MEASUREMENT CONTRIBUTION TO SECOND DERIVATIVE OF THE COST FUNCTION

PARAMETER	NO.	Y01	Y02	Y03	Y04	Y05
FPHPT	1	2.9708E+04	1.6397E+01	4.7036E+01	3.7540E+04	2.4319E+04
ADIFF	2	2.3147E+00	3.2444E-01	3.2852E-01	5.2537E-01	5.6486E-01
ALINR	3	2.1887E+00	6.7588E-04	1.1046E-01	2.4928E+00	1.2288E-01
VOL35	4	5.2781E-02	1.6758E-05	1.6059E-05	4.1162E-05	3.0294E-05
VOL4	5	5.7899E-02	1.9302E-05	7.2045E-05	8.0268E-02	3.5176E-03
AP3	6	3.4560E+10	4.4292E+06	4.3190E+06	9.0123E+06	7.8214E+06
BP3	7	2.0826E+05	8.5707E+01	8.3519E+01	1.1393E+02	1.3565E+02
AP35	8	3.4960E+10	4.5016E+06	0.0000E+00	0.0000E+00	0.0000E+00
BP35	9	2.1651E+05	8.8889E+01	0.0000E+00	0.0000E+00	0.0000E+00
AP4	10	0.0000E+00	0.0000E+00	4.4393E+06	0.0000E+00	4,3120E+06
BP4	11	0.0000E+00	0.0000E+00	8.8889E+01	0.0000E+00	8.6876E+01
AT3	12	8.1480E+05	3.7409E+02	8.7973E+02	2.2183E+06	1.5706E+05
BT3	13	3.2584E+00	2.1900E-04	5.2577E-04	3.7536E+00	2.3726E-01
AT4	18	0.0000E+00	0.0000E+00	0.0000E+00	1.7932E+07	1.0620E+06
BT4	19	0.0000E+00	0.0000E+00	0.0000E+00	2.0000E+00	1.2037E-01
TAUT4	20	0.0000E+00	0.0000E+00	0.0000E+00	3.9615E+08	2.0392E+07
AWF	21	4.3421E+05	3.2413E+02	8.2458E+02	8.9460E+06	4.9621E+05
BWF	22	6.8015E+04	5.1916E+01	1.2917E+02	1.2365E+06	6.8794E+04
CSTABE	29	4.3563E+02	1.2887E-01	5.4077E-01	3.8099E+02	1.6081E+01
CSTABC	30	3.0444E-01	6.8410E-05	2.8302E-04	1.7460E-01	7.3234E-03
CTAU	31	2.1790E+08	4.8078E+04	2.1430E+05	1.9965E+08	7.9230E+06
CTAUN	32	1.7617E+04	5.2082E+00	2.1775E+01	1.4539E+04	6.1244E+02
CEFFA	33	2.5184E-01	5.5479E-05	9.0475E-05	5.7692E-02	2.8032E-03
CEFFB	34	6.9238E+01	2.5095E-02	8.2657E-02	9.9136E+02	5.4070E+01
TAUP3	35	2.2082E+11	4.0879E+08	3.6449E+08	7.7806E+08	7.5913E+08
TAUP35	36	2.3777E+11	4.6717E+08	0.0000E+00	0.0000E+00	0.0000E+00
TAUP4	37	0.0000E+00	0.0000E+00	4.5897E+08	0.0000E+00	4.7319E+08
deloff	41	6.3041E+05	4.4872E+02	1.1541E+03	1.4856E+07	8.2171E+05
betime	42	2.4515E+10	8.1313E+06	2.9275E+07	4.6931E+10	2.1617E+09

RUN SUMMARY

ESTIMATION

PARAMETER NO.	LABEL	STANDARD ERRORS	ESTIMATION BIAS
1	FPHPT	7.831E-03	4.073E+00
2	ADIFF	5.603E-01	2.807E+02
4	VOL35	6.222E+00	8.030E+03
41	doloff	5.271E-04	2.729E-01

NUISANCE

PARAMETER NO.	LABEL	LEVEL
3	ALINR	1.000E+01
5	VOL4	2.600E+02
6	AP3	2.000E-03
7	BP3	5.000E-01
8	AP35	2.000E-03
9	BP35	5.000E-01
10	AP4	2.000E-03
11	BP4	5.000E-01
12	AT3	3.000E-03
13	BT3	3.000E+00
18	AT4	3.000E-03
19	BT4	3.000E+00
20	TAUT4	5.000E-05
21	AWF	2.500E-02
22	BWF	7.000E-02
29	CSTABE	1.000E-01
30	CSTABC	1.000E-01
31	CTAU	6.000E-04
32	CTAUM	1.000E-01
33	CEFFA	4.000E-06
34	CEFFB	4.000E-04
35	TAUP3	5.000E-05
36	TAUP35	5.000E-05
37	TAUP4	5.000E-05
42	betime	1.000E-02

APPENDIX E

SENSOR NOISE AND BIAS LEVELS

SENSITIVITY DATA FOR THE FOLLOWING PARAMETERS
WAS GENERATED BY THE SCIDNT PROGRAM

PARAMETER NO.	1	2	3	4	5	6	7	8	9	10
LABEL	FPMPT	ADIFF	ALINR	VOL35	VOL4	AP3	BP3	AP35	BP35	AP4
NORMALIZATION	1.000E+01	7.000E+01	1.000E+02	2.500E+03	2.600E+03	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

PARAMETER NO.	11	12	13	14	19	20	21	22	29	30
LABEL	BP4	AT3	BT3	AT4	BT4	TAUT4	AWF	BWF	CSTABE	CSTABC
NORMALIZATION	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	5.000E+00	5.000E+00

PARAMETER NO.	31	32	33	34	35	36	37	41	42
LABEL	CTAU	CTAUM	CEFFA	CEFFB	TAUP3	TAUP35	TAUP4	deloff	betime
NORMALIZATION	1.000E+00	1.000E+00	1.963E+00	2.501E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	5.000E-03

FOLLOWING MEASUREMENTS WERE USED BY THE SCIDNT PROGRAM

1 : Y01 2 : Y02 3 : Y03 4 : Y04 5 : Y05

ESTIMATION PARAMETER SET

PARAMETER NO.	1	2	4	41
LABEL	FPUPT	ADIFF	VOL35	deloff
APRIORI UNCERT	1.000E+06	1.000E+06	1.000E+06	1.000E+06

NUISANCE PARAMETER SET

3 : ALIMR	5 : VOL4	6 : AP3	7 : BP3	8 : AP35	9 : BP35	10 : AP4	11 : BP4
12 : AT3	13 : BT3	18 : AT4	19 : BT4	20 : TAUT4	21 : AWF	22 : BWF	29 : CSTARE
30 : CSTARC	31 : CTAU	32 : CTAUN	33 : CEFFA	34 : CEFFB	35 : TAUP3	36 : TAUP35	37 : TAUP4
42 : botime							

MEASUREMENT SET

MEAS NO.	1	2	3	4	5
LABEL	Y01	Y02	Y03	Y04	Y05
NOISE	5.00000E-01	1.50000E+00	1.50000E+00	1.00000E+01	5.00000E-01

M11 MATRIX

	1	2	3	4
1	9.1631E+04	3.5264E+01	-3.2614E+01	-1.0055E+06
2	3.5264E+01	4.0579E+00	1.6827E-01	-2.0101E+03
3	-3.2614E+01	1.6827E-01	5.2885E-02	1.0087E+02
4	-1.0055E+06	-2.0101E+03	1.0087E+02	1.6310E+07

M12 MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-3.0711E+02	-8.7089E+01	-2.9588E+07	-7.2677E+04	-3.0796E+07	-7.7964E+04	3.0922E+05	1.3885E+03	-1.8870E+05	-3.3539E+02
2	1.0842E+00	1.0306E-01	1.8517E+05	4.3557E+02	1.8235E+05	4.2483E+02	2.4198E+03	1.0386E+01	-2.0890E+03	-1.8004E+00
3	2.5867E-01	5.3152E-02	3.8889E+04	9.9226E+01	3.9010E+04	1.0113E+02	1.6639E+01	7.8243E-02	-2.0006E+02	-1.8282E-01
4	2.7139E+03	9.0712E+02	1.1507E+00	2.6795E+05	1.3023E+08	3.2484E+05	-1.8137E+06	-8.1075E+03	5.4254E+06	7.4964E+03

M12 MATRIX

	11	12	13	14	15	16	17	18	19	20
1	-9.6953E+05	-3.2584E+02	-8.5477E+05	-7.8280E+05	-2.9328E+05	-4.4636E+03	-8.1359E+01	-3.0813E+06	-2.6473E+04	-6.7191E+01
2	-3.2063E+03	-1.0609E+00	2.9097E+03	-1.5363E+03	-5.5615E+02	3.7934E+00	6.5774E-02	2.6664E+03	2.2390E+01	-7.4770E-02
3	-2.8607E+01	-9.6552E-03	-4.2285E+01	7.9431E+01	3.1195E+01	3.8495E+00	7.6628E-02	2.6887E+03	2.4036E+01	5.5742E-03
4	1.7247E+07	5.7483E+03	2.4288E+06	1.2686E+07	4.7289E+06	3.5256E+04	5.8409E+02	2.3798E+07	1.9689E+05	9.8007E+02

M12 MATRIX

	21	22	23	24	25
1	8.5293E+03	-6.3902E+07	-7.4098E+07	2.3372E+06	-5.3728E+07
2	1.4695E+01	3.8360E+05	3.7452E+05	9.1888E+03	-3.8148E+04
3	-1.5759E+00	1.0764E+05	1.1151E+05	1.9287E+02	2.7688E+04
4	-1.3188E+05	1.6929E+08	2.7646E+08	-1.3065E+07	6.0769E+08

BIAS MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-1.1103E-03	-4.4117E-04	-2.8037E+02	-4.2039E-01	-2.1621E+02	-4.8887E-01	1.2865E+01	5.8029E-02	1.7351E+00	6.7981E-04
2	1.8371E-01	1.6209E-02	2.1307E+04	4.1553E+01	2.0992E+04	3.8741E+01	6.4874E+02	2.7601E+00	-1.9373E+02	-2.6950E-02
3	3.4325E+00	6.3002E-01	5.5563E+05	1.5069E+03	5.4924E+05	1.5159E+03	4.7876E+03	2.2222E+01	-2.9240E+03	-3.9487E+00
4	9.9361E-05	2.6516E-05	-6.1079E+00	-1.4188E-02	-6.1549E+00	-1.6823E-02	7.3227E-01	3.2832E-03	4.3382E-01	5.2263E-04

BIAS MATRIX

	11	12	13	14	15	16	17	18	19	20
1	1.5920E+00	3.6073E-04	-4.5187E+01	-1.1748E-02	-4.7358E-02	-2.7734E-02	-5.1375E-04	-2.0112E+01	-1.7072E-01	-4.3259E-04
2	-1.9374E+02	-6.1882E-02	1.1046E+03	7.5055E+00	6.2910E+00	-1.3641E+00	-3.5588E-02	-8.6448E+02	-9.9818E+00	1.5329E-02
3	-1.1143E+03	-4.6081E-01	-2.7745E+04	-1.3232E+01	-8.3479E+00	6.0195E+01	1.2607E+00	4.1878E+04	3.8490E+02	-2.8081E-01
4	1.1386E+00	3.6996E-04	-2.3290E+00	7.7812E-01	2.8785E-01	-8.8588E-05	-8.0437E-06	-1.6112E-01	-2.0639E-03	3.7046E-05

BIAS MATRIX

	21	22	23	24	25
1	8.4109E-04	2.1114E+01	-9.9421E+01	1.0209E+02	-2.5385E+02
2	3.3510E-01	1.1253E+04	9.1713E+03	1.9987E+03	-1.4231E+04
3	-1.5201E+01	2.0114E+06	2.0190E+06	4.9887E+04	3.7887E+05
4	-7.8983E-03	6.2920E-01	-5.3498E-01	5.4304E+00	1.7512E+01

MEASUREMENT CONTRIBUTION TO SECOND DERIVATIVE OF THE COST FUNCTION

PARAMETER	NO.	Y01	Y02	Y03	Y04	Y05
FPHPT	1	2.9708E+04	1.6397E+01	4.7036E+01	3.7540E+04	2.4319E+04
ADIFF	2	2.3147E+00	3.2444E-01	3.2852E-01	5.2537E-01	5.6486E-01
ALIHR	3	2.1807E+00	6.7588E-04	1.1046E-01	2.4928E+00	1.2288E-01
VOL3S	4	5.2781E-02	1.6758E-05	1.6059E-05	4.1162E-05	3.0294E-05
VOL4	5	5.7899E-02	1.9302E-05	7.2045E-05	8.0268E-02	3.5176E-03
AP3	6	3.4560E+10	4.4292E+06	4.3190E+06	9.0123E+06	7.8214E+06
BP3	7	2.0826E+05	8.5707E+01	8.3519E+01	1.1393E+02	1.3565E+02
AP3S	8	3.4960E+10	4.5016E+06	0.0000E+00	0.0000E+00	0.0000E+00
BP3S	9	2.1651E+05	8.8889E+01	0.0000E+00	0.0000E+00	0.0000E+00
AP4	10	0.0000E+00	0.0000E+00	4.4393E+06	0.0000E+00	4.3120E+06
BP4	11	0.0000E+00	0.0000E+00	8.8889E+01	0.0000E+00	8.6876E+01
AT3	12	8.1480E+05	3.7409E+02	8.7973E+02	2.2183E+06	1.5706E+05
BT3	13	3.2584E+00	2.1900E-04	5.2577E-04	3.7536E+00	2.3724E-01
AT4	18	0.0000E+00	0.0000E+00	0.0000E+00	1.7932E+07	1.0620E+06
BT4	19	0.0000E+00	0.0000E+00	0.0000E+00	2.0000E+00	1.2037E-01
TAUT4	20	0.0000E+00	0.0000E+00	0.0000E+00	3.9615E+08	2.0392E+07
ANF	21	4.3421E+05	3.2413E+02	8.2458E+02	8.9460E+06	4.9621E+05
BNF	22	6.8015E+04	5.1916E+01	1.2917E+02	1.2365E+06	6.8794E+04
CSTABE	29	4.3563E+02	1.2887E-01	5.4077E-01	3.8099E+02	1.6081E+01
CSTABC	30	3.0444E-01	6.8410E-05	2.0302E-04	1.7460E-01	7.3234E-03
CTAU	31	2.1790E+08	4.8070E+04	2.1430E+05	1.9965E+08	7.9230E+06
CTAUH	32	1.7617E+04	5.2082E+00	2.1775E+01	1.4539E+04	6.1244E+02
CEFFA	33	2.5184E-01	5.5479E-05	9.0475E-05	5.7692E-02	2.8032E-03
CEFFB	34	6.9230E+01	2.5095E-02	8.2657E-02	9.9136E+02	5.4070E+01
TAUP3	35	2.2082E+11	4.0879E+08	3.6449E+08	7.7806E+08	7.5913E+08
TAUP3S	36	2.3777E+11	4.6717E+08	0.0000E+00	0.0000E+00	0.0000E+00
TAUP4	37	0.0000E+00	0.0000E+00	4.5897E+08	0.0000E+00	4.7319E+08
deloff	41	6.3041E+05	4.4872E+02	1.1541E+03	1.4856E+07	8.2171E+05
betime	42	2.4515E+10	8.1313E+06	2.9275E+07	4.6931E+10	2.1617E+09

RUN SUMMARY

ESTIMATION

PARAMETER NO.	LABEL	STANDARD ERRORS	ESTIMATION BIAS
1	FPHPT	7.831E-03	2.724E+00
2	ADIFF	5.603E-01	1.527E+02
4	VOL35	6.222E+00	4.237E+03
41	deloff	5.271E-04	2.282E-01

NUISANCE

PARAMETER NO.	LABEL	LEVEL
3	ALINR	1.000E+01
5	VOL4	2.600E+02
6	AP3	2.000E-05
7	BP3	5.000E-04
8	AP35	2.000E-06
9	BP35	5.000E-04
10	AP4	2.000E-04
11	BP4	5.000E-01
12	AT3	3.000E-04
13	BT3	3.000E+00
18	AT4	3.000E-04
19	BT4	3.000E+00
20	TAUT4	5.000E-05
21	AWF	2.500E-02
22	BWF	7.000E-02
29	CSTABE	1.000E-02
30	CSTABC	1.000E-01
31	CTAU	6.000E-05
32	CTAUN	1.000E-03
33	CEFFA	4.000E-06
34	CEFFB	4.000E-04
35	TAUP3	5.000E-05
36	TAUP35	5.000E-05
37	TAUP4	5.000E-05
42	betime	1.000E-02

SENSITIVITY DATA FOR THE FOLLOWING PARAMETERS
WAS GENERATED BY THE SCIDNT PROGRAM

PARAMETER NO.	1	2	3	4	5	6	7	8	9	10
LABEL	FPHPT	ADIFF	ALINR	VOL35	VOL4	AP3	BP3	AP35	BP35	AP4
NORMALIZATION	1.800E+01	7.000E+01	1.000E+02	2.500E+03	2.600E+03	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

PARAMETER NO.	11	12	13	18	19	20	21	22	29	30
LABEL	BP4	AT3	BT3	AT4	BT4	TAUT4	AWF	BWF	CSTABB	CSTABC
NORMALIZATION	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	5.000E+00	5.000E+00

PARAMETER NO.	31	32	33	34	35	36	37	41	42
LABEL	CTAU	CTAUN	CEFFA	CEFFB	TAUP3	TAUP35	TAUP4	deleff	betime
NORMALIZATION	1.000E+00	1.000E+00	1.963E+00	2.501E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	5.000E-03

FOLLOWING MEASUREMENTS WERE USED BY THE SCIDNT PROGRAM

1 : Y01   2 : Y02   3 : Y03   4 : Y04   5 : Y05

ESTIMATION PARAMETER SET

PARAMETER NO.	1	2	4	41
LABEL	FPHPT	ADIFF	VOL35	deloff
APRIORI UNCERT	1.000E+06	1.000E+06	1.000E+06	1.000E+06

NUISANCE PARAMETER SET

3 : ALINR	5 : VOL4	6 : AP3	7 : BP3	8 : AP35	9 : BP35	10 : AP4	11 : BP4
12 : AT3	13 : BT3	18 : AT4	19 : BT4	20 : TAUT4	21 : AWF	22 : BWF	29 : CSTABE
30 : CSTABC	31 : CTAU	32 : CTAUN	33 : CEFFA	34 : CEFFB	35 : TAUP3	36 : TAUP35	37 : TAUP4
42 : botime							

MEASUREMENT SET

MEAS NO.	1	2	3	4	5
LABEL	Y01	Y02	Y03	Y04	Y05
NOISE	5.00000E-01	1.50000E+00	1.50000E+00	1.00000E+01	5.00000E-01

M11 MATRIX

	1	2	3	4
1	9.1631E+04	3.5264E+01	-3.2614E+01	-1.0055E+06
2	3.5264E+01	4.0579E+00	1.6827E-01	-2.0101E+03
3	-3.2614E+01	1.6827E-01	5.2885E-02	1.0087E+02
4	-1.0055E+06	-2.0101E+03	1.0087E+02	1.6310E+07

M12 MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-3.0711E+02	-8.7089E+01	-2.9588E+07	-7.2677E+04	-3.0796E+07	-7.7964E+04	3.0922E+05	1.3885E+03	-1.8870E+05	-3.3539E+02
2	1.0842E+00	1.0306E-01	1.8517E+05	4.3557E+02	1.8235E+05	4.2483E+02	2.4198E+03	1.0386E+01	-2.0890E+03	-1.8004E+00
3	2.5867E-01	5.3152E-02	3.8889E+04	9.9226E+01	3.9010E+04	1.0113E+02	1.6639E+01	7.8243E-02	-2.0006E+02	-1.8282E-01
4	2.7139E+03	9.0712E+02	1.1507E+08	2.6795E+05	1.3023E+08	3.2484E+05	-1.8137E+06	-8.1075E+03	5.4254E+06	7.4964E+03

M12 MATRIX

	11	12	13	14	15	16	17	18	19	20
1	-9.6952E+05	-3.2584E+02	-8.5477E+05	-7.8280E+05	-2.9328E+05	-4.4636E+03	-8.1359E+01	-3.0813E+06	-2.6473E+04	-6.7191E+01
2	-3.2063E+03	-1.0609E+00	2.9097E+03	-1.5363E+03	-5.5615E+02	3.7934E+00	6.5774E-02	2.6664E+03	2.2390E+01	-7.4770E-02
3	-2.8607E+01	-9.6552E-03	-4.2205E+01	7.9431E+01	3.1195E+01	3.8495E+00	7.6628E-02	2.6887E+03	2.4036E+01	5.5742E-03
4	1.7247E+07	5.7483E+03	2.4288E+06	1.2686E+07	4.7289E+06	3.5256E+04	5.8409E+02	2.3798E+07	1.9689E+05	9.8007E+02

M12 MATRIX

	21	22	23	24	25
1	8.5293E+03	-6.3902E+07	-7.4098E+07	2.3372E+06	-5.3728E+07
2	1.4695E+01	3.8360E+05	3.7452E+05	9.1888E+03	-3.8148E+04
3	-1.5759E+00	1.0764E+05	1.1151E+05	1.9287E+02	2.7688E+04
4	-1.3188E+05	1.6929E+08	2.7646E+08	-1.3065E+07	6.0769E+08

BIAS MATRIX

	1	2	3	4	5	6	7	8	9	10
1	-1.1103E-03	-4.4117E-04	-2.0037E+02	-4.2839E-01	-2.1621E+02	-4.8887E-01	1.2865E+01	5.8029E-02	1.7351E+00	6.7981E-04
2	1.8371E-01	1.6209E-02	2.1307E+04	4.1553E+01	2.0992E+04	3.8741E+01	6.4874E+02	2.7601E+00	-1.9373E+02	-2.6958E-02
3	3.4325E+00	6.3082E-01	5.5563E+05	1.5069E+03	5.4924E+05	1.5159E+03	4.7876E+03	2.2222E+01	-2.9240E+03	-3.9487E+00
4	9.9361E-05	2.6516E-05	-6.1079E+00	-1.4180E-02	-6.1549E+00	-1.4823E-02	7.3227E-01	3.2832E-03	4.3382E-01	5.2263E-04

BIAS MATRIX

	11	12	13	14	15	16	17	18	19	20
1	1.5920E+00	3.6073E-04	-4.5187E+01	-1.1748E-02	-4.7358E-02	-2.7734E-02	-5.1375E-04	-2.0112E+01	-1.7072E-01	-4.3259E-04
2	-1.9374E+02	-6.1882E-02	1.1066E+03	7.5055E+00	6.2910E+00	-1.3641E+00	-3.5588E-02	-9.8448E+02	-9.9818E+00	1.5329E-02
3	-1.1143E+03	-4.6881E-01	-2.7745E+04	-1.3232E+01	-8.3479E+00	6.0195E+01	1.2607E+00	4.1878E+04	3.8490E+02	-2.8081E-01
4	1.1386E+00	3.6996E-04	-2.3290E+00	7.7812E-01	2.8785E-01	-8.8588E-05	-8.0437E-06	-1.6112E-01	-2.0639E-03	3.7046E-05

BIAS MATRIX

	21	22	23	24	25
1	8.4109E-04	2.1114E+01	-9.9421E+01	1.0209E+02	-2.5385E+02
2	3.3510E-01	1.1253E+04	9.1713E+03	1.9987E+03	-1.4231E+04
3	-1.5201E+01	2.0114E+06	2.0190E+06	4.9887E+04	3.7887E+05
4	-7.8983E-03	6.2920E-01	-5.3498E-01	5.4304E+00	1.7512E+01

MEASUREMENT CONTRIBUTION TO SECOND DERIVATIVE OF THE COST FUNCTION

PARAMETER	NO.	Y01	Y02	Y03	Y04	Y05
FPHPT	1	2.9708E+04	1.6397E+01	4.7036E+01	3.7540E+04	2.4319E+04
ADIFF	2	2.3147E+00	3.2444E-01	3.2852E-01	5.2537E-01	5.6406E-01
ALINR	3	2.1887E+00	6.7588E-04	1.1046E-01	2.4926E+00	1.2288E-01
VOL35	4	5.2781E-02	1.6758E-05	1.6059E-05	4.1162E-05	3.0294E-05
VOL4	5	5.7899E-02	1.9302E-05	7.2045E-05	8.0268E-02	3.5176E-03
AP3	6	3.4560E+10	4.4292E+06	4.3190E+06	9.0123E+06	7.8214E+06
BP3	7	2.0826E+05	8.5707E+01	8.3519E+01	1.1393E+02	1.3565E+02
AP35	8	3.4960E+10	4.5016E+06	0.0000E+00	0.0000E+00	0.0000E+00
BP35	9	2.1651E+05	8.8889E+01	0.0000E+00	0.0000E+00	0.0000E+00
AP4	10	0.0000E+00	0.0000E+00	4.4393E+06	0.0000E+00	4.3120E+06
BP4	11	0.0000E+00	0.0000E+00	8.8889E+01	0.0000E+00	8.6876E+01
AT3	12	8.1480E+05	3.7409E+02	8.7973E+02	2.2183E+06	1.5706E+05
BT3	13	3.2584E+00	2.1900E-04	5.2577E-04	3.7536E+00	2.3724E-01
AT4	18	0.0000E+00	0.0000E+00	0.0000E+00	1.7932E+07	1.0620E+06
BT4	19	0.0000E+00	0.0000E+00	0.0000E+00	2.0000E+00	1.2037E-01
TAUT4	20	0.0000E+00	0.0000E+00	0.0000E+00	3.9615E+08	2.0392E+07
ANF	21	4.3421E+05	3.2413E+02	8.2458E+02	8.9460E+06	4.9621E+05
BNF	22	6.8015E+04	5.1916E+01	1.2917E+02	1.2365E+06	6.0794E+04
CSTABE	29	4.3563E+02	1.2887E-01	5.4077E-01	3.8099E+02	1.6081E+01
CSTABC	30	3.0446E-01	6.8410E-05	2.8302E-04	1.7460E-01	7.3234E-03
CTAU	31	2.1790E+08	4.8078E+04	2.1430E+05	1.9965E+08	7.9230E+06
CTAUM	32	1.7617E+04	5.2082E+00	2.1775E+01	1.4539E+04	6.1244E+02
CEFFA	33	2.5184E-01	5.5479E-05	9.0475E-05	5.7692E-02	2.8032E-03
CEFFB	34	6.9238E+01	2.5095E-02	8.2657E-02	9.9136E+02	5.4078E+01
TAUP3	35	2.2082E+11	4.0879E+08	3.6449E+08	7.7806E+08	7.5913E+08
TAUP35	36	2.3777E+11	4.6717E+08	0.0000E+00	0.0000E+00	0.0000E+00
TAUP4	37	0.0000E+00	0.0000E+00	4.5897E+08	0.0000E+00	4.7319E+08
deleff	41	6.3041E+05	4.4872E+02	1.1541E+03	1.4856E+07	8.2171E+05
betime	42	2.4515E+10	8.1313E+06	2.9275E+07	4.6931E+10	2.1617E+09

RUN SUMMARY

ESTIMATION			
PARAMETER NO.	LABEL	STANDARD ERRORS	ESTIMATION BIAS
1	FFHPT	7.031E-03	2.300E-02
2	ADIFF	5.603E-01	1.500E+00
4	VOL35	6.222E+00	2.463E+01
41	deleff	5.271E-04	4.125E-02

NUISANCE		
PARAMETER NO.	LABEL	LEVEL
3	ALINR	5.000E-01
5	VOL4	2.600E+00
6	AP3	2.000E-06
7	BP3	5.000E-04
8	AP35	2.000E-06
9	BP35	5.000E-04
10	AP4	2.000E-04
11	BP4	5.000E-02
12	AT3	3.000E-04
13	BT3	3.000E-01
18	AT4	3.000E-04
19	BT4	3.000E-01
20	TAUT4	5.000E-05
21	AWF	2.500E-02
22	BWF	7.000E-02
29	CSTABE	1.000E-02
30	CSTABC	1.000E-01
31	CTAU	6.000E-05
32	CTAUN	1.000E-03
33	CEFFA	4.000E-01
34	CEFFB	4.000E-04
35	TAUP3	1.000E-06
36	TAUP35	1.000E-06
37	TAUP4	5.000E-05
42	betime	1.000E-06

END
FEb.
1988
DTIC