

CONTENTS III

PREFACE XI

ACKNOWLEDGMENTS XIII

1 Introduction 1

- Short History of Packaging in the USA 2
- Functions and Goals of Transport Packaging 2
- The Cost of Packaging 3
- The Environmental Challenge to Packaging 4
- Packaging's Placement in the Corporate Structure 5
- Sources of Professional Information 6
- Definitions 6

2 The Package Design Process 9

- Taking a Total-System Approach to Package Design 9
- The Protective Package Concept 11
- The 10-Step Process of Transport Package Design 13
 - 1. Identify the Physical Characteristics of the Product 13
 - 2. Determine Marketing and Distribution Requirements 13
 - 3. Learn about the Environmental Hazards Your Packages Will Encounter 13
 - 4. Consider Packaging and Unitizing Alternatives 13
 - 5. Design the Transport Package 14
 - 6. Determine Quality of Protection Through Performance-Testing 14
 - 7. Redesign Package (and Unit Load) Until it Successfully Passes All Tests 15
 - 8. Redesign the Product if Indicated and Feasible 15
 - 9. Develop the Packing Methods 15
 - 10. Document All Work 15
- A Final Check 16

3 Rules and Regulations Governing Transport Packaging 17

- Hazardous Materials (Hazmat) Regulations 18
- Common Carrier Rules and Regulations 18
- National Motor Freight Classification 19
- Uniform Freight Classification 20
- Small-Parcel Carrier Regulations 21
- Air Cargo Regulations 21
- Export 21

4 Hazards in the Distribution Environment 23

- Environmental Hazards in Domestic Distribution 23
 - Shock Hazard in Handling and Transportation 24
 - Vibration hazard in Transportation 26
 - Static Compression Hazard in Warehousing 28
 - Dynamic Compression Hazards in Distribution 29
 - Concentrated Dynamic Pressure 29
 - Altitude-Extreme Variations 30

High-Humidity Hazard	30
Temperature Extremes in Distribution	30
Hazards in the Distribution Environment	31

5 Testing of Transport Packaging and Unit Loads 33

Sources of Testing Methods	34
Engineering Development Testing	34
Shock Hazard: Free Fall and Shock Machine Testing	35
Example	37
Shock Hazard: Incline Impact Testing	37
Shock Hazard: Horizontal Impact Testing	38
Vibration Hazard: Repetitive-Shock Testing	38
Vibration Hazard: Resonance by Sine Sweep and Dwell Testing	39
Vibration Hazard: Random Vibration Testing	40
Compression Hazard Testing	40
Tests for Other Physical Hazards	41
Natural Hazards: Temperature and Humidity Conditioning	42
Performance Testing of Shipping Containers and Systems	43
ASTM D4169	43
ISTA Procedures	44
Regulatory Use of Performance Testing	46
Example	47

6 Testing for Product Fragility 49

Shock Fragility Assessment	49
Vibration Fragility Assessment	52

7 Corrugated Boxes 55

Corrugated Packaging: Sustainable, Renewable and Recyclable	56
Recyclable	56
Containerboard Manufacturing	57
Raw Materials to the Paper Mill	57
At the Paper Mill	58
Corrugated Structure	59
Single Face	59
Single Wall	59
Double Wall	59
Triple Wall	59
Corrugated Box Manufacturing	61
At the Box Plant	61
Corrugator	61
Corrugated Adhesive System	62
Converting Operations	62
Printer-Slotter	62
Flexo Folder-Gluer	62
Die-Cutter	63
Graphics Press	63
Inks	64
Joining	64
Labeler	64
Specialty Processes	64

Box Styles 64

Box Dimensions 65

Designing Transport Packaging 65

The Development Process 66

Identify the Requirements 66

Design and Engineer 66

Qualify 66

Redesign and Optimize 66

Finalize the Process 66

Checklists for Efficient Acquisition of Corrugated Products 66

The Product Itself 67

Set-Up and Packing 67

Distribution and Storage 67

Marketing Considerations 68

Regulatory and Other Issues 68

How Carrier Regulations Fit In 68

The Boxmaker's Certificate 68

Understanding the BMC 69

Package Engineering with Example 70

Stacking and Compression 72

Distribution Environment and Container Performance 72

Example 74

Compression Solutions 75

Cost Effectiveness 75

Containment 75

Bulge Resistance 76

Unitizing 76

Testing of Containerboard, Combined Board and Corrugated Products 77

Conditioning 78

Transport Packaging Test Methods 78

Compression Strength 78

Drop and Incline Impact 81

Vibration 82

Preshipment Evaluations 82

Compliance with Carrier Regulations 82

Edge Crush (ECT) 82

Burst/Puncture 83

One Additional Test Method: Caliper/Thickness 84

Testing Facilities 84

8 Unitizing: Pallets, Slip Sheets and Load Stabilizers 87

Unit Load Components 87

Pros and Cons of Unitizing 88

Costing a Unit Load System 88

Costs 88

Savings 89

Sizing the Unit Load 89

Load Bases 90

Pallets 90

Slip Sheets 95

Pallet Patterns 95

- Load Stabilizers 95
 - Stretch-Wrapping 96
 - Strapping 98
 - Adhesives 98
 - Shrink-wrapping 98
- Palletizing Equipment 99

9 Returnable Containers and Dunnage 101

- Advantages and Disadvantages of Returnables 102
- System Features for Success with Returnables 103
- Types of Returnables 103
- Design Criteria for Returnables 105
 - Importance of a Tracking System 106
- Cost Analysis 106

10 Cushioning Systems: Interior Packaging for Shock and Vibration Protection 109

- How Cushioning Works 110
- Cushioning Materials and Systems 111
 - Types 111
 - Properties 111
- Measuring Cushioning Performance 114
 - Shock from Impact 114
 - Vibration Performance 115
 - Compressive Creep 117
 - Temperature Extremes 117
 - High Humidity 117
- Cushioned-Package Design 118
 - Example 118
- Cushioning-System Design 122
 - Example 122*

11 Dunnage: Interior Packaging for Blocking & Bracing/Spacing, Void Fill and Abrasion Protection 123

- Functions of Dunnage 124
 - Blocking & Bracing/Spacing 124
 - Void Fill 124
 - Abrasion Prevention 124
 - Add Stacking Strength 125
- Materials and Forms 125
 - Corrugated Fiberboard 125
 - Expanded Polystyrene 125
 - Foam-in-Place 126
 - Molded Pulp 127
 - Honeycomb 127
 - Retention Packaging 128
 - Skin Packaging 128
 - Vacuum Forms 129
 - Loose Fill 129
 - Paper Varieties 129

- Air Bubble 130
- Foam Sheeting 130
- Inflatable Void Fill 130
- Miscellaneous Dunnage Materials 130
- Suspension Packaging 131
- Checking Performance of Dunnage Packs 131

12 Corrosion- and ESD-Protective Packaging 133

- Corrosion Control 133
 - Condensation 134
 - Preventive Measures 134
 - Preservatives 134*
 - Volatile Corrosion Inhibitors 135*
 - Desiccants 135*
- Electrostatic Damage Control 137
 - Protective Materials 137
 - Electrostatic Moisture Barriers 137
 - Static-shielding Materials 138
 - Conductive Bags 139
 - Static-dissipative Materials 139

13 Other Shipping Containers 141

- Wood Containers 141
 - Container-Load Descriptions 141
 - Common Wood Container Types 142
 - Wood Boxes 142
 - Wood Crates 143
 - Wirebound Crates and Boxes 145
- Drums and Pails 147
 - Steel Drums and Pails 147
 - Plastic Drums and Pails 149
 - Fiber Drums 150
- Shipping Sacks 151
 - Paper Shipping Sacks 151
 - Plastic Shipping Sacks 152
 - Flexible Intermediate Bulk Containers 152
- Applicable Regulations 152

14 Marking and Coding of Transport Packages 153

- Pictorial Markings for Handling of Goods 153
- Hazardous Materials/Dangerous Goods Warning Labels 155
- Package Certification 156
- Bar Coding of Transport Packages and Unit Loads 158
- Applying Markings to Transport Packages 159

APPENDIX: Sources of Transport Packaging Information 161

- Standards 161
- Transportation Packaging Rules 162
- Trade Associations 162

