

CERTIFICATION
CERTIFICATION
CERTIFICATION
CERTIFICATION
CERTIFICATION
**CERTIFICATION
MANUAL**

**For
Welding Inspectors**

Fourth Edition



American Welding Society

International Standard Book Number: 0-87171-626-7

American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126

© 2000 by American Welding Society. All rights reserved
Printed in the United States of America

Fourth Edition 2000
Revised 3/00
Reprinted 5/03

All rights reserved. No part of this book may be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage or retrieval system, without permission in writing from the publisher.

NOTE: Although care was taken in choosing and presenting the data in this guide, AWS cannot guarantee that it is error free. Further, this guide is not intended to be an exhaustive treatment of the topic and therefore may not include all available information, including with respect to safety and health issues. By publishing this guide, AWS does not insure anyone using the information it contains against any liability or injury to property or persons arising from that use.

Photocopy Rights

Authorization to photocopy items for internal, personal, or educational classroom use only, or the internal, personal, or educational classroom use only of specific clients, is granted by the American Welding Society (AWS) provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: 978-750-8400; online: <http://www.copyright.com>.

Contents

Page No.

Chapter 1—The Welding Inspector	1
Introduction	2
Important Qualifications for the Welding Inspector.....	3
Physical Condition	3
Vision	3
Professional Attitude.....	3
Knowledge of Welding and Inspection Terminology	3
Knowledge of Drawings and Specifications	4
Knowledge of Testing Methods	4
Ability to Produce and Maintain Records.....	4
Knowledge of Welding Processes.....	4
Ability to be Trained.....	4
Inspection Experience.....	4
Ethical Requirements for the Welding Inspector	5
Introduction.....	5
Preamble	5
Integrity.....	5
Responsibility to the Public	5
Public Statements.....	5
Conflict of Interest	5
The Solicitation of Employment.....	6
Unauthorized Practice.....	6
Establishing Lines of Communication	6
Reporting Supervisor	6
Welders	7
Welding Foremen or Supervisors.....	7
Shop or Field Superintendent	8
Plant Manager	8
Design/Project Engineers.....	8
Welding Engineer.....	8
Summary	8
Review—Chapter 1—The Welding Inspector	9
Figure 1.1—Industries Utilizing Welding Inspectors.....	2
Figure 1.2—The Welding Inspector—A Communicator	6
Figure 1.3—Establishing Lines of Communication.....	7
Chapter 2—Welding Inspector Responsibilities	11
Introduction	12
Inspection Responsibilities Before Welding.....	12
Inspection Responsibilities During Welding	12
Inspection Responsibilities After Welding	12
Inspection Responsibilities Before Welding	12
Knowledge of Drawings and Standards.....	12
Purchase Specifications Check	14
Job Material Verification.....	14
Chemical Analysis and Mechanical Properties Tests	14
Base Metal Defects Investigation.....	16
Condition and Storage of Filler Materials Check	16

Welding Equipment Check	16
Weld Joint Edge Geometry Check	16
Weld Joint Fit Check	17
Weld Joint Cleanliness Check	17
Welding Procedure Qualification Check	17
Welder Qualification Check	17
Preheat Temperature Check	17
Welding Inspector Responsibilities During Welding	18
Check Production Welding for Compliance with Welding Procedure	18
Check the Quality of Individual Passes	18
Check Interpass Cleaning	19
Check Interpass Temperature	19
In-Process Nondestructive Examination (NDE)	19
Welding Inspector Responsibilities After Welding	20
Check Final Weld Appearance	20
Check Final Weld Sizes and Lengths	20
Check Dimensional Accuracy of Completed Weldment	23
Selection of Production Test Samples	23
Evaluation of Test Results	23
Final Nondestructive Examination	23
Maintaining Records and Reports	23
Review—Chapter 2—Welding Inspector Responsibility	24
Figure 2.1—Knowledge of Drawings and Standards is Important	13
Figure 2.2—Typical Example of a Mill Test Report	15
Figure 2.3—Electrode Oven	16
Figure 2.4—Temperature-Sensitive Crayon for Measuring Metal Temperature	18
Figure 2.5—Tong Test Ammeter	18
Figure 2.6—Proper Cleaning Between Weld Passes	19
Figure 2.7—Cross Section of a Partial Penetration Groove Weld with Heavy Slag Inclusion	19
Figure 2.8—Magnetic Particle Testing of a Partially Filled Groove Weld	20
Figure 2.9—Evaluating Size with a Fillet Weld Gauge	21
Figure 2.10—Acceptable and Unacceptable Weld Profiles	22
Chapter 3—Safety	27
Introduction	28
Management’s Responsibility	28
The Working Environment	28
Eye and Face Protection	29
Oxyfuel Gas Welding, Cutting, Brazing, Soldering, and Submerged Arc Welding	29
Protective Clothing	29
Ear Protection	30
Fumes and Gases	30
Confined Spaces	31
Handling of Compressed Gases	32
Gases	32
Oxygen	32
Fuel Gases	32
Fuel Gas Fires	33
Shielding Gases	33
Electric Shock	33
Review Chapter 3—Safety	34
Table 3.1—Lens Shade Selector	30

Figure 3.1—Designated Welding Area	28
Figure 3.2—Eye, Ear, and Face Protective Equipment	29
Figure 3.3—Movable Fume Extractor Positioned Near the Welding Arc.....	31

Chapter 4—Standards, Including Codes and Specifications 37

Introduction	38
Requirements of Standards, Codes, and Specifications	38
Codes Important to Welding	39
Structural Welding Code—Steel (AWS D1.1).....	39
Other AWS Structural Welding Codes (D1.2, D1.3, D1.4, D1.5, and D1.6).....	39
ASME Boiler and Pressure Vessel Code (PVC).....	40
Definition of Inspector	40
Codes and Materials.....	40
Codes and Procedures.....	41
Codes and Personnel.....	41
Codes and Nondestructive Examination (NDE).....	41
ASTM Standards.....	41
API Standards	41
Military Standards.....	41
ANSI Standards	41
AWS Filler Metal Specifications	42
Summary	43
Review—Chapter 4—Standards, Including Codes and Specifications	44
Table 4.1—Nondestructive Testing Methods—D1.1 Code Reference.....	39
Table 4.2—ASME Boiler and Pressure Vessel—Code Reference.....	40
Table 4.3—Alphabetic Index to AWS Filler Metal Specifications	42
Table 4.4—Numeric Index to AWS Filler Metal Specifications.....	43

Chapter 5—Weld Geometry and Welding Terminology..... 47

Introduction	48
Types of Joints	48
Parts of the Weld Joint	48
Types of Welds	51
Parts of Completed Welds.....	53
Fusion and Penetration Terminology	55
Weld Size Terminology	55
Weld Application Terminology	56
Summary	60
Review—Chapter 5—Weld Joint Geometry and Welding Terminology	61
Figure 5.1—Joint Types	49
Figure 5.2—Groove Weld	50
Figure 5.3—Fillet Weld.....	51
Figure 5.4—Groove Welds.....	52
Figure 5.5—Edge Weld.....	52
Figure 5.6—Spot Welds	53
Figure 5.7—Seam Welds.....	53
Figure 5.8—Plug and Slot Welds	53
Figure 5.9—Surfacing Weld.....	54
Figure 5.10—Parts of a Weld	54
Figure 5.11—Parts of a Weld	55
Figure 5.12—Fusion Welds.....	56

Figure 5.13—Incomplete Joint Penetration or Partial Joint Penetration	56
Figure 5.14—Heat-Affected Zone.....	56
Figure 5.15—Joint Penetration.....	57
Figure 5.16—Unequal Leg Fillet Weld	57
Figure 5.17—Fillet Welds	58
Figure 5.18—Size of Seam or Spot Weld.....	58
Figure 5.19—Cross-Sectional Welding Sequence.....	58
Figure 5.20—Weld Beads.....	58
Figure 5.21—Welding Sequences	59
Figure 5.22—Intermittent Fillet Welds	60
Figure 5.23—Boxing.....	60

Chapter 6—Welding and Nondestructive Examination Symbols..... 71

Introduction	72
Elements of the Welding Symbol.....	72
Reference Line	72
Arrow	73
Basic Weld Symbols	73
Dimensions and Other Data.....	74
Supplementary Symbols	82
Finish Symbols	87
The Tail of the Symbol	87
Specifications, Process, or Other Reference	87
Brazing Symbols.....	87
Nondestructive Examination (NDE) Symbols.....	89
Summary	91
Review—Chapter 6—Welding and Nondestructive Examination Symbols	94
Table 6.1—Designations and Abbreviations of NDE Testing Processes	91
Figure 6.1—Standard Location of Elements of a Welding Symbol	73
Figure 6.2—Arrow Location Significance	74
Figure 6.3—Weld Symbols	75
Figure 6.4—Specification of Groove Weld Size and Depth of Bevel	76
Figure 6.5—Groove Weld Symbol with Combined Dimensions	77
Figure 6.6—Symmetrical Groove Welds with Backgouging	77
Figure 6.7—Specification of Size and Length of Fillet Welds.....	78
Figure 6.8—Applications of Intermittent Fillet Weld Symbols	79
Figure 6.9—Applications of Information to Plug Weld Symbols.....	80
Figure 6.10—Applications of Information to Spot and Seam Weld Symbols	81
Figure 6.11—Applications of Back or Backing Weld Symbol	83
Figure 6.12—Applications of Surfacing Weld Symbol.....	84
Figure 6.13—Applications of Stud Weld Symbols	85
Figure 6.14—Supplementary Symbols	85
Figure 6.15—Applications of Weld-All-Around Symbol.....	86
Figure 6.16—Applications of Field Weld Symbols	87
Figure 6.17—Applications of Melt-Through Symbol.....	88
Figure 6.18—Joints with Backing or Spacers	89
Figure 6.19—Consumable Insert Symbol.....	89
Figure 6.20—Applications of Flush and Convex Contour Symbols	90
Figure 6.21—Supplementary Data Shown in the Tail of the Welding Symbol.....	91
Figure 6.22—Multiple Reference Lines.....	91
Figure 6.23—Applications of Brazing Symbols	92
Figure 6.24—Location of Elements of a Nondestructive Examination Symbol	93

Chapter 7—Weldability, Welding Metallurgy, and Welding Chemistry..... 107

Introduction	108
Welding Metallurgy	109
Solids vs. Liquids.....	109
Melting and Freezing	109
Welds Under the Microscope.....	110
Other Metallurgical Factors	114
Thermal Expansion	115
Diffusion	117
Solid Solubility	118
Welding Chemistry	118
Shielding	118
Weld Metal Composition	119
Welding Chemistry of Specific Base Metals	121
Carbon Equivalent Calculation	121
Welding Chemistry of Stainless Steels	121
Welding Chemistry of Aluminum Alloys	123
Welding Chemistry of Copper Alloys.....	123
Welding Chemistry of the Reactive Metals	123
Summary	124
Review—Chapter 7—Weldability, Welding Chemistry, and Welding Metallurgy	125
Table 7.1—Typical Thermal Stress Relief Heat Treatments.....	116
Figure 7.1—Solid State vs. Liquid State of Metals.....	109
Figure 7.2—Position of Atoms in the Solid State	109
Figure 7.3—Increase in Temperature Causes Atom “Breakaway”	110
Figure 7.4—Heat Loss Causes Atoms to “Settle Down” and Liquid Metal to Solidify	110
Figure 7.5—Photomicrograph of Commercially Pure Iron, Nominally Called Ferrite (No Carbides are Present, the Acid Etch Reveals Grain Boundaries, and the Dark Globules are Nonmetallic Inclusions).....	111
Figure 7.6—Typical Lamellar Appearance of Pearlite (1500X Etchant:Picral)	111
Figure 7.7—Quenched Martensite Showing Acicular Structure (500X Etched)	112
Figure 7.8—Transformation of Steels to Austenite on Heating.....	112
Figure 7.9—Common Crystalline Structures of Metals and Alloys	112
Figure 7.10—Variation of Cooling Conditions in a Weld as a Function of Preheat; Diagram Includes Some of the Property Changes Brought About by These Conditions (Also Shown is a CCT Diagram for a Steel, to Illustrate Why the Cooling Conditions Promote the Property Changes)	113
Figure 7.11—Effects of Tempering.....	113
Figure 7.12—Relation Between the Peak Temperatures Experienced by Various Regions in a Weld, and How These Correlate with the Iron-Carbon Phase Diagram.....	114
Figure 7.13—Thermal Expansion	115
Figure 7.14—Shrinkage in a Weld Caused by Internal Restraint (Also Shown is the Nature of Residual Stress)	116
Figure 7.15—Peening the Middle Weld Layer Distributes and Balances Distortion.....	117
Figure 7.16—An Example of Migrating or Diffusing Atoms	117
Figure 7.17—Chemical Interactions While Welding	119
Figure 7.18—Common Elements that can Cause Problems	119
Figure 7.19—Shielded Metal Arc Welding.....	120
Figure 7.20—Self-Shielded Flux Cored Arc Welding	120
Figure 7.21—Schematic View of Submerged Arc Welding Processes	120
Figure 7.22—Corrosion by Intergranular Attack (IGA) Caused by Sensitization of the HAZ.....	122
Figure 7.23—For Stabilization Heat Treatment Use 1500°F, No Quench Needed.....	123
Figure 7.24—Prevention of Corrosion in Welded Stainless Steel.....	123
Figure 7.25—Welding in a Controlled Atmosphere.....	124

Chapter 8—Destructive Testing 129

Introduction 130
Tensile Testing..... 131
Hardness Testing..... 136
Toughness Testing..... 139
Soundness Testing..... 143
Destructive Tests for Chemical Properties 149
Metallographic Testing..... 150
Metric Conversions..... 151
 Scientific Notation Examples 151
 Examples of Prefixes for Powers of Ten..... 151
Review—Chapter 8—Destructive Testing..... 157

Table 8.1—Brinell Hardness Numbers..... 138
Table 8.2—Rockwell Standard Hardness 140
Table 8.3—SI Prefixes..... 151
Table 8.4—Commonly Used Metric Conversions..... 152
Table 8.5—General Conversions 154
Table 8.6—Conversions for Common Welding Terms..... 156

Figure 8.1—Inspectors Must Be Able to Interpret Data from a Variety of Tests 130
Figure 8.2—Round Tensile Specimens 132
Figure 8.3—Transverse Rectangular Tension Test Specimen (Plate) 133
Figure 8.4—Abrupt Yielding of Yield Point in Mild Steel 135
Figure 8.5—Engineering Stress-Strain Diagram for Polycrystalline Copper 135
Figure 8.6—Shapes and Types of Indenters Used with Various Hardness Tests 137
Figure 8.7—Indenter Measurements 139
Figure 8.8—Principle of the Rockwell Test 141
Figure 8.9—Knoop and Vickers Microhardness Testing 141
Figure 8.10—ASTM Standard Dimensions for the Type A Charpy V-Notch Specimen and the Striker-Anvil Arrangements 142
Figure 8.11—Schematic of Typical Charpy Testing Machine 143
Figure 8.12—Relation Between Energy Transition and Fracture Appearance Transition in Charpy V-Notch Impact Specimens with Changes in Temperature 144
Figure 8.13A—Face and Root Bend Specimens 145
Figure 8.13B—Side Bend Specimens 146
Figure 8.14A—Guided Bend Test Jig 147
Figure 8.14B—Alternative Roller-Equipped Guided Bend Test Jig for Bottom Ejection of Test Specimen 148
Figure 8.14C—Alternative Wraparound Guided Bend Test Bend Jig 148
Figure 8.15—Nick-Break Test Specimen..... 149
Figure 8.16—Method of Testing Fillet Weld Break Specimen 150
Figure 8.17—Typical Weld Photomicrograph (Crack Adjacent to the Weld)..... 150

Chapter 9—Welding Procedure and Welder Qualification 161

Introduction 162
Welding Procedure Specification 162
 Contents 162
Welding Procedure Qualification 166
 Code Qualification Requirements..... 167
 Welding Inspector Responsibilities..... 168
Welder and Brazier Qualification 168
 Qualification Testing..... 168
 Retests 172

Code Requirements	172
Destructive Test Qualification	174
Summary	174
Review—Chapter 9—Welding Procedure and Welder Qualification	181
Table 9.1—Welder Performance Qualification Tests	177
Figure 9.1—Joint Design and Tolerances.....	163
Figure 9.2—Joint Preparation and Cleaning of Surfaces for Welding	163
Figure 9.3—Positions of Groove Welds	164
Figure 9.4—Positions of Fillet Welds	165
Figure 9.5—Peening the Middle Layer of a Weld Distributes and Balances Stresses	166
Figure 9.6—Marking a Completed Weldment	166
Figure 9.7—Sample Specimens for Destructive Testing.....	167
Figure 9.8—Test Plate for Unlimited Thickness—Welder Qualification.....	170
Figure 9.9—Optional Test Plate for Unlimited Thickness—Horizontal Position—Welder Qualification	170
Figure 9.10—Test Plate for Limited Thickness—All Positions—Welder Qualification	171
Figure 9.11—Optional Test Plate for Limited Thickness—Horizontal Position—Welder Qualification.....	171
Figure 9.12—Fillet Weld Break and Macroetch Test Plate—Welder Qualification—Option 1	172
Figure 9.13—Fillet Weld Root Bend Test Plate—Welder Qualification—Option 2	173
Figure 9.14—Typical Tubular Butt Joint Welder Qualification	174
Figure 9.15—Positions of Test Pipes or Tubing for Fillet Welds.....	175
Figure 9.16—Positions of Test Pipe or Tubing for Groove Welds.....	176
Figure 9.17—Positions of Test Plates for Groove Welds	179
Figure 9.18—Positions of Test Pipes for Fillet Welds	180
Chapter 10—Welding, Brazing, and Cutting Processes.....	183
Introduction	184
Limiting Factors	184
Dimensions of Material	184
Welding Position.....	184
Root Requirements	184
Back Side Accessibility	184
Joint Preparation	186
Availability of Welding Equipment	186
Welding Processes	186
Shielded Metal Arc Welding (SMAW).....	186
Gas Metal Arc Welding (GMAW)	189
Flux Cored Arc Welding (FCAW)	191
Gas Tungsten Arc Welding (GTAW)	193
Plasma Arc Welding (PAW).....	195
Submerged Arc Welding (SAW).....	197
Electroslag Welding (ESW).....	199
Oxyacetylene Welding (OAW)	202
Stud Welding (SW)	203
Brazing (B)	203
Torch Brazing (TB).....	205
Furnace Brazing (FB)	205
Induction Brazing (IB).....	205
Resistance Brazing (RB).....	206
Dip Brazing (DB).....	206
Infrared Brazing (IRB).....	206
Diffusion Brazing (DFB)	206

Cutting Processes	207
Oxyfuel Gas Cutting (OFC).....	207
Air Carbon Arc Cutting (CAC-A)	208
Plasma Arc Cutting (PAC).....	208
Mechanical Cutting.....	208
Summary	208
Review—Chapter 10—Welding, Brazing, and Cutting Processes	210
Table 10.1—Significance of Last Digit of SMAW Identification	188
Table 10.2—Effect of Welding Current Type on Penetration for GTAW	194
Table 10.3—AWS Tungsten Electrode Classifications	195
Figure 10.1—Master Chart of Welding and Allied Processes.....	185
Figure 10.2—Shielded Metal Arc Welding.....	187
Figure 10.3—Typical Welding Circuit for Shielded Metal Arc Weld.....	187
Figure 10.4—SMAW Electrode Identification System	187
Figure 10.5—Magnetic Field Around Electric Conductor.....	188
Figure 10.6—Distorted Magnetic Fields and Ends of Welds	189
Figure 10.7—Gas Metal Arc Welding Process	189
Figure 10.8—Diagram of Gas Metal Arc Welding Equipment.....	190
Figure 10.9—The Four Types of Metal Transfer	190
Figure 10.10—GMAW Electrode Identification System	191
Figure 10.11—Self-Shielded Flux Cored Arc Welding	192
Figure 10.12—Diagram of Flux Cored Arc Welding Equipment	192
Figure 10.13—FCAW Electrode Identification System.....	193
Figure 10.14—Gas Tungsten Arc Welding Operation	193
Figure 10.15—Gas Tungsten Arc Welding Equipment.....	193
Figure 10.16—Plasma Arc Welding (Keyhole Mode)	195
Figure 10.17—Typical Equipment for Plasma Arc Welding.....	196
Figure 10.18—Comparison of GTAW and PAW Torches	196
Figure 10.19—Keyhole Technique for Plasma Arc Welding	197
Figure 10.20—Schematic View of Submerged Arc Welding Process.....	198
Figure 10.21—Submerged Arc Welding Equipment	198
Figure 10.22—SAW Filler Metal Classification System	199
Figure 10.23—Solidification Cracking Because of Weld Profile	200
Figure 10.24—Electroslag Welding Equipment.....	201
Figure 10.25—Oxyacetylene Welding	202
Figure 10.26—Oxyfuel Welding Equipment.....	202
Figure 10.27—Stud Welding	204
Figure 10.28—Basic Equipment Setup for Arc Stud Welding.....	205
Figure 10.29—Brazing Process.....	206
Figure 10.30—Process Diagram Oxygen Cutting.....	207
Figure 10.31—Kerf and Drag in Oxyfuel Gas Cutting	207
Figure 10.32—Typical Operating Procedures for Air Carbon Arc Gouging	208
Figure 10.33—Typical Air Carbon Arc Gouging Equipment	209
Figure 10.34—Typical Plasma Arc Cutting Torch.....	209
Figure 10.35—Mechanical Cutting	209
Chapter 11—Weld and Base Metal Discontinuities	223
Introduction	224
Types of Discontinuities	224
Porosity	224
Inclusions	228
Underfill.....	231

Incomplete Fusion.....	231
Incomplete Joint Penetration	231
Overlap.....	231
Undercut.....	235
Lamination and Delamination	235
Seams and Laps	237
Lamellar Tearing.....	237
Cracks	238
Arc Strike	243
Size of Discontinuity	244
Location of Discontinuity	244
Summary	244
Review—Chapter 11—Weld and Base Metal Discontinuities	245
Table 11.1—Common Types of Discontinuities	225
Table 11.2—Discontinuities Commonly Encountered with Welding Processes.....	226
Figure 11.1—Porosity Illustrated	227
Figure 11.2—Cluster Porosity	228
Figure 11.3—Scattered Porosity	229
Figure 11.4—Linear Porosity	230
Figure 11.5—Surface Appearance of Piping Porosity	231
Figure 11.6—Slag Inclusions	232
Figure 11.7—Elongated Slag Lines	233
Figure 11.8—Tungsten Inclusions	233
Figure 11.9—Underfill.....	234
Figure 11.10—Various Locations of Incomplete Fusion	234
Figure 11.11—Incomplete Fusion at Weld Face	235
Figure 11.12—Incomplete Fusion Between Individual Weld Beads	235
Figure 11.13—Incomplete Joint Penetration.....	236
Figure 11.14—Undercut and Overlap	237
Figure 11.15—Undercut at Weld Toe.....	238
Figure 11.16—Lamination and Delamination.....	238
Figure 11.17—Laminations.....	239
Figure 11.18—Weld Configuration Which May Cause Lamellar Tearing.....	239
Figure 11.19—Redesigned Corner Joint to Prevent Lamellar Tearing	239
Figure 11.20—Crack Types.....	240
Figure 11.21—Longitudinal Cracks.....	241
Figure 11.22— Cracks.....	242
Figure 11.23—Throat Crack	242
Figure 11.24—Toe Cracks.....	243
Figure 11.25—Underbead Cracks	243
Figure 11.26—Underbead Cracks and Microfissure.....	244
Chapter 12—Nondestructive Examination (NDE) Processes	249
Introduction	250
Selection of Examination Method	250
Limitations of the Examination Method.....	250
Acceptance Standards	250
Economics (Cost).....	250
Examination Methods and Limitations	251
Visual Examination	251
Penetrant Testing (PT)	252
Magnetic Particle Testing (MT).....	253

Radiographic Testing (RT).....	256
Ultrasonic Testing (UT)	257
Eddy Current (Electromagnetic) Testing (ET).....	259
Acoustic Emission Testing (AET)	261
Leak Tests (LT)	261
Proof Tests	262
Magnetic Test for Delta Ferrite.....	262
Qualification of NDE Personnel	262
Summary	263
Review—Chapter 12—Nondestructive Examination (NDE) Processes	264
Table 12.1—SNT-TC-1A Levels of Qualification.....	263
Figure 12.1—Visual Inspection Tools	251
Figure 12.2—Developer Interpretation	253
Figure 12.3—Magnetism.....	254
Figure 12.4—Yoke and Prod Methods	255
Figure 12.5—Iron Powder Build-Up Reveals Discontinuity	256
Figure 12.6—Shim and Wire Type Image Quality Indicators (Penetrameters)	257
Figure 12.7—Ultrasonic Inspection	258
Figure 12.8—Calibration Sequence for Longitudinal Beam Transducer.....	258
Figure 12.9—Induced Eddy Currents in Test Objects.....	259
Figure 12.10—Typical CRT Displays for Eddy Current Testing	260
Figure 12.11—Leak Tests	261
Figure 12.12—Ferrite Indicator (Severn Gauge)	263
Chapter 13—Inspection Reports	271
Introduction	272
Report Content	272
Report Format	272
AWS D1.1 Report Forms.....	272
ASME Section IX Report Forms	273
API 1104 Report Forms	273
Multiple Inspection	273
Unstructured Reports	273
Report Checklist	273
Conclusion	274
Review—Chapter 13—Inspection Reports	275
Annex A—Additional Resources.....	277
Technical and Scientific Organizations of the Welding Fabricating Industry	278
Examination Method Selection Guide	281
Annex B—Sample Forms.....	283
AWS D1.1	
Form E-1 (Front) Welding Procedure Specification (WPS)	284
Form E-1 (Back) Procedure Qualification Record (PQR)	285
Form E-3 Welding Procedure Qualification Test Record For Electroslag and Electrogas	286
Form E-4 Welder, Welding Operator or Tack Welder Qualification Test Record	287
Form E-7 Report of Radiographic Examination of Welds.....	288
Form E-8 Report of Magnetic Particle Examination of Welds.....	289

ASME B31.1 SECTION IX	
Form E00006 (Front) QW-482 Suggested Format For Welding Procedure Specifications (WPS).....	290
Form E00006 (Back) QW-482.....	291
Form E00007 (Front) QW-483 Suggested Format for Procedure Qualification Record (PQR).....	292
Form E00007 (Back) QW-483.....	293
Form E00008 QW-484 Suggested Format for Manufacturer’s Record of Welder or Welding Operator Qualification Tests (WPQ).....	294
API 1104	
Procedure Specification Form.....	295
AWS QC-1	
Certified Welding Inspector Certificate	296
Annex C—Answer Key—Review Questions for Chapters 1–13	297

CHAPTER 1

The Welding Inspector

Contents

Introduction	2
Important Qualifications for the Welding Inspector	3
Ethical Requirements for the Welding Inspector	5
Establishing Lines of Communication	6
Summary	8
Review—Chapter 1—The Welding Inspector	9

Chapter 1—The Welding Inspector

Introduction

Welding inspectors function as quality representatives of organizations that may be a manufacturer, purchaser, insurance company, or government agency. The inspector is responsible for judging the acceptability of a product according to a written specification. The inspector must understand both the limitations and intent of the specification. The goal of the welding inspector is to strive for the required quality, but not to delay completion and delivery schedules without proper cause.

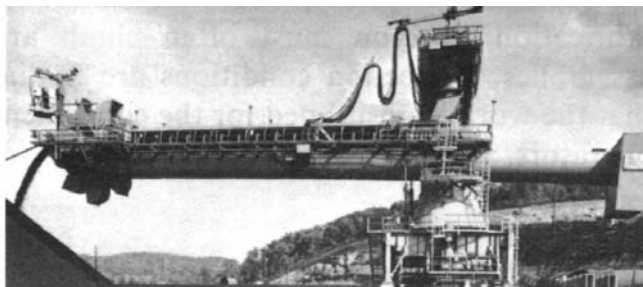
Welding inspectors find themselves working in dozens of different industries, with each situation having slightly different job responsibilities. Among those industries employing welding inspectors are energy production, chemical processing, petroleum product refining and distribution, transportation, and bridge and building construction (see Figure 1.1).

The welding inspector is a composite person—a highly qualified specialist in the field of welding. Welding inspectors can be classified as:

- Code or governing agency inspector



Nippon Steel



Lukens Steel Company



Cessna Aircraft Corporation



Western Oceanic Inc.

Figure 1.1—Industries Utilizing Welding Inspectors