**Westinghouse
Astronuclear
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WANL-TME- 2717
SEPTEMBER 1970

DATA ITEM S-54

**PHASE 1-NSS PARAMETRIC
PERFORMANCE EVALUATION**

TRADE STUDY 716

MASTER

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PHASE 1-NSS PARAMETRIC PERFORMANCE EVALUATION

TRADE STUDY 716

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ABSTRACT

WANL Trade Study 716 established the recommended NSS performance parameters and estimated variations in these parameters at the rated operating condition and for build-to-build uncertainties. The results of Trade Study 710 were reexamined for the ten-hour full flow engine, the decrease in the nominal chamber temperature, and the chamber pressure derived from Trade Study 717. The present trade study documents the work done as of March 1, 1970.

The nominal values and estimates of the 2.326σ variations in temperature rise and pressure drop for each NSS component were determined by a Monte Carlo analysis. The recommended NSS performance parameters and their estimated variations are given in tabular form. It is recommended that future revisions to the NSS performance uncertainties be obtained by a Monte Carlo Analysis of the NSS. This will require a representation of the engine components.

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TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
	ABSTRACT	iii
1	SCOPE	1-1
2	IDENTIFICATION OF REQUIREMENTS	2-1
3	ANALYSES APPROACHES	3-1
4	SELECTION OF ANALYSIS APPROACH	4-1
5	REFERENCES	5-1

1. SCOPE

The purpose of this trade study is to provide preliminary estimates of the NSS performance parameters and the variations in these parameters (i.e., temperature rise and pressure drop across each NSS component) at rated operating conditions for ANSC to be used as input to Trade Study 021.

A Monte Carlo Analysis was made for the entire NSS with all engine component performance parameters at their nominal values.

The recommended NSS performance parameters and variations in these parameters are given in tabular form.

2. IDENTIFICATION OF REQUIREMENTS

The original selection of recommended NSS performance parameters and the variations in these parameters for the hot bleed cycle is documented in Reference 4. Since that time two major revisions in the performance specification have occurred which necessitates a review of the original selection. These changes are use of a full flow or topping cycle instead of a hot bleed cycle, and a decrease in chamber temperature.

As a Category B trade study, the purpose of this study was to select a set of NSS performance parameters and their variations for the full flow engine at rated operating conditions. The NSS model used is that described by WANL Drawing 939J685 Revision B and Reference 5 as modified for the full flow cycle. Reference 6 lists the one sigma uncertainty values for the NSS parameters that were used in the Monte Carlo analysis. The functional requirements affecting this selection of performance parameters and their uncertainties follow from Technical Directive 70-26. The selection is made utilizing those analyses techniques which properly account for component interactions and are not overly conservative in estimating the parameter variations due to build-to-build uncertainties. In general, the selection is made on the basis of the following requirements:

1. Method (T. D. 70-26)
2. Minimize Component Tolerances (T. D. 70-26)
3. Account for Interaction Between Components
4. Detailed Knowledge of System
5. NSS Performance at Engine/NSS Fluid Interface Points

Method: Either the Propagation of Error or Monte Carlo technique may be used to estimate the NSS performance parameters and their variations.

Component Tolerances: The NSS performance variations computed by the Monte Carlo method involve making random choices of the magnitudes of the variations to be applied

to the nominal value of each NSS parameter. These variations are based upon the estimated one sigma variations assigned to each parameter. It is unlikely that all such random variations in the individual NSS parameters would be such that they all caused a variation in some NSS state point parameter to be in one direction, that is increasing or decreasing. It is more likely that a number of the variations would tend to compensate each other. As a result, uncertainty effects would not stack up unidirectionally and penalize the system by requiring more conservative component designs.

Interaction Between Components: The NSS performance parameter variations may be influenced by the interaction between components. These synergistic effects may cause significant differences in the values of the performance parameter variations calculated by considering the system perturbations to act independently as opposed to considering these perturbations to interact with one another.

Detailed Knowledge of the System: Depending upon the analysis technique used, there may be differences in the amount of information obtained as to how a perturbation in a parameter of one component affects the performance of the other system components.

NSS Performance at Engine/NSS Fluid Interface Points: The Monte Carlo analysis of the NSS provides an understanding of the NSS performance variations at the fluid interface points since it includes interactions between the various NSS components.

3. ANALYSES APPROACHES

The NSS parametric performance evaluation trade study is concerned with the selection of a set of NSS performance parameters and their variation rather than a mechanical design selection. The variations computed will affect the component design so that an iterative process is required between the systems analysis and component design analysis. Both the Monte Carlo and Propagation of Error methods may be used to compute the performance parameter variations. For the former method the entire engine, the NSS, or individual components may be treated. In this study the NSS was analyzed by the Monte Carlo technique.

4. SELECTION OF ANALYSIS APPROACH

The recommended NSS performance parameters and their estimated variations are those computed by the Monte Carlo technique. These values are presented in Table I. Since these performance variations were determined by applying the Monte Carlo technique to the NSS as a subsystem with fixed engine components, the variations shown in the table include interactions between the NSS components.

Table I contains the same material presented at the WANL Category B Trade Study Presentation, February 13, 1970 (Reference 1). The only exception is that at the trade study presentation 3σ values for the uncertainties were presented whereas Table I uses 2.326σ values. This corresponds to the 95% confidence level, 99% probability value for a one-sided limit and infinite sample size.

The following material presents the explanation and technical backup for the analysis approach selected.

Interaction Between Components:

The Monte Carlo Analysis of the NSS accounts for the interactions between components since it is essentially a computer experiment which simulates the building of an NSS and its test at some operating condition. A set of state points is computed for each NSS and the appropriate statistical information is calculated. Within the limits of the model detail synergistic effects are properly accounted for in the system calculation.

If the Monte Carlo Analysis is carried out on single NSS components, the problem arises as to how these variations, calculated independently of other system perturbations, must be combined to give the overall NSS variations at the NSS/Engine fluid interfaces.

Magnitude of Uncertainties:

The Monte Carlo Analysis of the NSS leads to a realistic set of variations in the performance parameters. This results from the fact that the variations in the independent component parameters are selected in a random fashion so that these perturbations in general will not cause changes in some dependent variable that are all additive; that is, there will be some compensating effects present.

The Monte Carlo Analysis of individual NSS components leads to the problem as to how to combine the variations found for the component parts to obtain the variations for the entire NSS. At present, there is no clear cut method for doing this with the Monte Carlo technique.

Detailed Knowledge of System:

The Monte Carlo technique for the NSS does not require detailed knowledge of the effects of each parameter variation on the system since state points are computed for each particular set of system variations. From the results of these calculations, it is not possible to ascertain the contribution of each system parameter perturbation to a given performance parameter variation.

When the Monte Carlo method is applied to individual components, it is necessary to have some knowledge of how changes in the components that were not varied affect the calculated performance parameter variations. More information is available on how each component variation affects the system but a set of correction factors and a method for applying them are required to obtain the overall system uncertainties.

NSS Performance at the Engine/NSS Fluid Interface Points:

The Monte Carlo Analysis of the NSS as a subsystem with nominal engine components provides an understanding of the behavior of the NSS performance variations at the fluid interface points. Interactions between NSS components are included in the

analysis. In order to completely define the NSS performance variations at these interface points, the effect of engine component variations on the NSS would be required. This would require additional computations.

RECOMMENDATIONS

It is recommended that the preliminary NSS parametric performance for the full-flow cycle and the estimated variations in these parameters be as shown in Table I.

It is also recommended that future revisions to the NSS performance uncertainties continue to be obtained by a Monte Carlo Analysis of the NSS. It is felt that this method

- (1) correctly accounts for system component interactions and synergistic effects within the limits of the model detail, and
- (2) does not "stack" uncertainty effects unidirectionally, thus giving a better estimate of performance parameter variations.

TABLE I
NSS PERFORMANCE PARAMETERS

<u>Component and Parameter</u>	<u>Nominal Value ⁽¹⁾</u>	<u>2.326 σ Variation</u>
1. Reflector		
ΔP ⁽²⁾	50	± 7.75
ΔT ⁽³⁾	64	± 14.73
2. Structural Support		
ΔP	195	± 7.75
ΔT	205	± 38.77 $- 32.56$
3. Extension Shield		
ΔP	23 ⁽⁴⁾	± 3.88
ΔT	2.5	± 1.55
4. Central Shield		
ΔP	28	± 3.88
ΔT	4	± 1.55
5. Support Plate		
ΔP	11	± 3.10
ΔT	2.4	± 1.16
6. Core		
ΔP	170	± 7.75
ΔT	4002	± 42.64

(1) Based on start of life conditions

(2) (lb/in²) difference

(3) °R

(4) Includes the pressure from the extension shield inlet to the pressure vessel interface with the turbine inlet piping

(5) Includes the baffle pressure drop

5. REFERENCES

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