
TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 OVERVIEW.....	1
2.0 BASICS OF STATIC ELECTRICITY	1
2.1 INTRODUCTION	1
2.2 HISTORY	2
2.3 NATURE OF STATIC ELECTRICITY.....	2
2.4 SOURCES OF STATIC ELECTRICITY.....	6
2.5 MATERIAL ELECTRICAL CHARACTERISTICS: INSULATIVE, CONDUCTIVE AND DISSIPATIVE	7
2.6 MATERIAL TEST PRINCIPLES.....	9
2.7 ESD CONTROL PRINCIPLES	10
2.8 FOR FURTHER REFERENCE	11
3.0 DEVICE DAMAGE, THREAT CATEGORIES, AND MODELS	12
3.1 EFFECTS OF ESD ON DEVICES.....	12
3.2 ESD THREAT CATEGORIES AND MODELS.....	12
3.3 DEVICE SENSITIVITY.....	14
3.4 DETERMINING ESD SENSITIVITY THROUGH DEVICE TESTING	14
3.5 SUMMARY.....	17
3.6 FOR FURTHER REFERENCE	17
4.0 PERSONNEL SAFETY	17
4.1 OVERVIEW.....	17
4.2 GROUND POTENTIAL OF ELECTRICAL EQUIPMENT AND POWER TOOLS	17
4.3 CONDUCTIVE WORKSURFACE CONSIDERATIONS	18
4.4 GROUNDING TRADE-OFFS	18
5.0 ESD CONTROL PROGRAM PLAN - ADMINISTRATIVE REQUIREMENTS	18
5.1 DEVELOPING AN ESD CONTROL PROGRAM PLAN.....	18
5.2 DEVELOPING A TRAINING PLAN.....	20
5.3 DEVELOPING A PRODUCT QUALIFICATION PLAN.....	21
5.4 DEVELOPING A COMPLIANCE VERIFICATION PLAN.....	22
6.0 ESD CONTROL PROGRAM PLAN—OVERVIEW	26
6.1 MEASUREMENT CONSIDERATIONS	26
6.2 HUMIDITY	27
7.0 GROUNDING / EQUIPOTENTIAL BONDING SYSTEMS	28
7.1 INTRODUCTION	28
8.0 PERSONNEL GROUNDING	30
8.1 SYSTEM REQUIREMENTS.....	31

8.2	WRIST STRAP SYSTEM.....	31
8.3	FOOTWEAR/FLOORING SYSTEM.....	32
9.0	ESD PROTECTED AREAS	32
9.1	IDENTIFICATION.....	32
9.2	INSULATORS	33
9.3	ISOLATED CONDUCTORS	34
10.0	WORKSURFACES	34
10.1	INTRODUCTION	34
10.2	FACTORS IN SELECTING WORKSURFACES.....	35
10.3	TYPES OF DISSIPATIVE WORKSURFACE MATERIALS.....	36
10.4	TESTING.....	37
10.5	MAINTENANCE	38
10.6	FOR FURTHER REFERENCE	38
11.0	WRIST STRAPS	38
11.1	INTRODUCTION	38
11.2	DESCRIPTION OF A WRIST STRAP	39
11.3	WRIST STRAP USE AND SELECTION.....	40
11.4	WRIST STRAP TESTING	40
11.5	CONTINUOUS WRIST STRAP MONITORS	42
11.6	CURRENT LIMITING	42
11.7	SUMMARY.....	42
11.8	FOR FURTHER REFERENCE	43
12.0	FOOTWEAR.....	43
12.1	INTRODUCTION	43
12.2	TYPES OF FOOTWEAR	44
12.3	PROPER USAGE.....	44
12.4	TESTING.....	45
12.5	COMMON TESTING PROBLEMS.....	45
12.6	FOR FURTHER REFERENCE	45
13.0	STATIC PROTECTIVE FLOOR MATERIALS.....	45
13.1	INTRODUCTION	45
13.2	FUNCTION OF STATIC PROTECTIVE FLOOR MATERIALS	46
13.3	RELATIONSHIP BETWEEN FLOORS AND FOOTWEAR	46
13.4	BENEFITS OF FLOOR MATERIALS	46
13.5	LIMITATIONS OF FLOOR MATERIALS	46
13.6	APPLICATIONS OF FLOOR MATERIALS	47
13.7	TYPES OF FLOOR MATERIALS	47
13.8	TEST METHODS	50
13.9	HAZARDS	52
13.10	CLEANROOM CONSIDERATIONS.....	52
13.11	TEST METHODS, STANDARDS, AND SPECIFICATIONS – ELECTRICAL RESISTANCE	54

13.12 FOR FURTHER REFERENCE	55
14.0 STATIC PROTECTIVE SEATING	56
14.1 INTRODUCTION	56
14.2 RELATIONSHIP BETWEEN CHAIRS, FLOORING, AND THE USER	56
14.3 BENEFITS	56
14.4 TYPES AND SELECTION	56
14.5 TESTING.....	57
14.6 CLEANING.....	57
14.7 FOR FURTHER REFERENCE.....	57
15.0 IONIZATION	57
15.1 INTRODUCTION	57
15.2 STATIC CHARGE CONTROL	58
15.3 WHAT IS AIR IONIZATION	59
15.4 MEASUREMENT OF AIR IONIZATION	60
15.5 PURPOSE OF IONIZATION.....	61
15.6 TYPES, USE, SELECTION, AND INSTALLATION OF AIR IONIZERS.....	61
15.7 TESTING OF AIR IONIZERS	67
15.8 MAINTENANCE/CLEANING.....	69
15.9 ENVIRONMENTAL/HUMIDITY IONIZATION CONSIDERATIONS.....	69
15.10 OTHER CONSIDERATIONS	70
15.11 FOR FURTHER REFERENCE	71
16.0 SHELVING	72
16.1 WORKSTATION SHELVING.....	72
16.2 STORAGE AREA SHELVING (I.E., WAREHOUSE, KITTING, ETC.).....	72
17.0 MOBILE EQUIPMENT	72
18.0 CONTINUOUS MONITORS	73
18.1 INTRODUCTION	73
18.2 WRIST STRAP CHECKERS	73
18.3 TYPES OF CONTINUOUS MONITORS	74
18.4 CONTINUOUS MONITOR FEATURES	75
18.5 PERIODIC VERIFICATION TESTING	75
18.6 SUMMARY.....	76
18.7 FOR FURTHER REFERENCE	76
19.0 GARMENTS	76
19.1 INTRODUCTION	76
19.2 TYPES AND SELECTION	76
19.3 APPLICATION	77
19.4 PROPER USE.....	78
19.5 TESTING AND QUALIFICATION	78
19.6 MAINTENANCE AND CLEANING	79

19.7 ENVIRONMENTAL/HUMIDITY	80
19.8 OTHER CONSIDERATIONS.....	80
19.9 FOR FURTHER REFERENCE	80
20.0 PACKAGING ELECTRONIC PRODUCTS FOR SHIPMENT AND STORAGE.....	80
20.1 INTRODUCTION	80
20.2 ITEM SENSITIVITY TO ESD.....	81
20.3 ESD THREAT EXPOSURE	81
20.4 PROTECTIVE PROPERTIES OF ESD PACKAGING	81
20.5 SELECTING A PACKAGE	82
20.6 FOR FURTHER REFERENCE	83
21.0 MARKING.....	83
21.1 MARKING OF ASSEMBLIES AND EQUIPMENT	83
21.2 MARKING OF PACKAGING	83
21.3 OTHER CONSIDERATIONS.....	84
21.4 FOR FURTHER REFERENCE	84
22.0 ESD GLOVES AND FINGER COTS.....	85
22.1 INTRODUCTION	85
22.2 GLOVES AND FINGER COT MATERIAL ISSUES	85
22.3 INTRINSIC RESISTANCE OF ESD GLOVES AND FINGER COTS	85
22.4 IN-USE RESISTANCE OF ESD GLOVES OR FINGER COTS	85
22.5 CHARGE GENERATION OF ESD GLOVES AND FINGER COTS.....	85
22.6 TEST METHODS TO MEASURE CHARGE GENERATION AND ACCUMULATION OF ESD GLOVES AND FINGER COTS	86
22.7 PERSONNEL GROUNDING	86
22.8 SELECTION OF THE APPROPRIATE ESD GLOVE/FINGER COT	86
22.9 FOR FURTHER REFERENCE	86
23.0 EQUIPMENT	87
23.1 INTRODUCTION	87
23.2 EQUIPMENT TYPES	87
23.3 TESTING - QUALIFICATION/PERIODIC VERIFICATION	88
23.4 EQUIPMENT - CAUSED ELECTRICAL OVERSTRESS (EOS)	89
23.5 TRIBOCHARGING	89
23.6 FOR FURTHER REFERENCE	89

FIGURES

Figure 1: Triboelectric Charge Materials Make Intimate Contact.....4

Figure 2: Triboelectric Charge – Separation4

Figure 3: Simplified HBM Simulator Circuit.15

Figure 4: HBM Current Waveform Through a Shorting Wire Indicating Decay Time and Peak Current.....15

Figure 5: Schematic of the CDM Test Setup from ANSI/ESDA/JEDEC JS-002.....16

Figure 6: Typical CDM ESD Waveform using a Single-Shot 8 Gigahertz Bandwidth Oscilloscope and Indicating Peak Current and Full Width Half Maximum (FWHM) .16

Figure 7: Common Point Ground Symbol28

Figure 8: Typical ESD Protective Workstation29

Figure 9: Relationship between Body Voltage and Resistance to Ground31

Figure 10: Example of an EPA Caution Sign33

Figure 11: Process Required Insulators34

Figure 12: Ionization by Alpha and X-ray Radiation.....59

Figure 13: Corona Ionization – Positive60

Figure 14: Corona Ionization – Negative.....60

Figure 15: ESD Sensitive Part or Assembly.....83

Figure 16: ESD Protective Material Marking84

TABLES

Table 1. Typical Static Electricity Sources7

Table 2. Distance Rules in ANSI/ESD S20.2034

Table 3. Comparison of Selected Properties of ESD Protective Floor Material.....48

Table 4. Floor Material Evaluation Criteria54

Table 5. Ionizer Selection Checklist64