

# WELDING PRINT READING



EIGHTH EDITION

Write-In Text

John R. Walker • W. Richard Polanin

Publisher  
The Goodheart-Willcox Company, Inc.  
Tinley Park, IL  
[www.g-w.com](http://www.g-w.com)

Copyright © 2024  
by  
The Goodheart-Willcox Company, Inc.

Previous editions copyright 2020, 2013, 2007, 2001, 1996, 1991, 1986

All rights reserved. No part of this work may be reproduced, stored, or transmitted in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission of The Goodheart-Willcox Company, Inc.

Library of Congress Control Number: 2022944119

ISBN 978-1-68584-572-8

1 2 3 4 5 6 7 8 9 – 24 – 27 26 25 24 23 22

**The Goodheart-Willcox Company, Inc. Brand Disclaimer:** Brand names, company names, and illustrations for products and services included in this text are provided for educational purposes only and do not represent or imply endorsement or recommendation by the author or the publisher.

**The Goodheart-Willcox Company, Inc. Safety Notice:** The reader is expressly advised to carefully read, understand, and apply all safety precautions and warnings described in this book or that might also be indicated in undertaking the activities and exercises described herein to minimize risk of personal injury or injury to others. Common sense and good judgment should also be exercised and applied to help avoid all potential hazards. The reader should always refer to the appropriate manufacturer's technical information, directions, and recommendations; then proceed with care to follow specific equipment operating instructions. The reader should understand these notices and cautions are not exhaustive.

The publisher makes no warranty or representation whatsoever, either expressed or implied, including but not limited to equipment, procedures, and applications described or referred to herein, their quality, performance, merchantability, or fitness for a particular purpose. The publisher assumes no responsibility for any changes, errors, or omissions in this book. The publisher specifically disclaims any liability whatsoever, including any direct, indirect, incidental, consequential, special, or exemplary damages resulting, in whole or in part, from the reader's use or reliance upon the information, instructions, procedures, warnings, cautions, applications, or other matter contained in this book. The publisher assumes no responsibility for the activities of the reader.

**The Goodheart-Willcox Company, Inc. Internet Disclaimer:** The Internet resources and listings in this Goodheart-Willcox Publisher product are provided solely as a convenience to you. These resources and listings were reviewed at the time of publication to provide you with accurate, safe, and appropriate information. Goodheart-Willcox Publisher has no control over the referenced websites and, due to the dynamic nature of the Internet, is not responsible or liable for the content, products, or performance of links to other websites or resources. Goodheart-Willcox Publisher makes no representation, either expressed or implied, regarding the content of these websites, and such references do not constitute an endorsement or recommendation of the information or content presented. It is your responsibility to take all protective measures to guard against inappropriate content, viruses, or other destructive elements.

**Image Credits.** Front cover: B Brown/Shutterstock.com

# Preface

Just about every manufactured product uses welding, either directly or indirectly. Over the years, a system of symbols and notations has been developed to convey exact weld specifications. Welding symbols and notations allow a large amount of data about a weld to be condensed into a small amount of space on a print. They simplify communications between the designer/engineer and the welder, and also between other workers associated with the production of a weldment. Symbols and notations help assure that welds meet design requirements.

A welder, or anyone else (technician, engineer, drafter, etc.) working with welding prints, must know how to use the welding symbols and notations. This text is designed to help you grasp this information as quickly and easily as possible.

*Welding Print Reading* provides instruction on interpreting and using the type of engineering drawings and prints found in the welding trade. It is a write-in text, or text-workbook, that starts out with the basics and progresses to more specialized coverage of specific welding symbols and notations. The information in this text follows to the most recent standards set up by the American Welding Society (AWS) and the American National Standards Institute

(ANSI). However, this text is based on actual prints that are used in industry. While most industry practices conform to the national standards, any variation in a particular print has been retained for realistic experience. This will prepare you to work with prints being used in industry today.

This text is intended for students in high schools, vocational/technical schools, community colleges, for apprentices, and for workers on the job. It may also be used as a self-study course for those unable to attend print reading classes.

Each unit is designed to deliver complete coverage of specific welding print reading topics. Example prints, illustrations, symbols, and notations are used throughout each unit to reinforce these topics. At the end of each unit, there are problems that deal with the topics covered in the unit. These problems are used to review the key concepts learned in the unit.

Unit 25, Print Reading Activities, consists of additional prints and related questions. These activities are designed to give you the opportunity for added practice of your welding print reading skills. It is suggested that these activities be performed after the completion of the first 24 units, but they may be used anytime as a review.

## About the Authors

Each author has many years of experience in the teaching, welding, and print reading fields. They are confident that you will find this text a tremendous tool for learning how to read and interpret welding prints.

### John R. Walker

John R. Walker is the author of thirteen textbooks and has written many magazine articles. Mr. Walker did his undergraduate studies at Millersville University and has a Master of Science degree in Industrial Education from the University of Maryland.

He taught industrial arts and vocational education for thirty-two years and was Supervisor of Industrial Education for five years. He also worked as a machinist for the U.S. Air Force and as a draftsman at the U.S. Army Aberdeen Proving Grounds.

### W. Richard Polanin

Dr. W. Richard Polanin is a retired professor and program chair of the Manufacturing Engineering Technology and Welding Technology programs at Illinois Central College. He is the Co-Principal Investigator for Weld-Ed, the National Center for

Welding Education and Training. He is also the Principal Investigator for a Weld-Ed project in collaboration with the American Society for Nondestructive Testing to identify nondestructive testing technician student learning outcomes.

Dr. Polanin is also a consultant in manufacturing engineering, and welding engineering and inspection. He has published numerous papers and has made many technical presentations in the areas of manufacturing, robotics, welding, and manufacturing education.

Dr. Polanin holds bachelor's and master's degrees from Illinois State University and a doctorate degree from the University of Illinois. He is a graduate of the Illinois Scholars Program sponsored by the Illinois State Board of Education and the Illinois Community College Board. He is also a Certified Manufacturing Engineer, a Certified Welding Inspector, and a Certified Welding Educator. Dr. Polanin was elected to the AWS 2014 Class of Counselors and Fellows and is currently President-Elect of the American Welding Society.

## Reviewers

The authors and publisher wish to thank the following industry and teaching professionals for their valuable input into the development of *Welding Print Reading*.

**Bonnie Adams**

St. Helens High School  
St. Helens, OR

**Michael R. Allen**

Pennsylvania College of  
Technology  
Williamsport, PA

**Chuck Carr**

Rice Lake School District  
Rice Lake, WI

**Alan Corder**

Houston Community College  
Houston, TX

**Bob Couillard**

Burlington Technical Center  
Burlington, VT

**Clyde Ellertson**

Fremont High School  
Plain City, UT

**Billy M. Elliott, Jr.**

Southern Crescent Technical  
College  
Griffin, GA

**Phil Evans**

Southwest Mississippi Community  
College  
Summit, MS

**Nathan B. Fisher**

Isothermal Community College  
Spindale, NC

**Elliott Hedgepeth**

Webber High School  
North Ogden, UT

**Richard Larson**

Texas State Technical College  
Waco, TX

**Michael D. Lederman**

The Greater Southern Tier BOCES  
Elmira, NY

**Eric Phye**

West-MEC Southwest Campus  
Buckeye, AZ

**Joshua Seitzer**

North Montco Technical Career  
Center  
Lansdale, PA

**Mark Thomas**

Southeastern Illinois College  
Harrisburg, IL

**Robert Tosch**

Alpena Community College  
Alpena, MI

**Robert A. Udy**

Salt Lake Community College  
Salt Lake City, UT

**Len Walsh**

Goodwin University  
East Hartford, CT

# The Weld-Ed Mission: Enriched Curricula, Enhanced Educators

Weld-Ed, in collaboration with business and industry, improves the quality, quantity, and availability of welding technicians through the advancement of educational curriculum and professional development for instructors.

To accomplish this mission, the Center's staff and partners work collaboratively on the development of new and improved curricula in all areas of the materials joining industry. As a result of these efforts,

faculty and instructors are provided continuing education opportunities throughout the academic year and summer months.

These programs are specifically designed to train the next generation of workers for the materials joining industry, while enhancing the skills of incumbent workers.

For more information about Weld-Ed, visit [www.Weld-Ed.org](http://www.Weld-Ed.org).

## New to This Edition

This edition of *Welding Print Reading* contains the following enhancements to help students succeed.

- Unit 1 has been updated to reflect the latest industry practices.
- A new section on 3D modeling has been added to the text.
- New information on the use of cobots in the welding field has been added to Unit 10.
- New images showing current equipment have been added to the text.



# Features of the Textbook

The instructional design of this textbook includes student-focused learning tools to help you succeed. This visual guide highlights these features.

## Unit Opening Materials

Each unit opener contains unit outcomes, key words, and an introduction. The **Unit Outcomes** clearly identify the knowledge and skills to be gained when the unit is completed. **Key Words** list the important terms to be learned in the unit. The **Introduction** provides an overview and preview of the unit content.

Unit  
5

Understanding Prints

After completing Unit 5, you will be able to:

- Identify and explain the significance of the principal views on a multi-view drawing.
- Explain how the major types of section views are read and used on a print.
- Identify methods to read prints.

Key Words

auxiliary view

broken-out section

conventional break

crosshatching

cutting-plane line

first angle projection

full section

half section

multiview drawings

offset section

orthographic projection

partial auxiliary views

principal views

removed section

revolved sections

section lining

sectional views

thin section

third angle projection

title block

Introduction

A print shows a series of views that give the welder an exact shape and size description of an object, Figure 5-1. Additional information necessary to make or assemble the product is also included on the print.

The best way to read a print is to mentally break it into smaller parts. First, try to look at the shape of the part with the dimensions and notes removed. Second, try to determine the overall size of the part so you have some understanding of how big or small the part is. Third, look at the **title block** for information about the title part, material, scale, tolerance requirements, and other general pieces of information. Finally, read all of the notes on the drawing.

Multiviews

Most prints are in the form of multiviews. **Multiview drawings** are needed

## Illustrations and Sample Prints

**Illustrations** have been designed to clearly and simply communicate the specific topic. **Sample prints** provide examples of the types of welding prints encountered in industry.

58 Welding Print Reading

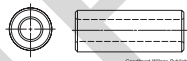


Figure 5-12. Only two views are needed on simple objects like this (cylinder), which can be fully understood on a drawing with little difficulty.

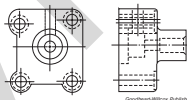


Figure 5-13. A complex object with many interior features may result in a drawing with a maze of confusing hidden lines.

**Sectional views** (or sections) permit the true internal shape of a complex object to be shown without the confusion caused by a myriad of hidden lines. A sectional view shows how the object would appear if an imaginary cut (known as the cutting plane) were made through the object perpendicular to the direction of sight. Shown in Figure 5-14, the section or portion of the object between the eye and the cutting plane is removed or broken away to reveal the interior features of the object. This makes the shape of the object more understandable.

Figure 5-15A shows the exterior of a part. Notice that the interior features are easier to visualize if a full section is shown.

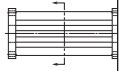


Figure 5-14. A sectional view shows how an object would appear if an imaginary cut were made through it to the direction of sight. This allows the interior features to be seen without the confusion of many hidden lines.

51




Figure 5-15. A complex object with many interior features may result in a drawing with a maze of confusing hidden lines.

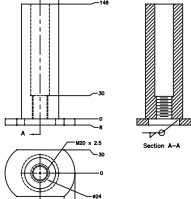


Figure 5-15A. A full section view of the mechanical part shown in Figure 5-15, revealing the internal features (a hole and a slot) to illustrate how a full section view makes the shape of the object more understandable.

182 Welding Print Reading

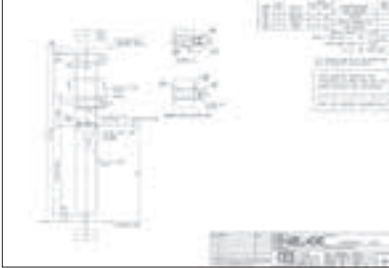


Figure 12-2. The assembly shown in this structural steel drawing is made from stock structural shapes.

metallic element. When a pure metal is used as the principal alloying agent in an alloy, it is known as a **base metal**.

There are no simple answers to these questions. Additional study and experience, however, can help a welder develop a working knowledge of metals to make the job safer, easier, and more successful.

**Metals Supplied for Welding**

The welder usually has little or no control over the metal furnished for welding. It must be assumed metal provided by the employer for a specific job meets print specifications. The metal supplier or the mill that produced the metal can certify the metallurgical characteristics of a metal.

As a welder, it is important to know the characteristics of the metal(s) you will be welding. This is important for three reasons:

- It aids in ensuring the welds meet design specifications.
- It permits you to take special safety precautions when welding metals that give off toxic fumes and residue.
- It allows you to match the filler metal to the base metal.

**Metal Specifications**

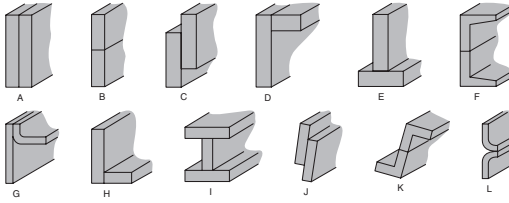
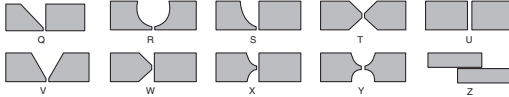
**Metal specifications**, or specs, are usually located in a special section of the title block. Figure 12-3 shows an example. There are times when the metal specs may be given elsewhere on the drawing.

You can think about metals in a variety of ways. For example, you can think about a metal's shape, finish, atomic structure, alloy elements, and strength. For those who work with metals extensively, a more specific method of specifying metals may be needed. Professional organizations, the military, steel mills, testing laboratories, and companies may have a detailed method of specifying metals. A few common

Name \_\_\_\_\_ Date \_\_\_\_\_ Class \_\_\_\_\_

**Review Questions**

Identify the following types of joints and welds.

**Joints****Welds****Joint Combinations**

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Copyright Goodheart-Willcox Co., Inc. May not be reproduced or posted to a public website.

**End-of-Unit Content**

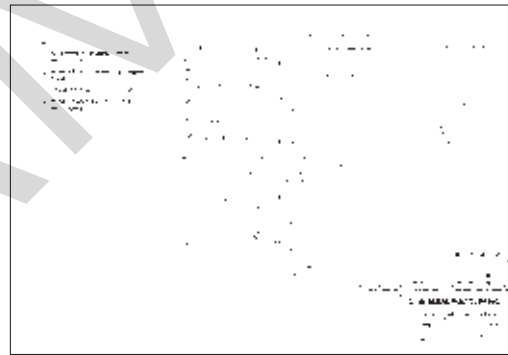
End-of-unit material provides an opportunity for review and application of concepts. **Review Questions** allow you to demonstrate your comprehension of unit material. **Print Reading Activities** at the ends of the units allow you to apply the concepts learned in the unit.

Name \_\_\_\_\_ Date \_\_\_\_\_ Class \_\_\_\_\_

**Print Reading Activities****Part I**

Refer to the drawing below to answer the following questions.

- What is the drawing title?
- Name the drawing number.
- How many parts make up the assembly?
- What welding process is to be used?
- The gussets are located \_\_\_\_\_" from the edges of the support.
- The gusset is made from \_\_\_\_\_" x \_\_\_\_\_" stock. There are \_\_\_\_\_ required in each assembly.
- The width and thickness dimensions of the material used to make the support are \_\_\_\_\_" and \_\_\_\_\_".
- What type of weld is specified?
- Name the type of welding rod that is specified.
- What is the size of the specified weldments?
- Sketch the specified welds on the front and side views in the drawing.
- Each corner of the bracket is chamfered \_\_\_\_\_" x \_\_\_\_\_".
- How many holes are to be drilled?
- The hole size is \_\_\_\_\_ diameter.
- The complete bracket is to be finished by \_\_\_\_\_.



Copyright Goodheart-Willcox Co., Inc. May not be reproduced or posted to a public website.

Goodheart-Willcox Publisher

## Student Tools

### Student Text

*Welding Print Reading* is a write-in text that teaches the welding symbols and specifications students need to understand to be successful. The text starts by reviewing the basics, including welding processes, and then progresses to more specialized topics, such as prints for pipe welding and brazed joints.



### G-W Digital Companion

For digital users, e-flash cards and vocabulary exercises allow interaction with content to create opportunities to increase achievement.



## Instructor Tools

### LMS Integration

Integrate Goodheart-Willcox content within your Learning Management System for a seamless user experience for both you and your students. EduHub LMS-ready content in Common Cartridge® format facilitates single sign-on integration and gives you control of student enrollment and data. With a Common Cartridge integration, you can access the LMS features and tools you are accustomed to using and G-W course resources in one convenient location—your LMS.

G-W Common Cartridge provides a complete learning package for you and your students. The included digital resources help your students remain engaged and learn effectively:

- **Digital Textbook**
- **Drill and Practice** vocabulary activities

When you incorporate G-W content into your courses via Common Cartridge, you have the flexibility to customize and structure the content to meet the educational needs of your students. You may also choose to add your own content to the course.

For instructors, the Common Cartridge includes the Online Instructor Resources. QTI® question banks are available within the Online Instructor Resources for import into your LMS. These prebuilt assessments help you measure student knowledge and track results in your LMS gradebook. Questions and tests can be customized to meet your assessment needs.

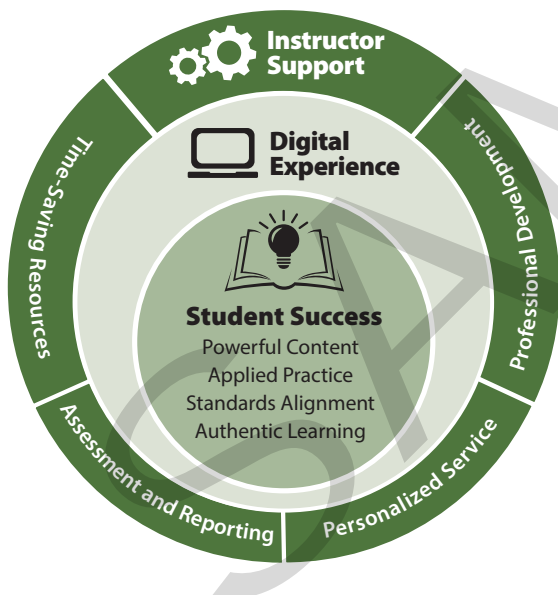
### Online Instructor Resources

- The **Instructor Resources** provide instructors with time-saving preparation tools such as answer keys, editable lesson plans, and other teaching aids.
- **Instructor's Presentations for PowerPoint®** are fully customizable, richly illustrated slides that help you teach and visually reinforce the key concepts from each unit.
- Administer and manage assessments to meet your classroom needs using **Assessment Software with Question Banks**, which include hundreds of matching, completion, multiple choice, and short answer questions to assess student knowledge of the content in each unit.

See [www.g-w.com/welding-print-reading-2024](http://www.g-w.com/welding-print-reading-2024) for a list of all available resources.

### Professional Development

- Expert content specialists
- Research-based pedagogy and instructional practices
- Options for virtual and in-person Professional Development





# Brief Contents

## Introduction

Unit 1: Prints—The Language of Industry .....	1
Unit 2: Review of Measurement .....	11
Unit 3: A Review of Fractions and Decimals .....	27

## Print Reading Basics

Unit 4: Alphabet of Lines .....	39
Unit 5: Understanding Prints .....	51
Unit 6: Types of Prints .....	75
Unit 7: Print Format .....	91
Unit 8: Basic Plane Geometry .....	105
Unit 9: Dimensioning Welding Prints .....	115

## Welding Fundamentals

Unit 10: Welding Processes .....	129
Unit 11: Threaded Fasteners .....	147
Unit 12: Structural Metals .....	159
Unit 13: Common Types of Joints and Welds .....	167

## Reading Welding Prints

Unit 14: Welding Symbols .....	173
Unit 15: Fillet Welds .....	193
Unit 16: Groove Welds .....	209
Unit 17: Plug and Slot Welds .....	227
Unit 18: Spot, Seam, and Projection Welds .....	243
Unit 19: Surfacing Welds .....	261
Unit 20: Edge Welds .....	267
Unit 21: Pipe Welding .....	273
Unit 22: Brazed Joints .....	287

## Manufacturing and Testing for Industry

Unit 23: Basic Metalworking Processes .....	295
Unit 24: Examining and Testing Welds .....	325
Unit 25: Print Reading Activities .....	337

# Contents

## Introduction

### Unit 1 | Prints—The Language of Industry ..... 1

Introduction	1
Evolution of Making Drawings	2
<i>CAD Systems</i>	2
<i>3D Modeling</i>	2
What Is a Print?	4
Why Are Prints Used?	4
Reproduction Techniques	5
<i>Tracings</i>	5
<i>Xerography (Electrostatic) Process</i>	5
<i>The Microfilm Process</i>	5
<i>Older Printmaking Processes</i>	5
Electronic Storage	6
Importance of Prints to Welders	6
Care of Prints	6
Welder Certification	7
<i>Preparation for Certification</i>	7
<i>Entry Level Welding</i>	7

### Unit 2 | Review of Measurement ..... 11

Introduction	11
U.S. Customary and Metric Measuring Systems	11
<i>Reading a Fractional Inch Graduated Rule</i>	11
<i>Reading a Decimal Inch Graduated Rule</i>	13
<i>Reading a Metric Graduated Rule</i>	13
Converting Linear Measurements	13
Converting Decimal Fractions to Common Fractions	14
Converting Common Fractions to Decimal Fractions	15
Interpreting Dimensions on Drawings	16
<i>Metric Unit Symbols</i>	16
<i>Reading Inch and Metric Measurements on Drawings</i>	17

### Unit 3 | A Review of Fractions and Decimals 27

Introduction	27
Fractions	27
Rules for Using Fractions	28
Adding Fractions	28
<i>Addition Problems (Fractions)</i>	29
Subtracting Fractions	29
<i>Subtraction Problems (Fractions)</i>	29
Multiplying Fractions	29
<i>Multiplication Problems (Fractions)</i>	30
Dividing Fractions	30
<i>Division Problems (Fractions)</i>	30

Decimal Fractions	30
<i>Writing Problems (Decimal Fractions)</i>	31
Adding and Subtracting Decimal Fractions	31
<i>Addition Problems (Decimal Fractions)</i>	31
<i>Subtraction Problems (Decimal Fractions)</i>	31
Multiplying Decimal Fractions	31
<i>Multiplication Problems (Decimal Fractions)</i>	32
Dividing Decimal Fractions	32
<i>Division Problems (Decimal Fractions)</i>	32
Additional Information on Decimal Fractions	32
Metrics	33
<i>Metric Addition Problems</i>	34
<i>Metric Subtraction Problems</i>	34
<i>Metric Multiplication Problems</i>	34
<i>Metric Division Problems</i>	34
Conversions	35
<i>Decimal Fraction to Fraction Conversion</i>	35
<i>Decimal Fraction to Fraction Conversion Problems</i>	35
<i>Metric to Decimal Fraction or Fraction Conversion</i>	35
<i>Metric to Decimal Fraction and Fraction Conversion Problems</i>	35

## Print Reading Basics

### Unit 4 | Alphabet of Lines..... 39

Introduction	39
Types of Lines	39
<i>Visible Line</i>	39
<i>Hidden Line</i>	39
<i>Center Line</i>	42
<i>Section Line</i>	42
<i>Cutting-Plane Line</i>	42
<i>Break Line</i>	43
<i>Dimension and Extension Lines</i>	44
<i>Phantom Line</i>	44
How the Alphabet of Lines Is Used	44

### Unit 5 | Understanding Prints ..... 51

Introduction	51
Multiviews	51
Auxiliary Views	54
Sectional Views	56
<i>Cutting-Plane Line</i>	58
<i>Section Lining</i>	59
<i>Thin Section</i>	60
<i>Full Section</i>	60
<i>Half Section</i>	61

<i>Revolved Section</i>	61
<i>Removed Section</i>	61
<i>Offset Section</i>	61
<i>Broken-Out Section</i>	62
<i>Conventional Break</i>	62
<i>Sections through Webs and Ribs</i>	63
Rules on Reading Prints	63

## Unit 6 | Types of Prints ..... 75

Introduction	75
Welders Who Read Prints	75
Working Drawings	76
<i>Detail Drawing</i>	76
<i>Assembly Drawing</i>	76
Specialized Drawings	78
<i>Erection Drawing</i>	78
<i>Process Drawing</i>	78
Parts List	78

## Unit 7 | Print Format ..... 91

Introduction	91
Shape Description	92
Size Description	92
Print Title Block	95
<i>Material Specification</i>	95
<i>Tolerances</i>	95
<i>Quantity of Units</i>	96
<i>Scale of Drawing</i>	96
<i>Finish</i>	96
<i>Revisions</i>	98
<i>Next Assembly</i>	98
<i>Drawing Title</i>	98
<i>Print Number</i>	98
<i>Heat Treatment</i>	98
<i>Notes</i>	98
Print Sheet Size	99
Zoning	99
Security Classification	100
Dimensioning Symbols	100

## Unit 8 | Basic Plane Geometry ..... 105

Introduction	105
Plane Figures	105
<i>Circles</i>	106
<i>Angular Measurement</i>	108
<i>Triangles</i>	110
Parallel Lines and Interior Angles	112

## Unit 9 | Dimensioning Welding Prints.... 115

Introduction	115
Extension and Dimension Lines	116
Datum Dimensions	117
Zero Plane Dimensions	118
Direct and Calculated Dimensions	118

Linear and Angular Tolerance	118
Reference Dimensions	120
Geometric Dimensioning and Tolerancing	120
Definitions and Symbols	121
Application of GD&T	122
Orientation Geometric Tolerances	122
Form Geometric Tolerances	123
Other Geometric Tolerances	123

# Welding Fundamentals

## Unit 10 | Welding Processes ..... 129

Introduction	129
Soldering (S)	130
Brazing (B)	130
Welding	130
Modern Welding Processes	130
<i>Oxyfuel Gas Welding (OFW)</i>	131
<i>Shielded Metal Arc Welding (SMAW)</i>	131
<i>Gas Metal Arc Welding (GMAW)</i>	132
<i>Gas Tungsten Arc Welding (GTAW)</i>	132
<i>Flux Cored Arc Welding (FCAW)</i>	132
<i>Submerged Arc Welding (SAW)</i>	133
<i>Arc Stud Welding (SW)</i>	134
<i>Resistance Welding (RW)</i>	134
Additional Welding Processes	136
<i>Electron Beam Welding (EBW)</i>	136
<i>Friction Welding (FRW)</i>	136
<i>Friction Stir Welding (FSW)</i>	136
<i>Electroslag Welding (ESW)</i>	138
<i>Laser Beam Welding (LBW)</i>	138
<i>Ultrasonic Welding (USW)</i>	138
<i>Cold Welding (CW)</i>	138
<i>Microwelding</i>	139
<i>Flame Spraying (FLSP)</i>	140
<i>Automatic (Robotic) and Mechanized Welding Systems</i>	142
Standard Welding, Joining, and Allied Processes	144

## Unit 11 | Threaded Fasteners ..... 147

Introduction	147
Thread Forms	148
<i>Thread Series</i>	148
<i>Thread Fit Classes</i>	148
Thread Notes	149
Standard Thread Representations	150
<i>Detailed Representation</i>	150
<i>Schematic Representation</i>	150
<i>Simplified Representation</i>	150
Metric Threads	151
Types of Fasteners	151

## Unit 12 | Structural Metals ..... 159

Introduction	159
What Is Metal?	159
Metals Supplied for Welding	162
Metal Specifications	162

## Unit 13 | Common Types of Joints and Welds ..... 167

Introduction	167
Joint Types	167
Weld Types	167
Joints and Grooves	169
Terms Used to Describe Welds	169

# Reading Welding Prints

## Unit 14 | Welding Symbols ..... 173

Introduction	173
Elements of a Welding Symbol	173
<i>Reference Line</i>	175
<i>Weld Symbol</i>	175
<i>Arrow</i>	176
<i>Tail</i>	178
<i>Supplementary Symbols</i>	178
<i>Dimensions</i>	180
<i>Contour and Finish Symbols</i>	181
<i>Notations</i>	181
Nonpreferred Weld Symbols	181
Reading and Explaining a Welding Symbol	184
International Welding Symbols	184

## Unit 15 | Fillet Welds ..... 193

Introduction	193
General Use of Fillet Weld Symbol	193
Intermittent Fillet Welds	196
Fillet Welds in Holes and Slots	196
Specifying Fillet Weld Contours	196
Combination Weld Symbols	197

## Unit 16 | Groove Welds ..... 209

Introduction	209
Root Opening, Groove Angle, and Bevel Angle	210
Preparation Size and Effective Throat of Groove Welds	210
General Use of Groove Weld Symbol	211
Groove Dimensions	212
Surface Finish and Contour of Groove Welds	213
Melt-Through, Back, and Backing Welds	213
Backing, Joint Spacers, and Runoff Weld Tabs	214
Flare-Groove Welds	215
Combination Weld Symbols	216

## Unit 17 | Plug and Slot Welds ..... 227

Introduction	227
General Use of the Plug and Slot Weld Symbol	228
Size of Plug Welds	228
Countersink Angle of Plug Weld	228
Slot Weld Details	230
Filling Depth of Plug or Slot Welds	230
Spacing Plug or Slot Welds	231
Surface Contour of Plug or Slot Welds	231

## Unit 18 | Spot, Seam, and Projection Welds ..... 243

Introduction	243
Spot Welds	244
<i>Size and Strength of Spot Welds</i>	244
<i>Spacing of Spot Welds</i>	244
<i>Extent of Spot Welding and Number of Spot Welds</i>	244
<i>Flush Spot Weld Joints</i>	245
<i>Multiple Member Joint Spot Welds</i>	246
Seam Welds	246
<i>Size and Strength of Seam Welds</i>	246
<i>Length of Seam Welds</i>	247
<i>Dimensioning of Intermittent Seam Welds</i>	247
<i>Orientation of Seam Welds</i>	248
<i>Flush Seam Weld Joints</i>	248
<i>Multiple Joint Seam Welds</i>	248
Projection Welds	248
Stud Welds	250
<i>Side Significance</i>	251
<i>Stud Size, Spacing, and Number of Studs</i>	251
<i>Location of Stud Welds</i>	251

## Unit 19 | Surfacing Welds ..... 261

Introduction	261
General Use of Surfacing Weld Symbol	262
Surfacing Weld Dimensions	262
Location, Extent, and Orientation of Surfacing Welds	262

## Unit 20 | Edge Welds ..... 267

Introduction	267
Multiple Member Edge Welds	267

## Unit 21 | Pipe Welding ..... 273

Introduction	273
Piping Drawings	276

## Unit 22 | Brazed Joints ..... 287

Introduction	287
--------------	-----

# Manufacturing and Testing for Industry

## Unit 23 | Basic Metalworking Processes..... 295

Introduction	295
Castings	295
Permanent Mold Casting	296
Die Casting	297
Investment or Lost Wax Casting	298
Shell Molding	298
Sand Casting	298
Forging	299
Extrusion	301
Machine Tools	301
Lathe	303
Drill Press	303
Planing Machines	305
Milling Machines	307
Computer Numerical Control (CNC) Machine Tools	308
Grinding Machines	310
Saws	310
Cold Forming Metal	312
Spinning	312
Shear Spinning	313
Explosive Forming	314
Stamping	315
Shearing	315
Stretch Forming	317
Bending	317
Roll Forming	317
Tube Bending	319

## Unit 24 | Examining and Testing Welds..... 325

Introduction	325
Basic Classifications of Quality Control Techniques	326
Destructive Examination	326
Guided Bend Test	326
Tensile Test	326

Nondestructive Examination (NDE)	327
Basic Nondestructive Examination Symbols	327
Elements of the Examination Symbol	327
Location Significance of Arrow	328
Location of Examination Symbol	328
Direction of Radiation	329
Combination of Nondestructive Examination Symbols and Welding Symbols	329
Specifying Length of Section to Be Examined	329
Specifying a Section or Plane Area to Be Examined	330
Major Nondestructive Examination (NDE) Methods	330
Visual Testing (VT)	330
Magnetic Particle Testing (MT)	330
Liquid Penetrant Testing (PT)	331
Radiographic Testing (RT)	332
Ultrasonic Testing (UT)	332

## Unit 25 | Print Reading Activities.....337

Introduction	337
25A—Floor Support Assembly	339
25B—Side Sill Assembly	341
25C—Center Sill Web and Flange Assembly	343
25D—Bulkhead Assembly	345
25E—Sheave Wheel Bracket Assembly	347
25F—Striker Assembly	349
25G—Spacer Support, H.D.	351
25H—Bracket	353
25I—Pump Plate	355
25J—Exhaust Support Assembly	357
Reference Section	359
Glossary	377
Index	387





# Section **1** Introduction

Unit **1** Prints—The Language of Industry

Unit **2** Review of Measurement

Unit **3** A Review of Fractions and Decimals