

# Total Productive Maintenance

Proven strategies and techniques  
to keep equipment running  
at peak efficiency



- TPM Implementation with Measurable Results
- Improve Overall Equipment Effectiveness (OEE)
- SMED: Single Minute Exchange of Dies for Quick Changeovers
- Integrate TPM with Other Maintenance Management Programs

Steven Borris

---

# Contents

**List of Figures, Formulas, and Tables** ix

**Preface** xxi

**Acknowledgments** xxiii

<b>Introduction</b>	<b>1</b>
The Development of Maintenance Systems	1
The Writing Technique and the Contents of the Book	3
The Pillars of TPM	7
The Toyota Production System (Also Known As Lean Manufacturing)	12
Finally, Advice for Using the Techniques	12
 <b>Chapter 1. TPM—Basic, Use, and Ideal Conditions</b>	 <b>15</b>
Fault Development	15
The Basic Condition	21
Technical Standards	24
Overall Equipment Efficiency	26
The availability of the equipment	29
The performance of the equipment	31
The quality of the product	31
Natural and Forced Deterioration	32
Use Conditions	34
The Ideal Condition	37
Improvement Methodology	37
How Do We Restore the Basic Condition?	41
 <b>Chapter 2. TPM Jishu-Hozen—Autonomous Maintenance</b>	 <b>43</b>
The TPM Initial Clean and Inspect and F-Tagging	45
The Cleaning Map: What and Where to Clean	50
F-Tags: How to Record Fugui	52
Discovery of a Serious Fault during the Cleaning	58
Tracking the Progress of the Initial Cleans	58

<b>Chapter 3. TPM—Analyzing and Categorizing the Failure Data</b>	<b>61</b>
F-Tags, The Machine History Log, and Minor Stops or Unrecorded Losses	
Categorizing	63
Finding Out the TPM Causes for the F-Tags to Help Find the Cure	71
Pareto Charts	80
The Defect Map	83
<b>Chapter 4. TPM—Creating Standards and Preparation for Autonomous Maintenance</b>	<b>85</b>
Task Transfer: Red to White F-Tags or PM to AM Tasks	89
Explanation of the Embedding and Responsibility Spreadsheet	95
PM Teams (Kobetsu Kaizen)	97
<b>Chapter 5. TPM: The Education &amp; Training and Safety Pillars</b>	<b>103</b>
The TPM Education & Training Pillar	106
Equipment training	113
A sequence for training equipment	116
Competency: How does TPM assess the skill level of the team members?	120
The TPM Safety Pillar	126
The area map	127
The hazard map	129
Risk assessment	131
Safe working procedures: Using as standards	146
<b>Chapter 6. 5S: Organization and Improvements by Default</b>	<b>153</b>
5S: SSSSS—The Meaning	154
The Benefits of 5S	154
The Decision to Implement 5S	156
Initial Management Implementation	157
Audit sheets	159
The red tag holding area	160
Step 1: Seiri—Sort	162
Red tag details	162
Step 2: Seiton—Set in Order	164
Step 3: Seiso—Shine	174
The 5S cleaning map or assignment map	175
Step 4: Seiketsu—Standardization	179
Step 5: Shitsuke—Self-Discipline	181
<b>Chapter 7. SMED—Single Minute Exchange of Die</b>	<b>183</b>
Where Did SMED Originate?	183
Step 1: Creating the SMED Team	186
The team members and their responsibilities	186
Step 2: Select the Tool	187
Step 3: Document Every Step of the Changeover	188
Step 4: Viewing the Changeover as a Bar Graph	196
Step 5: Define the Target Time for the Changeover	197

Step 6: Analysis of the Elements	198
The SMED Analysis	204
Implementing ideas	208
Create the new procedure	208
Step 7: Repeating the Exercise	211
Applying SMED to Maintenance and the Use of Turnaround Parts	211
<b>Chapter 8. Deciding on a Maintenance Strategy</b>	<b>213</b>
The TPM PM Analysis	214
The malfunction and PM maps	215
Interpreting PM maps	220
Scheduled maintenance or scheduled restoration	223
Scheduled replacement or scheduled discard	226
The RCM PM Analysis	227
The RCM decision diagram	228
Failure is unacceptable: Redesign the system	243
Recording the process on the decision worksheet	249
Failure finding and calculating acceptable risk	252
<b>Chapter 9. RCM—Reliability Centered Maintenance</b>	<b>257</b>
The First Stage in an RCM Analysis: The Operating Context	257
Example of a Furnace Boatloader Operating Context: Tool Analysis Level	261
Equipment Defined as Functions	267
Identifying Functions and Labeling	280
Functional Failures to Failure Effects	284
Failure modes	285
Failure effects	289
Where Did RCM Come From?	292
Non-Time-Based Failures	297
Infant mortality	298
<b>Chapter 10. Time- and Condition-Based Maintenance</b>	<b>299</b>
Introduction to On-Condition Maintenance	302
Friction between Maintenance and Production	304
What if we were starting from scratch?	311
In Summary	313
<b>Chapter 11. Fault Analysis: A Few Ways to Help Find Root Causes</b>	<b>315</b>
The 5 Why's	317
Fishbone Diagrams	320
Fault Tree Diagrams	323
OCAPs: Out-of-Control Action Plans	324
<b>Chapter 12. Team Objectives and Activity Boards</b>	<b>327</b>
Activity Boards	328
Team Goals	329
Monitoring Progress	331

What do we monitor?	331
How do we calculate the failure rate and the target improvement?	331
<i>Authority for Working in Specific</i>	
Machine Areas	334
What Do the Results of a Real RCM Analysis Look Like?	335
Summary of the boatloader analysis	337
Lean Manufacturing	340
Defects	342
Overproduction	343
Waiting	344
Transporting	344
Overprocessing	347
Unnecessary inventory	348
Unnecessary operator movement	349
Value	350
Equipment	353
Pull	355
 <b>Chapter 13. Six Sigma: A High-Level Appreciation</b>	 <b>359</b>
Graphs and Their Use in Six Sigma	361
Average and standard deviation	362
Standard deviation and z scores	364
The x-y graph	365
The Main Terms of Six Sigma	367
The customer	367
The teams and the leaders	368
The Champion or Sponsor	368
Six Sigma Controller	368
The Rules and Expectations	368
The Six Sigma Charter	368
The Technical Stuff	369
The sigma value	369
Defects per opportunity	369
Defects per million opportunities	369
The Stages of a Six Sigma Analysis	371
Considerations or Limitations in Using Six Sigma	373
Faultfinding the cause of a lamp failure	374
Possible Limitations with Using Statistics	376
 <b>Index</b>	 <b>379</b>