

# 3G HANDY GUIDE: Welding



## Features:

- ▶ Interactive Activities, question and quizzes
- ▶ Compelling visual examples, case studies and graphic design
- ▶ Easily customisable learning content and assessments



3G E-LEARNING



# 3G HANDY GUIDE: WELDING



3G E-LEARNING

## 3G HANDY GUIDE: WELDING



3G E-LEARNING

© 2019 3G E-learning LLC

90 Church Street

FL 1 #3514

New York, NY 10008

United States of America

[www.3ge-learning.com](http://www.3ge-learning.com)

email: [info@3ge-learning.com](mailto:info@3ge-learning.com)

Authored and Edited by 3G E-learning LLC, USA

ISBN: 978-1-98462-566-3

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise without prior written permission of the publisher.

This book contains information obtained from highly regarded resources. A Wide variety of references are listed. Reasonable efforts have been made to publish reliable data and information, but the authors, editors, and the publisher cannot assume responsibility for the legality of all materials or the consequences of their use. The authors, editors, and the publisher have attempted to trace the copyright holders of all material in this publication and express regret to copyright holders if permission to publish has not been obtained. If any copyright material has not been acknowledged, let us know so we may rectify in any future reprint. Registered trademark of products or corporate names are used only for explanation and identification without intent to infringe.

**Notice:** Registered trademark of products or corporate names are used only for explanation and identification without intent of infringement. Case Studies and/or Images presented in the book are the proprietary information of the respective organizations, and have been used here specifically and only for educational purposes. Although care has been taken to check accuracy of formulas and procedures, the detailed methods should be tested further on a small scale before being adopted commercially.

For more information visit about 3G E-Learning LLC and its products, visit [www.3ge-learning.com](http://www.3ge-learning.com)



# TABLE OF CONTENTS

<i>Preface</i>	ix
<b>Chapter 1 Welding</b>	<b>1</b>
Overview of Welding .....	3
Need for Welding .....	4
Advantage of Welding .....	5
Disadvantage of Welding .....	5
Application of Welding .....	6
Welding Equipment .....	6
Classification of Welding Processes .....	10
Types of Welding .....	11
The History of Welding .....	12
Middle Ages .....	13
Welding Symbols .....	25
Reference Line .....	25
Arrow and Other Side .....	25
Finish Symbols .....	27
Tail .....	27
Specifications, Process, or Other Information .....	28
Knowledge Check .....	32
References .....	35
<b>Chapter 2 Physics of Welding Arc</b>	<b>37</b>
Arc Welding Fundamentals .....	39
Structure and Characteristics of Welding Arc: .....	39
Electron Emission Mechanisms .....	41
The Cathode Drop Zone .....	43
The Arc Column .....	43
The Anode and the Anode Drop Zone: .....	46
Types of Welding Arcs .....	48
Methods of Initiating and Maintenance of the Welding Arc .....	51



Arc Initiation .....	51
Maintenance of Arc .....	53
Arc Characteristic .....	55
Temperature of the Arc.....	57
Knowledge Check.....	61
References .....	64

### **Chapter 3 Laser Welding 65**

Principle and Mechanism of Laser Welding.....	67
Ruby Laser Equipment and Setup of Laser Welding .....	69
Process Parameters for Laser Welding .....	75
Weld Characteristics for Laser Welding.....	76
Weld Joint Design for Laser Welding .....	76
Applications of Laser Welding .....	77
Variants of Laser Beam Welding .....	78
Automation in Laser Beam Welding.....	78
Safety Aspects of Laser Welding .....	80
Laser Beam Welding.....	83
The Ruby LASER.....	84
The CO <sub>2</sub> LASER.....	85
Solid State LASER.....	85
The Excimer LASER.....	85
Knowledge Check.....	91
References .....	94

### **Chapter 4 Heat Flow in Welding 95**

Weld Thermal Cycle.....	97
Factors Affecting Welding Thermal Cycle .....	98
Cooling Rate.....	99
Peak Temperature and Heat Affected Zone.....	105
Solidification Rate.....	107
Residual Stresses.....	108
Knowledge Check.....	118
References .....	121

### **Chapter 5 Gas Welding 123**

Process of Gas Welding.....	125
Inert Gas Welding.....	126



Gas Metal Arc Welding.....	127
Different Types of Flames in Gas Welding.....	131
Use of Gas in MIG Welding .....	133
Need of Welding Torch.....	134
Types of Gas Welding .....	135
Gas Welding and Gas Cutting .....	136
Thermochemical Processes.....	136
Progression in Weld Pass.....	137
Gas Welding in Carbon Steel Plates and Tubes.....	149
Perform Surface Preparation.....	150
Gas Welding Equipment and Accessories.....	152
The Principle of Pressure Regulator .....	154
Tanks or Cylinders Secured in a proper place.....	158
Knowledge Check.....	162
References .....	165

## **Chapter 6 Design of Weld Joints 167**

Weld Joint.....	169
Modes of Failure of the Weld Joints.....	169
Design of Weld Joints and Mechanical Properties.....	169
Factors Affecting the Performance of the Weld Joints.....	170
Design of Weld Joints and Loading Conditions.....	171
Need of Welding Symbols.....	171
Types of Weld Joints.....	172
Types of Welding Position.....	174
Need for Edge Preparation in Welding .....	178
Groove Weld.....	178
Factors Affecting Selection of Suitable Groove Geometry for Edge Preparation .....	179
Welding and Weld Bead Geometry.....	182
Design of Weld Joints for Fatigue Loading.....	184
Procedure of Weld Joint Design for Fatigue Loading .....	184
Factors Affecting Fatigue Life.....	187
Material Characteristics .....	198
Environment.....	200
Knowledge Check.....	203
References .....	206



# INDEX

## A

Alloys 3  
Arc blow 46, 49, 62  
Arc burn 8  
Arc voltage 55, 56, 57  
Arc welding 3  
arrow side 25  
Automation 78, 79

## B

base metal 8, 10, 11  
bead-on-plate (BOP) welding 102  
butt weld 8

## C

Carbonizing flame 132  
Consumable electrode 126, 127  
Continuous wave (CW) 78  
cooling rate (CR) 99  
corner joints 20  
cover pass 8  
critical cooling rate (CCR) 102  
Cylinder 125, 126, 135, 152, 154, 155,  
156, 157, 159  
Cylindrical enclosure 70, 71

## D

diffusion welding 10

## E

Edge preparation 178  
electric arc 3, 13  
Electrode 51, 52, 53, 54, 55, 57, 58  
Energy beam welding 3  
energy density 98  
excitation energy 43

## F

fatigue crack growth (FCG) 193  
fatigue crack growth rate (FCGR) 192  
Fiber optics 65  
field weld 27  
filler material 169  
filler pass 8  
fillet weld 8  
finish symbol 27  
Flash lamp 70, 71, 73  
flat welding 174, 175  
forge welding 3  
friction welding 10

## G

Gas cylinders 158  
 gas flame 3  
 Gas tungsten arc welding (GTAW) 16  
 Gas welders 127, 132  
 Gas welding 125, 131, 135, 136, 137, 149  
 Groove weld 178

## H

heat affected zone (HAZ) 99, 169  
 Heat dissipation 53  
 Heliarc welding 38  
 hot pass 8

## I

Inert gas welding 126, 127

## J

Joint 8, 20, 21

## L

Laser beam welding (LBW) 65

## M

metal industry 6  
 Metal inert gas (MIG) 131, 133, 134  
 Metal inert gas welding (MIG) 126  
 Methyl acetylene-propadiene-petroleum  
 (MAPP) 135  
 Mirror system 72

## N

Non-destructive testing (NDT) 142

## O

overhead welding 175, 176, 183  
 Oxidizing flame 132  
 Oxy-acetylene 135, 152  
 Oxy-acetylene welding 135, 152

Oxyfuel gas welding (OFW) 123  
 oxyfuel welding 11

## P

peak temperature 97, 98, 99, 105, 106,  
 107, 110  
 photo-electric emission 41  
 Plastic Welding 10  
 Plug welding 9  
 Polarity 9  
 Pressure 169  
 Pressure Welding 10, 11  
 Pulse repetition frequency (PRF) 72

## Q

Quantum energy 67

## R

reference line 25  
 Residual stresses 108, 109, 110, 111  
 Resistance welding 3  
 root bead 10

## S

Shielded metal arc welding (SMAC) 37  
 Soldering 123, 136, 160, 163  
 Solidification 107, 108  
 solid-state welding 10  
 stainless steel 3  
 Static pressure 45  
 Streamline flow 45  
 stringer pass 8, 10  
 Supplementary symbols 27  
 Surface preparation 150, 169

## T

Thermal conductivity 57  
 Transverse electromagnetic mode (TEM) 69  
 Tungsten electrode 38, 41, 43  
 Tungsten inert gas welding (TIG) 127



## U

ultrasonic welding 10

## V

vertical welding 175

Visual inspection 140, 142

## W

welded joint 8, 25

Welder Qualification Test Record (WQTR)  
138

weld fusion boundary 99

Weld groove 10

Welding 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,  
13, 14, 15, 16, 17, 18, 19, 22, 23, 24,  
25, 26, 27, 28, 29, 30, 31, 32, 33, 34,  
35

Welding application 131

Welding code 151

welding current 170, 183

welding parameters 98, 100, 105

Welding procedure specification (WPS)  
143

Welding processes 10

Welding speed 183

Welding torch 125, 126, 131, 134, 135

Weld joints 167, 169, 170, 184

weld metal 8, 10, 98, 99, 100, 107, 110,  
111, 167, 169, 170, 174, 175, 179,  
183, 185, 186, 198, 199

weld pass 10

Weld symbols 26

Weld thermal cycle 97, 100, 110

## Y

Yttrium aluminium garnet (YAG) 65