
TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 OVERVIEW.....	1
1.2 STATIC CHARGE CONTROL.....	2
2.0 BASICS OF STATIC ELECTRICITY	2
2.1 INTRODUCTION	2
2.2 HISTORY	3
2.3 NATURE OF STATIC ELECTRICITY AND FUNDAMENTAL EQUATIONS.....	3
2.4 CHARGING MECHANISMS.....	5
2.5 SOURCES OF STATIC ELECTRICITY.....	7
2.6 MATERIAL ELECTRICAL CHARACTERISTICS: INSULATIVE, CONDUCTIVE, AND DISSIPATIVE	8
2.7 MATERIAL TEST PRINCIPLES.....	10
3.0 MEASUREMENT TECHNIQUES TO ASSESS PROPERTIES OF STATIC ELECTRICITY	12
3.1 GENERAL CONSIDERATIONS	12
3.2 TYPES OF MEASUREMENTS	12
4.0 DEVICE DAMAGE, THREAT CATEGORIES, AND MODELS	20
4.1 EFFECTS OF ESD ON DEVICES	20
4.2 ESD THREAT CATEGORIES AND MODELS.....	21
4.3 DEVICE SENSITIVITY.....	22
4.4 DETERMINING ESD SENSITIVITY THROUGH DEVICE TESTING	22
4.5 SUMMARY.....	25
5.0 PERSONNEL SAFETY	26
5.1 OVERVIEW.....	26
5.2 GROUND POTENTIAL OF ELECTRICAL EQUIPMENT AND POWER TOOLS	26
5.3 CONDUCTIVE WORKSURFACE CONSIDERATIONS	27
6.0 ESD CONTROL PROGRAM PLAN - ADMINISTRATIVE REQUIREMENTS	27
6.1 DEVELOPING AN ESD CONTROL PROGRAM PLAN.....	27
6.2 DEVELOPING A TRAINING PLAN	30
6.3 DEVELOPING A PRODUCT QUALIFICATION PLAN.....	31
6.4 DEVELOPING A COMPLIANCE VERIFICATION PLAN.....	32
6.5 ACCEPTANCE TESTING.....	33
7.0 ESD CONTROL PROGRAM PLAN – TECHNICAL REQUIREMENTS.....	33
8.0 GROUNDING/EQUIPOTENTIAL BONDING SYSTEMS	34
8.1 INTRODUCTION	34
9.0 PERSONNEL GROUNDING.....	37

9.1	SYSTEM REQUIREMENTS	37
9.2	WRIST STRAP SYSTEM.....	38
9.3	FOOTWEAR/FLOORING SYSTEM.....	38
9.4	GROUNDABLE STATIC CONTROL GARMENT SYSTEM.....	39
10.0	ESD PROTECTED AREA (EPA).....	39
10.1	IDENTIFICATION.....	40
10.2	INSULATORS	41
10.3	ISOLATED CONDUCTORS	42
10.4	HUMIDITY	43
11.0	WORKSURFACES	45
11.1	INTRODUCTION	45
11.2	VOLTAGE SUPPRESSION AND CHARGE DISSIPATION	45
11.3	FACTORS IN SELECTING WORKSURFACES.....	45
11.4	WORKSURFACE MATERIALS	47
11.5	TYPES OF WORKSURFACE MATERIALS	47
11.6	TESTING.....	48
12.0	WRIST STRAPS	48
12.1	INTRODUCTION	48
12.2	DESCRIPTION OF A WRIST STRAP	49
12.3	WRIST STRAP USE AND SELECTION	50
12.4	WRIST STRAP TESTING	50
12.5	CURRENT LIMITING	51
13.0	FOOTWEAR.....	51
13.1	INTRODUCTION	51
13.2	TYPES OF FOOTWEAR	52
13.3	PROPER USAGE.....	52
13.4	TESTING.....	53
13.5	COMMON TESTING PROBLEMS.....	53
14.0	STATIC PROTECTIVE FLOOR MATERIALS.....	53
14.1	INTRODUCTION	53
14.2	FUNCTIONS OF STATIC PROTECTIVE FLOOR MATERIALS	54
14.3	RELATIONSHIP BETWEEN FLOORING SYSTEMS AND FOOTWEAR	54
14.4	BENEFITS OF FLOOR MATERIALS	54
14.5	LIMITATIONS OF FLOOR MATERIALS	54
14.6	APPLICATIONS FOR FLOOR MATERIALS	54
14.7	TYPES OF FLOOR MATERIALS	55
14.8	TEST METHODS	58
15.0	STATIC PROTECTIVE SEATING	59
15.1	INTRODUCTION	59
15.2	RELATIONSHIP BETWEEN CHAIRS, FLOORING SYSTEMS, AND THE USER.....	60

15.3 BENEFITS	60
15.4 TYPES AND SELECTION	60
15.5 TESTING.....	61
15.6 CLEANING.....	61
16.0 IONIZATION	61
16.1 INTRODUCTION	61
16.2 PURPOSE OF IONIZATION.....	61
16.3 WHAT IS AIR IONIZATION?	62
16.4 MEASUREMENT OF AIR IONIZATION	64
16.5 TYPES, USE, SELECTION, AND INSTALLATION OF AIR IONIZERS.....	65
16.6 TESTING OF AIR IONIZERS	72
16.7 MAINTENANCE/CLEANING.....	74
16.8 ENVIRONMENTAL/HUMIDITY IONIZATION CONSIDERATIONS.....	75
16.9 OTHER CONSIDERATIONS.....	75
17.0 SHELVING	76
17.1 WORKSTATION SHELVING.....	76
17.2 STORAGE AREA SHELVING (FOR EXAMPLE, WAREHOUSE, KITTING, ETC.)	76
17.3 TESTING.....	77
18.0 MOBILE EQUIPMENT	77
18.1 TESTING.....	77
19.0 CONTINUOUS MONITORS	78
19.1 CONTINUOUS WRIST STRAP MONITORS	78
19.2 CONTINUOUS MONITOR FEATURES	79
19.3 COMPLIANCE VERIFICATION TESTING.....	79
19.4 SUMMARY.....	80
20.0 GARMENTS	80
20.1 INTRODUCTION	80
20.2 TYPES AND SELECTION	80
20.3 APPLICATION	81
20.4 PROPER USE.....	81
20.5 GARMENT TESTING AND QUALIFICATION	82
20.6 LAUNDRY.....	83
20.7 ENVIRONMENTAL/HUMIDITY.....	83
20.8 OTHER CONSIDERATIONS.....	83
21.0 PACKAGING ELECTRONIC PRODUCTS FOR SHIPMENT AND STORAGE.....	83
21.1 INTRODUCTION	83
21.2 ITEM SENSITIVITY TO ESD.....	84
21.3 ESD THREAT EXPOSURE	84
21.4 PROTECTIVE PROPERTIES OF ESD PACKAGING	84
21.5 SELECTING A PACKAGE	85

21.6 TESTING AND QUALIFICATION	86
22.0 MARKING.....	86
22.1 MARKING OF ASSEMBLIES AND EQUIPMENT	86
22.2 MARKING OF PACKAGING (INSIDE THE EPA).....	87
22.3 MARKING ON PACKAGING SHIPPED OR TRANSPORTED (OUTSIDE THE EPA)	87
23.0 GLOVES AND FINGER COTS	88
23.1 INTRODUCTION	88
23.2 GLOVES AND FINGER COT MATERIAL ISSUES	88
23.3 CHARGE GENERATION OF GLOVES AND FINGER COTS.....	89
23.4 TEST METHOD FOR CONTACT AND SEPARATION OF MATERIALS HANDLED BY A PERSON	89
23.5 SELECTION OF THE APPROPRIATE GLOVES AND FINGER COTS.....	90
24.0 HAND TOOLS	90
24.1 GENERAL CONSIDERATIONS	90
24.2 ELECTRICAL SOLDERING/DESOLDERING HAND TOOLS.....	90
24.3 NON-POWERED HAND TOOLS AND FIXTURES	91
25.0 AUTOMATED HANDLING.....	92
25.1 INTRODUCTION	92
25.2 TESTING – QUALIFICATION/COMPLIANCE VERIFICATION	93
25.3 EQUIPMENT-CAUSED ELECTRICAL OVERSTRESS (EOS)	93
25.4 TRIBOCHARGING	93
26.0 PROCESS ASSESSMENT	93
26.1 GENERAL CONSIDERATIONS	93
26.2 ESD PROCESS ASSESSMENT WITH ANSI/ESD SP17.1	94
26.3 SUMMARY.....	97
Annexes	
Annex A (Informative): Bibliography	98
Annex B (Informative): Revision History for ESD TR20.20	102
Tables	
Table 1: Example of a Triboelectric Series.....	6
Table 2: Typical Sources of Static Electricity	8
Table 3: Comparison of Selected Properties of ESD Protective Floor Material	56
Table 4: Floor Material Evaluation Criteria	59
Table 5: Ionizer Selection Checklist	69
Table 6: Measurement Techniques Used in ESD Process Assessment According to ANSI/ESD SP17.1	96

Figures

Figure 1: Triboelectric Charge – Contact of Two Materials	5
Figure 2: Triboelectric Charge – Separation	6
Figure 3: Concentric Ring Electrode Assembly	14
Figure 4: Resistance Measurement Electrode	14
Figure 5: Two-Point Probe	14
Figure 6: Verification of Resistance System	16
Figure 7: Example of a Body Voltage Measurement According to ANSI/ESD STM97.2	18
Figure 8: Simplified HBM Simulator Circuit	23
Figure 9: HBM Current Waveform Through a Shorting Wire Indicating Decay Time and Peak Current	24
Figure 10: Schematic of the CDM Test Set-up From ANSI/ESDA/JEDEC JS-002	25
Figure 11: Typical CDM ESD Waveform Using the Small Verification Module at 1000 Volts With a Single-Shot 8-Gigahertz Bandwidth Oscilloscope	25
Figure 12: Comparison of HBM and CDM Waveforms	26
Figure 13: Common Point Ground Symbol	34
Figure 14: A Typical Workstation Set-up as an EPA	35
Figure 15: An Example of an Isolated Ground Receptacle	36
Figure 16: Relationship Between Body Voltage and Resistance to Ground of Personnel Using a Wrist Strap System	38
Figure 17: Examples of EPA Configurations	39
Figure 18: Example of an EPA Caution Sign	40
Figure 19: Requirements for Process Essential Insulators According to ANSI/ESD S20.20	42
Figure 20: Wrist Strap	48
Figure 21: Corona Ionization – Positive	63
Figure 22: Corona Ionization – Negative	63
Figure 23: Ionization by Alpha Radiation	64
Figure 24: ESD Susceptibility Symbol	87
Figure 25: ESD Protective Symbol	88
Figure 26: Charge Generation Test Method for Parts Handled by a Person Wearing Gloves	89
Figure 27: Systematic Flow to Assess the Risk of ESD to an ESDS Item	95
Figure 28: Flow to Assess the ESD-Induced Risk by Charged ESDS Items According to ANSI/ESD SP17.1	97