

Manufacturing Facilities Design and Material Handling

Third Edition



Fred E. Meyers • Matthew P. Stephens

Contents

CHAPTER 1 INTRODUCTION TO MANUFACTURING FACILITIES DESIGN AND MATERIAL HANDLING 1

- The Importance of Manufacturing Facilities Design and Material Handling 1
- Lean Thinking and Lean Manufacturing 4
- The Goals of Manufacturing Facilities Design and Material Handling 5
- The Manufacturing Facilities Design Procedure 11
- Types and Sources of Manufacturing Facilities Design Projects 13
- Computers and Simulation in Manufacturing Facilities Design 14
 - ISO 9000 and Facilities Planning* 15
- Glossary of Some Major Terms and Concepts in Facilities Planning 17
- Questions 20
- A Project in the Making 21

CHAPTER 2 SOURCES OF INFORMATION FOR MANUFACTURING FACILITIES DESIGN 25

- The Marketing Department 26
 - Determining Takt Time or Plant Rate* 27
 - Calculating Scrap and Rework Rates* 28
- The Product Design Department 29
- Management Policy Information 38
 - Inventory Policy* 39
 - Lean Thinking and Muda as a Part of Management Policy* 39
 - Investment Policy* 40
 - Startup Schedule* 40
 - Make or Buy Decisions* 41
 - Organizational Relationships* 41
 - Feasibility Studies* 41
- Conclusion 42
- Questions 43
- A Project in the Making 45

CHAPTER 3 TIME STUDY 50

What is a Time Standard? 50

The Importance and Uses of Time Study 52

1. *How Many Machines Do We Need?* 542. *How Many People Should We Hire?* 553. *How Much Will Our Product Cost?* 574. *When Should We Start a Job, and How Much Work Can We Handle with the Equipment and People We Have? Or, How Do We Schedule and Load Machines, Work Centers, Departments, and Plants?* 595. *How Do We Determine the Assembly Line Balance and the Conveyor Belt Speed, Load the Work Cells with the Correct Amount of Work, and Balance the Work Cells* 606. *How Do We Measure Productivity?* 617. *How Can We Pay Our People for Outstanding Performance?* 628. *How Can We Select the Best Method or Evaluate Cost Reduction Ideas?* 639. *How Do We Evaluate New Equipment Purchases to Justify Their Expense?* 6510. *How Do We Develop a Personnel Budget?* 65

Techniques of Time Study 65

Predetermined Time Standards Systems 66*Stopwatch Time Study* 66

Time Study Procedure and the Step-by-Step Form 70

Rating, Leveling, and Normalizing 79

Allowances 81

Types of Allowances 81*Methods of Applying Allowances* 85*Work Sampling* 88*Standard Data* 89*Expert Opinion Time Standards and Historical Data* 90

Time Standards for Manufacturing Facilities Design 91

Questions 92

A Project in the Making 94

CHAPTER 4 PROCESS DESIGN 95

Fabrication: Making the Individual Parts 96

Route Sheets 96*The Number of Machines Needed* 99

Work Cell Load Chart 101

Step-by-Step Procedure for Preparing a Work Cell Load Chart 105

Assembly and Packout Process Analysis 106

The Assembly Chart 106*Time Standards for Every Task* 106*Plant Rate and Conveyor Speed* 107

	<i>Paint Conveyor Speed</i>	108
	<i>Assembly Line Balancing</i>	109
	Step-by-Step Procedure for Completing the Assembly Line Balancing Form	112
	Calculating the Efficiency of the Assembly Line	120
	<i>Use of Computer Simulation</i>	120
	Layout Orientation	124
	Questions	124
	A Project in the Making	126
CHAPTER 5	<i>FLOW ANALYSIS TECHNIQUES</i>	136
	Fabrication of Individual Parts	140
	<i>String Diagram</i>	140
	<i>Multicolumn Process Chart</i>	142
	<i>From-To Chart</i>	144
	<i>Process Chart</i>	146
	<i>Step-by-Step Description for the Process Chart</i>	148
	Total Plant Flow	152
	<i>Flow Diagrams</i>	152
	<i>Step-by-Step Procedure for Developing a Flow Diagram</i>	155
	<i>The Operations Chart</i>	156
	<i>Step-by-Step Procedure for Preparing an Operations Chart</i>	156
	<i>Flow Process Chart</i>	158
	<i>Step-by-Step Procedure for Preparing a Flow Process Chart</i>	162
	<i>Computer-Aided Flow Design and Analysis</i>	162
	Conclusion	165
	Questions	165
	A Project in the Making	169
CHAPTER 6	<i>ACTIVITY RELATIONSHIP ANALYSIS</i>	180
	Activity Relationship Diagram	181
	<i>Determining the Relationship Code</i>	183
	Worksheet	185
	Dimensionless Block Diagram	185
	Flow Analysis	188
	Computer-Generated Activity Relationship Chart	188
	Questions	194
	A Project in the Making	196

CHAPTER 7 **ERGONOMICS AND WORKSTATION DESIGN** **SPACE REQUIREMENTS 203**

- Workstation Design 203
- Ergonomics and the Principles of Motion Economy 206
- Principle 1: Hand Motions* 209
- Principle 2: Basic Motion Types* 211
- Principle 3: Location of Parts and Tools* 212
- Principle 4: Freeing the Hands from as Much Work as Possible* 215
- Principle 5: Gravity* 215
- Principle 6: Operator Safety and Health Considerations* 217
- Space Determination 218
- Questions 222

CHAPTER 8 **AUXILIARY SERVICES REQUIREMENT SPACE 223**

- Receiving and Shipping 223
- Advantages and Disadvantages of Centralized Receiving and Shipping* 223
- The Trucking Industry's Effect on Receiving and Shipping* 224
- Functions of a Receiving Department* 225
- Facilities Required for a Receiving Department* 227
- Space Requirements for a Receiving Department* 228
- Functions of a Shipping Department* 229
- Space Requirements for a Shipping Department* 232
- Storage 235
- Just-in-Time Inventories* 237
- Maximizing the Use of the Cubic Space* 237
- Providing Immediate Access to Everything (Selectivity)* 239
- Providing Safekeeping* 248
- Warehousing 248
- Warehouse Design Criteria* 249
- Functions of a Warehouse* 251
- Procedure for Sales Analysis of ABC Inventory* 252
- ABC Inventory Layout of a Hand Tool Manufacturing Company's Warehouse* 253
- Warehouse Space Determination* 256
- Warehouse Equipment* 258
- Conclusion* 258
- Maintenance and Tool Room 259
- Utilities, Heating, and Air Conditioning* 261
- Questions 261

CHAPTER 9 EMPLOYEE SERVICES—SPACE REQUIREMENTS 264

- Parking Lots 264
- Employee Entrance 266
- Locker Rooms 268
- Restrooms and Toilets 269
- Cafeterias or Lunchrooms 270
- Recreational Facilities 274
- Drinking Fountains 275
- Aisles 275
- Medical Facilities 276
- Break Areas and Lounges 277
- Miscellaneous Employee Services 277
- Questions 279
- A Project in the Making 280

CHAPTER 10 MATERIAL HANDLING 287

- Cost Justification 288
 - Sample Material Handling Cost Problem* 289
- Goals of Material Handling 290
- Twenty Principles of Material Handling 290
 - 1. *Planning Principle* 291
 - 2. *Systems Principle* 292
 - 3. *Material Flow Principle* 292
 - 4. *Work Simplification Principle* 292
 - 5. *Gravity Principle* 293
 - 6. *Maximizing the Building Code Principle* 293
 - 7. *Unit Size Principle* 294
 - 8. *Mechanization Principle* 295
 - 9. *Automation Principle* 295
 - 10. *Equipment Selection Principle* 295
 - 11. *Standardization Principle* 297
 - 12. *Adaptability Principle* 298
 - 13. *Dead Weight Principle* 298
 - 14. *Utilization Principle* 298
 - 15. *Maintenance Principle* 298
 - 16. *Obsolescence Principle* 299
 - 17. *Control Principle* 299
 - 18. *Capacity Principle* 299
 - 19. *Performance Principle* 300
 - 20. *Safety Principle* 300

The Material Handling Problem-Solving Procedure	301
Questions	305

CHAPTER 11 MATERIAL HANDLING EQUIPMENT 307

Receiving and Shipping	308
<i>Receiving and Shipping Docks</i>	308
<i>Dock Equipment</i>	310
<i>Moving Equipment</i>	312
<i>Telescopic Conveyor</i>	320
<i>Weight Scale</i>	322
<i>Systems Required on Receiving and Shipping Docks</i>	323
Stores	323
<i>Storage Units</i>	323
<i>Stores Mobile Equipment</i>	327
<i>Systems Required for the Stores Department</i>	333
Fabrication	336
<i>Shop Containers</i>	336
<i>Tubs and Baskets</i>	336
<i>Workstation Material Handling Devices</i>	340
<i>Manipulators and Lifting Devices</i>	343
<i>Mobile Fabrication Equipment</i>	351
Assembly and Paint	359
<i>Belt Conveyors</i>	360
<i>Powered Roller Conveyors</i>	360
<i>Car-Type Conveyors</i>	360
<i>Slat Conveyors</i>	361
<i>Tow Conveyors</i>	363
<i>Overhead Trolley Conveyors</i>	364
<i>Power and Free Conveyors</i>	366
Packout	366
<i>Box Formers</i>	367
<i>Automatic Taping, Gluing, and Stapling</i>	367
<i>Palletizers</i>	368
<i>Pick and Place Robots</i>	368
<i>Banding</i>	372
<i>Stretch Wrap</i>	372
Warehousing	372
<i>Picking Carts</i>	373
<i>Gravity Flow Bins</i>	373
<i>Tractor-Trailer Picking Carts</i>	374
<i>Clamp Trucks</i>	374
<i>Rotary Conveyor Bins</i>	375

Vertical Warehouse and Picking Cars 375

Packing Station 376

Shipping Containers 376

Bulk Material Handling 377

Bulk Material Conveyors 378

Computer-Integrated Material Handling Systems 385

Cross-Docking and Flow-Through 389

Questions 392

A Project in the Making 393

CHAPTER 12 OFFICE LAYOUT TECHNIQUES AND SPACE REQUIREMENTS 399

Goals of Office Layout Design 399

Types of Office Space 400

Supervisors' Offices 401

Open Office Space 401

Conventional Offices 404

The Modern Office 404

Special Requirements and Considerations 407

Techniques of Office Layout 412

Organizational Chart 413

Flowchart 414

Communications Force Diagram 414

Activity Relationship Diagram 418

Activity Worksheet 419

Dimensionless Block Diagram 419

Office Space Determination 422

Detailed Master Layout 423

Questions 424

CHAPTER 13 AREA ALLOCATION 426

Space Requirements Planning 426

Under the Floor 428

Overhead Areas 428

Truss Level 429

Roof 429

Building Size Determination 429

Dimensionless Block Diagram 430

Area Allocation Procedure 430

Office Area Allocation 432

Questions 436

CHAPTER 14 FACILITIES DESIGN—THE LAYOUT 437

- Plot Plan 437
 - Plant Layout Methods* 440
- Master Plan 440
 - Three-Dimensional (3-D) Models* 446
 - Computer-Aided Design (CAD) Technique* 446
 - Advanced Computer Systems* 446
- Plant Layout Procedure—Toolbox Plant 450
 - Office Layout for the Toolbox Plant* 453
- Evaluation 455
- Questions 459
- A Project in the Making 460

CHAPTER 15 APPLICATION OF COMPUTER SIMULATION AND MODELING 466

- Introduction 466
- Defining Computer Simulation 467
- Advantages and Disadvantages of Simulation 468
- Simulation in Facilities Planning 468
- How Simulation Works 469
- An Overview of Layout and Simulation Software 471
- Computer-Aided Layout Design 471
 - Computer-Assisted Layout Performance Analysis* 474
- Case Studies 477
 - Simulation in Manufacturing* 478
 - Simulation in Health Care* 478
 - Simulation in Waste Handling* 480
- Questions 480

CHAPTER 16 SELLING THE LAYOUT 481

- The Project Report 481
- The Presentation 483
- Adjustments 484
- Approval 484
- The Rest of the Project 484
 - Sourcing* 485
 - Installation* 485
 - Engineering Plot* 485

Production Start 486

Debugging and Follow-Up 486

Conclusion 486

ANSWERS 489

INDEX 501