NUCLEAR DIVISION

Report No. RN-S-0456

PREDICTED MEASUREMENT UNCERTAINTIES,
XECF

To

AEC-NASA Space Nuclear Propulsion Office

NERVA Program

Contract SNP-1

February 1968

MASTER

NUCLEAR ROCKET OPERATIONS

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PREDICTED MEASUREMENT UNCERTAINTIES,
XECF

D. G. Kneeland

A handwritten signature in black ink, appearing to read 'C. M. Rice', with a large, stylized loop at the beginning.

C. M. Rice
Program Manager
Nuclear Rocket Operations

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CONTENTS

	<u>Page</u>
I. Introduction	1
II. Technical Discussion	1

TABLES AND FIGURES

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
AT805..A		28
AT806..A		28
HT102R.A		29, 35
HT123R.A		30, 36
HT124R.A		30, 36
HT125L.A		30, 36
HT201R.A		31, 37
HT202R.A		31, 37
HT203R.A		31, 37
HT204R.A		31, 37
HT205L.A		31, 37
HT206L.A		31, 37
HT800R.A		32, 38
HT801R.A		32, 38
HT802L.A		32, 38
HT805R.A		29, 35
HT808R.A		29, 35
HT809L.A		29, 35
HT820L.A		33
HT821R.A		33
HT822T.A		33
MG115L.A		1
MG801L.A		2
MG802L.A		2

TABLES AND FIGURES (cont.)

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
MG803L..A		34
MG804L..A		34
MG805L..A		34
MG806L..A		34
PD114..A	1, 4	
PD133..A	1, 4	
PD163..A	1	
PD205..A	1	
PD208..A	1, 4	
PD209..A	1, 4	
PD801..A	1	
PD802..A	1	
PD804..A	1, 4	
PD810..A	1	
PD812..A	1	
PT114..A	2, 4	
PT151..A	2	
PT160..A	2	
PT168..A	2	
PT172..A	2	
PT210..A	2	
PT212..A	2	
PT214..A	2	
PT226..A	2, 4	
PT810..A	2, 3	
PT814..A	2, 4	
PT815..A	2	
PT864..A	2, 4	
PT868..A	2	

TABLES AND FIGURES (cont.)

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
PT870..A	2	
PT872..A	2, 4	
PT878..A	2	
PT880..A	2, 4	
PT882..A	2	
PT883..A	2, 4	
PT885..A	2	
PT890..A	2	
TE131..A		3
TE132..A		3
TE134..A		3
TE136..A		3
TE143..A		4, 39
TE160..A		3
TE161..A		3
TE225..A		5
TE226..A		5
TE813..A		6
TE814..A		6
TE832..A		8, 40
TE833..A		8
TE834..A		9
TE844..A		9, 41
TE845..A		9
TE847..A		10
TE849..A		10, 42
TE856..A		3
TE857..A		3
TE858..A		3
TE859..A		3

TABLES AND FIGURES (cont.)

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
TE868..A		6
TE890..A		5
TE898..A		3
TE899..A		3
TE900..A		3
TE901..A		3
TE902..A		3
TE903..A		3
TE904..A		3
TE905..A		3
TT109..A		13
TT110..A		14
TT120..A		15, 44
TT121..A		15
TT123..A		15
TT227..A		16, 45
DP867.AE		24, 49
DP868.AE		24, 49
DP870..E		25, 50
DR100W.E		26
DR102..E		27
DR104W.E		26
DR106W.E		26
DR108W.E		26
DR110W.E		26
P.120..E	2	
P.132..E	2	
P.158..E	2, 4	
PT104..E	2, 4	
PT106..E	2	

TABLES AND FIGURES (cont.)

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
PT110.AE	2, 4	
PT112.AE	2, 3	
PT124.AE	2, 3, 4	
PT128.AE	2	
PT148.AE	2	
PT149.AE	2, 3, 4	
PT866..E	2, 4	
PT876..E	2, 4	
T.158..E		19
T.306..E		20
TE835..E		11, 43
TE836..E		12
TE837..E		12
TE838..E		12
TE839..E		12
TE840..E		12
TE841..E		12
TE843..E		12
TE871..E		12
TT103..E		17, 46
TT105..E		13
TT108..E		17, 46
TT138.AE		18, 47
TT139.AE		18
TT144.AE		18
TT207.AE		15
TT210.AE		15
TT216.AE		15
PT800..F	2	
TE870..F		6

TABLES AND FIGURES (cont.)

<u>Parameter</u>	<u>Table</u>	<u>Figure</u>
TT262..F		23, 48
TT263..F		23, 48
PT834..R	2	
PT891..R	2	
PT894..R	2	
PT895..R	2	
PT896..R	2	
PT897..R	2	
TE112..R		3
TE113..R		3
TE848..R		7
TE881..R		21
TT889..R		22

I. INTRODUCTION

This report provides the data user with uncertainty values that define the uncertainty band associated with each point in the measurement range for the listed parameters. Uncertainties attributable to the transducers and those attributable to the data-recording and -reduction system have been evaluated independently and are shown separately to demonstrate the relative contributions. The total measurement uncertainty is also indicated and was obtained by assuming that the transducer and data-system uncertainties are random and can be combined through the square-root-of-the-sum-of-the-squares (RSS) technique.

II. TECHNICAL DISCUSSION

Transducer calibration uncertainties are obtained from various sources, including purchase specifications, acceptance-test data, evaluation-test data, and calibration data. In addition to calibration uncertainties, the transducers are affected by environmental changes. Deviations in transducer performance due to the operating environment are included as part of the transducer uncertainty when they are nonpermanent. Permanent deviations in performance (such as might be caused by cumulative radiation effects) are a function of test chronology and cannot be reported until posttest data are available. Nonpermanent uncertainties due to environmental conditions are obtained by analyzing the effects of expected test extremes.

Data-acquisition-system uncertainties for the XECF test series are based on the preliminary results obtained from the ETS-1 data-acquisition-system tests. A summary of the system uncertainties follows.

Digital-Data-Acquisition-System Uncertainties

<u>Mode</u>	<u>System Uncertainty Range, %</u>
Strain gage	<u>+0.12</u>
RTT (constant current, 35 - 60°R)	<u>+0.4</u>
RTT (triple bridge)	<u>+0.26</u>
Thermocouple (copper/constantan)	<u>+0.45</u>
Thermocouple (chromel/alumel)	<u>+0.23</u>
Potentiometer	<u>+0.58</u>

Quick-Look Data-Recorder Uncertainties

<u>End Recorder</u>	<u>System Uncertainty Range, %</u>
Strip chart	<u>+4.0</u>
Oscillograph	<u>+3.3</u>

Wide-Band (WB) Data-Acquisition-System Uncertainty

All modes	<u>+9.9%</u>
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The system uncertainties specified for the narrow-band (NB) digital-data-acquisition system are applicable only to engineering-unit printouts obtained from the DN-3 tapes. That is, data presentations other than digital printouts will contain additional uncertainties that are not included in the above figures.

The indicated total-measurement-system uncertainties for data recorded on the NB system and on the strip-chart recorders are applicable to steady-state data only. The specified bandwidths reflect the capabilities of the NB system, but these capabilities generally exceed those of the transducer and its mode of coupling to the measurand.

The total uncertainties indicated for data recorded on the WB system and on oscillograph recorders are applicable to all data within the specified bandwidth. However, corrections must be applied by the data user to compensate for low- or high-frequency roll-off, when present.

The vibration measurement channels where strain-gage-type accelerometers are used merit special attention. These transducers have a flat ($\pm 5\%$) frequency response to 720 Hz at room temperature, but this response changes markedly as temperature varies, especially as temperature decreases. The strain-gage-type accelerometers on XECF are ± 15 -g units that have a natural, undamped, resonant frequency of approximately 800 Hz. The temperature extremes to which these transducers will be subjected will result in frequency-response variations of about 100%. However, most of the variation will occur at frequencies above 160 Hz, and data below this frequency will remain within the $\pm 5\%$ frequency-response criterion.

Data-system uncertainty values used in this report do not include noise resulting from coupling the transducer to the data system through long cables with connectors and other types of terminations at intermediate points. Low-level signal inputs are affected proportionately more by the noise than are the high-level inputs.

The total-uncertainty values indicated in this report are based on the RSS combination of the transducer error and the data-system error (data-system error defined for a 99% confidence interval such that 99.9% of all data points will fall within the specified interval). The uncertainties are specified in such a way that, for any true measurand value appearing on the abscissa, the recorded value will fall within the interval established by the corresponding ordinate values.

A cross-listing of tables (No. 1 through 4) and figures (No. 1 through 50) that apply to the various parameters is given immediately after the listing of contents in the front of this report. Parameters are listed in the order in which they appear on the XECF Measurements Requirements List (MRL).

TABLE 1

<u>Channel Number</u>	<u>Transducer Description</u>	<u>Transducer Part No.</u>	<u>Measurement Range, Psid</u>	<u>Bandwidth, Hz</u>	<u>Uncertainty, psi</u>		
					<u>Transducer</u>	<u>Data System</u>	<u>Total</u>
PD114..A	FB Strain Gage Type ↑ ↓	PM280TC ↑ ↓	0-200	0-20	<u>+6.4</u>	<u>+0.24</u>	<u>+6.4</u>
PD133..A			0-100	0-10	<u>+1.5</u>	<u>+0.12</u>	<u>+1.5</u>
PD163..A			0-20	0-2	<u>+0.3</u>	<u>+0.02</u>	<u>+0.3</u>
PD205..A			0-10	0-2	<u>+0.15</u>	<u>+0.01</u>	<u>+0.15</u>
PD810..A							
PD812..A							
PD208..A			0-10	0-10	<u>+0.15</u>	<u>+0.01</u>	<u>+0.15</u>
PD804..A							
PD209..A			0-20	0-10	<u>+0.3</u>	<u>+0.02</u>	<u>+0.3</u>
PD801..A			0-200	0-2	<u>+6.4</u>	<u>+0.24</u>	<u>+6.4</u>
PD802..A	FB Strain Gage Type	PM280TC	0-20	0-20	<u>+0.3</u>	<u>+0.02</u>	<u>+0.3</u>

TABLE 2

Channel Number	Transducer Description	Transducer Part No.	Measurement Range	Bandwidth, Hz	Uncertainty, psi		
					Transducer	Data System	Total
PT114..A	FB Strain Gage Type	1117165	0-300 psig	0-10	<u>+3.0</u>	<u>+0.36</u>	<u>+3.0</u>
PT151..A		217	0-100 psia	0-20	<u>+1.5</u>	<u>+0.12</u>	<u>+1.5</u>
PT160..A		217	0-200 psig	0-10	<u>+3.0</u>	<u>+0.24</u>	<u>+3.0</u>
PT168..A							
PT172..A		206	0-500 psig	0-2	<u>+7.5</u>	<u>+0.6</u>	<u>+7.5</u>
PT210..A		206	0-500 psig	0-10	<u>+7.5</u>	<u>+0.6</u>	<u>+7.5</u>
PT212..A		702420	0-300 psig	0-10	<u>+4.5</u>	<u>+0.36</u>	<u>+4.5</u>
PT214..A							
PT226..A		702418	0-200 psig	0-10	<u>+3.0</u>	<u>+0.24</u>	<u>+3.0</u>
PT810..A		217	0-100 psig	0-20	<u>+1.5</u>	<u>+0.12</u>	<u>+1.5</u>
PT814..A		1117165	0-100 psig	0-10	<u>+1.0</u>	<u>+0.12</u>	<u>+1.0</u>
PT815..A							
PT864..A							
PT868..A							
PT870..A							
PT872..A							
PT878..A							
PT880..A							
PT882..A							
PT866..E							
PT876..E	FB Strain Gage Type						

TABLE 2 (cont.)

Channel Number	Transducer Description	Transducer Part No.	Measurement Range	Bandwidth, Hz	Uncertainty, psi		
					Transducer	Data System	Total
PT883..A PT885..A	FB Strain Gage Type	1117227	0-50 psia	0-2	<u>+0.75</u>	<u>+0.06</u>	<u>+0.75</u>
PT890..A		1114152	0-200 psia	0-2	<u>+3.0</u>	<u>+0.24</u>	<u>+3.0</u>
PT104..E		1117165	0-100 psig	0-20	<u>+1.0</u>	<u>+0.12</u>	<u>+1.0</u>
PT106..E		1117165	0-100 psig	0-2	<u>+1.0</u>	<u>+0.12</u>	<u>+1.0</u>
PT110.AE PT112.AE		1117165	0-500 psig	0-20	<u>+5.0</u>	<u>+0.6</u>	<u>+5.0</u>
PT124.AE PT128.AE		206	0-500 psig	0-20	<u>+7.5</u>	<u>+0.6</u>	<u>+7.5</u>
PT148.AE PT149.AE		701615	0-750 psia	0-20	<u>+7.5</u>	<u>+0.9</u>	<u>+7.6</u>
PT800..F PT894..R		1117165	0-50 psig	0-2	<u>+0.5</u>	<u>+0.06</u>	<u>+0.5</u>
PT834..R PT895..R		1117165	0-100 psig	0-2	<u>+1.0</u>	<u>+0.12</u>	<u>+1.0</u>
PT891..R		1117165	0-1200 psig	0-2	<u>+12.0</u>	<u>+1.44</u>	<u>+12.1</u>
PT896..R		1117165	0-750 psig	0-2	<u>+7.5</u>	<u>+0.9</u>	<u>+7.6</u>
PT897..R	FB Strain Gage Type	1117165	0-300 psig	0-2	<u>+4.5</u>	<u>+0.36</u>	<u>+4.5</u>
P.120..E	N/A	N/A	0-500 psig	0-2	<u>+3.5</u>	<u>+10.0</u>	<u>+10.6</u>
P.132..E	N/A	N/A	0-500 psig	0-2	<u>+5.0</u>	<u>+10.0</u>	<u>+11.2</u>
P.158..E	N/A	N/A	0-750 psia	0-20	<u>+6.75</u>	<u>+2.03</u>	<u>+7.0</u>

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5
Page 11

Figure 6

Figure 7
13

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

Figure 22

Figure 23

Figure 24

Figure 25

Figure 26

Figure 27

WIDE-BAND DATA

TABLE 3

<u>Channel Number</u>	<u>Transducer Description</u>	<u>Transducer Part No.</u>	<u>Measurement Range</u>	<u>Bandwidth, Hz</u>	<u>Uncertainty, psi</u>		
					<u>Transducer</u>	<u>Data System</u>	<u>Total</u>
PT810..A	FB Strain Gage Type	217	0-100 psig	0-300	<u>+1.5</u>	<u>+9.9</u>	<u>+10.0</u>
PT112.AE	FB Strain Gage Type	1117165	0-500 psig	0-100	<u>+5.0</u>	<u>+49.5</u>	<u>+50.0</u>
PT124.AE	FB Strain Gage Type	206	0-500 psig	0-300	<u>+7.5</u>	<u>+49.5</u>	<u>+50.1</u>
PT149.AE	FB Strain Gage Type	701615	0-750 psia	0-100	<u>+7.5</u>	<u>+74.3</u>	<u>+74.6</u>

Figure 28

Figure 29

Figure 30
 38

Figure 32

Figure 33

TABLE 4

Channel Number	Transducer Description	Transducer Part No.	Measurement Range	Bandwidth, Hz	Uncertainty, psi		
					Transducer	Data System	Total
PD114..A	FB Strain Gage Type ↑ ↓	PM280TC	0-200 psid	0-20	+6.4	+8.0	+10.2
PD133..A		PM280TC	0-100 psid	0-10	+1.5	+3.3	+3.6
PD208..A		PM280TC	0-10 psid	0-10	+0.15	+0.33	+0.36
PD209..A		PM280TC	0-20 psid	0-10	+0.3	+0.8	+0.85
PD804..A		PM280TC	0-10 psid	0-10	+0.15	+0.4	+0.43
PT114..A		1117165	0-300 psig	0-10	+3.0	+12.0	+12.4
PT226..A		702418	0-200 psig	0-10	+3.0	+8.0	+8.5
PT814..A		1117165	0-100 psig	0-10	+1.0	+4.0	+4.1
PT864..A							
PT872..A							
PT866..E							
PT876..E							
PT880..A		1117165	0-100 psig	0-10	+1.0	+3.3	+3.4
PT883..A		227	0-50 psia	0-2	+0.75	+2.0	+2.1
PT104..E		1117165	0-100 psig	0-20	+1.0	+4.0	+4.1
PT110.AE		1117165	0-500 psig	0-20	+5.0	+20.0	+20.6
PT124.AE		206	0-500 psig	0-20	+7.5	+20.0	+21.4
PT149.AE	FB Strain Gage Type	701615	0-750 psia	0-20	+7.5	+24.75	+25.9
P.158..E	N/A	N/A	0-750 psia	0-20	+6.75	+30.0	+30.8

Figure 35

Figure 36

Figure 37

Figure 38
47

Figure 39
 48

Figure 40

Figure 41

Figure 42
 51

Figure 43

Figure 44

Figure 45
 54

Figure 46

Figure 47

Figure 48

Figure 49

Figure 50