

UNCLASSIFIED

AD 433088

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

64-10

433088

RTD-TDR-63-4287
VOLUME II

ITEM ___ COPY ___

CATALOGED BY DDC
AS AD No. _____

A STUDY OF NUCLEAR RADIATION
EFFECTS ON TELEMETRY

VOLUME II - NUCLEAR RADIATION
EFFECTS DESIGN ALLOWABLES

TECHNICAL DOCUMENTARY REPORT NO. RTD-TDR-63-4287

FEBRUARY 1964

AIR FORCE AVIONICS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

PROJECT NO. 4107, TASK NO. 410721

(PREPARED UNDER CONTRACT NO. AF 33(657)-11646)

BY

LTV VOUGHT AERONAUTICS DIVISION
Ling-Temco-Vought, Inc.
P. O. Box 5907
Dallas, Texas 75222

DDC
MAR 30 1964
TISIA B

433088

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Qualified requesters may obtain copies of this report from the Defense Documentation Center (DDC), (formerly ASTIA), Cameron Station, Bldg. 5, 5010 Duke Street, Alexandria, Virginia, 22314.

This report has been released to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., for sale to the general public.

Items and materials used in the study, or called out in the report by trade name or specifically identified with a manufacturer, were not originated for use in this specific study or for applications necessary to this study. Therefore, the failure of any item or material to meet requirements of the study is no reflection on the quality of a manufacturer's product or on the manufacturer. No criticism of any item or material is implied or intended, nor is any indorsement of any item or material by the USAF implied or intended.

Copies of this report should not be returned to the Research and Technology Division, Wright-Patterson Air Force Base, Ohio, unless return is required by security considerations, contractual obligations, or notice on a specific document.

FOREWORD

This report was prepared by LTV Vought Aeronautics Division of Ling-Temco-Vought, Inc., Dallas, Texas, under Contract Number AF 33(657)-11646, Project Number 4107, Task Number 410721. The contract effort was administered under the cognizance of the Electronic Warfare Division (AVW), AF Avionics Laboratory (AFAL), AFSC, Wright-Patterson Air Force Base, Ohio. Project monitor for the effort was Mr. Kenneth W. Foulke (AVWC).

This report consists of two volumes.

ABSTRACT - VOLUME II

Approximately 1500 nuclear radiation effects "Design Allowables" on electronic materials and parts were compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. The radiation effects Design Allowable is a nuclear radiation environmental exposure under which the associated material or part is expected to exhibit certain specified characteristic changes. The information presented does not include all available data, but is felt to be representative of the current nuclear radiation effects state-of-technology. This data should serve as an aid in performing nuclear radiation effects analyses of currently available telemetry systems and provide useful inputs for hardening such systems for use in a nuclear radiation environment.

This technical documentary report has been reviewed and is approved.

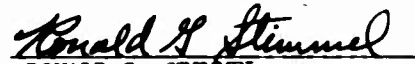

RONALD G. STIMMEL
Asst Chief
Electronic Warfare Division

TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 STEADY-STATE IRRADIATION DATA.	5
2.1 Batteries	6
2.2 Capacitors.	7
2.2.1 Ceramic.	7
2.2.2 Electrolytic	11
2.2.2.1 Aluminum.	11
2.2.2.2 Columbium	12
2.2.2.3 Tantalum.	13
2.2.3 Glass.	17
2.2.4 Mica	19
2.2.5 Mylar.	22
2.2.6 Mylar and Paper.	27
2.2.7 Paper.	29
2.2.8 Plastic.	37
2.3 Coaxial Cables.	39
2.4 Connectors, Electrical.	41
2.5 Cores, Computer	45
2.6 Crystals.	46
2.7 Delay Lines	63
2.8 Dielectric Materials.	65
2.9 Glass	68
2.10 Inductors	70
2.11 Insulation, Electrical.	71
2.12 Laminates	81
2.13 Lubricants.	85
2.14 Magnetic Materials.	87
2.14.1 Ferrimagnetic.	87
2.14.2 Ferromagnetic.	89
2.14.3 Permanent Magnets.	95

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.15 Motors	100
2.16 O-Rings.	101
2.17 Potentiometers	104
2.17.1 Carbon Composition	104
2.17.2 Wirewound.	105
2.18 Potting Compounds.	107
2.19 Printed Circuits	110
2.19.1 Assemblies	110
2.19.2 Boards	111
2.20 Protective Coatings.	117
2.20.1 Enamels.	117
2.20.2 Finishes	118
2.20.3 Fluorinated Vinyls	120
2.20.4 Lacquers	121
2.21 Relays	122
2.22 Resistors.	126
2.22.1 Boron-Carbon Composition	126
2.22.2 Boron-Carbon Film.	127
2.22.3 Carbon Composition	128
2.22.4 Carbon Film.	132
2.22.5 Metal Film	141
2.22.6 Temperature Sensitive.	146
2.22.7 Wirewound.	147
2.23 Semiconductor Devices.	159
2.23.1 Diodes	159
2.23.2 Temperature Sensors.	165
2.24 Solder	167
2.25 Switches	168
2.26 Terminals, Electrical.	171
2.27 Thermocouples.	172
2.28 Transducers.	173

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.29 Transformers	180
2.30 Transistors.	186
2.30.1 Germanium.	186
2.30.1.1 NPN.	186
2.30.1.2 PNP.	187
2.30.2 Silicon.	189
2.30.2.1 NPN.	189
2.30.2.2 PNP.	194
2.31 Tubes, Electron.	196
2.32 Wire, Electrical	226
3.0 PULSE IRRADIATION DATA	235
3.1 Amplifiers	236
3.2 Capacitors	237
3.2.1 Ceramic.	237
3.2.2 Electrolytic	238
3.2.3 Glass.	239
3.2.4 Mica	240
3.2.5 Mylar.	241
3.2.6 Paper.	242
3.2.7 Tantalum	243
3.3 Circulators.	244
3.4 Coaxial Cables	245
3.5 Crystals	247
3.6 Inductors.	248
3.7 Isolators.	249
3.8 Limiters	250
3.9 Oscillators.	251
3.10 Power Supplies	252
3.11 Resistors.	253
3.11.1 Carbon Composition	253
3.11.2 Carbon Film.	254
3.11.3 Film	255
3.11.4 Wirewound.	256

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.12 Semiconductor Devices.	257
3.13 Tubes, Electron.	260
4.0 DESIGN ALLOWABLE REFERENCES.	267
4.1 Steady-State Irradiation	267
4.2 Pulse Irradiation.	276
5.0 LIST OF ABBREVIATIONS USED IN DESIGN ALLOWABLES.	278
6.0 CONVERSION FACTORS	279
7.0 RADIATION EFFECTS FACILITIES UTILIZED IN GENERATING TEST DATA REFERENCED IN THIS REPORT	282
7.1 Steady-State Reactor Facilities.	282
7.2 Gamma Sources and Particle Accelerators.	284
7.3 Pulsed Reactors.	285
8.0 ADDITIONAL REFERENCES.	287

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Format for Presenting Nuclear Radiation Effects Test Data	4
2	Number of Gamma Rays Vs. Dose Rate for Various Gamma Energies.	280
3	Curve to Convert Neutron Flux to Dose Rate. . . .	281

1.0 INTRODUCTION

The radiation effects information presented in this Volume was compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. Most of the data was taken from the 92 different reports listed in the references. Inconsistencies in experimental conditions, variations in test objectives, and different methods of reporting test data make it impossible to give equal credence to each entry in the following tables. This should not detract from the usefulness of such tables, however, if the designer recognizes this fact and takes it into account in formulating his design goals. The information presented herein will suffice to select nuclear radiation tolerant materials and parts to be used in a wide range of nuclear environments.

This data, entitled nuclear radiation effects Design Allowables, is presented in a form that will give the designer a summary of extracted data on the behavior, stability and capabilities of components and materials operating in a nuclear radiation environment without having to examine in detail numerous documents containing the results of irradiation tests on these components and materials. The term "Radiation Effects Design Allowable" is defined as the nuclear radiation environmental exposure under which the associated material or component is expected to exhibit certain specified characteristic changes. These specific characteristic changes are presented as the basis for the "Design Allowable." This information cannot be interpreted as specific parameter variations for other materials or components made by the same or different manufacturers unless an accurate evaluation establishes the similarity of the two items. Material formulation, processing, quality control, fabrication techniques, parameter utilization, and environmental test conditions all have pertinent bearing on the data presented in these tables, hence, care must be exercised in its application.

Although both steady-state (Section 2.0) and pulse (Section 3.0) radiation effects information is contained in this document, the major effort (about 90 percent) has been devoted to the steady-state effects. This represents a logical division based on the availability of useful information and the nature of the respective problems. The steady-state data readily lends itself to the tabular presentation used here and should be most useful for designing nuclear radiation tolerant telemetry systems. The nature of pulse radiation effects and the lack of good experimental pulse data on parts make this type of presentation extremely difficult to compile and use. However, when Section 3.0 is used in conjunction with the information presented in Section 2.0 of Volume I, it should serve a very useful purpose in giving the designer a feel for the primary pulse effects problems, the general type of experimental work which has been conducted, and sufficient source references to obtain additional information as required.

Manuscript released by the author January 1964 for publication as an RTD Technical Documentary Report.

The information contained herein does not include all available data but is representative of the current nuclear radiation effects state-of-technology. Ninety-two documents were selected from a total of 800 reviewed. From the 92 documents 1500 radiation effects "Design Allowables" have been extracted, analyzed, compiled, and presented in a tabular form in this Volume. In general, the tables contain a description of the material or part, the nuclear radiation exposure to which it was tested, the specific changes observed, and the source reference (Figure 1). The following paragraphs further describe the specific information contained in the tables and discuss the general guidelines which were used in extracting and presenting the data.

Components and materials are categorized under their general classification. Specific identification, such as manufacturer, part numbers, functional rating values, element composition, basic use and other identifying remarks, are called out to the extent that this information is available in the referenced reports. Also, whenever known, the number of items irradiated are given. Manufacturers are listed in alphabetical order under the specified material or component. Under each manufacturer, the materials are listed in alphabetical order and the components are listed in ascending functional rating value. The exceptions to these two types of listings are crystals and electron tubes which are listed in ascending numerical order by part number identification. Materials and components for which the manufacturer is unknown are listed within the section under the heading of Miscellaneous.

The "Design Allowables" are presented as previously defined. Selective "characteristic changes" observed during the irradiation and the corresponding nuclear radiation levels at which they occurred are presented as the basis for the Design Allowables. If no defined exposure is given in this column, the percentage changes were assumed to refer to the total exposures presented in the "Design Allowable" columns. In most cases these changes are expressed in the percentage of change from the pretest value.

The exposure data presented in the "Design Allowable" Tables are based on the definitions given below:

Nomenclature	Symbol	Definition
Thermal Neutrons	n_t	Neutrons whose energy are above .025 ev. ($E > .025$ ev)
Epicadmium Neutrons	n_e	Neutrons whose energy is above the cadmium cutoff, approximately 0.4 ev. ($E > .4$ ev)
Fast Neutrons	n_f	Neutrons with energies greater than 0.01 Mev. ($E > .01$ Mev)

Nomenclature	Symbol	Definition
Neutron Flux	$n/\text{cm}^2\text{-sec}$ or $n \phi$	The number of neutrons passing through an imaginary sphere of one cm^2 cross-sectional area in one sec.
Neutron Exposure or Time Integrated Flux	n/cm^2 or nvt	The total number of neutrons passing through an imaginary sphere of one cm^2 cross-sectional area in a specified time t.
Gamma Dose Rate	ergs/gm-(C)-sec	The energy, in ergs, which would be absorbed from the gamma field by a gram of carbon per second.
Gamma Exposure Dose	ergs/gm-(C)	Gamma dose rate times time.
Proton Exposure	P/cm^2	The total number of protons passing through an imaginary sphere of one cm^2 cross-sectional area in a specified time t.

For converting gamma exposures reported in roentgens to ergs/gm-(C), a nominal conversion factor of 100 was used. In recording all nuclear radiation exposures only one decimal place accuracy was used.

The Radiation Effects Reference Number refers to the source of information as listed in the references, Section 4.0, and the respective pages from which this data was extracted. These references may be consulted for more detailed information if required.

Additional information on the general effects of nuclear radiation on numerous materials and components, certain criteria for designing nuclear radiation tolerant telemetry systems, and specific examples of the use of these tables in establishing the nuclear radiation effects state-of-technology on telemetry systems are contained in Volume I.

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT General Classification or Special Component	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{cm^2}$ mm-(C)	$\frac{n}{cm^2}$		
Component Identification - Manufacturer, component value, type or part number and number of items tested. The two exceptions are the electron tubes and crystals which are listed in numerical order followed by the manufacturer and number tested. i.e., Aerovox Corp. 100 pf $\pm 20\%$, C-80 - V101AM (Cerafil) (2 ea) i.e., 2D21W/5727 Thyratron-Xenon Gas CE (3 ea) RCA (3 ea)	Gamma Radiation Exposure Dose in ergs/cm-Carbon. This represents the total exposure dose that the article received during the test. i.e., 1(X) (X denotes power of ten)	Time Integrated Neutron Flux (n/cm^2) with the neutron energy (E) given when known. This represents the maximum time integrated flux to which the article was exposed in the test. ne = epicadmium neutrons ($E > .4$ ev) nt = thermal neutrons nf = fast neutrons of unknown energies i.e., 1(X) (X denotes power of ten) ($E > Y$ Mev)	Selective "characteristic changes" observed during the irradiation and the corresponding nuclear radiation levels at which they occurred are presented here. If no exposure is given, the percentage changes refer to the total doses presented in the Design Allowable columns. i.e., Resistance (-5%) @ 2.1(15)nf	Radiation Effects References as given in Bibliography, Section 4.0. i.e., AA p. BB, CC-DD AA - Document Reference No., p. - page BB, CC-DD - pages on which information was obtained

FIGURE 1 FORMAT FOR PRESENTING NUCLEAR RADIATION EFFECTS TEST DATA

1.0 INTRODUCTION

The radiation effects information presented in this Volume was compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. Most of the data was taken from the 92 different reports listed in the references. Inconsistencies in experimental conditions, variations in test objectives, and different methods of reporting test data make it impossible to give equal credence to each entry in the following tables. This should not detract from the usefulness of such tables, however, if the designer recognizes this fact and takes it into account in formulating his design goals. The information presented herein will suffice to select nuclear radiation tolerant materials and parts to be used in a wide range of nuclear environments.

This data, entitled nuclear radiation effects Design Allowables, is presented in a form that will give the designer a summary of extracted data on the behavior, stability and capabilities of components and materials operating in a nuclear radiation environment without having to examine in detail numerous documents containing the results of irradiation tests on these components and materials. The term "Radiation Effects Design Allowable" is defined as the nuclear radiation environmental exposure under which the associated material or component is expected to exhibit certain specified characteristic changes. These specific characteristic changes are presented as the basis for the "Design Allowable." This information cannot be interpreted as specific parameter variations for other materials or components made by the same or different manufacturers unless an accurate evaluation establishes the similarity of the two items. Material formulation, processing, quality control, fabrication techniques, parameter utilization, and environmental test conditions all have pertinent bearing on the data presented in these tables, hence, care must be exercised in its application.

Although both steady-state (Section 2.0) and pulse (Section 3.0) radiation effects information is contained in this document, the major effort (about 90 percent) has been devoted to the steady-state effects. This represents a logical division based on the availability of useful information and the nature of the respective problems. The steady-state data readily lends itself to the tabular presentation used here and should be most useful for designing nuclear radiation tolerant telemetry systems. The nature of pulse radiation effects and the lack of good experimental pulse data on parts make this type of presentation extremely difficult to compile and use. However, when Section 3.0 is used in conjunction with the information presented in Section 2.0 of Volume I, it should serve a very useful purpose in giving the designer a feel for the primary pulse effects problems, the general type of experimental work which has been conducted, and sufficient source references to obtain additional information as required.

Manuscript released by the author January 1964 for publication as an RTD Technical Documentary Report.

2.1

BATTERIES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE NO.
	$\dot{\phi} \leq 10^6 \text{ cm}^{-2} \text{ (sec)}^{-1}$	$\dot{n} \leq 10^6 \text{ cm}^{-2} \text{ (sec)}^{-1}$		
Batteries				
Eagle-Rich.				
GAP-4019, 1.5v or 28v 5A, Silver-zinc (3ea)	2.6(10)	8.6(15) ($E > 1 \text{ Mev}$)	No effect on the operation of 2 of these batteries. The output of the remaining battery was cut-off. A small increase in neutron & gamma exposure may cause batteries of this type to fail.	34-p20
LAP-6034, 28v Thermal battery (6 ea)	2(10)	1.5(16) ($E > 1 \text{ Mev}$)	No effects on battery operation	34p20
#5062 Thermal Battery (2 ea)	2.7(10)	3.7(16) ($E > 3 \text{ Mev}$)	No damage	31p 376-82
#767A, 14.5v Lifetime 1500 watt-min. Silver Oxide-zinc (2 ea)	2.7(10)	3.7(16) ($E > 3 \text{ Mev}$)	-75% Capacity	31p 376-82
Rechargeable Silver-Oxide-zinc cell (1ea)	2.7(10)	3.7 (16) ($E > 3 \text{ Mev}$)	Inconclusive	31p 376-82

2.2 CAPACITORS

2.2.1 CERAMIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Ceramic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{cm^2} - (C)$	$\frac{n}{cm^2}$		
Allen-Bradley Co.				
220pf $\pm 10\%$, 500VDC C16-2211 Epoxy Sealed	2.8 (10)	1.3 (15)nf 1.1 (15)ne	Capacitance (-11.2%) at 1.29 (14)nf	4p142
	2.6 (9)	7.8 (15)nf (E > 0.5 Mev)	Capacitance (-3.2%)	4p142
Aerovox Corp.				
45pf CC25CH4505 (4 ea)	2.9 (10)	1.0 (15)ne	Capacitance (-0.6%) at 7.1 (14)ne	1p84, 87, 685
100pf $\pm 20\%$ C-80-V101AM (Cerafil) (2 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R (-99.9%) at 8.58 (15)nf	12p213
1500pf CK60Y3212 (4 ea)	2.4 (10)	7.4 (14)ne	Capacitance (-13.2%) at 3.7 (14)ne	1p127, 685
1720pf CK27W1522 (4 ea)	2.6 (10)	4.3 (14)ne	Capacitance (-6.5%) at 2.88 (14)ne	1p105, 685
2000pf CK61Y1522 (4 ea)	2.4 (10)	5.5 (14)ne	Capacitance (-25.5%) at 4.33 (14)nf	1p135, 685
5200pf CK37W4722 (4 ea)	2.0 (10)	1.9 (14)ne	Capacitance (-13%) at 1.9 (14)ne	1p121-125, 685
0.1mf $\pm 20\%$ CR-90 M11-C-11015A	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R (-99.9%) at 1.65 (16)nf	12p208
0.25mf $\pm 20\%$ CR-90 M11-C-11015A (1 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R (-99.9%) at 1.3 (16)nf	12p207

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2 \text{ (C)}}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Ceramic				
Centralab Division				
45pf CC25CH450J(4 ea)	2.9 (10)	1.0 (15)ne	Capacitance (-10%) at 4.18(14)ne	1p84,685
1500pf CK60Y621Z(4 ea)	2.4 (10)	7.4 (14)ne	Capacitance (-16.5%) at 4.95(14)ne	1p127,685
2000pf CK61Y152Z(4 ea)	2.4 (10)	5.5 (14)ne	Capacitance (-16.5%) at 4.33(14)ne	1p135,685
2300pf CK27W152Z(4 ea)	2.6 (10)	4.3 (14)ne	Capacitance (-13%) at 3.58(14)ne	1p105,685
5000pf CK37W472Z(4 ea)	2.0 (10)	1.9 (14)ne	Capacitance (-5.5%) at 1.3(14)ne	1p121-125,685
6200pf, +80% to -20% Type CE or CF(1 ea)	7.1 (10)	4.7 (16) (E>1 Mev)	Leakage R(-99.9%) at 1.45(16)nf	12p217
0.02mf, +30% to -30% D.F. 2%, DDA-104(1 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.8%) at 3.58(15)nf	12p215
0.1mf, +30% to -30% DDA-104, 75-V(1 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.8%) at 3.58(15)nf	12p216
0.4mf, +30% to -20% DA 10-474 (1 ea)	7.5 (10)	3.9 (16) (E>1 Mev)	Leakage R(+16.9%) at 2.13(16)nf	12p219
Cornell-Johnston Electric Corp.				
40pf CD-White (1 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.8%) at 3.58(15)nf	12p209
1.001mf $\pm$ 40% CD (Black) (2 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.9%) at 3.58(15)nf	12p211

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{\text{n}}{\text{cm}^2}$		
<u>Erie Resistor Corp.</u>				
45pf CC25CH45QJ(4 ea)	2.9 (10)	1.0 (15)ne	Capacitance (-0.4%) at 8.63(14)ne	1p84,685
1500pf CK60Y321Z(4 ea)	2.4 (10)	7.4 (14)ne	Capacitance (-11.5%) at 5.85(14)ne	1p127,685
2000pf CK61Y152Z(4 ea)	2.4 (10)	5.5 (14)ne	Capacitance (-14%) at 4.5(14)ne	1p135,685
2300pf CK27W152Z(4 ea)	2.6 (10)	4.3(14)ne	Capacitance (-9%) at 2.88(14)ne	1p105,685
5200pf CK37W472Z(4 ea)	2.0 (10)	1.9 (14)ne	Capacitance (-5.5%) at 1.3(14)ne	1p121-125,685
<u>Litton Systems, Inc.</u>				
500pf BaTiO3 Wafer(2 ea)		1.5(16) (E>2.9 Mev)	Leakage R(-88.5%) at 4.59(15)nf	11p29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2} - (C)$	$\frac{n}{\text{cm}^2}$		
Capacitors, Ceramic				
<u>Onondaga Pottery Co.</u>				
1000pf @200%(Temp. Sensitive) Type CH, Hi K	6 (9)	2.1 (16)nf (E>0.5Mev)	Capacitance (-24.6%) @ 2 (16) nf	4p100,133
"	4.1 (10)	2.4 (14)nf (E>0.5Mev)	Capacitance (-44%) at 1(13)nf	4p100,133
<u>Sprague Products Co.</u>				
4700pf, +80% to -20% 600VDC, Ceramic Disc (1 ea)	7.1 (10)	4.7 (16) (E>1 Mev)	Leakage R(-99.9%) at 9.54(15)nf	12p218
" (1 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.9%) at 1.65(16)nf	12p210

2.2 CAPACITORS

2.2.2 ELECTROLYTIC

2.2.2.1 Aluminum

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (AL)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Bell Telephone Labs, Inc.				
0.3mf, 35VDC Experimental (3 ea)		2.6(17)nf	Capacitance (+65%) at 2(16)nf	16p167
3mf, 35VDC Experimental (3 ea)		2.6(17)nf	Capacitance (-20%) 1 failure	16p167

2.2 CAPACITORS

2.2.2 ELECTROLYTIC

2.2.2.2 Columbium

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/cm ² (Co)	n/cm ²		
Capacitors: Electrolytic (Columbium)				
Pansteel Metallurgical Co.				
17mi, 10VDC with Teflon Spacer, 41037-1	6.3(10)	1.6(16) (E>0.5Mev)	Capacitance (-10%)	35p 10.18-25
17mi, 10VDC 41037-2	6.3(10)	1.6(16) (E>0.5Mev)	Capacitance (-10%)	35p 10.18-25

2.2 CAPACITORS

2.2.2 ELECTROLYTIC

2.2.2.3 Tantalum

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electro- lytic (Tantalum)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Astron Corp.</u>				
1.0mf $\pm$ 20%, dissipation 6%, TES-1M-25-20 Mil-C-26655(USAF) (100 ea)	9.0 (10)	2.1 (16) (E>2.9Mev)	Capacitance-92 ea were out of tolerance. No catastrophic failures. Tolerance threshold is 5.15(13) nf > 2.9 Mev & 1.475(8) ergs/gm-(C)	45p11
<u>Fansteel Metallurgical Corp.</u>				
20mf, 35V STA377(Teflon Spacer) (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	2 Failed 6.2(15)nf Capacitance (-1%)	35p 10.10-17
20mf, 35V STA377(modified)(12ea)	6.4(10)	1.6(16) (E>0.5Mev)	2 Failed 6.2(15)nf	35p 10.10-17
70mf, 10V STA357 (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	All good No failures	35p 10.10-17
<u>General Electric Co.</u>				
75mf, 30VDC (Foil) (Minuteman) (2 ea)		1.5(16) (E>0.1Mev)	Capacitance (-9.35%) at 3.8(13)nf	32 Fig. 23
75mf, 30VDC (Foil) (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p118

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>General Electric (Cont'd)</u>				
1000mf 50VDC Wet Slug, Hermetically Sealed, 200D180-6113 (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance (+6.6%) at 1.3(6)ergs/gm-(C) & 1(13)nf	53 Fig 29
<u>ITT</u>				
100mf 20VDC Solid Tant. Hermeti- cally Sealed (1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+4%)	10p118
100mf, 20VDC, Solid, HS (1 ea)		6.5(15) (E>0.1Mev)	Capacitance (+11.5%)	32 Fig. 23
<u>Kemet Co.</u>				
5mf 50V K5H50D6 (11 ea)	6.4(10)	1.6(16) (E>0.5Mev)	1 failure at 4.4(15)nf	35p 10.10-17
1.2mf, ±10%, 60 VDC K3R2J60K, J Series (Solid)	7.6(9)	3.7 (15) (E>1 Mev)	Leakage R(-97.8%) at 1.8(15)nf	12 p 201
15mf. 75VDC K15J75 (Solid Tant.) (9 ea)	1(9)	7 (15) (E>0.1Mev)	Capacitance (-30%) at 3(15)nf @ 150°C	10p 124

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electro- lytic (Tantalum)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>Kemet Cont.</u>				
15mf 75VDC @ 85°C K15J75 (10 ea)		1(16) (E>0.1Mev)	Capacitance (+11.2%)	53 Fig. 28
25mf, 45V K25H45 (30 ea)	1.3 (11)	4.3 (16) (E>0.5Mev)	8 failed <1(16)nf 14 failed between 1(16) & 3.8(16)nf	35p 10.10-17
35mf @ 6V K35H6D5 (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	Leakage R(large decrease) 3 failed at <1(16)nf	35p 10.10-17
<u>Sprague Products Co.</u>				
40mf, 50VDC, hermeti- cally sealed, (foil) 143D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
40mf, 50VDC, H.S.(foil) 142D (2 ea)		1(16) (E>0.1Mev)	Capacitance (+17.5%) at 9(14)nf	32 Fig. 9 & 24
40mf, 50VDC, H.S. (foil) 143D (2 ea)		6(15) (E>0.1Mev)	Capacitance (+10%) at 9(14)nf	32 Fig. 9 & 24
75mf, 30VDC (Herm. Seal) Etched foil, 143D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
75mf, 30VDC, double seal, Foil tant., 222D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
75mf, 30VDC, double seal, Tant. foil, 222D (2 ea)		1.5(16) (E>0.1Mev)	Capacitance (-9.3%)	32 Fig. 23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Electrolytic (Tantalum)				
U. S. Sencor				
18mf, 100VDC Wet Tant. Slug(1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+21 %) at 5.5(15)nf	10p 119 ..
47mf, 100VDC Wet Tant. Slug(1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+12%) at 9(15)nf	10p 119 ..
47mf, 100VDC Wet Tant. Slug(1 ea)		1.5(15) (E>0.1Mev)	Capacitance (+38%)	32 Fig. 9 & 24
Western Electric Co.				
40mf, 35VDC, Solid Tant., Hermetically Sealed (4 ea)	5.6(10)	2.4(17)nf	Capacitance (+5%) at 1(16)nf 2 failed	15p 21,22

2.2 CAPACITORS

2.2.3 GLASS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitor, Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Corning Glass Works</u>				
4.7pf $\pm 5\%$, 300VDC CY20C-472J Mil-C-112728	7.6(9)	3.7 (15) (E>1 Mev)	Leakage R(-78.4%) at 2.08(15)nf	12p 200
1200pf CY15C122J (6 ea)	3.1 (10)	1.1 (15)ne	Capacitance (+2.5%) at 2.34(14)ne	1p 253, 687
5100pf CY20C512J (6 ea)	3.1 (10)	1.1 (15)ne	Capacitance (+1.5%) at 1.86(14)ne	1p259, 687
0.02mf 200VDC (4 ea)	5.6 (10)	2.4(17)nf	Capacitance (+2%)	15p 17, 19
<u>Vitramon, Inc.</u>				
200pf, 500VDC CY13C201J-A (Vitreous Enamel)	7.3(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.5%) at 8.14(15)nf	4p 119
220pf, 300VDC CY13C221J-A (Vitreous Enamel)	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+2%) at 8(15)nf	4p 119
220pf, 500VDC (Vitreous Enamel) CY17C221J-A	7.3(9)	2.27(16)nf (E>0.5Mev)	Capacitance (+2%) at 1.09(16)nf	4p 119
560pf, 300VDC (Vitreous Enamel) CY17561J-A	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+1.6%) at 8(15)nf	4p 119
560pf, 500VDC (Vitreous Enamel) CY22C561J-A	2.8 (10)	1.4(14)nf (E>0.5Mev)	Capacitance (+0.4%) at 1.25(14)nf	4p 124

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Vitramon Cont.</u>				
560pf, 500VDC (Vitreous Enamel) CY22C561J-A	6.0(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.6%) at 1.04(16)nf	4p 125
1200pf, 300VDC (Vitreous Enamel) CY22C122J-A	3.1 (10)	1.8 (14)nf (E>0.5Mev)	Capacitance (+0.4%) at 7.4(13)nf	4p 124
"	7.3(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.5%) at 4.3(15)nf	4p 125
1200pf, 500VDC (Vitreous Enamel) CY32C122J-A	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+2%) at 3.69(15)nf	4p 125
"	2.6 (10)	1.2 (14)nf (E>0.5Mev)	Capacitance (-0.5%) at 2.25(12)nf	4p 128
5600pf, 300VDC (Vitreous Enamel) CY32C562J-A	2.7 (10)	1.3 (14)nf (E>0.5Mev)	Capacitance (+1%)	4p 128

2.2 CAPACITORS

2.2.4 MICA

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Aerovox Corp.</u>				
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14)ne	Capacitance (-1.5%) at 7.68(14)ne	1p 94, 685
6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (-5.5%) at 7.97(14)ne	1p 143, 686
" (6 ea)	1.7 (11)	1.1 (15)ne	Capacitance (-1%)	5p12
0.1mf CM65B104J (4 ea)	9.0 (10)	2.4 (15)ne	Capacitance (-5%)	5p17
<u>Bendix Corp.</u>				
0.12mf, 500VDC E-315, Hi-Temp "Samica" (6 ea)	1.3(9)	2.2(14) (E > 0.5Mev)	Capacitance (0.0%)	35p 10.34
<u>Centralab</u>				
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14)nf	Capacitance (+10.5%) at 3.82(14)nf	1p 94, 685

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Cornell-Dubilier Electrical Corp.</u>				
6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (-0.26%) at 1.13(15)ne	1p 143, 686
0.1mf CM65C104J (6 ea)	3.4 (10)	1.1 (15)ne	Capacitance (-1.7%) at 1.05(15)ne	1p 174, 686
<u>Erie Resistor Corp.</u>				
100pf CB11PX681G (6 ea)	1.9 (10)	6.4 (14)ne	Capacitance (-3.5%) at 5.35(14)ne	1p 72, 685
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14)ne	Capacitance (-2%) at 7.68(14)ne	1 p 94, 685
680pf CB21FX101G (6 ea)	1.9 (10)	6.4 (14)ne	Capacitance (-1%) at 5.35(14)ne	1 p 78, 685

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Micamold Radio Corp.</u> 6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (+0.26%) at 1.34(14)ne	1p 143, 686
<u>Sprague Products Co.</u> 0.1mf CM65C104J (6 ea)	3.4 (10)	1.1 (15)ne	Capacitance (-2.2%) at 1.03(15)ne	1p 174, 686

2.2 CAPACITORS

2.2.5 MYLAR

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Capacitors, Mylar</u>				
<u>Balco Research Labs</u>				
0.5mf, 200vdc QTM-1 (Zinc-Metalized Mylar) (6 ea)	4.3(10)	1.4(16) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
<u>Cornell-Dubilier Electric Corp.</u>				
0.25mf+20%, 400vdc STM (Miniroc) (6 ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%)	35p 10.25-33
0.25mf+20%, 400vdc MUF (6ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%)	35p 10.25-33
<u>Electron Products Div. Preco, Inc.</u>				
36500pf+5%, 200vdc Dry Mylar (3 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance(-15%) @ 4.5(15)nf	10p 118
0.047mf+20%, Diss.> 0.6%, Mylar film & foil, E-120 (1 ea)	6.2 (10)	4.2 (16) (E> 1Mev)	Leakage R(-99.7%) @ 1.65(16)nf	12p 205
0.1mf, 200vdc (Metalized Mylar) DG2-104(1S) (2 ea)	3.9 (8)		Leakage R(-90%) @ 2.8(6) ergs/gm-(C)	12p 183
" (1 ea)	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-94.6%)	12p 189

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2} - (C)$	$\frac{n}{\text{cm}^2}$		
<u>Capacitors, Mylar</u>				
<u>Electron con't</u>				
0.22mf @400vdc +20% Mylar film & foil E4-224 (IS)	7.6(9)	3.7 (15) (E> 1Mev)	Leakage R(-96.1%) @ 7.5(13)nf	12p 203
0.22mf+20%, Diss<0.6% Mylar Film E-120, E4-224 (1 ea)	6.2 (10)	4.2 (16) (E> 1Mev)	Leakage R(-98%) @ 8.58(15)nf	12p 204
0.68mf+1%, 200vdc Dry Mylar (3 ea)	1.5(9)	1(16) (E>.1Mev)	Capacitance(-7.3%) @ 9(15)nf	10p 118
<u>Electronic Fabricators, Inc.</u>				
0.5mf+10%, 200vdc Type Mw Mylar	2.2(9)	5.6(14) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
<u>General Electric Co.</u>				
0.039mf, 300vdc Dry Impregnated CTM 393VDK, 2V104 (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance (<1%)	10p 122
0.039mf 300vdc Dry Impregnated CTM 393VDK, 2V104 (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+3.62%)	53 Fig 29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Mylar				
<u>Good-All Electric Manufacturing Co.</u>				
2200pf+20%, 100vdc 663-UW	5.3(9)	1.6(16)ne	Capacitance(+9.2%) @ 5.4(15)ne	4p 112
" 200vdc			Capacitance(+10.4%) @ 8(15)ne	
" 400vdc			Capacitance(+8.5%) @ 8(15)ne	
" 600vdc			Capacitance(+14.3%) @ 1.01(15)ne	
0.047mf, 600vdc Dry Impregnated 663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(+2.28%)	53 Fig 29
0.047mf, 600vdc X663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-6%) @ 2(13)nf	10p 122
0.05 mf, 50 vdc Dry impregnated X601PE (446) (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-7.2%) @ 2(12)nf	10p 121
" (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-5.9%) at 2.4(15)nf	53 Fig. 29
0.1mf, 100vdc Dry Impregnated 613G (1049.1W2)(3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-9.3%) @ 1(13)nf	53 Fig. 29
" (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-1%)	10p 121

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Capacitors: Mylar				
Good-All con't				
0.1mf, 50vdc Dry Impregnated 627G (1049.5W2)(3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+9.8%) @ 2.4(15)nf & 3.6(8) ergs/gm-(C)	53 Fig. 29
0.1mf, 50vdc Dry Impregnated X601PE (3ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-2.63%) @ 3.2(6)ergs/gm-(C), 2.1(15)nf	53 Fig. 29
0.1mf, 50vdc X601PE (446) (3ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-1%)	10p 121
0.15mf, 50vdc Liquid Impregnated 617G (1540-S) (3ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(+2.5%) @ 2(13)nf	10p 121
" (3ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+3.1%) @ 7.6(14)nf	53 Fig. 29
0.22mf+10%, 300vdc BSAD-I 663 VW (6 ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%) Leakage R -1(3)	35p 10.26-33
0.3mf, 100vdc Dry Impregnated 663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-2.3%) @ 2.4(15)nf	10p 121
" (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-7.15%)	53 Fig. 29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Capacitors, Mylar</u>				
<u>Hopkins Engineering Co.</u>				
0.1mf, 200vdc P-12M (Metalized Mylar)	1.9(10)	1.5(15) (E>2.9Mev)	Leakage R(-94.6%) @ 5.2(8) ergs/gm-(C)	12p 193
0.1mf @200vdc+20% P-12M(A03678-5) (film)	7.6(9)	3.8(15) (E>1Mev)	Leakage R(-80.8%) @ 4.2(9) ergs/gm-(C)	12p 197
0.12mf @200vdc+5% P-122MFC (film)	7.6(9)	3.8(15) (E>1Mev)	Leakage R(-82.3%) @ 1.0(9)ergs/gm-(C)	12p 199
<u>Plastic Capacitors, Inc.</u>				
0.01mf+20% Impregnated with Stycast #62 LS4-103 (9 ea)	1.6(11)	7.6(14)ne	Capacitance(+8.3%) immediately	2p 328
<u>Sprague Products Co.</u>				
1mf HYDREL MIL-C-26244 (100 ea)	9.1(10)	2.2(16) (E>2.9Mev)	Capacitance(small increase) 94ea failed Threshold of failure 1.845(15)nf 2.9Mev & 8.495(9)ergs/gm-(C)	45p 11,19

2.2 CAPACITORS

2.2.6 MYLAR & PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar & Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Sangamo Electric Co.</u>				
0.1mf, CPM08 impregnated with Cl6-18 alkyl biphenyl dielectric fluid(10ea)	1(10)		100% of all capacitors tested failed under a voltage pulse of 2000 volt @ 135°C after a dose of 8(8)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Bis(Phenoxphenyl) Ether Dielectric Fluid (10 ea)	1(10)		86% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C after a dose of 1(9)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with MONO ISOPROPYLBIPHENYL Dielectric Fluid (25 ea)	1(10)		65% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Etherm "A" dielectric fluid	1(9)		57% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Etherm "A" Dielectric fluid with 4 % inhibitor (14 ea)	1(9)		50% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9)e/g-C	70 p. 96 p. 10 p. 1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar & Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm \cdot (C)}$	$\frac{n}{cm^2}$		
<u>Sangamo con't</u>				
0.1mf, CPM08 impregnated with Bis(Phenoxyphenyl) Ether Dielectric Fluid (50 ea)	1(10)		8% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C after a dose of 1(9)	70 p 96,10,1
0.1mf, CPM08 impregnated with Mono IsopropylBiphenyl Dielectric Fluid without inhibitor	1(10)		62% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p 96,10,1
0.1mf, CPM08 impregnated with Mono IsopropylBiphenyl Dielectric Fluid with inhibitor	1(10)		30% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p 96,10,1
0.1mf, CPM08 with Etherm "A" Dielectric Fluid	1(10)		10% of all capacitors tested failed under a voltage pulse of 2000vdc @ 135°C after a dose of 1(9) e/g-C	70 p 100,1,10
0.1mf, CPM08 impregnated with oversized inhibited FC-43 Dielectric Fluid (Perfluorutributylamine) (8 ea)	1(10)		100% of all capacitors tested failed under a voltage pulse of 2000volts @ 135°C after a dose of 6.2(8) e/g-C	70 p 98,1,10

2.2 CAPACITORS

2.2.7 PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Paper				
<u>Aerovox Corp.</u>				
0.1mf + 20% CP04A1EE104M (3 ea)	3.3 (10)	2.7 (15)ne	Capacitance (-12.6%) at 6.24(14)ne	1 p 185
" (3 ea)	2.6 (10)	1.1 (15)ne	Capacitance (-20%)	2p 285, 286
0.1mf CP04A1KE104M (3 ea)	2.6 (10)	1.1 (15)ne	Capacitance (-11%) 1 shorted	2p 297
" (3 ea)	3.3 (10)	2.7 (15)ne	Capacitance (-14.5%) at 3.95(14)ne	1p 193, 686
0.1mf CP25A1EF104K (3 ea)	2.6 (10)	1.1 (15)ne	All failed 2 shorted, 1 rupture	2p 307
0.5mf CP53B2FF504K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-20.9%) at 6.25(14)ne	1p 219, 687
0.5mf CP53B1D504K (3 ea)	2.9 (10)	2.4 (15)ne	Capacitance (-32.3%) at 2.13(14)ne	1p 206, 687
" (3 ea)	4.6 (10)	3.0 (15)ne	Capacitance All 3 shorted out in pile, All had oil leaks at end of test	2 p 316
0.5mf CP53B1FF504K (3 ea)	4.6 (10)	7.2(15)ne	Capacitance (-16.5%) at 6.6(14)ne 2 shorted at 3.78 (15)ne	2p 319
1.0mf CP63B1EF105K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-28%) at 3.36(14)ne	1p 229, 687
10 mf CP70E1EF106K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-34.5%) at 3.19(14)ne	1p 240, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Astron Corp.</u> 1.0 mf CPO8ALKE105M M11-C-25A (100 ea)	8.1(10)	1.8(16) (E > 2.9 Mev)	89 Failed Catastroph- ically. General capa- cittance decrease, 22- had exploded, 59- shorted. Threshold tolerance-1.04(14)nf >2.9 Mev & 3.92(8) ergs/gm-(C)	45 p. 11-17 .
<u>Bendix Corp.</u> <u>Scintilla Div.</u> 0.1 mf E - 200 Impregnated with Polyester Resin	1(9)		10% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C	70 p. 100
<u>Chicago Condensor</u> <u>Corp.</u> 10. mf CP70ELEF106K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-37.6%)	1 p. 245, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Cornell-Dubilier Elect. Corp.</u>				
0.1 mf CP04A1EE104M (3 ea)	2.6 (10)	1.1 (15) ne	Capacitance (-13.7%) @ 1.11(15)ne, 1 shorted	2 p. 285, 286
0.1 mf CP04A1EE104M (3 ea)	3.3 (10)	2.7 (15) ne	Capacitance (-12.6%) @ 6.23(14) ne	1 p. 185, 686
0.1 mf CP04ALKE104M (3 ea)	3.3 (10)	2.7 (15) ne	Capacitance (+16.2%) @ 2.58 (15)ne	1 p. 198, 686
0.1 mf CP04ALKE104M (3 ea)	3.3 (10)	1.1 (15) ne	Capacitance (+17%) @ 1.11(15)ne, 1 opened	2 p. 297
0.1 mf CP25A1EF104K (3 ea)	2.6 (10)	1.1 (15) ne	Capacitance (-20.5%) @ 5.81 (14)ne	2 p. 303
0.5 mf CP53B1FF504K (3 ea)	4.6 (10)	6.9(15)ne	Capacitance, All failed < 3(15)ne	2 p. 321
0.5 mf CP53B1EF504K (3 ea)	2.9 (10)	2.4 (15) ne	Capacitance (-18%) @ 9.9(14)ne, 2 shorted	1 p. 215
0.5 mf CP53B2FF504K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-36.2%) @ 2.19(14)ne	1 p. 225, 687
1 mf CP63B1EF105K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-32.6%) @ 3.36(14)ne	1 p. 229, 687
10 mf CP70E1EF106K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-31.9%) @ 2.09(14)ne	1 p. 249, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Paper				
<u>Crocker, Burbank Paper, Inc.</u>				
0.5mf, 400 vdc Metal clad tubular, Impregnated with refined Sun-XX oil	1(10)		Capacitance decreased about 3% @ 25°C & 7% @ 125°C, D.F. more than doubled @ 25°C & increased 6 times @ 125°C, I.R. (-33%) @ 25°C & (-12.5%) @ 125°C. The paper was also weakened & shorted when voltage was applied.	70p 32
<u>Electron Products Division, Preco, Inc.</u>				
0.1 mf. 200 vdc (Metalized) MG2-104 (2 ea)	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-95.2%)	12p 191
" (2 ea)	3.9 (8)		Leakage R(-44%) @ 6.88(6) ergs/gm-(C)	12p 184
0.1 mf @ 200 vdc ± 10% (Metalized) encased in epoxy tube, ME2-104E (Epicon)	7.6(9)	3.7 (15) (E>1 Mev)	Leakage R(-83%) @ 2.79(15) nf	12p 202
0.1 mf ± 20%, DF<1% Metalized Paper Epoxy Impregnated M150 (1ea)	6.2 (10)	4.2 (16) (E> 1Mev)	Leakage R(-99.8%) @ 1.65(16)nf	12p 206
0.47 mf, 200 vdc Metalized Paper, Epoxy impregnated , wrap & end fill, M2-474	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-94.7%)	12P 190
" (2 ea)	3.9 (8)		Leakage R(-44%) @ 6.88(6) ergs/gm-(C)	12p 184

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Capacitor, Paper				
<u>Micamold Radio Corp.</u>				
0.1 mf CP04ALEE104 M (3ea)	3.3(10)	2.7 (15)ne	Capacitance (+18.5%) @ 2.6(15)ne	1p 180,686
" (3ea)	2.6(10)	1.1 (15)ne	Capacitance (+16.9%) @ 1.11(15)ne 1 shorted	2p 286
0.1 mf CP25ALKE104 M (3ea)	2.6(10)	1.1 (15)ne	Capacitance (+21.6%) @ 1.11(15)ne	2p 298
0.1 mf CP04ALKE104 M (3ea)	3.3(10)	2.7 (15)ne	Capacitance (+17.5%) @ 2.6(15)ne	1p 201,686
<u>Sangamo Electric Co.</u>				
0.1 mf CMP08	1(10)		Capacitance (-6%). Factor of 2 increase in dissipation factor, factor of 7 decrease in insu- lation R	70p 30
0.1 mf, Samica with C-oil solid impreg- nated	1(9)		30% of all capacitors tested failed under a voltage pulse of 2000v @ 135°C	70p 100
0.1 mf, Samica with mono-isopropyl- biphenyl dielectric fluid	1(10)		20% of all capacitors tested failed under a voltage pulse of 2000v @ 135°C	70p 100

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Capacitor, Paper				
<u>Sprague Products Co.</u>				
0.1 mf CP04ALEE104M (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(+24.1%) @ 6.8(14) ne 1 opened	2p 285,286
" (3 ea)	3.9(10)	2.7 (15)ne	capacitance (-17%) @ 3.6(14)ne	1p 188, 686
0.1 mf CP04ALEE104M (2 ea)	3.9(10)	2.7 (15)ne	capacitance (-18.5%)	1p 188, 686
" (3 ea)	2.6(10)	1.1 (15)ne	Capacitance (-21%) 1 shorted	2p 291
0.1 mf CP04ALKE104K (3ea)	2.6(10)	1.1 (15)ne	Capacitance (-26.2%) 1 shorted	2p 294
" (2ea)	3.9(10)	2.7 (15)ne	Capacitance (-19%)@ 3.95(14)ne	1p 204,687
0.1mf CP04ALKE104M (3 ea)	3.9(10)	2.7 (15)ne	Capacitance (-18.4%) @6.05(14)ne	1p 193,686
" (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(-28.5%) 1 shorted	2p 298
0.1 mf CP25ALEF104K (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(-28.5%) 1 shorted	2p 311
0.1 mf, 200vdc 195P (Hyrel) (4 ea)	5.7(10)	2.4(17)nf	Capacitance(-12%) @ 1.1(17), all failed from outgassing	15p 17,20
0.47mf @600vdc Hi Density paper impregnated with standard amount of Vitamin Q (3ea)	1.9(10)		Paper deteriorates & capacitor burst due to outgassing of impregnant & paper, capacitance (-10%) at 4.38 (7)ergs/gm-(C)	55p 3, 11, 16
0.47mf @600 vdc Standard paper im- pregnated extra full with Vitamin Q (8 ea)	5.8(9)		Paper deteriorates & capacitor burst due to outgassing. capacitance (-8%) @ 4.38(7)ergs/gm-(C)	55p 3,11, 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Paper				
<u>Sprague Con't</u>				
0.47mf @600vdc Hi density paper impregnated extra full with VitaminQ (8 ea)	1(10)		Paper deteriorated due to outgassing of impregnant & paper. capacitance (-1.8%) at 2.26(7)ergs/gm-(C)	55p 3, 11, 16
0.47mf @ 600vdc standard paper, standard impregnated with ether	1.9(10)		Paper gasses and becomes weak , brittle and flakey. Dissipation factor increases several orders of magnitude. Capacitance (-13%)	55p 3,11,17
0.47 mf @600vdc standard paper and impregnated with standard ether (extra full)	1.9(10)		Paper gasses and becomes weak, brittle and flakey. Capacitor ruptures due to out- gassing of paper and ether. Capacitance (-13%)	55p 3, 11, 17
0.47mf @600vdc Hi density paper and impregnated extra full with ether	1.9(10)		Paper gases and deteriorates. Capacitor ruptures due to outgassing of paper and ether. Capacitance (5.8%) @ 2.26(7)ergs/gm-(C)	55p 17
0.47mf @600vdc Hi density paper and impregnated with a standard load of ether	1.9(10)		Paper gases and deteriorates. Capacitor ruptures due to outgassing of paper and ether. Capacitance(-13.3%) @2.26(7)ergs/gm-(C)	55p 17
0.5 mf CP53B2FF504K (3 ea)	2.8(10)	1.4(15)ne	Capacitance (-19.5%) @ 2.25 (14)ne	1p 225

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Sprague Con't</u>				
0.5mf CP53B1EF504K (3 ea)	2.9(10)	2.4(15)ne	Capacitance (-17.3%) @ 3.97 (14)ne	1p 217,687
1 mf CP63B1EF105K (3 ea)	2.7(10)	1.4(15)ne	Capacitance (-30.2%)	1p 229,687
10mf CP70E1EF106K (3 ea)	2.7(10)	1.3(15)ne	Capacitance (-35.7%) @ 6.8(14)ne	1p 240,687

2.2 CAPACITORS

2.2.8 PLASTIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Plastic				
<u>Bendix Corp., Cincinnati Div.</u>				
3000pf+10%, 600vdc Experimental, Modified Polystyrene Dielectric (6 ea)	2.2(9)	5.6(14) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
<u>Plastic Capacitors Corp.</u>				
0.01mf+10% Cellulose Acetate Dielectric, OC6-103 (6 ea)	2.4(10)	1.3(15)ne	Capacitance(-8%) 6 Failed - Shorted	2p 327
0.02mf, Teflon Dielectric, TG75-202 (6 ea)	3.1(10)	9.6(14)ne	Capacitance(+14%)	2p 332
1mf, OC6-105 (6 ea)	9.1(10)	2.4(15)ne	Capacitance(+11%) 5 failed	5p 71
<u>Hopkins Engineering Co.</u>				
0.1 mf @ 100 vdc ± 1% Polystyrene dielectric P11PF	1.9(10)	1.5(15) (E>2.9Mev)	Leakage R (-96.9%) @ 5.2(8)ergs/gm-(C)	12 p 192
"	7.6(9)	3.8(15) (E>1 Mev)	Leakage R (-87.5%) @ 1.1(7)ergs/gm-(C)	12 p 198

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Capacitors, Plastics				
<u>Sprague Products Co.</u>				
0.3mf, 1000vdc Polyester dielectric in dry metal can Type 65213 (4 ea)		1.1(17) (E>0.5Mev)	Capacitance(-10%) 1 failed	35p 10.39-43
0.3mf, 1000vdc Polyester dielectric with oil-filled can Type 65214 (5 ea)		1.1(17) (E>0.5Mev)	Capacitance(-10%) 3 failed	35p 10.39-43
<u>Western Electric Co.</u>				
0.04mf Polystyrene dielectric (4 ea)	5.7(10)	2.4(17)nf	Capacitance(+8%) @ 6(16)nf, 1 failure	15p 17,18

2.3

COAXIAL CABLES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Coaxial Cables	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Amphenol-Borg Electronics Corp.</u>				
RG-29/U Polyethylene (Amphenol #21-018) Z = 53.5 ohms	1.3(9)	2.2(14) (E>0.5Mev)	Z (/ 9.7%) Leakage R increased by factor 100	35 p 10.90
RG 59/U Polyfoam Equivalent (Amphenol #621-715) Z 73 ohms	1.3(9)	2.4(14) (E>0.5Mev)	Z (/ 31%) Leakage R fairly constant	35 p. 10.90
<u>Andrews Corp.</u>				
Air Dielectric Type with "Refrasil" insulator, 43 ohms 3/8" diameter (50ft)	~1(11)		Insulation R decrease factor ~100 VSWR 1.15: 1.26 unable to maintain air pressure in cable due to silicone grease leak	4 p 8-15
<u>Prodelin, Inc.</u>				
RG-260/U 50 ohm "Spir-O-Line" (3ea)	7 (10)	6.1(16) (E>0.3Mev)	Attenuation(/13%) at 4.1(16)nf, Z 2 ohms	31 p 173-189
<u>Raychem Corp.</u>				
RG-8/U Equivalent Polyolefin (09-008R)	2.5(11)	1.9(17) (E>1 Mev)	Z(/7%) at 2(10)e/g-c Attenuation(/8.3%)at 2.5(10) e/g-c	30 p. 111-122
RG-9/U Equivalent 50 ohms, Raylin R(3ea)	7(10)	6.1(16) (E>0.3Mev)	Attenuation(/11%) at 4.8(16)nf Z /- 2 ohms	31 p. 173-189

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Coaxial Cables</u>				
<u>Rockbestos Products</u>				
Aircraft Cable, Hi-Temp, Fire Resistant, Ni Clad Cu Wire, Inorganic Barrier, Impregnated Teflon Jacket & Glass Braid	3.7(10)	1.9(15) ne	Insulation R decreased by order ~ 100	60 p42, 36, 46, 61
<u>Thomas A. Edison Industries</u>				
Solid Dielectric Type Silica Dielectric, 50 ohms, 0.170" diameter (48 ft)	$\sim 1(11)$		Insulation R decreased by order ~ 100 VSWR 1.05:1.11	4 p8-15
<u>Times Wire and Cable</u>				
RG-8A/u Standard Mil-C-17 (3 ea)	2.7(11)	1.9(17) $\cdot$ ($E > 1 \text{ Mev}$)	Z (+10%) @ 5(8) ergs/g- (C) attenuation ($\pm 4.76\%$)	30 p111-122
<u>Miscellaneous</u>				
RG-225/u Teflon (60 ft.)	2(9)	1(16) ($E > 0.1 \text{ Mev}$)	VSWR 1.09:1 Teflon cracked & soft	10 p24

CONNECTORS, ELECTRICAL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Connectors, Electrical				
<u>Amphenol-Borg Electronics Corp.</u>				
AN-3102A-12S-3P & S (1ea)	2.4(8)		Leakage I increased by factor $\sim 10^4$	14 p 11
26-4100-32P 32 contacts (1ea)	2.2(10)	1.6(14)ne	R between pins increased by factor $\sim 10^5$	5 p 129
<u>Bendix Corp.</u>				
AN Hi-Temp Type (Scintilla Div) Mil-C-5015-C, Series K, 20 Amp, 700vdc or 500vac, Glass-Bonded Mica and Silicone Rubber (6ea)	1.4(9)	2.5(14) ($E > 0.5\text{Mev}$)	Leakage R decreased by factor > 10 , not rec. for nuc. environments	35 p 10.100
PTO6CE-8-4S (Bendix Special Blend rubber insert) (1 ea)	1.3(9)	8.7(11)nf 1(12)nt	Insert swelled and Turned gray. Good condition.	8 p 113-120
PTO0SE-12-10P and PTO6SE-12-10S (Neoprene Inserts) (3ea)	1(9)	5.1(15) ($E > 0.1\text{Mev}$)	Pin/Pin R decreased by order $\sim 10^3$	10 p 141
PT 1H-1210P (hermetic Seal)(2ea)	1(9)	5.1(15) ($E > 0.1\text{Mev}$)	Pin/Pin R decreased by order $\sim 10^4$	10 p 141

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Connectors, Electrical				
<u>Cannon Electric Co.</u>				
CAOZHR-14S-55 & 5P (1 ea)	2.4(8)		Leakage I increased factor $\sim 10^4$	14 p 11
CAO2HR-20(2006-44)P 14 pins, ceramic in- serts	1.2(9)	1.8(15) (E>0.5Mev)	Insulation R decreased factor ~ 100 , No other damage	35 p 10.105
CAO6HR-20(2006-44)S 14 pins, ceramic in- serts	1.2(9)	1.8(15) (E>0.5Mev)	Insulation R de- creased factor ~ 100 , no other failure	35 p 10.105
DA-15S & 15P-(C-7) (1 ea)	2.4(8)		Leakage I increased by factor $\sim 10^4$	14 p 11
HR Type (4ea)	6.2(9)	2.2(16)nf (E>0.5Mev)	Contact R increased factor ~ 10 All Survived	4 p 54
"	4.4(9)	2.2(14)nf	Contact R Changes from 7.8(-4) $\rightarrow$ 63(-4), No change in insulation R	72 p 78
"	3.8(10)	1.03(16)nf	Contact R Changes from 6.3(-4) 1000(-4), No change in insulation R	72 p 78

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Deutsch Co.</u>				
262DTK00-12-10P and 262DTK06-12-10S (Silicone Rubber and diallyl phthalate Inserts) (lea)	1(9)	5.1(15) (E>0.1Mev)	Pin/Pin R decreased factor ~100	10 p 140
Deutsch with silicone rubber inserts	7.2(10)	4.8(16) (E>1Mev)	Leakage R (-91.6%) at 1.45(16)nf	12 p 229
<u>Seal Corp.</u>				
Hermetic glass type	7.5(10)	4.8(16) (E>1Mev)	Leakage R(-92.7%) at 1.8(16)nf	12 p 231
<u>Titeflex, Inc.</u>				
H06-7-50S-9 Type with: RTV-90potting with: PRL201-Q " with: Teflon(TFE)"	1.3(9)	8.7(11)nf 1(12)nt	Good condition " " Soft but o.k. (Not Rec. for use in Nuc. Environment)	8 p 117

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Winchester Electronic Inc.				
Winchester connectors with the following inserts: Diallyl phthalate	7.5(10)	4.8(16) ($E > 1\text{Mev}$)	Leakage R(-90.9%) at 2.7(16)nf	12 p 233
: Melamine Formaldehyde	"	"	Leakage R (-92.5%) at 1.8(16)nf	12 p 232
: Phenolic Formaldehyde	"	"	Leakage R(-99.2%) at 1.5(16)nf	12 p 229

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Cores, Computer	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Engineered Magnetics Corp.				
EM # W30-2-1207 Mag. Metals 2A-8602 Wire: 40 HF Potting: Hysol 6620 Cup: 22042-1A (2 ea)	6.7(8)	4.8(15) (E>0.1MEV)	V _S (7.8%) at 1.4(14) nf, I _S (48%) at 3.3(13)nf	10 p. 23, 163
EM #W29-2-1207 Arnold Eng. 6T534052 Wire: 40 HF Potting: Hysol 6620 Cup: 22042-1A (2 ea)	6.7(8)	4.8(15) (E>0.1MEV)	V _S (7.5%) and I _S (55.5 %) at 3.3 (13) nf	10 p. 23, 163
EM #W 32-2-1207 Mag. Metals 75A-4602 Wire: 27HF Insul: HL 1/2 Mil Mylar (2 ea)	6.7 (8)	4.8 (15) (E>0.1MEV)	V _S (5%) at 1.4(14), I _S (-52.3%) at 2.8 (12) nf	10 p. 23, 163
EM #W31-2-1207 Arnold Eng. 2T5772R4 Wire: 25 HF Insul: HL 1/2 MIL Mylar (2 ea)	6.7(8)	4.8 (15) (E>0.1MEV)	V _S (-3.15% and I _S (104%) at 4 (12)nf	10 p. 23, 163

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Crystals</u>				
<u>CR-16/U</u>				
120Kc "DT" Cut Quartz in HC-5/U Holder	3.6(10)	5.7(13)nf		2 p769, 660
James Knights Co. (2 ea)			Parallel Resonant Freq. (-94.1 ppm)@2.5(13)nf Ser. Resonant Freq. (-128.3ppm)@1.2(12)nf	
Midland Manufacturing " Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. (+140ppm)@4.9(13)nf Series Resonant Freq. (failed)	"
Wright Electronics Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) Series Res- onant Freq.(-538.3ppm) @ 1.2(12)nf	"
<u>CR-(XM-17)/U</u>				
17Mc Gold Plated Glass Holder (5 ea)	8.8(9)		Freq.(- 0.880Kc)	27 p4-15, A-8
" (5 ea)		3.6(12) p/cm ²	Freq.(- 0.087Kc)	27 pA-10

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Crystals				
<u>CR-18/U</u>				
5275Kc $\pm 0.0005\%$, (12 ea) Scientific Radio Products, Inc.	2.7(9)	7.4(13) ($> 2.9\text{Mev}$)	Resonance Frequency (50 ppm)	22 p3,59
4Mc Anti-resonant Alum. plated, metal holder Y-Bar synthetic quartz (5 ea)		3.6(12) p/cm ²	Freq. (- 0.042Kc)	27 p15,A-2
13.025Mc, Unpolished Finish, Compression Base Scientific Radio Products Inc. (3 ea)	3.8(10)	2.9(14)nf	Frequency (-1355ppm)	35 pA-73-77
17Mc Alum. Plated Anti-resonant, Metal Holder (5 ea)	8.8(9)		Freq. (- 0.875Kc) @ 6.5(7)ergs/gm-(C)	27 p4-15, A-5
" (5 ea)		3.6(12) p/cm ²	Freq. (- 0.080Kc)	27 pA-6
<u>CR-19/U</u>				
1Mc "AT" Cut HC-6/U Holder James Knights Co. (3 ea)	1.7(10)	2.1(13)nf	Parallel Resonant Freq. (+46.5ppm) @ 2.3(12)nf, Series Resonant Freq. failed @ 1(13)nf	2 p666, 769

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
CR-19/U (Cont.)				
Midland Mfg. Co., Inc. (2 ea)	1.7(10)	2.1(13)nf	Parallel Resonant Freq. (-343.2ppm), Series Resonant Freq.(failed) @ 1(13)nf	2 p666, 769
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 9.4(12)nf Series Resonant Freq. (-1134.4ppm)	
Wright Electronics, Inc., (2 ea)	"	"	Parallel Resonant Freq. (+19.5ppm) @ 5.2(12)nf Series Resonant Freq. (-2217 ppm)	
12Mc "AT" Cut Quartz HC-6/U Holder	3.5(10)	2.1(15)ne		2 p672, 769
Midland Manufacturing Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. - failed @ 2.3(14)nf Series Resonant Freq. - failed @ 2.3(14)nf	
Scientific Radio Products Inc.(2 ea)	"	"	Parallel Resonant Freq. (-4925ppm), Series Resonant Freq.(-3971ppm)	
Sherold Crystals, Inc. (2 ea)	"	"	Parallel & Series Resonant Freq. - failed @ 3.3(14)nf	
Wright Electronics (2 ea)	"	"	Failed @ 3.5(14)nf	
20Mc "AT" Cut Quartz HC-6/U Holder	1.8(10)	1(15)ne		2 p769, 680-689
Wright Electronics (2 ea)	"	"	Parallel Resonant Freq. (failed @ 7.9(14)ne) Series Resonant Freq. (failed @ 7.5(14)ne)	

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>CR-23/U</u>				
29.3 Mc, "AT" Cut Quartz				
Midland Mfg. Co. Inc. (3 ea)	2.3(10)	1.8(16) ($E > 0.3 \text{ Mev}$)	Freq. (+60ppm)	31 pl4-48
40Mc, AL. plated Crystals				
Midland Mfg. Co. Inc. (2 ea)	3.2(10)	1.4(15)ne	Freq. (-44.4ppm)	35 pA-94
Scientific Radio Products. Inc. with following: (1) Au Electrodes, polished Quartz, metal holder with compression base (2 ea)	3.1(10)	2(15)ne	Freq. (-1120 cps) @ 1.6(18) ergs/gm-(C)	35 pA-19-24
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (+2863 cps)	"
(2) Same as (1) except standard base (2 ea)	"	"	Freq. (-2743 cps) @ 6.7(14)ne	35 pA-25-30
" (2 ea)	3.1(10)	2(15)ne	Freq. (+2216 cps) @ 5.7(9) ergs/gm-(C)	"
(3) Same as (1) except unpolished (2 ea)	"	"	Freq. (-2861 cps) @ 4.8(18) ergs/gm-(C)	35 pA-31-35
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (+5773 cps) @ 2.1(16)ne	"
(4) Same as (3) except standard base (2 ea)	"	"	Freq. (-625 cps) @ 9.4(14)ne	35 pA-36-40
" (2 ea)	3.1(10)	2(15)ne	Freq. (+1579 cps) @ 6(9) ergs/gm-(C)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>CR-23/U 40Mc (Cont.)</u>				
Scientific Radio Products, Inc. (Cont.)				
(5) Au Electrodes, unpolished quartz plate, all-glass holder, T6 $\frac{1}{2}$ (2 ea)	3.1(10)	2(15)ne	Freq. (-1799 cps) @ 1.6(8) ergs/gm-(C)	35 pA-41-45
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-674 cps) @ 1.4(15)ne	"
(6) Al Electrodes, polished quartz plate, metal holder with compression base (2 ea)	1.9(10)	2.4(16)ne	Freq. (-971 cps) @ 9.4(14)ne	35 pA-46-50
" (2 ea)	3.1(10)	2(15)ne	Freq. (-1268 cps) @ 1.8(8) ergs/gm-(C)	"
(7) Same as (6) except standard base (2 ea)	"	"	Freq. (-614 cps) @ 1.8(18) ergs/gm-(C)	35 pA-51-55
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-934 cps) @ 1.1(16)ne	"
(8) Same as (6) except unpolished plate (2 ea)	"	"	Freq. (+1259 cps) @ 2.1(16)ne	35 pA-56-60
" (2 ea)	3.1(10)	2(15)ne	Freq. (-1670 cps) @ 1.8(8) ergs/gm-(C)	"
(9) AL Electrodes, unpolished plate, metal holder with standard base (HC-6/U) (2 ea)	"	"	Freq. (+1137 cps) @ 6.4(9) ergs/gm-(C)	35 pA-61-65
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-1228 cps) @ 1.1(15)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>CR-23/U 40Mc (Cont.)</u>				
Scientific Radio Products, Inc. (Cont.)				
(10) Same as (9) except all-glass holder T6 $\frac{1}{2}$ (2 ea)	"	"	Freq. (+1215 cps)	35 pA-66-70
" (2 ea)	3.1(10)	2(15)ne	Freq. (-814 cps) @ 1.8(8) ergs/gm-(C)	"
45Mc, Al plated Crystals				
Midland Mfg. Co. Inc. (2 ea)	3.2(10)	1.4(15)ne	Freq. (-25.2ppm)	35 pA-94
<u>M-23</u>				
14.27 Mc, Ag plated Crystal, metal holder				
McCoy Electronics Co. (2 ea)	3.2(10)	1.4(15)ne	Failed to oscillate, One open - circuited	35 pA-91

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-24/U</u> 25 Mc ± 50 ppm, "AT" Cut Quartz in HC-10/U Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.4(10)	2.1(15)ne 5.4(13)nf	Parallel Resonant Freq. (failed) @ 1.2(15)ne, Series Resonant Freq. (-21.4 ppm) @ 1.9(13)ne	2 p769, 690- 697
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (+35.4 ppm), Series Resonant Freq. (-42.8 ppm) @ 1.9(13)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Series and Parallel Freq.'s (failed) @ 1.2(15)ne	"
<u>CR-25/U</u> 300Kc ± 100 ppm, Metal plated, "DT" Cut Quartz in HC-6/U metal holder				
Midland Mfg. Co., Inc., (2 ea)	1.7(10)	6.1(14)ne 2.1(13)nf	Parallel Resonant Freq. (+688.3 ppm), Series Resonant Freq. (+388.3 ppm)	2 p769, 698-707
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (+117.3 ppm), Series Resonant Freq. (+122 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
CR-25/U (Cont.) 300Kc(Cont.) Wright Electronics, Inc. (2 ea)	1.7(10)	6.1(14) 2.1(13)	Parallel Resonant Freq. failed @ 1.3 (14)ne, Series failed on insertion	2 p769, 698- 707
CR-27/U 833.33 Kc ± 30 ppm Scientific Radio Products, Inc. (12 ea)	2.7(9)	7.4(13) (E>2.9Mev)	Frequency (18 ppm)	22 p3, 59
3400 Kc ± 30 ppm Scientific Radio Products, Inc. (12 ea)	"	"	Frequency (21 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-32/U</u> 56.99Mc ± 34 ppm Scientific Radio Products, Inc. (12 ea)	2.7(9)	7.4(13) ($E > 2.9 \text{ Mev}$)	Frequency (33 ppm)	22 p3, 59
<u>CR-38/U</u> 60Kc ± 120 ppm, Metal plated, "NT" Cut Quartz, HC-13/U Metal holder James Knights Co. (2 ea)	3.4(10)	2.1(15)ne 5.4(13)nf	Parallel Resonant Freq. (-83.3 ppm) @ 3.5(14)ne, Series Resonant Freq. (-121.6 ppm)	2 p769, 703- 707
Midland Mfg. Co., Inc., (2 ea)	"	"	Parallel Resonant Freq. (Failed) @ 1.5(15)ne, Series Resonant Freq. (-341.6 ppm)	"
Wright Electronics, Inc. , (2 ea)	"	"	Parallel Resonant Freq. (Failed) @ 1.5(15)ne, Series Resonant Frequency (Failed) @ 3.9(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-39/U</u> 200 Kc, "GT" Cut Quartz (unpolished), Vacuum Tube Type Holder Bliley Electric Co. (3 ea)	2(10)	1.5(16) (E>0.3Mev)	Frequency (-115ppm)	31 pl4-48
250Kc ± 30 ppm @ 25°C Metal plated "GT" Cut Quartz, Vacuum Tube Type Holder James Knights Co. (4 ea)	2.7(10)	9.5(14)ne 3.3(13)nf	Parallel Resonant Freq. (-68 ppm) @ 1.4(14)ne, Series Resonant Freq. (-103.6 ppm) @ 1.8(14)ne	2 p769, 708-714
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-168.4 ppm) @ 1.8(14)ne, Series Resonant Freq. (-126.8 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-47/U</u> 300 Kc, Fund. Freq. Gold Plating, Metal Holder Antiresonant (4 ea) " (5 ea)	8.8(9)	3.6(12) p/cm ²	Frequency (-29 cps) Frequency (+3 cps)	27 p4-15, A-24 27 p4-15, A-26
<u>CR-51/U</u> 13.025, Al Electrodes, Standard HC-6/U, glass base, unpolished Scientific Radio Products, Inc. (3 ea)	3.5(10)	2.2(15)ne	Frequency (-456ppm) @ 1.3(13)ne	35 pA-78-84
<u>CR-52/U</u> 15 Mc ± 50 ppm, Metal plated "AT" Quartz, HC-6/U, Metal Holder Midland Mfg. Co., Inc. (2 ea)	3.9(10)	2.4(15)ne	Parallel Resonant Freq. (failed) @ 3.1(14)ne	2 p770, 715-723

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-52/U (Cont.)</u>				
15Mc (Cont.)				
Scientific Radio Products, Inc.	3.9(10)	2.4(15)ne	Parallel Resonant Freq. (-1664 ppm), Series Resonant Freq. (-262 ppm) @ 1.1(15)ne	2 p770,715- 723
Sherold Crystals, Inc. (2 ea)	"	"	Series & Parallel Freq. (failed) @ 2.1(14)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2042 ppm), Series Resonant (Circuit Malfunctioned)	"
18Mc, Au plated, Series Resonant, Metal Holder (5 ea)	8.8(9)		Frequency (-1006cps)	27 p4-15, A-17
" (5 ea)		3.6(12) p/cm ²	Frequency (-114 cps)	27 p4-15, A-19
19.5Mc, Al Electrodes, Unpolished, Compression bases				
Scientific Radio Products, Inc. (3 ea)	3.8(10)	2.4(15)ne	Freq. (-418 cps) @ 2.7(14)ne	35 pA-85- 89

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Crystals</u>				
<u>CR-52/U (Cont.)</u>				
50Mc ± 50 ppm, Metal plated "AT" Cut Quartz in HC-6/U Metal Holder				
Midland Mfg. Co. Inc. (2 ea)	1.8(10)	1(15)ne	Series & Parallel Resonant Freq.(failed) @ 6.7(14)ne	2 p770, 724-734
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-1392ppm), Series Resonant Freq. (-1988ppm)	"
Sherold Crystals Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 9.8(14)ne, Series Resonant Freq. (-2173ppm)	"
Wright Electronics Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2580ppm), Series Resonant Freq. (-1669ppm)	"
<u>CR-53/U</u>				
70Mc, "AT" Cut Quartz Au plated, polished with Metal Compression Base				
Midland Mfg. Co. Inc. (3 ea)	2.1(10)	1.8(16) ($>0.3\text{Mev}$)	Frequency (+76ppm) One failed @ 1.2(16)nf	31 pl4-48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-54/U</u>				
60 Mc $\pm 50\text{ppm}$, Metal Plated "AT" Cut Quartz HC-6/U Metal Holder				
James Knights Co. (2ea)	3.5(10)	2.1(15)ne	Parallel Resonant Freq. (-26ppm) @ 2.7(13)ne, Series Resonant Freq. (-29ppm)@1.5(15)ne	2 p770,735- 745
Midland Mfg. Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. (-26ppm) @ 4.7(12)ne, Series Resonant Freq. (-50ppm) @ 1.5(15)ne	"
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 1.5(15)ne, Series Resonant Freq. (-442ppm) @ 1.2(15)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-4362ppm), Series Resonant Freq. (failed) @ 1.3(15)ne	"
75Mc $\pm 50\text{ppm}$, Metal Plated, "AT" Cut Quartz, HC-6/U Metal Holder				
Midland Mfg. Co. Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-110.5ppm), Series Resonant Freq. (+46.1ppm) @ 3.7(13)ne	2 p770,746- 752

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
CR-54U (Cont.)				
75Mc (Cont.)				
Scientific Radio Products, Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-1141.3ppm) @ 1(15)ne, Series Res. Freq. (-930.3ppm) @ 8.5(14)ne	2 p770,746- 752
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2750.6ppm), Series Resonant Freq. (-2362.7ppm)	"
Wright Electronics, Inc.	"	"	Parallel Resonant Freq. (-2605.6ppm), Series Resonant Freq. (-3533.3ppm)	"
85Mc, Al Plating, Series Resonant, Metal Holder (5 ea)	8.8(9)		Frequency (+8768cps)	27 p4-15, A-20
" (5 ea)		3.6(12) p/cm ²	Frequency (-466cps)	27 p4-15, A-23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR-55/U</u> 40Mc $\pm 50\text{ppm}$, Metal Plated, "AT" Cut Quartz HC-18/U Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.1(10)	1.1(15)ne 3.6(13)nf	Series & Parallel Freq. (failed) @ 5.6(14)ne	2 p770, 753- 758
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel & Series Resonant Freq. (failed) @ 5.6(14)ne	"
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-641.8ppm), Series Resonant Freq. (failed)	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 5.6(14)ne, Series Resonant Freq. (failed) @ 8.2(14)ne	"
<u>CR-56U</u> 70Mc $\pm 50\text{ppm}$, Metal Plated, "AT" Cut Quartz HC-18/U Subminiature Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-27.9ppm) @ 2(12)ne Series Resonant Freq. (-10.5ppm) @ 2(12)ne	2 p760- 770

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CR56/U (Cont.)</u>				
70 Mc (Continued)				
Scientific Radio Products. Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-2481ppm), Series Resonant Freq. (failed) @ 1(15)ne	2 p760-770
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 4.2(14)ne, Series Resonant Freq.(failed) @ 5.8(14)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 8.7(14)ne, Series Resonant Freq.(failed) @ 1.8(15)ne	"
<u>CR-74/U</u>				
47.5Mc, Ag Plated, Glass Holder				
McCoy Electronics Co. (2 ea)	3.2(10)	1.4(15)ne	Frequency (-29.8ppm)	35 pA-91
62.5Mc, Ag Plated, Glass Holder				
McCoy Electronics Co. (2 ea)	"	"	Frequency (-30.4ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Delay Lines	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Corning Glass Works</u>				
100 μ sec Pb-Potash Glass Delay Piezoelectric Ceramic Transducers, Type 852798 S/N 32001 Corning Series C-Z (1 each)	7.6(10)	5.7(16) (E>.3 Mev)	No effect from radiation observed at the time of instrumentation failure @ 1.5(16) nf and 2(10) ergs/gm-(c)	31 p 239-263
<u>General Electric Co.</u>				
2 μ sec Transmission Media is Ni Span C, magneto - strictive Type - Alnico V & Ni Alloy Experimental (1 each)	2.1(11)	6.8(16) (E>1 Mev)	Output - 95% @ 3.16(16) nf (failed)	30 p 157-162
170 μ sec Same composition as 2 μ sec delay Line Experimental (1 each)	5.8(10)	5(16) (E>.3 Mev)	No change in delay time. Output signal begins to degrade @ 5.3(15) nf & 6(8) ergs/gm-(c)	31 p 239-263
298 μ Sec Transmission wire is Ni Span C, Ceramic Transducer is PZT Type, Experimental (1 each)	5.8(10)	5(16) (E>.3 Mev)	No change in delay time. Output (-50%) @ 2.5(15) nf & 3.3(9) ergs/gm-(c)	31 p 239-263

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Delay Lines	DESIGN ALLOWABLES		LASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
NYT Electronics, Inc. 1.0 $\pm 5\%$ μ sec Z = 1K $\pm 10\%$, 500 vdc Attenuation (25% Max) Rise Time = 0.15 μ sec Max., Mil-C-15305A, Grade 1, Class B (6 each)		5.3(16) ($E > .5$ Mev)	Delay time average (-2.3 %). Rec. for use in Nuclear Environment	35 p 10.137

DIELECTRIC MATERIALS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Dielectric Materials</u>				
<u>EI Dupont De Nemours & Co.</u>				
Mylar Sheet, Type "C" Polyester	1(10)		No effect noted	70 p30
Orlon	1(10)		Thickness (+140%), Tensile Strength (-60%), Torque Tear (-91.5%)	70 p35
<u>Electrical Industries, Inc.</u>				
Compression glass end seals	1(10)		No effects noted	70 p29-30
<u>Hooker Chemical Corp</u>				
FS-5 (Trifluorovinyl chloride polymer)	1(10)		0.235 cc gas formed per cc of material	70 p 23, 28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Minnesota Mining & Mfg Co.</u>				
FC-43 (Perfluoro-Tri-butyl-amine)	1(10)		0.18 cc gas formed per cc of material	70 p23,28
<u>Wiemand Industries</u>				
Kraft Paper Insulators	1(10)		Paper becomes brittle and cracks on handling	70 p30
<u>Republic Foil Co.</u>				
Aluminum Foil	1(10)		No effects noted	70 p30
<u>Stevens Paper Mill</u>				
Kraft Dielectric Tissue	1(10)		Tissue becomes brittle and cracked	70 p30

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Dielectric Materials				
<u>Miscellaneous</u>				
Bis (Phenoxyphenyl) Ether	1(10)		0.003 cc gas formed per cc of material	70 p28
Chlorinated Biphenyl (Aroclor 1254 with added stablizer of the quinone type)	1(10)		0.0246 cc gas formed per cc of material	70 p28
Etherm "A" (Mineral oil, Sun XX with added stablizer of the quinone type)	1(10)		1.97 cc gas formed per cc of material	70 p28
Etherm "B" (Mixture of Polybutene (Ornite 32-X) and water-white mineral oil, stablizer of the quinone type)	1(10)		1.79 cc gas formed per cc of material	70 p28
Monoisopropylbiphenyl	1(10)		0.0917 cc gas formed per cc of material	70 p28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Corning Glass Works</u>				
Type 1723 Alumino Silicate(5ea)		5.8(18)nt	All enclosures o.k. but Gassy	49 p.8, 11
" (5 ea)		9.2(16)nt	Badly discolored Questionable Reduction in stress	49 p.8, 12
Type 7052 No leads (5 ea)		3.6(18)nt	Some enclosures leaky, all gassy	49 p.6, 11
Types 7056 Enclosure with kovar leads (5 ea)		7.5(17)nt	All enclosures o.k. but gassy	49 p.11
Type 7720 Nonex under vacuum (2ea)		2.1(17)nt	Both cracked	49 p.11
" in air (2ea)		7.5(17)nt	1 cracked	49 p.11
" with Ni-W-Ni leads (5 ea)		5.8(18)nt	Some leakers all gassy	49 p.11

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Kimble Glass Co., Sub.				
<u>Owens-Illinois Glass Co.</u>				
Type 51-26 Boron-Free (5ea)		9.2(16)nt	Slight discoloration, Questionable Re- duction in stress	49 p. 11
" Enclosures with Moly leads (5ea)		5.8(18)nt	All enclosures o.k., no trace of gas	49 p. 8, 11
Type 57-529 5% B ₂ O ₃ (5 ea)		9.2(16)nt	Some discoloration, Questionable re- duction in stress	49 p. 8, 12
Type 58-20 3% B ₂ O ₃ (5ea)		9.2(16)nt	Some discoloration, Questionable re- duction in stress	49 p. 8, 12

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Inductors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Arnold Magnetics Corp.</u> Type 384-3000 3 hy, Toroidal (12ea)		4.3(16) (E>0.5Mev)	Induction (5%) DC Resistance (10%) No damage	35 p 10.139- 141
<u>Engineered Magnetics Corp.</u> Type G 357 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(-8.1%)	10 p 23, 162

INSULATION, ELECTRICAL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
<u>Dow Corning Corp.</u>				
DC-675 (Methyl Phenyl Polysiloxane Silicone Elastomer)	1.3(10)		Shore A Durometer Hardness(+54%) compression set (+90%)	69 p23,31
Silastic 80 (3 ea) Wire Insulation		4.1(16) (E>0.5Mev)	Insulation R (failed) Cracked and brittle	35 pl0.96-100
<u>General Aniline & Film Co.</u>				
Gafite (Methyl Alpha-Chloroacrylate)	3.2(8)		Luminous Transmittance (-66%)	57 pl0
"	1(9)		Tensile Strength = 20% of original	57 pl2
"	3(9)		Flexural Strength = 10% of original	57 pl3
"	1(10)		Heat Distortion Temperature (-15%)	57 pl4

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
General Electric Co.				
SE-361 (Methylvinyl Polysiloxane) Silicone Elastomer	1.3(10)		Shore A Durometer Hardness (+75%) Compression Set - (+334%)	69 p23, 31
SE-551 (Methylphenyl Polysiloxane) Silicone Elastomer	1.3(10)		Shore A Durometer Hardness (+100%) Compression Set - (+2400%)	69 p23, 31
SE-975 (Wire Insulation)		4.1(16) (E>0.5Mev)	Insulation Resistance (failed) cracked and brittle	35 pl0.96-100
XE-9003A (Wire Insulation)		4.1(16) (E>0.5Mev)	Insulation Resistance (failed) cracked and brittle	35 pl0.96-100
Kish Industries, Inc.				
358G (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	Large variation in volume resistivity	35 pl0.85-88
412M (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 pl0.85-88
420A (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 pl0.85-88

[illegible]

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
<u>Marblette Corp.</u>				
Maraset 622-E (Also used for potting)	1(11)	1.1(16) (E>0.5Mev)	Volume resistivity (+1900%), Dissipation factor (+1570%) Dielectric Constant (No change)	35 pl0.85-86
Marblette 3056 with Boron (Primarily used for neutron shielding)	1(11)	1.1(16) (E>0.5Mev)	Electrical characteristics failed @ 1.5(15)nf	35 pl0.85-86
<u>McDaniel Refractory Porcelain Corp.</u>				
AP 35 (Ceramic Alumina) in a boiling dissolver solution of 1M Nitric Acid with 75 g/l Stainless steel metal components. Material unaffected in this solution with no weight loss.	1(11)		Impact strength - (+39%), Compressive strength (+26%), Volume resistivity decreases by factor ~100	64 pl5
	1(12)		Impact strength - (+18.5%), Compressive strength (<1%)	64. pl5

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
<u>Insulation, Electrical</u>				
<u>Minnesota Mining & Mfg. Co.</u>				
Scotchcast 5 (also used for potting)	~1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 pl0.85-88
Scotchcast 212 (also used for potting)	~1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 pl0.85-88
<u>Mycalex</u>				
Supramica 555	1.2(10)		Material becomes brittle	33 p2,8
Mycalex Bobbin		2.2(14) (E>0.5Mev)	Warped	35 pl0.123
<u>Pennsalt Chemical Corp.</u>				
KYNAR (Polyvinylidene Fluoride Resin) in boiling dissolver solution of 1M nitric acid with 75 g/l stainless steel metal components. Resistant to this solution but undergoes slight weight gain	1(10) 1(11)		Impact strength - (-41.4%), Compressive strength - (+4.2%) Impact strength (-27%) Compressive strength (-37%), Volume Resistivity decreases by factor ~ 10 ³	64 pl5 "

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
<u>Phillips Petroleum Co.</u>				
MARLEX (Hi-density Polyethylene of Polyolefin Resin family) In boiling dissolver solution of 1M Nitric Acid with 75 g/l stainless steel metal components. Resistant to solution with no weight loss.	1(10) 1(11)		Impact strength (-4.3%), Compressive strength (<1%) Impact strength(-85%) Compressive strength (0.0%), Volume resistivity decreases by factor $\sim 10^5$	64 pl5 "
<u>Raychem Corp.</u>				
Modified Polyolefin	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition	8 pl18
<u>Rayclad Tubes, Inc.</u>				
Thermofit Tubing (Modified Polyolefin)	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition	8 pl18

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2}$	$\frac{n}{\text{cm}^2}$		
<u>Insulation, Electrical</u>	10 ¹⁰ -(C)			
<u>Rohm & Haas Co.</u>				
Flexiglas 55 (methyl Methacrylate)	5(8)		Luminous Transmittance (-33%)	57 pl0
	1(9)		Tensile strength(-10%)	"
	1(10)		Flexural strength = 10% of original, Heat distortion temperature (-20%)	"
<u>Sierracin Corp.</u>				
Sierracin 611 Polyester	1(10)		Luminous transmittance (-52%), Tensile strength (+20%), Flexural strength (+5%), Heat distortion temp. (-20%)	57 pl0
<u>Miscellaneous</u>				
Diallyl Phthetate (in Winchester Plug)	7.5(10)	4.8(16) (E>1Mev)	Leak R (-91%) @ 2.7(16) nf	12 p233
Fiberglass Impregnated with Teflon	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition but has temperature limited use.	8 pl18

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
<u>Miscellaneous (Cont.)</u>				
Fiberglass (Epoxy coated) Insulating Sheet	3.3(9)	8(15)ne	Tensile strength (-60%), Ultimate Elongation (-55%)	65 p10 Table IV
"	3.1(11)	9(17)ne	Electrical Breakdown V (-90%)	65 p10 Table II
Fiberglass (silicone varnished) Insulation Sheet	3.5(10)	8(16)ne	Tensile strength(-11%) Ultimate Elongation (-97%), Electrical Breakdown V (-7%)	65 p10 Table II Table IV
"	3.1(11)	9(17)ne	Electrical Breakdown V (-90%)	65 p10 Table II
Hermetic Glass in Seal Corp. Connector	7.5(10)	4.8(16) (E>1MEV)	Leak R (-93%) @ 1.8(16)nf	12 p231
Kraftpaper Insulating Sheet	3.3(9)	8(15)ne	Electrical Breakdown V (-17%)	65 p9 Table II
"	3.5(10)	8(16)ne	Electrical Breakdown V (failed), Tensile strength (-100%), Ultimate Elongation (-100%), All parameters failed at this dose	"
Melamine, GP Red 1077-RV22 Melma	1.3(10)		Material became brittle	33 p2, 8
Melamine Formaldehyde in Winchester Connectors	7.5(10)	4.8(16) (E>1Mev)	Leak R (-92.5%) @ 1.8(16)nf	12 p232
Mica (Reconstructed) Silicone Treated Insulating Sheet	3.3(9)	8(15)ne	Tensile strength (-80%), Ultimate Elongation (-80%)	65 p10 Table IV
"	3.1(11)	9(17)ne	No effect on electric breakdown voltage	65 p9 Table II

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
Miscellaneous (Cont.)				
Neoprene WRT 45.5% by weight Vulcanizate	1(9)		Compression Set (+38%)	46 p19
"	1(11)		Compression Set(+100%)	"
Phenolic, GP Black #7345 Resinox	1.3(10)		Material becomes brittle	33 p2, 8
Phenolic, GP Black ES 024 03	1.3(10)		Material becomes brittle	33 p2, 7
Phenolic Formaldehyde in Winchester Connectors	7.5(10)	4.8(16) (E>1Mev)	Leak R (-99.2%) @ 1.5(16)nf	12 p229
Polyester Enamel with Oil-modified Phenolic Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (-16%) @ 200°C	63 p7
Polyester Enamel (Modified) with Oil-modified Phenolic Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (+10%) @ 200°C	63 p7
Polyethylene Insulating Sheet	2.5(8)	6(14)ne	Tensile strength (no change), Ultimate Elongation (-24%)	65 p10 Table IV
"	3.5(10)	8(16)ne	Electrical breakdown V (-15%)	65 p9 Table II
"	3.1(11)	9(17)ne	Electrical breakdown V (failed)	"
Polyethylene Disks	1.3(10)		Volume (-0.018%)	13 p19
"	3.1(10)		Thickness 0.025" to 0.125", Diameter 1.33" to 0.55"	13 p22, 24
Polyethylene	1.6(9)		Viscosity increases by factor ~ 103, Shore A D. Hardness (+22.5%)	13 p29, 28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
Miscellaneous (Cont.)				
Polyethylene Terephthalate Insulating Sheet	3.5(10)	8(16)ne	Tensile strength(-52%) Ultimate elongation = 0% of original, Electrical breakdown V (-14%)	65 pl0 Table IV
"	3.1(11)	9(17)ne	Electrical breakdown V = 0% of original	65 p9 Table II
Polyfluoroethyl-Propylene (FEP Teflon) Insulation Sheet	2.5(8)	6(14)ne	Tensile strength(-60%) Ultimate Elongation (-65%)	65 pl0 Table IV
"	3.5(10)	8(16)ne	Electric Breakdown V (-94%)	65 p9 Table II
Polytetrafluoroethylene (TFE Teflon) Insulating Sheets	4.7(8)	4(14)ne	Tensile strength & Ultimate Elongation = 0% of original	65 pl0 Table IV
"	2.5(8)	6(14)ne	Electric breakdown V (-53%)	65 p9 Table II
"	3.3(9)	8(15)ne	Electric breakdown V = 0% of original	65 p9 Table II
Polytetrafluoroethylene (TFE Teflon) Wiring Insulation	1.3(9)	8.7(11)nf 1(12)nt	Brittle and powdery	8 pl17
Polytetrafluoroethylene (TFE) Tubing	4.7(18)	4(14)ne	Breakdown V (-53%)	65 p9 Table III
"	3.4(9)	4.5(15)ne	Breakdown V (failed)	"
Polytetrafluoroethylene Enamel with Silicone Varnish, Magnet Wire Insulation	2.5(9)		Zero thermal life	63 p7
Polyurethane-Fiberglass Insulating Tube	5(11)	5(17)ne	Tensile strength(-40%) Ultimate Elongation (-35%), Electric Breakdown V(-68%)	65 pl0 Table V

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Insulation, Electrical				
Miscellaneous (Cont.)				
Polyvinyl Chloride (PVC) 105°C Tubing	5(11)	5(17)ne	Tensile strength and Ultimate Elongation failed at this dose, Electric Breakdown V (-68%)	65 p10 Table V 65 p9 Table III
Polyvinyl Formal Enamel with no Varnish Magnet Wire Insulation	2.1(10)		Thermal life (-13%)	63 p7
Silicone Enamel with Silicone Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (-11%)	63 p7
Silicone Rubber in Deutsch Connector	7.2(10)	4.8(16) (E > 1Mev)	Leak R (-91.6%) @ 9.5(15)nf	12 p230
Silicone LS-53 (Fluorinated Methyl/Tri-Fluoropropyl) 76.9% by weight	1(9)		Compression Set (+77%)	46 p19
	1(11)		Compression Set (+108%)	"
Silicone Resin-Fiberglass, Insulating Tube	3.4(9)	4(15)ne	Tensile strength (-11%), Ultimate Elongation (-20%)	65 p10 Table V
"	5(11)	5(17)ne	Electric breakdown Voltage (no change)	65 p9 Table III
Viton A (Vinylidene Fluoride/Hexafluoropropylene Copolymer) 70% by weight	1(9)		Compression Set(+84%)	46 p19
	1(11)		Compression Set (+105%)	"
Silicone Rubber (Extruded) Tubing	3.4(9)	4(15)ne	Tensile strength (-26%), Ultimate Elongation (-62%)	65 p10 Table V
"	3.6(10)	4(16)ne	Electrical Breakdown V (-41%)	65 P9 Table III
"	5(11)	5(17)ne	Breakdown Voltage failed at this dose	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Laminates</u>				
<u>American Cyanamid Co.</u>				
AC-4232 (Polyester Resin-Glass Fabric)	9.3(9)	1.2(15) ($E > 2.9 \text{ Mev}$)	Modulus of Elasticity ($\pm 1.7\%$), Tensile strength ($\pm 4.2\%$)	25 p 8
AC-4232 (Polyester Resin-Asbestos Fabric)	9.3(9)	1.2(15) ($E > 2.9 \text{ Mev}$)	Modulus of Elasticity ($\pm 4.5\%$), Compression Strength ($\pm 3.9\%$)	25 p 8
<u>Coast Mfg. and Supply Co.</u>				
CTL-9LLD Laminate	8.3(11)		Tensile Strength (-43%), Compressive Strength ($\pm 57\%$) Flexural Rigidity ($\pm 10\%$)	56 p 19
DC-2106 Plastic Laminate	2.5(11)		Compressive Strength (-25%)	56 p 20
"	8.3(11)		Tensile Strength (-26%), Flexural Strength (-80%)	"
F 120-19 (Phenolic Resin- Asbestos Fabric)	9.3(9)	1.2(15) ($E > 2.9 \text{ Mev}$)	Tensile Strength (-4.7%)	25 p 8
F120-19 (Phenolic Resin- Glass Fabric)	9.3(9)	1.2(15) ($E > 2.9 \text{ Mev}$)	Tensile Strength ($\pm 28\%$), Compression Strength (-5.3%)	25 p 8
EPON 828CL Laminate	8.3(11)		Tensile Strength (-57%) Compressive Strength (-50%), Flexural Rigidity (-72%)	56 p 18
LAMINAC 4232 Laminate	8.3(11)		Tensile strength (-30%) Compressive strength (-54%), Flexural strength (-71%)	56 p 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Coast Manufacturing (cont.)</u>				
Electron 5003 Laminate	8.3(11)		Tensile strength (No change), compressive strength (-64%), Flexural rigidity (-71%)	56 p 17
<u>Cordo Moulding Pds.</u>				
Mobiloy AH-81 (Phenolic Resin-Asbestos Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile strength ($\neq$ 2.6%), Modulus of Elasticity (-7.7%)	25 p 8
Mobiloy AH-81 (Phenolic Resin-Glass Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength ($\neq$ 5%), Modulus of Elasticity (-5%)	25 p 8
<u>Insulation Mfrs. Corp.</u>				
G-7 Glass Fabric-silicone resin laminate, in boiling dissolver solution of 1 M nitric acid with 75 g/l of stainless steel metal. Resistant to this solution but suffers 10% weight loss	1(11)		Compressive strength (-29%)	64 p 15
	1(12)		Compressive strength (-72.2%)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Narmco Mfg. Co.</u>				
CONOLON 506 (Phenolic Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (-13.5%), Tensile Strength (/3.4%)	25 p 8
CONOLON 506 (Phenolic Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (-13.2%), Compression strength (/1.5%)	25 p 8
<u>Shell Development Co.</u>				
EPON 828 (Epoxy Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Compressive strength (/4.3%), Tensile Strength (-4%)	25 p 8
EPON 828 (Epoxy Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (/2.6%), Modulus of Elasticity (-2.5%)	25 p 8
EPON X-131 (Epoxy Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (/5%), Modulus of Elasticity (-2.1%)	25 p 8
EPON X-131 (Epoxy Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Compressive Strength (/8%), Tensile strength (/4.7%)	25 p 8

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Laminates				
<u>Shell, Con't.</u>				
X-131-Plastic Laminate with BF3400	8.3(11)		Tensile strength (-8.3%), Compression strength (-88%), Flexural strength (-75%)	56 p 21
X-131-Plastic laminate with dicyandiamide	8.3(11)		Tensile strength (-22%), Flexural strength (-51%)	56 p 22
<u>Taylor Corp.</u>				
G-7 Glass fabric-silicone resin laminate, In boiling dissolver solution of 1M Nitric acid with 75 g/l stainless steel metal components. Resistant to this solution but suffers 10% weight loss	1(10)		Impact strength (-27%), Compressive strength (-16%)	64 p 15
	1(11)		Impact strength (60%), Compressive strength (-29%), Volume resistivity decreases factor $\sim 10^8$	"
	1(12)		Impact strength decreases factor ~ 10	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Lubricants	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Hooker Chemical Co.</u>				
Fluorolube (Gyro Fluid)		$\sim 1(16)$ ($E > 2.9\text{Mev}$)	Outgassing (0.37 ML gas/ML fluid)	12 p225
<u>Shell Development Co.</u>				
Shell APL grease	2.7(9)	2.9(15) ($E > 2.9\text{Mev}$)	Grease apparently Crystallizes	31 p319
Type Hi Temp Jet Oil A, (Complex-ester base) (-45°F to 350°F) Ref. GTO-790	7.4(9)	5.8(14) ($E > 2.9\text{Mev}$)	5 change in neutrali- zation No (Mgm KOH/gm) Viscosity (+19%) Flash point (-24%)	44 p55-56
<u>Sinclair Refining Co.</u>				
Turbo S-Oil (L-697) Mil-C-7808C, Sebacate- base fluid, -65°F to 300°F	8.6(9)	5.1(14) ($E > 2.9\text{Mev}$)	12.5 change in neutral- ization No (Mgm KOH/gm) Viscosity (-31%) Flash Point (-23.2%)	44 p55-56

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Lubricants	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
<u>Sperry Gyroscope Co.</u>				
Bromotrifluoroethylene (Gyro fluid)		$\sim 1(16)$ ($E > 2.9 \text{ Mev}$)	Outgassing (1.6 ML gas/ML fluid)	12 p226
<u>Miscellaneous</u>				
Mil-L-9236A, Substituted-ester base	1(11)		Undergoes 90% decomposition @ 500°F	68 p94
Mil-L-9236B, Substituted-ester base, -65°F to 400°F, Ref. GTO-915 furnished by ASD	1.1(10)	6.3(14) ($E > 2.9 \text{ Mev}$)	7.2 change in neutralization No (Mgm KOH/gm), Viscosity (+19%), Flash Point (-24%)	44 p55-56
4P3E, Bis (Mix-phenoxyphenoxy) Benzene in Gear Test	1(11)		Viscosity changes from 65cs to 10,000cs	68 p74,87
Mixed-4P3E, Mix Bis (Phenoxyphenyl) Ether, 350°F, 3000 psi, Ref. GTO-927, hydraulic Fluid (also for lubrication use)	2.7(10)	3.9(15) ($E > 2.9 \text{ Mev}$)	Viscosity (cs) (+4.75%) +0.145 change in neutralization No. (Mgm KOH/gm), Filtration (particles $> 5 \mu$ (Mgm/100 ML)) +14.04, Boiling Range Broadened	50 p21-35
5P4E Mix-Bis (Phenoxyphenoxy) Benzene in gear test	1(11)		Viscosity changes from 400cs to 17000cs @ 600°F. Undergoes 40% decomposition @ 600°F and 50% @ 700°F. Acid No. changes from 0 to 12 (μ gm KOH/gm)	68 p68,79,86

2.14 MAGNETIC MATERIALS

2.14.1 FERRIMAGNETIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferrimagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Diamonite	3.7(9)		No effect on Dielectric	212 p 4-50
Ferramic Q "permalloy type"	1.1(10)	1(18)nf	Hysteresis Loop flattened considerably	42 Fig. 15
MF3876 Memory Core General Ceramics Corp.	7.7(9)	2(17)ne	Br/Bm % of initial Value ($\pm 1\%$)	15 p65
223MI - Mg, Mn, Fe RCA	1.6(11)	1.2(17) ($E > 1 \text{ Mev}$)	d Vz (+40%) @ 85°F and 4(14)nf	30 pl28-132
226MI - Mg, Mn, Fe, Zn, RCA	1.6(11)	1.2(17) ($E > 1 \text{ Mev}$)	d Vz (+50%) @ 85°F and 4(14)nf	30 pl28 - 132
231 MI - Mg, Mn, Fe, Zn, Cd, RCA	1.6(11)	1.2(17) ($E > 1 \text{ Mev}$)	d Vz (+20%) @ 85°F and 4(14)nf	30 pl28-132
Nickel Ferrite Ni Fe ₂ O ₄		3(18)nf	Hysteresis Loop flattened considerably	42 Fig. 15
NiZn and MnZn Western Electric	7.7(9)	2(17)ne	Loss of magnetic properties due to temperature heating. No radiation effects damage	15 p63
NXF 0023 - Mg, Mn, Fe, Li, RCA	1.6(11)	1.2(17) ($E > 1 \text{ Mev}$)	d Vz (+150%) @ 158°F and 3.5(15)nf	30 pl28-132
S-5 Memory Core General Ceramics Corp.	7.7(9)	2(17)ne	Br/Bm % of initial value (-7%)@1.2(17)ne	15 p65
Square-Loop Bell Tele. Labs (2 ea)	7.7(9)	2(17)ne	Br/Bm % of initial value (-12%)@1.2(17)ne	15 p65
T-1 (Square Loop Ferrite) fast switching, Telemeter Mag. Inc	1.1(10)	3(18)nf	Hysteresis Loop flattened slightly	42 Fig. 13
T-5 (Square Loop Ferrite) Slower Switching, Telemeter Mag. Inc	1.1(10)	3(18)nf	Hysteresis Loop flattened considerably	42 Fig. 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferrimagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot \text{C}}$	$\frac{n}{\text{cm}^2}$		
Yttrium Iron Garnet	3.7(9)		Linewidth (+10%) ϵ_{eff} factor does not change, Dielectric constant ($< < 1\%$)	212 p4-49
Yttrium Iron Garnet (polycrystalline)	1.1(10)	3(18)nf	Hysteresis Loop flattens considerably	42 Fig. 16
40% Yttrium Iron Garnet - 60% Gadolinium Iron Ferrite	3.7(9)		Linewidth ($< 1\%$) ϵ_{eff} factor does not change	212 p4-49
Yttrium Aluminum Garnet Ferrite	3.7(9)		Linewidth (-6%), ϵ_{eff} factor does not change Dielectric Constant ($< < 1\%$)	212 p4-49

2.14 MAGNETIC MATERIALS

2.14.2 FERROMAGNETIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetics	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Alfenol (Disordered) 16 Al, Bal. Fe		2(18)nt	60 cps Coercive force (0%), 60 cps Residual Induction (0%), Max. Permeability (-4%), Permeability @ 30 gauss (-4%), negligible effect on normal induction curve and hysteresis loop, no decrease in initial permeability	61 p19, 18, 52, 46
Alfenol (Oriented) 16 Al, Bal. Fe		2(18)nt	Max. permeability (+15%), Permeability @ 20 gauss (+34%), coercive force (-8%), Remanence (+8%), Induction @ 30 Oersteds (-5%), Squareness Ratio (+13%), Remanence @ 60 cps (-2%), Coercive force @ 60 cps (+8%), negligible effect on normal induction curve	61 p18, 19, 45
Carbonyl Iron E (Glass Binder) 98.5 Fe, Bal. C,N,O		2(18)nt	Eddy I loss coefficient (-40%), Core loss factor (+16.7%), Permeability (No change)	61 p20
Carbonyl Iron E (Plastic Binder) 98.5 Fe, Bal. C,N,O		2(18)nt	Permeability (no change) Eddy I loss coefficient (+25%), Core loss factor (-28.6%)	61 p20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetics	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Deltamax Arnold Eng. Corp.	7.7(9)	2(17)ne	Br/Bm % of initial value (-9%) @ 1.2 (17)ne	15 p65
Flakenol, Sendust Flake, 5.5 Al, 9.5 Si, Bal. Fe		2(18)nt	Permeability (+11.4 %), hysteresis loss coefficient (+10%), Eddy I loss coefficient (+500%), Residual loss coefficient (+88.9%), Core loss factor (+100%)	61 p20
2-81 Mo Permalloy, Pressed Powder, 2 Mo, 81 Ni, Bal. Fe		2(18)nt	Permeability (< 1%), Hysteresis loss coefficient (-33%), Eddy I loss coefficient (+100%), Residual loss coefficient (0%), Core loss factor (+100%)	61 p20
4-79 Mo Permalloy 4 Mo, 79 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-89%), Max. permeability (-79%) Coercive force (+403%), Coercive force @ 60 cps (+110%) Remanence (-44%) Remanence @ 60 cps (-51%), Induction @ 30 Oersteds (+1%), Squareness Ratio (-44%), Normal induction curve @ 0.2 oersteds (-60%), Initial permeability (-91%)	61 pl8, 19, 28, 52
4-79 Mo Permalloy Arnold Eng. Corp. (2 ea)	7.7(9)	2(17)ne	Br/Bm % of Initial Value (no change) Coercive force increased factor of 4	15 p69
4-79 Mo Permalloy Arnold Eng. Corp. (2ea)	7.7(9)	2(17)ne	Br/Bm % of initial value (-46%)	15 p65

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials Ferromagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Mumetal 5 Cu, 2 Cr, 77 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-65%), Max. permeability (-38%), Coercive force (+158%), Coercive force @ 60 cps (+35%), Remanence (-26%), Remanence @ 60 cps (-16%), Induction @ 30 Oersteds (-3%), Squareness Ratio (-23%), Initial permeability (-74%), Normal induction curve @ 0.2 Oersteds (+8.8%)	61 pl8, 19, 31, 52
Nickel Ferrite NiO · Fe ₂ O ₃		2(18)nt	Permeability (no change), hysteresis loss coefficient (-11%), Core loss factor (-44%)	61 p20
48 Nickel-Iron 48 Ni, Bal Fe		2(18)nt	Permeability @ 20 gauss (-70%), Max. permeability (-10%), Coercive force(+99%), Coercive force @ 60 cps (+35%), Remanence (-26%), Remanence @ 60 cps (-33%), Induction @ 40 Oersteds (-2%), Squareness ratio (-26%), Initial permeability(-75%), Normal induction curve @ 0.2 Oersteds (-36%)	61 pl8, 19, 34, 52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Orthonol, 50 Nickel-Iron, 50 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-31%), Max. permeability (+15%), Coercive force (-28%), Coercive force @ 60 cps (+44%), Remanence (-24%), Remanence @ 60 cps (-20%), Induction @ 30 oersteds (-4%), Squareness ratio (-21%), Initial permeability (-37%), Normal induction curve @ 0.2 oersteds (-7.9%)	61 pl8, 19, 35, 52
2 V Permendur, 2 V, 49 Co, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+3%), Max. permeability (+2%), Coercive force (-2%), Coercive force @ 60 cps (+5%), Remanence (-1%), Remanence @ 60 cps (-6%), Induction @ 30 oersteds (-1%), Squareness ratio (0%), Initial permeability (0%), Normal induction curve @ 0.2 oersteds (no effect)	61 pl8, 19, 48, 52
3-1 Silicon-Aluminum-Iron, 3 Si, 1 Al, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+1%), Max. permeability (+1%), Coercive force (-2%), Coercive force @ 60 cps (0%), Remanence (-1%), Remanence @ 60 cps (0%), Induction @ 30 oersteds (-1%), Squareness ratio (0%), Initial permeability (0%), No effect on normal induction curve or hysteresis loop	61 pl8, 19, 43, 44, 52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
3 Silicon-Iron (Oriented) 3 Si, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+18%), Max. permeability (+1%), Coercive force (-2%), Coercive force @ 60 cps (0%), Remanence (-3%), Remanence @ 60 cps (0%), Induction @ 30 oersteds (-1%), Squareness ratio (-1%), Initial permeability (0%), No effect on normal induction curve or hysteresis loop	61 pl8, 19, 41, 42, 52
3.5 Silicon-Iron 3.5 Si, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+8%), Max. permeability (-1%), Coercive force (+6%), Coercive force @ 60 cps (+9%), Remanence (+1%), Remanence @ 60 cps (+2%), Induction @ 30 oersteds (0%), Squareness ratio (+1%), No effect on normal induction curve	61 pl8, 19, 40
Superalloy 50 Mo, 79 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-93%), Max. permeability (-93%), Coercive force (+815%), Coercive force @ 60 cps (+1000%), Remanence (-38%), Remanence @ 60 cps (-46%), Induction @ 30 oersteds (-3%), Squareness ratio (-36%), Initial permeability (-98%)	61 pl8, 19, 52

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

2.14 MAGNETIC MATERIALS

2.14.3 PERMANENT MAGNETS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Alnico II		5(20) ($E > 0.025\text{ev}$)	4% decrease in open circuit induction	66 Fig. 1
"		1(20)ne	Change in open mag- netic circuit induc- tion: -2% @ 60°C -3% @ 235°C & 325°C	59 p77
"		2(18)ne	No change in demag- netization curve	59 p28
Alnico IIA		2(19)ne	Open magnetic circuit induction change: -5% @ 3(18)ne -2% @ 2(19)ne	59 pl9
Alnico V		5(20) ($E > 0.025\text{ev}$)	1 % decrease in open circuit induction	66 Fig. 1
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds) (-10%) B(K gauss)(+1.4%) @ 500°C	59 p25
"		1(20)ne	Open magnetic circuit induction change: -2.5% @ 60°C -1% @ 235°C +1% @ 325°C	59 pl7
Alnico VC		2(19)ne	Open magnetic circuit induction change: -9% @ 3(18)ne -3.5% @ 2(19)ne	59 pl9
Alnico XII		2(19)ne	Open magnetic circuit induction change: -1.5% @ 3(18)ne -2% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: -6.5% @ 60°C -4.5% @ 235°C -1.5% @ 325°C	59 pl7

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Alnico XII		2(18)ne	Demagnetization Curve intercepts change: H(oersteds)(-2.5%) B(Kguass)no change @ 500°C	59 p2
"		5(20) (E>0.025ev)	1% decrease in open circuit induction	66 Fig. 1
Barium Ferrite (Oriented)		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-2.5%) B(K gauss)(-2.6%)	59 p26
"		2(19)ne	Open magnetic circuit induction change: -3% @ 3(18)ne 8% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: -63% @ 60°C -24.5% @ 235°C -24% @ 325°C	59 pl7
"		5(20) (E>0.025ev)	24% decrease in open circuit induction	66 Fig. 1
Barium Ferrite (Unoriented)		2(19)ne	Open magnetic circuit induction change: -3% @ 3(18)ne -8% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: -54.5% @ 60°C -21% @ 235°C ~ 0 @ 325°C	59 pl7
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-9.2%) B(K gauss)(no change)	59 p26
"		5(20) (E>0.025ev)	24% decrease in open circuit induction	66 Fig. 1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
3 $\frac{1}{2}$ Chromium Steel		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-71.4%) B(K gauss)(-40%) @ 500°C	59 p27
"		1(20)ne	Open magnetic circuit induction change: +2.5% @ 60°C -68% @ 235°C -66.5% @ 325°C	59 pl7
"		2(19)ne	Open magnetic circuit induction change: -8% @ 2(18)ne -4.5% @ 2(19)ne	59 pl9
36 Cobalt Steel		2(19)ne	Open magnetic circuit induction change: -30.5% @ 3(18)ne -9% @ 2(19)ne	59 pl9
"		1(20)ne	Open Magnetic circuit induction change: -37% @ 60°C -37.5% @ 235°C -34.5% @ 325°C	59 pl7
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-62.5%) B(K gauss)(-36.3%) @ 500°C	59 p25
"		5(20) (E>0.025ev)	40% decrease in open circuit induction	66 Fig. 1
Cunico I		2(19)ne	Open magnetic circuit induction change: -5.5% @ 3(18)ne -1.5% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: -7.5% @ 60°C -4.5% @ 235°C -8.5% @ 325°C	59 pl7

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Cunico I		2(18)ne	Demagnetization Curve intercepts change: H(oersteds)(-8.75%) B(Kgauss)(-.5%) @ 500°C	59 p25
"		5(20) (E>0.025ev)	8% decrease in open circuit induction	66 Fig. 1
Cunife I		2(19)ne	Open magnetic circuit induction change: -45.5% @ 3(18)ne -1.5% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: +13% @ 60°C -52.5% @ 235°C -92% @ 325°C	59 pl7
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-3.8%) B(Kgauss)(-1.8%)	59 p25
"		5(20) (E>0.025ev)	97% decrease in open circuit induction	66 Fig. 1
ESD Fine Iron		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-5%) B(Kgauss)(-4.7%)@500°C	59 p27
"		2(19)ne	Open magnetic circuit induction change: -3.5% @ 3(18)ne -2% @ 2(19)ne	59 pl9
ESD Fine Iron Cobalt		3(18)ne	Open magnetic circuit induction change: (-6.5%)	59 pl9
"		2(18)ne	Demagnetization curve induction change: H(oersteds)(-25.7%) B(Kgauss)(-7.7%)	59 p28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Platinum Cobalt		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-2.7%) B(Kgauss)(-4%)@500°C	59 p26
"		5(20) (E>0.025ev)	67% decrease in open circuit induction	66 Fig. 1
"		2(19)ne	Open magnetic circuit induction change: (-12%)	59 pl7
"		1(20)ne	Open magnetic circuit induction change: -38% @ 235°C -40% @ 325°C	59 pl7
Silmanal		2(19)ne	Open magnetic circuit induction change: -10% @ 3(18)ne +5.5% @ 2(19)ne	59 pl9
"		1(20)ne	Open magnetic circuit induction change: -46.5% @ 60°C -72.5% @ 235°C -93.5% @ 325°C	59 pl7
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds) (-60%) B(Kgauss)(-50%) @ 500°C	59 p26
"		5(20) (E>0.025ev)	95% decrease in open circuit induction	66 Fig. 1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Motors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Diehl Manufacturing Co.</u>				
60 cps, 2-pole, 2-phase FPE216 Servomotor (1 ea)	1.5(11)	1.1(17) (E>1 Mev)	Failed @ 8.7(16) nf	30 p 152-157
<u>Electric Indicator Co., Inc.</u>				
Hysteresis Synchronous Motor, Class H insulation, 115 v @ 60cps with CAL Research #159 grease, Type AL4541 (1 ea)	6.6(10)		Much of the original power was lost	71 p 6, 13, 16
<u>Inland Motor Corp.</u>				
T2139C, DC Torquer Motor (1 ea)	1.6(10)	1.2(15) (E>2.9Mev)	Apparent Torquer Load (oz-inch) increases from zero to ~ 1	12 p 69
<u>Lear-Siegler, Inc.</u>				
D. C. Actuator Motor (1 ea)	2.7(9)	2.9(15) (E>0.3 Mev)	APL grease failed	31 p 276-319

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT O-Rings	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Alleghany Plastic</u>				
Teflon X	5(6)		Weight Change(-0.01%)	8 p 125
<u>Dupont Co.</u>				
Teflon Back-up Ring	1.3(9)		Brittle	47 p 80
<u>Linear, Inc.</u>				
Copolymer XP-9-13	5 (6)		Shore Durometer Hardness(-1%)	8 p 125
XWT-15T (Experimental Com- pound Viton A- Asbestos)	4.9(9)		Performance satisfactory	47 p 80
<u>Precision Rubber Products</u>				
Compound 1387 (Oil-Resistant)	1(11)		Hardness(~~4~~ 38%) Tensile (~~4~~ 110%) Elongation (-91%) Flat bend (Broke)	Technical Bulletin from PRP
Compound 4387 (Non-oil Resistant)	1(11)		Hardness (~~4~~ 41%) Elongation (-97%) Tensile (-20%) Flat bend (Broke)	"
Compound 1700 (Viton A)	4.9(9)		Failed-hardened and Leaked Tensile (-20%)	47 p 80

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
O-Rings				
<u>Miscellaneous</u>				
Acrylonitrile TDXE-121 #72 (2ea)	5 (6)		Weight ($\neq 1.08\%$) Shore Durometer hardness (-2%)	8 p 125
Acrylonitrile TDXE-35 #74 (2 ea)	5(6)		Weight Change ($\neq 1.16\%$) Shore Durometer hardness (-10%)	8 p 125
Buna-N	3.1(9)		Hardened but kept seal	47 p 42, 80
En-Jay Butyl XI-351 (2 ea)	5(6)		Weight (-0.09%) Shore Durometer Hardness ($\neq 2\%$)	8 p 125
KEL-F Poppet	1.1(10)		Crystallized Brittle and Cracked	8 p 88
Leather Backup Ring	1.3(9)		No damage	47 p 42, 80
Neoprene #72 Compound (2 ea)	5(6)		Weight ($\neq 1.009\%$) Shore Durometer Hardness (0.0%)	8 p 125
Neoprene #74 Compound (2 ea)	5(6)		Weight ($\neq 1.007\%$)	8 p 125
Parco 805 (Butyl Rubber)	1.1(10)		Melted (Not Rec. For Nuc. Use)	8 p 88
Parker B-496-7 (2 ea)	5(6)		Weight ($\neq 1\%$) Shore Durometer Hardness (-10%)	8 p 125

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT O-Rings	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Miscellaneous Con't</u>				
Rubber 366YV (2 ea)	5 (6)		Weight (-0.85%) Shore Durometer Hardness (-9%)	8 p 125
Rubber 524A (2 ea)	5(6)		Weight (1%) Shore Durometer Hardness (4%)	8 p 125
50% Teflon loaded XIT 351 (2 ea)	5(6)		Weight (0.04%) Shore Durometer Hardness (-3%)	8 p 125
Teflon (TFE)	1.1(10)		Shredded, Brittle	8 p 88

2.17

POTENTIOMETERS

2.17.1

CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potentiometers, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
<u>Allen-Bradley</u>				
0-0.1K $\pm$ 10% at 120°C RV4LAYS101A (6 ea)	4.5(10)	6.3(13)nf 2.4(15)ne	Max R (-1.2%) at 9.2 (12)nf, Min R (-72%) at 4.9(13)nf	2 p. 216, 218
0-25K (Molded) RV6LAXSA253A (6ea)	1.6(11)	4(16) (E>0.5MEV)	Max R ($\neq$ 12%) at 1.5(6) nf, Contact Arm R (<1%)	35 p. 10.41-59
0-100K $\pm$ 10% at 120°C RV4LAYS104A (3ea)	4.5(10)	6.3(13)nf	Max R (-3.1%) at 1.3 (15)ne, Min R ($\neq$ 61%) at 2.3(15) ne	2 p. 216, 221
0-250K (Molded) RV6LAXSA254A (6ea)	1.6(11)	4(16) (E>0.5MEV)	Max R ($\neq$ 8.3%) at $\sim$ 1(16) nf, Contact Arm R (<1%)	35 p. 10.41-59
0-1 Meg $\pm$ 10% at 120°C RV4LAYS105A (6ea)	3.5(10)	1.1(15)ne 3.7(13)nf	Max R (-4.1%) at 2.6 (14) ne, Min R ($\neq$ 35%) at 5.2(14)ne	2 p. 216, 223
<u>Chicago Telephone Supply Corp.</u>				
0-50K (Film Type) RV5LAXSB503A (6ea)	1.6(11)	4(16) (E>0.5MEV)	Max R (-23%) at 2.3(16) nf, contact R (< 1%)	35 p. 10. 41-59
0-500K (Film Type) RV5LAXSB504A (6ea)	"	"	Max R (-19%) Contact R (< 1%)	"
0-2.5 Meg (Film Type) RV5LAXSD255B (6 ea)	"	"	Max R (-24%) Contact R (< 1%)	"

2.17 POTENTIOMETERS

2.17.2 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Potentiometers, Wire- wound				
<u>Bourns Labs, Inc.</u>				
0-0.5K, Trim-pot 3040-W-1-501 (6ea)	1.3(11)	5.1 (16) (E>1 MEV)	Resistance ($\neq$ 0.85%) at 2(14)nf, one opened	30 p. 190-202
0-20K $\pm$ 10%, Trim-pot 220-W-1-203 (1ea)	6.3(10)	4.3(16) (E>1 MEV)	MaxR($\neq$ 1.5%) at 8.6 (13)nf	12 p. 165
0-20K, Trim-pot 3040-W-1-203 (6 ea)	1.3(11)	5.1(16) (E>1 MEV)	Resistance ($\neq$ 0.1%) at 3(15)nf	30 p.190-202
<u>Chicago Telephone Supply Corp.</u>				
0-15K $\pm$ 5% RA 30A1SD153AJ (6ea)	2.5 (10)	6.1(14)ne 3.6(13)nf	Max R ($\neq$ 0.008%) at 3(14)ne, Min R(-19%) at 3.1(13)ne	2 p.209, 212
<u>Hadley Co. Inc., Robert M.</u>				
0-0.5K $\pm$ 5%, 1/2W, Temp Coeff $\pm$ 20ppm/ $^{\circ}\text{C}$ Trimpot, 500 TP (1ea)	7.2(10)	4.8(16) (E>1MEV)	Max R ($\neq$ 4.78%) at 1.4(15)nf	12 p.180 11 p. 11
<u>P.R. Mallory and Co.</u>				
0-5K, $\pm$ 5% RA15A1SD502AJ (6ea)	2.5(10)	1.4(15)ne 3.6(13)nf	Max R ($\neq$ 3.3%) at 1.2 (15)ne, MinR(-26%) at 5.7 (13)ne	2 p.209, 210

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potentiometer, Wire- wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Ohmite Mfg. Co.</u>				
0-10 Ω $\pm 10\%$ RP101SJ100KK (12 ea)	3.2(10)	1.4(15)ne	MaxR ($\neq 13.1\%$) at 3.5 (14)ne	2 p.194, 196- 199
0-100 Ω $\pm 10\%$ RP101SJ101KK (6ea)	5.1(10)	3.7(15)ne	Max R ($\neq 1.15\%$) at 1.4(15)ne	2 p.194, 200- 201
0-1K $\pm 10\%$ RP101SJ102KK (9ea)	3.8(10)	1.7(15)ne	MaxR ($\neq 3.7\%$) at 1(15)ne	2 p.194, 202- 204
0-5K $\pm 10\%$ RP101SJ502KK (6ea)	5.1(10)	3.7(15)ne	MaxR ($\neq 1.1\%$) at 1.9 (15)ne	2 p.194, 205- 207

POTTING COMPOUNDS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Potting Compounds				
<u>American Latex Fibre Corp.</u>				
Stay Foam AA-402 (2 ea)	2(8)	1.5(15) ($E > 0.1 \text{ Mev}$)	Resistance Ratio $R_o/R = 31$, Volume (+15.4%)	10 pl51
<u>Dennis Chemical Co.</u>				
Insulating Lacquer 1162 A/B (2 ea)	"	"	Resistance Ratio $R_o/R = 38$ Volume (+1.4%)	10 pl49
<u>Dow Corning Corp.</u>				
RTV-501 (2 ea)	5(8)	3.3(15) ($E > 0.1 \text{ Mev}$)	R. Ratio $R_o/R = 18$ Volume (+16%) changed from tan to grey	10 pl47
<u>Emerson & Cuming, Inc.</u>				
Conducting Epoxy 57C	1.9(10)	1.5(15) ($E > 2.9 \text{ Mev}$)	Resistance (+1.03%) @ 9.2(12)nf	12 p239
Stycast 2651 MM (2 ea)	5(8)	3.3(15) ($E > 0.1 \text{ Mev}$)	R. Ratio $R_o/R = 3.3$ Volume (-0.58%)	10 pl46

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potting Compounds	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>General Electric Co.</u>				
Silicone Rubber RTV-90	1.3(9)	8.7(11)nt 1(12)nt	Good condition but less pliable	8 pl17
<u>Hysol Corp.</u>				
#12.007 (2 ea)	2(8)	1.5(15) (E>0.1Mev)	R. Ratio Ro/R = 1.3 No volume change	10 pl50
<u>Mica Corp.</u>				
EG758T (2 ea)	2(8)	1.5(15) (E>0.1Mev)	R. Ratio Ro/R = 450 Volume (+6.9%), darkened	10 pl52
<u>Minnesota Mining & Mfg. Co.</u>				
Scotchcast #3 (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 2.7 Volume (+0.89%)	10 pl46
Scotchcast foam Resin #603 (2 ea)	"	"	R. Ratio Ro/R = 170	10 pl54

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Potting Compounds				
Products Research Co.				
Polysulfide Rubber PR-1201-Q	1.3(9)	8.7(11)nf 1(12)nt	Good Condition	8 pl17
Shell Chemical Co.				
EPON 828 Cat. D (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 2.7 Volume (+1.3%), Darkened	10 pl48

2.19 PRINTED CIRCUITS

2.19.1 ASSEMBLIES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuits (Assemblies)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Aerovox Corp.</u> Type PA-95 consisting of a resistor and a capacitor (6 ea)	4.9(10)	2.8(15)ne	Resistance (-10.8%) capacitance (-46%) No effect on board.	2 p. 796
<u>Centralab Division</u> Type PC-33 with resistor and capacitor (6 ea)	4.9(10)	2.8(15)ne	Resistance (-13.8%) Capacitance (-31%) No Effect on Board.	2 p. 796

2.19 PRINTED CIRCUITS

2.19.2 BOARDS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit, Boards				
<u>Centralab Division</u>				
Steatite Type (Uncoated) (3 ea)	5.5 (10)	3.6(15)ne	Capacitance between leads ($\neq$ 3.3%)	2 P. 776, 793
(Acrylic Coated)(3ea)	"	"	Capacitance between leads ($\neq$ 2%) Some permanent effects on both types	"
<u>Chance Vought Corp.</u>				
Copper-clad fiberglass Melamine (2.5" x 4") following coatings were used: (1) Nitro-cellulose lacquer	2.1(8)		Leakage I increased by factor 1(3) at 2.6(7) ergs/gm-(C)	14 p. 3, 6
(2) Silicone Varnish (DC 997)			Leakage I increased by factor 1(5) at 2.6(7)e/g- ~~c~~ at 70°C Breakdown V(-30%)	14 p. 3, 10
(3) Epoxy - polyamid			Leakage I increased by factor 1(4) at 2.6(7)e/g- ~~c~~ at 70°C Breakdown V(-20%)	14 p. 3, 10
(4) Polyester catalyzed with methyl ethyl ketone (MEK) peroxide			Leakage I increased by factor ~1(3) at 2.6(7)e/g- ~~c~~ at 70°C Breakdown V(-25%) Superior coating of those tested.	14 p. 3, 10
(5) Uncoated			Leakage I increased by factor ~1(5) at 2.6(7) ergs/gm-(c) Breakdown V (0.0%)	14 p. 3, 10

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit, Boards				
Continental Connector Corp.				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor 1(4) at 1.2(14)ne and 1.7 (9)e/g-c, corroded, and blistered.	2 p. 782, 776
(Acrylic Coated) (2ea)	"	"	Insulation resistance decreased by factor 1(3) at 2.8(15) ne and 4.3 (10)ergs/gm-(C) corroded and blistered.	"
Glass Melamine Type	5.5(10)	3.6(15)ne	Copper corroded, 1 lead opened, capacitance between leads ($\neq 14\%$)	2 P. 776, 785
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance between leads (-5%), No Physical damage but leads easily removed from board	2 p. 776, 792-794
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance between Leads ($\neq 7.7\%$), Boards were extremely Brittle	2 P. 776, 787
Teflon Type	5.5(10)	3.6(15)ne	Board was destroyed by radiation	2 p. 776, 791

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit Boards				
<u>Formica Corp.</u> <u>Subs. American</u> <u>Cyanamid Co.</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (0%) Copper Strips cor- roded	2 p. 776, 786
Paper Phenolic Type 36	5.5(10)	3.6(15)ne	Capacitance ($\neq 24.7\%$) Boards were extremely Brittle	2 p. 776, 788
<u>General Electric Co.</u>				
Paper Phenolic Type- XXXP	5.5(10)	3.6(15)ne	Capacitance ($\neq 14.4\%$) Boards were Extremely Brittle, 1 Lead opened	2 p. 776, 788
<u>Mica Corp.</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance ($\neq 40\%$) Copper Strip Corroded	2 p. 776, 786
Paper Phenolic Type- 6038	5.5(10)	3.6(15)ne	Capacitance ($\neq 16.5\%$) Boards Extremely Brittle	2 p. 776, 788

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit Boards				
<u>New England Electronic Component, Inc.</u>				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor 1(14) @ 3.2(15)ne & 3.3(10)ergs/gm-(C) Blistered & Warped	2 p776,781
(Acrylic Coating) (2 ea)			Insulation resistance decreased by factor 1(4) @ 3.2(15)ne & 3.3(10)ergs/gm-(C) Blistered & Warped	
Paper Phenolic Type XXXP230	5.5(10)	3.6(15)ne	Capacitance (+30%), Boards extremely brittle	2 p776,788
<u>Richardson Company</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (+12.5%), Badly corroded	2 p776,786
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance (+12.1%), Extremely brittle, 1 broke by normal handling	2 p776,788

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit Boards				
Synthane Corporation				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor $\sim 1(4) @ 2.9(15)ne$ & $4.3(10) \text{ergs/gm}-(C)$ Strips corroded, No other damage	2 p776,782
(Acrylic Coating) (2 ea)	"	"	Insulation resistance decreased by factor $\sim 1(4) @ 3.2(15)ne$ & $3.3(10) \text{e/g}-(C)$, No physical damage	"
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (+10%), Corroded strips, Extremely brittle	2 p776,786
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance (+21%), No physical damage, Copper strips easily removed	2 p776,791
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance (+17%), Extremely brittle	2 p776,787
Taylor Fibre Company				
Glass Epoxy Type (uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor $\sim 1(4)$ immediately, Blistered & Warped	2 p776,781
(Acrylic Coating) (2 ea)	"	"	Insulation resistance decreased by factor $\sim 1(3) @ e.2(15)ne$ & $3.3(10) \text{ergs/gm}-(C)$ Blistered & Warped	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Printed Circuit Boards				
<u>Taylor Fibre Company (Cont.)</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (-60%), Corroded, Extremely brittle	2 p776,786
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance (+16%), No physical damage, Copper strips loose	2 p776,791
Paper Phenolic Type XXXP242	5.5(10)	3.6(15)ne	Capacitance (+27%), Extremely brittle	2 p776,788
<u>Miscellaneous</u>				
Flourcarbon Type	5.5(10)	3.6(15)ne	Boards melted in-pile due to radiation	2 p792

2.20 PROTECTIVE COATINGS

2.20.1 ENAMELS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Enamels)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
Type I, white Enamel MIL-E-7729	1(11)	.	Change of 5% in reflectance, a mark- ed decrease in adhesion, a marked increase in abrasion resistance	73 p. 17
Type I, Red Enamel MIL-E-7729	7(10)		A change in color, a slight decrease in adhesion, decrease in corrosion re- sistance.	73 p. 17
Type I, Black Enamel, MIL-E-7729	7(10)		A decrease in adhesion, improved flexibility. No effects were noted at 1 (10) ergs/gm-(C)	73 p. 17
Drying Oil Alkyd Enamel Type 1 MIL-E-7729	1(11)		Very good resistance to radiation. Further Irradiation would seriously degrade this material	73 p. 17
Glyceryl Pthalate Alkyd Enamel, Type I, MIL-E-5557	1(11)		Very good resistance to radiation	73 p. 17

2.20 PROTECTIVE COATINGS

2.20.2 FINISHES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Finishes)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Phenolic (A Phenol-formaldehyde thermosetting resin colored by a blue organic dye.) MIL-C-3043 Blue	1 (11)		This dose was slightly harmful at 250°F but improved the coating at 500°F. At 500°F the humidity resistance and film condition improved.	73 p. 18
Epoxy Coatings MIL-C-4456 (USAF) Blue - Gray	1 (11)		Increased Irradiation caused a decrease in humidity resistance, adhesion, reflectance for the unbaked samples. For the baked samples, adhesion, abrasion resistance, humidity resistance, flexibility, and film properties decreased; the color changed also.	73 p. 19
Silicone - Alkyds MIL-E-25606 (USAF)	1 (10)		Little Effect	73 p. 19
White (Plaskon St-873 resin)	5 (11)		Large decrease in reflectance, adhesion, and film condition. A large increase in abrasion resistance.	73 p. 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Finishes)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Nitrocellulose Lacquer MIL-L-7178	7 (10) 5 (10)		Moderate degradation. Appears to be the upper limit of usefulness.	73 p. 20
Phenolic Coating MIL-R-3043	1 (11)		Excellent resistance to radiation and heat	73 p. 21

2.20 PROTECTIVE COATINGS

2.20.3 FLUORINATED VINYL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Fluorinated Vinyls)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>M. W. Kellogg Co.</u>				
Fluorinated vinyl Lacquer, aluminized,	1 (11)		Unbaked samples showed greatly in- creased abrasion resistance and apparent adhesion.	73 p. 19
"	5 (11)		Decreased abrasion resistance and ap- parent adhesion due to flaking of the film.	73 p. 19
"	1 (11)		Baked samples de- creased apparent adhesion and increas- ed abrasion re- sistance	73 p. 19
"	5 (11)		Greatly decreased apparent adhesion, abrasion resistance, and flexibility	73 p. 19
Fluorinated Vinyl Lacquer, aluminized KEL-F-800	5 (11)		This material has poor resistance to radiation. At 1(11) there was moderate degradation at 75°F and 250°F. Degrada- tion was severe at 5 (11) at 75°F and 250°F.	73 p. 21

2.20 PROTECTIVE COATINGS

2.20.4 LACQUERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Lacquers)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
White Nitrocellulose Lacquer, MIL-L-7178	1 (11)		A marked yellowing (27% change in re- flectance), an in- crease in adhesion and humidity re- sistance, a decrease in flexibility, abrasion resistance, gloss, and film condition.	73 p. 17
Red nitrocellulose Lacquer, Mil-L-7178	1 (11)		A noticeable darkening increase in adhesion and abrasion re- sistance decrease in flexibility, gloss, and film condition.	73 p. 17
Black nitrocellulose Lacquer, MIL-L-7178	1 (11)		Increased adhesion, abrasion resistance, humidity resistance, and a loss of gloss.	73 p. 17
			N. B. Irradiations of 7 (10) embrittled the lacquers, in- creased blistering in humidity. No effect was noted at 1 (10)ergs/gm-(C)	73 p. 17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Allied Control Co., Inc.</u>				
Type MH-180 hermetically sealed (4 ea)	4.46(10)	4.38(12) (E>2.9MEV)	Coil R ($\nearrow$ 7.3%) at 1.38(11)nf, Drop out current- erratic	21 p. 35, 66
<u>Branson Corp.</u>				
Time Delay, 6.3v heater 2P2T, 115V Type MTRH-3127 (1ea)		6.3(16) (E>0.5MEV)	No damage to Relay operation	35 p. 6.55, 10.127
<u>C.P. Clare and Co.</u>				
Telephone Type (uncovered) A29634 (4ea)	4.3(10)	3.3(12) (E>2.9MEV)	Coil R ($\nearrow$ 2.87%) at 1.06(11)nf, Drop-out current ($\nearrow$ 3.26%)	21 p. 37, 68
<u>General Electric Co.</u>				
ZL176 Magnet wire (Basically Formex) Type FB 100Y1 (3 ea)	7.8 (8)	5.1(15) (E>0.1MEV)	Coil R ($\nearrow$ 3.54%) at 1.4(15)nf, contact R ($\nearrow$ 12%)	10 p. 16, 131
TFE Teflon wire Type FB100Y2 (3 ea)	8.8(8)	5.7(15) (E>0.1MEV)	Coil R ($\nearrow$ 5.9%) at 4.2(15)nf, contact R (12.5%)	10 p. 16, 132
ML Enamel Magnet Wire Type FB100Y3 (3 ea)	9.7(8)	6.1(15) (E>0.1MEV)	Coil R ($\nearrow$ 5.5%) at 5.1(15)nf, Contact R (12.5%)	10 p. 16, 133

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Hartman Electrical Manufacturing</u> Power Contractor Coil: 28VDC Contacts: 200VAC, 400cps Type BH-138AH (1ea)	3(10)	1.7(16) (E>1MEV)	Satisfactory operation throughout test. Contact operation o.k.	30 p.183
<u>Hathaway Electronics Inc.</u> Dri-reed relay Series M-Form A (1ea)	6.7(10)	5.3(16) (E>0.3MEV)	Normal operation throughout test	31 p.190
<u>Potter and Brumfield Inc.</u> DPDT 2A at 30 VDC Type PBSC11DA (3ea) SP2T, 2A, 1.8K, 65mw Coil, 500V(RMS) PW Type (2 ea)	1.1(9)	6.5(15) (E>0.1MEV) 6.1(15) (E>0.5MEV)	Coil R ($\nearrow$ 4.5%) at 2.3(15)nf, Contact R ($\nearrow$ 45%) at 2.3(15)nf Contact resistance increased, contacts were pitted and black; not rec. for H1-I or low Signal application in Nuc. Environment	10 p.16, 134 35 p.10.119-124
General Purpose Uncovered Type SP11D (4 ea)	5.4(10)	4.5(12) (E>2.9MEV)	Coil R ($\nearrow$ 7.9%) at 1.42(11) nf Drop-out I ($\nearrow$ 3.85%)	21 p.33, 64

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Potter and Brumfield</u> <u>Con't</u>				
Midget, Hermetically Sealed, Type SM5DS (4 ea)	5.5(10)	4.9(12) (E>2.9MEV)	Coil R ($\pm$ 7.8%) at 1.56(11)nf Drop-out I ($\pm$ 13.4%)	21 p. 36, 67
2 PST - N.O., 28VDC 5.6 ma, 5K Type MH (4 ea)		1.2(17) (E>0.5MEV)	Pull-in V (+30%) Drop-out V ($\pm$ 20%) Satisfactory oper- ation	35 p. 10.124- 127
<u>Price Electric Co.</u>				
Rotary (uncovered) Type 76-3 (4 ea)	7.6(10)	6.1(12) (E>2.9MEV)	Coil R ($\pm$ 7.37%) at 1.93(11)nf	21 p. 39
26VDC, Selenoid type Hermetically sealed KB part # 300R022 (3 ea)	3.7(10) 5.7(9)	2.2(14)nf 1.7(16)nf (E>0.5Mev)	Pull-in, drop-out Time, current and voltage all remained within specification	4 p. 16-35

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Sigma Instruments, Inc</u>				
Midget Hermetically Sealed Type 22 RJC-200G(4ea)	6.9(10)	6(12) (E>2.9MEV)	Coil R (48%) @ 2(11)nf Drop-out I (45.7%) at 1.1(12)nf	21 p. 38, 69
Sensitive Aircraft Type Hermetically Sealed Type 5 RJ-20006 (4ea)	5.5(10)	4.5(12) (E>2.9MEV)	Coil R (46.9%) at 1.42(11)nf, Drop-out I (47.5%) at 3.7(12) nf	21 p. 31, 62
Sensitive Aircraft Type Type 5R-20006 (4ea)	9.9(10)	7.6(12) (E>2.9Mev)	Coil R (47.6%) at 2.4 (11)nf, Drop-out I (43.85%)	21 p. 33, 64
<u>Western Electric</u>				
Mercury-wetted contacts Hermetically sealed Type 275C (4ea)	5.4(10)	4.5(12) (E>2.9Mev)	Coil R (47.7%) at 1.5 (11)nf Drop-out I (43.95%)	21 p. 34, 65
<u>Westinghouse Air Brake Co.</u>				
26.5VDC, Hermetic #312587-002 (4ea)	3.9(10) 5.5(9)	2.3(14)nf 1.7(16)nf (E>0.5Mev)	Satisfactory oper- ation, 1 coil opened	4 p. 16-35

2.22 RESISTORS

2.22.1 BORON-CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Boron- Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
International Resistance Co.				
0.1K +1%, 2W Type BOH, RN30 (12 ea)	2.4(10)	5.1(15) (E>2.9Mev)	Resistance(-0.2%)	23p 19, 48
10K+1%, 2W Type BOH, RN30 (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	No Resistance change	22p 3, 31
10K+1%, 2W Type BOH, RN30 (12 ea)	2.4(10)	5.1(15) (E>2.9Mev)	Resistance(+0.6%)	23p 19. 48

2.22 RESISTORS

2.22.2 BORON-CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Corning Glass Works</u>				
4.65K+1% RN25R4631F (7 ea)	2.6(10)	1.4(15)ne 9.0 (17)nt	Resistance(+4.6%)	2p 163,145
<u>International Resistance Co.</u>				
0.1K+2% RN20R1000G (4 ea)	2.5(10)	1.2(15)ne 8.9(17)nt	Resistance(+16.9%) @ 1.13(15)ne	2p 147,144
1K+1% RN70B1001F (3 ea)	4.1(10)	2.1(15)ne 1.7(18)nt	Resistance(+1.1%)	2p 145,186
100K+2% RN20R1003G (4 ea)	4.0(10)	2.0(15)ne 1.3(18)nt	Resistance(+11.8%) @ 1.88(15)ne	2p 144,149
1 Meg+2% RN20R1004G (4ea)	4.0(10)	2.0(15)ne 1.3(18)nt	Resistance(+3.1%) @ 1.22(15)ne	2p144,150

2.22 RESISTORS

2.22.3 CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Allen-Bradley Co.</u>				
0.1K+10%, 1W Type GB, RC-30(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.9%) @ 2.88(10)ergs/gm-(C)	23p 19,48,61
0.1K $\frac{1}{2}$ W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-12%)	15p 26
0.1K, MIL-R-11B RC32GF101J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-2.7%) @ 4.34(14)ne	2p 25
0.1K RC20 BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-2.9%)	1p 300 689
0.1K+10%, $\frac{1}{2}$ W Type EB, RC-20(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+7.5%) @ 3.54(9)ergs/gm-(C)	23p 19,48,63
0.1K+10%, 2W Type HB, RC-30 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.1%) @ 1.95(10)ergs/gm-(C)	23p 19,48,61
1K, MIL-R-11B RC32GF102J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-3.3%) @ 7.06(14)ne	2p 27
1K, RC20BF102J (5 ea)	2.9(10)	1.0(15)ne	Resistance(-5.5%)	1p 308, 689
10K+10%, $\frac{1}{2}$ W Type EB, RC-20(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4%) @ 1.5(10)ergs/gm-(C)	23p 19,48,60
10K+10%, 1W Type GB, RC-30 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.9%) @ 1.95(10)ergs/gm-(C)	23p 19,48,60

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Allen-Bradley con't</u>				
22K+5% RC07 (1 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(+0.14%)	10p 126
34K+5% RC07 (1 ea)	1(9)	7(15) (E>0.1Mev)	Resistance<<1%)	10p 126
125K RC20BF124J (4 ea)	5.7(10)	2.1(15)ne	Resistance(-7.7%) @ 1.87(15)ne	1p 325, 690
125K RC32GF124J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-6.5%) @ 6.58(14)ne	2p 29
240K, $\frac{1}{2}$ W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-12%)	15p 26
1 Meg $\frac{1}{2}$ W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-9%)	15p 26
1 Meg RC32GF105J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-6.8%) @ 6.58(14)ne	2p 31
10 Meg, $\frac{1}{2}$ W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-10%)	15p 26

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>International Resistance Co.</u>				
0.1K+10%, 2W Type BTB, RC-41 (12ea)	6.2(10)	1.4(16) (E)2.9Mev)	Resistance(+5%) @ 1.95(10)ergs/gm(C)	23p 19,48,50
10K+10%, 2W Type BTB, RC-41 (12ea)	6.2(10)	1.4(16) (E)2.9Mev)	Resistance(+6.3%) @ 1.95(10)ergs/gm-(C)	23p 19,48,51
10K+10%, 2W BT-13, RC41G1002K (12 ea)	1.6(9)	7.5(13) (E)2.9Mev)	Resistance(+0.75%) @ 2.97(13)nf	22p 3,31
<u>Speer Carbon Co.</u>				
0.1K RC20BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-10.3%)	1p 300,689
1K RC20BF102J (3 ea)	2.9(10)	1.0(15)ne	Resistance(-4.8%) @ 9.45(15)ne	1p 308, 689
125K RC20BF124J (4 ea)	5.7(10)	2.1(15)ne	Resistance(-5.9%) @ 1.9(15)ne	1p 325,690
1 Meg RC20BF105J (4 ea)	2.1(10)	6.6(14)ne	Resistance(-20.5%)	1p 317, 690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistor, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Stackpole Carbon Co.</u>				
0.1K RC20BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-3.3%)	1p 300,689
1K RC20BF102J (4 ea)	2.9(10)	1.0(15)ne	Resistance(-6.7%)	1p 308,689
125K RC20BF124J (4 ea)	5.7(10)	2.0(15)ne	Resistance(-15.8%) @ 1.9(15)ne	1p 325,690
1 Meg RC20BF105J (4 ea)	2.1(10)	6.6(14)ne	Resistance(-13.1%) @ 6.2(14)ne	1p 317,690

2.22 RESISTORS

2.22.4 CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2} \text{-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>Aerovox Corp.</u>				
0.1K+2% RN20X1000G	4.0(10)	2.0(15)ne	Resistance(+4.3%) @ 1.4(15)ne	2p152,144
0.1K+2% RN25X1000F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1.7%) @ 9.9(14)ne	2p167,144
0.1K+2% RN25X1000G (4 ea)	2.5(10)	1.2(15)ne	Resistance(+1.6%) @ 1.04(15)ne	2p 177,144
1K+2% RN20X1001G (4 ea)	2.5(10)	1.2(15)ne	Resistance(-1.7%) @ 2.54(14)ne	2p 153,144
1K+2% RN25X1001G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.5%) @ 2.49(13)ne	2p 179,144
100K+2% RN20X1003G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-1.9%) @ 1.75(14)ne	2p 156,144
100K+2% RN25X1003G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.5%) @ 1.34(13)ne	2p 181,145
250K+1% RN25X2503F (2 ea)	4.5(10)	2.3(15)ne	Resistance(-0.8%) @ 1.76(15)ne	2p 175,144
1 Meg+2% RN25X1004G (3 ea)	3.8(10)	2(15)ne	Resistance(-5%) @ 1.42(15)ne	2p 182,145
1 Meg+2% RN20X1004G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-2%) @ 1.67(14)ne	2p 159,144
1 Meg+2% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-2.7%) @ 2.63(13)ne	2p 172,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>Daven Co., The</u>				
0.1K+1% RN25X1000F (4 ea)	2.5(10)	1.2(15)ne	Resistance(+2.6%)	2p 168,144
<u>International Resistance Co.</u>				
0.1K+1%, 2W Type DCH, RN-30(12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+3%) @ 1(10)ergs/gm-(C)	23p 19,48,55
0.1K+2% RN20X1000G (4 ea)	2.5(10)	1.2(15)ne	Resistance(-1.6%) @ 2.67(14)ne	2p176,144
0.1K+2% RN20X1000G (4 ea)	4.0(10)	2.0(15)ne	Resistance(-1.4%) @ 2.49(13)ne	2p 151,144
0.1K+1% RN25X1000F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1.1%) @ 8.54(14)ne	2p 165,144
0.1K+1% RN75B1000F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+1.3%) @ 9.6(13)ne	2p 188,144
0.1K, $\frac{1}{2}$ W (Molded) (3 ea)	5.67(10)	2.5(17)ne	Resistance(+2.5%)	15p 25, 29
1K+2% RN25X1001G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.7%) @ 1.3(13)ne	2p 178,144
1K+2% RN20X1003G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-1.1%) @ 1.59(14)ne	2p 154,144
1K+2% RN70A1001F (3 ea)	4.1(10)	2.1(15)ne	Resistance(+25.1%)	2p 185,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>I R C con't</u>				
1K $\pm$ 1%, $\frac{1}{2}$ W Type HTC (6 ea)	3(10)	1.4(14) (E > 0.5 Mev)	Resistance(+0.2%) @ 5.2(13)nf	4p 42
" (6 ea)	6(9)	2.2(16) (E > 0.5 Mev)	Resistance(-1.8%) @ 1.04(16)nf	40p 40
1K $\pm$ 1%, 1W Type HTF (6 ea)	5.4(10)	1.6(16) (E > 0.5 Mev)	Resistance(-1.8%) @ 1.09(16)nf	4p 41
" (6 ea)	2.6(10)	1.2(14) (E > 0.5 Mev)	Resistance(-0.5%) @ 4.47(12)nf	4p 43
1K RF50K102 (3 ea)	2.9(10)	1.7(15)ne	Resistance Varies from (+5.6%)-max.of (+6.04%) at shutdown	1p 367,690
10K RF50K103 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+6.69%) 1 failed-opened	1p 375,690
10K $\pm$ 1%, 2W DCH, RN30X1002F (12ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-2.1%)	22p 3,31
10K $\pm$ 1%, 2W Type DCH, RN30 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.5%) @ 4.43(9)ergs/gm-(C)	23p 19,48,55
77K $\pm$ 2%, $\frac{1}{2}$ W RN20X, DCC Series (3 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-1.3%) @ 7.5(14)nf	10p 126
100K RF40K104K (6 ea)	2.9(10)	1.7(15)ne	Resistance(-4.93%) @ 3.19(14)ne	1p 349,690
100K RF50K104 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+9.93%)	1p 384,690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2}(\text{C})$	$\frac{n}{\text{cm}^2}$		
Resistors, Carbon Film				
I R C con't				
100K+2% RN25X1003G (4 ea)	3.9(10)	2(15)ne	Resistance(-1.8%) @ 1.34(13)ne	2p 180,144
240K, $\frac{1}{2}$ W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+2.5%)	15p 25,29
250K+1% RN75B2503F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+4.4%) @ 2.19(15)ne	2p 191, 144
250K+1%, $\frac{1}{2}$ W, 350V Type HTC (6 ea)	3.8(9)	1.6(16) (E > 0.5 Mev)	Resistance(+4.2%) @ 5.4(13)nf	4p 40
" (6 ea)	3 (10)	1.4(14)nf	Resistance(+1.7%)	4p 42
250K+1%, 1W, 500V Type HTF (6 ea)	6(9)	1.6(16) (E > 0.5 Mev)	Resistance(-2.7%) @ 1.34(16)nf	4p 41
" (6 ea)	3.3(10)	1.9(14) (E > 0.5 Mev)	Resistance(+2.3%) @ 1.07(14)nf	4p 43
250K+1% RN25X2503F (2 ea)	4.2(10)	2.0(15)ne	Resistance(+1.1%) @ 8.6(14)ne	2p 173,144
1 Meg+2% RN25X1004G (4 ea)	3.9(10)	2(15)ne	Resistance(-2.4%) @ 2.26(14)ne	2p 183, 144
1 Meg+1% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(+2.7%) @ 9(14)ne	2p 170, 144
1 Meg+1% RN75B1004F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+2.5%) @ 4.31(14)ne, all opened @ 9.6(14)ne	2p 190,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Film	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>I R C con't</u>				
1 Meg, $\frac{1}{2}$ W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+7%)	15p 25,29
1 Meg+1%, $\frac{1}{2}$ W, 350V Type HTC (6 ea)	7.4(9)	2.2(16) (E > 0.5 Mev)	Resistance(-2.8%) @ 6.8(15)nf	4p 40
" (6 ea)	2.6(10)	1.2(14)nf	Resistance(+3.4%)	4p 42
1 Meg+1%, 1W, 500V Type HTF (6 ea)	5.4(9)	1.6(16) (E > 0.5 Mev)	Resistance(-2.2%) @ 3.68(15)nf	4p 41
" (6 ea)	3.3(10)	1.9(14) (E > 0.5 Mev)	Resistance(+2.4%) @ 1.08(14)nf	4p 43

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>Mepco, Inc.</u>				
0.1K+1% RN75B1000F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+2.7%) @ 9.6(14)ne	2p 187,145
0.1K+1%, 5W Type C-25P (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+2.4%) @ 2.52(10)ergs/gm-(C)	23p 19,48,57
10K+1%, 2W C177BN, RN80B1002F (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-0.6%)	22p 3, 33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-0.5%) @ 3.54(9)ergs/gm-(C)	23p19,48,57
10K+1%, 5W Type C-25P (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-0.2%)	22p 3, 31
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.8%) @ 8.63(9)ergs/gm-(C)	23p 19,48,57
10K+1%, 1/8W(Herm.Seal) LS 8456-090 (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.63%)	10p 129
" (4 ea)		1.3(16) (E>0.1Mev)	Resistance(+1%)	32p 3, Fig.28
15K+1%, 1/8 W, RN60B (Herm. Sealed) (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(+0.13%)	10p 130
" (4 ea)		1.3(16)nf	Resistance(+1%)	32p 3, Fig.28
27K+1% RN65B2702 (4 ea)	2.6(10)	1.4(15)ne	Resistance(-1.59%) @ 3.28(14)ne	2p 184,145

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>Mepco con't</u>				
250K+1% RN75B2503F (3 ea)	4.6(10)	2.2(15)ne	Resistance(-0.8%) @ 1.05(15)ne	2p 191, 145
1 Meg+1% RN75B1004F (3 ea)	4.6(10)	2.2(15)ne	Resistance(-1.9%) @ 1.62(15)ne	2p145,189
 <u>Resistance Products Co.</u>				
10 Ω RF40 K100 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-1.68%) @ 1.68(15)ne	1p332,690
10 Ω RF50 K100 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+3.81%) @ 1.68(15)ne	1p 356,690
0.1K RF50 K101 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-9.63%)	1p 361,690
1K RF50 K102 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-1.1%) @ 1.59(15)ne	1p 369,690
1K RF40 K102 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-4.89%) @ 6.47(13)ne	1p337,690
10K RF40 K103 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-2.27%) @ 6.47(13)ne	1p343,690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>RPC con't.</u>				
10K RF50K103 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-0.91%) @ 5.18(14)ne, 1 ea opened in-pile	1p377, 690
100K RF50 K104 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-1.11%) @ 3.19(14)ne	1p386, 690
<u>Sprague Products Co.</u>				
0.1K+1%, $\frac{1}{4}$ W(Filmistor) RN65B, 406E 1000F (1 ea)	6.2(10)	4.2(16) (E>0.1Mev)	Resistance(+26.9%) @ 1.29(15)nf	12p 178
1K (Pyrolytic) RN65B, Type 406E	7.2(9)		Resistance(+0.2%)	43p212-14
1 Meg (Pyrolytic) RN65B, Type 406E	7.2(9)		Resistance(-0.2%)	43p 212-14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2} \text{ (C)}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Carbon Film</u>				
<u>Texas Instruments Inc.</u>				
0.1K+1% RN25X100F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1%) @ 1.61(14)ne	2p166,144
0.931K+1% CD $\frac{1}{4}$ R	7.5(9)	3.7(15) (E>1Mev)	Resistance(+1.84%) @ 5(14)nf	12p 157
"		1.3(15) (E>2.9Mev)	Resistance<<<1% Rec. for Low Pwr. Nuc. Environments	11p 23,25
250K+1% RN25X2503F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-0.6%) @ 1.23(15)ne	2p 174,144
1 Meg+1% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-5%) @ 2.63(13)ne	2p 171,144
<u>Western Electric</u>				
0.1K $\frac{1}{2}$ W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+0.8%) Not Rec. for Nuc. use	15p 25,28
250K $\frac{1}{2}$ W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+13%) 1 failed, not Rec. for Nuc. use	15p 25,28
1 Meg $\frac{1}{2}$ W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+38%) Not Rec. for Nuc. use	15p 25,28
1 Meg 2W Glass Enclosed (3ea)	5.6(10)	2.5(17)ne	Resistance(+6%) 1 failed @ 2(17)ne	15p 30,31
5 Meg 2W Glass Enclosed (3ea)	5.6(10)	2.5(17)ne	Resistance(+5%) 1 failed @ 9(16)ne	15p 30,31

2.22 RESISTORS

2.22.5 METAL FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Metal Film</u>				
<u>Corning Glass Works</u>				
0.1K+2%, 7W, Pyrex Core, RD31P1000G (6ea)	3.0(10)	3.1(13)nf	Resistance(+2.8%) @ 2.69(13)nf	2p 38, 36
0.1K+2%, 2W, Solid Glass core RD65P1000G (6 ea)	4.5(10)	2.3(15)ne	Resistance(+8.5%) @ 1.36(15)ne	2p 42, 36
5.65K+2%, $\frac{1}{2}$ W, @ 120°C 350V Pyrex core, CGW-S-20 (1 ea)	6.2(10)	4.2(16) (E>1 Mev)	Resistance(-0.64%) @ 1.65(16)nf	12p 161
"		1.5(16) (E>2.9Mev)	Resistance(-0.64%) @ 5.9(15)nf, Rec. for Low Pwr. Nuc. use	11p 11,25
15K+2%, 2W, Solid Glass core, RD65P1502G	4.5(10)	2.3(15)ne	Resistance(+7%) @ 1.58(15)ne	2p 43, 36
30K+2%, 2W, Solid Glass core, RD65P3002G	4.2(10)	6.1(13)nf	Resistance(+22.99%) @ 5.3(13)nf	2p 44, 36
38K+2%, 7W, Pyrex core RD31P3832 (3 ea)	4.2(10)	2.0(15)ne	Resistance(+4.4%) @ 1.48(15)ne	2p 39, 36
" (3 ea)	3.0(10)	2.1(13)nf	Resistance(+2.1%) @ 2.77(13)nf	2p 40, 36
40K+2%, 2W, Solid Glass core, RD65P4003G (6 ea)	3.0(10)	3.1(13)nf	Resistance(+26.4%) @ 2.8(13)nf	2p 45, 36
68K+2%, 7W, Pyrex core RD31P6812G (6 ea)	3(10)	3.1(13)nf	Resistance(+2.9%) @ 2.01(13)nf	2p 41, 36

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Metal Film</u>				
<u>Daystrom, Inc.</u>				
1K+1%, $\frac{1}{2}$ W, Vamistor 1001F #9852 (1ea)	6.2(10)	4.2(16) (E>1Mev)	Resistance(+2.26%) @ 1.29(15)nf	12p 179
<u>International Resistance Co.</u>				
0.1K, $\frac{1}{2}$ W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+1.5%) @ 9(16)ne	15p 26, 23
2.5K+1% (glass) XLT Series (4 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.28%)	10p 126
2.87K+1%, 0.1W RN55, EM Series (4ea)	1(9)	7(15) (E>0.1Mev)	Resistance(+0.28%) @ 6(12)nf	10p 126
9.75K+1%, 1/8W Herm. Sealed-Glass Type XLT (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance(0.0%)	10p 128
10K+1%, $\frac{1}{4}$ W CEB Series (4 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.28%) @ 6(12)nf	10p 126
10K+1%, 1/8W, MEA Series, RN60C1002F (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance(+0.02%) @ 1.5(13)nf	10p 127
67K+1% RN60C (2 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(0.0%)	10p 126
81K+1% RN60C (2 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.12%) @ 6(12)nf	10p 126

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Metal Film</u>				
<u>I R C con't</u>				
240K, $\frac{1}{2}$ W Molded (3 ea)	5.7(10)	2.5(17)ne	Resistance(+0.9%)	15p 26, 23
1 Meg $\frac{1}{2}$ W Molded (3 ea)	5.7(10)	2.5(17)ne	Resistance(+1.3%) @ 7(16)ne	15p 23, 26
<u>Key Resistor Corp</u>				
0.1K+1% Type A-66 (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(+27.1%) @ 9.54(13)nf	12p 177
30K+1%, $\frac{1}{2}$ W @ 125°C 350V, EM-70, MIL-R- 10509-C (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-5.8%)	12p 175
100K+1%, $\frac{1}{2}$ W @ 125°C 350V, EM-70, Mil-R- 10509-C (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-2.06%) @ 2.67(16)nf	12p 174
100K+1% A-66, Mil-R-10509-C (1ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-1.6%) @ 2.67(16)nf	12p 176

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Metal Film				
<u>Litton Systems, Inc.</u>				
0.26K, Deposited Ni Cr film on BaTiO ₃ wafer (1 ea)	7.5(10)	4.0(16) (E>1Mev)	Resistance(+8.86%) @ 1.9(15)nf	12p 167
0.28K, Deposited NiCr film on BaTi O ₃ wafer (1 ea)	7.5(10)	4.0(16) (E>1Mev)	Resistance(+8.66%)	12p 166
<u>Ohmite Manufacturing Co.</u>				
0.1K+1%, $\frac{1}{4}$ W Type 771-2 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+2.1%) @ 1.81(10)ergs/gm-(C)	23p 19, 48
10K+1%, $\frac{1}{4}$ W Type 771-2 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.4%) @ 4.87(9) ergs/gm-(C)	23p 19, 48
<u>Pyrofilm Resistor Co., Inc.</u>				
125K+1% Type PT-60 (1 ea)	7.5(10)	4.0(16) (E>1Mev)	Resistance(+2.65%) @ 1.19(15)nf	12p 168
2 15K+1% Type PT-60 (1 ea)	6.3(10)	4.3(16) (E>1Mev)	Resistance(-6.42%) @ 1.3(16)nf	12p 169

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Metal Film</u>				
<u>Sprague Products Co.</u>				
1K RN65C, Type 419E	7.1(9)		Resistance(+0.1%)	43p 214
750K RN65C, Type 419E	7.1(9)		Resistance(-0.05%)	43p 214
<u>Varo Manufacturing Co., Inc.</u>				
0.65K, Experimental Microcircuit, NiCr Film, No. 235	1.9(10)	1.5(15) (E>2.9Mev)	Resistance(0.0%) Rec. for use in Nuc. Environment	12p 153 11p 25
<u>Weston Instruments Div of Daystrom, Inc.</u>				
0.25K $\frac{1}{2}$ W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Resistance(+200%) 2 failed, (not Rec. for Nuc. use)	15p 25,27
10K+1%, $\frac{1}{2}$ W, 9800Series RN 60C1002F (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance<<1%	10p 127
240K, $\frac{1}{2}$ W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Opened after a dose 2.7(16)ne, (not Rec. for Nuc. use)	15p 25, 27
1 Meg, $\frac{1}{2}$ W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Opened after dose of 2.7(16)ne (Not Rec. for Nuc. use)	11

2.22 RESISTORS

2.22.6 TEMPERATURE SENSITIVE

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Temp. Sensitive	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Texas Instruments, Inc.				
0.1K+10% @ 25°C Sensistor, Silicon Temp. Sens. P-100	7.6(9)	3.8(15) (E>1Mev)	Resistance(+2280%)	12p 158
0.1K+10% @ 25°C Type T012 Silicon, Sensistor, TC-1/8	7.6(9)	3.8(15) (E>1Mev)	Resistance(+6290%)	12p 159 11p 23

2.22 RESISTORS

2.22.7 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Wire wound</u>				
<u>Cinema Engineering</u>				
1K+1% @ 25°C, ½W @ 300V, Mil-R-93, Mil-R-9444, CE 276E (1ea)	6.3(10)	4.3(10) (E > 1Mev)	Resistance(+2.34%) @ 1.29(15)nf	12p 171
1K+1% @ 25°C, 1W @ 600V, CE 278E (1 ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(+1.74%) @ 2.4(16)nf	12p 173
100K+1% @ 25°C, 1W @ 600V, CE 278E (1ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-1.74%) @ 3.35(16)nf	12p 172
100K+1% @ 25°C, ½W @ 300V, CE 276E (1ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-2.29%) @ 2.4(16)nf	12p 170
<u>Dale Products, Inc.</u>				
1K+1%, 1W, Precision RS-1A (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.9%) @ 6(15)nf	10p 129
1K+1%, 1W, Precision Power, ARS-2 (2 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(<< 1%)	10p 129

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
Daven Co., The				
0.1K+0.5% Mil-R-9444 (USAF) AFRT 19E100ROD (3ea)	4.5(10)	6.4(13)nf	Resistance(+0.4%) @ 1(12)nf	2p 129,117
0.1K+0.5% Mil-R-9444 (USAF) AFRT19J100ROD (3ea)	4.5(10)	6.4(13)nf	Resistance(-0.7%) @ 2.3(13)nf Blistered	2p 117, 135
10K+1% AFRT Series (4ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.07%) @ 6(15)nf	10p 129 32p 3, Fig.28
360K+0.5% Mil-R-9444 (USAF) AFRT 19J36002D (3 ea)	4.2(10)	6.1(13)nf	Resistance(-0.3%) @ 5.2(12)nf	2p 136,117
360K+0.5% Mil-R-9444 (USAF) AFRT 19E 36002D (3ea)	4.5(10)	6.4(13)nf	Resistance(-0.3%) @ 3.1(13)nf	2p 131,117
1 Meg+0.5% Mil-R-9444 (USAF) AFRT 19E 10003D (3ea)	3.4(10)	3.6(13)nf	Resistance(-2.2%) @ 1.3 (13)nf	2p 133,117
1 Meg+ 0.5% Mil-R-9444 (USAF) AFRT 19J 10003D (3ea)	2.5(10)	3.6(13)nf	Resistance(+3.5%) @ 7.4(11)nf	2p 139,117

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
<u>International Resistance Co.</u>				
20 ~~W~~ RW33G20R0 (4 ea)	3(10)	2.2(15)ne	Resistance(+9.41%) @ 1.9(14)nf	1p 410, 691
20 ~~W~~ +5%, 1W Mil-R-26C RW31G20R0 (4 ea)	2.6(10)	7.4(14)ne	Resistance(+12.5%) @ 4.1(13)ne	2p 53, 49
0.1K RB17AE100R0F (4 ea)	3.1(10)	1.2(15)ne	Resistance(+0.49%) @ 9.6(13)ne, 1 ea. operated intermittent	1p 271, 689
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+0.3%) @ 8.8(14)ne	1p 394, 691
0.2K+5%, 18W Mil-R-26C RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1.1%) @ 1.54(15)ne	2p 74, 49
0.2K+5%, 38W Mil-R-26C RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance(-0.2%) @ 1.26(15)ne	2p 94, 50
0.314K+0.05% Type 208A	7.5(9)	3.7(15) (E > 1Mev)	Resistance(-0.06%) @ 2.63(13)nf, Rec. for Low Pwr. Nuc. environ- ment	12p 160 11p 25, 23
1K RB 17AE10000F(4 ea)	1.8(10)	6.5(14)ne	Resistance(+0.19%) @ 3.5(14)ne, 1 opened in-pile	1p 280, 689
1K+1%, 3W @ 25°C Mil-R-26C P/N AS2 (1 ea)	6.3(10)	4.2(16) (E > 1Mev)	Resistance(+7.3%) @ 8.58(13)nf	12p 164

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
I R C con't				
2K+5%, 38W Mil-R-26C RW35G202 (4 ea)	3.3(10)	1.5(15)ne	Resistance(-0.2%) @ 1.1(13)ne	2p 100, 50
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance(+1%) @ 1.24(15)ne	1p 417, 691
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+0.65%) @ 5.9(14)ne	1p 403, 691
10K+1%, 2W WW-2-J, RB16AE1002F (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(0.0%)	22p 3, 33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.3%) @ 1.35(10)ergs/gm-(C)	23p 19, 48, 59
10K+5%, 2W RW32G1002, Type 2C (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(0.0 %)	22p 3, 33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.6%) @ 2.3(10)ergs/gm-(C)	23p 19, 48, 59
20K+5%, 10W, Mil-R-26C, RW31G203 (4ea)	3.4(10)	1.9(15)ne	Resistance(0.0%)	2p 58, 49
20K+5%, 38W Mil-R-26C RW35G203 (4 ea)	3.8(10)	2.4(15)ne	Resistance(+0.7%) @ 2(15)ne	2p 49, 102
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance(-2.5%) @ 1.8(14)ne	1p 424, 691
100K RB17AE10002F (4 ea)	2.9(10)	9.6(14)ne	Resistance(-0.99%) @ 9.6(13)ne	1p 291, 689

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
<u>Kelvin Electric Co.</u>				
10K+1%, 0.1W EP Series (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance << 1%	10p 127, 4 36 Fig. 32
11K+1%, $\frac{1}{4}$ W EP Series (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance (-5.17%) @ 1.5(13)nf	10p 127, 4
<u>Mepco, Inc.</u>				
0.1K RB17AE100ROF (4 ea)	3.1(10)	1.2(15)ne	Resistance (+3.94%) @ 8.8(14)ne	1p 271, 689
0.1K+ $\frac{1}{2}$ %, Mil-R-9444 AFRT14E100ROD (6 ea)	3.9(10)	5.7(13)ne	Resistance (+0.62%) @ 1.5(13)ne	2p 119, 117
0.1K+ $\frac{1}{2}$ %, Mil-R-9444 AFRT14J100ROD (6 ea)	3.9(10)	5.7(13)ne	Resistance (+0.6%) @ 3.8(13)ne, Blistered	2p 122, 117
0.1K+ $\frac{1}{2}$ %, Mil-R-9444 AFRT14K100ROD (3 ea)	4.5(10)	6.4(13)ne	Resistance (+0.3%) @ 1(13)ne, Blistered	2p 117, 125
0.1K+ $\frac{1}{2}$ %, Mil-R-9444 AFRT19E100ROD (3 ea)	4.5(10)	6.4(13)ne	Resistance (+0.4%) @ 1(13)ne, Blistered	2p 117, 128
0.1K+ $\frac{1}{2}$ %, Mil-R-9444 AFRT19J100ROD (3 ea)	4.5(10)	6.4(13)ne	Resistance (+0.5%) @ 2.26(13)ne, Blistered	2p 117, 134
1K RB17AE100OF (4 ea)	1.8(10)	6.5(14)ne	Resistance (+0.79%) @ 3.7(14)ne	1p 280, 689
100K RB17AE10002F (4 ea)	2.5(10)	9.6(14)ne	Resistance (-0.89%) @ 4.1(14)ne	1p 291, 689

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
Mepco con't				
360K $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14E36002D (6 ea)	3.9(10)	5.7(13)ne	Resistance(+0.9%) @ 4.4(12)ne, Blistered	2p 120, 117
360K $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14J36002D (6 ea)	4.6(10)	6.6(13)ne	Resistance(-0.4%) @ 1.2(13)ne, one opened	2p 117, 123
360K $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14K 36002D (6ea)	4.5(10)	6.4(13)ne	Resistance(-1.1%) @ 2.26(13)ne	2p 117, 126
360K $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT19E36002D (3 ea)	4.5(10)	6.4(13)ne	Resistance(-0.3%) @ 3(13)ne	2p 117, 130
360K $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT19J36002D (3 ea)	4.2(10)	6.1(13)ne	Resistance(-0.4%) @ 5.2(12)ne	2p 117, 137
1 Meg $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14E10003D (5 ea)	3.9(10)	5.7(13)ne	Resistance(+3.2%) @ 4.7(13)ne	2p 117, 121
1 Meg $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14J10003D (6 ea)	4.5(10)	6.4(13)ne	Resistance(-1.5%) @ 3.1(13)ne	2p 117, 124
1 Meg $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT14K10003D (6 ea)	4.6(10)	6.6(13)ne	Resistance(-3.6%) @ 3(13)ne, 1 opened in-pile	2p 117, 127
1 Meg $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT19E10003D (3 ea)	3.4(10)	3.6(13)ne	Resistance(-2%) @ 1.3(13)ne	2p 117, 132
1 Meg $\pm\frac{1}{2}\%$, Mil-R-9444 AFRT19J10003D (3 ea)	2.5(10)	3.6(13)ne	Resistance(+3.5%) @ 1.1(12)ne	2p 117, 138

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
Resistors, Wire wound				
Ohmite Manufacturing Co.				
20 Ω RW33G20R0 (4 ea)	3(10)	2.3(15)ne	Resistance(+15.06%) @ 1.27(15)ne	1p 470, 691
20 Ω +5%, 38W RW35G200 (3 ea)	3.7(10)	2.3(15)ne	Resistance(-3.4%) @ 1.7(15)ne	2p 89, 49
20 Ω +5%, Mil-R-26C RW31G20R0 (4 ea)	2.6(10)	7.4(14)ne	Resistance(+6.9%) @ 4.1(13)ne	2p 54, 49
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+2.34%) @ 5.4(14)ne, 1 opened in-pile	1p 394, 691
0.2K+5%, 18W Mil-R-26C, RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+4.4%) @ 1.54(15)ne	2p 75, 49
0.2K+5%, 26W, Mil-R- 26C, RW33V201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1.2%) @ 1.3(15)ne	2p 82, 49
0.2K+5%, 38W Mil-R-26C, RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance(+1.2%) @ 1.57(15)ne	2p 50, 92
0.2K+5%, 14W Mil-R-26C, RW31V201 (3 ea)	4.4(10)	2.3(15)ne	Resistance(+2.9%) @ 1.92(15)ne	2p 49, 63
0.2K+5%, 55W Mil-R-26C, RW35V201 (3 ea)	3.5(10)	1.4 (15)ne	Resistance(+4.1%) @ 1.3(15)ne	2p 50, 106
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance(+1.5%)	1p 417, 691
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+1.75%) @ 5.4(14)ne, 2 opened in-pile	1p 403, 691

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Resistors, Wire wound</u>				
<u>Ohmite con't</u>				
2K+5%, 14W Mil-R-26C, RW31V202 (4 ea)	3.5(10)	1.8(15)ne	Resistance(+1%) @ 1.3(15)ne	2p 49, 68
2K+5%, 26W Mil-R-26C, RW33V202 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1 %) @ 1.53(15)ne	2p 49, 85
2K+5%, 38W Mil-R-26C, RW35G202 (4 ea)	3.3(10)	1.5(15)ne	Resistance(+1.15%) @ 8.9(14)ne	2p 96, 50
2K+5%, 55W Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance(+4.1%) @ 9.6(14)ne	2p 110, 49
6K+1%, 1W Size A Mil-R-26C, Mil-R-10509-C, Type 88A (1 ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-0.78%) Recommended for low Pwr. Nuc. Environ- ment	12p 162 11p 25
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance(+0.9%)	1p 424, 691
20K+5%, 55W, Mil-R-26C, RW35V203 (4 ea)	3.8(10)	2.4(15)ne	Resistance(+3.8%) @ 1(15)ne	2p 112, 50
<u>Resistors, Inc.</u>				
2K+5%, 14W Mil-R-26C, RW31V202 (4 ea)	3.2(10)	1.6(15)ne	Resistance(-1%) @ 1.1(14)ne	2p 70, 49

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Sprague Products Co.</u>				
20 Ω +5%, 14W, Mil-R-26C, RW31Y20R0 (4 ea)	4.8(10)	3.1(15)ne	Resistance (+0.3%) @ 2.4(14)ne	2 p. 49, 61
20 Ω +5%, 26W, Mil-R-26 C, RW 33V20R0 (4 ea)	3.1(10)	1.9(15)ne	Resistance (-2.8%) @ 8.6(14)ne	2 p. 49, 79
20 Ω +5%, 55W, Mil-R-26C, RW35V20R0 (4 ea)	4(10)	3.1(15)ne	Resistance (+3.9%) @ 7.2(14)ne	2 p. 50, 105
0.1K RB17AE100R0F (4 ea)	3.1(10)	1.2 (15) ne	Resistance (+3.31%) @ 9.3(14)ne	1 p. 272, 689
0.2K +5%, 14W, Mil-R-26C, RW31V201 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+0.25%) @ 1.5(14)ne	2 p. 49, 64
1K RB17AE10000F (4 ea)	1.8(10)	6.5(14)ne	Resistance (+1.58%) @ 5.5(14)ne	1 p. 280, 689
2K +5%, Mil-R-26C K001ohm, 10 NIT (1 ea)	6.3(10)	4.3(16) (E > 1 Mev)	Resistance (+4.1%) @ 8.6(13)nf	12 p. 163 11 p. 25
2K +5%, 14W, Mil-R-26C, RW31V202 (4 ea)	3.5(10)	1.8(15)ne	Resistance (-0.7%) @ 2.8(14)ne	2 p. 69, 49
2K +5%, 55W, Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance (+0.3%)	2 p. 49, 168
20K +5%, 10W, Mil-R-26C, RW31G203 (4 ea)	3.4(10)	1.8(15)ne	Resistance (+0.1%) @ 8.2(14)ne	2 p. 49, 56
20K +5%, 14W, Mil-R-26C, RW31V203 (3 ea)	4.4(10)	2.3(15)ne	Resistance (-2.3%) @ 4.6(11)ne	2 p. 72, 49
20K +5%, 26W, Mil-R-26C, RW33V203 (4 ea)	3.1(10)	1.9(15)ne	Resistance (+0.2%) @ 8.3(14)ne	2 p. 88, 49
100K RB17AE10002F (4 ea)	2.5(10)	9.6(14)ne	Resistance (-0.99%) @ 1.46(14)ne	1 p. 291, 689
2K $\pm$ 5%, 26W, Mil-R-26C, RW33V202 (4ea)	4.1(10)	2.4(15)ne	Resistance (+0.4%) @ 3(14)ne	2 p. 49, 84

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Truohm Products Div.</u> <u>Model Eng. and Manuf.</u> <u>Co.</u>				
20 Ω RW33G20RO (4 ea)	3(10)	2.3(15)ne	Resistance (-4.92%) @ 1.7(14)ne	1 p. 410, 691
20 Ω +5%, 10W, Mil-R-26C, RW31G20RO (4 ea)	2.6(10)	7.4(14)ne	Resistance (-1%) @ 1.04(13)ne	2 p. 55, 49
20 Ω +5%, 14W, Mil-R-26C, RW31V20RO (4 ea)	4.8(10)	3.1(15)ne	Resistance (+0.3%) @ 1.25(15)ne	2 p. 60, 49
20 Ω +5%, 26W, Mil-R-26C, RW33V20RO	3.1(10)	1.9(15)ne	Resistance (+8.7%) @ 1.3(15)ne	2 p. 49, 78
20 Ω +5%, 38W, Mil-R-26C, RW35G200 (4 ea)	3.7(10)	2.2(15)ne	Resistance (-0.5%) @ 2(14)ne	2 p. 90, 50
20 Ω +5%, 55W, Mil-R-26C, RW35V20RO (4 ea)	4(10)	3.1(15)ne	Resistance (+5.3%) immediately	2 p. 104, 50
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance (+1.66%) @ 5.4(14)ne	1 p. 394, 691
0.2K +5%, 14W, Mil-R-26C, RW31V201 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+2.2%) @ 1.9(15)ne	2 p. 49, 66
0.2K +5%, 18W, Mil-R-26C, RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+4.3%) @ 1.5(15)ne	2 p. 49, 76
0.2K +5%, 26W, Mil-R-26C, RW33V201 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+1.3%) @ 1.3(15)ne	2 p. 49, 80
0.2K +5%, 38W, Mil-R-26C, RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance (+0.4%) @ 1.6(14)ne	2 p. 50, 93
0.2K +5%, 55W, Mil-R-26C, RW35V201 (3 ea)	3.5(10)	1.4(15)ne	Resistance (-1.1%) @ 1.1(15)ne	2 p. 50, 107
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance (+1.73%) @ 5.9(14)ne, 2 shorted in-pile	1 p. 403, 691
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance (+1.6%) @ 1.45(15)ne	1 p. 417, 691

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Truohm Cont'd</u>				
2K +5%, 14W, Mil-R-26C, RW31V202 (4 ea)	3.2(10)	1.6(15)ne	Resistance (+1.2%) @ 1.1(15)ne	2 p. 67, 49
2K +5%, 26W, Mil-R-26C, RW33V202 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+1%) @ 1.5(15)ne	2 p. 83, 49
2K +5%, 38W, Mil-R-26C, RW35G202 (4 ea)	3.3(10)	1.4(15)ne	Resistance (+1.21)@ 1(15)ne	2 p. 50, 98
2K +5%, 55W, Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance (+3.6%) @ 9.4(14)ne	2 p. 49, 109
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance (+1.9%)	1 p. 424, 691
20K +5%, 10W, Mil-R-26C, RW31G203 (4 ea)	3.4(10)	1.9(15)ne	Resistance (+3.7%) @ 1.7(15)ne	2 p. 49, 57
20K +5%, 14W, Mil-R-26C, RW31V203 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+4%) @ 1.95(15)ne	2p. 71, 49
20K +5%, 26W, Mil-R-26C, RW33V203 (4 ea)	3.1(10)	1.9(15)ne	Resistance (+4.59%)	2 p. 87, 49
20K +5%, 55W, Mil-R-26C, RW35V203 (4 ea)	3.8(10)	2.4(15)ne	Resistance (+3.3%) @ 2(15)ne	2 p. 113, 50
<u>Ultronix, Inc.</u>				
1K +0.1% 102P-AA	3.9(8)		Resistance(-1.52%) @ 4.7(6)ergs/gm-(C)	12p. 147
1K +0.1% 102P-AA	1.8(10)	1.4(15) (E > 2.9 Mev)	Resistance (0.0%)	12 p. 151

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Ultronix, Inc. Cont.				
100K +0.1% 102P-MB	3.9 (8)		Resistance (0.0%)	12 p. 147
100K +0.1% 102P-MB	1.8(10)	1.4(15) (E > 2.9 Mev)	Resistance (0.0%)	12 p. 152

2.23 SEMICONDUCTOR DEVICES

2.23.1 DIODES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor De- vices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Bell Telephone Labs</u>				
Diff. junction (zinc)(1 ea.)		4.6 (15) (E>0.1 Mev)	Forward Bias (+19.4%) Reverse V (+20.5%)	17 p 135
Magnesium - doped, Tin Alloyed junction (1 ea.)		4.6 (15) (E>0.1 Mev)	Forward Bias (+43.5%) & Reverse V (37.5%) @ 2.2 (15)nf	17 p 145
<u>Bomac Labs</u>				
1N21B, Si Crystal Rectifier (2 ea)	1.1 (10)	6.6(14)ne	Backward I (+1100%) @ 4.5 (14)ne, Permanent damage	1 p 462-473
<u>CBS Hytron, Div. of Columbia Broadcast- ing System</u>				
1N58 Crystal Rectifier (2 ea.)	3.9(10)	2.4(15)ne	Forward I (-85.5%) Backward I (+7115%) Failed in-pile	1 p 476-484

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
CD3137, Zener Diode (3 ea.)	1(9)	6.8 (15) (E>0.1 Mev)	Zener V @ 100 μ A (-36.3%) @ 5.4 (15) nf, Knees round	10 p 11, 77, 113 36 Fig. 31
CD 3147 Zener Diode (2 ea)	1(9)	6.8(15) (E>0.1 Mev)	Zener V @ 100 μ A (-6.4%) @ 2(13) nf, Knees Round	10 p 11, 77, 113 36 Fig. 30
CD 4113, Zener Diode, Temp. Compensated (2 ea)	1(9)	6.8(15) (E>0.1 Mev)	Zener V @ 100 μ A (-41%) @ 5.4(15)nf, Knees Round	10 p 11, 77, 113 36 Fig. 29
<u>Fairchild Semi- Conductor Corp.</u>				
FD204 Diode (4 ea)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (+185%)	10 p 10, 75, 110 36 Fig. 27
FA 2083 Diode (4 ea)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (-23.8%) @ 5.4(15) nf	10 p 10, 110 36 Fig. 25

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor De- vices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>General Electric Co.</u>				
C35, Si PNP Rectifier (2 ea.)	1.7(7)	7(13) (E>0.1 Mev)	I_{TO} (+1900%) good to ~1(14)nf	16 p 121-131
C5B139, Si Controlled Rectifiers (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 1(12)nf	10 p 13, 116
2N490 Silicon Unijunction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 5(11)nf	10 p 14, 80 53 p 1
2N491 Silicon Unijunction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 5(11)nf	10 p 14, 80 53 p 1
1N2939 Tunnel Diode (5 ea.)	7.5(9)	6.4(15) (E>0.1 Mev)	I_p (-9%) @ 1(14)nf I_p^v (+122%) V_{fp} (-23%)	10 p 19, 136 139
EN13920A (Graded 2N490) Sil. Uni- junction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed 5(11)nf	10 p 14, 80
6RS7PH 70THB1, 1575 VAC Single phase, half-wave, 1.6ma, Selenium Rectifier (2 ea.)	2.5(10)	1.6(16) (E>1 Mev)	DC Output (+10%)	30 p 181-182
6RS32LBIADH1, 28 Vdc 10A, Single phase, full-wave Selenium Rectifier (1 ea.)	2.5(10)	1.6(16) (E>0.1 Mev)	No changes noted	30 p 181-182

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor De- vices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Kemtron Electron Pds., Inc.</u>				
LN21B Si Crystal Rectifier (1 ea.)	1.1(10)	6.6(14)ne	Backward I (+150%) @ 5(14)ne, Permanent damage	1 p 462-473
<u>Microwave Associates, Inc.</u>				
LN21B Si Crystal Rectifier (1 ea.)	1.1(10)	6.6(14)ne	Backward I (Failed @ 2.2(14)ne	1 p 462-473
MA-159D Si Mixer 1 to 4 KMc (6 ea.)	8.7(10)	2.1(16) (E>1 Mev)	Still Operational at end of test, gradual degradation	30 p 91-106
<u>Motorola, Inc.</u>				
LN943, Si Reference Diode, Temp. Com- pensated (5 ea.)	9(8)	8(15) (E>0.1 Mev)	Zener V @ 2.5 ma (+37.2%) Rounding of "breaking point" @ 4.7(14)nf, Zener V changes appreciably @ 3(15)nf	10 p 11, 77, 114 53 p 2
<u>Pacific Semicon- ductors, Inc.</u>				
PD105 Diode (3 ea.)	1.8(10)	7.9(15) (E>1 Mev)	Forward I @ 2V (-94.2%) @ 2.6(15)nf, Reverse I @ 23.5 V (-94%) @ 2.8(15)nf	12 p 124-126
PC115, Alloyed Si, Abrupt Junction type (3 ea.)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (+425%)	10 p 110 36 Fig. 2

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor De- vices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Pacific Semicon- ductors, Inc. (con't)</u>				
PD-400 Diode (1 ea.)	3.9(8)		Forward I @ 1v (-23.5%) @ 2.4(6) ergs/gm -(C), Re- verse I (-50%)	12 p 115
PD-400 Diode (1 ea.)	1.9(10)	1.4(15) (E>2.9 Mev)	Forward I @ 1v (-78.6%), Reverse I (+1300%)	12 p 119
PD-400 Diode (3 ea.)	1.8(10)	7.9(15) (E>1 Mev)	Forward I (+7.1%) Reverse I (-96%)	12 p 130-132
<u>RCA</u>				
Experimental GaAs Tunnel Diodes, Ceramic-to-Metal Seals (7 ea.)	2.7(11)	2.4(17) (E>1 Mev)	Excessive Leakage I @ 6.5 (14)nf	30 p 141
<u>Sylvania Electric Products</u>				
1N21B Si Crystal Rectifier (2 ea.)	1.1(10)	6.6(14)ne	Backward I (Failed) @ 2.2(14)ne	1 p 462-473
1N58 Crystal Rectifier (2 ea.)	3.9(10)	2.4(15)ne	Forward I (one failed) @ 2.3(14)ne, Backward I (one failed) @ 1(15)ne	1 p 476-484
1N263, Ge Crystal Mixer, 12 KMc (max) (6 ea.)	6(10)	1.6(16) (E>1Mev)	Still operational at end of test, degraded Signal	30 p 91-106

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor De- vices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2} \text{ (C)}$	$\frac{n}{\text{cm}^2}$		
<u>Texas Instruments, Inc.</u>				
TI-2 Silicon Diode (1 ea.)	5.8(9)	2.9(15) (E>1Mev)	Forward I (-8.2%) Reverse I (+~150%)	12 p 123
<u>Transitron Electronic Corp.</u>				
1N690 Diode (3 ea.)	1.8(10)	7.9(15) (E>1Mev)	Forward I (+14.3%) Reverse I (-89.4%)	12 p 127-129
1N919 Si Diode (4 ea.)	6.4(10)	3.4(16) (E>1Mev)	Forward V drop (+22,013%)	12 p 136
SG 1537 Diode (3 ea.)	1.8(10)	7.9(15) (E>1Mev)	Forward I (-68.3%) Reverse I (-88.4%)	12 p 133-135
<u>Westinghouse Electric Corp.</u>				
Experimental gallium - phosphide Diodes (2 ea.)		1.1(16) (E>0.1 Mev)	Reverse V (+391%) Forward V (+69.6%)	17 p 138
Experimental Si- Carbide Rectifiers (1 ea.)	6.3(9)		Reverse V breakdown (-7.2%), Reverse Bias I (-31%)	17 p 127
Experimental Si- Carbide Rectifiers (3 ea.)		3.5(6) (E>0.1 Mev)	Forward V @ 5 ma (+1400%) @ 1.2(16)nf Reverse V beakdown (+2567%)	17 p 133

2.23 SEMICONDUCTOR DEVICES

2.23.2 TEMPERATURE SENSORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Temp. Sensors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Fenwall Electronics, Inc.</u>				
Thermistors Type X-A 10K 100°C (4 ea.)	3.8(9)	7.2(15) (E>2.9 Mev)	Radiation sensitive. All decreased in resistance due to Radiation but no permanent damage	24 p 296-298
X-B 20 Meg 100°C (4 ea.)				
X-C 100 Meg 100°C (4 ea.)				
<u>Gulton Industries</u>				
45 T G-2 Thermistor (4 ea.)	7.3(9)		Decrease in R $\approx$ (30%)	10 p 17, 91, 145
45 T G-2 Thermistor (4 ea.)	7.5(9)	4(15) (E>0.1 Mev)	Decrease in R $\approx$ (50%)	10 p 17, 91,
<u>Micro-Sensors Corp.</u>				
T 101-1000, 1K Temp. Sensor (4 ea.)	7.8(8)	4.4(15) (E>0.1 Mev)	Failed @ 1(13)nf	10 p 21, 145
<u>Texas Instruments Inc.</u>				
TC-1/8-6038 0.22K Temp. Sensing Resistor (2 ea.)	1.5(9)	1(16) (E>0.1 Mev)	Failed @ 5(13)nf, Not Recommended for use in Nuclear Environment	10 p 12, 46, 115 11 p 25

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Semiconductor Devices, Temp. Sensors				
<u>Miscellaneous</u>				
<u>Giannini Controls</u> <u>Corp.</u>				
Model 8643, Photo- Pots	8.5(8)	4.5(15) (E > 1Mev)		10 p 20, 96
(a) Stinted and Powdered			$V_{\text{out}} \begin{cases} +69\% \\ +67\% \end{cases}$	
(b) Single crystal				

2.24

SOLDER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Solder				
MIL Ag 1.5 (97.5% Pb, 1.5% Ag, 1% Sn)			Higher tensile strength than available electronic hardware. High and increasing impact strength at low temperatures; N.B. This appears to be the optimum solder for nuclear environments.	67 P.89

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Autronics Corp.</u>				
400 cps Transfer Switch Type III, 1360 (1ea)	1(9)	1(16) (E>0.1Mev)	Unit failed at 4(12)nf and 5(5) ergs/gm-(C)	10 p 23
" (1ea)	1(8)	6.8(14) (E>0.1Mev)	Drop-out V (475%) Pick-up V (47%) Unit Failed	10 p 159, 23
<u>Giannini Controls Corp.</u>				
Acceleration inte- grating switch. Type 2358 (2 ea)	2(10)	1.5(16) (E>1 Mev)	1 Failed at 1.8(14)nf No effect on other switch	37 p 8
<u>Kinetics Corp.</u>				
Main Power Transfer, Motor Driven, SPDT M362-1, Ser. 0045 (1 ea)	1(9)	5.8 (15) (E>0.1 Mev)	Satisfactory Operation throughout test	10 p 23, 158

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Leach Corp</u> 400 cps Transfer, Type 9410, Serial 123 (1 ea)	1(9)	1(16) (E>0.1Mev)	Satisfactory Operation up to 8 (13)nf and 1(7)ergs/gm-(C)	10 p 23
<u>Micro Switch Div.</u> <u>Minn-Honeywell</u> <u>Regulator Co.</u> Type 1EN1-6	1.5(10)		Satisfactory Performance Teflon Seal-rings deteriorate	33 p 2, 4
Type 1HS1	1.3(10)		No Effects Noted	33 p 2,4
Model 1HT1, H1 Temp	1.1(11)		No effects Noted	71 p 8
Type 1LS1	1.2(10)		No effect on Switch but rubber seals hardened	3 p 2, 3
Type 1SE1-3	1.5(9)		Increase in Operating and release force and pretravel	33 p 2,5
Type 1SM1	1.3(10)		Case material became Brittle-GF Black Phenolic #7345 Resinox	33 p 2,8

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Micro Switch Con't</u>				
Type 2EPZ-E	1.2(10)		Seal Becomes Brittle and Breaks	33 p 2
Type BA-2R	1.3(10)		Black Phenolic (ESO2403) case became Brittle	33 p 2, 7
Type BZ-2R	1.3(10)		Black Phenolic case becomes Brittle	33 p 2, 7
Type V3-1	1.3(10)		GP Rad Malamine 1077-RV22 Melma cover became Brittle	33 p 2, 8
Type V3-1301	1.2(10)		Supramica 555 case became Brittle	33 p 2, 8
<u>Transco Products, Inc.</u>				
SPDT RF Switch 28VDC Type 13730-30 (1 ea)	1.5(9)	8(15) (E>0.1Mev)	Negligible Changes Occurred	10 p 24

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Terminals, Electrical</u>				
<u>Alac, Inc.</u>				
Type 530, Small size composition = Glass-fiber-filled diallyl insulation (6 ea)	9.8(10)	3.1(16) (E>0.5Mev)	All Failed	35 p 10.81
Type 533, Medium Size, Same composition as 530 (6 ea)	9.8(10)	3.1 (16) (E>0.5Mev)	3 Failed, Leakage Resistance decreased by factor of 1 (4)	35 p 10.81
Type 535 Large Size Same composition as 530 (6 ea)	9.8(10)	3.1 (16) (E>0.5Mev)	3 Failed, Leakage Resistance decreased by factor of 1 (4)	35 p 10.81

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
Thermocouple				
Platinum temperature probe, 100 μ at 0°C			Used to measure air temperature. Induced activity precludes damage error analysis. In previous gamma test, error at 3.96 (8) ergs/g-(C) $\sim$ 0.26°C at 0°C.	11 p 21

TRANSDUCERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Atlantic Research Corp.</u>				
Model No. LD-77 Lead Zirconate, piezoelectric, type- Pressure (1 ea)		1(18)nvt	90% loss of output-not suited for high Radiation Fields	58 p 20, 46
Model #LD-80 Lead Zirconate, Piezoelectric pressure type (1ea)		1(17)nvt	Failed, 20-25% Loss of output at 1(16)nt, not suited for high radiation fields	"
<u>Baldwin-Lima- Hamilton Corp.</u>				
Type AB-7 Resistance-Wire Strain Gage (3 ea)	1.9(9)	2.9(13) (E>0.3Mev)	Strain level (-1.8%) at 4(12)nf	41 p 49-55
Type EBDF-7D Resistance-wire Strain gage (3 ea)	5.8(9)	6.1(13) (E>0.3Mev)	Strain Level- Slight drop through- out test, one failure	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Bourns, Inc.</u>				
Model 2421 0-4000 PSID Pressure type (1ea)	2.1(10)	5.4(15) (E>1Mev)	Output error Max. of 25%, No Permanent damage	9 p 78
<u>Century Electronics and Instruments, Inc.</u>				
Model 750X 0-75 psig, Si. strip Element, Pressure (1ea)	6.1(10)	2.7(16) (E>1Mev)	Gradual shift in calibration	30 p 202-217
<u>Consolidated Electro- dynamics Corp.</u>				
Model 4-102A vibration pickup fluid-damaged (6 ea)	4.7(9)	4.9(13) (E>.3Mev)	Sensitivity ($\pm 17\%$) at 2.5(13)nf Damping factor (-20%)	41p 14-24
Model 4-118 Magnetic damping, Vibration Pickup(3ea)	"	"	Response curve ($\pm 5.8\%$)	"
Model 4-312 Element-unbonded Strain gage (0-75psia) Pressure Pickup(3ea)	2.1(10)	7.7(15) (E>0.3Mev)	Output($\pm 4000\%$) at 5.2(15)nf	41 p 36

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>CEC con't</u>				
Type 4-316A Unbonded strain- gauge windings Pressure pickup(1ea)	1(11)		Unaffected by gamma radiation	71 p 16
<u>Dynamic Instrument Co.</u>				
Model P3A1M unbonded strain wire (1 ea)		1(18)nvt	No effects noted	58 p 20
<u>Endevco Corp.</u>				
Model #2501-1000 Ceramic element piezoelectric type (1ea)		1(18)nvt	93% loss of output	58 p 20
<u>Erich Brosa</u>				
Model 6014 quartz Piezoelectric (1ea)		1(17)nvt	10% loss of first Peak at 1(16)nvt	58 p 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Fairchild Controls Corp.</u>				
Model 747E Double Angular position, potentiometer type (1ea)	3.1(10)	7.6(15) (E>1Mev)	Failed in-pile due to electrical wire degradation	9 p 78, 82
<u>Giannini Controls Corp.</u>				
Model 45154 0-20 psia, Pressure pickup Potentiometer Actuated (3ea)	3.2(10)	4.5(15) (E>2.9Mev)	Response curve slope at 10 psig (-6%), Internal wiring was brittle	41 p 37-48
Model 46119Y 0-1500 psia, Potentiometer type, Pressure	2.3(10)	6.7(15) (E>1Mev)	1.8% Max deviation	9 p 73, 102
Model 46155-H-D 0-4000 Psid Pressure Responsive Bourdon tube and Potentiometer (1ea)	2.4(10)	5.1(15) (E>1Mev)	Response Degraded 8% at 1.8(15)nf and 8.5(9)ergs/gm-(C) DC 510 silicone fluid Failure	9 p 73

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Giannini Con't</u>				
Model 451218 0-30 Psig NI-Span C Element Potentiometer, Pressure type (lea)	2.9(10)	7.2(15) (E>1Mev)	Output (< 1%) up to 3.3(15)nf, Failure due to unknown origin	9 p 69, 101
Model 461265J 1000 psia Potentiometer output	6.4(10)	2.7(16) (E>1Mev)	Satisfactory Performance, No Malfunctions	30 p 202-217
<u>Kistler Instrument Corp. (SLM)</u>				
Model #PZ-14, Quartz Element Piezoelectric type (lea)		1(18)nvt	No effects Noted	58 p 20
Model 701 Quartz Element Pressure pickup (lea)	1(11)		Very sensitive to Radiation, Not Rec. for use in Radiation Field	71 p 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Markite Corp.</u>				
Model 3108 Double angular Position, pot. type (1ea)	3.1(10)	7.6(15) (E>1 Mev)	Failure due to degradation of Electrical wire Insulation	9 p 78
<u>Nerwood Controls</u>				
<u>Div. Of Detroit Controls</u>				
Model #EPK-1000 Strain Wire Type bonded - 2-arms of bridge element (1ea)		1(17)nvt	10% Loss of Out- put at 1(16)nvt	58 p 20
<u>Omega Instrument Co.</u>				
Model #21-10 Variable Capacitance Type (1 ea)		1(17)nvt	50% loss of output	58 p 20
<u>Statham Instruments Inc.</u>				
Model PA-217a-1M-350 unbonded 4-armbridge Element, strain wire Type (1 ea)		1(18)nvt	Failed Electrically	58 p 20
Model PA-217ca-1M-350 unbonded 4-armbridge element, strain wire Type (1 ea)		1(17)nvt	No effects noted	58 p 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Transducers</u>				
<u>Trans-Sonics, Inc.</u>				
Model 1301D Bulb Resistance Thermometer, Platinum winding pickup (2ea)	1(11)	3.2(13) ($E > 0.3 \text{ Mev}$)	Response (-22%) at 4(12)nf	41 p 25 - 30
Model 2115 0-150 psia Pressure Type (1ea)	2.3(10)	6.7(15) ($E > 1 \text{ Mev}$)	Max. of 6.5% Output Error, Operated Satisfactorily	9 p 78, 81
<u>Ultradyme Engineer- ing Lab, Inc.</u>				
Model S-3 0-50 psia, inductive sensing element, pressure pickup(3ea)	2.1(10)	7.8(15) ($E > 0.3 \text{ Mev}$)	Output at 50 Psia (-87.7%), permanent radiation damage incurred	41 p 36, 38, 43-46
<u>Wiancko Engineering Co.</u>				
Model PX94 0-1000psig Variable-reluctance, pressure type (1ea)	6.3(10)	2.6(16) ($E > 1 \text{ Mev}$)	(0.5%) zero shift & (-2.8%) slope shift at 1.6(16)nf	30 p 201-217

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Aladdin Electronics</u> Type 02-164 1:10 step-up Epoxy encapsulated Al cased, pulse type (4ea)		4.5(16) (E>0.5Mev)	Wave-forms showed slight degradation, Output V (decrease) Rec. for use in Nuc. Environment	35 p 10.35
<u>Arnold Magnetics Corp.</u> Part #533-769 Encapsulated, 6.3 V 400 cycle, filament XFmr. at 3.5A, 115V single phase Primary Pwr. XFmr.		3.2(16) (E>0.5Mev)	No Physical Damage Resistance & second- ary V-No degradation	35 p 10.130
Part #77-777 hermetically sealed, 500v, 400 cycle Secondary at 100ma, 115V, single phase secondary, Pwr. XFmr.		3.2(16) (E>0.5Mev)	"	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Transformers				
<u>Electron Mfg. Co.</u>				
Encapsulated Type (various elements used in construction make-up)	9.5(9)	3.2(16)ne	No Physical or Electrical damage.	3 p 12-25
Hermetically sealed type (Various elements used in construction make-up)	1.1(10)	3.2(16)ne	Some samples ruptured (wax potted and some asphalt potted is cause of rupture and failure), All electrical parameters remained unchanged.	3 p 12-25
<u>Engineered Magnetics Div. of Gulton Industries, Inc.</u>				
Type #14902 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(1%)	10 p 23, 161
Type #14898 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(37.7% at 150V for #1, #2 (1500%) at 2(14)nf	10 p 23, 160

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Microtran Co., Inc.</u> Type VM5-H(Transistor) Hermetically Sld. Interstage, 5mw, (3ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R(5.3%) Self Inductance(-18%) IR-Pri. To sec. decreased factor~100	4 p 81-97
Type VM 8-H, Hermetically sealed Audio output, 15mw (Transistor)(3ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R(-16%) Self Inductance (25%),IR-Pri. to Sec. decreased factor~100	4 p 81-97
<u>Raytheon Mfg. Co.</u> HTL-T-434-A Power Xfmr, silicone rubber encapsulate (4 ea)	~5(9)	~1(16) (E>0.5Mev)	IR-Pri. to sec. at 600v-decreased factor~100, silicone cracked and flaked off.	4 p 60-80
<u>Schaevitz Engineering Co.</u> Model 200SS-L Linear variable diff. Transformer, (9with cores cycled, 3 with cores locked in null position) (12ea)		5.1(16) (E>0.3Mev)	Insulation on wire disintegrated, Inconclusive due to leads shorting	41 p 29-22

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Transformers</u>				
<u>Stancor (Chicago Standard Transformer Corp.)</u>				
S-16147 Metal case, potted with silicasand Power Xfmr. (4 ea)	~5(9)	~1(16) (E>0.5Mev)	IR-Pri. to sec. at 600v-decreased factor ~100, one drew excessive primary I in-pile	4 p 60-80
S-16148 same as S-16147 without metal case (4ea)	"	"	IR-Pri. to sec. at 600V-decreased factor ~100	"
UM-110, Audio Interstage, 1mw Open frame (3ea)	2.5(10)	1.3(14) (E>0.5Mev)	Primary R(-15%) Self induction(∇ 36%) Primary to core short on all units	4P 81 - 97
UM-112, Audio Hi-Z Input, 1mw, Open frame (3ea)	3.9(10)	2.3(14) (E>0.5Mev)	Primary R(-3.5%) Self Inductance (∇ 420%) IR-Pri. to core decreased factor ~100	"
UM-114 Audio Output, 1mw, open Frame (3 ea)	"	"	Primary R (failed) Self Induction(-28%) Ir-Primary to core decreased factor ~10	"
<u>Sylvania Electric Products, Inc.</u>				
Type 23130, Audio Z =9K ∇ - 10% (11ea)		3.9(16) (E>0.5Mev)	Pri. and Sec. R (small) Inductance (∇ 20%) constitutes failure	35 p 10.131-

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Telex, Inc.</u>				
Telex, Inc.				
Type 11135, Audio Interstage, 1 mw, Open Frame (3 ea)	2.5(10)	1.3(14) (E>0.5Mev)	Primary R (Failed) Self Inductance(-15%) IR-Pri. to core decreased factor ~100	4 p 81-97
Type 11137, Audio Output, 1 mw, Open Frame (3ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R (/5.8%) Self Inductance (-9.5%), IR-Pri. to sec. decreased factor ~10	"
Type 8929, Audio Output, 3mw, open Frame (3ea)	5.1(9)	1.8(16) (E>0.5Mev)	Primary R (/5.9%) Self Inductance(-11%) IR-Pri. to core de- creased factor ~10	"
<u>United Transformer Corp.</u>				
AR-378, Audio Hermetically sealed, Epoxy resin fill, (4ea)	7.6(12)	3.5(16) (E>0.5Mev)	Cases ruptured due to outgassing	35 p 10.133, 3.27
Dot-1-Audio Interstage, 50 mw, Hermetically sealed (3 ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R (/32%) Self Induction(/21%) IR-Pri. to sec- de- creases factor ~100	4 p 81-97
" (3 ea)	2.6(10)	1.3(14) (E>0.5Mev)	Primary R (/13%) Self induction (/23%), IR-Pri. to core decreases factor ~ 100	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>UTC con't</u>				
Dot - 5, audio Output, 100 mw, Hermetically sealed (3 ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R(-2%) Self Inductance (/8%) IR-Pri. to Sec. decreases factor~100	4 p 81-97
Dot-7- Audio Input, 25 mw, Hermetically Sealed (3 ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R (+8.9%) Self Inductance (+15%) IR-Pri. to Sec decreases factor ~10 ³	"
" (3 ea)	4.1(10)	2.5(14) (E>0.5Mev)	Primary R (+13.5%) Self Induction(-15.6%) IR-Pri. to Core decreases factor~100	"

2.30 TRANSISTORS

2.30.1 GERMANIUM

2.30.1.1 NPN

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Texas Instruments, Inc.				
2N797 Mesa (1 ea)	3.9(8)		$\beta/\beta_0(\text{dc}) (-23.3\%)$ @ 7.1(17)ergs/gm-(C)	12 p73
2N797, Mesa (1 ea)	4(9)	2.7(14) (E>2.9Mev)	$\beta/\beta_0(\text{dc}) (+9.14\%)$ @ 7.6(13)nf	12 p79
2N797, Mesa (3 ea)	9.5(9)	4.2(15) (E>2.9Mev)	$\beta/\beta_0(\text{dc}) (-92\%)$	21 p99-101
2N797 Epitaxial	5.9(9)	2.9(15) (E>1 Mev)	$\beta/\beta_0(\text{dc}) (-82.8\%)$ @ 2.8(15)nf	12 pl02

2.30 TRANSISTORS

2.30.1 GERMANIUM

2.30.1.2 PNP

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Bendix Corporation</u>				
EM73327-U, diff. alloy (Graded 2N1653) F_T 600Kc(min) (3 ea)	1(9)	1(16) ($E>0.1\text{Mev}$)	Failed @ 3(13)nf	10 p59
<u>Motorola Semiconductor Products, Inc.</u>				
2N700 Mesa (1 ea)	4(8)		$\beta/\beta_o(\text{dc}) (+9.47\%)$	12 p74
" (1 ea)	5.9(8)	1.5(13) ($E>2.9\text{Mev}$)	$\beta/\beta_o(\text{dc}) (+1900\%)$ @ 1.1(13)nf	12 p80
" (2 ea)	1.1(10)	5(15) ($E>1 \text{ Mev}$)	$\beta/\beta_o(\text{dc}) (-36.7\%)$	12 pl08-109
2N828, Epitaxial Mesa (3 ea)	1.8(10)	7.9(15) ($E>1 \text{ Mev}$)	$\beta/\beta_o(\text{dc}) (-96\%)$ @ 2.6(15)nf	12 pl10-112
2N1561 Mesa (1 ea)	1.8(10)	7.9(15) ($E>1 \text{ Mev}$)	$\beta/\beta_o(\text{dc}) (-55\%)$ @ 1.2(15)nf	12 pl06
<u>Philco Corporation</u>				
2N769 (1 ea)	4(8)		$\beta/\beta_o(\text{dc}) (+100\%)$ @ 6(6) ergs/gm-(C)	12 p75
" (1 ea)	1.4(9)	7.6(13) ($E>2.9\text{Mev}$)	$\beta/\beta_o(\text{dc}) (+764\%)$	12 p81
L-5446 MADT (5 ea)		1(14)nvt	No Serious Damage	75 p47

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Texas Instruments, Inc.</u>				
2N1141 Mesa (1 ea)	1.8(10)	7.9(15) (E>1 Mev)	$\beta/\beta_o(\text{dc})$ (-97%) @ 4.9(15)nf	12 p103
2N1195 Mesa (2 ea)	1.8(10)	7.9(15) (E>1 Mev)	$\beta/\beta_o(\text{dc})$ (-94%) @ 2.9(15)nf	12 p104-105
2N1908, Alloy diff. FT 20 Mc(min) (2 ea)	7.5(9)	1(16) (E>0.1Mev)	Failed @ 4.8(13)nf	10 p65
<u>Western Electric Co., Inc.</u>				
2N599, Diff. Low Power, Hi-speed Switching, Epitaxial (10 ea)		1.4(15) (E>0.1Mev)	Igain (-5.15%) βV_{cs_o} (-77%)	19 p51,53,54
2N599E, Epitaxial Switching (10 ea)		1.4(15) (E>0.1Mev)	Igain (-14.4%) βV_{cs_o} (-58.4%)	19 p51,53,54

2.30 TRANSISTORS

2.30.2 SILICON

2.30.2.1 NPN

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Transistors, Silicon (NPN)				
<u>Cyrstalronics, Inc.</u>				
C652 (Hi Resistance) Field Effect Device (2 ea.)		6.8(14) ($E>0.48$ ev)	94% decrease in Mutual Conduc- tion	62 Fig. 2
C652 (Low Resistance) Field Effect Device (3 ea.)		6.8(14) ($E>0.48$ ev)	83% decrease in Mutual Conduc- tance	62 Fig. 2
<u>Fairchild Semiconduc- tor, Corp.</u>				
2N699, DD Planar. f_T 50 Mc (Min) (3 ea)	1(9)	1(16) ($E>0.1$ Mev)	Failed @ 4.8(13)nf	10 p. 66
2N706, Mesa, (3 ea)	1.8(10)	7.9(15) ($E>1$ Mev)	β/β_0 (dc) (-100%) Failed	12 p. 86-88
2N708, Planar F_T 60 Mc(Min) (3 ea)	~1(8)	8.3(14) ($E>0.1$ Mev)	β/β_0 (-95%)	10 p. 54
2N708, Planar F_T 60 Mc(Min) (1 ea)		2.6(13) ($E>0.1$ Mev)	$\beta = 34\%$ of β_0	36 Fig. 24
2N708, Planar F_T 300 Mc (Min) (2 ea)	7.5(9)	1(16) ($E>0.1$ Mev)	β/β_0 (-80%) @ 1.8(14) nf	10 p. 63
2N709, Planar F_T 600 Mc (Min) (2 ea)	~1(8)	1(15) ($E>0.1$ Mev)	β/β_0 (-85%)	10 p. 54
2N709, Planar F_T 600 Mc(Min) (1 ea)		5(14) ($E>0.1$ Mev)	$\beta = 20\% \beta_0$	36 Fig. 24
2N718A, DD Planar, F_T 300 Mc(Min) (2 ea)	7.5(9)	1(16) ($E>0.1$ Mev)	β/β_0 (-95.7%) @ 2.2(14) nf	10 p. 63
2N718A, DD Planar, F_T 60 Mc(Min) (1 ea)	1(9)	1(16) ($E>0.1$ Mev)	β/β_0 (-34.3%) @ ~5(7)ergs/gm-(C)	10 p. 60
2N917, DD Planar, F_T 500 Mc (Min)(3 ea)		1(15) ($E>0.1$ Mev)	β/β_0 (-90%)	10 p. 53

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Transistors, Silicon (NPN)				
<u>Fairchild Semiconductor Corp. (Cont.)</u>				
2N917 (Cont.)				
" (1 ea)		5(14) (E>0.1Mev)	$\beta = 20\% \text{ of } \beta_0$	36 Fig. 24
2N1613, DD Planar, F_T 60 Mc(min) (2 ea)	~2(6)	2.2(13) (E>0.1Mev)	$\beta/\beta_0 (-80.4\%)$	10 p52
" (2 ea)	5(9)	1(16) (E>0.1Mev)	$\beta/\beta_0 (-92\%) @$ 2.4(14)nf	10 p64,65
"		2(13) (E>0.1Mev)	$\beta = 9\% \text{ of } \beta_0$	36 Fig. 24
<u>General Electric Company</u>				
2N2193A, Epitaxial Planar, F_T 50Mc(min) (4 ea)	5(9)	1(16) (E>0.1Mev)	Failed @ 2(14)nf	10 p64,57
2N2193A, Sandwich Construction (2 ea)		3(12) (E>0.1Mev)	$\beta = 20\% \text{ of } \beta_0$	53 p2
<u>Motorola Semiconductor Products, Inc.</u>				
2N707A, DD Epitaxial Mesa, F_T 70Mc(min) (2 ea)	~1(6)	3.5(13) (E>0.1Mev)	$\beta/\beta_0 (-41\%)$	10 p52
2N707A, Mesa, F_T 500 (1 ea)		3(13) (E>0.1Mev)	$\beta = 65\% \text{ of } \beta_0$	36 Fig. 24

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Motorola Semiconductor Products, Inc. (Cont.)				
2N834, Epitaxial Mesa (2 ea)	1.8(10)	7.5(15) (E>0.1Mev)	$\beta/\beta_0(\text{dc})$ Failed	12 p97,98
Pacific Semiconductors, Inc.				
PT 901, 10 Amp (2 ea)		3.2(14) (E>0.1Mev)	I_c (-48%) @ 1.8(13)nf	17 p63, 98
PT 955, Triple diff. Mesa, (Graded 2N1902) FT 50Mc(min) (1 ea)	7.5(9)	1(16) (E>0.1Mev)	β/β_0 (-68.7%) @ 3.3(13)nf	10 p65
" (1 ea)	8(9)		β/β_0 No change	10 p62
EM-13531-A1 (Graded 2N1259) FT 160Mc(min) (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_0 (-100%), Failed @ 3.3(14)nf	10 p55
EM 13531-A1 (Graded 2N1613) 200Mc (2 ea)		4(12) (E>0.1Mev)	$\beta = 75\%$ of β_0	53 p2
EM74706-U, Triple diff. Mesa, (Graded 2N1893) 50Mc(min) (2 ea)	8(9)		β/β_0 (-52.5%) @ ~8(7)ergs/gm-(C)	10 p60
" (2 ea)	7.5(9)	1(16) (E>0.1Mev)	β/β_0 (-91.5%) @ 1.3(14)nf	10 p63

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Silicon Transistor Corporation				
2N1722, diff. F_T 1Mc (min) (2 ea)	1(9)	1(16) ($E > 0.1 \text{ Mev}$)	Failed @ 9(12)nf	10 p58
" (1 ea)		2(12) ($E > 0.1 \text{ Mev}$)	$\beta = 20\% \text{ of } \beta_0$	53 p 2
Texas Instruments, Inc.				
TI605 (2 ea)	1(9)	1(16) ($E > 0.1 \text{ Mev}$)	β/β_0 (-93%) @ 2(13)nf	10 p52 36 Fig. 24
2N706A, Mesa (3 ea)	1.8(10)	7.9(15) ($E > 1 \text{ Mev}$)	β/β_0 (dc) Failed	12 p89-92
2N753, Mesa (3 ea)	1.8(10)	7.9(15) ($E > 1 \text{ Mev}$)	β/β_0 (dc) Failed	12 p93-96
2N1717, Triple diff. Mesa F_T 16Mc(Min)(4ea)	1(9)	1(16) ($E > 0.1 \text{ Mev}$)	Failed @ 1.2(14)nf	10 p56, 64
" (2 ea)		3(12) ($E > 0.1 \text{ Mev}$)	$\beta = 20\% \text{ of } \beta_0$	53 p2
2N1722, Triple diff. Mesa F_T 10Mc(min)(2ea)	1(9)	1(16) ($E > 0.1 \text{ Mev}$)	Failed @ 5.7(13)nf	10 p58
" (2 ea)		2(12) ($E > 0.1 \text{ Mev}$)	$\beta = 50\% \text{ of } \beta_0$	53 p2
2N1936, Triple diff. Mesa, F_T 7Mc(min)(2ea)	1(9)	1(16) ($E > 0.1 \text{ Mev}$)	Failed @ 7.7(13)nf	10 p56
"		2(12) ($E > 0.1 \text{ Mev}$)	$\beta = 50\% \text{ of } \beta_0$	53 p2

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Western Electric Co., Inc				
2N1060, Epitaxial Switching (10 ea)		2.2(14) (E>0.1Mev)	Igain (-28.4%) @ 6.5(13)nf	18 p47,51
2N1060E, Epitaxial (10 ea)		2.2(14) (E>0.1Mev)	Igain (-27.5%) @ 2.1(14)nf	18 p47,51
2N1675 double Diff. 50W, 10 Amp (5 ea)		2.1(13) (E>0.1Mev)	Igain ($I_c = \frac{1}{2}A$)(-15%) @ 2(13)nf	17 p63,78
2082(prototype of 2N1675) (15 ea)		3.2(14) (E>0.1Mev)	Igain ($I_c = 0.1A$) -20% @ 1.8(13)nf	17 p63,74

2.30 TRANSISTORS

2.30.2 SILICON

2.30.2.2 PNP

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2 \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Transistors, Silicon (PNP)				
Fairchild Semiconductor Corp.				
2N869, Planar DD, F_T 100Mc (Min) (2 ea)	1(9)	1(16) ($E > 0.1\text{Mev}$)	Failed @ 2(13)nf	10 p43
" (1 ea)		4.4(14) ($E > 0.1\text{Mev}$)	$\beta = 4\%$ of β_0	36 Fig. 24
2N1132, diff., F_T 60Mc (min) (2 ea)	1(9)	1(16) ($E > 0.1\text{Mev}$)	β/β_0 (-93%) @ 3.4(13)nf	10 p54
2N1132, Mesa, F_T 100Mc (1 ea)		3(13) ($E > 0.1\text{Mev}$)	$\beta = 12\%$ of β_0	36 Fig. 24
Hughes Aircraft Co.				
EM 74709, DD Mesa, (Graded 2N1259) F_T 40Mc (min) (2 ea)	5(9)	1(16) ($E > 0.1\text{Mev}$)	β/β_0 (-64.3%) @ 4.8(13)nf	10 p66
" (2 ea)		1(13) ($E > 0.1\text{Mev}$)	$\beta = 60\%$ of β_0	53 p2
Philco Corporation				
2N861, Precision Alloy, F_T 75Mc (min) (2 ea)	1(9)	1(16) ($E > 0.1\text{Mev}$)	β/β_0 (-88%) @ 2.3(13)nf	10 p53
" (1 ea)		3.4(13) ($E > 0.1\text{Mev}$)	$\beta = 14\%$ of β_0	36 Fig. 24
2N2187, Precision Alloy, F_T 22Mc(min) (2 ea)	1(9)	1(16) ($E > 0.1\text{Mev}$)	β/β_0 (-91%) @ 1.8(13)nf	10 p52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>Philco Corporation (Cont.)</u>				
2N2187 (Cont.)				
" (1 ea)		4(13) (E>0.1Mev)	$\beta = 6\% \text{ of } \beta_0$	36 Fig. 24
<u>Texas Instruments, Inc.</u>				
2N1385 Mesa (1 ea)	1.8(10)	7.9(15) (E>0.1Mev)	$\beta / \beta_0(\text{dc})(-92\%)$	12 p107
Experimental, Field Effect Device	5.9(9)	2.9(15) (E>1 Mev)	$G_m(\text{umhos})(-98.2\%)$ $G_m/G_{m0}(-98\%)$	12 p85

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>0A2WA</u> Gaseous, Voltage Rectifier				
CBS (Hytron) (3 ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 30 ma dc (+1.6%) @ 2.5(14)ne	1 p435
RCA (3 ea)	"	"	Plate V @ 30 ma dc (+5.5%) @ 2.4(14) ne	1 p435
<u>0B2WA</u> Miniature Voltage Regulator				
Raytheon (3 ea)	3.5(10)	1.2(15) ne 1.2(18) nt	Plate V @ 30 ma dc (-2%) @ 2.5(14) ne	1 p444
Sylvania (3 ea)	"	"	Plate V @ 30 ma dc (< 1%)	1 p444

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>OZ4</u> Full-wave Gas, Cathode Rectifier Raytheon (6 ea)	1.6(10)	5.4(14)ne 5.4(17)nt	Plate I (+17.2%) @ 1.1(13)ne	1 p449
<u>1AD4</u> RF Sharp Cut-off Pentode Raytheon (3 ea)	3.4(10)	1.9(15)ne 1(18) nt	Plate I (+50%) @6.5(14) ne	1 p453-461
Tung-Sol (3 ea)	"	"	Plate I (-50%) @ 5.8(14) ne	"
<u>1B35A</u> Gas Switching Tube (ATR) Bomac & Sylvania (Static)	3.8(10)	4.5(13)nf 1.4(18)nt	Cracks in RF window	2 p390

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}^2(\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>1B63A</u>				
Gas Switching Tube TR (Band Pass)				
Bomac (1 ea)	3.1(9)	1.1(15)ne 7.3(17)nt	Insertion Loss (-73%) @ 2.3(13) ne	2 p394
Bomac (1 ea)	6.5(9)	2.4(15)ne 1.5(18)nt	Keep-Alive I intermittent, RF window cracked	2 p395
Sylvania (2 ea)	6.5(9)	2.4(15)ne 1.5(18)nt	Keep-Alive I - Failed @ 5(13)ne, RF window cracked	2 p395
Sylvania (2 ea)	3.1(9)	1.1(15)ne 7.3(17)nt	Insertion Loss (-88%) @ 1.9(14)ne	2 p394
<u>1Z2</u>				
Half-wave Hi-vacuum Rectifier				
Chatham (6 ea)	3(10)	1(15)ne 1(18)nt	Rectifier Operation in ma dc (+7.3%) @ 7.3(13)ne	1 p489

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
VG 1 A Ionization Gauge with Pyrex Glass (1 ea)		6.6(16) NVT	Completely Shattered	49 p 11, 7
with Type 008 lime glass (1 ea)		3.7(15) NVT	Discolored Prepressure reading 10^{-6} mm but weld opened on collector in-pile	49 p 7, 12
with type 7720 Nonex Glass (1ea)		3.7(15) NVT	Pressure reading changes from 10^{-6} mm to 5×10^{-3} mm	49 p 7, 12
with type 1723 alumino silicate glass (1 ea)		3.7(15) NVT	Pressure reading changes from 10^{-6} mm to 3.7×10^{-3} mm	49 p 7, 12

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>LC-2</u> Ceramic Power Tetrode Eitel-McCullough(4 ea)	3.5(9)	1.3(15)ne 8.2(17)nt	Excessive Screen I, 2 failed in Grid V	2 p555
<u>2C39</u> UHF Triode (hi-mu) Eitel-McCullough(2ea)	7.2(9)	6.7(14)ne 3.7(17)nt	Failed @ 1.7(13)ne due to glass fracture	2 p474
G.E. (Ceramic) (2 ea)	"	"	Plate I (-6.8%) @ 5.3(14)ne, no failures	"
Machlett (2 ea)	"	"	Failed @ 1.7(13) ne due to glass fracture	"
<u>2C40</u> UHF Triode G.E. (6 ea)	4.7(10)	1.7(15)ne 1.6(18)nt	Plate I (-0.118%) Transconductance (-0.7%) @ 4.9(14)ne 1 failed in-pile	1 p494-501

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>2D21W/5727</u> Thyratron-Xenon gas				
G. E. (3 ea)	4.1(10)	2.6(15)ne 1.3(18)nt	Output V (-13%)@ 7.4(14)ne, deionizing time (-40%)@ 9(14)ne 1 failed in pile	2 p414-421
RCA (3 ea)	"	"	Output V (-3.5%) and deionizing Time (+25%) @ 2(14) ne 1 failed in pile	"
Tung-Sol (6 ea) (3 ea) with Cadmium Shields	1.2(11)	2.4(16) (E>0.5 Mev)	Deionizing Time (+14%), 1 failed Plate V (-9%) @ 3.2(15)nf	6 p27, 35, 53
<u>2K50</u> Reflex Klystron, K- Band 23.5 → 24.5KMC				
Bendix (3 ea)	2.5(8)	5.2(13)ne 3.5(16)nt	Failed in-pile immediately due to glass fracture	2 p400-405

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>3B28</u>				
Half-Wave Xenon gas Rectifier				
Chatham (1 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Load I - (+5.3%) @ 3.8(14)ne	2 p450
Chatham (1 ea)	3.2(9)		Output I (+6.2%) @ 6.7(8)ergs/gm-(C)	2 p610
Electronic Enterprises (1 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Load I - failed @ 5.4(14) ne due to glass fracture	2 p450
RCA (1 ea)	3.2(9)		Output I (+11%) @ 2.1(9)ergs/gm-(C)	2 p610
RCA (2 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Both failed in-pile due to glass fracture	2 p450
United Electronics (2 ea)	"	"	One failed in-pile due to glass fracture	2 p450
<u>3CX100A5</u>				
Ceramic Hi-Mu (UHF) Triode				
Eitel-McCullough(3ea)	1.5(10)	3.8(16) (E>0.5Mev)	Cathode V (+800%) @ 3.1(15)nf, Control Grid I (+133%) @ 2.9(16)nf, Survived Irradiation	6 p27,50,53

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>3D21B</u> Pulsed Modulator Pentode CBS-Hytron (3 ea)	1.3(11)	3.8(16) ($E > 0.5 \text{ Mev}$)	Transconductance (-14.5%), Plate V (+39%), Test Leads shorted in-pile on all samples	6 p27,46,53
<u>3E29</u> Dual Tetrode RCA (6 ea) (3 ea cadmium Shielded)	1.2(11)	2.4(16) ($E > 0.5 \text{ Mev}$)	Transconductance (+11%) @ 2.2(15)ne, Glass fracture caused failure on 3 tubes in-pile	6 p27,31,53
<u>4D21</u> Transmitting Type Tetrode Lewis & Kaufman (2 ea)	1.4(9)	3.1(14)ne 1.2(17)nt	Grid V @ 75 ma dc (-250%) @ 1.7(13)ne	1 p511-524
Penta Labs (1 ea)	"	"	Grid V @ 65 ma dc (failed @ 1.9(14)ne)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>4J52A</u> Pulsed Magnetron Frequency - 9375 Mc Litton Industries(2ea) 4(7)		1.1(13)ne 1(16)nt	Both failed due to glass fractures	2 p406
<u>5C22/HT-415</u> Hydrogen Thyatron Kuthe Labs (3 ea) 1.8(9)		4.9(14)ne 3.5(17)nt	Plate I (-10%) @ 1.9(12)ne, All failed @ 3.8(14)ne due to glass fracture	2 p427-430
<u>5R4WGA</u> Duodiode Tung-Sol (4 ea)		7.8(16) NVT	All cracked	49 pl1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>5Y3WGTA</u>				
Full-Wave Rectifier				
CBS-Hytron (3 ea)	3(10)	1.2(15)ne 1(18)nt	Output I (-1.3%) @ 3.8(14)ne	2 p461
Sylvania (3 ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Output I (-2.2%) @ 1.2(13)ne	2 p460
 <u>6AG7Y</u>				
Power Amplifier, Pentode				
G.E. (3 ea)	2.8(9)	2.1(15)ne 9.4(17)nt	Plate I (+7.1%) and Transconductance (+8.5%) @ 7.6(14)ne	1 p525-536
RCA (3 ea)	"	"	Plate I (+14.4%); Transconductance (+10.5%) @ 7.6(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6AK5/5654/6096</u>				
Sharp Cutoff, Miniature Pentode				
G.E. (1 ea)	3(10)	1.4(15)ne 1(18)nt	Plate I (+13%) @ 7(14)ne, Transconductance (-7%) @ 1.7(13)ne	1 p537-547
Raytheon (2 ea)	3(10)	"	Plate I (+36%) @ 1.4(14)ne Transconductance (-10%) @ 1.1(14)ne	"
RCA (2 ea)	"	"	Plate I (+19%) @ 1.4(14)ne Transconductance (-12%) @ 9.2(14)ne	"
Sylvania (1 ea)	"	"	Plate I (+14%) @ 2.9(13)ne, Transconductance (-12%) @ 2.9(13)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Tubes, Electron				
<u>6AL5WA</u>				
Receiving Twin Diode Type				
CBS(Hytron) (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%), Emission I(+19%) @1(14)ne	1p 548-557
GE (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I (+20%)	1p 548-557
RCA (2ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(-1%)@ 2.1(14)ne, Emission I(+200%)	1p 548-557
Sylvania (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I(+10%)@ 1(14)ne	1p 548-557
Tung-Sol (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I(+20%)@ 1.6(15)ne	1p 548-557
<u>6AU6WA</u>				
Sharp Cutoff Mini- ature RF Pentode				
GE (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(-8%)@ 4.8(14)ne Transconductance (+3.3%)@ 2(14)ne	1p 558-568
Sylvania (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(+12%)@ 1.4(15)ne Transconductance (+5%)@ 1.2(15)ne	1p 558-568
Tung-Sol (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(-23%)@ 1.3(15)ne Transconductance (-14%)	1p 558-568

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6BB6/5750</u> Miniature Pentagrid Converter				
GE (6ea)	3.3(10)	1.1(15)ne 1.1(18)nt	Plate I(+5.9)% @ 9(13)ne Screen I(-6.1)%@ 8.1(14)ne Grid V(-14)%@ 3.1(14)ne	1p 569-579
<u>6C4</u> Hi Freq. Medium-Mu Triode				
GE (2ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-31)%@ 1.4(14)ne Emission I(-30)%@ 1.4(14)ne	1p 580-589
RCA (2ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-48)%@ 5.9(14)ne Emission I(-35)%@ 5.6(14)ne	1p 580-589
Tung-Sol (2 ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-30)%@ 7.1(14)ne Emission I(-23)%@ 2.4(14)ne	1p 580-589
<u>6L6WGB</u> Beam Power Amplifier				
Tung-Sol (6ea)	4.6(10)	3 (15)ne 1.4(18)nt	Plate I(+33)%@ 1.9(15)ne Screen I(-24.4)%@ 8.1(14)ne, believed gassy	2p 602-606

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>12WT7WA</u>				
Twin Triode (Mini-ature)				
GE (3ea)	4.4(10)	2.9(15)ne 1.4(18)nt	Plate I(+70.8%)@ 3(14)ne gassy	2p 501-504
Sylvania (3ea)	4.4(10)	2.9(15)ne 1.4(16)nt	Plate I (+38%)@ 1.1(15)ne gassy	2p 501-504
<u>12AU7/6182</u>				
Twin Triode (Mini-ature)				
GE (3ea)	3.2(10)	1.4(15)ne 1.1(18)nt	Plate I(-24.5%)@ 1.5(14)ne	2p 498-500
Sylvania (3ea)	3.2(10)	1.4(15)ne 1.1(18)nt	Plate I(-32.2%)@ 1.5(14)ne	2p 498-500
<u>CD-16</u>				
Twin Triode (Cere-mic)				
Eitel-McCullough (6ea)	3.5(10)	2.1(15)ne 1.2(18)nt	Plate I(+28.5%)@ 1.5(15)ne	2p 506
<u>CD-18</u>				
Miniature Sharp Cut-off Pentode (Cera-mic)				
Eitel-McCullough (4ea)	3.5(10)	1.5(15)ne 1.2(18)nt	Plate I(+66.7%)@ 2.9(14)ne, 1 Failure	2p 569-573

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>SK-221F</u> Reflex Klystron Sylvania (2ea)	8.5(10)	6.2(16) (E>1Mev)	freq.(+0.16%) power output ($\pm$ 11.1%)	30p 83-90
<u>371B</u> HiVacuum Half-Wave Rectifier Electronic Enterprises (3ea)	1.1(9)	5.1(14)ne 2.7(17)nt	Plate I(-88%) 1 Failed in-pile due to glass fracture	2p 453-458
Electronic Enterprises (1ea)	4(9)		Plate I(-2.3%)@ 6.9(8)ergs/gm-(C)	2p 611
United Electronics (1ea)	4(9)		Plate I(-2.4%)@ 6.9(8)ergs/gm-(C)	2p 611
United Electronics (3ea)	1.1(9)	5.1(14)ne 2.7(17)nt	Plate I(+72.5%)@ 2.9(13)ne, 2 failed in-pile due to glass fracture	2p 453-458
<u>4-65A</u> Transmitting Tetrode Eitel-McCullough (6ea)	~8.2(9)	~8(13)ne ~8(16)nt	Grid V - all tubes failed in pile due to glass fracture	1p 590-595

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Tubes, Electron				
<u>583</u> Hi-Vacuum, Clipper, Diode United Electronics (6ea)	2(9)	3.9(14)ne 4.4(17)nt	Plate I(+102%)@ 1.1(14)ne, all had fractured envelopes	1p 596-605
<u>BL800A</u> Klystron Bomac (3ea) (2ea with cadmium shields)	6.8(10)	3.5(16) (E>0.5 Mev)	Beam I(+5%) freq.(-50%) power out (+75%) all survived but silicon rubber anode caps deteriorated	6p 27, 39, 53
<u>829B</u> Push-Pull RF Beam Power Amplifier RCA (6ea)	2(10)	2.4(14)ne 1.4(17)nt	all failed in-pile due to glass fracture	1p 606-612
<u>SN-2146B</u> Metal-Ceramic Pentode Sylvania (5ea)		8.8(15) (E>0.5 Mev)	no change in tube characteristics noted	35p 10.77-81

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Tubes, Electron				
<u>SN-2225A</u> Twin-Triode (Cer- amic)				
Sylvania	6.3(10)	1.6(16) (E>0.5 Mev)	Large Grid I increase, probably not suitable for Nuclear use	35p 10.73-77
<u>5517</u> Half-Wave Rectifier				
Raytheon (5ea)	2.3(9)	6.8(14)ne 8.5(17)nt	Cathode I (+10.4%)@ 4.3(12)ne	2p 447-449
<u>5636</u> Subminiature, dual- control Pentode				
GE (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-52.7%) & Screen I(-57.2%)@ 3.1(13)ne	2p 586-591
Sylvania (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-32%) & Screen I(-37%)@ 3.1(13)ne	
Tung-Sol (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-29%) & Screen I(-35%)@ 3.1(13)ne	2p 586-591

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electror	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>5639</u> Subminiature Video Amplifier; Pentode				
Raytheon (3ea)	4.5(10)	2.5(15)ne 1.6(18)nt	Plate I(+16.4%)@ 1.5(15)ne	2p 557-561
Sylvania (3ea)	4.5(10)	2.5(15)ne 1.6(18)nt	Plate I(-17.4%)@ 1.7(15)ne	2p 557-561
<u>5643</u> Subminiature Thyatron Gas Tetrode				
Sylvania (6ea)	1.1(10)	9.1(14)ne 4.8(17)nt	Plate I(-3.4%)@ 1.5(14)ne, two failed in-pile	1p 613-620
<u>5651</u> Voltage Reference Tube				
Raytheon (3ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 3.5 mAdc (+5%) @ 9(14)ne,	1p 621-629
RCA (3ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 3.5 mAdc (+2.5%) @ 8.3(14)ne	1p 621-629

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(\text{C})}$	$\frac{n}{\text{cm}^2}$		
Tubes, Electron				
<u>5670</u>				
Miniature Medium-Mu, Twin Triode				
GE (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+36%)@ 3.7(14)ne, gassy	2p 518-525
Sylvania (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+28.5%)@ 2(15)ne, gassy	2p 518-525
Tung-Sol (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+66.6%)@ 2(15)ne, gassy	2p 518-525
<u>5687</u>				
Miniature, Low-Mu, Twin Triode				
Tung-Sol (6ea)	3.1(10)	1.8(15)ne 1 (18)nt	Plate I(-22.2%)@ 1.3(15)ne	2p 508-510
<u>5702</u>				
Sharp Cut-off Pen- tode				
Raytheon (12ea)	3.1(9)	7.6(13) (E>2.9 Mev)	Plate I(-5%)@ 4.1(12)nf	22p 3, 46
Raytheon (12ea)	3.9(10)	8.6(15) (E>2.9 Mev)	Plate I(+6%)@ 1.4(15)nf	23p 19, 32

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>57C3WA</u> Subminiature Triode Raytheon (6ea)	2.9(10)	1.9(15)ne 9.4(17)nt	Cathode I(-4.7%)@ 3.7(14)ne, Transcon- ductance (-24%)@ 8.3(14)ne	2p 483-486
<u>5718</u> Subminiature Triode GE (1ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(+17.5%)@ 7.6(13)ne	1p 630-636
RCA (2ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(-18%)@ 6.6(14)ne	1p 630-636
Sylvania (2ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(-13.8%)@ 8.3(14)ne	1p 630-636
<u>5712</u> Subminiature Triode GE (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(+12.5%) 3.6(14)ne, Trans- conductance (-12.4%) @ 1.3(15)ne	2p 487-495
RCA (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(-14%)@ 1.3(15)ne Transconductance (-16%)@ 1.3(15)ne	2p 487-495
Sylvania (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(-25%) & Transconductance (-25%)@ 1.3(15)ne	2p 487-495

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>5725/6AS6W</u>				
Miniature Sharp Cut-off, Dual Con- trol Pentode				
GE (3ea)	4.1(10)	2.6(15)ne 1.4(18)nt	Plate I(-20.7%) & Screen I(-28%) @ 2(15)ne	2p 581-585
Tung-Sol (3ea)	4.1(10)	2.6(15)ne 1.4(18)nt	Plate I(-22.8%) & Screen I(-45.4%)@ 2(15)ne	2p 581-585
<u>5744WA</u>				
Subminiature Hi-Mu Triode				
Raytheon (6ea)	4(10)	2.4(15)ne 1.3(18)nt	Plate I(-19%)@ 6.8(13)ne	2p 480-482
<u>5751WA</u>				
Miniature Hi-Mu Twin Triode				
GE (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+50%)@ 1.8(15)ne	2p 511-517
Sylvania (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+50%)@ 1.8(15)ne	2p 511-517
Tung-Sol (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+57.1%)@ 1.5(15)ne	2p 511-517

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}-(C)}$	$\frac{n}{\text{cm}^2}$		
<u>5814WA</u> Miniature Medium-Mu Twin Triode				
G.E. (1 ea)	4.3(10)	1.8(15)ne 1.5(18)nt	Plate I(-33.9%) at 9.2(14)ne, possibly gassy	2 p 527-533
Sylvania (2 ea)	"	"	Plate I (-25%) at 9.1 (14)ne	"
Tung-Sol (2 ea)	"	"	Plate I (18%) at 7.4(14)ne	"
<u>5819</u> Photo-Multiplier				
RCA	2.2(7) ergs/gm -(C)-hr		40.3 ma Anode current	9 p 91
<u>5829</u> Dual Diode				
Raytheon (12ea)	3.1(9)	7.6(13) (E>2.9Mev)	I_p/E_p Ratio (0.0%)	22 p 3, 48
Raytheon (12ea)	3.9(10)	8.6(15) (E>2.9Mev)	Plate I (1%) at 2.9(15)nf	23 p 19, 33

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Tubes, Electron				
<u>5840 (6205)</u>				
Subminiature Sharp-cutoff Pentode				
GE (2 ea)	6.6(10)	4.4(15)ne 2.1(18)nt	Plate I(-19.2%) and screen I(+16%) @ 2.4(12)ne, gassy	2 p 574-580
RCA (2 ea)	"	"	Plate I(-22.4%) and screen I(+15%) @ 2.4(12)ne	2 p 574-580
Sylvania (2 ea)	"	"	Plate I (+25.6%) and screen, I(+18.2%) @ 2.4(12)ne, gassy	"
<u>5876</u>				
Subminiature pencil Type, UHF Triode				
RCA (6 ea)	5.9(10)	3.3(15)ne 2.1(18)nt	Plate I(-19%) at 1.7(15)ne, all gassy	2 p 477-479
<u>5896</u>				
Subminiature dual diode				
GE (1 ea)	3.7(10)	1.2(15)ne 1.2(18)nt	Output V (-0.5%) at 8.6(13)ne, Emission I (-28%) at 1.1(15)ne	1 p 648-659
Sylvania (3ea)	"	"	Output V(-1%) at 7.6(13)ne, Emission I (+15%)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>5899A</u> Subminiature semi-re- mote cutoff Pentode				
GE (2ea)	4.8(10)	3.2(15)ne 1.6(18)nt	Plate I(21%) at 3.6(14)ne, Screen I (25%) at 2.5(15)ne	2 p 562-568
Sonotone (2 ea)	"	"	Plate I(-30%) at 2.5(15)ne, Screen I (-13.6%) at 2(15)ne, All failed to Survive Irradiation	"
Sylvania (2ea)	"	"	Plate I(-7%) and Screen I (-8.3%) at 7.2(14)ne	"
<u>5902</u> Subminiature Pentode (Beam Pwr.)				
GE (3ea)	3.3(10)	2.6(15)ne 1.4(18)nt	Plate I(-9.1%) at 1.4(14)ne, Screen I (-19%)	1 p 660-671
" (3ea)	3.1(9)	7.6(13) (E>2.9Mev)	Plate I (5%) at 2.2(13)nf	22 p 3, 44
GE and Sylvania (12ea)	3.9(10)	8.6(15) (E>2.9Mev)	Plate I(5%) at 6.6(15)nf	23 p 19, 30
Sylvania (6ea)	3.1(9)	7.6(13) (E>2.9Mev)	Plate I(5%) at 2.2(13)nf	22 p 3, 44
" (3ea)	3.3(10)	2.6(15)ne 1.4(18)nt	Plate I(-13%) Screen I (-19%) at 1.9(15)ne	1 p 660-671

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>5903</u> Dual diode (UHF) Sylvania (3ea)	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Turned Brown but no other Damage	35 p 10.71-73
<u>5907</u> Remote Cut-off Pentode Sylvania (3ea)	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Brown, No other damage	35 p 10.71-73
<u>5908</u> Sharp Cut-off, dual control pentode Sylvania (3ea)	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Brown, No other damage	35 p 10.71-73
<u>5993</u> Miniature, full-wave, hi-vacuum rectifier Bendix (6 ea)	3(10)	1.3(15)ne 1(18)nt	Output I(-1.3%) at 1.4(13)ne, All survived	2 p 463

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6005/6AQ5</u> Miniature beam power pentode				
GE (6ea)	3.6(10)	1.6(15)ne 1.3(18)nt	Plate I(-37%) at 1(15)ne, Screen I (-16.7%) at 3.5(14)ne one failed in-pile	2 p 593-595
<u>6021</u> Subminiature Medium Mu twin triode				
GE (1ea)	3.7(10)	2.3(15)ne 1.2(18)nt	Plate I(-37%) at 7.3(14)ne	2 p 534-536
Raytheon (2 ea)	"	"	Plate I(-180%) at 3.7(14)ne; gassy	"
Sylvania (2 ea)	"	"	Plate I(-61.4%) at 1.7(15)ne	2 p 534-536
" (11ea)	3.1(9)	7.6(13) (E>2.9Mev)	I_p/E_p Ratio(-5%) at 1.8(12)nf	22 p 3, 47
GE, Raytheon and Sylvania (12 total)	3.9(10)	8.6(15) (E>2.9Mev)	Plate I(-3%) at 2.7(15)nf	23 p 19, 31

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6080</u> Low-Mu Twin Triode				
RCA (6ea)	2.5(10)	8.2(14)ne 8.2(17)nt	Cathode V (-2.4%) at 2.7(13)ne	1 p 672-679
<u>6111</u> Subminiature Med-Mu Twin Triode				
GE (3 ea)		3(17)nt	Tube failed	52 p 8, 17
" (2 ea)	2.9(10)	1.2(15)ne 1(18)nt	Plate I (11.4%) at 1(15)ne	2 p 546-551
Raytheon (2 ea)	"	"	Plate I (20%) at 3.8(14)ne	"
Sylvania (2ea)	"	"	Plate I (-21%) at 3.2(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6112</u> Subminiature hi-mu twin triode				
GE (2ea)	3.6(10)	2(15)ne 1.3(18)nt	Plate I(-45%) at 3(14)ne	2 p 537-543
GE(in circuit with GE 6111) (2 circuits)		3(17)nt	Circuit Failed	52 p 8
Raytheon (2 ea)	3.6(10)	2(15)ne 1.3(18)nt	Plate I(-20%) at 3(14)ne, gassy	2 p 537-543
Sylvania (2ea)	"	"	Plate I(-27.3%) a 3(14)ne	"
<u>6292</u> Multiplier Phototube				
Dumont (2ea)	2.27(7) ergs/gm -(C)-hr.		1.25 ma anode current	9 p 91
<u>6384</u> Beam Power Amplifier				
Bendix (9 ea)	4.1(10)	2.5(15)ne 1.3(18)nt	all failed due to glass fractures	2 p 596-601

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>6442</u> Ceramic Triode GE (5ea)	7(10)	5.5(16) (E>0.3Mev)	No damage	31 p 2-14
<u>F-6867</u> SHF, intermediate- pwr. Traveling Wave Amplifier Federal Tele. and Radio (2ea)	3.1(9)	8.6(13)ne 6.5(16)nt	Both Failed at 7.2(13)ne	2 p 431-436
<u>7077</u> Class A ceramic Triode GE (5ea)	7(10)	5.5(16) (E>0.3Mev)	No damage	31 p 14
<u>7296</u> Ceramic Triode GE		2.2(18)nt	No damage	52 p 17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>7588</u> Ceramic Triode GE (4ea)	7 (10)	5.5(16) (E>0.3Mev)	No damage	31 p 14
<u>7895</u> Metal-Ceramic Nuvistor RCA (4 Tested in 2 circuits)		1.4(18)nt	1 circuit failed at 9.7(17)nt and the other at 1.4(18)nt	52 p 17
<u>Miscellaneous Type</u> <u>MgC</u> Cold Cathode Type Tung-Sol (4 ea)	5(9)	5(16)nf	Three had large signal degradation	28 p 3

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Autolite Mil-W-5086, Ag Plated Cu conductor, Sil- cone Rubber Insula- tion, 1st Braid Com- bination of glass fibre and synthetic fibre, 2nd Braid synthetic fiber and heat resistant Lacquer Insulation, Hi-volt. (3 ea)	4.3 (10)	1.8(15)ne	Insulation R, de- creased by order ~ 10	60 p36, 42, 46
Belden Mfg. Co. Mil-W-583, Heavy Beldtherm, Class "B" Insulation (Epoxide- Polyester Resin) Magnet Wire (3 ea)	2.8(10)	8.1(13)ne	Insulation R de- creased by order ~ 100	60 p36, 42, 46, 59
Heavy Nyclad, Nylon & Vinyl-Acetal Insulation, Magnet Wire (3 ea)	3.3(10)	1.1(15)ne	Insulation R de- creases factor $\sim 10^3$	74 p33
Heavy Formvar, Vinyl- Acetal Insulation, Magnet Wire (3 ea)	3.2(10)	1.1(15)ne	Insulation R de- creases factor $\sim 10^3$ @ 1.1(14)ne	74 p31,26
Mil-W-583, Heavy Beldsol, Polyrthane- Disocyanate Insula- tion (3 ea)	2.8 (10)	8.1(14)ne	Insulation R de- creases by order $\sim$ 10^2 immediately	60 p37,43,46 60

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
Birnback Radio Co., Inc. Mil-W-16878A #20 AWG, Insulated type E (Teflon) Hi-Temp.	4.3(10)	1.8(15)ne	Insulation R decreased by factor ~ 100	60 p35, 46, 42, 56
600V, Copper, Aircraft, Shielded by Copper Shield (3 ea)	3.7(10)	1.4(15)ne 1.4(18)nt	Insulation R decreased by factor $\sim 10^4$, two shorted in-pile	74 p30
" (3 ea)		2.2(16)ne	Insulation R decreased by factor $\sim 10^5$ @ 1.7(16)ne. Two shorted in-pile	74 p42
600V, Copper, Aircraft (3 ea)	4(10)	2.2(15)ne	Insulation R decreased by factor $\sim 10^5$ @ 1.9(15)ne	74 p26, 39
" (3 ea)		2.2(16)ne	Insulation R decreased by factor $\sim 10^4$ @ 1.9(16)ne	74 p42, 27
<u>William Brand Co.</u>				
AWG 22, 19 Strands #34 AWG Tinned Soft Cu, Insulation 0.016" Dow Corning Silastic 80 (10 ft)		4.1(16) (E>0.5Mev)	Cracked and became so brittle that no tests could be performed	35 p10. 96-100
AWG 22, 7 Strands of #30 AWG, Ag-plated Soft Cu, Insulation 0.031" GE XE-9003A (10 ft)		"	"	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Wire, Electrical				
<u>William Brand Co. (Cont.)</u>				
AWG 20, 19 Strands of #32 AWG Ag-plated Soft Cu, Insulation 0.016" Silastic 80 (10 ft)		4.1(16) (E>0.5Mev)	Cracked and became so brittle that no tests could be performed.	35 p10. 96-100
AWG 14, 19 Strands of #27 Tinned Soft Cu, Insulation 3/64" GE SE-975 (10 ft)		"	"	"
AWG 14, 19 Strands of #27 AWG Ag-Plated Soft Cu, Insulation 3/64" Silastic 80 (10 ft)		"	"	"
<u>Gavitt Wire & Cable Co.</u>				
Mil-W-76A, Hook-up Covering "J", Nylon Jacket, Polyvinyl Insulation (3 ea)	3.3(10)	9.6(14)ne	Insulation R decreased by factor $\sim 10^4$ @ 1.9(12)ne	60 p35, 46, 48
" (3 ea)	3(11)	1.1(15)ne	Insulation R decreased by factor $\sim 10^5$ @ 3.8(13)ne. All shorted in-pile	74 p40, 27
Mil-W-76A, Hook-up Covering "B", Glass Yarn Braid, PVC Insulation (3 ea)	3.3(10)	9.6(14)ne	Insulation R decreased by factor $\sim 10^3$ @ 1.8(12)ne	60 p35, 46, 48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (C)}$	$\frac{n}{\text{cm}^2}$		
Wire, Electrical				
Gavitt Wire & Cable Co. (Cont.)				
Mil-W-76, Hook-up Covering "BS," Glass Yarn Braid & Cu Shield PVC Insulation (3 ea)	4.2(10)	2.2(15)ne	Insulation R de- creased by factor $\sim 10^4 @ 4.5(13)ne$	60 p35, 46, 52
" (3 ea)	3(11)	1.1(15)ne	Insulation R de- creased by factor $\sim 10^4 @ 3.2(13)ne$	74 p40, 27
Mil-W-76A, Hook-up Covering "S" Cu Shield PVC Insulation (3 ea)	4.3(10)	2.2(15)ne	Insulation R de- creased by factor $\sim 10^4 @ 1.5(14)ne$	60 p35, 46,
Mil-W-76A, Hook-up Covering "U," PVC Insulation (3 ea)	4.1(10)	1.9(15)ne	Insulation R decrease factor $\sim 10^3 @$ $1.8(14)ne$	60 p35, 46,
Phelps Dodge Copper Products, Corp.				
Mil-W-583, Magnet Wire, Heavy Thermaleze Single Daglas, Silicone Glass fiber, Dacron Yarn (polyester), Class "B" Insulation (Epoxide-polyester Resin) (Ethylene glycol & Terephthalic Acid Insulation)(3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor $\sim 100 @ 9.8(13)ne$	60 p36, 42, 46, 59

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
Phelps Dodge Copper Prod. Corp. (Cont.)				
Mil-W-583, Magnet Wire, Heavy Thermaleze, Single Daglas, Silicone Glass fiber, Dacron Yarn (polyester), Class "B" Insulation (Epoxyde-polyester Resin)(Ethylene glycol & Terephthalic Acid Insulation) (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 47
Mil-W-583, Magnet Wire, Same as above but has double rather than single Daglas (3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor ~100 @ 9.8(13)ne	60 p36, 42, 46, 59
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 47
Mil-W-583, Magnet Wire, Single Soldereze, polyurathane, Disocyanate Insulation (3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor ~100 @ 9.8(13)ne	60 p37, 43, 46, 60
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 3.3(12)ne	74 p50, 27
Mil-W-583, Magnet Wire, Heavy Thermaleze "B" Insulation (epoxyde-Polyester Resin) (Ethylene glycol & Terephthalic Acid Insulation) (3 ea)	3.6(11)	1.9(15)ne	Insulation R decreases by factor ~100 @ 6.8(12)ne	74 p46, 26
Mil-W-583, Magnet Wire, Single Nyform Combination of Vinyl-Acetal & Nylon Enameled Insulation (3 ea)	"	"	Insulation R decreases by factor ~100 @ 8.4(12)ne	74 p26, 48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Wire, Electrical				
Phelps Dodge Copper Prod. Corp. (Cont.)				
Mil-W-583, Magnet Wire, Heavy Nyform, similar to wire of last item on previous page (3 ea)	4.1(10)	1.5(15)ne	Insulation R decreases by factor ~10 @ 1.6(14)ne	74 p26, 36
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 49
Mil-W-583, Magnet Wire, Heavy Formvar, Vinyl-Acetal Insulation (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 49
Mil-W-583, Magnet Wire, Heavy Formvar, Single Daglas, Glass fibre, Dacron Yarn (Polyester) (3 ea)	4.1(10)	2.2(15)ne	Insulation R decreases by factor ~10 @ 2.3(14)ne	74 p26, 34
Same as above except Single Formvar, & double Daglas(3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 3.4(12)ne	74 p27, 50

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C})}$	$\frac{n}{\text{cm}^2}$		
<u>Sprague Products, Inc.</u>				
Mil-W-583, Magnet Wire, Ceroc, Teflon, Inorganic Ceramic & Teflon Insulation (3 ea)	3.5(10)	1.9(15)ne	All Shorted in-pile	74 p48, 26
Mil-W-583, Magnet Wire, Ceroc, Silicone, Inorganic Ceramic & Silicone Insulation (3 ea)	"	"	Two shorted in-pile	74 p 26, 52
<u>Miscellaneous</u>				
Mil-W-16878C, Type (1000V) Extruded Insulation (Teflon - TFE)	1.3(9)	8.7(11)nf 1(12)nt	Very brittle & powdery	8 pl17, 114
Mil-W-16878C, Teflon Wire, Single Conductor 1000V, Ag-plated Cu Shield Jacket of Wrapped Teflon, Also twisted pair types	"	"	Flaked off & powdery	8 pl17, 114
Mil-W-12349(SIGC) Modified Polyolefin Insulation	"	"	Withstood radiation in good condition	8 pl17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Wire, Electrical				
<u>Miscellaneous (Cont.)</u>				
Mil-W-7139A, Inner Insulation. Two servings of wrapped Teflon. Outer - Two servings of braided fibre - glass impregnated with Teflon	1.3(9)	8.7(11)nf 1(12)nt	Inner was very brittle Outer is in good condition and confines inner	8 pl17

3.0 PULSE IRRADIATION DATA

3.1

AMPLIFIERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Amplifiers				
<u>Miscellaneous</u>				
Two Stage Instrument Amplifier (Transistor 2N43A And 2N952)		1 (16)	Amplifier gain (-8%)	211 p 99
Low Level Servo Amplifier (Transistor 3 Type 2N43)		1 (16)	Amplifier gain (-15%)	211 p 99
Mixer or Buffer Magnetic Amplifier (Diodes) 4 Types HD 6006		1 (16)	No effect on amplifier gain	211 p 99

3.2 CAPACITORS

3.2.1 CERAMIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Ceramic				
<u>Aerovox Corp.</u>				
0.01mf C80AT	3.0 (9)	~9(16)	Capacitance ($\pm 1.6\%$) Diss. factor ($\pm 8.7\%$)	203 p 5, 12, 62
<u>Sprague Pdts Co.</u>				
0.01mf Type C46	4.3 (9)	>1(17)	Capacitance (0%) diss. factor ($\pm 4\%$)	203 p 5
<u>Vitramon, Inc.</u>				
00047mf Type VK 20 (2ea)	3.1(9)	~9(16)	Capacitance #1 ($\pm 0.22\%$) Capacitance #2 (-0.11%) Diss. factor (-3.2%)	203 p 5, 13, 62
<u>Miscellaneous</u>				
0.01mf, 500 VDC Disk Type Ceramic	2.7 (8)		Initial V change (-0.4%)	208 p 83, 109

3.2 CAPACITORS

3.2.2 ELECTROLYTIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>G.E.</u> 6 mf, 600 VDC Dykanal C (chlori- nated diphenyl) TJU 6000J	4.3(8)		No Electric Breakdown, No capa- cittance Change	208 p. 83, 114
<u>Sprague Products Co.</u> 10 mf TVL Type	1.78(9)	~5(16)	2270 Microamp Leakage Current	203 p. 6, 62
40 mf TVL Type	1.02(9)	~3(16)	>>2700 Microamp Leakage Current	203 p. 6, 62
100 mf TVL Type (2 ea)	9.1(9)	~1(16)	569 Microamp Leakage Current	203 p. 6, 62

3.2 CAPACITORS

3.2.3 GLASS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Glass				
<u>Corning Glass Works</u>				
0.01 mf Glass Type CY30	3.4(9)	$\sim 9(16)$	No change in capacitance	203 p. 5, 12, 62
<u>International Business Machines</u>				
0.01 mf Evaporated Glass	4.0 (9)	$\sim 1(17)$	No change in capacitance. 64 microamp leakage current.	203 p. 6, 62

3.2 CAPACITORS

3.2.4 MICA

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Mica				
<u>El Menco</u>				
0.01 mf Ruby Mica	4.3 (9)	>1(17)	Capacitance (-0.02%)	203 p. 12, 62
0.01 mf, 500 VDC Silver-Mica	1.1 (8)		Capacitance (0.15%) Initial V Change (-0.6%)	208 p. 83, 109

3.2 CAPACITORS

3.2.5 MYLAR

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Mylar				
<u>Good-All</u>				
1 mf, 600 VDC Type 613G	2.0 (8)		Capacitance ($0 \pm 15\%$)	208 p. 83, 101
<u>Miscellaneous</u>				
Type Polyethylene Terephthalate (Mylar) Capacitor	3.8(8)		Induced conductivity (ohm-cm^{-1}) (1.1×10^{-11})	202 p. 14

3.2 CAPACITORS

3.2.6 PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Paper				
<u>Cornell-Dubilier Co.</u>				
0.1mf 600 vdc Oil-impregnated CP28A1EF104K Cub Type	2.7 (8)		Maximum Voltage Change less than 5.4 volts. Capacitance (-3.5%)	211 p. 62 208 p. 83, 101
1 mf 600 vdc Wax-impregnated Pup Type (6 ea)	1.2 (8)		Initial V Change (-0.7%)	208 p. 83, 101
6 mf - Epoxy Kish' Potting Compound, Pup Type (6 each 1 mf in parallel)	1.1(8)		Maximum Voltage Change = 10.8 volts	211 p. 62
<u>Sprague Products Co.</u>				
0.01 mf Vitamin Q Impreg- nated	6.3(8)		Capacitance (+7.6%) Diss. factor (-25%)	200 p 12
0.47 mf 400 VDC Vitamin Q Impreg- nated	2.0 (8)		Capacitance (0 $\pm$ 12%)	208 p 83, 101

3.2 CAPACITORS

3.2.7 TANTALUM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Capacitors, Tantalum				
<u>Sprague Products Co.</u>				
0.01 mf Type 150D	3.7(9)	~1(17)	Capacitance (+0.36%) Diss. factor (-3.2%) Leakage I (26.6 ma)	203 p. 12, 62
0.1 mf Type 150D	3.4(9)	~9(16)	Capacitance (+0.47%) Diss. factor (-10.9%)	203 p. 12, 62
1 mf Type 150D	~3(9)	~7(16)	Capacitance (+0.77%) diss. factor (-13.9%)	203 p. 12, 62
4 mf Type 120D (2 ea)	2.1 (9)	~6.3(16)	Capacitance (+1.2%) Diss. factor (+24%)	203 p. 6, 12, 62
10 mf Type 150D (3 ea)	3.4(9)	~9(16)	Capacitance (+6.1%) Diss. factor (-27.2%) Leakage I (+160 ma)	203 p. 12, 62, 6
10 mf Type 120D (2 ea)	~2(9)	~6(16)	Capacitance (-2.5%) Diss. factor (-21.3%) Leakage I (19.7 ma)	203 p. 6, 12, 62
10 mf Type 109D (4 ea)	3.2 (9)	~7.2(16)	Capacitance (+6.5%) Diss. factor (-19.6%) Leakage I (872 ma)	203 p. 6, 12, 62
12 mf Type 120D	1.8 (9)	~5.8(16)	Capacitance (+3.7%) Diss. factor (-7.2%)	203 p. 12, 62
22 mf Type 150D (2 ea)	~3.3(9)	~7.2(16)	Capacitance (+4.79%) Diss. factor (-3%)	203 p. 12, 62
12 mf Tantalex Type (2ea)	6.5(8)	~2(15)	Capacitance (+0.33%) Diss. factor (+16.66%)	200 p. 12

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Circulators</u>				
<u>Sperry - Rand Corporation</u>				
C - Band Coaxial Y - Junction Circulator	2.2 (7)	1.3 (17)	Changes in Output signal levels from the antenna port of the unpotted circulator and the antenna and receiver ports of the potted circulator area less than 0.05db.	212 p. 5-1

COAXIAL CABLES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Coaxial Cables</u>				
<u>Phelps Dodge Copper Products</u>				
Air dielectric coaxial cable (Spirafil)	1.2 (7)	7 (16)	The degree of ionization was found to increase when the air pressure was reduced below one atmosphere	212 p. 5-2
<u>Miscellaneous</u>				
Coaxial Cable (Open Circuit) RG-58/u and RG-9A/u.	~ 7 (9)		RG-58/U. Voltage Pulse of 0.2 → 05 volt is developed during the burst RG-9A/u voltage pulse of 1.0 to 2.0 volts.	204 p. 8
RG-62 Coaxial	~ 7 (9)		-0.90 induced voltage in cable	210 p. 29
RG-59/u	~ 7 (9)	1 (16)	0.10 induced voltage in cable & 6.1 induced microamps in cable	211 p. 21
RG-62/u	~ 7 (9)	1 (16)	-15% capacitance	211 p. 21
RG-58/u Solid Polyethylene dielectric, solid center conductor shield tinned - Cu Braid	9.5 (8)	5.5 (16)	Induced I 100 μ a @ 1500v Induced I 30 μ a no volts applied	205 p. 36-39, 45

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Coaxial Cables				
RG-8/u Solid polyethylene dielectric stranded center conductor, shield Cu braid	1 (9)	5.9(16)	Induced I @ 1500v applied (600 μa) Induced I, no volts applied (25 μa)	205 p. 39-43, 45

3.5

CRYSTALS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Crystals				
<u>Bulova</u> 300 GAX 161.73 KC	$\sim 1(9)$		Oscillator Amplitude (-50%) Freq. remained stable	200 p21

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Inductors				
Ferrite Inductor Mn-Zn	2.8 (9)		Core located at the reactor. No shunt resistance. ΔV Percent = - 42	206 Table III
Ferrite Inductor Mn-Zn	2.8 (9)		Core located outside reactor with a 100K Ω shunt resistance outside the reactor. ΔV = - 58 percent	206 Table III
Ferrite Inductor Ni-Zn	2.8 (9)		No shunt resistance ΔV = - 47% Core located at the reactor	206 Table III
Ferrite Inductor Ni-Zn	2.8 (9)		No shunt resistance ΔV = - 32 percent Core located 60 in. back from the reactor	206 Table III

3.7

ISOLATORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Isolators				
<u>Sperry Rand Corporation</u>				
Internal Magnet Coaxial Isolator	2.2 (7)	1.2 (17)	Changes in output signal levels from the potted and unpotted isolators are less than 0.05db.	212 p 5-1

3.8

LIMITERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Limiters	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Sperry Rand Corp.</u> Gyromagnetic Coupling Limiter	3.1 (7)	1.7(17)	Changes in output signal levels from the unpotted and potted limiters are less than 0.05db	212 p. 5-1

3.9

OSCILLATORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Oscillators</u>				
<u>Hewlett - Packard</u>				
Model 200 CD	1 (9)	1(12)	Output vanishes for a period of about 30 mil sec	203 p34
<u>Miscellaneous</u>				
22 Kc, Model 1250 A with 3 ea. Type 2N1139 & 2 ea. Type 2N495 Xsistors	3.8(8)	5.5 (15)	Freq. Shift (+26%) Amplitude Shift (-90%)	211 p98-99
22 Kc, Model 1250 A with 3 ea. Type 2N1139 & 2 ea. Type 2N495 Xsistors	1.1 (8)		Freq. Shift (-20%) Amplitude Shift (-30%)	211 p99, 97
40 Kc, EMR Model 75B with 2 type 5840 Tubes	3.8(8)	4.9 (15)	Freq. Shift (-4%) Amplitude Shift (-40%)	211 p 98
40 Kc, EMR Model 75B with 2 type 5840 Tubes	1.1 (8)		Amplitude Shift (-7%) Freq. Shift (< 1%)	211 p99, 97
70 Kc, TDI Model 1202A with 4 type 611 Tubes	3.5 (8)	5(15)	Freq. Shift (+20%) Amp. Shift (-60%)	211 p 98
70 Kc, TDI Model 1202A with 4 type 611 Tubes	1.1 (8)		Amp. Shift (-10%) Freq. Shift (+3%)	211 p 99, 97
900 cps. Oscillator with 3 type 2N903 Xistors (6ea)		1 (16)	4 Units failed	211 p 99
40 Kc, EMR Model 75B with types 5840, 5718, 5719 Tubes(2 ea)	8.7(8)	1(15)	Center Frequency Shift (-0.6%)	211 p 100
70 Kc, EMR Model 75B with types 5840, 5718, 5719 Tubes	8.7 (8)	1(15)	Center freq. Shift ($\pm 0.4\%$)	211 p 100
Blocking Oscillator Multivibrator (6 ea) with 1N137A & 2N904		1 (16)	3 failed, output amp (-80%)	211 p 99

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Power Supplies	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Boeing Co. PS-210, 150 VDC Transistorized		1 (16)	Power unit went out of specification limits due to changes in transistor parameters	216 p 1 211 p 97
PS-223, 250 VDC Transistorized Power Supply		1 (16)	Output V (0.05V) failed, ripple V (0.3mv)	211 p 97
PS-210, 150VDC Transistors: 1 type 2N 338, 2N 539, & 2N 575		1.4 (16)	Output V (-1.4%) poor regulation ripple V (1 V)	211 p 97

3.11 RESISTORS

3.11.1 CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Allen Bradley Co.</u>				
0.1 K 2W (3 ea) Unpotted	1.4(9)		Resistance (<1%)	200 p. 7 211 p. 47
1 K, 2W	1.6(9)		Resistance (1.65%)	200 p. 7
1 K, 2W	3.8(8)		Resistance (2.3%)	211 p. 47-49
1.021 K, 2W, paraf- fin potted	3.8(9)		Resistance (0.3%)	211 p. 47-49
10 K 2W (3 ea)	1(9)		Resistance (4.8%)	200 p. 7
10 K 2W, Unpotted	1.4(9)		Resistance (0.2%)	211 p. 47-49
10 K, 2W, paraffin potted	4.3(8)		Resistance (1.5%)	211 p. 47-49
100 K 2W (3 ea)	1(9)		Resistance (25%)	200 p. 7
100 K	7.4(9)		Resistance (-16%)	201 p. 29
100 K 2W Acrylic potted	2.3(8)		Resistance (2.2%)	211 p. 48
100 K, 2W, paraffin potted	4.2 (9)		Resistance (3.1%)	211 p. 48
1 Meg 2W (3 ea)	1.1(9)		Resistance (75%)	200 p. 7
1 Meg, 2W, Unpotted	2.3(8)		Resistance (5.6%)	211 p. 48
1 Meg, 2W, paraffin potted	8.1(8)		Resistance (30.5%)	211 p. 48
10 Meg 2W Unpotted (1 ea)	1.3(9)		Resistance (87%)	200 p. 7
10 Meg, 2W, Paraf- fin potted	4.8(9)		Resistance (85%)	211 p. 49

3.11 RESISTORS

3.11.2 CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Resistor, Carbon Film				
<u>Miscellaneous</u>				
0.1K, 1/2 watt,	~3(9)	2(17)	$\Delta V(\text{max volts}) = 0$ $\frac{\Delta R}{R_0} = 0$ (Applied voltage = 6 volts)	206 p.6
0.1K, 1/2 watt	~3(9)	2(17)	$\Delta V(\text{max. volts}) = -0.005$ $\frac{\Delta R}{R_0} = -0.09$ (Applied voltage = 22 volts.)	206 p. 6
0.1K, 1/2 watt	~3(9)	2(17)	$\Delta V(\text{Max. Volts}) = 0.005$ $\frac{\Delta R}{R_0} = -0.04$ applied voltate = -45 volts	206 p. 6
0.1K, 1/2 watt,	~3(9)	2(17)	$\Delta V(\text{max volts}) = 1.0$ $\frac{\Delta R}{R_0} = 0$, Applied voltage = 3 vac	206 p 6
1K, 1/2 watt	~3(9)	2(17)	$\Delta V(\text{max. volts}) = 0.16$ $\frac{\Delta R}{R_0} = -1.6$. Applied voltage = 45 volts	206 p. 6
1K, 1/2 watt	~3(9)	2(17)	$\Delta V(\text{max volts}) = 4.0$ $\frac{\Delta R}{R_0} = -7.2$ Applied Voltage = -200 volts	206 p 6
10K, 1/2 watt	~3(9)	2(17)	$\Delta V = -0.65$ $\frac{\Delta R}{R_0} = -21.6\%$ Applied Voltage = 12V	206 p 6
100K, 1/2 watt	2(9)	2(17)	$\Delta V(\text{max volts}) = -4.2$ $\frac{\Delta R}{R_0} = -147\%$	206 p 6

3.11 RESISTORS

3.11.3 FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Resistors, Film</u>				
<u>Corning Glass</u>				
100K Film Resistor	8.7(9)		Resistance (-18%)	201 p. 29
100K Film Resistor	1.1(10)		Resistance (-15%)	201. p. 29
<u>International Resistance Corporation</u>				
100K Metal Film	7.9(9)		Resistance (-14%)	201 p. 29
100K Metal Film	5.9 (9)		Resistance (-15%)	201. p. 29
<u>Victoreen Instrument Co.</u>				
0.1K, 5W Vacuum-En- capsulated deposited Film	3.9(8)		Resistance (11.3%)	200 p. 7

3.11 RESISTORS

3.11.4 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{cm}^2 \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Resistors, Wirewound				
<u>Mepco, Inc.</u>				
10 K, Paraffin Pot- ted	6.0 (8)		1.8% change in resis- tance	211 p 52
100K, Paraffin Pot- ted	9.4 (8)		13.2% change in resis- tance	211 p 52
100K	8.7(9)		Resistance (-22%)	201 p 29
1 Meg, Paraffin Pot- ted	8.5 (8)		53.6% change in resis- tance	211 p 52
1 Meg, Paraffin Pot- ted	7.0 (8)		51.2% change in resis- tance	211 p 52

SEMICONDUCTOR DEVICES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot \text{C}} \cdot \text{sec}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Semiconductor Devices				
IBM01 (Tunnel Diode) Ge PNP	1.5 (9)		I_{co} (98%) @ Peak	211 p 14
IN76A Ge Diode	2(8)		Reverse I pulse @ 15V (50 ua) @ 50 V (62 ua)	211 p 18
IN277 Diode	7.2(8)		peak increase I (132 ua)	211 p 18 Table 3
IN254 Alloy-Junction Silicon Diode Recti- fier		1 (17)	Increase of 200 to 450 ua from an origi- nal reverse (Leakage) I of < 1 ua were ob- served during first half mil sec. The Amount of Change & subsequent recovery are Neutron dose dependent	210 p 2, 33
IN 629 Si Diode	2 (8)		Forward I pulse @ 0v (11 ua), Reverse I pulse @100v (18ua)	211 p 18
2N 123 Ge PNP	1.5 (9)		I_{co} increase from Pretest value of 0.4 ua to 2800 ua at peak Transient	211 p 14
2N 167 Ge PNP	1.4(9)		I_{co} increases from pretest value of 1ua to 250 ua @peak Transient	211 p 14
IN251 Diode Transitron	5 (9)		Peak Leakage I @ 90°C (40 ua)	201 p 22
IN543 Diode Pacific Semiconductor, Inc.	7 (9)		Peak Leakage I @ 25°C (425 ua)	201 p 23
IN 658 Diode Radio Receptor	~6 (9)		Peak Leakage I @ 25°C (310 ua)	201 p 24
2N335 Si NPN T.I.	2 (9)		I_{co} Peak Transient value (35ua)	211 p 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Semiconductor Devices				
2N 335 T. I.	4 (9)		Peak I_{CO} (800 ua) B/B_0 (Failed)	201 p 7
2N 335 General Electric	1 (10)		Peak I_{CO} (360ua) B/B_0 (-90%)	201 p 8, 14
2N 335 Si NPN G E	4 (9)		I_{CO} Peak Transient (480 ua)	211 p 14
2N 338 Si NPN	1 (9)		Peak I_{CO} Transient (540 ua)	211 p 14
2N338 T I	1 (10)		Peak I_{CO} (240ua)	201 p 6
2N 338 Si NPN T I	2 (9)		I_{CO} Peak Transient (35 ua)	211 p 14
2N 389 Si NPN	1 (9)		I_{CO} Peak Transient (12000 ua)	211 p 14
2N 389 TI	1 (6)		B/B_0 (-80%)	201 p 15
2N 495 Si PNP Philco	1 (10)		I_{CO} Peak Transient (170 ua)	211 p 14 201 p 9
Z 3.9 Zener Diode U.S. Semiconductor, Inc	7.3 (9)		14 mv change in regulation V	201 p 27
IN 1313A Zener diode Hoffman	1 (9)		Knee reverse Characteristics (No change) Min diode V did not return to zero	211 p 19
SV-6 Zener diode Transitron	7.5 (8)		29 mv changes in regulator V	201 p 27
651 C4 Zener diode TI	1 (9)		Knee reverse charac- teristics (no change) Min. diodes V did not return to zero	211 p 19
SE 6M16 Selenium Diode Rectifier	2 (8)	1 (17)	Leakage I (+60%)	210 p 2,28
IBM 51 Ge PNP	1.4(9)		I_{CO} Peak Transient (3000 ua)	211 p 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Semiconductor Devices				
1275 Si PNP	1.5 (9)		I_{∞} Peak Transient (66 ua)	211 p 14
HD6008 Si Diode	2 (8)		Current pulse @ 100v (75 ua)	211 p 18

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Tubes, Electron</u>				
<u>O B 2</u>				
Gas filled voltage regulator				
Westinghouse (2 ea)	1.1 (9)		12.95% Change in Current	200 P. 17
<u>XDIC</u>				
Gas Diode (Firing) $V_f = 113\text{v}$				
GE	~2.8(9)		Diode Bias firing = 88% of V_f	213 P 11
<u>1 P 28</u>				
Photomultiplier				
RCA (1 ea)	1.8(8)		Current Change (8900 $\pm$ 500 μa)	211 P. 34

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm}(\text{C})\text{-sec}}$	$\frac{n}{\text{cm}^2\text{-sec}}$		
Tubes, Electron				
<u>2D21</u> Thyratrons				
G.E. (2 ea)	5.9(8)		9.85% change in tube current. Pulsed radiation caused non-conducting tubes to fire.	200 P. 15
G.E.	2.4 (9)		Critical Grid Voltage = -1.75 volts, applied grid voltage = -2 volts. The tube fired during this burst.	203 p. 23
G.E.	4.1(9)		Critical Grid Voltage = -0.75 volts. Applied grid voltage = -4 volts. The tube did not fire during the burst.	203 p. 23
G.E.	3.7(9)		Critical Grid Voltage = -4 volts. Applied grid voltage = -1.8 volts. The tubes fired during the burst.	203 p. 23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Tubes, Electron				
<u>XD-100</u>				
Gas firing Diode $V_f = 100 \text{ V}$				
G.E.	~2.8(9)		Diode Bias firing = 68% of V_f	213 p. 10
<u>XD-150</u>				
Gas firing Diode $V_f = 150 \text{ V}$				
G.E.	~6.5(9)		Diode Bias firing = 58% of V_f	213 p. 12
<u>XD-225</u>				
Gas firing Diode $V_f = 225 \text{ V}$				
G.E.	~6.5(9)		Diode Bias firing = 55% of V_f	213 p. 13
<u>XD-300</u>				
Gas firing Diode $V_f = 300 \text{ V}$				
G.E.	~6.5(9)		Diode Bias firing = 57% of V_f	213 p. 14
<u>XD-375</u>				
Gas firing Diode $V_f = 375 \text{ V}$				
G.E.	~8(9)		Diode Bias firing = 52% of V_f	213 p. 15

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Tubes, Electron				
<u>XD-750</u>				
Gas firing Diode $V_f = 750 \text{ V}$				
G.E.	$\sim 8(9)$		Diode Bias firing $= 62\%$ of V_f	213 p. 16
<u>1724G</u>				
Ceramic Equivalent of 6J6				
Sylvania (Operating under Applied Voltage)		3.8(16)	Signal Attenuation varies with Distance from the reactor. (-33%) @ 3.7 cm from reactor screen.	209 p. 15
Sylvania (No voltage)		3.1(16)	No effect on Tube	209 p. 24
<u>2146 B</u>				
Ceramic Equivalent of 6AQ5				
Sylvania (Operating Under Applied Volt- age)		3.8(16)	Tube Output Completed Attenuated for 150 milsec after Burst Tube Behavior varies with distance from Reactor.	209 p. 24

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Tubes, Electron				
<u>2225A</u> Ceramic Equivalent of 12AT7				
Sylvania (Operating under Applied Voltage)		3.8(16)	Signal Amplitude attenuated to zero at 250 milsec after burst. Varies with distance from reactor.	209 p. 15
Sylvania (No Voltage)		3.1(16)	No effect on tube	209 p. 24
<u>Z-5312</u> Voltage-Tunable Magnetron (VTM)				
G.E. #1697 (air atmosphere)	1.7(9)	1(17)	Power Output (+64%) Freq. (-15 Mc or -0.75%) Anode I (+10 ma or +107.6%)	205 p. 19-25, 45
G.E. #1697 (Nitrogen Atmosphere)	3.9(8)	~ 7(16)	Power (+64%) Freq. (No change)	225 p. 21
G.E. #1674	2.8(8)	1.6(16)	Freq. (-6 Mc or -0.26%) Power output (+33%) Anode I (+3 ma or +20%) for 125 usec. Control Electrode I (+130 ua)	205 p. 31, 45
G.E.	1.5(9)		Negligible Effect on Parameters.	204 p. 53

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
<u>Tubes, Electron</u>				
<u>Z-5337</u> Voltage Tunable Magnetron GE #193	1.8 (9)	1.1 (17)	Power output (+2.5%) Freq. (Unchanged) Control Electrode I + 75 μa for 200 μsec	205 p. 12-16, 45
<u>Z-5428</u> Voltage Tunable Magnetron GE #30	9.2 (8)	5.8 (16)	Freq. & Power (Unaffected) Anode I (+3 ma or +20%) for 100 μsec , control Electrode I (+100 μa) for 250 μsec .	205 p. 31-35, 45
<u>5636</u> Triode Sylvania (3 ea)	6.4 (9)		0.98 ma increase in current @ cutoff	201 p. 33
<u>5840</u> Pentode RCA (3 ea)	1.1 (10)		0.82 ma increase in current @ cutoff	201 p. 33
<u>5896</u> Duo diode Sylvania (8 ea)	7.8 (8)		Plate I (6%)	200 p. 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm} \cdot (\text{C}) \cdot \text{sec}}$	$\frac{n}{\text{cm}^2 \cdot \text{sec}}$		
Tubes, Electron				
<u>6111</u> Sylvania (2 ea)	6.8 (9)		1.01 ma increase in current @ cutoff	201 p. 33
<u>6590</u> Subminiature Thyratron		1.8(15)ne	83% amplitude decrease	215 p. 58
<u>6690</u> Triode		9.8(14)ne	Plate signal (90%) Shift, no permanent damage	215 p. 51
<u>7071</u> Ceramic Triode				
GE (4 ea)	9.1 (9)		1.5 ma increase in current @ cutoff	201 p. 33
Unknown		1.8(15)ne	Plate signal (71%) Shift, no permanent damage	215 p. 51

4.0 DESIGN ALLOWABLE REFERENCES

4.1 STEADY-STATE IRRADIATION

Radiation
Effects Ref.
Number

- 1 Pfaff, E. R. and Skelton, R. D. Effects of Nuclear Radiation on Electronic Components. WADC-TR-57-361 Vol. I. Admiral Corp., Chicago, Illinois. Contract No. AF 33(616)-3091. August 1958. DDC AD155789.
- 2 Pfaff, E. R. and Skelton, R. D. Effects of Nuclear Radiation on Electronic Components. WADC-TR-57-361 Vol. II. Admiral Corp., Chicago, Illinois. Contract No. AF 33(616)-3091. August 1958. DDC AD155790.
- 3 Pfaff, E. R. Effects of Nuclear Radiation on Electronic Components. WADC-TR-57-361 Vol. III. Admiral Corp., Chicago, Illinois. January 1960.
- 4 Pfaff, E. R. Effects of Nuclear Radiation on Electronic Components. WADC-TR-57-361 Vol. IV. Admiral Corp., Chicago, Illinois. Contract No. AF 33(616)-5464. December 1960.
- 5 Pfaff, E. R. Effects of Nuclear Radiation on Electronic Components, Phase I. Scientific Report #5. Admiral Corporation., Chicago, Illinois. Contract No. AF 33(616)7329. October 15, 1956. DDC AD111976.
- 6 Pfaff, E. R. The Effects of Nuclear Radiation on Electronic Components, Vol. V - Electron Tubes. WADC-TR-57-361 Vol V. Admiral Corp., Chicago, Illinois. Contract No. AF 33(616)7033. November 1962. DDC AD291657.
- 7 Sosnovosky, Dr. H. C. Radiation Effects on Semiconductor Catalysts. ASD-TDR-62-233. Armour Research Foundation, Chicago, Illinois. Contract No. AF 33(616)7740. October 1962.
- 8 Goodman, M. R. Nuclear Irradiation Effects on Plastic and Elastomeric Materials and Components for Space Vehicle Applications. Report No. 9123-920003. Bell Aerosystems Co., Buffalo, N. Y. September 1962.
- 9 Lowrey, B. T. and Mitchell, J. C. Irradiation of a Telemetering System and Related Reconnaissance Sensors. ASD-TDR-62-420. Chance Vought Corp., Dallas, Texas. Contract No. AF 33(657)7229. May 1962. DDC AD283351.

Radiation
Effects Ref.
Number

- 10 Armstrong, E. L. Results of Irradiation Tests on Electronic Parts and Modules Conducted at the Vallecitos Atomic Laboratory. Report No. SS-840-T62-6, IMSC-A054870. Lockheed Missiles and Space Co., Sunnyvale, Calif. August 27, 1962.
- 11 Kaufman, A. B. and Gardner, L. B. NGL Platform Nuclear Radiation Program, Vol. 1. ASD-TDR-61-511 Vol. I. Litton Systems, Inc., Woodland Hills, Calif. Contract No. AF 33(600)41452. January 1962. DDC AD284445.
- 12 Kaufman, A. B. and Gardner, L. B. NGL Platform Nuclear Radiation Program, Vol. II-Material and NGL Components Appendices Section. ASD-TDR-61-511 Vol. II. Litton Systems, Inc., Woodland Hills, Calif. Contract No. AF 33(600)41452. October 1961.
- 13 Fritz, E. G. and Johnson, P. M. Hot-Flow Characteristics of Irradiated Polyethylene. Report No. NARF-63-1T, MR-N-300. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(657)7201. May 15, 1963. DDC AD407815.
- 14 Hanson, J. F. and Cary, H. The Effects of Gamma Induced Ionization on Electrical Properties of Printed Circuits and Connectors. Battelle Memorial Institute, Columbus, Ohio. for Chance Vought Corp. March 5, 1959.
- 15 Nuclear Electronic Effects Program - Report for the Tenth Quarter. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(600)-32662. December 31, 1958. DDC AD214533.
- 16 Nuclear Electronic Effects Program - First Triannual Technical Note. WADC-TN-59-295. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. July 15, 1959. DDC AD226168.
- 17 Nuclear Electronic Effects Program - Sixth Triannual Technical Note. WADC-TN-61-17. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. March 15, 1961. DDC AD257011L.
- 18 Nuclear Electronic Effects Program - Seventh Triannual Technical Note. ASD-TDR-61-137. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. July 15, 1961. DDC AD264121.

Radiation
Effects Ref.
Number

- 19 Nuclear Electronics Effects Program - Eight Triannual Technical Note. ASD-TDR-62-189. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. November 15, 1961. DDC AD273100.
- 20 Burnett, J. R. et al. Transducers for Nuclear Vehicles, Vol. II. ASD-TRD-62-551 Vol. II. Bendix Corp., Southfield (Detroit), Mich. Contract No. AF 33(616)-8077. January 24, 1962.
- 21 Spears, A. B. Effect of Radiation on the Electrical Properties of Electronic Components, V-Relays. Report No. NARF-58-35T, MR-N-216. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(600)-32054. August 22, 1958.
- 22 Howell, D. et al. The Effects of Reactor Radiation on the Electrical Properties of Electronic Components, Part VI - Resistors, Vacuum Tubes, and Piezo Crystals. Report No. NARF-60-1T, MR-N-250. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(600)-28946. February 1, 1960.
- 23 Palmer, E. E. and Howell, D. The Effects of Reactor Radiation on the Electrical Properties of Electronic Components, Part VII - Resistors and Vacuum Tubes. Report No. NARF-61-5T, MR-N-268. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(600)-28946. June 7, 1961.
- 24 Owens, W. R. "The Effects of Nuclear Radiation on High Temperature Thermistors." General Dynamics Corp., Fort Worth, Texas. Proceedings of the IRE. October 1961. pp. 296-298.
- 25 Bauerlein, R. R. Effects of Irradiation on Plastic Laminates. Report No. NARF-59-8T, MR-N-225. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(600)-32054. February 1959.
- 26 Haley, F. A. Effects of Mixed-Field Radiation on Aircraft Fuels - I. Report No. NARF-58-7T, MR-N-194. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(600)-32054. February 3, 1958.

Radiation
Effects Ref.
Number

- 27 Gerstein, B., Schlueter, A. and Fuego, A. Effects of Nuclear Radiation on Quartz Crystal Units. Report No. 3. Admiral Corp., Chicago, Illinois. Contract No. DA36-039-SC-85322. March 30, 1962. DDC AD277814.
- 28 Saelens, R. G. Nuclear Radiation Effects on the Cold Cathode-Type Electron Tube at the Curtis-Wright Five-Megawatt Research Reactor. USASRD-L-TR-2153. U. S. Army Signal Research and Development Laboratory, Ft. Monmouth, N. J. DA Task No. 3A99-1300101. December 1960. DDC AD251147.
- 29 Crewe, A. V. Reactor Development Program Progress Report. ANL-6619. Argonne National Laboratory, Argonne, Illinois. AEC Contract No. W-31-109-eng-38. September 1962.
- 30 Hallmark, W. C. Radiation Effects Study for TERCOM. ASD-TDR-62-550. Chance Vought Corp., Dallas, Texas. Contract No. AF 33(616)-7250. May 1962. DDC AD284191.
- 31 Aerothermodynamic Data and Design Criteria Pertinent to the Development of the Propulsion System of a Supersonic Low-Altitude, Nuclear Propelled Vehicle, Part II - Technical Information, Series III - Analysis and Tests, Vol. 13 - Experimental Nuclear Radiation Effects Results. ASD-TDR-63-165 Vol. 13. Chance Vought Corporation, Dallas, Texas. Contract No. AF 33(657)-8686. March 1963.
- 32 Lockheed Progress Report #10 - Snapshot Irradiation. Report No. 347.60.00.00-E9-06. Lockheed Aircraft Corp. Sunnyvale, Calif. March 1, 1962.
- 33 Hocraffer, V. D. Permanent Effects of Gamma Radiation on Various Switches. Laboratory Test Report No. 15027-1, File Reference #6335. Micro Switch Division, Minneapolis-Honeywell Regulator Co., Freeport, Illinois. December 30, 1960.
- 34 Walker, R. C. and Scarborough, J. R. Nuclear Radiation Effects Test on Thermal and Silver-Zinc Batteries. Report No. CVC 2-53010/2R415. Chance Vought Corp., Dallas, Texas. July 1962.

Radiation
Effects Ref.
Number

- 35 M and TC System Study - Final Engineering Report, Vol. I, Part I. Report No. BSR 371. Bendix Corp., Ann Arbor, Mich. Contract No. AF 33(600)-35026. December 1960.
- 36 Lockheed Progress Report #7 - Snapshot Irradiation. No. IDC 6533.025. Lockheed Aircraft Corporation, Sunnyvale, Calif. February 1962.
- 37 Walker, R. C. and Scarborough, J. R. Nuclear Radiation Effects Test of an Acceleration Integrating Switch. Report No. CVC 2-53010/2R507. Chance Vought Corp., Dallas, Texas. June 1962.
- 38 Scarborough, J. R. Nuclear Radiation Effects Tests of a Permanent Magnet Generator. Report No. CVC 2-53010/2R506. Chance Vought Corp., Dallas, Texas. June 1962.
- 39 Scarborough, J. R. Nuclear Radiation Effects Test of a Rotary Actuator. Report No. CVC 2-53010/2R380. Chance Vought Corp., Dallas, Texas. March 19, 1962.
- 40 Walker, R. C. and Scarborough, J. R. Nuclear Radiation Effects Test of an Electromechanical Repeat Cycle Timer. Report No. CVC 2-53010/2R508. Chance Vought Corp., Dallas, Texas. June 1962.
- 41 Bradford, E. W. Irradiation Test of Selected Transducers. Report No. NARF-61-24T, MR-N-265. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF 33(657)-7201. December 15, 1961.
- 42 Moss, R. W. , Kooi, C. F. and Baldwin, M. E. Neutron and Gamma Irradiation of Some Square Loop and Microwave Ferrites. AIEE Conference Paper No. CP60-1015. Boeing Airplane Co., Seattle, Washington and Lockheed Aircraft Corp., Palo Alto, Calif. August 1960.
- 43 Dorst, S. O. and Wurzel, L. H. "The Effect of Radiation Environment on Film Resistors." Sprague Electric Co., Nashua, N. H. IRE Convention Record. March 26-29, 1962. Part 6. pp.206-214.

Radiation
Effects Ref.
Number

- 44 Haley, F. A. Effects of Mixed-Field Radiation on Lubrication Oils. Report No. NARF-61-22T, MR-N-281. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF 33(657)-7201. November 15, 1961.
- 45 Pryor, II; S.G. Reliability Testing of Capacitors in Combined Environments. Nuclear Report No. 116. Lockheed Aircraft Corp., Georgia Div., Marietta, Ga. Contract No. AF 33(600)-38947. December 1960.
- 46 Fritz, E. G. and Johnson, P. M. Compression-Set Behavior of Irradiated Elastomers. Report No. NARF-62-10T, MR-N-296. General Dynamics, Ft. Worth, Texas. Contract No. AF 33(657)-7201. August 1962.
- 47 MacCullen, A. Gamma Irradiation of an Electro-Hydraulic Servo Test Loop Using Oronite 8515 Hydraulic Fluid. WADC-TR-59-592. Lockheed Aircraft Corp., GNL, Dawsonville, Ga. Contract No. AF 33(600)-38947. Jan. 1960.
- 48 Voyce, A. M. A New Low-Frequency Amplifier with Radiation-Tolerant Properties. Report No. NARF-60-20-T, MR-N-257. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF 33(600)-38946. December 30, 1960.
- 49 Spencer, R. Development and Evaluation of Electron Tube Glasses Resistant to Radiation Damage. 2nd Series - Annual Progress Report. Chatham Electronics Div. of Tung-Sol Electric, Inc., Livingston, N. J. Contract No. DA36-039-SC-78312. May 1, 1960. DDC AD243561.
- 50 Shellhase, E. C. et al. Effects of Reactor Irradiation on the Properties of Mix-Bis (Phenoxyphehyl) Ether Operating in a Hydraulic Pump Loop. Report No. NARF-62-3T, MR-N-292. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF33(657)-7201. March 30, 1962.
- 51 Scarborough, J. R. and Laden, S. C. Nuclear Radiation Effects Test of an Air Turbine Drive Generator Set. Report No. CVC 2-53010/2R50077. Chance Vought Corp., Dallas, Texas. Contract No. AF 33(616)-7250. July 1962.

Radiation
Effects Ref.
Number.

- 52 Mitchell, J. C. High-Flux Irradiation of Electronic Components. Report No. CVC AER-E1R-2-53-1-/2R379
Chance Vought Corp., Dallas, Texas. March 15, 1962
- 53 Lockheed Snapshot Progress Report No. 11 at GE
Vallecitos Laboratory. Report No. 347.60.00.00-E9-10.
Lockheed Aircraft Corp., Sunnyvale, Calif. May 1962.
- 54 Howell, Jr., D. B., et al. Irradiation of an
AN/ARC-34 Transceiver. Nuclear Report No. 80.
Lockheed Aircraft Corp., Georgia Div., Marietta, Ga.
Contract No. AF 33(600)-32055 and AF 33 (600)-38947.
February 1960.
- 55 Zelmer, Capt. USAF, M.E. and Johnson, D. R. Radiation
Effects on Electronic Components: A Comparison of
Paper Capacitors Impregnated with Vitamin "Q" Mineral
Oil and Bis-(P-Phenoxyphenyl) Ether. WADC-TR-60-645.
Wright-Patterson AFB, Ohio. Project 7360. November 1960
- 56 Keller, R. L. Nuclear Radiation of Reinforced Plastic
Materials. WADC-TR-56-296 Supplement I. Wright-
Patterson AFB, Ohio. Project No. 7340. December 1959.
- 57 Schmidt, D. L. and Johnson R. H. 1/Lt's U.S.A.F.
Effects of Gamma Radiation on Aircraft Transparent
Materials, Part I. WADC-TR-56-557. Wright-Patterson
AFB, Ohio. Project No. 7340. March 1957. DDC AD118111.
- 58 Harris, S. P. and Bumpas, Jr., C. F. Pressure and
Temperature Instrumentation for Dynamic Measurements
in the KEMB Program. Report No. NAA-SR-4709.
Atomics International Division of North American
Aviation, Inc., Canoga, Calif. Contract No. AT
(11-1)-Gen-3. November 1960.
- 59 Sery, R. S. et. al. Radiation Damage Thresholds for
Permanent Magnets. NOITR 61-45. U.S. Naval Ordnance
Labs., White Oak, Maryland. Task No. RMA-02008/2121/
RO07-01-001. May 12, 1961. DDC AD262051.
- 60 Pfaff, E. R. The Effects of Nuclear Radiation on
Electronic Components, Phase 2. Scientific
Report No. 1. Admiral Corporation, Chicago, Illinois.
Contract No. AF 33(616)-5464. April 1958. DDC AD159900.

Radiation
Effects Ref.
Number

- 61 Sery, R. S. and Gordon, D. I. Nuclear Irradiation Effects on Ferromagnetic Core Materials. NAVORD Report 6127. U. S. Naval Ordnance Lab., White Oak, Maryland. June 3, 1958. DDC AD202404.
- 62 Gardner, L. B. et al. Field-Effects Device Neutron Irradiation. Litton Corp., Woodland Hills, Calif. and Chance Vought Corp., Dallas, Texas. January 1962.
- 63 Campbell, F. J. Effects of Combining Thermal and Radiation Environments on Magnet Wire Life. Progress Report. U. S. Naval Research Laboratory, Washington, D.C. April 1963.
- 64 Decker, L. A. The Effect of Radiation and Nitric Acid-Nitrate Salt Solution on Some Non-Metallic Materials. Report No. IDO-14598. Phillips Petroleum Co., Idaho Falls, Idaho. Contract No. AT(10-1)-205. December 10, 1962.
- 65 Rogers, J. and Craig, C. L. Degradation of Electrical Insulation from Reactor Irradiation. ATEE Conference Paper No. CP 62-1297. Sperry Gyroscope Company, Great Neck, New York. June 1962.
- 66 Gordon, D. I. and Sery, R. S. Effects of Charged Particles and Neutrons on Magnetic Materials. IEEE Transactions Paper No. 63-950. U. S. Naval Ordnance Laboratory, Silver Spring, Maryland. June 1963.
- 67 Kaufman, A. B. "Which Soft Solder for Nuclear Service?" Litton Industries, Woodland Hills, Calif. Reprint from Materials In Design Engineering. February 1960. pp. 37-40.
- 68 Borsoff, V. M. et al. High Temperature Lubrication in the Presence of Nuclear Irradiation. WADD-TR-60-424. Shell Development Co., Emeryville, Calif. Contract No. AF 33(616)-6658. November 1960.
- 69 Fritz, E. G. and Johnson, R. M. Compression - Set Behavior of Irradiated Silicone Elastomers. Report No. NARF-63-2T, IER-W-301. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF 33(657)-7201. May 15, 1963. DDC AD406689.

Radiation
Effects Ref.
Number

- 70 Final Development Report For Evaluation-Development of MIL-C-14157B Capacitors for Nuclear Radiation Environments. Admiral Corp., Chicago, Illinois. Contract No. NObsr-77612. August 21, 1961. DDC AD265046.
- 71 Ayer, J. E. and Pokorny, G. J. The Performance of a Motor, a Switch, and Two Types of Pressure Pickup in a High Gamma-Flux Environment. ANL-6347. Argonne National Laboratory, Argonne, Illinois. Contract No. W-31-109-eng-38. June 1961.
- 72 Pfaff, E. R. The Effects of Nuclear Radiation on Electronic Components, Phase 2. Scientific Report #3. Admiral Corp., Chicago, Illinois. Contract No. AF 33 (616)-5464. February 1960. DDC AD236450.
- 73 Horrocks, L. A. , 1/Lt. USAF. The Effects of Nuclear Radiation on Military Specification Paints. WADC-TR-57-186. Wright-Patterson AFB, Ohio. Project 7312. November 1957. DDC AD142143.
- 74 Pfaff, E. R. The Nuclear Radiation on Electronic Components, Phase 2. Scientific Report #2. Admiral Corp., Chicago, Illinois. Contract No. AF 33(600)-5464. July 1958. DDC AD200278.
- 75 Byer, A. Nuclear Radiation Resistant Power Transistors. Final Report. Philco Corp., Landsdale, Penn. Contract No. DA36-039-SC-78307. July 1960. DDC AD249085.

4.2

PULSE IRRADIATIONRadiation
Effects Ref.
Number

- 200 Some Effects of Pulse Neutron Radiation on Electronic Components - III, Results of January 1959 Godiva Test Series. International Business Machines Corp., Owego, New York. DDC AD234768.
- 201 Some Effects of Pulsed Neutron Radiation on Electronic Components - II, Results of August 1958 Godiva Test Series. International Business Machines Corp., Owego, New York. DDC AD234767
- 202 Conrad, E. E. and Marcus, S. M. Gamma Induced Photoconductivity in a Polyethylene Terephthalate Capacitor. DOFL TR-1037. Diamond Ordnance Fuze Laboratories, Washington, D. C. DOFL Project 23300. 4 May 1962.
- 203 Final Report on Some Effects of Pulsed Neutron Radiation on Electronic Components. WADC-TR-60-71. International Business Machines Corp., Owego, New York. Contract No. AF 33(600)-31315. January 1960. DDC AD 232386.
- 204 Plankis, E. P. Radiation Effects on Microwave Devices. Report No. 3. General Electric Co., Schenectady, N.Y. Contract No. DA36-039-SC-87253. 31 March 1962. DDC AD276646.
- 205 Plankis, E. P. Radiation Effects on Microwave Devices. Report No. 4. General Electric Co., Schenectady, N.Y. Contract No. DA36-039-SC-87253. 30 June 1962. DDC AD286882.
- 206 Schlosser, W. et al. "Pulsed Nuclear Radiation Effects on Electronic Components and Materials." U. S. Army Electronics R&D Laboratory, Ft. Monmouth, N. J. Reprint from Electro-Technology. May 1963.
- 207 Adom, T. and Kothstein, T. Nuclear Pulse Testing of a Vidicon Camera Head. Frankford Arsenal, Philadelphia, Pa January 1961.

Radiation
Effects Ref.
Number

- 208 Keister, G. L. Transient Radiation Effects on Electronics, Part I- Kukla Transient Radiation Tests. WADD-TN-61-8. Boeing Airplane Co., Seattle, Washington. Contract No. AF 33(616)-7531. January 1961. DDC AD 261933.
- 209 Saelens, R. G. Radiation Effects on Ceramic Electron Tube Types at Godiva II Facility. USASRD TR-2030. U. S. Army Signal R&D Laboratory, Ft. Monmouth, N. J. DA Task Nr. 3-19-01-701. 17 March 1959. DDC AD218006
- 210 Long, A. L. and Degenhart, H. J. Transient Effects of Pulsed Nuclear Radiation on Electronic Parts and Materials. USASRD TR-2007. U. S. Army Signal R & D Laboratory, Ft. Monmouth, N. J. DA Task Nr. 3-93-01-701. 20 January 1959. DDC AD227502.
- 211 Wyler, E. N. et al. Transient Radiation Effects on Electronic Components and Semiconductor Devices. RWIC Report No. 26. Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-10085. April 19, 1963.
- 212 Harrison, G. R. and Scheiwe, J. R. Study of Pulsed Radiation Effects on Microwave Ferrite Duplexers. Report No. 2. Sperry Rand Corp., Clearwater, Fla. Contract No. DA36-039-SC-89113. November 1962. DDC AD296917.
- 213 Talbert, A. J. and Wilkin, M. D. Pulsed Gamma Initiation of Breakdown in Gas Tubes. DOFL TR-961. Diamond Ordnance Fuze Laboratory, Washington, D. C. DOFL Project 54050. 10 July 1962. DDC AD260821.
- 214 Plankis, E. P. Radiation Effects on Microwave Devices. Report No. 2. General Electric Co., Schenectady, New York. Contract No. DA36-039-SC-37253. 31 December 1961. DDC AD273695.
- 215 Sauer, H. S. A Study of Radiation Effects on Electronic Devices, Second Interim Report (Part II). EG & G Report No. B-2115. Edgerton, Germeshausen and Grier, Inc., Boston, Mass. Contract No. DA36-039-SC-78171. 31 July 1960. DDC AD249346.
- 216 Vassilakos, D. Radiation Test on the PS210 Transistorized 150 Volt Regulated Power Supply. Report No. D5-5851. Boeing Airplane Co., Seattle, Washington. Contract No. AF 33(600)-35030. October 14, 1959. DDC AD244774.

5.0 LIST OF ABBREVIATIONS USED IN DESIGN ALLOWABLES

absolute.	abs	kilovolt.	.kv
alternating-current(as adj.only).	a-c	kilovolt-ampere	kva
American wire gauge	Awg	kilowatt.	.kw
ampere.	amp	magnetomotive force	mmf
ampere-hour	amp-hr	maximum	max
amplification factor of vacuum tube	"	megacycle	Mc
amplitude modulated(as noun or adj.).	AM	megavolt-ampere	mva
atmosphere.	atm	megawatt.	Mw
audio-frequency (as adj. only).	a-f	microampere	μa
average	avg	microfarad	μf or mf
Balance	bal	micromicrofarad	μμf or pf
British thermal unit.	Btu	micromicron	μμ
calorie	cal	micron.	μ
centimeter.	.cm	microsecond	μsec
centimeter-gram-second(system).	cgs	microvolt	μV
centistokes	.CS	microwatt	μW
circular-mil (adjective).	cir-mil	milliampere	ma
coefficient	coeff	millihenry	mh
counter electromotive force	.cemf	millimeter	mm
cubic	.cu	millimicron	mμ
current	I	millivolt	mV
cycles per second	cps	minimum	min
decibel	.db	minute	mi
power in decibels referred to 1 milliwatt.dbm		ohm (Ω)	spell out
degree.	deg	ohm-centimeter.	.ohm-cm
degree (angular measure).	°	ounce	.oz
degree centigrade	C	pound	.lb
degree Fahrenheit	F	pound per square inch	psi
diffused	.diff	pound per square inch gauge	psig
diameter	.diam	power	pwr
direct-current (as adj. only)	d-c	primary	pri
dissipation factor	D.F.or Diss.F	pulse time modulation	PTM
electric.	.elec	radio-frequency (as adj.)	r-f
electromotive force	emf	recommended	rec
ergs/gm-(C)	e/g-c	resistance	R
foot.	.ft	revolutions per minute.	rpm
frequency	.freq	short-circuit ratio	scr
frequency modulated (as noun or adj.)	FM	signal-to-noise ratio	s/n
Germanium	Ge	single side band.	ssb
gram	.gm	square.	.sq
gravitational acceleration.	g	standing-wave ratio	swr
henry	h	superhigh frequency	shf
hermetically sealed	H.S.or Herm.S	temperature	temp
horsepower.	.hp	thousand.	.M
hour	.hr	transformer	.Xfmr
impedance	Z	transistor	Xsistor
inch	.in	ultrahigh frequency	uhf
intermediate-frequency (as adj.)	i-f	very high frequency	vhf
Insulation Resistance	.IR	volt	V
kilocycles per second	.Kc	volt-ampere	va
kilomegacycles	KMc	watt	W
kilometer	km	watthour.	whr
		yard	.yd

6.0 CONVERSION FACTORS

To permit comparison of data from various sources, reported in a variety of units, it is frequently necessary to convert to a standard set of units. The standard units used in this document are ergs/gm-(C) for electromagnetic radiation and particles/cm² for any type of particulate radiation. In many cases, insufficient information is presented to permit an accurate conversion. The values, marked with an asterisk, are approximately correct for hydrocarbons, assuming an average energy of 1 Mev for the radiation. These values should be used with caution and only in cases where more applicable information is not available.

<u>To Convert</u>	<u>To</u>	<u>Multiply By</u>
Rads (for any material)	ergs/gm (of that material)	100
Roentgen	ergs/gm-(C)	87.7
Roentgen	ergs/gm (Tissue)	96.4
Rep	ergs/gm-(C)	84.6
Rep	ergs/gm (Tissue)	93.0
Rad (Tissue)	ergs/gm-(C)	90.9
Rad (water)	ergs/gm-(C)	90.0
*(1) Photons/cm ²	rep	5×10^{-10}
*Rep/hr	n/cm ² -Sec	7.1×10^4
*Rad/hr	n/cm ² -Sec	8.3×10^4
*(2) Rem/hr	n/cm ² -Sec	8.3×10^3
** Photons/cm ²	ergs/gm-(C)	5.7×10^{-8}

-
- * Based on average energy of 1 Mev
 (1) For any energy other than 1 Mev, See Figure 2
 (2) For any energy other than 1 Mev, See Figure 3
 ** Based on Co-60 source

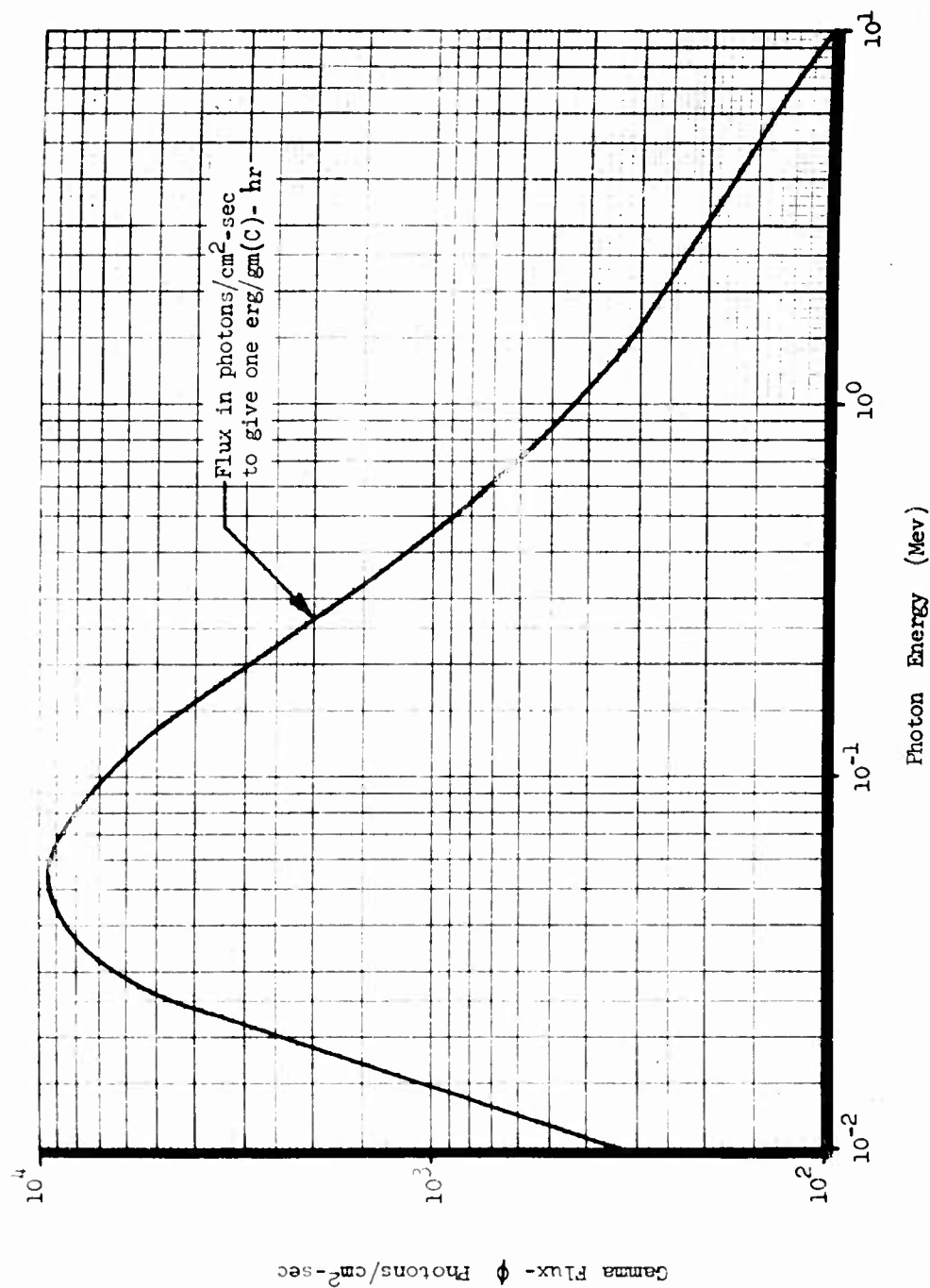


FIGURE 2 NUMBER OF GAMMA RAYS VS. DOSE RATE FOR VARIOUS GAMMA ENERGIES

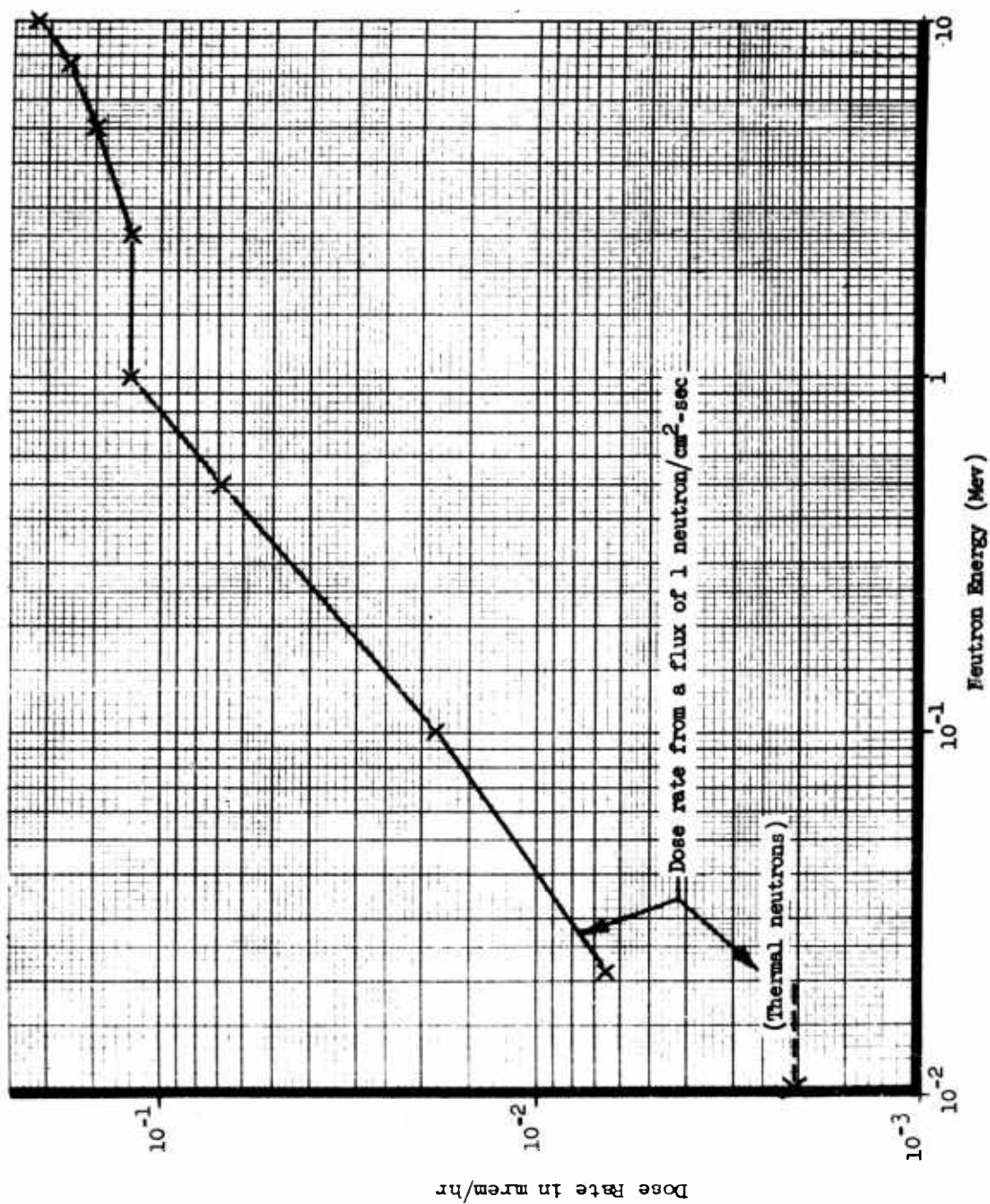


FIGURE 3 CURVE TO CONVERT NEUTRON FLUX TO DOSE RATE

7.0 RADIATION EFFECTS FACILITIES UTILIZED IN GENERATING
TEST DATA REFERENCED IN THIS REPORT

7.1

STEADY-STATE REACTOR FACILITIES

Argonne Research Reactor CP-5
Argonne National Laboratory
Argonne, Illinois

R. E. No. 1, 2, 3, 4, 5, 6, 11, 12, 59, 60, 66, 72, 74

Battelle Research Reactor
Battelle Memorial Institute
Columbus, Ohio

R. E. No. 52, 65

Brookhaven Research Reactor
Brookhaven National Laboratory
Upton, New York

R. E. No. 15, 16, 17, 49, 59, 61, 65, 66

Curtiss-Wright Research Reactor
Curtiss-Wright Corporation
Quehanna, Pennsylvania

R. E. No. 28, 75

Ford Nuclear Reactor
University of Michigan
Ann Arbor, Michigan

R. E. No. 35

General Electric Nuclear Test Reactor (GENTR)
Vallecitos Atomic Laboratory
Pleasanton, California

R. E. No. 10, 32, 36, 53

Georgia Nuclear Laboratories Radiation Effects Reactor
(GNL)
Lockheed-Georgia Company
Marietta, Georgia

R. E. No. 45, 54

Ground Test Reactor (GTR)
General Dynamics Corporation
Fort Worth, Texas

R. E. No. 9, 11, 12, 13, 21, 22, 23, 24, 25, 26, 30, 31,
34, 37, 38, 39, 40, 41, 44, 46, 48, 50, 51, 62, 69

Materials Testing Reactor (MTR)
National Reactor Testing Station
Idaho Falls, Idaho

R. E. No. 42, 56, 58

MTR & ETR Spent Fuel Radiation Irradiation Facility
Idaho Falls, Idaho

R. E. No. 46, 64

MIT Research Reactor
Massachusetts Institute of Technology
Cambridge, Massachusetts

R. E. No. 75

Oak Ridge Research Reactor
Oak Ridge National Laboratory
Oak Ridge, Tennessee

R. E. No. 58

Penn St. Research Reactor
Penn St. University
University Park, Pennsylvania

R. E. No. 16, 17, 18, 19, 75

7.2

GAMMA SOURCES AND PARTICLE ACCELERATORS

Admiral Cobalt-60 Source
Admiral Corporation
Chicago, Illinois

R. E. No. 1, 2, 3, 6, 60, 70, 74

Argonne Cyclotron and Linear Accelerator Facility
Argonne National Laboratory
Argonne, Illinois

R. E. No. 27

Argonne High Level Gamma Irradiation Facility
Argonne National Laboratory
Argonne, Illinois

R. E. No. 8, 33, 71

Armour Research Ion Bombardment Chamber
Armour Research Foundation
Chicago, Illinois

R. E. No. 7

Battelle Gamma-Irradiation Facility
Battelle Memorial Institute
Columbus, Ohio

R. E. No. 14

Bell Telephone Laboratories Cobalt-60 Gamma Cell
New York, New York

R. E. No. 17

Brookhaven Gamma Irradiation Facility
Brookhaven National Laboratory
Upton, New York

R. E. No. 19

Cook Technological Gamma Facility
Cook Electric Company
Morton Grove, Illinois

R. E. No. 47

General Atomics 45 Mev Linear Accelerator
General Dynamics Corporation
San Diego, California

R. E. No. 213

Shell Van de Graaff Accelerator
Shell Development Company

R. E. No. 68

University of Minnesota Gamma-Irradiation Facility
University of Minnesota

R. E. No. 33

Van de Graaff (WNYRC)
Western New York Research Center, Inc.
Buffalo, New York

R. E. No. 8

WADD Cobalt-60 Source
Wright-Patterson Air Force Base, Ohio

R. E. No. 11, 12, 55, 57, 73

Miscellaneous Cobalt-60 Sources

R. E. No. 63

7.3

PULSED REACTORS

DOFL TRIGA Mark F
Harry Diamond Laboratories
Washington, D. C.

R. E. No. 202

General Atomics TRIGA Mark F
General Dynamics Corporation
Torrey Pines, California

R. E. No. 207

Godiva
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

R. E. No. 200, 201, 203, 205, 209, 210, 216

KEWB (Kinetic Experiments on Water Boilers)
National Reactor Testing Station
Idaho Falls, Idaho

R. E. No. 215

Kukla
Lawrence Radiation Laboratory
Livermore, California

R. E. No. 208

SPRF (Sandia Pulsed Reactor Facility)
Sandia Corporation
Albuquerque, New Mexico

R. E. No. 11, 12, 30, 204, 206, 212, 214

References for a detailed description of the above facilities.

(1) Hamman, D. J. and Veazie, Jr. W. H. Survey of Irradiation Facilities. REIC Report No. 31 (Part I). Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-1005. September 15, 1963.

(2) Hamman, D. J. and Veazie, Jr. W. H. Survey of Particle Accelerators. REIC Report No. 31 (Part II). Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-1005. September 15, 1963.

8.0 ADDITIONAL REFERENCES

The following list of references may be consulted for additional radiation effects information. These reports were received after the cut-off date for tabulating the "Design Allowables" and, therefore, were not used in this study.

1. Chapin, W. E. et al. Space-Radiation Damage to Electronic Components and Materials. REIC Report No. 32. Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-10085. October 30, 1963.
2. Curtsinger, B. E. Effects of Irradiation on Three Silicone Dielectric Fluids. Report No. NARF-63-7T, FZK-9-188. General Dynamics Corp., Fort Worth, Texas. Contract No. AF 33(657)-7201. July 31, 1963.
3. Burnett, J. R. et al. Calibration of Pressure Transducers for Pluto Radiation Environments. Report No. S-238-R. Edgerton, Germeshausen and Grier, Inc., Santa Barbara, California. Contract No. SANL 730/3186005 for University of California, Lawrence Radiation Laboratory. August 1963.
4. Study of Effect of High-Intensity Pulsed Nuclear Radiation on Electronic Parts and Materials (SCORRE), Report No. 10. IBM Report No. 63-928-12. IBM Corp., Owego, N.Y. Contract No. DA 36-039SC-85395. January 31, 1963. DDC AD404493.
5. Wicklein, H. W. et al. Godiva III Minuteman Radiation Effects Tests, October 1960. IDEP Report No. 347.60.00.00-C6-01. Boeing Airplane Company, Seattle, Washington. Contract No. AF 04(647)-289. December 30, 1960. DDC AD271339.
6. Shatzkes, M. and Boyd, G. Study of Effect of High-Intensity Pulsed Nuclear Radiation on Electronic Parts and Materials (SCORRE), Report No. 5. IBM Report No. 61-521-10. IBM Corp., Owego, New York. Contract No. DA 36-039SC85395. September 30, 1961. DDC AD267398.
7. Study of Effect of High-Intensity Pulsed Nuclear Radiation on Electronic Parts and Materials (SCORRE), Report No. 6. IBM Report No. 62-521-3. IBM Corporation, Owego, New York. Contract No. DA 36-039SC85395. December 31, 1961. DDC AD 273701.
8. Study of Effect of High-Intensity Pulsed Nuclear Radiation on Electronic Parts and Materials (SCORRE), Report No. 2. IBM Report No. 61-521-1. IBM Corporation, Owego, New York. Contract No. DA 36-039SC85395. December 31, 1960. DDC AD252023.

9. Pulsed Radiation Effects on Electronic Components, Second Triannual Report. IBM Report No. 60-521-10. IBM Corporation, Owego, New York. Contract No. AF 33(600)-40462. October 31, 1960. DDC AD245538L.
10. Pulsed Radiation Effects on Electronic Components, Third Triannual Report. IBM Report No. 60-521-2. IBM Corporation, Owego, New York. Contract No. AF 33(600)-40462. February 28, 1961. DDC AD253120L.
11. Wong, H. Y. and Price, W. E. Final Report on Evaluation of Field-Effect Transistors. Report No. LMSD 8-19-62-12. Lockheed Missiles and Space Company, Sunnyvale, California. October 4, 1962.
12. Lehr, L. J. et al. Equipment Design Consideration for Space Environment. IDEP Report No. 347.60.00.00-64. Space Technology Laboratories, Inc., Los Angeles, California. February 1962. DDC AD288341.
13. Ihnat, M. E. Radiation From Space Powerplants and Its Effect Upon Material. RAD-9-TM-60-82. Avco Corporation, Wilmington, Massachusetts. Contract No. AF 04(647)-305. January 9, 1961. DDC AD249502.
14. Hamre, H. G. et al. Semiconductor Diode Performance in Nuclear Radiation Environments. Report No. ASD-TDR-62-12. Armour Research Foundation, Chicago, Illinois. Contract No. AF 33(616)-7329. May 1962.
15. Aboaf, J. A. et al. Irradiation Damage to Glass. Bausch and Lomb, Incorporated, Rochester, New York. Contract No. AT (39-1)-1312. November 1961.
16. Magee, R. M. et al. Study to Determine Effects of Fission Product Gamma Radiation on Electronic Parts and Equipment, Final Report. Report No. BSC 39655. Bendix Corporation, Ann Arbor, Michigan. Contract No. N0bar-87267. August 1963.
17. NEEP-Nuclear Electronic Effects Program, Ninth Triannual Technical Note. Report No. ASD-TDR-62-477. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. March 15, 1962. DDC AD278181.
18. NEEP-Nuclear Electronic Effects Program, Eleventh Triannual Technical Note. Report No. ASD-TDR-62-1101. Bell Telephone Laboratories, Inc., New York, New York. Contract No. AF 33(616)-6235. October 31, 1962.

19. Fritz, E. G. and Johnson, P. M. Tensile Behavior and Molecular Characteristics of Irradiated Elastomers. Report No. NARF-62-8T, MR-N-274. General Dynamics Corporation, Fort Worth, Texas. Contract No. AF 33(657)-7201. July 1962.
20. Fritz, E. G. and Johnson, P. M. Stress-Strain Behavior of Irradiated Polyurethane Elastomers. Report No. NARF-62-2T, MR MR-N-293. General Dynamics Corporation, Fort Worth, Texas. Contract No. AF 33(657)-7201. February 23, 1962.
21. Wattier, D. M. et al. Effects of Reactor Radiation on the Engineering Properties of Elastomers and Plastics. Report No. NARF-62-5T, FZK-9-174. General Dynamics Corporation, Fort Worth, Texas. Contract No. AF 33(657)-7201. June 1962.
22. Fritz, E. G. and Johnson, P. M. Ultimate and Pseudo-Equilibrium Tensile Properties of Irradiated Elastomers. Report No. NARF-62-7T, MR-N-295. General Dynamics Corp., Ft. Worth, Texas. Contract No. AF 33(657)-7201. August 1962.
23. Hopkins, G. R. et al. Transient Radiation Effects on Coaxial Cables. Report No. GA-3616. General Atomics Division of General Dynamics Corporation, San Diego, California. Contract No. DA 36-039-SC-89196. December 18, 1962. DDC AD295486.
24. Poll, R. A. and Van Lint, V. A. J. Transient Radiation Effects in Pressure Transducers. Report No. AFSWC-TDR-62-63. General Atomics Division of General Dynamics Corporation, San Diego, California. Contract No. AF 29(601)-4953. June 1962. NASA N62-16174.
25. Colley, H. C. A Report of the In-Pile Testing of 12 Bourne Trimpots - XCI-42. Report No. DC 59-11-196. General Electric Company, Cincinnati, Ohio. November 11, 1959.
26. Jaffe, L. D. Effects of Space Environment Upon Plastics and Elastomers. Technical Report No. 32-176. Jet Propulsion Laboratory of California Institute of Technology, Pasadena, California. Contract No. NASw-6. November 16, 1961. DDC AD268432.
27. Research and Investigation on Radiation Resistant High Temperature Thermionic Circuitry. Report No. ASD-TDR-62-1039. General Electric Company, Owensboro, Kentucky. Contract No. AF 33(616)-8096. December 1962.
28. Perkins, C. W. Transient Radiation Effects on Passive Parts, Second Quarterly Progress Report. Report No. FR 63-17-37. Hughes Aircraft Company, Fullerton, California. Contract No. DA 36-039-SC-89112. November 30, 1962. DDC AD296880.

29. Golub, M. A. and Walrath, R. L. Radiation-Induced Reactions in Swollen Polymers. Report No. PMU-4062. Stanford Research Institute, Menlo Park, California. Contract No. AT(04-3)-115 November 30, 1962.
30. Falk, R. A. Nuclear Radiation Resistant Gyroscope Bearing Lubricants and Flctation Media, Part I. Report No. WADD-TR-60-753 Part I. Sperry Gyroscope Company, Great Neck, New York. Contract No. AF 33(616)-6187. March 1961.
31. Honaker, W. C. and Bryant, F. R. Irradiation Effects of 40 and 440 MEV Protons on Transistors. Report No. NASA-TND-1490. Langley Research Center, Langley Field, Virginia. January 1963.
32. Rendler, N. J. Apparatus for In-pile Electrical Measurements and Effect of Radiation Upon Strain Guage Insulation Components. NRL Report No. 5674. U. S. Naval Research Laboratory, Washington, D. C. October 2, 1961. DDC AD265773.
33. Schindler, A. I. The Effects of Irradiation on Magnetic Properties of Alloys and Ferrites. NRL Report 5686. U. S. Naval Research Laboratory, Washington, D. C. August 11, 1961. DDC AD262261.
34. Zagorites, H. A. et al. Effects of Nuclear Radiation on Shipboard Electronic Equipment, 1. Some Effects of Simulated Transit Radiation on Parts, a. Transistors. Report No. USNRDL-TR-577. U. S. Naval Radiological Defense Laboratory, San Francisco, California. August 3, 1962. DDC AD287649.
35. Kilp, G. R. and Mitchell, P. V. Radiation Effects on Thermo-electric Materials. Report No. WCAP-1680. Westinghouse Electric Corporation, Pittsburgh, Pennsylvania. Contract No. AT (30-3)-500. May 1961.
36. Brownlee, J. and McNally, J. P. The Effects of Simulated Space Environments on Structural Plastic Materials. Report No. SP-TP-24, RD-R60-80. Aerojet-General Corporation, Azusa, Calif. August 1960. DDC AD293597.
37. RIFT Radiation Effects Program Radiation Test No. 7 DC Amplifier-Transducer Exciters. Report No. ND-409. Lockheed-Georgia Company, Marietta, Georgia. Contract No. NAS 8-5600. October 7, 1963.
38. Ebeoglu, D. B. and Saur, A. J. Transient Radiation Effects in Electronic Materials, Report No. 3. Report No. AI-7860. Atomics International Division of North American Aviation, Inc., Canoga Park, California. Contract No. MIPR R62-16SC-00-93. December 26, 1962. DDC AD401170.

39. Chapin, W. E. et al. The Effects of Nuclear Radiation on Transducers. REIC Report No. 25. Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-10085. April 19, 1963. NASA N63-15866.
40. McNally, P. J. The Effect of Nuclear Radiation at Cryogenic Temperatures on Semiconductor Materials. REIC Report No. 30. Battelle Memorial Institute, Columbus, Ohio. Contract No. AF 33(657)-10085. September 30, 1963.
41. Perkins, C. W. Transient Radiation Effects on Passive Parts, Report No. 3. Report No. FR-63-17-102. Hughes Aircraft Co., Fullerton, California. Contract No. DA 36-039SC-89112. February 28, 1963. DDC AD405446.
42. Scheiwe, J. P. and Harrison, G. R. Study of Pulsed Radiation Effects on Microwave Ferrite Duplexers. Quarterly Report No. 3. Sperry Microwave Electronics Company, Clearwater, Florida. Contract No. DA 36-039SC-89113. February 1963. DDC AD407077.
43. Hopkins, G. R. et al. Transient Radiation Effects on Electronic Parts, Quarterly Progress Report No. 4. Report No. GA 4190. General Atomics Division of General Dynamics Corporation, San Diego, California. Contract No. DA 36-039SC-89196. May 30, 1963. DDC AD407501.
44. Dorman, D. R. Gamma Irradiation Effects on Candidate Electronic, Lighting, Optical, Instrument, and Structural Components for In-Reactor Monitoring Equipment. Report No. HW 76263. General Electric Company, Richland, Washington, Contract No. AT(45-1)-1350. January 23, 1963.
45. Gerstein, B. et al. Effects of Nuclear Radiation on Frequency Control Devices. Report No. 1. Admiral Corporation, Chicago, Illinois. Contract No. DA 36-039AMC-00002 (E). December 31, 1962. DDC AD 408427.
46. Study of Effect of High-Intensity Pulsed Nuclear Radiation on Electronic Parts and Materials (SCORRE), Report No. 9. IBM Report No. 63-521-1. IBM Corporation, Owego, New York. Contract No. DA 36-039SC-85395. September 30, 1962. DDC AD296023.
47. Hopkins, G. R. et al. Transient Radiation Effects on Electronic Parts, Report No. 3. Report No. GA-3858. General Atomics Division of General Dynamics Corporation, San Diego, Calif. Contract No. DA 36-039SC-89196. March 18, 1963. DDC AD299233.

48. Stanley, J. M. The Effects of Pulse Nuclear Radiation on Quartz Crystal Units. USAELRDL-TR-2320. U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey. DA Task Nr. 3A99-15-001-02. November 1962. DDC AD298552.
49. Johnson, E. R. Literature Study of Radiation Effects on Electronic Devices. Final Report for December 1961 - 30 November 1962. Stevens Institute of Technology, Hoboken, New Jersey. Contract No. DA 36-039SC-89148. 1963. DDC AD412531.
50. Wicklien, H. W. Transient Radiation Effects in Coaxial Cables Due to Gamma-Neutron Pulses. Document No. D2-90172. Boeing Airplane Company, Seattle, Washington. May 15, 1962. DDC AD412858.
51. Degenhart, H. J. et al. Pulsed Nuclear Radiation Induced Transients in Electronic Parts and Materials (Godiva IV and V). USAELRDL TR-2299. U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey. January 1963. DDC AD409579.
52. Linden, E. G. and Lascaro, C. P. Neutron and Gamma Radiation Effects on Dielectrics. USAELRDL TR-2323. U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey. January 1963. DDC AD409681.
53. McAdory, J. L. and Steffey, C. A. (UNCLASSIFIED TITLE) Pulsed Nuclear Effects on Airborne Instrumentation Systems (Interim Report No. 1). TR No. SELWS-E-105. U. S. Army Electronics Research and Development Activity, White Sands Missile Range, New Mexico. October 1962. DDC AD337637. (CONFIDENTIAL REPORT)
54. Hunter, E. T. and Wannemacher, H. E. Transient and Steady-State Nuclear Radiation Effects on Germanium PNP Alloy Transistors. USAELRDL TR-2310. U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey. DA Task Nr. 3A99-21-001-01. October 1962. DDC AD296283.
55. Keister, G. L. et al. Contributions to the State-of-the-Art of Transient Radiation Effects in Electronic Parts and Materials - Volume 2. Report No. D2-9878-3. The Boeing Company, Seattle, Washington. June 1962. NASA N63-20231.
56. Gray, P. D. et al. Rockets in Space Environment, Volume I - The Experimental Program. RTD-TDR-63-1050. Aerojet-General Corporation, Azusa, California. Contract No. AF 04(611)-7441. February 1963. DDC AD416294.

UNCLASSIFIED

UNCLASSIFIED