



American Welding Society®

Education Services

D1.1 Code Clinic



CODE CLINIC

For Study of

**AWS D1.1/D1.1M: 2010
Structural Welding Code—Steel**

**Published by
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AWS Code Clinic Reference Manual—AWS D1.1/D1.1M: 2010

FOREWORD AWS Education Services publishes the *AWS Code Clinic Workbook* to guide and assist quality professionals – inspectors, supervisors, etc. – and quality-conscious engineers and managers in reading, understanding, and learning to apply industrial codes such as *AWS D1.1/D1.1M: 2010, Structural Welding Code—Steel*. *AWS D1.1/D1.1M: 2010* covers the welding requirements for any type of welded structure made from the commonly used carbon and low-alloy steels.

This 2008 edition of the *Code Clinic Reference Manual* for the study of *AWS D1.1/D1.1M: 2008 Structural Welding Code—Steel* is based on information from *AWS D1.1/D1.1M: 2008 Structural Welding Code—Steel*. This edition supersedes previous editions of the *Code Clinic Reference Manual*.

This *D1.1 Code Clinic Reference Manual* consists of an introduction and nine sections. Sections 1 through 8 cover the eight corresponding sections of the code; Section 9 covers the annexes, commentary, and index. Each section begins with an orientation to and general discussion of that code section's contents.

For each section, exercise questions and answers are provided at the end of this document. Answering them provides a valuable review of the section contents. These questions also illustrate the types of questions you're likely to encounter in practice.

The authors of this book want you to write in this book and in D1.1 to clarify your understanding of the figures, tables, and text in both volumes.

As you read this book, open the code to the corresponding page. Remembering excerpts from the code is neither necessary nor desirable. You need not memorize the code; just learn how to use it.

The American Welding Society appreciates feedback from participants in its education programs. Please send comments or questions to:

American Welding Society
Education Services Department
550 NW LeJeune Rd
Miami FL 33126

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Chapter 1

Introduction

Introduction.....

Objectives

How to Prepare.....

How to Use This Book

Introduction Checklist



INTRODUCTION

The first iteration of the D1.1 code, *The Code for Fusion Welding and Gas Cutting in Building Construction*, was published by the American Welding Society in 1928. Since that time, the D1.1 has undergone numerous revisions, upgrades, and name changes, ultimately culminating in this latest version: *D1.1/ D1.1M:2010 Structural Welding Code – Steel*. This code clinic reference manual is designed to guide potential test takers through the D1.1 code and provide them with the strategies and skills necessary to competently navigate the D1.1 code book.

The skill set obtained through this program, as either part of the AWS Certified Welding Inspector Seminar, or as individual self-study, will aid future welding inspectors in the navigation of the D1.1 code book, allowing them to quickly and accurately identify specifications related to their current code work. The purpose of the D1.1 Code Clinic Reference Manual is both to prepare the reader to sit for the “Code Book” portion of the Certified Welding Inspector Examination or the D1.1 endorsement Exam, and to provide practical knowledge, advice, and techniques utilized to develop the needed skill set. While many of the techniques and advice provided in this reference manual can be applied to virtually any code and specification, the information contained in herein is meant to solely reference the AWS *D1.1/ D1.1M:2010 Structural Welding Code – Steel*. This edition of the D1.1 Code Clinic Reference Manual supersedes previous editions of the CCRM.

OBJECTIVES

The express purpose of the Code Clinic Reference Manual is to instruct the reader on efficiently and effectively navigating the D1.1 Code Book. By the end of the program the reader should be able to:

- 1) Identify the eight clauses of the D1.1:2010 codebook and describe the content of each clause.
- 2) Effectively implement the system taught in this reference manual for identifying keywords.
- 3) Utilize the index, table of content, and list of tables and figures to identify specific areas of the code.
- 4) Differentiate information located in the D1.1 text, tables, and figures.
- 5) Prepare the D1.1 cod50 for a given examination.
- 6) Confidently, efficiently, and accurately navigate the D1.1 code book.

WHAT THIS BOOK IS NOT

While the D1.1 Code clinic Reference Manual is designed to provide a thorough examination of navigation techniques and methodologies, the CCRM is **not**:

- 1) A short cut. Simply reviewing this reference manual will not substantially

HOW TO PREPARE?

Preparing for the D1.1 Code Book Exam, much like the layout of this workbook, is divided into five phases:

- 1) **Understanding** the exam and the code
- 2) **Familiarizing** oneself with the individual clauses
- 3) **Strategizing** techniques for answering questions
- 4) **Preparing** oneself and the codebook
- 5) **Practicing**, practicing, and practicing

UNDERSTANDING

The Code Clinic Reference Manual begins with an analysis of the D1.1 code exam and a basic overview of the code structure, which are the foundation of this program. These topics are reviewed in Chapters 2 and 3 respectively.

Chapter 2 “*Putting the Test into Perspective*” provides a detailed description of the D1.1 Certification Exam structure, making a direct connection between the exam’s body of knowledge and how to prepare for it. The chapter enables the readers to:

- See the exam from the test maker’s perspective.
- Understand the way AWS has structured the test including the type of questions, exam length, and time requirements.
- Develop fundamental testing strategies such as exam pacing and benchmarking.

Chapter 3 “The Code: An Overview” facilitates the utilization of the code by breaking down its structure and major components. The chapter includes:

- A basic top-level overview of each of the eight major clauses including the major topics and topic areas.
- A description of the code’s clauses, including their interrelationships, allowing the reader to view the code from a practical perspective and thereby locate information more efficiently and accurately.

FAMILIARIZING

The next eight chapters, 3 through 11, provide an in-depth description of the eight clauses in the D1.1 code: General Requirements, Design of Welded Connections, Prequalification of WPSs, Qualification, Fabrication, Inspection, Stud Welding, and Strengthening and Repairing Existing Structures. Each chapter focuses on a single clause and identifies:

- The purpose of the clause. *Why is this clause necessary? What information can be found in this clause?*
- The structure of the clause. *What are the major topics? What information is found in the text, tables, and figures?*

- The important topics. *What information is especially relevant to a welding inspector and where is that information located?*

STRATEGIZING

Chapters 12, 13, and 14 will equip the reader with test taking strategies geared specifically to the AWS D1.1 Code Book Exam. These chapters focus on utilizing the code's structure to the reader's advantage in locating the pertinent information in the most efficient manner.

Chapter 12 "*Attacking the Question*" provides:

- Strategies to help the reader understand the question's prompt. *What is the question really asking?*
- Strategies for identifying the keywords in a question. *What words should the reader use to start looking for an answer?*

Chapter 13 "*Using the Index and Table of Contents*" provides:

- Strategies for locating information efficiently in the codebook. *What are the most efficient ways to refer to the Index and Table of contents? How does the reader determine whether to refer to the Index or Table of Contents first?*

Chapter 14 "*Text, table, figure*" provides:

- Strategies for predicting where an answer will be found within a clause. *Should the reader expect the answer to be found in a section of text, a table, or a figure?*

Together these three chapters provide an effective system for quickly locating information in the D1.1 Code Book that will transcend the exam itself, and provide a systematic approach that can be efficiently utilized in the field.

PREPARING

The last chapters of the code clinic, Chapters 15 and 16 focus on preparing the codebook and oneself for the certification examination. Chapter 15, "*Tabbing and Highlighting*", covers the do's and don'ts on tabbing and highlighting the code book. Chapter 16, "*Test Taking Tips*", includes general test taking tips that are critical for any multiple choice exam (D1.1 exam included) as well as strategies that can be used to put oneself in the right mind-frame before and during the exam.

PRACTICING

The single most important aspect of preparing for the D1.1 Code Examination is practicing, practicing, practicing. The last section of the clinic contains four sample D1.1 tests, of varying length and complexity that can be used to practice for the exam while simulating a test day environment.

HOW TO USE THIS BOOK

Chapter 2

Putting the Exam Into Perspective

What is Being Tested?.....

Exam Pacing.....

It's not About Getting an "A"

Breaking Down the D1.1 Code Book Exam.....





The D1.1 code book exam is most commonly administered as the third section (Part C) of the AWS CWI Certification Examination, and may also be taken as a stand alone code endorsement assessment. Similar to the other code exams provided by AWS, the D1.1 examination is strictly a **navigation exam**, and not a theoretical or computational test; therefore, participants are expected to bring their own code book to utilize while taking the exam. AWS allows test takers to prepare their code books in any method they choose prior to taking the D1.1 exam. Chapter 15 of this workbook will provide general methods for tabbing, highlighting, and preparing your code book.

The first step in preparing for any exam is putting the exam into perspective by identifying the number of questions on the exam, the time allotted for completion, the type(s) of questions, and the required passing rate.

D1.1 Code Book Exam Facts

Number of Questions	Time Allotted	Passing Score	Type of Questions
46-60	Two (2) hours	72%	Multiple Choice

Image 2.1

Establishing this baseline of information will allow test takers to develop efficiency and time management strategies, as well as allow them to walk into the exam with a positive mind-frame. The following chapter examines the D1.1 examination structure and content at length, providing test takers with a positive first step in the development of a preparation plan.

What is Being Tested?

Preparations for an exam should always begin by asking the simple question: “What is being tested?” Oftentimes, test takers focus too much on the exam topics, and not enough on the “desired outcome” for the test taker. AWS recognizes that in a real world scenario, welding inspectors would never be expected to memorize the D1.1 code; therefore, testing their ability to memorize the particulars of the code would not be an accurate representation as to how well they would fulfill their job duties. Instead AWS designed the D1.1 exam to measure how efficiently the test taker can understand the question being asked and locate the appropriate information; how well the test taker can navigate through the code.

Understanding the purpose of the exam and the format in which it is provided establish the frame work in which the test taking strategies you develop in this program will operate. Memorizing individual specifications or sub-clauses will yield very little benefit when taking this type of exam. A test taker’s time is better spent developing navigational strategies, understanding the code layout, and in practice, practice, practice.

Exam Pacing

While AWS does not provide the exact number of question that will appear on the D1.1 code book exam, they do provide a range. As of the printing of this book, the D1.1 exam will contain between forty-six (46) and sixty (60) multiple choice questions.



The AWS certification exams, including the code book exams, are designed by volunteers from the welding industry. These volunteers vigilantly monitor exam results and test taker's feedback in order to ensure the most relevant, accurate, and complete tests possible. At times, the volunteer committees may find it necessary to change the parameters of a given exam. Always verify information, such as the question number range, with the certification exam information AWS mails to all exam participants.

The D1.1 code book exam, much like all AWS certification exams, is a timed test. Test takers are provided two hours to complete as many questions as possible. Combining the time allotted with the range of possible questions provides test takers with a key piece of information: time allotted per question. Calculating the "allotted time per question" will dictate the testing pace for the exam, ensuring that test takers effectively manage their time.

In order to calculate "time allotted per question", divide the total time allowed by the number of questions on the test. The answer will be in a decimal format. The whole number equals the number of minutes. Take the remainder and multiply it by 60 to determine the number of seconds. For example, $120 \text{ minutes} \div 46 \text{ questions} = 2.60$. The whole number 2 equals two whole minutes. The value of .60 when multiplied by 60 produces the number of seconds; in this case 36. The total time allotted is 2:36.

Number of Questions	Time Allotted	Minutes per Question
46 Questions	120 min.	2 min 36 seconds
47 Questions	120 min.	2 min 33 seconds
48 Questions	120 min.	2 min 30 seconds
49 Questions	120 min.	2 min 27 seconds
50 Questions	120 min.	2 min 24 seconds
51 Questions	120 min.	2 min 21 seconds
52 Questions	120 min.	2 min 18 seconds
53 Questions	120 min.	2 min 16 seconds
54 Questions	120 min.	2 min 13 seconds
55 Questions	120 min.	2 min 11 seconds
56 Questions	120 min.	2 min 9 seconds
57 Questions	120 min.	2 min 6 seconds
58 Questions	120 min.	2 min 4 seconds
59 Questions	120 min.	2 min 2 seconds
60 Questions	120 min.	2 minutes

Image 2.2

Utilizing the data provided in Image 2.2, a test taker can set testing benchmarks to ensure they keep an appropriate pace. For example, on a sixty question exam, a participant knows that if after fifteen minutes he has completed 10 questions, then he is five minutes ahead of his ideal pace, allowing him to spend additional time on tougher questions. Conversely, if a participant realizes that after 20 minutes he has only completed five questions, then he must adjust his pace or implement a new strategy, otherwise, his chances of obtaining a passing score will decrease substantially.

Does this mean that a test taker cannot spend more time than that allotted on a question?

Test takers can spend as much or as little time as they require answering questions. The D1.1 exam will include questions of varying difficulty. Simple questions may be answered in less time than difficult questions. The time allotted per question data is a simple means of keeping pace during the exam. If a test taker has spent six minutes on a question and is not close to locating the answer, it may be beneficial to skip the question for the time being and return to it if there is time remaining towards the end of the exam. The central idea behind this information is that of keeping a general pace. Test takers should not time each individual question, instead they should use benchmarks, set at varying intervals, to ensure they have kept pace with the exam.



One of the worst mistakes made by test takers is ignoring the pace, and realizing, with minimal time remaining that they have yet to answer a significant portion for the exam. Test takers must walk a fine line between keeping pace and obsessing over time. Checking their pace after every question will be detrimental to the test taker, as doing so will only use up more of their precious time. Setting a series of benchmarks, like

those found in Image 2.3 will allow the test taker to check their pace often enough to ensure they have enough time remaining to answer as many questions as possible, but not too often as to be a detriment.

Time Remaining	Questions Remaining (Ideal Pace)	Questions Remaining (Actual Pace)
120 min.	60	
90 min.	45	
60 min.	30	
30 min.	15	
15 min.	7	
5 min.	2	

Image 2.3

Additionally, when the time allotted per question data is combined with the information provided in the next section, it becomes clear that a test taker should not spend too much time on any individual question. The ability to keep a pace geared towards passing the exam, as opposed to answering 100% of the questions, will make the D1.1 examination much more manageable.

It's not about getting an "A"

One of the most common mistakes test takers make when sitting for a certification exam is trying to get the "A". While early schooling has taught students to always strive for the "A", this same approach could be detrimental to the test taker trying to pass a certification exam. Consider for a moment that certification exams are graded on a "Pass/fail" basis, and that the "pass" or "fail" result is not quantified into categories like "A", "B", "C", "D", or "F". So while at school an "A" is a better grade than a "C", when taking AWS certification exams, a "pass" is a "pass."



According to the QC1: 2007, if a test taker fails a single part of the exam, but obtains a composite score of 72% on all three sections, then the test taker would only need to retake the individual section he or she failed. Therefore, obtaining as high of a score as possible should always be the goal of test taker.

Calculating the minimum number of correct answers a test taker would need to pass the D1.1 exam does provide tangible and intangible benefits when preparing for the exam. To begin with, test takers can utilize this information to establish general parameters about how they approach the exam. For example, the longer the exam the more questions test takers may score incorrectly or skip, and still pass. Shorter exams provide test takers more allotted time per question, but will also provide less leeway with skipped or incorrect answers.

Additionally, understanding that not every question must be answered correctly in order to pass, is a great psychological and practical tool for the test taker. Using an example from the previous section, if a test taker has spent six minutes trying to answer an individual question, and is not near locating the answer, skipping that question and returning to it if there is time remaining towards the end of the exam would be the correct strategy to implement. Furthermore, if that same test taker was able to recognize after reading the question that he had no real clear means of locating the answer, and decided to move on towards a questions that he is more comfortable answering, he has saved additional minutes of test time, without reducing his chance of passing the exam.

Currently, the minimum passing score for the D1.1 code book examination is 72%. This percentage translates into a specific number of correct answers needed to pass the exam. The number of correct answers needed to pass is directly proportional to the total number of questions provided as seen in image 2.4.

In order to calculate the number of correct answers needed to pass, simply take the total number of questions provided and multiply by .72 (72% converted to a decimal format). For example, an exam with 46 questions would require 33 correct answers to pass. $46 \times .72 = 33.12$ (rounded down to 33).

Number of Questions	Passing Percentage	Operation	Correct Answers Needed to Pass
46	72%	46 x .72 ≈	33 correct
47	72%	47 x .72 ≈	34 correct
48	72%	48 x .72 ≈	35 correct
49	72%	49 x .72 ≈	35 correct
50	72%	50 x .72 ≈	36 correct
51	72%	51 x .72 ≈	37 correct
52	72%	52 x .72 ≈	37 correct
53	72%	53 x .72 ≈	38 correct
54	72%	54 x .72 ≈	39 correct
55	72%	55 x .72 ≈	40 correct
56	72%	56 x .72 ≈	40 correct
57	72%	57 x .72 ≈	41 correct
58	72%	58 x .72 ≈	42 correct
59	72%	59 x .72 ≈	42 correct
60	72%	60 x .72 ≈	43 correct

Image 2.4

Breaking Down the D1.1 Code Book Exam

The D1.1 code book is divided into eight (8) clauses, each containing the provisions for welding “steel structures that utilize carbon or low alloy steels that are 1/8 in. or thicker with minimum specific yield strength of 100 ksi or less.”¹ Although each of the clauses contain important standards for building steel structures, not all clauses are equally relevant to the welding inspector. As the D1.1 code exam is geared towards the welding inspector and not the welding engineer, the number of questions which reference the various clauses are weighed according to their importance to the inspection field.

Simply put, all eight clauses will not be tested equally. The AWS B5.1 breaks down the concentration of questions per clause. These numbers (see Image 2.5) represent the percentage of questions whose answers will be found in a given clause.

Code Applications	Percent of Total Questions
Materials and Design	10%
Fabrication	30%
Inspection	25%
Qualification	30%

Image 2.5

The Code Applications (Materials and Design, Fabrication, Inspection, and Qualification) match up with the code in such a way that you can expect virtually all of the answers to exam questions to be located in clause 2, 3, 4, 5, or 6. Furthermore, a rudimentary analysis of this information provides some key insights into the design of the exam.

¹ AWS D1.1/D1.1 M:2010 pg 1

According to the breakdown of questions test takers can draw some fundamental conclusions that can be utilized to focus their test preparations:

- The industry experts who designed and developed the D1.1 code book exam placed a great emphasis in areas dealing with welding inspection, therefore, sections of the listed clauses detailing information critical to the welding inspector should be given emphasis in the code review period of preparation.
- Test takers should familiarize themselves thoroughly with the clauses concerning fabrication, inspection, and qualification as more than three-fourths of answers to exam questions can be found in these sections.
- When prioritizing time spent reviewing the code book, test takers should not focus on the clauses dealing with materials and design to the detriment of fabrication, inspection, and qualification.
- Test takers should still factor in time to review all sections of the code to ensure enough familiarity with each clause, so as not to allow a lack of familiarity to become a hindrance during the exam. The ten percent of questions whose answers are found in materials and design could be the difference between passing and failing.
- The total percentage of question outlined in Image 2.5 is only ninety-five percent (95%), indicating that a total of 5% of the questions on the exam will have their answers found either in multiple locations, or outside of the areas listed.

The example found in Image 2.6 illustrates these points even further. If the test taker were taking a D1.1 code book exam with 50 total questions, then the answer location breakdown would be as follows :

Code Applications	Percentage of Total Questions	Operation	Number of Questions
Materials and Design	10%	$50 \times .10 \approx$	5
Fabrication	30%	$50 \times .30 \approx$	15
Inspection	25%	$50 \times .25 \approx$	12 or 13
Qualification	30%	$50 \times .30 \approx$	15

Image 2.6

In addition to the eight clauses, the D1.1:2010 code book contains Annexes and Commentary that comprise a great bulk of the pages in the code book, namely pages 293 to 526.

The D1.1 code contains two types of Annexes, normative and informative. Normative Annexes (pg 293-332) “contain information that is considered a part of the standard.”² Informative Annexes (pg 333-409) “are not considered part of the standard and are provided for informational purposes only.”³ The

² AWS D1.1/D1.1 M:2010 pg 293

³ AWS D1.1/D1.1 M:2010 pg 293

commentary is prepared “to generate better understanding in the application of the code to welding in steel construction.”⁴

When you combine the concentration of questions on the aforementioned Code Applications and the exclusion of most of the Annexes and Commentary, the D1.1 code book shrinks down to a much more manageable size.

⁴ AWS D1.1/D1.1 M:2010 pg 413

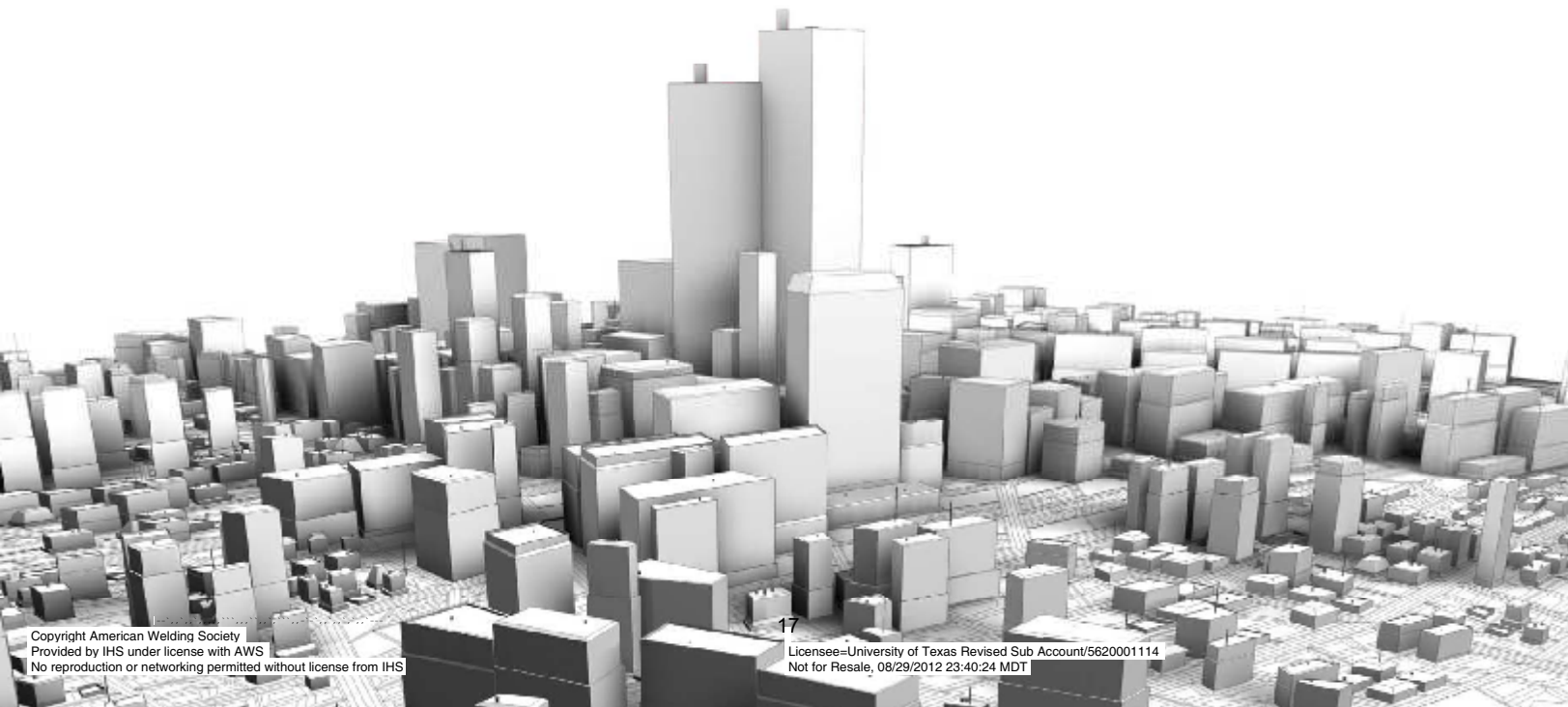
Chapter 3

The Code – An Overview

The History

The Sequence

Review



D1.1 code is the American National Standard for welding statically and dynamically loaded steel structures. However, there are some limitations for the range (broad and narrow) of structures to which it applies. Materials and pressure are the two variables that determine application. The D1.1 code is limited to welded steels structures that utilize:

1. Carbon or low alloy steels
2. Steels that are 1/8 inch or thicker
3. Steels with a specific yield strength of 100 ksi (kilopound per square inch) or less

Outside of these limitations, the code *may* be used. However, this is a determination that has to be made by the Engineer and must include a written stipulation of any changes made to the requirements of the code *within* the contract. The Engineer is also advised to refer to other codes and standards that have bearing over structures that involve materials and pressures outside of the limitations of D1.1.

THE HISTORY

The foreword in D1.1 provides a brief history of the evolution of this document.

The first edition of the *Code for Fusion Welding and Gas Cutting in Building Construction* was published by the American Welding Society in 1928 and called Code I Part A. It was revised and reissued in 1930 and 1937 under the same title. It was revised again in 1941 and given the designation D1.0. D1.0 was revised again in 1946, 1963, 1966, and 1969. The 1963 edition published an amended version in 1965, and the 1966 edition published an amended version in 1967. The code was combined with D2.0, *Specifications for Welding Highway and Railway Bridges*, in 1972, given the designation D1.1, and retitled *AWS Structural Welding Code*. D1.1 was revised again in 1975, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, and 2008. From 1972 to 1988, the D1.1 code covered the welding of both buildings and bridges. In 1988, AWS published its first edition of *AASHTO/AWS D1.5, Bridge Welding Code*; coincident with this, the D1.1 code changed references of buildings and bridges to statically loaded and dynamically loaded structures, respectively, in order to make the document applicable to a broader range of structural applications. This 2010 edition is the 22nd edition of D1.1.

Image 3.1

The D1.1 code is a fluid document that has undergone numerous revisions and updates since first being published in 1928. As welding technologies continue to evolve, so too will the D1.1 code. This constant revision process necessitates a means of tracking changes from one edition of the code to another. For this reason the authors of D1.1:2010 underlined the changes that are implemented in the code from the previous edition. This can range from editorial corrections, to several sub-clauses of new provisions and information that have been added. The following are some examples as to how the authors of the D1.1:2010 have indicated changes.

5.8	Minimum Fillet Weld Sizes	209
5.9	Weld Profiles	210
5.10	Weld Profile Schedules	210
6.1	Visual Inspection Acceptance Criteria	239

Image 3.2 Example of new tables

3.13.1 Joint Dimensions. Dimensions of groove welds specified in 3.13 may vary on design or detail drawings within the limits or tolerances shown in the "As Detailed" column in Figure 3.4. Fit up tolerance of Figure 3.4 may be applied to the dimension shown on the detail drawing.

3.13.2 Backing. Prequalified CJP groove welds made from one side only, except as allowed for tubular structures, shall have steel backing. Other backing, such as listed in 5.10, may be used, if qualified in conformance with Clause 4.

3.13.3 Double-Sided Groove Preparation. J- and U-grooves and the other side of partially welded double-V and double-bevel grooves may be prepared before or after assembly. After backgouging, the other side of partially welded double-V or double-bevel joints

Processes, 3.2.1, 3.2.2, 3.2.3
Profile effects, 2.21.6.7
Profiles, weld, 2.21.6.2, 5.24,
C-2.21.6.2, C-2.21.6.7, Fig. 5.4
Progression of welding, 3.7.1

Image 3.4 Example of new sub clause 3.13.2

Image 3.3 Example of new subclause 3.13.2

THE SEQUENCE

The D1.1 code is laid out in eight (8) clauses that follow a logical sequence relevant to both the engineer and the inspector. When analyzed, the sequence of clauses closely resembles a "construction building sequence," or the sequence of events that constitute the construction a new building. Individuals preparing for the exam are encouraged to use this analogy to familiarize themselves with the general layout of the D1.1 code, as well as to establish a broad understanding of the type of information contained in each clause. The benefit of understanding this information will become obvious while answering practice questions.

Clause 1 – General Requirements

The first clause (pg 1-3) of the code lays out the foundations for interpreting the code. When considering the "construction building sequence" and the fact that the D1.1 code is written as a legal document, one can logically predict that the 1st clause would define the responsibilities of the "major players" (i.e. Contractor, Contractor's inspector, Verification inspector, and Original Equipment Manufacturer) in the construction process. Additionally, the first clause also defines the scope of the code as well as:

- 1.2 Limitations
- 1.4 Responsibilities
- 1.7 Safety Precautions

Clause 2 – Design of Welded Connections

Keeping with the construction analogy, after the major players that are in charge of construction are defined, as well as the scope of the project and code, the actual work has to begin. Before welding together the foundation of the building, those welds must undergo the design process.

Clause 2 includes common requirements in designing weld connections for statically and dynamically loaded structures. Expect to find provisions for weld variables that are required of all welds regardless of the particular circumstances. Some important sections include:

- Part A– Common Requirements for Design of Welded Connections (Nontubular and Tubular members)
 - Sub clauses 2.2-2.4
- Part B – Specific Requirements for Design of Nontubular Connections (Statically or Cyclically Loaded)
 - Sub clauses 2.5-2.12
- Part C – Specific Requirements for Design of Nontubular Connections (Cyclically Loaded)
 - Sub clauses 2.13-2.19
- Part D – Specific Requirements for Design of Tubular Connections (Statically and Cyclically Loaded)
 - Sub clauses 2.20-2.27

Clause 3 – Prequalification of WPSs

The process of designing and testing welds is both costly and time consuming. The D1.1 code offers specific weld combinations that are prequalified and do not require destructive or nondestructive testing to be approved. These combinations include the welding process, base metal, weld metal, gases, etc... Thus clause three (3) offers the construction team a way of economizing the qualification process by having numerous prequalified welds to choose from. Some important sections of Clause 3 include:

- 3.2 Welding Processes
- 3.3 Base Metal/Filler Metal Combinations
- 3.5 Minimum Preheat and Interpass Temperature Requirements
- 3.9 Fillet Weld Requirements
- 3.11 Common Requirements of PJP and CJP Groove Welds
- 3.12 PJP Requirements
- 3.13 CJP Groove Weld Requirements

Clause 4 –Qualification

Even though many of the prequalified welds can be utilized in the design of the new building, some specific weld designs may need to be created and tested by the engineers. Clause 4 specifies the process for the qualification of welds and welding personnel. (An exception is made for those welds that are already prequalified). Clause 4 contains instructions for testing of WPSs as well as performance qualification tests for the welders. Important sections include:

- Part A – General Requirements
 - Sub clauses 4.2-4.3
- Part B – Welding Procedure Specification (for non Prequalified WPSs)
 - Sub clauses 4.4-4.18
- Part C – Performance Qualification
 - Sub clauses 4.19-4.33
- Part D – Requirements for CVN Testing
 - Sub Clauses 4.34-4.39

Clause 5 –Fabrication

After the design process is completed with the development of WPSs and the qualification of the welding personnel, the actual construction may begin. Clause 5 contains provisions that cover the entire fabrication process including: preheating, welding passes, repairs, and weld cleaning. Major sections include:

- 5.3 Welding Consumables and Electrode Requirements
- 5.5 WPS Variables
- 5.6 Preheat and Interpass Temperatures
- 5.10 Backing
- 5.12 Welding Environment
- 5.14 Minimum Fillet Weld Sizes
- 5.18 Tack Welds and Construction Aids
- 5.22 Tolerance of Joint Dimensions
- 5.26 Repairs
- 5.27 Peening
- 5.28 Caulking

Clause 6 – Inspection

Once welds begin to be produced, so too must the inspection process begin. Qualified Welding Inspectors must inspect the work of the welding team, test their quality, and ultimately approve or reject the welds. “Accordingly, clause 6 contains all requirements for the Inspector’s qualifications and responsibilities, acceptance criterion for discontinuities, and procedures for NDT (Non Destructive testing).”¹

- Part A – General Requirements
 - Sub clauses 6.1-6.5
- Part B – Contractor Responsibilities
 - Sub clauses 6.6
- Part C – Acceptance Criteria
 - Sub Clauses 6.7-6.13
- Part D – NDT Procedures
 - Sub clauses 6.14-6.15
- Part E – Radiographic Testing (RT)
 - Sub clauses 6.16-6.19
- Part F – Ultrasonic Testing (UT) of Groove Welds
 - Sub clauses 6.20-6.33
- Part G – Other Examination Methods
 - Sub clauses 6.34-6.37

Clause 7 – Stud Welding

This clause is a departure somewhat from the construction analogy as it contains provisions for stud welding, and can be viewed as a small parenthetical break from the *sequence* in order to stipulate instructions on welding studs. In some ways, this clause is like a miniature “construction sequence” in that it contains provisions for stud welding for all phases: materials, qualification, testing, fabrication, and inspection. Important section includes:

- 7.3 Mechanical Requirements
- 7.4 Workmanship/Fabrication
- 7.8 Fabrication and Verification Inspection Requirements
- 7.9 Manufacturer’s Stud Base Qualification Requirements

¹ D1.1 pg 219

Clause 8 – Strengthening and Repairing Existing Structures

The last step of the construction process is strengthening or repairing all the welds identified by the inspector as not meeting the standards. All modifications must meet design requirements as specified by the Engineer, as well as the specification contained in this clause. Important sections include:

- 8.2 Base Metal
- 8.3 Design for Strengthening and Repair
- 8.4 Fatigue Life Enhancement
- 8.5 Workmanship and Technique
- 8.6 Quality

Review

The construction sequence outlined above is a learning tool meant to facilitate an understanding of the D1.1 structure, but also reflects the real world application of the document. The order of the D1.1 is not accidental; it was designed to be used in the field. Utilizing this sequence to maintain a general understanding of the D1.1 structure and layout will prove invaluable when taking a timed exam. The valuable seconds saved by knowing the information contained in each clause will add up, and eventually culminate in a less stressful testing experience.

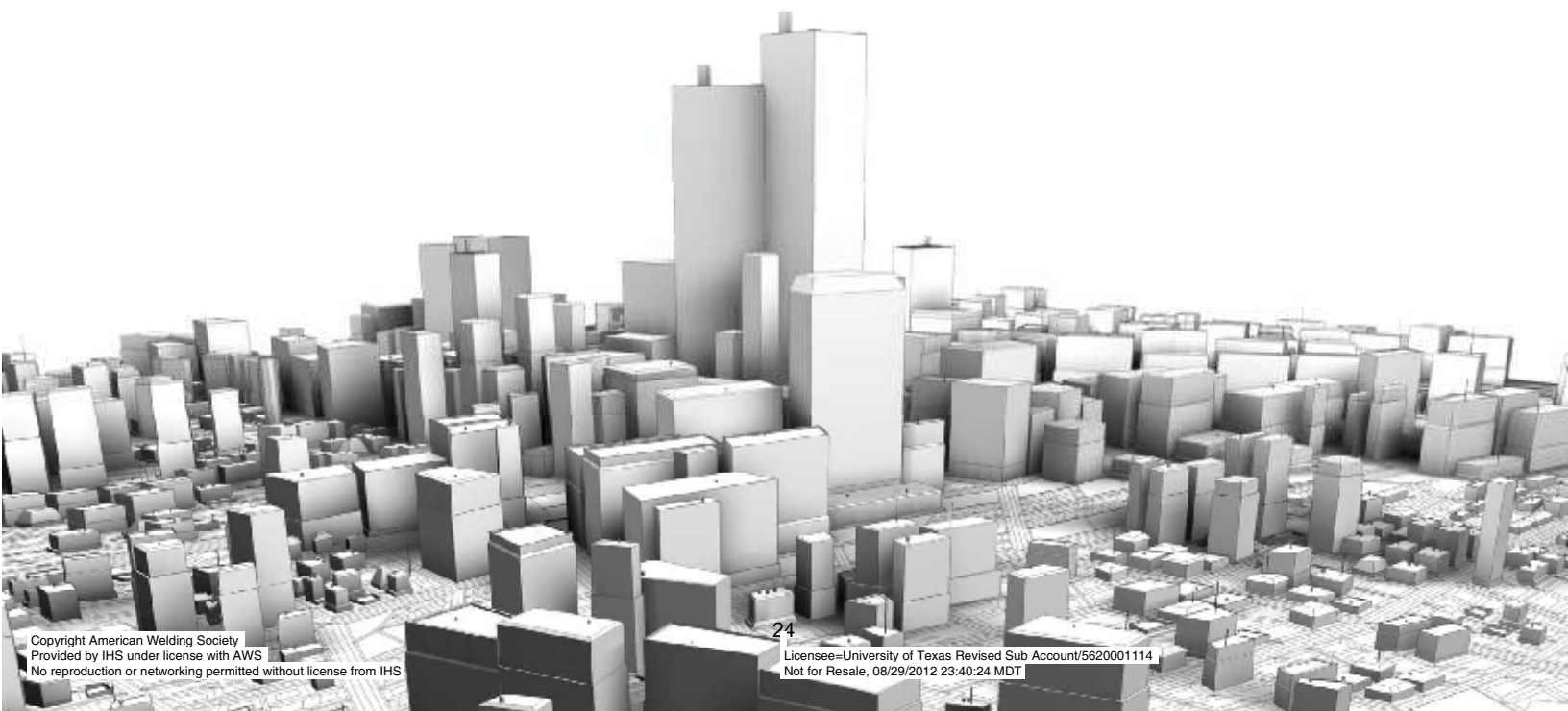
Although a general understanding of the code structure may seem enough to tackle a navigation exam, a familiarity with each clause is paramount to success, because ultimately, test takers will be asked to delve into the code, and locate specific pieces of information. Chapters 4 through 11 will provide a thorough breakdown of each clause, and identify subclauses that are important to the welding inspector.

Chapter 4

Clause 1: General Requirements

Text.....

Subclauses



Clause 1 contains the general requirements for the D1.1 code such as: the scope and limitations for the code, key definitions, and the major responsibility of the key personnel in the fabrication process.

Clause 1 is all but three pages long. However in this small portion of the code, there are several universally important provisions that lay the groundwork for the rest of the standard. The clause is divided into nine subsections, each detailing requirements that apply to the whole of D1.1: Scope, Limitations, Definitions, Responsibilities, Approval, Welding Symbols, Safety Precautions, Standard Units of Measurement, and Reference Documents.

TEXT

Clause 1 runs from page 1 to 3 of the D1.1:2010 and is distributed amongst 9 sub clauses. Clause 1 has no tables and figures making it the second smallest clause in the code, second only to clause 8. This section provides an overview of the general structure of the text in clause 1, as well as reviews of some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents:

1. General Requirements	1
1.1 Scope	1
1.2 Limitations	1
1.3 Definitions	1
1.4 Responsibilities	2
1.5 Approval	2
1.6 Welding Symbols	3
1.7 Safety Precautions	3
1.8 Standard Units of Measurement	3
1.9 Reference Documents	3

Clause 1 is not further subdivided into parts like clauses 2, 4 and 6, nor is it as extensive as clauses 2, 3, 4, 5, or 6. Therefore each of the nine subclauses is treated as their own entity.

In the following section we highlight important information contained in clause 1 accompanied by the sub clauses they fall under.

1.1 Scope

This subclause stipulates that the D1.1 contains requirements for fabricating and erecting welded steel structures. When a contract specifies use of the code, all of its provisions are mandatory, unless the contract documents or the authority having jurisdiction modifies or exempts them. The D1.1 is divided as follows:

- Clause 1 – *General Requirements* – Basic information on the scope and limitations of the code, key definitions, and the major responsibilities of the parties involved in steel fabrication.
- Clause 2 – *Design of Welded Connections* – Requirements for designing welded connections between tubular and/or nontubular product form members.
- Clause 3 – *Prequalification of WPSs* – Requirements for exempting Welding Procedure Specifications (WPSs) from the codes qualification testing requirements.
- Clause 4 – *Qualification* – Requirement for the qualification of welding procedures and the welding personnel necessary to perform work to code requirements.
- Clause 5 – *Fabrication* – Requirements for base metals, welding consumables, welding technique, welded details, material preparation and assembly, workmanship, weld repair, and other requirements for fabrication and erection of welded steel structures.
- Clause 6 – *Inspection* – Criteria for qualification and responsibilities of welding inspectors, acceptance of welds, procedures for visual inspection, RT and UT, and other NDE requirements.
- Clause 7 – *Stud Welding* – Requirements for the welding of studs to structural steel.
- Clause 8 – *Strengthening and Repairing Existing Structures* – Provisions for design and welding to modify or repair existing structures.

1.2 Limitations

AWS D1.1 was specifically developed for welded steel structures that utilize carbon or low-alloy steels that are 1/8 inch [3 mm] or thicker with a minimum specified yield strength of 100 ksi [690 MPa] or less. Although the code may be suitable to govern structural fabrications outside of this scope, the Engineer should evaluate such suitability and modify the contract documents accordingly. When stainless steel is involved, use AWS D1.6, Structural Welding Code—Stainless Steel instead of AWS D1.1.

1.3 Definitions

Defines key words and the major players of the Fabrication process:

- 1.3.1 Engineer: The duly designated individual who acts for, and in behalf of, the Owner on all matters within the scope of the code.
- 1.3.2 Contractor: any company, or individual representing a company, responsible for the fabrication, erection, manufacturing, or welding, in conformance with the provisions of this code.
- 1.3.3 Defines the types of Inspectors:
 - 1.3.3.1 Contractor's inspector: the person who acts on behalf of the contractor for inspection purposes within the contract limits.
 - 1.3.3.2 Verification Inspector: the person who acts on behalf of the Owner or Engineer for inspection purposes within the contract limits.

-
- 1.3.3.3 The unqualified terms 'inspection' or 'inspector' are used, they shall apply equally to fabrication and erection inspections and to verification inspections, within the limits of responsibility defined in 6.1.2.
 - 1.3.4 Owner: the individual or company that exercises legal ownership of the product or structural assembly produced under the code.

1.4 Responsibilities

- 1.4.1 Engineer's Responsibilities
- 1.4.2 Contractor's Responsibilities
- 1.4.3 Inspector's Responsibilities
 - 1.4.3.1 Contractor Inspection
 - 1.4.3.2 Verification Inspection

1.7 Safety Precaution

Refers the reader to ANSI Z49.1, Safety in Welding, Cutting, and Allied Processes, to Annex R of AWS D1.1, and to other pertinent documents. If they are mandatory in the context of the project, they are incorporated by reference into AWS D1.1. The reader must follow all relevant regulatory requirements and ensure the health and safety of your personnel.

1.8 Standard Units of Measure

Notes that AWS D1.1/D1.1M is two codes in one. AWS D1.1 contains values stated in U.S. Customary (inch-pound) units; AWS D1.1M contains values stated in SI (metric) units. The U.S. Customary values appear first, followed by the SI units in brackets, but the SI units are an approximation of the corresponding U.S. Customary units. The reader must use one system or the other, and not combine or comeingle them in a project.

Chapter 5

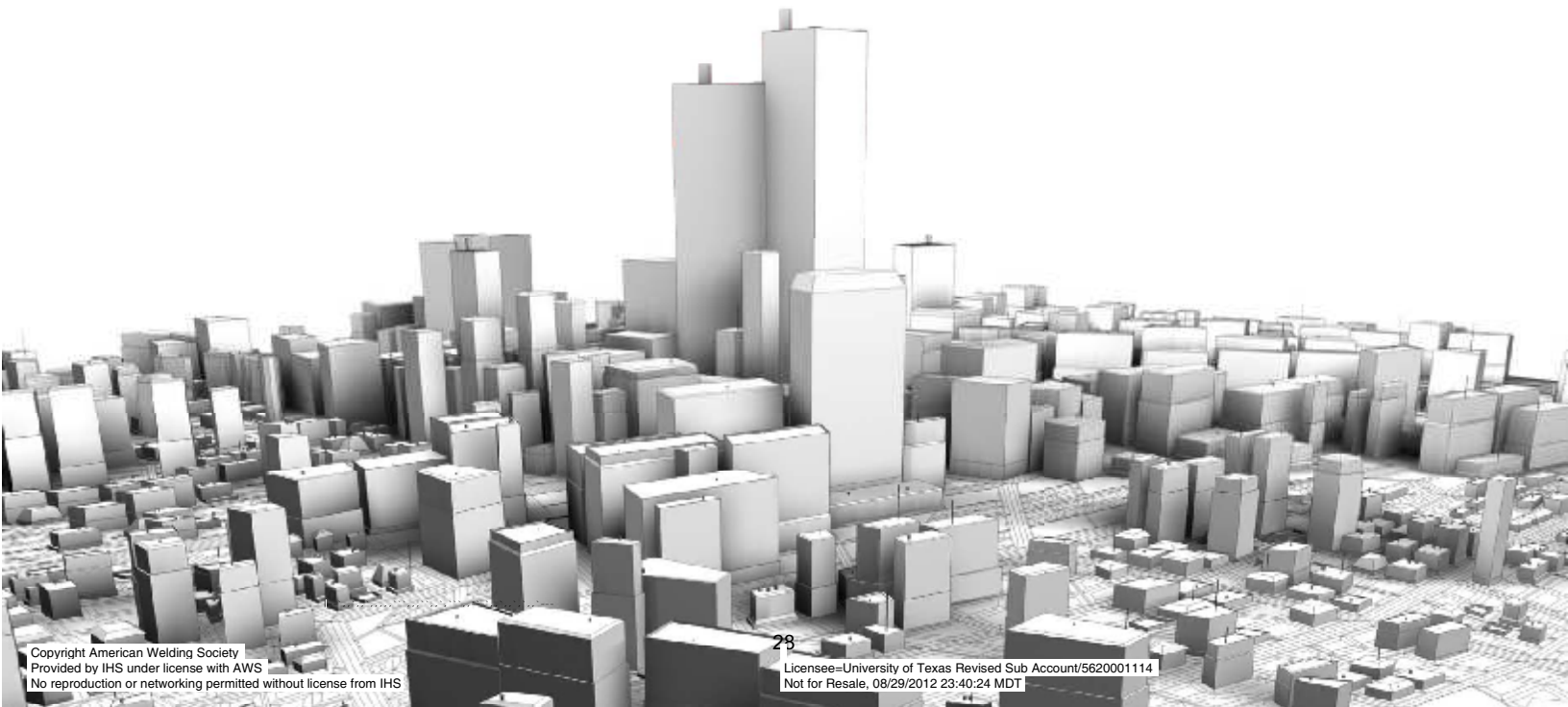
Clause 2: Design of Welded Connections

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

According to D1.1, clause 2 “contains the requirements for design of welded connections.”¹ This clause is a compilation of requirements that are necessary for all welded connections regardless of application, materials, or process. The clause includes requirements for tubular and nontubular connections that are either statically or cyclically loaded.

Clause 2 is the first step in the construction process. It lays out all the “rules of the game” for erecting welded structures (that fall within the scope of the code). Regardless of the variety of metals, the architecture of the structure or even the type of welding process that the construction team will use, clause 2 is the framework for all welding done according to D1.1.

TEXT

The text portion of Clause 2 is the biggest section of the clause, running from page 5 to 23, and is distributed amongst twenty-seven sub clauses. This section reviews the general structure of the text in clause 2 as well as some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents:

2. Design of Welded Connections	5
2.1 Scope	5
Part A—Common Requirements for Design of Welded Connections (Nontubular and Tubular Members)	5
2.2 General	5
2.3 Contract Plans and Specifications	5
2.4 Effective Areas	6
Part B—Specific Requirements for Design of Nontubular Connections (Statically or Cyclically Loaded)	8
2.5 General	8
2.6 Stresses	8
2.7 Joint Configuration and Details	9
2.8 Joint Configuration and Details—Groove Welds	10
2.9 Joint Configuration and Details—Fillet Welded Joints	10
2.10 Joint Configuration and Details—Plug and Slot Welds	11
2.11 Filler Plates	11
2.12 Built-Up Members	12
Part C—Specific Requirements for Design of Nontubular Connections (Cyclically Loaded)	12
2.13 General	12
2.14 Limitations	12
2.15 Calculation of Stresses	13
2.16 Allowable Stresses and Stress Ranges	13
2.17 Detailing, Fabrication, and Erection	14
2.18 Prohibited Joints and Welds	15
2.19 Inspection	15

¹ D1.1 pg 5

Part D—Specific Requirements for Design of Tubular Connections (Statically or Cyclically Loaded).....	15
2.20 General.....	15
2.21 Allowable Stresses	15
2.22 Identification	17
2.23 Symbols.....	17
2.24 Weld Design.....	17
2.25 Limitations of the Strength of Welded Connections	18
2.26 Thickness Transition	22
2.27 Material Limitations.....	22

As indicated above, clause 2 is divided into 4 main parts, A, B, C, and D, which contain all of the subclauses with the exception of subclause 2.1, which details the scope for clause 2. The scope introduces the general structure of the clause which is as follows:

Part A – Common Requirements for Design of Welded Connections (Nontubular and Tubular Members)

Part B – Specific Requirements for Design of Nontubular Connections (Statically or Cyclically Loaded)

Part C – Specific Requirements for Design of Nontubular Connections (Cyclically Loaded)

Part D – Specific Requirements for Design of Tubular Structures (Statically and Cyclically Loaded)

Part A – Common Requirements for Design of Welded Connections (Nontubular and Tubular Members)
--

2.3 Contract Plans and Specifications

Requires that contract plans and specifications specify the base metal designation, and the location, type, size and extent of all welds.

- 2.3.1 Defines design drawings as contract documents. The Engineer is required to specify field welds. Additionally this subclause requires that contract plans and specifications specify the base metal specification designation, and the location, type, size and extent of all welds.
- 2.3.2 Specifies Notch Toughness requirements. It is the Engineer's responsibility to specify the minimum absorbed energy requirements, the test temperature, and the requirements for weld and heat-affected zone (HAZ) tests.
- 2.3.3 Requires both the Engineer and the Contractor to specify assembly order, welding sequence, welding technique, or other special precautions, if necessary.
- 2.3.5 Covers drawing requirements, PJP Groove welds, fillet welds and welds in skewed T-joints, symbols, and prequalified detail dimensions.

2.4 Effective Areas – Groove and Fillet Welds

- 2.4.1.2 Effective size of CJP Groove welds.
- 2.4.1.3 Minimum Size of PJP Groove welds.
- 2.4.2.6 Covers the calculation for Effective Throat.
- 2.4.2.9 Sets the formula for maximum weld size in lap joints. Refer to Figure 2.1 detail A and B.
- 2.4.3 Skewed T-Joints
 - 2.4.3.1 Defines skewed T-joints as those T-joints in which the angle between the joined parts is greater than 100 degrees or less than 80 degrees.

-
- | | |
|---------|---|
| 2.4.3.5 | States that the effective length of a skewed T-joint shall be the overall length of the full size weld. |
| 2.4.3.6 | States that the minimum weld size for skewed T-joints will be the same as that of the requirements for all fillet welds in 2.4.2.8. |
| 2.4.3.8 | Defines the effective area of skewed T-Joints as the effective throat multiplied by the effective length. |
-

Part B – Specific Requirements for Design of Nontubular Connections (Statically or Cyclically Loaded)

Part B's requirements for statically loaded nontubular connections apply in conjunction with the requirements of Part A. However, for cyclically loaded nontubular connections, the requirements for Part A and B apply *except* as modified by Part C. Part B starts on sub clause 2.5 and ends on 2.12.

2.6 Stresses

- 2.6.1. Covers Calculated Stresses.
- 2.6.2. Calculated Stresses Due to Eccentricity.
- 2.6.3. Allowable Base Metal Stresses.
- 2.6.4. Allowable Weld Metal Stresses.
- 2.6.4.1. Stress in Fillet Welds.
- 2.6.4.2. Alternative Allowable Fillet Weld Stresses.

2.7 Joint Configuration and Details

- 2.7.3. Cautions the designer to provide joints that minimize the stress intensity in the through thickness direction. The designer is also advised that specifying weld sizes larger than necessary to transmit calculated stresses shall be avoided.

2.8 Joint Configuration and Details- Groove Welds

- 2.8.1. Covers Transitions in Thickness and Widths. Refers to Figure 2.3 for transition requirements.

2.9 Joint Configuration and Details- Fillet Welded Joints

- 2.9.1.2. Covers Minimum Overlap. Refers to Figure 2.4.
- 2.9.3.5. Requires fillet welds on the Opposite Sides of a Common Plane to be interrupted at the corner common to both welds. Refers to Figure 2.8.

2.10 Joint Configuration and Details- Plug and Slot Welds

- 2.10.1. Defines the minimum center-to-center spacing of plug welds.
- 2.10.2. Defines the minimum center-to-center spacing of slot welds.
- 2.10.4. Prohibits plug and slot welds in quenched and tempered steels.

2.11 Filler Plates

Covers the use of filler plates used to transfer applied force.

2.12 Built-Up Members

Covers using two or more plates or rolled shapes to build up a member.

Part C – Specific Requirements for Design of Nontubular Connections (Cyclically Loaded)

Part C applies only to nontubular members and connections subject to cyclical load when the effects of repeated stress cause cracking or fatigue.

2.14 Limitations

Provides that fatigue resistance evaluation is not necessary if the load stress range is less than the threshold stress range.

2.15 Calculations of Stresses

2.16 Allowable Stresses and Stress Ranges

2.19 Inspection

Requires that CJP welds that are subject to cyclic transverse applied stress into the tensile range to be inspected using RT or UT.

Part D – Specific Requirements for Design of Tubular Connections (Statically or Cyclically Loaded)

Part D's requirements apply only to tubular connections and is meant to be used in addition to the requirements in Part A.

2.21 Allowable Stresses

Defines allowable stresses and fatigue.

2.24 Weld Design

Covers the design of welds. The sub clauses under 2.24 reference tables and figures frequently in order to layout the key provisions.

2.24.3. Contains the formulas for calculating the stresses in the welds.

2.24.5. Covers box connection lengths, including T-, Y-, and K-connections.

2.27 Material Limitations

Covers limitations on materials due to the possibility of local yielding and plastic strains at the design load of tubular connections due to stress concentrations.

2.27.1.1. Provides that tubular connections are not intended for circular tubes having a minimum specified yield strength over 60 ksi [415 MPa], or for box sections over 52 ksi [360 MPa].

TABLES

The 10 tables in clause 2 are found in pages 24-42 and are listed in the List of Tables by their respective titles and page numbers. Additionally a brief review of some important tables and their respective references within the text in clause 2 are discussed. Below is the list of tables for clause 2

2.1	Effective Size of Flare-Groove Welds Filled Flush.....	24
2.2	Z Loss Dimension (Nontubular)	24
2.3	Allowable Stresses	25
2.4	Equivalent Strength Coefficients for Obliquely Loaded Fillet Welds.....	26
2.5	Fatigue Stress Design Parameters	27
2.6	Allowable Stresses in Tubular Connection Welds	37
2.7	Stress Categories for Type and Location of Material for Circular Sections	39
2.8	Fatigue Category Limitations on Weld Size or Thickness and Weld Profile (Tubular Connections).....	41
2.9	Z Loss Dimensions for Calculating Prequalified PJP T-, Y-, and K-Tubular Connection Minimum Weld Sizes.....	41
2.10	Terms for Strength of Connections (Circular Sections).....	42

Table 2.3 – Allowable Stresses. This table provides the variances for allowable stresses as they differ for CJP and PJP groove Welds, Fillet, Plug, and Slot welds. Below is a preview of table 2.3.

Table 2.3 Allowable Stresses (see 2.6.4 and 2.16.1)		
Type of Applied Stress	Allowable Stress	Required Filler Metal Strength Level
CJP Groove Welds		
Tension normal to the effective area ^a	Same as base metal	Matching filler metal shall be used ^b
Compression normal to effective area	Same as base metal	Filler metal with a strength level equal to or one classification (10 ksi [70 MPa]) less than matching filler metal may be used.
Tension or compression parallel to axis of the weld ^c	Not a welded joint design consideration	Filler metal with a strength level equal to or less than matching filler metal may be used
Shear on effective area	0.30 × classification tensile strength of filler metal except shear on the base metal shall not exceed 0.40 × yield strength of the base metal	
PJP Groove Welds		
Tension normal to the effective area	0.30 × classification tensile strength of filler metal	Filler metal with a strength level equal to or less than matching filler metal may be used
Compression normal to effective area of weld in joints designed to bear	0.90 × classification tensile strength of filler metal, but not more than 0.90 × yield strength of the connected base metal	
Compression normal to effective area of weld in joints not designed to bear	0.75 × classification tensile strength of filler metal	
Tension or compression parallel to axis of the weld ^c	Not a welded joint design consideration	
Shear parallel to axis of effective area	0.30 × classification tensile strength of filler metal except shear on the base metal shall not exceed 0.40 × yield strength of the base metal	

Table 2.5- Fatigue Stress Design Parameters. This table is referenced by sub clause 2.14 as the threshold for determining whether or not an evaluation of fatigue resistance is necessary for a cyclically loaded nontubular connection. Table 2.5 spans 10 pages from page 27 to 36. Below is a preview of page 27.

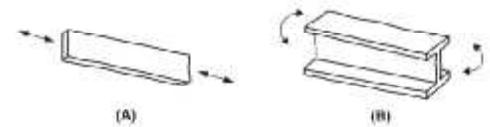
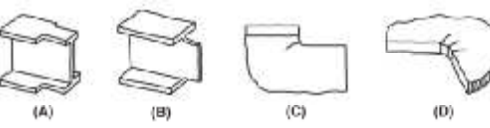
Table 2.5 Fatigue Stress Design Parameters (see 2.14.1)					
Description	Stress Category	Constant C_1	Threshold F_{TH} ksi [MPa]	Potential Crack Initiation Point	Illustrative Examples
Section I—Plain Material Away from Any Welding					
1.1 Base metal, except non-coated weathering steel, with rolled or cleaned surface and rolled or flame-cut edges with ANSI smoothness of 1000 or less, but without reentrant corners.	A	250×10^3	74 [166]	Away from all welds or structural connections	1.1/1.2 
1.2 Non-coated weathering steel base metal with rolled or cleaned surface and with rolled or flame-cut edges with ANSI smoothness of 1000 or less.	B	120×10^3	16 [110]	Away from all welds or structural connections	
1.3 Flame-cut reentrant corners, except weld access holes, meeting the requirements of 2.17.5 with ANSI smoothness of 1000 or less.	B	120×10^3	16 [110]	From irregularities in surface of reentrant corner	1.3 
1.4 Weld access holes made to the requirements of 2.17.5 and 5.17.1.	C	44×10^3	10 [69]	From irregularities in surface of reentrant corner of weld access hole	1.4 

Table 2.7- Stress Categories for Type and Location of Material for Circular Sections - and Table 2.8 – Fatigue Category Limitations on Weld Size Thickness and Weld Profile (Tubular Connections) – are important tables. Table 2.7 defines stress categories and table 2.8 lists fatigue category limitations on weld size or thickness and weld profile. Below is a preview of table 2.8.

Table 2.8 Fatigue Category Limitations on Weld Size or Thickness and Weld Profile (Tubular Connections) (see 2.21.6.7)		
Weld Profile	Level I	Level II
	Limiting Branch Member Thickness for Categories X_1 , K_1 , DT in [mm]	Limiting Branch Member Thickness for Categories X_2 , K_2 in [mm]
Standard flat weld profile Figure 3.8	0.375 [10]	0.625 [16]
Profile with toe fillet Figure 3.9	0.625 [16]	1.50 [38] qualified for unlimited thickness for static compression loading
Concave profile, as welded, Figure 3.10 with disk test per 2.21.6.6(1)	1.00 [25]	unlimited
Concave smooth profile Figure 3.10 fully ground per 2.21.6.6(2)	unlimited	—

FIGURES

The 21 figures in clause 2 are found in pages 43-57 and are listed in the List of Figures by their respective titles and page numbers. Additionally we will briefly take a look at some important figures and their respective references within the text in clause 2. Below is the list of figures for clause 2.

2.1	Maximum Fillet Weld Size Along Edges in Lap Joints	43
2.2	Transition of Butt Joints in Parts of Unequal Thickness (Cyclically Loaded Nontubular)	44
2.3	Transition of Thicknesses (Statically Loaded Nontubular).....	45
2.4	Transversely Loaded Fillet Welds.....	45
2.5	Minimum Length of Longitudinal Fillet Welds at End of Plate or Flat Bar Members.....	46
2.6	Termination of Welds Near Edges Subject to Tension.....	46
2.7	End Return at Flexible Connections	47
2.8	Fillet Welds on Opposite Sides of a Common Plane	47
2.9	Thin Filler Plates in Splice Joint	48
2.10	Thick Filler Plates in Splice Joint	48
2.11	Allowable Stress Range for Cyclically Applied Load (Fatigue) in Nontubular Connections (Graphical Plot of Table 2.5).....	49
2.12	Transition of Width (Cyclically Loaded Nontubular).....	50
2.13	Allowable Fatigue Stress and Strain Ranges for Stress Categories (see Table 2.7), Redundant Tubular Structures for Atmospheric Service.....	50
2.14	Parts of a Tubular Connection.....	51
2.15	Fillet Welded Lap Joint (Tubular).....	54
2.16	Tubular T-, Y-, and K-Connection Fillet Weld Footprint Radius	54
2.17	Punching Shear Stress.....	55
2.18	Detail of Overlapping Joint.....	55
2.19	Limitations for Box T-, Y-, and K-Connections.....	56
2.20	Overlapping K-Connections.....	56
2.21	Transition of Thickness of Butt Joints in Parts of Unequal Thickness (Tubular)	57

Figure 2.1- Maximum Fillet Weld Size Along Edges in Lap Joints. This table is referred to in sub clause 2.4.2.9 to be used in conjunction with the requirements for maximum size of fillet welds in lap joints.

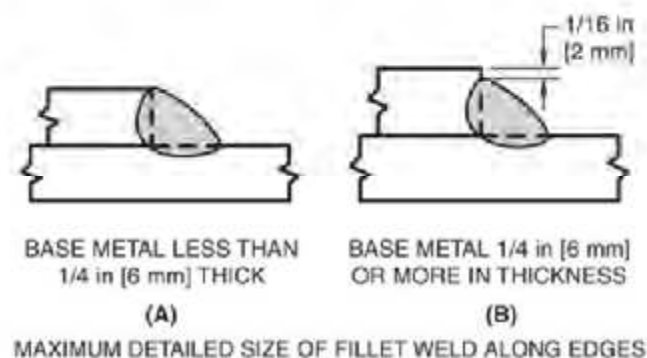
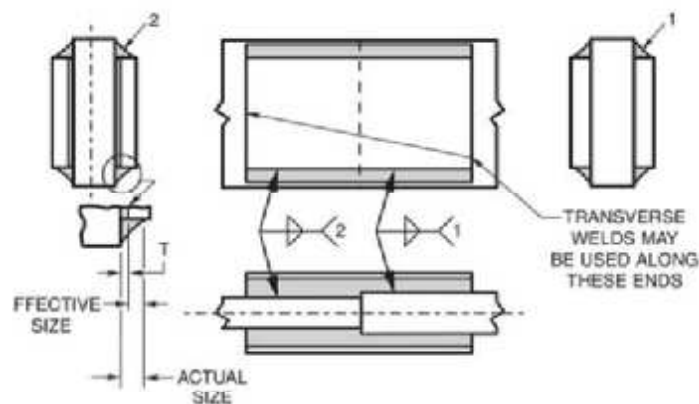


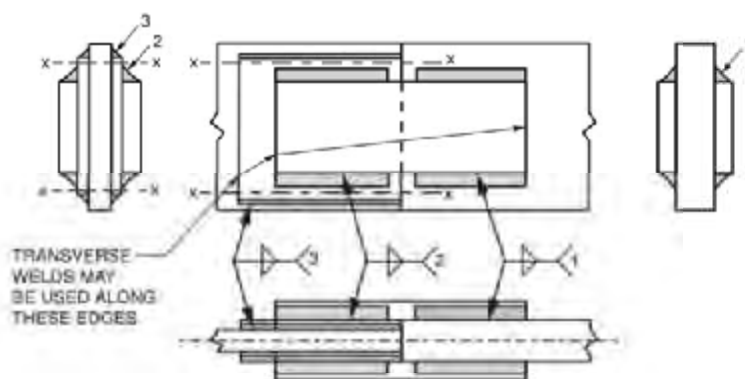
Figure 2.1—Maximum Fillet Weld Size Along Edges in Lap Joints (see 2.4.2.9)

Figure 2.9 – Thin Filler Plates – and **Figure 2.10 – Thick Filler Plates in Splice Joint** – are important figures. Filler plates are used to transfers applied force. These two figures show the use of thin and thick plates in splice joints.



Note: The effective area of weld 2 shall equal that of weld 1, but its size shall be its effective size plus the thickness of the filler plate T .

Figure 2.9—Thin Filler Plates in Splice Joint (see 2.11.1)



Note: The effective areas of welds 1, 2, and 3 shall be adequate to transmit the design force, and the length of welds 1 and 2 shall be adequate to avoid overstress of filler plate in shear along planes $x-x$.

Figure 2.10—Thick Filler Plates in Splice Joint (see 2.11.2)

Chapter 6

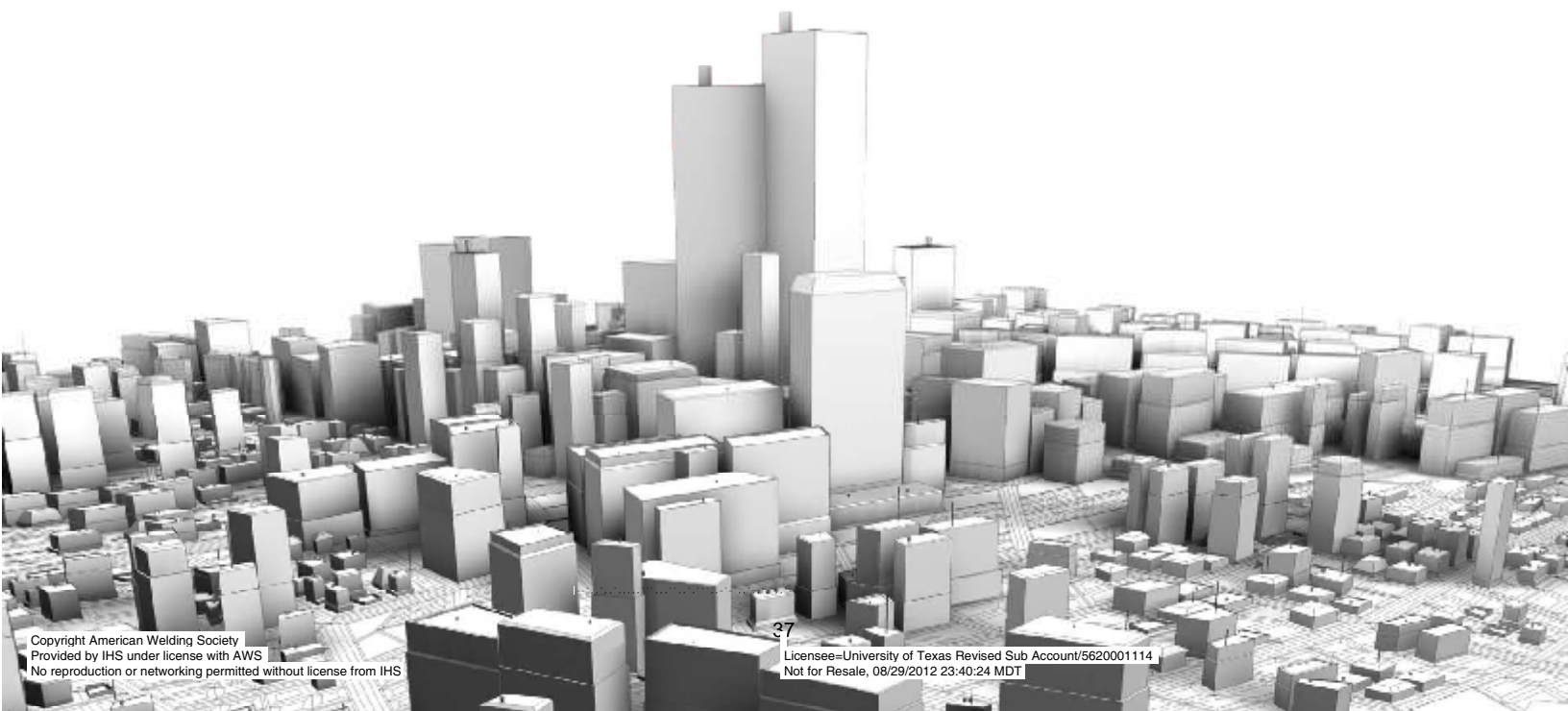
Clause 3: Prequalification of WPSs

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

According to D1.1, clause 3 provides the requirements for prequalified WPSs which is defined by the code as those WPSs that “are exempt from the WPS qualification testing required in clause 4.” Essentially the writer’s of the code have provided several preapproved welds by specifying combinations of the major welding variables (base metal, filler metal, welding process, etc...). These are not required to undergo the rigor of laboratory experimentation and destructive testing that is detailed in clause 4 in order to be D1.1 compliant. Therefore these WPSs are considered *prequalified* by D1.1.

Clause 3 is the second step in the construction process. The previous clause lays the ground rules for all welding done according to the code. This clause provides prequalified WPSs that allow the major players to get a ‘jump start’ in construction. By providing preapproved welds, they can skip the laboratory testing phase, and begin to create the welds to erect the structure. Unless the structure requires innovative or different WPSs than those that are provided in this clause, which would require qualification, clause 3 can provide the welds needed for construction.

TEXT

The text portion of Clause 3 is the smallest section of the clause. It runs from page 59 to 63 and is distributed amongst 14 sub clauses. This section goes over the general structure of the text in clause 3 and reviews some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents.

3. Prequalification of WPSs.....	59
3.1 Scope.....	59
3.2 Welding Processes.....	59
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As indicated above, the clause has no major sub divisions like clauses 2, 4, and 6. However, because of the relative small size of the text (4 pages), the 14 sub clauses are adequate to discuss the information contained therein. The following section is a review of the important provisions contained in clause 3 accompanied by the subclauses they fall under.

3.2 **Welding Processes**

- 3.2.1. Limits the welding processes for prequalified WPSs to SMAW, SAW, GMAW (except GMAW-S), and FCAW.
- 3.2.2. The ESW, EGW, GMAW-S, and GTAW processes are approved for use if qualified as in Clause 4.
- 3.2.3. Other welding processes may be used with the Engineer's approval and qualification according to Clause 4 requirements.

3.5 **Minimum Preheat and Interpass Temperature Requirements**

Details Minimum Preheat and Interpass Temperature Requirements which specifies that the preheat and interpass temperature shall be sufficient to prevent cracking. It then specifies that Table 3.2 shall be used to determine the minimum preheat and interpass temperatures for steels listed in the code.

- 3.5.2. Provides that as an option, the method set out in 3.5.2 may be adopted to determine the required preheat and interpass temperature for welds made with the SAW process. The use of this option could also establish that for base metals having a minimum specified tensile strength not exceeding 70 ksi [485 MPa], a lower preheat and interpass temperature may be used. In this case, approval of the Engineer is required and the Vickers hardness of the heat-affected zone must be kept below specified.

3.6. **Limitations of WPS Variables**

Requires that all prequalified WPSs are prepared as written documents by the manufacturer, fabricator, or contractor. The suggested form is shown as Form N-1 in Annex N.

3.7 **General WPS Requirements**

- 3.7.1. Requires that vertical up welding is the normal progression, with vertical down limited to a few specific cases.
- 3.7.2. A significant provision is that neither the depth nor the maximum width of weld metal deposited in each pass shall exceed the width of the surface of the weld pass.

3.8 **Common Requirements for Parallel Electrode and Multiple Electrode SAW**

- 3.8.1. Provides that welds may also be made in the root of groove or fillet welds using GMAW, followed by parallel or multiple electrodes submerged arcs, provided that the GMAW conforms to the requirements of this section, and providing the spacing between the GMAW arc and the following SAW arc does not exceed 15 in.

3.9 **Fillet Weld Requirements**

- 3.9.3. Requires skewed to be in conformance with Figure 3.11.

3.10 **Plug and Slot Weld Requirements**

Limits welding processes to SMAW, FCAW, and GMAW (except GMAW-S).

3.11 **Common Requirements of PJP and CJP Groove Welds**

- 3.11.1. Allows the use of SMAW groove preparations for prequalified GMAW and FCAW.
 - 3.11.2. Corner joints may be made by preparing either or both joint members provided adequate edge distance is maintained to support the welding operation without
-

	excessive melting.
3.11.3.	Provides that for automatic or machine welding using SAW, GMAW or FCAW, the maximum root opening variation, as fit-up, shall not exceed 1/8 inch.
3.12	PJP Requirements
3.12.1.	Provides that a PJP groove is defined as a groove joint welded from one side without steel backing or welded from both sides without back gouging.
3.12.4.	PJP Groove Welds considered prequalified must abide by the following provisions:
3.12.4(1)	PJP tubular groove welds other than T-, Y-, and K-connections are considered prequalified if all the joint dimensions of Figure 3.3 are satisfied.
3.12.4(2)	PJP, T-, Y-, and K-connections, welded with SMAW, GMAW, or FCAW are also considered prequalified when joint dimensions are within the limits shown in Figure 3.5.
3.13	CJP Groove Weld Requirements
3.13.3.	U-grooves and J-grooves and the other side of partially welded double V-grooves and double bevel grooves may be prepared before or after assembly.
3.14	Post Weld Heat treatment
	Provides that Post Weld Heat Treatment (PWHT) shall be prequalified, provided that it is approved by the Engineer, and it adheres to the rules specified in 3.14.

TABLES

The 8 tables in clause 3 are found in pages 64-75 and are listed in the List of Tables by their respective titles and page numbers. Additionally a brief review of some important tables and their respective references within the text in clause 3 are discussed. Below is the list of tables for clause 3.

3.1	Prequalified Base Metal—Filler Metal Combinations for Matching Strength	64
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3.3	Filler Metal Requirements for Exposed Bare Applications of Weathering Steels.....	71
3.4	Minimum Prequalified PJP Weld Size (E).....	71
3.5	Joint Detail Applications for Prequalified CJP T-, Y-, and K-Tubular Connections.....	71
3.6	Prequalified Joint Dimensions and Groove Angles for CJP Groove Welds in Tubular T-, Y, and K-Connections Made by SMAW, GMAW-S, and FCAW	72
3.7	Prequalified WPS Requirements.....	73
3.8	Prequalified WPS Variables	74

Table 3.1 – Prequalified Base Metal–Filler Metal Combinations for Matching Strength. This table provides the different filler metals that can be used with the listed base metals. The table runs from page 64 to 67. Essentially to identify a combination an item on the left hand column (base metal) has to be matched with the appropriate item on the right (filler metal). For example ASTM A 53 steel grade B using SAW process can be welded using a A5.17 electrode of the F6XX-EXXX series. Below is a preview of Table 3.1.

Table 3.1 Prequalified Base Metal—Filler Metal Combinations for Matching Strength (see 3.3)											
Group	Steel Specification Requirements					Filler Metal Requirements					
	Steel Specification	Minimum Yield Point/Strength		Tensile Range		Process	AWS Electrode Specification	Electrode Classification			
		ksi	MPa	ksi	MPa						
I	ASTM A 36	(≤ 3/4 in [20 mm])	36	250	58–80	400–550	SMAW	A5.1	E60XX, E70XX		
	ASTM A 53	Grade B	35	240	60 min.	415 min.					
	ASTM A 106	Grade B	35	240	60 min.	415 min.					
	ASTM A 131	Grades A, B, CS, D, DS, E	34	235	58–75	400–520	SAW	A5.5 ^a	E70XX-X		
	ASTM A 139	Grade B	35	240	60 min.	415 min.					
	ASTM A 381	Grade Y35	35	240	60 min.	415 min.					
	ASTM A 500	Grade A	33	230	45 min.	310 min.					
		Grade B	42	290	58 min.	410 min.					
		Grade C	46	315	62 min.	425 min.					
	ASTM A 501		36	250	58 min.	400 min.	A5.23 ^a	F7XX-EXXX-XX, F7XX-ECXXX-XX			
	ASTM A 516	Grade 55	30	205	55–75	380–515					
		Grade 60	32	220	60–80	415–550	GMAW	A5.18	ER70S-X, E70C-XC, E70C-XM (Electrodes with the GS suffix shall be excluded)		
	ASTM A 521	Grade I	35	240	60–85	415–585					
		Grade II	30	205	55–80	380–550					
	ASTM A 573	Grade 65	35	240	65–77	450–530	A5.28 ^a	ER70S-XXX, E70C-XXX			
		Grade 58	32	220	58–71	400–490					
	ASTM A 709	Grade 36 (≤ 3/4 in [20 mm])	36	250	58–80	400–550	FCAW	A5.30	E7XT-X, E7XT-XC, E7XT-XM (Electrodes with the -2C, -2M, -3, -10, -13, -14, and -GS suffix shall be excluded and electrodes with the -11 suffix shall be excluded for thicknesses greater than 1/2 in [12 mm])		
	ASTM A 1008 SS	Grade 30	30	205	45 min.	310 min.					
		Grade 33 Type 1	33	230	48 min.	330 min.					
		Grade 40 Type 1	40	275	52 min.	360 min.					
	ASTM A 1011 SS	Grade 30	30	205	49 min.	340 min.					
		Grade 33	33	230	52 min.	360 min.					
		Grade 36 Type 1	36	250	53 min.	365 min.					
		Grade 40	40	275	55 min.	380 min.					
		Grade 45	45	310	60 min.	410 min.					
	API 5L	Grade B	35	240	60	414				A5.29 ^a	E6XTX-X, E6XTX-XC, E6XTX-XM, E7XTX-X, E7XTX-XC, E7XTX-XM
		Grade X42	42	290	60	414					
	ABS	Grades A, B, D, CS, DS	34	235	58–75	400–520					
		Grade E ^b	36	250	58–75	400–520					

Table 3.2 – Prequalified Minimum Preheat and Interpass Temperature. This table matches four important variables (from left to right): base metal, welding process, thickness, and minimum preheat and interpass temperature. For example if a ASTM A 36 steel that is 1/4 in. thick is being welded with SMAW using a low hydrogen electrode, then the minimum preheat and interpass temperature is 32 degree Fahrenheit or 0 degrees Celsius. Below is a preview of table 3.2.

C a t e g o r y	Steel Specification		Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature	
				in	mm	°F	°C
A	ASTM A 36	Grade B	SMAW with other than low- hydrogen electrodes.	1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
	ASTM A 53	Grade B					
	ASTM A 106	Grade B					
	ASTM A 131	Grades A, B, CS, D, DS, E		Over 3/4 thru 1-1/2 incl.	Over 20 thru 38 incl.	150	65
	ASTM A 139	Grade B					
	ASTM A 381	Grade Y35					
	ASTM A 500	Grade A		Over 1-1/2 thru 2-1/2 incl.	Over 38 thru 65 incl.	225	110
		Grade B					
		Grade C					
	ASTM A 501			Over 2-1/2	Over 65	300	150
	ASTM A 516						
	ASTM A 524	Grades I & II					
	ASTM A 573	Grade 65					
	ASTM A 709	Grade 36					
	ASTM A 1008 SS	Grade 30					
B		Grade 33 Type 1	SMAW with low- hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
		Grade 40 Type 1					
	ASTM A 1011 SS	Grade 30					
		Grade 33		Over 3/4 thru 1-1/2 incl.	Over 20 thru 38 incl.	50	10
		Grade 36 Type 1					
		Grade 40					
		Grade 45		Over 1-1/2 thru 2-1/2 incl.	Over 38 thru 65 incl.	150	65
		Grade 50					
		Grade 55					
	API 5L	Grade B		Over 2-1/2	Over 65	225	110
		Grade X42					
	ABS	Grades A, B, D, CS, DS					
		Grade E					
	ASTM A 36	Grade B		1/8 to 3/4 incl.	3 to 20 incl.	32 ^a	0 ^a
	ASTM A 53	Grade B					
	ASTM A 106	Grade B					
	ASTM A 131	Grades A, B, CS, D, DS, E	SMAW with low- hydrogen electrodes, SAW, GMAW, FCAW	Over 3/4 thru 1-1/2 incl.	Over 20 thru 38 incl.	50	10
		AH 32 & 36					
		DH 32 & 36					
		EH 32 & 36		Over 1-1/2 thru 2-1/2 incl.	Over 38 thru 65 incl.	150	65
	ASTM A 139	Grade B					
	ASTM A 381	Grade Y35					
	ASTM A 441			Over 2-1/2	Over 65	225	110
	ASTM A 500	Grade A					
		Grade B					
		Grade C					
	ASTM A 501						
	ASTM A 516	Grades 55 & 60 65 & 70					
	ASTM A 524	Grades I & II					
	ASTM A 529	Grades 50 & 55					
	ASTM A 537	Classes 1 & 2					
	ASTM A 572	Grades 42, 50, 55					

(Continued)

Table 3.7 – Prequalified WPS Requirements. This table gives ranges for specific variables that must be met when prequalified welding procedures are employed (maximum electrode diameter, maximum current, maximum root pass thickness, maximum fill pass thickness, maximum single pass fillet weld size, and maximum). Below is a preview of table 3.7.

Variable	Position	Weld Type	SMAW	SAW ²			GMAW/ FCAW ³
				Single	Parallel	Multiple	
Maximum Electrode Diameter	Flat	Fillet ⁴	3/16 in [8.0 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove ⁵	1/4 in [6.4 mm]				
		Root pass	3/16 in [4.8 mm]				
	Horizontal	Fillet	1/4 in [6.4 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove	3/16 in [4.8 mm]				
	Vertical	All	3/16 in [4.8 mm] ⁶				3/32 in [2.4 mm]
Overhead	All	3/16 in [4.8 mm] ⁶	5/64 in [2.0 mm]				
Maximum Current	All	Fillet	Within the range of recommended operation by the filler metal manufacturer	1000A	1200A	Unlimited	Within the range of recommended operation by the filler metal manufacturer
	All	Groove weld root pass with opening		800A	700A		
		Groove weld root pass without opening			900A		
		Groove weld fill passes			1200A		
		Groove weld cap pass		Unlimited			
Maximum Root Pass Thickness ⁴	Flat	All	3/8 in [10 mm]	Unlimited			3/8 in [10 mm]
	Horizontal		5/16 in [8 mm]				5/16 in [8 mm]
	Vertical		1/2 in [12 mm]				1/2 in [12 mm]
	Overhead		5/16 in [8 mm]				5/16 in [8 mm]
Maximum Fill Pass Thickness	All	All	3/16 in [5 mm]	1/4 in [6 mm]	Unlimited		1/4 in [6 mm]
Maximum Single Pass Fillet Weld Size ⁶	Flat	Fillet	3/8 in [10 mm]	Unlimited			1/2 in [12 mm]
	Horizontal		5/16 in [8 mm]	5/16 in [8 mm]	5/16 in [8 mm]	1/2 in [12 mm]	3/8 in [10 mm]
	Vertical		1/2 in [12 mm]				1/2 in [12 mm]
	Overhead		5/16 in [8 mm]				5/16 in [8 mm]
Maximum Single Pass Layer Width	All (for GMAW/ FCAW) F & H (for SAW)	Root opening > 1/2 in [12 mm], or		Split layers	Laterally displaced electrodes or split layer	Split layers	Split layers
		Any layer of width w		Split layers if w ≤ 5/8 in [16 mm]	Split layers with tandem electrodes if w > 5/8 in [16 mm]	If w > 1 in [25 mm], split layers	(Note c)

¹ Except root passes.

² 5/32 in [4.0 mm] for E6014 and low-hydrogen electrodes.

³ See 3.7.3 for requirements for welding painted and exposed ASTM A 588.

⁴ See 3.7.2 for width-to-depth limitations.

⁵ In the F, H, or OH positions for nonbutt joints, split layers when the layer width w > 5/8 in [16 mm]. In the vertical position for nonbutt joints or the flat, horizontal, vertical, and overhead positions for butt joints, split layers when the width w > 1 in [25 mm].

⁶ Shaded area indicates nonapplicability.

⁷ GMAW-S shall not be prequalified.

Table 3.8 – Prequalified WPS Variables. This table shows whether or not changes to welding variables require requalification. For example a change in amperage using SMAW that is less than 10% does not require requalification. However any change, increase or decrease, above 10% does require requalification. Below is a preview of table 3.8.

Table 3.8 Prequalified WPS Variables				
Prequalified WPS Variable	Process			
	SMAW	SAW	GMAW	FCAW
General				
1) A change in welding process(es) ¹	X	X	X	X
2) A change in welding position(s)	X	X	X	X
Base Metal				
3) A change in base metal group number(s) (see Table 3.1)	X	X	X	X
4) A change in the base metal preheat category (see Table 3.2)	X	X	X	X
Filler Metal				
5) A change in electrode classification(s)	X	X	X	X
6) A change in electrode/flux classification(s)		X		
7) A change in nominal electrode diameter(s)	X	X	X	X
8) A change in the number of electrodes		X		
Process Parameters				
9) A change in amperage		> 10% increase or decrease	> 10% increase or decrease	> 10% increase or decrease
10) A change in type of current (ac or dc) or polarity	X	X	X	X
11) A change in the mode of transfer			X	
12) A change in voltage		> 15% increase or decrease	> 15% increase or decrease	> 15% increase or decrease
13) A change in wire feed speed (if not amperage controlled)		> 10% increase or decrease	> 10% increase or decrease	> 10% increase or decrease
14) A change in travel speed		> 25% increase or decrease	> 25% increase or decrease	> 25% increase or decrease
Shielding Gas				
15) A change in the nominal composition of shielding gas			X	X (for FCAW-G only)
16) A decrease in shielding gas flow rate			> 25%	> 25% (for FCAW-G only)
17) An increase in the gas flow rate			> 50%	> 50% (for FCAW-G only)

FIGURES

The 11 figures in clause 3 are found in pages 76-124 making it the largest number of figures for any clause in the code. A detailed list can be found in the List of Figures with their respective titles and page numbers. Additionally a brief review of some important figures and their respective references within the text in clause 3 are discussed. Below is the list of figures for clause 3.

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Figures 3.3 and 3.4 Prequalified PJP Groove Welded Joint Details and Prequalified CJP Groove Welded Joint Details. These two figures compose more than half of the figures section in clause 3. These figures are a series of paired up diagrams and tables of prequalified welds with all the variables that accompany it and their ranges. The figures cover pages 77 to 116, however there are diagrams for joint designs that appear twice: first the diagram has measurements expressed in inches, and then the same diagram has measurements in millimeters. For the purposes of the test, a test taker should ignore the figures in millimeters.

The figures contain a lot of formulas. Therefore in order to read them one must first become acquainted with the legend. (See below).

Legend for Figures 3.3 and 3.4	
Symbols for joint types B — butt joint C — corner joint T — T-joint BC — butt or corner joint TC — T- or corner joint BTC — butt, T-, or corner joint	Welding processes SMAW — shielded metal arc welding GMAW — gas metal arc welding FCAW — flux cored metal arc welding SAW — submerged arc welding
Symbols for base metal thickness and penetration P — PJP L — limited thickness-CJP U — unlimited thickness-CJP	Welding positions F — flat H — horizontal V — vertical OH — overhead
Symbol for weld types 1 — square-groove 2 — single-V-groove 3 — double-V-groove 4 — single-bevel-groove 5 — double-bevel-groove 6 — single-U-groove 7 — double-U-groove 8 — single-J-groove 9 — double-J-groove 10 — flare-bevel-groove 11 — flare-V-groove	Dimensions R = Root Opening α, β = Groove Angles f = Root Face r = J- or U-groove Radius S, S ₁ , S ₂ = PJP Groove Weld Depth of Groove E, E ₁ , E ₂ = PJP Groove Weld Sizes corresponding to S, S ₁ , S ₂ , respectively
Symbols for welding processes if not SMAW S — SAW G — GMAW F — FCAW	Joint Designation The lower case letters, e.g., a, b, c, etc., are used to differentiate between joints that would otherwise have the same joint designation.

The legend dictates how the symbols in the diagrams and tables must be read. For example, the diagram on page 78 has “B-P1a” as its first joint designation (see below). By using the legend to replace the variables it can be determined that the joint is a butt joint with partial penetration on a square groove.

See notes on Page 77

Square-groove weld (1)
Butt joint (B)

Diagram illustrating a square-groove weld joint (Butt joint B). The joint shows two plates of thickness T_1 joined by a square-groove weld. The groove has a root opening R . The weld is labeled $(E) | R$. A note indicates "REINFORCEMENT 1/32 TO 1/8 NO TOLERANCE".

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (E)	Notes	
				Root Opening	Tolerances					
		T_1	T_2		As Detailed (see 3.12.3)	As Fit-Up (see 3.12.3)				
SMAW	B-P1a	1/8	—	$R = 0 \text{ to } 1/16$	+1/16, -0	±1/16	All	$T_1 - 1/32$	b	
	B-P1c	1/4 max.	—	$R = \frac{T_1}{2} \text{ min.}$	+1/16, -0	±1/16	All	$\frac{T_1}{2}$	b	
GMAW FCAW	B-P1a-GF	1/8	—	$R = 0 \text{ to } 1/16$	+1/16, -0	±1/16	All	$T_1 - 1/32$	b, e	
	B-P1c-GF	1/4 max.	—	$R = \frac{T_1}{2} \text{ min.}$	+1/16, -0	±1/16	All	$\frac{T_1}{2}$	b, e	

Square-groove weld (1)
Butt joint (B)

The diagram shows a cross-section of a square-groove butt joint. Two plates, each with a thickness T_1 , are joined by a weld. The weld has a root opening R . The weld is labeled with (E_2) and (E_1) on either side of the root. A note indicates that $E_1 + E_2$ must not exceed $\frac{3T_1}{4}$.

$E_1 + E_2$ MUST NOT EXCEED $\frac{3T_1}{4}$

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($E_1 + E_2$)	Notes			
		T_1	T_2	Root Opening	Tolerances							
					As Detailed (see 3.12.3)	As Fit-Up (see 3.12.3)						
SMAW	B-P1b	1/4 max.	—	$R = \frac{T_1}{2}$	+1/16, -0	±1/16	All	$\frac{3T_1}{4}$				
GMAW FCAW	B-P1b-GF	1/4 max.	—	$R = \frac{T_1}{2}$	+1/16, -0	±1/16	All	$\frac{3T_1}{4}$	e			

Figure 3.3—Prequalified PJP Groove Welded Joint Details

Chapter 7

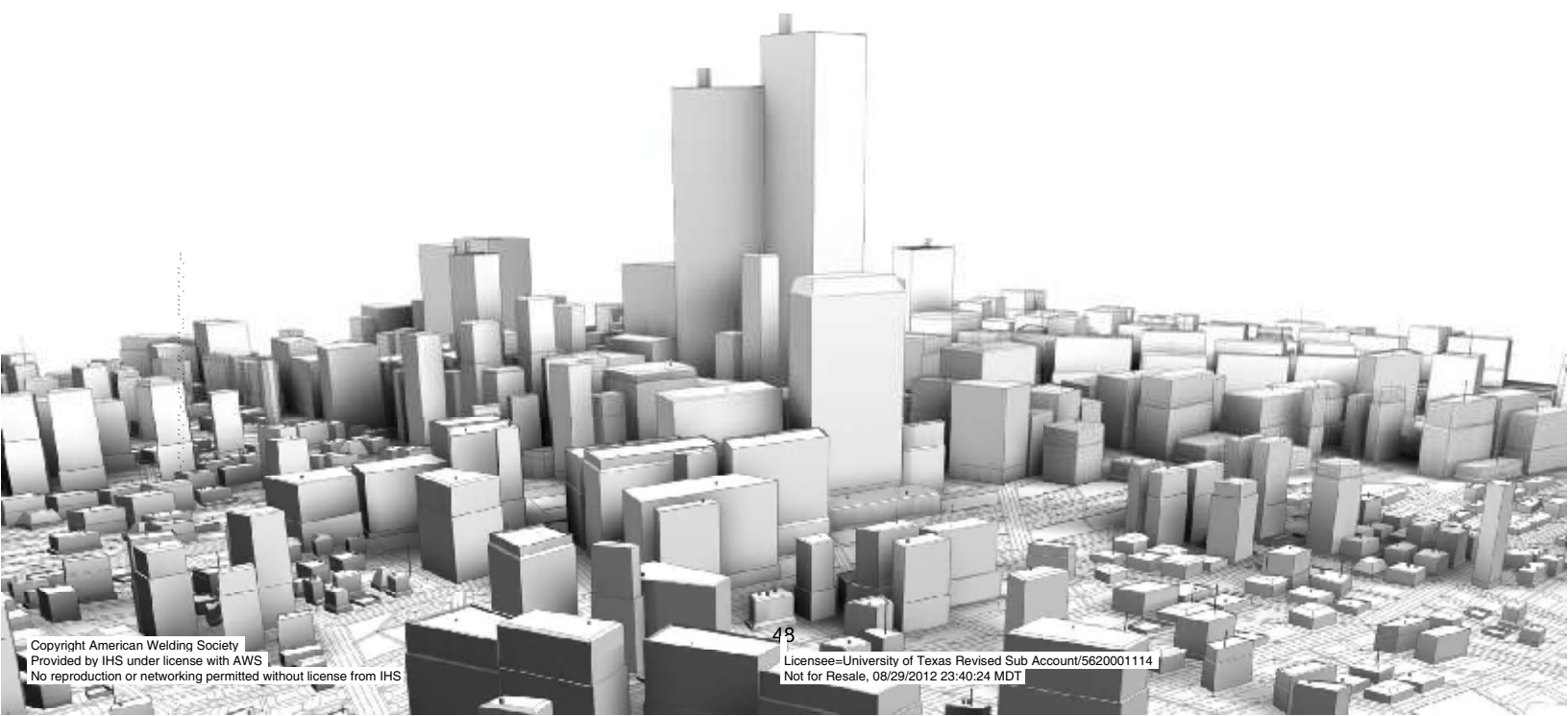
Clause 4: Qualification

Introduction.....

Text.....

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INTRODUCTION

According to D1.1, clause 4 contains “the requirements for qualifications testing of welding procedure specifications (WPSs) and welding personnel.”¹ The clause essentially provides the methods for qualifying WPSs on the one hand, and the performance requirements to qualify the personnel actually making the weld on the other.

Clause 3 provides a set of prequalified weld variables in order to facilitate WPSs. In clause 4, the code provides the requirements to give the freedom to the contractor to create alternative WPSs that are not already prequalified. Practically speaking, clause 4 sets the boundaries for how to test WPSs and how to qualify welders.

Clause 4 is strategically placed between the clause 3 which deals with prequalified WPSs and clause 5 concerning fabrication. In the sequence of erecting a structure, first the standard prequalified welds are selected (clause 3), then whatever welds that are needed for odd parts of the job that are beyond the scope of “premade” WPSs are designed (clause 4), finally the welds are created or fabricated (clause 5). Thinking of the order this way facilitates formulating an idea of what information each clause will contain.

TEXT

The text portion of clause 4 is the smallest portion of the clause. It runs from page 125 to page 137 and is distributed amongst 39 sub clauses. This section covers the general structure of the text in clause 4 and reviews some important provisions that are in the sub clauses. The following is a list of all the sub clauses as listed in the table of contents.

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Clause 4 like clause 2 and 6 is divided into 4 main parts – A, B, C, and D – which contain all of the sub clauses except clause 4.1 which is the scope. The scope serves to introduce the general structure of the clause which is as follows:

Part A – General Requirements

Part B – Welding Procedure Specifications (WPSs)

Part C – Performance Qualification

Part D – Requirements for CVN testing

Part A – General Requirements

Part A is an overview of the requirements for WPSs and performance requirements for welding personnel. Part A is all but 2 pages long and lays the groundwork for what will be discussed in further detail in Parts B, C, and D. Part A starts on sub clause 4.2 and ends on 4.3.

4.2 General

General Requirements for qualification testing of WPSs and welding personnel (defined as welders, welding operators, and tack welders).

- 4.2.1. States that unless exempted as provided in Clause 3 “...a WPS for use in production welding shall be qualified in conformance with Clause 4, Part B” However, properly documented evidence of previous qualification may be accepted, at the Engineers’ option.
 - 4.2.1.1 WPS qualification is the responsibility of the ‘manufacturer or contractor.’
 - 4.2.1.2. Qualification of WPSs to other standards besides D1.1 may be accepted, however, the acceptability of other standards is the Engineer’s responsibility.
 - 4.2.2. Requires that welders, welding operators and tack welders, working under this code and using SMAW, SAW, GMAW, GTAW, FCAW, ESW, or EGW shall have been qualified by the applicable tests as described in Part C.
 - 4.2.2.1. Qualification of welding personnel to other standards besides D1.1 may be accepted, however, the acceptability of other standards is the Engineer’s responsibility.
 - 4.2.2.2. Defines the responsibility for performance qualification as being that of the manufacturer or contractor but also adds a qualifying statement, “...whether the qualification is conducted by the manufacturer, contractor, or an independent testing agency.” The use of an independent testing agency for performance qualification testing is an accepted practice.
 - 4.2.3. Covers period of effectiveness.
 - 4.2.3.1 Welder and welding operator qualifications remain in effect indefinitely unless they do not weld with the process for which they are qualified for more than six months or unless there is some specific reason to question their ability. For tack welders, the qualification lapses only if there is some specific reason to question their ability.
-

Part B – Welding Procedure Specifications (WPSs)

Part B builds on the general requirements of Part A to further specify in greater detail the requirements for Welding Procedure specification. Part B starts on sub clause 4.4 and ends on 4.8.

4.5 Type of Qualification Tests

Sets out the required types of tests for procedure qualification. The number of tests and of specimens required is given in Table 4.2 (CJP groove), Table 4.3 (PJP groove), and Table 4.4 (fillet).

4.6 Weld Types for WPS Qualification

Classifies six types of welds for the purposes of WPS qualifications:

- CJP groove welds, nontubular connections
- PJP groove welds, nontubular connections
- Fillet welds, tubular, and nontubular connections
- CJP groove welds, tubular connections
- PJP groove welds, tubular T-, Y-, and K-connections and butt joints
- Plug and slot welds for tubular and nontubular connections

4.7 Preparation of WPS

States that a WPS is to be prepared as a written statement of each of the applicable essential variables, as enumerated in 4.7. "The specific values for these WPS variables shall be obtained from the procedure qualification record (PQR), which serves as written confirmation of a successful WPS qualification."

4.9 Methods of Testing

Methods of Testing and Acceptance Criteria for WPS Qualification

- 4.9.1. Covers requirements for visual inspection of groove welds which include descriptions of variables such as: cracking, undercut, craters, reinforcement, backing, concavity, melt through, etc...
- 4.9.2. Test coupons will be nondestructively examined by RT or UT before preparing mechanical test specimens. Acceptance criteria for the RT or UT shall be in accordance with clause 6 Part C.
- 4.9.3. Specifies acceptance criteria for bend tests.
- 4.9.5. States that in the event one test specimen of a 'set' fails, two retests for that particular type of test specimen may be taken from the original coupon, if available. Both new test specimens must satisfy the test criteria. In the case of material >1-1/2 inches in thickness, "...failure of a specimen shall require testing of all specimens of the same type from two additional locations in the test material."

4.12 Fillet Welds for Tubular and Nontubular Connections

- 4.12.5 Describes the required test procedure when an unlisted filler metal is to be used for fillet welds in production and the WPS to be used has not been qualified using a CJP or PJP weld test.
-

Part C – Performance Qualification

Part C builds on the general requirements of Part A to further specify in greater detail the performance qualification tests required to demonstrate the welder's, welding operator's, or tack welder's ability to produce sound welds. Part C starts on sub clause 4.19 and ends on 4.33.

4.19 Performance Qualification of Welding Personnel

- 4.19.1. Production welding Positions Qualified
- 4.19.1.2. Tack welders are required to be qualified for each position in which tack welding is to be carried out in production.

4.21 Weld Types for Welder and Welding Operator Performance Qualification

For the purposes of welder/welding operator qualification, weld types are classified as follows:

- CJP Groove Welds, Nontubular Connections
- PJP Groove Welds, Nontubular Connections
- Fillet Welds, Nontubular Connections
- CJP Groove Welds, Tubular Connections
- PJP Groove Welds, Tubular Connections
- Fillet Welds, Tubular Connections

4.21.1. Plug and Slot Welds, Tubular and Nontubular Connections

4.22 Preparation of Performance Qualification Forms

Preparation of Performance Qualification Forms requires performance tests to be carried out in accordance with a WPS. The WPS essential variable limitations of sub clause 4.7 apply together with the performance essential variables of sub clause 4.22.

4.31 Methods of Testing and Acceptance Criteria for Welder and Welding Operator Qualification

This sub clause details the various tests applicable for each of the performance qualifications.

4.32 Methods of Testing and Acceptance Criteria for Tack Welder Qualification

This sub clause requires the surface of welds to be free of overlap, cracks, and undercut exceeding 1/32 inch in depth and that the weld surface exhibits no porosity.

4.33 Retest

Covers qualification retesting in the event welders, welding operators, or tack welders fail a qualification test, or there is valid reason to doubt their welding ability, or the period of effectiveness has lapsed.

Part D – Requirements for CVN testing

Part D builds on the general requirements of Part A to further specify in greater detail the requirements for CVN testing. Part D starts on sub clause 4.34 and ends on 4.39.

4.34. General Requirements

- 4.34.1. Specifies that CVN test requirements and test procedures shall apply only when specified in the contract documents.
 - 4.34.2. Specifies that CVN test specimens shall be machined and tested in conformance with ASTM E 23, Standard methods for Notched Bar Impact Testing of Metallic Materials for Type A Charpy (simple beam) Impact Specimens, ASTM A 370, Standard Test Method and Definitions for Mechanical Testing of Steel Products, or AWS B4.0 Standard methods for Mechanical Testing of Welds.
-

TABLES

The 15 tables in clause 4 are found in pages 138-156 and are listed in the List of Tables by their respective titles and page numbers. Additionally a brief review of some important tables and their respective references within the text in clause 4 are discussed. Below is the list of tables for clause 4.

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Table 4.1 – WPS Qualification – Production Welding Positions Qualified by Plate, Pipe, and Box Tube.

This table provides the tests for welding positions for plate, pipe, and box tube, and provides the different weld positions for which the various test qualifies may qualify welds performed in other positions. For example if a CJP groove weld is successfully tested in the 2G position on a plate, this qualifies the same CJP groove weld in the flat (F) position and the horizontal (H) position. Below is Table 4.1.

Qualification Test		Production Plate Welding Qualified			Production Pipe Welding Qualified					Production Box Tube Welding Qualified				
Weld Type	Positions	Groove CJP	Groove PJP	Fillet ¹	Butt Joint		T, Y, K-Connections		Fillet ¹	Butt Joint		T, Y, K-Connections		Fillet ¹
					CJP	PJP	CJP	PJP		CJP	PJP	CJP	PJP	
P L A T E	CJP Groove	1G	F	F	F	P ²			F	F	F			F
		2G	F, H	F, H	F, H	(F, H) ³			F, H	F, H	F, H			F, H
		3G	V	V	V	V ⁴			V	V	V			V
		4G	OH	OH ⁵	OH	OH ⁶			OH	OH	OH			OH
	Fillet ¹	1F			F				F					F
		2F			F, H				F, H					F, H
		3F			V				V					V
		4F			OH				OH					OH
	Plug/Slot	Qualifies Plug/Slot Welding for Only the Positions Tested												
		1G Rotated	F	F	F	P ²			F	F	F			F
T U B E	CJP Groove	2G	F, H	F, H	F, H	(F, H) ³			F, H	F, H	F, H			F, H
		5G	F, V, OH	F, V, OH	F, V, OH	(F, V, OH) ⁶			F, V, OH	F, V, OH	(F, V, OH) ⁶			F, V, OH
		(2G + 5G)	All	All	All	All ⁷		All ⁷	All ⁷	All	All	All ⁷	All	All
		6G	All	All	All	All ⁷		All	All	All	All	All	All	All
		6GR	All ⁸	All	All	All ⁸		All ⁷	All	All	All	All ⁸	All	All
	Fillet	1F Rotated			F				F					F
		2F			F, H				F, H					F, H
		2F Rotated			F, H				F, H					F, H
		4F			F, H, OH				F, H, OH					F, H, OH
		5F			All				All					All

CJP—Complete Joint Penetration
PJP—Partial Joint Penetration

¹ Qualifies for a welding axis with an essentially straight line, including welding along a line parallel to the axis of circular pipe.

² Qualifies for circumferential welds in pipes equal to or greater than 24 in (600 mm) nominal outer diameter.

³ Production butt joint details without backing or back-grip require qualification testing of the joint detail shown in Figure 4.25(A).

⁴ Limited to prequalified joint details (see 4.12 or 4.13.1).

⁵ For production joints of CJP F, Y, and K-connections that conform to either Figure 3.8, 3.9, or 3.10 and Table 3.6, use Figure 4.27 detail for testing. For other production joints, see 4.13.4.1.

⁶ For production joints of CJP T, Y, and K connections that conform to Figure 3.5, and Table 3.6, use Figures 4.27 and 4.29 detail for testing, or alternatively, test the Figure 4.27 joint and cut macroetch specimens from the corner locations shown in Figure 4.29. For other production joints, see 4.13.4.1.

⁷ For production joints of PJP T, Y, and K connections that conform to Figure 3.5, use either the Figure 4.25(A) or Figure 4.25(B) detail for testing.

⁸ For matched box connections with corner radii less than twice the chord member thickness, see 3.12.4.1.

⁹ Fillet welds in production T, Y, or K connections shall conform to Figure 3.2, WPS qualification shall conform to 4.12.

Table 4.2 – WPS Qualification – CJP Groove Welds: Number Type of Test Specimens and Range Thickness and Diameter Qualified. This table provides the relationship between the number and dimensions of the test specimen for CJP Groove welds, and the welds that they qualify. For example, if a test plate specimen is ¼ of an inch thick, then it qualifies material anywhere from 1/8 of an inch to ½ of an inch thick. Below is Table 4.2.

Table 4.2									
WPS Qualification—CJP Groove Welds: Number and Type of Test Specimens and Range of Thickness and Diameter Qualified (see 4.5) (Dimensions in Inches)									
1. Tests on Plate ^{a, b}									
	Nominal Plate Thickness (T) Tested, in	Number of Specimens				Nominal Plate, Pipe or Tube Thickness ^{c, d} Qualified, in			
		Reduced Section Tension (see Fig. 4.14)	Root Bend (see Fig. 4.12)	Face Bend (see Fig. 4.12)	Side Bend (see Fig. 4.13)	Min.	Max.		
	1/8 ≤ T ≤ 3/8	2	2	2	(Note 1)	1/8	2T		
	3/8 < T < 1	2	—	—	4	1/8	2T		
	1 and over	2	—	—	4	1/8	Unlimited		
2. Tests on Pipe or Tubing ^{a, e}									
	Nominal Pipe Size or Diam., in	Nominal Wall Thickness, T, in	Number of Specimens				Nominal Diameter ^f of Pipe or Tube Size Qualified, in	Nominal Plate, Pipe or Tube Wall Thickness ^{c, d} Qualified, in	
			Reduced Section Tension (see Fig. 4.14)	Root Bend (see Fig. 4.12)	Face Bend (see Fig. 4.12)	Side Bend (see Fig. 4.13)		Min.	Max.
Job Size Test Pipes	< 24	1/8 ≤ T ≤ 3/8	2	2	2	(Note 1)	Test diam. and over	1/8	2T
		3/8 < T < 3/4	2	—	—	4	Test diam. and over	T/2	2T
		T ≥ 3/4	2	—	—	4	Test diam. and over	3/8	Unlimited
	≥ 24	1/8 ≤ T ≤ 3/8	2	2	2	(Note 1)	Test diam. and over	1/8	2T
		3/8 < T < 3/4	2	—	—	4	24 and over	T/2	2T
		T ≥ 3/4	2	—	—	4	24 and over	3/8	Unlimited
Standard Test Pipes	2 in Sch. 80 or 3 in Sch. 40		2	2	2	—	3/4 through 4	1/8	3/4
	6 in Sch. 120 or 8 in Sch. 80		2	—	—	4	4 and over	3/16	Unlimited
3. Tests on ESW and EGW ^{a, h}									
	Nominal Plate Thickness Tested	Number of Specimens				Nominal Plate Thickness Qualified			
		Reduced Section Tension (see Fig. 4.14)	All-Weld-Metal Tension (see Fig. 4.18)	Side Bend (see Fig. 4.13)	CVN Tests	Min.	Max.		
	T	2	1	4	(Note 1)	0.5T	1.1T		
^a All test plate, pipe or tube welds shall be visually inspected (see 4.9.1) and subject to NDT (see 4.9.2). One test plate, pipe or tube shall be required for each qualified position. ^b See Figures 4.10 and 4.11 for test plate requirements. ^c For square groove welds that are qualified without backing, the maximum thickness qualified shall be limited to the test plate thickness. ^d CJP groove weld qualification on any thickness or diameter shall qualify any size of fillet or PJP groove weld for any thickness or diameter (see 4.11.3). ^e Qualification with any pipe diameter shall qualify all box section widths and depths. ^f When specified, CVN tests shall conform to Clause 4, Part D. ^g See Table 4.1 for the groove details required for qualification of tubular butt and T-, Y-, K-connection joints. ^h See Figure 4.9 for plate requirements. ⁱ For 3/8 in plate or wall thickness, a side-bend test may be substituted for each of the required face- and root-bend tests.									

Table 4.5 – PQR Essential Variables Changes Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, and GTAW. This table provides the changes in variables in the different welding processes that would require requalification. For example, if a weld is qualified using the SMAW process with a low hydrogen electrode, but then the electrode is changed to a nonlow-hydrogen electrode, requalification of the procedure is required. However this requalification requirement does not apply to SAW, GMAW, FCAW, or GTAW.

Table 4.5 PQR Essential Variable Changes Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, and GTAW (see 4.8.1)					
Essential Variable Changes to PQR Requiring Requalification	Process				
	SMAW	SAW	GMAW	FCAW	GTAW
Filler Metal					
1) Increase in filler metal classification strength	X		X	X	
2) Change from low-hydrogen to nonlow-hydrogen SMAW electrode	X				
3) Change from one electrode or flux-electrode classification to any other electrode or flux-electrode classification ^a		X		X	X
4) Change to an electrode or flux-electrode classification ^a not covered in:	AWS A5.1 or A5.5	AWS A5.17 or A5.23	AWS A5.18 or A5.28	AWS A5.20 or A5.29	AWS A5.18 or A5.28
5) Addition or deletion of filler metal					X
6) Change from cold wire feed to hot wire feed or vice versa					X
7) Addition or deletion of supplemental powdered or granular filler metal or cut wire		X			
8) Increase in the amount of supplemental powdered or granular filler metal or wire		X			
9) If the alloy content of the weld metal is largely dependent on supplemental powdered filler metal, any WPS change that results in a weld deposit with the important alloying elements not meeting the WPS chemical composition requirements		X			
10) Change in nominal filler metal diameter by:	> 1/32 in [0.8 mm] increase	Any increase ^b	Any increase or decrease	Any increase	> 1/16 in [1.6 mm] increase or decrease
11) Change in number of electrodes		X	X	X	X
Process Parameters					
12) A change in the amperage for each diameter used by:	To a value not recommended by manufacturer	> 10% increase or decrease	> 10% increase or decrease	> 10% increase or decrease	> 25% increase or decrease
13) A change in type of current (ac or dc) or polarity (electrode positive or negative for dc current)	X	X	X	X	X
14) A change in the mode of transfer			X		
15) A change from CV to CC output			X	X	
16) A change in the voltage for each diameter used by:		> 7% increase or decrease	> 7% increase or decrease	> 7% increase or decrease	
17) An increase or decrease in the wire feed speed for each electrode diameter (if not amperage controlled) by:		> 10%	> 10%	> 10%	

(Continued)

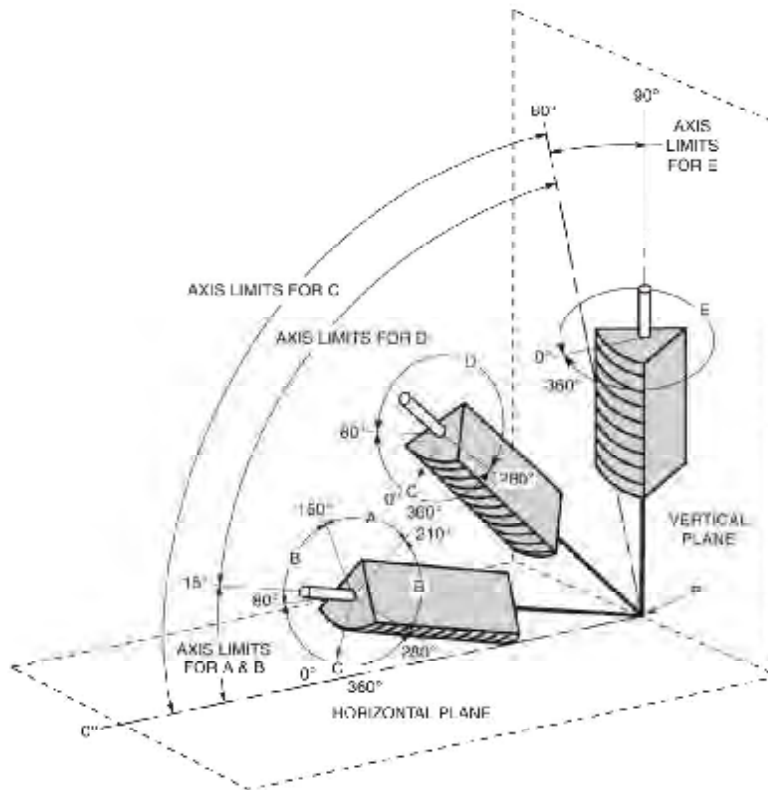
FIGURES

The 40 figures in clause 4 are found in pages 157-191 and listed in the List of Figures by their respective titles and page numbers. The 34 page extension of the figures section makes it the largest part of the clause. Additionally a brief review of some important figures and their respective references within the text in clause 4 are discussed. Below is the list of figures for clause 4.

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Figure 4.1 – Positions of Groove Welds. This figure provides the range of positions in degrees that determines the position of a groove weld. For example, a weld done in an 8% inclination of axis, and a 100% rotation of face, is considered to be in the horizontal position.

Tabulation of Positions of Groove Welds			
Position	Diagram Reference	Inclination of Axis	Rotation of Face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	80° to 150° 210° to 280°
Overhead	C	0° to 80°	0° to 80° 260° to 350°
Vertical	D	15° to 80°	80° to 280°
	E	80° to 90°	0° to 350°



The horizontal reference plane shall always be taken to lie below the weld under consideration.
 The inclination of axis shall be measured from the horizontal reference plane toward the vertical reference plane.
 The angle of rotation of the face shall be determined by a line perpendicular to the theoretical face of the weld which passes through the axis of the weld. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the angle increases. When looking at point P, the angle of rotation of the face of the weld shall be measured in a clockwise direction from the reference position (0°).

Figure 4.1—Positions of Groove Welds (see 4.3.4)

Figure 4.3 – Positions of Test Plates for groove welds. This figure provides picture diagrams of the different positions for groove weld test plates.

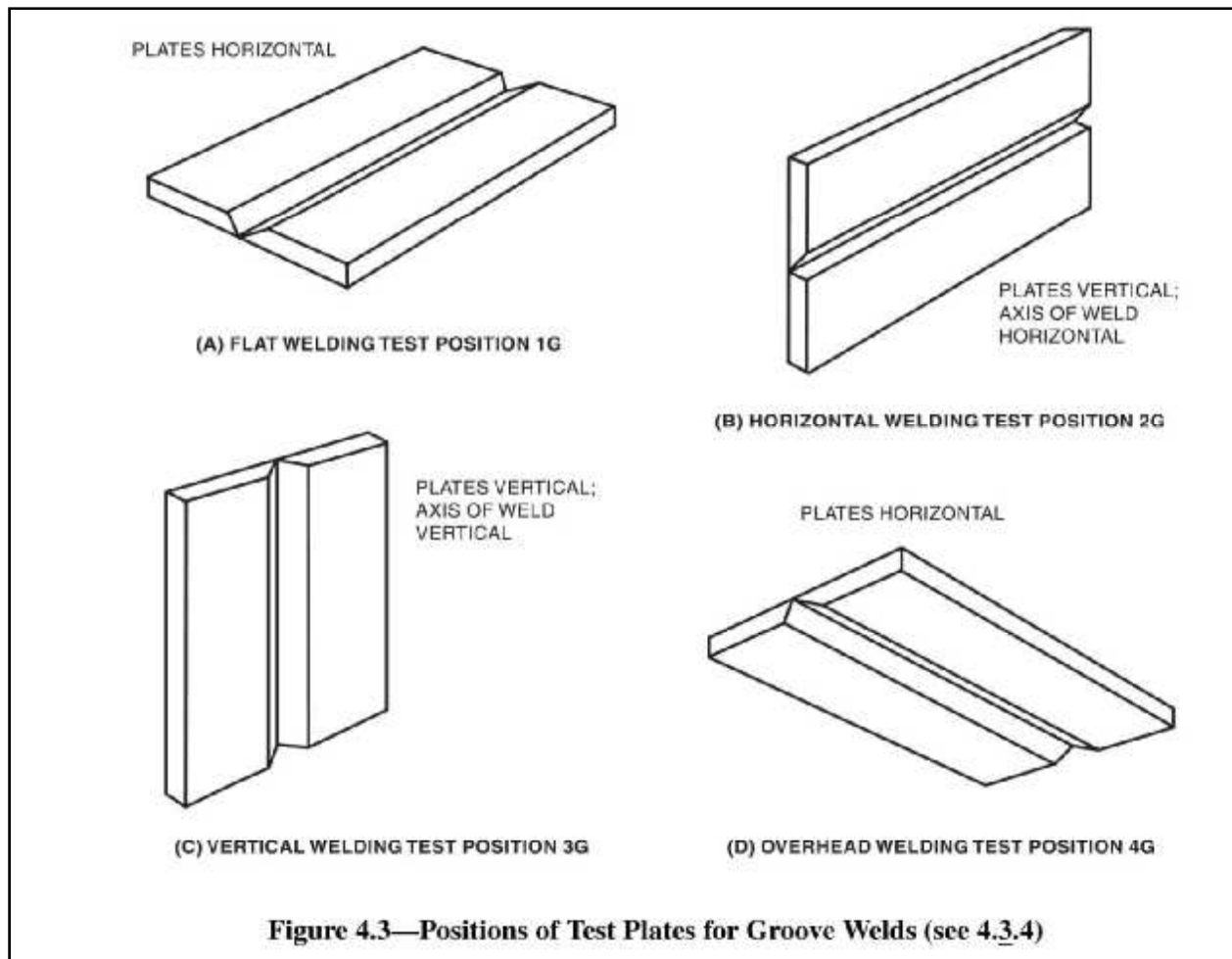
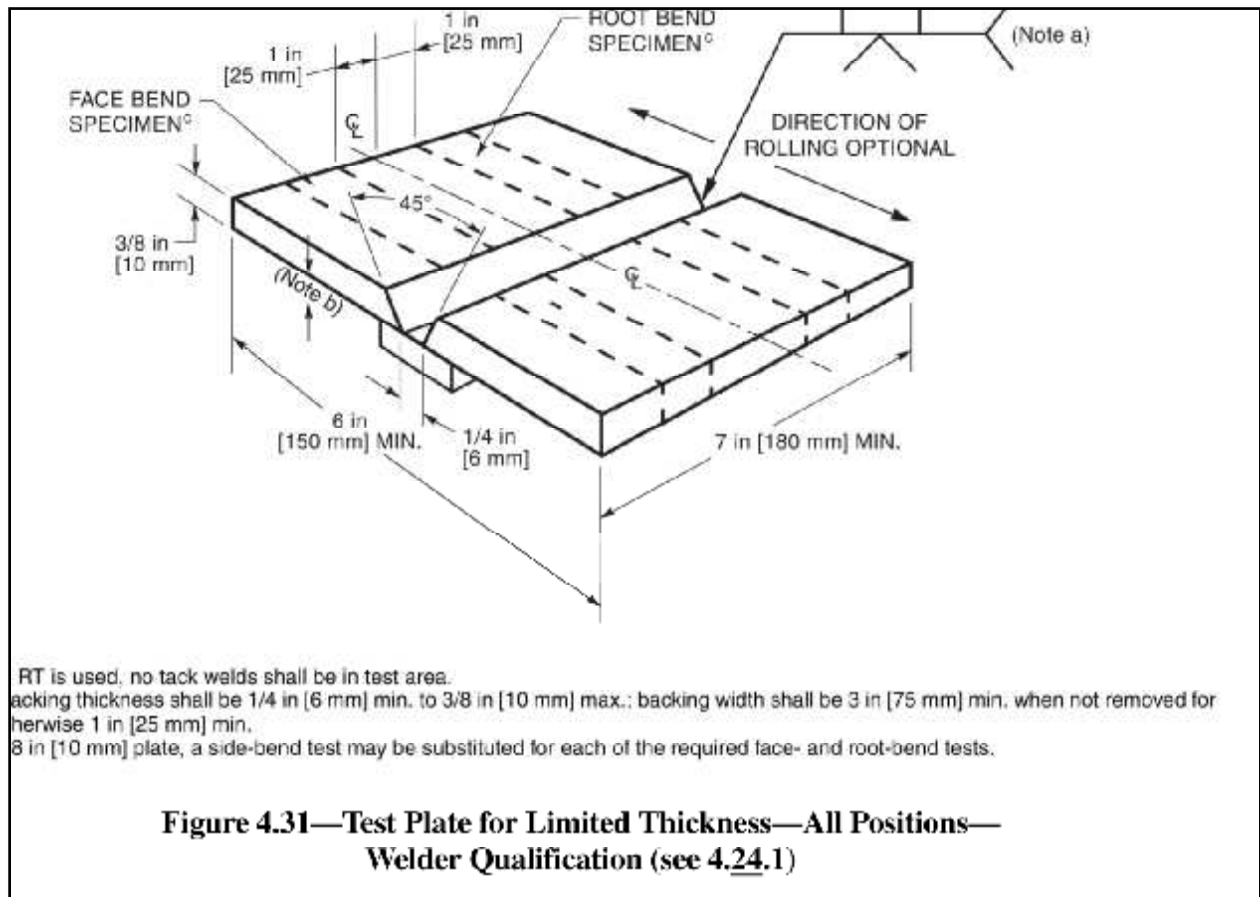


Figure 4.31 – Test Plate for Limited thickness – All positions – Welder Qualification. This figure provides the dimensions for the test for limited thickness. Clause 4 contains various figures that are diagrams of the appropriate design and dimensions of test plates. Below is a good example of one these, figure 4.31.



Chapter 8

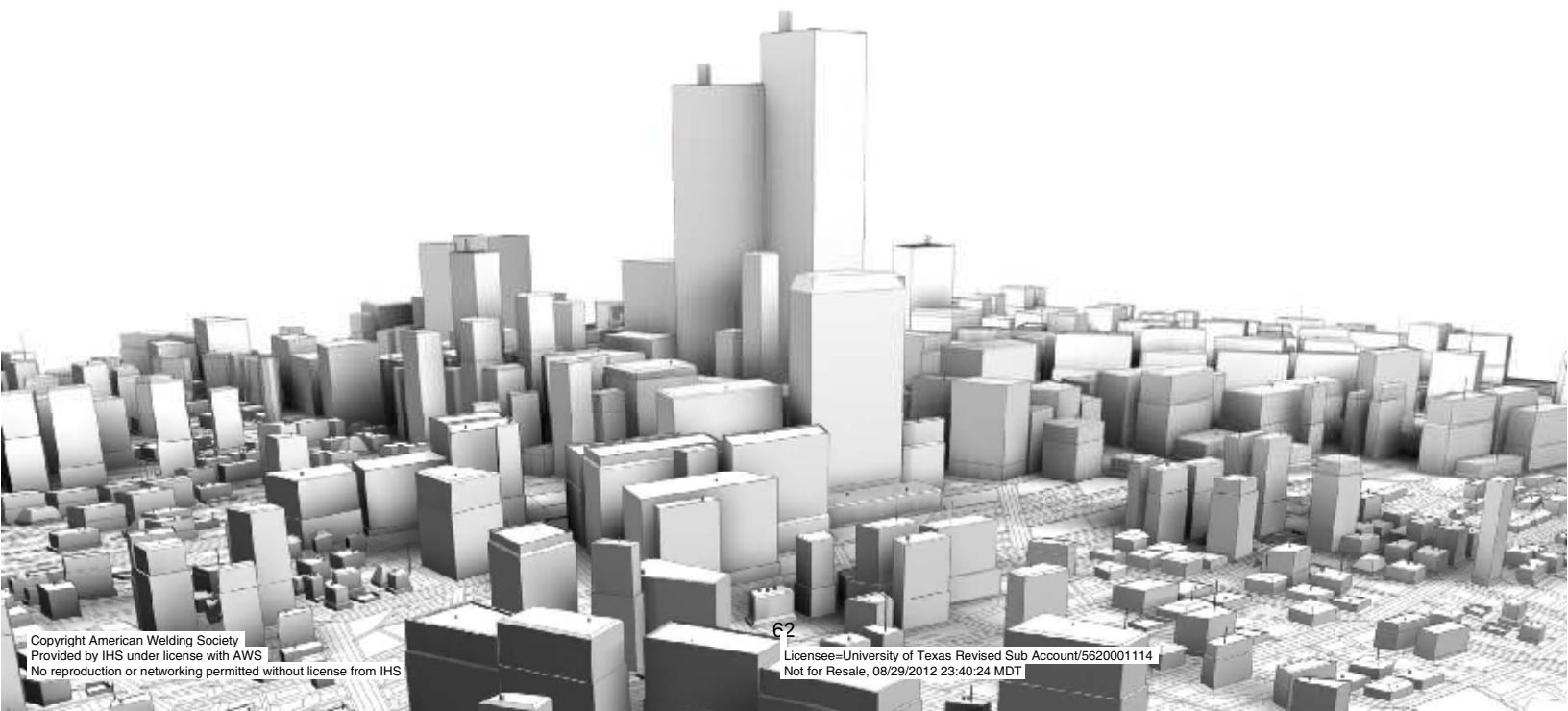
Clause 5: Fabrication

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

Clause 5 contains provisions to be “observed in the fabrication and erection of welded assemblies and structures produced by any process acceptable under this code.”¹The previous 4 clauses have been part of the designing and qualification process of construction. This clause contains requirements that cover the actual creating of the welds according to the contract documents. This includes provisions pertaining to all the components, variables, and steps in creating the welds.

Clause 5 finds its place in the code immediately after the two clauses dealing with qualification of WPSs (3 and 4), but immediately before the clause that covers inspection (6). Fittingly, these clauses are arranged in the sequence of construction: qualification, fabrication, and inspection. First the welds are designed and approved, then they are actually welded, and then the welds are inspected for discontinuities.

TEXT

The text portion of Clause 5 is the biggest section of the clause. It runs from page 193 to 207 and is distributed amongst 31 sub clauses. This section covers the general structure of the text in clause 5 and some of the important sub clauses in the clause are reviewed. The following is a list of all the sub clauses as listed in the table of contents.

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Clause 5 has no major sub divisions called “parts” elsewhere in the code. Instead all of the information is divided no further than the 31 sub clauses. The following is a review of some important portions of the text.

5.2 Base metal	
5.21.	Requires that base metal should be designated in terms of specification and classification in the contract documents, should be selected from those listed in Table 3.1 or Table 4.9 wherever possible.
5.3 Welding Consumables and Electrode Requirements	
5.3.1.1.	States that when required by the Engineer, the contractor (or fabricator) shall furnish certification to show conformance of electrode and/or electrode/flux combinations to the applicable classification.
5.3.1.2.	The electrode (and electrode/flux combinations), the electrode size, and welding parameters shall be appropriate for the specifics of each welding operation. The welding current shall be within the electrode manufacturer’s recommended range.
5.3.1.3.	Gases used for shielding are to be of welding grade with a dew point which meets

the requirements of AWS A5.32/A5.32M Specification For Welding Shielding Gases with certification if the Engineer so requests. Whether pure, premixed, or mixed at the point of welding, the shielding gas composition shall conform to applicable WPS requirements.

- 5.3.1.4. Once removed from their original containers, welding consumables shall be handled and stored so welding properties are not adversely affected. All electrodes shall be dry and suitable for use.
- 5.3.2. SMAW electrodes shall conform to the requirements of AWS A5.1/A5.1M (for carbon steels) or AWS A5.5/A5.5M (for low alloy steels) as appropriate for the base metal concerned.
 - 5.3.2.1. Low hydrogen electrodes (A5.1 or A5.5) shall be purchased in hermetically sealed containers or baked prior to use. As soon as the sealed containers are opened, the electrodes shall be held in storage ovens where a temperature of 250°F (120°C) minimum is maintained.
- 5.3.3. Submerged arc welding may be carried out using a variety of configurations for of single or multiple electrodes for groove or fillet welds. In the case of multiple electrodes, spacing is to be such that slag freezing does not occur between leading and trailing electrodes.
 - 5.3.3.1. Flux-wire combinations used are to meet the requirements of AWS A5.17/A5.17M (carbon steels) or A5.23/A5.23M (low alloy steels).
 - 5.3.3.2. Fluxes are to be free of dirt, mill scale, or other foreign matter, and purchased in containers suitable for at least six months storage without adversely affecting the product. Flux from damaged packages shall be discarded or dried for one hour at not less than 500°F (260°C). Flux hoppers are to be filled from newly opened packages or, in the case of previously opened packages, the top one inch of flux is to be discarded. Flux that has been wet shall not be used.
- 5.3.5. GTAW
 - 5.3.5.1. For GTAW, the tungsten electrodes are to conform to AWS A5.12/A5.12M requirements, and the filler metal for carbon steel weld metal is to be as per AWS A5.18/A5.18M.
 - 5.3.5.2. For low alloy steel weld metal, filler metal as per AWS A5.28/A5.28M shall be used. As noted above, welding gases shall have a dew point that meets the requirements of AWS A5.32/A5.32M.

5.6 Preheat and Interpass Temperatures

Requires the minimum interpass temperature to be the same as the preheat requirements unless otherwise specified in the WPS. The specified temperature shall be maintained during welding for a distance at least equal to the metal thickness, but not less than 3 inches in all directions from the point of welding. Preheat and interpass temperatures shall be checked immediately prior to initiating the arc for each pass.

5.8 Stress-Relief Heat treatment

- 5.8.1. Details of the procedures to be followed are given, with a recommended heat treatment temperature range of 1100 – 1200°F for all except quenched and tempered steels where the maximum temperature is 1100°F. Heat treatment times are given in Table 5.2 In the case of quenched and tempered steels, stress relief is not recommended.
-

5.9 Backing, Backing Gas, or Inserts

States that CJP grooves are to be welded with or without backing or the use of back gouging from the second side.

5.10 Backing

Roots of groove or fillet welds may be backed with copper, flux, glass tape, ceramic, iron powder, or a similar material used to prevent melt through.

5.12 Welding Environment

5.12.1. Requires that GMAW, GTAW, EGW, or FCAW-G shall not be done in draft or wind unless the draft is protected by shelter. The shelter must reduce wind velocity to 5 miles per hour.

5.12.2. Welding shall not be done:

- When the ambient temperatures is lower than 0 degrees Fahrenheit
- When surfaces are wet or exposed to rain or snow
- When there is wind at high velocities
- When welding personnel are exposed to inclement conditions

5.15 Preparation of Base metal

5.16 Reentrant Corners

5.18 Tack Welds and Construction Aid Welds

5.18.2. States that tack welds and construction aid welds are permitted with two exceptions: 1) In tensions zones of cyclically loaded structures except as permitted by 2.16.2; 2) On members made of quenched and tempered steel with specified yield strength greater than 70 ksi, except as approved by the engineer.

5.21 Control of Distortion and Shrinkage

5.21.1. Requires the sequence of welding to be such that distortion and shrinkage are minimized.

5.21.2. As far as possible, welding is to be carried out in a manner that continuously balances the heat of welding.

5.21.3. If required by the contract or by the Engineer, or if the adequacy of the structure could be adversely affected by distortion and/or shrinkage, the contractor is required to prepare, submit, and work to an approved welding sequence.

5.21.5. The general progression of welding is to be from areas of greatest towards the areas of least restraint. Joints with greater shrinkage should be welded before those with lesser shrinkage. In all cases, joint restraint should be minimized.

5.21.6. Shop splices of cover-plated beams or built-up members are to be made before assembly. Subassemblies, which may be used for large members, should be spliced with welding balanced between web and flange welds as well as about the major and minor member axes.

5.21.7. Specifies details for welds to be made under conditions of severe external restraint. Once begun, welding of the joint shall continue uninterrupted, with preheating and interpass temperature maintained, until the joint has been completely welded, or alternatively, until sufficient weld metal to ensure freedom from cracking has been

applied to the joint.

5.22 Tolerance of Joint Dimensions

- 5.22.1. Requires that fillet welds root opening shall not exceed 3/16 inch [5 mm] except for shapes ≥ 3 inches [75 mm] in thickness where, after straightening and in assembly, the maximum root opening shall not be greater than 5/16 inch [8mm], provided suitable backing is used. If the separation is greater than 1/16 inch [2 mm], the legs of the fillet weld to be applied shall be increased by the amount of the root opening.
- 5.22.2. The separation between faying surfaces of plug and slot welds, and of butt joints landing on a backing, shall not exceed 1/16 inch [2 mm].

5.26 Repairs

- 5.26.1. In all instances, the contractor has the option of repairing nonconforming discontinuities or replacing the entire weld. Repaired or replaced areas shall be tested in the same manner and to the same criteria as specified for the original weld area.
 - 5.26.1.1. Requires that where there is excess weld metal, such as convexity, reinforcement, or overlap, it shall be removed
 - 5.26.1.2. Where there is insufficient weld metal, such as concavity, undersized welds, or undercutting, additional weld metal shall be deposited.
 - 5.26.1.3. Where there is incomplete fusion, excessive porosity, or slag inclusions, the nonconforming portions shall be removed and replaced.
 - 5.26.1.4. Requires that the extent of all cracks have to be diagnosed by acid etching, MT, PT, or other effective methods. The crack and the sound metal 2 in. beyond each end of the crack has to be removed and rewelded.
- 5.26.3. Requires prior approval by the engineer for all repairs including repair of base metal repairs, repair of major or delayed cracks, and repair of internal discontinuities in electroslag and electrogas welded joints.

5.2 Peening

Provides that peening is allowed only in the intermediate weld layers if care is exercised to avoid overlapping or cracking. Peening is not allowed on the root or surface layers.

- 5.27.3. Prohibits the use of manual slag hammers and lightweight vibrating tools for slag and spatter removal.

5.28 Caulking

Caulking is prohibited for base metals with minimum specified yield strength greater than 50 ksi.

5.29 Arc Strikes

Requires that Cracks or blemishes caused by arc strikes shall be ground to a smooth contour and checked to ensure soundness.

5.30 Weld Cleaning

- 5.30.1. Before welding over previously deposited metal, all Slag shall be removed from the weld and spatter from the weld and adjacent base metal.
 - 5.30.2. All slag shall be removed from completed welds and spatter from the weld and adjacent base metal.
-

TABLES

The 10 tables in clause 3 are found in pages 208-210 and are listed in the List of Tables by their respective titles and page numbers. Additionally brief reviews of some important tables and their respective references within the text in clause 5 are discussed. Below is the list of tables for clause 5.

5.1	Allowable Atmospheric Exposure of Low-Hydrogen Electrodes.....	208
5.2	Minimum Holding Time	208
5.3	Alternate Stress-Relief Heat Treatment	208
5.4	Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces.....	208
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5.6	Camber Tolerance for Typical Girder	209
5.7	Camber Tolerance for Girders without a Designed Concrete Haunch.....	209
5.8	Minimum Fillet Weld Sizes	209
5.9	Weld Profiles	210
5.10	Weld Profile Schedules	210

Table 5.1 – Allowable Atmospheric Exposure of Low-Hydrogen Electrodes. This table, referred to by sub clause 5.3.2.2, shows the maximum time an electrode can be exposed to the atmosphere and the variations in time frames for different types of electrodes. For example an E7018M can be exposed to the atmosphere for a maximum of 9 hours after which it must be redried for use. Below is table 5.1.

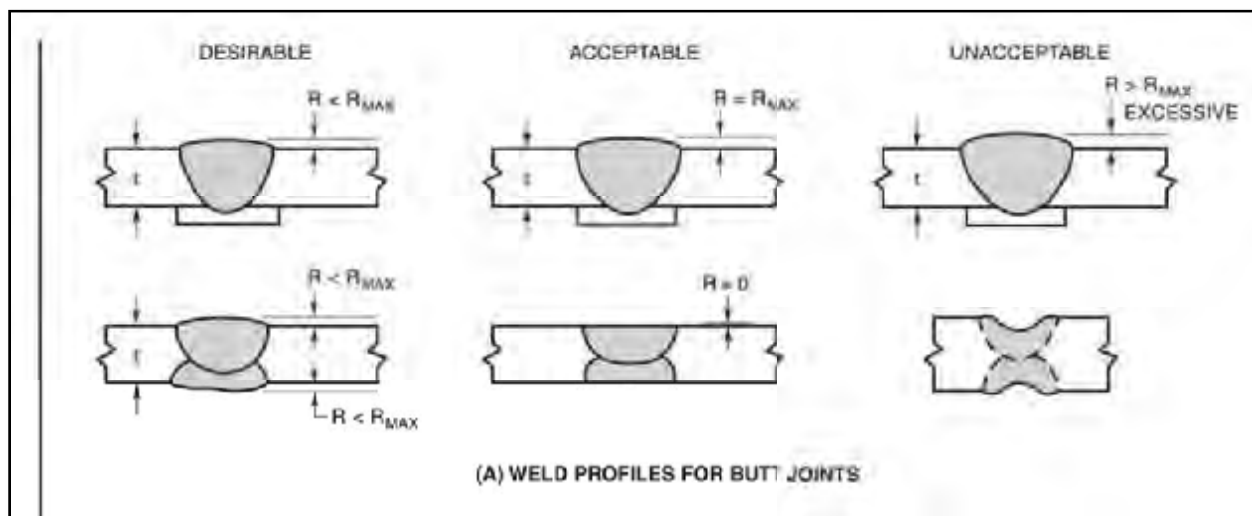
Table 5.1 Allowable Atmospheric Exposure of Low-Hydrogen Electrodes (see 5.3.2.2 and 5.3.2.3)		
Electrode	Column A (hours)	Column B (hours)
A5.1		
E70XX	4 max.	
E70XXR	9 max.	Over 4 to 10 max.
E70XXHZR	9 max.	
E7018M	9 max.	
A5.5		
E70XX-X	4 max.	Over 4 to 10 max.
E80XX-X	2 max.	Over 2 to 10 max.
E90XX-X	1 max.	Over 1 to 5 max.
E100XX-X	1/2 max.	Over 1/2 to 4 max.
E110XX-X	1/2 max.	Over 1/2 to 4 max.
Notes: 1. Column A: Electrodes exposed to atmosphere for longer periods than shown shall be redried before use. 2. Column B: Electrodes exposed to atmosphere for longer periods than those established by testing shall be redried before use. 3. Electrodes shall be issued and held in quivers, or other small open containers. Heated containers are not mandatory. 4. The optional supplemental designator, R, designates a low-hydrogen electrode which has been tested for covering moisture content after exposure to a moist environment for 9 hours and has met the maximum level allowed in AWS A5.1/A5.1M, <i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i> .		

FIGURES

The 4 figures in clause 5 are found in pages 211-214 making it the largest portion of figures for any clause in the code. A detailed list can be found in the List of Figures with their respective titles and page numbers. Additionally a brief review of one important figure is discussed. Below is the list of figures for clause 5.

5.1	Edge Discontinuities in Cut Material.....	211
5.2	Weld Access Hole Geometry	212
5.3	Workmanship Tolerances in Assembly of Groove Welded Joints	213
5.4	Requirements for Weld Profiles	214

Figure 5.4 – Requirements for Weld Profiles. This figure is composed by many diagrams that show the desirable, acceptable, and unacceptable profiles for welds. The figure is referred by table 5.9 and 5.10 which provide ranges and formulas for the weld profiles. Below is an example of the desirable, acceptable, and unacceptable diagrams for butt joints, where the unacceptable diagram demonstrates an excessive amount of convexity.



Chapter 9

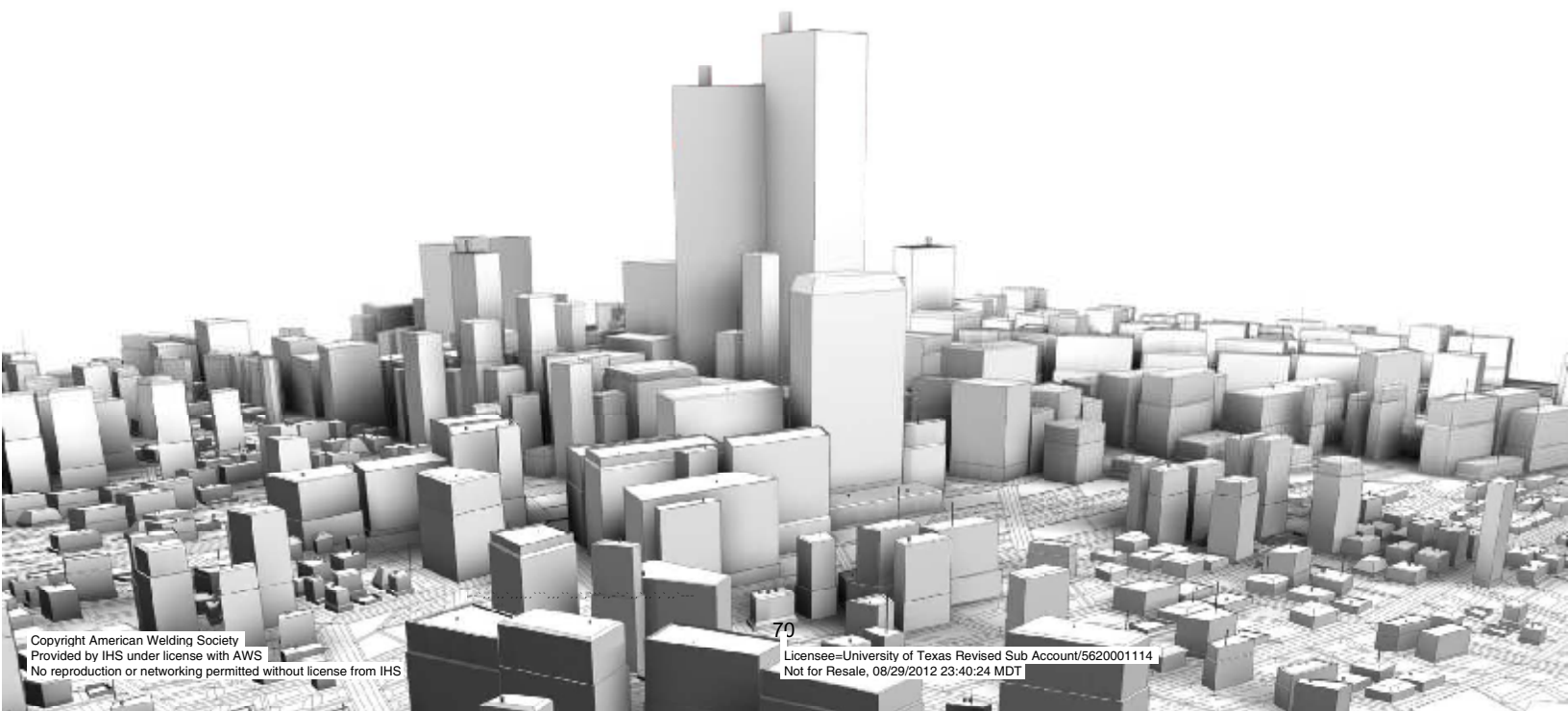
Clause 6: Inspection

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

Clause 6 “contains all of the requirements for the inspector’s qualifications and responsibilities, acceptance criteria for discontinuities, and procedures for NDT.”¹ This clause details the process of inspecting a weld. It covers the qualifications of the inspector, the appearance of the weld (what is acceptable and what is not acceptable) and finishes by stipulating provisions for non-destructive testing which can be performed on a completed weld without affecting its durability.

Clause 6 is the inspection portion of D1.1. It contains all the steps to determine the parameters of how to determine the soundness of the weld. It is appropriate for the clause to be after clause 5 (fabrication), precisely because inspection comes after fabrication. First a weld has to be done before it can be checked. Clause 6 is the inspection or “checking” clause. Requirements concerning the process of detecting, evaluating, and accepting or rejecting a weld are covered in the clause.

TEXT

The text portion of Clause 6 is second biggest second in the clause, shorter than the figures portion but longer than the tables portion. It runs from page 219 to 238 and is distributed amongst 37 sub clauses. This section covers the general structure of the text in clause 6 and reviews some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents.

¹ D1.1 219

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The clause is divided into 7 parts that vary in length – A, B, C, D, E, F and G – which contain all of the sub clauses. Unlike clause 2 and 4, clause 6 has the scope within the first Part A. Also, the parts are uneven in length depending on the subject that each contains. The structure of the clause is as follows:

Part A – General Requirements

Part B – Contractor Responsibilities

Part C – Acceptance Criteria

Part D – Non Destructive Testing (NDT) procedure

Part E – Radiographic Testing (RT)

Part F – Ultrasonic Testing (UT) of Groove Welds

Part G – Other Examination Methods

Part A – General Requirements

Part A stipulates the obligations and responsibilities that fall on the contractor, especially pertaining to visual inspection and deficiencies in material and workmanship.

6.1 General Requirements

- 6.1.2. Specifies that fabrication and erection inspection and testing, and verification inspection and testing, are considered as separate functions.
 - 6.1.2.1 Provides that fabrication and erection inspection is the responsibility of the contractor. Additionally, contractor's inspection shall be performed before, during, and after assembly and welding, as necessary, to ensure that contract conditions in terms of materials and workmanship are satisfied.
 - 6.1.2.2 Provides that verification inspection and testing are prerogatives of the owner, and may be exercised in any manner deemed appropriate by the owner.
 - 6.1.3. Definition of Inspector Categories
 - 6.1.3.1. The contractor's inspector is the person who acts on behalf of the contractor for inspection purposes within the contract limits.
 - 6.1.3.2. The verification inspector is the person who acts on behalf of the owner or engineer for inspection purposes within the contract limits.
 - 6.1.3.3. The unqualified terms 'inspection' or 'inspector' are used, they shall apply equally to fabrication and erection inspections and to verification inspections, within the limits defined in 6.1.2.
 - 6.1.4. Specifies "Inspectors responsible for acceptance or rejection of material and workmanship shall be qualified. The bases of Inspector qualification shall be documented." The paragraph lists three groups of persons deemed to have suitable qualifications.
 - Current or previous certification as a Certified Welding Inspector CWI
 - Current or previous qualification by the Canadian Welding Bureau
 - An individual who, by training or experience, is deemed competent to perform inspection work
 - 6.1.4.2. The period of effectiveness of inspector qualification is indefinite, provided the inspector remains active in inspection and there is no question as to competence.
 - 6.1.4.3. Assistant inspectors may be employed but the inspector is responsible. Both inspectors and assistant inspectors are required to pass an eye examination to prove their visual acuity every three years or less.
-

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- 6.1.4.4. Inspection personnel must pass an eye examination and must retest at least every three years to prove a near vision acuity of Jaeger J-2 at a distance of 12 in – 17 in.
 - 6.1.4.5. The inspector is responsible for establishing that all fabrication and erection by welding is carried out in accordance with the contract provisions.
 - 6.1.4.6. The inspector shall be provided with complete detailed drawings showing sizes, types, lengths and locations of all welds. A copy of the portions of the contract documents describing material and quality requirements for the subject products shall also be provided.
 - 6.1.4.7. The inspector shall be notified in advance of the start of operations subject to inspection.

6.2 Inspection Materials and Equipment

Inspection of Materials and Equipment requires inspectors to determine that only code conforming materials and equipment are used in construction.

6.4 Inspection of Welder, Welding Operator, and Tack Welder Qualification

Inspection of Welder, Welding Operator, and Tack Welder Qualifications requires that all personnel performing welding be qualified according to clause 4 Part C.

6.5 Inspection of Work and Records

Inspection of Work and Records, lists the duties and functions of the inspector in detail.

- 6.5.2. Requires examinations of work before, during and after welding to establish observance of and conformance to all applicable code provisions.
-

Part B – Contractor Responsibilities

Part B specifies the obligations of the contractor. This part is the smallest part of the clause and is contained in only one major sub clause- 6.6.

6.6 Obligations of the Contractor

- 6.6.1. The contractor is responsible for the visual inspection of all welding and the correction of deficiencies of materials and workmanship, in accordance with code provisions.
 - 6.6.2. The contractor must comply with all requests by inspectors to correct deficiencies, as defined in the contract documents.
 - 6.6.3. If either faulty welding, or the removal of faulty welding for rewelding causes damages to the base metal in a manner the Engineer determines is not in accordance with the intent of the contract, the contractor shall remove and repair the damaged base metal, or otherwise provide compensation to the satisfaction of the engineer.
 - 6.6.4. For contract specified nondestructive testing other than visual inspection, it is the contractor's responsibility to ensure the subject welds meet the quality criteria of clause 6 part c. If nondestructive testing was not specified in the contract but is later required by the owner, the contractor shall either perform the required tests or permit testing according to 6.14. All costs associated with non-contract specified tests shall be the responsibility of the owner, except for the repair of those discontinuities described in 6.9. If testing discloses any attempt to defraud or gross nonconformance to the code,
-

the contractor shall pay for the repair.

Part C – Acceptance Criteria

Part C specifies the acceptance criteria for visual and nondestructive testing of tubular connections and statically and cyclically loaded nontubular connections. The acceptance criteria and the extent of examination shall be specified in the contract documents.

6.8 Engineer's Approval for Alternate Acceptance Criteria

Alternate acceptance criteria for production welds differing from that specified in the code may be used if the Engineer approves. The basis of such changes may be past experience, experimental evidence, or engineering documents.

6.10 PT and MT

Specifies that surface nondestructive tests of MT and PT are carried out in accordance with paragraphs 6.14.4 or 6.14.5 whichever is acceptable.

6.11. NDT

Specifies that, all NDE equipment requirements and qualifications, the qualifications of NDE personnel and the techniques of testing shall be in accordance with the provisions of Section 6 of the code, except as provided in Subsection 6.18. Prior to any NDE, all welds shall have been found acceptable by visual inspection in conformance with 6.9 Welds Subject to VT, MT, and PT, (and tubular connections subject to RT and UT), may be tested as soon after the completion of welding as the base metal has cooled to ambient temperature. However, for ASTM A 514, A 517, and A709 Grade 100 and 100W steels, final NDT shall be performed no earlier than 48 hours after the completion of welding.

6.11.1. For CJP groove butt welds made from one side without backing, examination by RT or UT and conformance to the provisions of either paragraphs 6.12.1 (RT) or 6.13.3 (UT), respectively, is mandatory. Thus, if a CJP groove weld in a butt joint is specified for small diameter pipe work, RT or UT is a requirement.

6.12. RT

Discusses the acceptance criteria for welded joints examined by Radiographic Testing.

6.13. UT

Discusses the acceptance criteria for welded joints examined by Ultrasonic Testing.

Part D – Non Destructive Testing (NDT) Procedures

Part D specifies the different test techniques that shall be used for each of the nondestructive test methods.

6.14 Procedures

Warns the users of the code that all NDT has limitations. Expectation that any one method will detect all unacceptable discontinuities is totally erroneous and without merit.

-
- 6.14.6. NDT personnel performing NDT other than visual are to be qualified and certified to ASNT's Recommended Practice SNT-TC-1A.

6.15 Extent of Testing

The extent of NDT and the type of tests to be used are to be furnished to all bidders.

Part E – Radiographic Testing (RT)

Part E addresses the procedures to be used for radiographic testing when it is required by contract documents.

6.16 Radiographic Testing of Groove Welds in Butt Joints

- 6.16.1. Radiography of groove welds should be carried out in accordance with the ASTM test methods E 94, E 142, E 747, and E 1032, as applicable.
- 6.16.2. Variations in testing procedures, equipment, and acceptance standards are permitted if agreement is reached between the contractor and the owner.

6.17 Radiographic Testing Procedures

- 6.17.1. RT requires radiography to be carried out with a single source, either x-ray or gamma radiation. RT techniques are to provide sufficient sensitivity to clearly identify the 'essential hole' or the 'essential wire' of the image quality indicator (IQI) in use.
- 6.17.3. Removal of Reinforcement
- 6.17.3.3. For radiography, weld reinforcement is always a consideration, as are weld tabs and weld backing. Where the reinforcement is not removed, shims are required to be placed under each IQI so radiation will pass through approximately the same thickness as the base metal plus reinforcement.
-

Part F – Ultrasonic Testing (UT) of Groove Welds

Part F sets out the requirements to be used for Ultrasonic Testing when performed on groove welds. It also details the manner in which the equipment is qualified and calibrated and the way in which testing, evaluation, and reporting are to be carried out.

6.20 General

Sets out the thickness limits for UT to be from 5/16 inch to 8 inches when such testing is required in 6.14. It is also noted that the general procedures specified are not to be used for testing tube-to-tube T-, Y-, or K-connections.

6.21 Qualification Requirements

UT operators, as discussed in paragraph 6.14.6, are required to take a specific and a practical examination which shall be based on the requirements of this code. The UT operator must demonstrate ability to apply the code rules in accurate detection and disposition of discontinuities.

6.22 UT Equipment

Details the Ultrasonic Testing Equipment and describes the requirements for UT instruments

and the transducers to be used. The sub clauses in this major sub clause stipulate in detail all of the settings and specifications for UT testing.

Part G – Other Examination Methods

Part G addresses requirements for the procedures, operating techniques, and records required for alternative NDT methods that are not addressed in previous sub clauses including: radiation imaging systems (real-time radiography) and advanced ultrasonic systems.

6.34 General Requirements

The NDT methods in part G may be used as an alternative to the methods outlined in part D, E, or F of clause 6, providing procedures, qualification criteria for procedures and personnel, and acceptance criteria are documented in writing and approved by the Engineer.

6.35 Radiation Imaging Systems

Provides that examination of welds may be performed using ionizing radiation methods other than RT, such as electronic imaging, including real time imaging systems.

6.36 Advanced Ultrasonic Systems

Provides that Advanced Ultrasonic systems may be used, which includes but is not limited to : multiple probe, multi-channel systems, automated inspection, time-of-flight diffraction (TOFD), and phased array systems.

TABLES

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6.6	IQI Selection and Placement.....	243
6.7	Testing Angle	244

The 7 tables in clause 6 are found in pages 239-245 and listed in the List of Tables by their respective titles and page numbers. Additionally brief reviews of some important tables and their respective references within the text in clause 5 are discussed. Below is the list of tables for clause 6.

Table 6.1 – Visual Inspection Acceptance Criteria. This table is referenced by 6.9 stating “all welds shall be visually inspected and shall be acceptable if the criteria of table 6.1 are satisfied.” Essentially, this table is the standard that a welding inspector ought to utilize for determining what discontinuities or abnormalities are acceptable or not. Below is a preview of table 6.1.

Discontinuity Category and Inspection Criteria	Statically Loaded Nontubular Connections	Cyclically Loaded Nontubular Connections	Tubular Connections (All Loads)
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X	X	X
(2) Weld/Base-Metal Fusion Complete fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X	X	X
(3) Crater Cross Section All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X	X	X
(4) Weld Profiles Weld profiles shall be in conformance with 5.24.	X	X	X
(5) Time of Inspection Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Acceptance criteria for ASTM A 514, A 517, and A 709 Grade 100 and 100W steels shall be based on visual inspection performed not less than 48 hours after completion of the weld.	X	X	X
(6) Undersized Welds The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): $L,$ specified nominal weld size, in [mm] $\leq 3/16$ [5] $1/4$ [6] $\geq 5/16$ [8] $U,$ allowable decrease from L, in [mm] $\leq 1/16$ [2] $\leq 3/32$ [2.5] $\leq 1/8$ [3] In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, underrun shall be prohibited at the ends for a length equal to twice the width of the flange.	X	X	X
(7) Undercut (A) For material less than 1 in [25 mm] thick, undercut shall not exceed 1/32 in [1 mm], with the following exception: undercut shall not exceed 1/16 in [2 mm] for any accumulated length up to 2 in [50 mm] in any 12 in [300 mm]. For material equal to or greater than 1 in [25 mm] thick, undercut shall not exceed 1/16 in [2 mm] for any length of weld. (B) In primary members, undercut shall be no more than 0.01 in [0.25 mm] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1/32 in [1 mm] deep for all other cases.	X		
(8) Porosity (A) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1/32 in [1 mm] or greater in diameter shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld. (B) The frequency of piping porosity in fillet welds shall not exceed one in each 4 in [100 mm] of weld length and the maximum diameter shall not exceed 3/32 in [2.5 mm]. Exception: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld. (C) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 4 in [100 mm] of length and the maximum diameter shall not exceed 3/32 in [2.5 mm].	X		
		X	X
		X	X

Note: An "X" indicates applicability for the connection type; a shaded area indicates non-applicability.

Table 6.4 – Hole-Type IQI Requirements and **Table 6.5 Wire IQI Requirements**. These tables are referenced by 6.17.1. Radiographic sensitivity, in radiographic testing procedures is judged by the hole-type image or wire IQIs. Below are previews of table 6.4 and 6.5.

Table 6.4
Hole-Type IQI Requirements (see 6.17.1)

Nominal Material Thickness ^a Range, in	Nominal Material Thickness ^a Range, mm	Source Side		Film Side ^b	
		Designation	Essential Hole	Designation	Essential Hole
Up to 0.25 incl.	Up to 6 incl.	10	4T	7	4T
Over 0.25 to 0.375	Over 6 through 10	12	4T	10	4T
Over 0.375 to 0.50	Over 10 through 12	15	4T	12	4T
Over 0.50 to 0.625	Over 12 through 16	15	4T	12	4T
Over 0.625 to 0.75	Over 16 through 20	17	4T	15	4T
Over 0.75 to 0.875	Over 20 through 22	20	4T	17	4T
Over 0.875 to 1.00	Over 22 through 25	20	4T	17	4T
Over 1.00 to 1.25	Over 25 through 32	25	4T	20	4T
Over 1.25 to 1.50	Over 32 through 38	30	2T	25	2T
Over 1.50 to 2.00	Over 38 through 50	35	2T	30	2T
Over 2.00 to 2.50	Over 50 through 65	40	2T	35	2T
Over 2.50 to 3.00	Over 65 through 75	45	2T	40	2T
Over 3.00 to 4.00	Over 75 through 100	50	2T	45	2T
Over 4.00 to 6.00	Over 100 through 150	60	2T	50	2T
Over 6.00 to 8.00	Over 150 through 200	80	2T	60	2T

^a Single-wall radiographic thickness (for tubulars).

^b Applicable to tubular structures only.

Table 6.5
Wire IQI Requirements (see 6.17.1)

Nominal Material Thickness ^a Range, in	Nominal Material Thickness ^a Range, mm	Source Side Maximum Wire Diameter		Film Side ^b Maximum Wire Diameter	
		in	mm	in	mm
Up to 0.25 incl.	Up to 6 incl.	0.010	0.25	0.008	0.20
Over 0.25 to 0.375	Over 6 to 10	0.013	0.33	0.010	0.25
Over 0.375 to 0.625	Over 10 to 16	0.016	0.41	0.013	0.33
Over 0.625 to 0.75	Over 16 to 20	0.020	0.51	0.016	0.41
Over 0.75 to 1.50	Over 20 to 38	0.025	0.63	0.020	0.51
Over 1.50 to 2.00	Over 38 to 50	0.032	0.81	0.025	0.63
Over 2.00 to 2.50	Over 50 to 65	0.040	1.02	0.032	0.81
Over 2.50 to 4.00	Over 65 to 100	0.050	1.27	0.040	1.02
Over 4.00 to 6.00	Over 100 to 150	0.063	1.60	0.050	1.27
Over 6.00 to 8.00	Over 150 to 200	0.100	2.54	0.063	1.60

^a Single-wall radiographic thickness (for tubulars).

^b Applicable to tubular structures only.

FIGURES

The 23 figures in clause 6 are found in pages 247-279 and listed in the List of Figures by their respective titles and page numbers. Additionally brief reviews of some important figures and their respective references within the text in clause 6 are discussed. Below is the list of figures for clause 6.

6.1	Discontinuity Acceptance Criteria for Statically Loaded Nontubular and Statically or Cyclically Loaded Tubular Connections	247
6.2	Discontinuity Acceptance Criteria for Cyclically Loaded Nontubular Connections in Tension (Limitations of Porosity and Fusion Discontinuities)	252
6.3	Discontinuity Acceptance Criteria for Cyclically Loaded Nontubular Connections in Compression (Limitations of Porosity or Fusion-Type Discontinuities)	257
6.4	Class R Indications.....	262
6.5	Class X Indications	264
6.6	Hole-Type IQI.....	265
6.7	Wire IQI	266
6.8	RT Identification and Hole-Type or Wire IQI Locations on Approximately Equal Thickness Joints 10 in [250 mm] and Greater in Length	267
6.9	RT Identification and Hole-Type or Wire IQI Locations on Approximately Equal Thickness Joints Less than 10 in [250 mm] in Length	268
6.10	RT Identification and Hole-Type or Wire IQI Locations on Transition Joints 10 in [250 mm] and Greater in Length	269
6.11	RT Identification and Hole-Type or Wire IQI Locations on Transition Joints Less than 10 in [250 mm] in Length	270
6.12	RT Edge Blocks	270
6.13	Single-Wall Exposure—Single-Wall View	271
6.14	Double-Wall Exposure—Single-Wall View.....	271
6.15	Double-Wall Exposure—Double-Wall (Elliptical) View, Minimum Two Exposures	272
6.16	Double-Wall Exposure—Double-Wall View, Minimum Three Exposures	272
6.17	Transducer Crystal	273
6.18	Qualification Procedure of Search Unit Using IIW Reference Block	273
6.19	Typical IIW Type Block.....	274
6.20	Qualification Blocks.....	275
6.21	Plan View of UT Scanning Patterns.....	277
6.22	Scanning Techniques.....	278
6.23	Transducer Positions (Typical).....	279

Figure 6.10 – RT Identification and Hole-Type or Wire IQI Locations on Transition Joints 10 in [250 mm] and Greater in Length. This figure is referenced by 6.17.7. The sub clause specifies that IQIs shall be selected and be placed on the weldment in the area of interest as shown in figure 6.10. Below is 6.10.

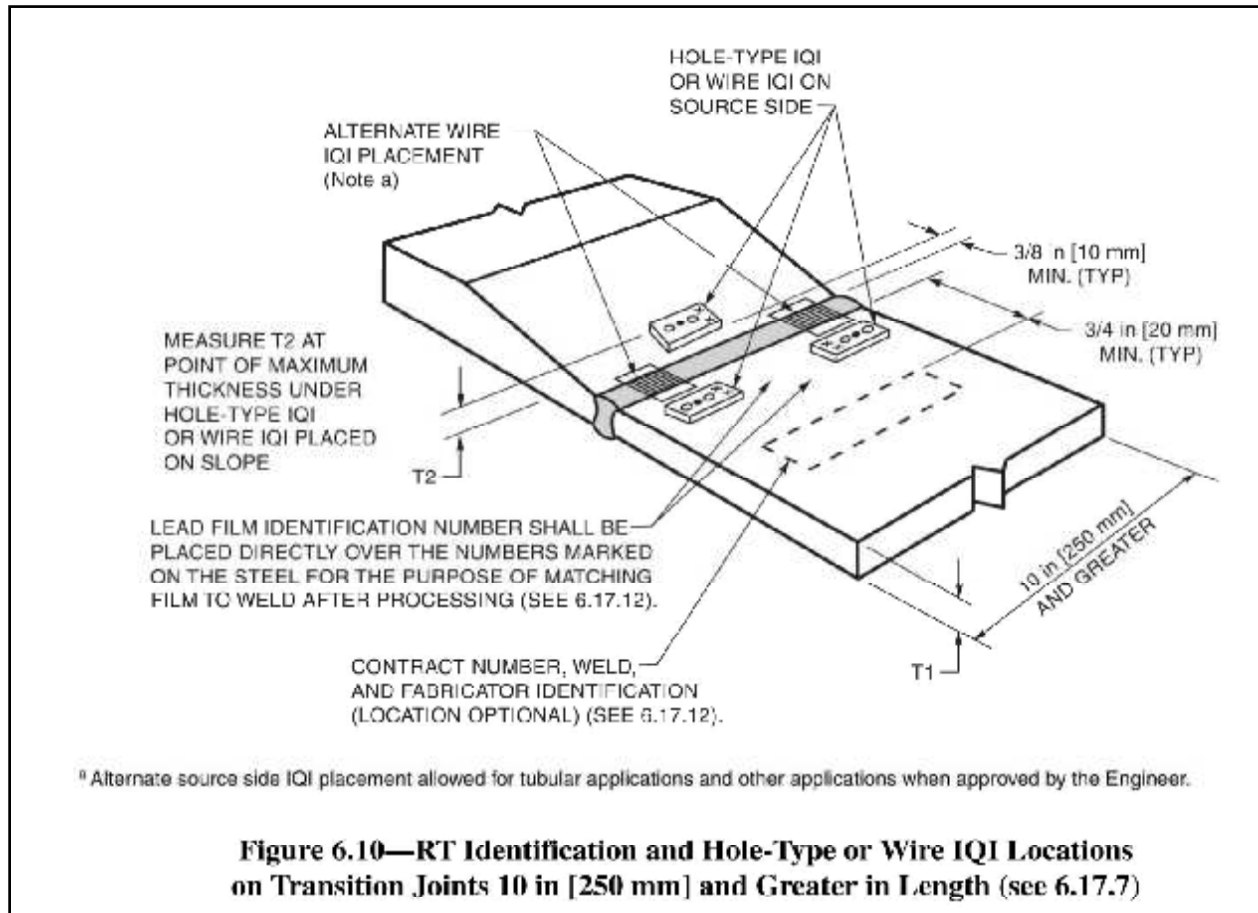
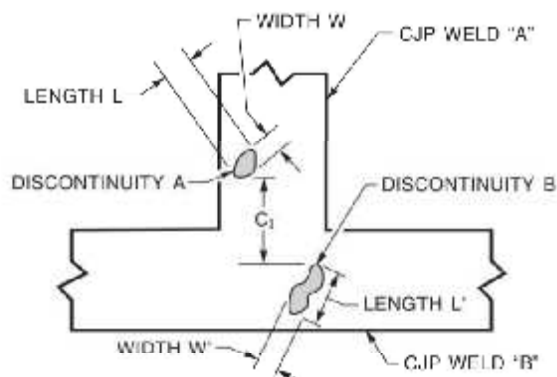


Figure 6.1 – Discontinuity Acceptance Criteria for Statically Loaded Nontubular and Statically or Cyclically Loaded Tubular Connections. Like figures 6.2 and 6.3, figure 6.1 gives the maximum allowable discontinuity size and minimum clearance requirements for the type of weld that is specified. Additionally, each figure also contains a detailed key which contains multiple cases covering specific situations, such as laminations, free edges of CJP groove welds, and weld intersections. Below figure 6.1.

KEY FOR FIGURE 6.1, CASES I, II, III, AND IV

DISCONTINUITY A = ROUNDED OR ELONGATED DISCONTINUITY LOCATED IN WELD A
 DISCONTINUITY B = ROUNDED OR ELONGATED DISCONTINUITY LOCATED IN WELD B
 L AND W = LARGEST AND SMALLEST DIMENSIONS, RESPECTIVELY, OF DISCONTINUITY A
 L' AND W' = LARGEST AND SMALLEST DIMENSIONS, RESPECTIVELY, OF DISCONTINUITY B
 E = WELD SIZE
 C₁ = SHORTEST DISTANCE PARALLEL TO THE WELD A AXIS, BETWEEN THE NEAREST DISCONTINUITY EDGES



CASE I DISCONTINUITY LIMITATIONS*

DISCONTINUITY DIMENSION	LIMITATIONS	CONDITIONS
L	$< E/3, \leq 1/4$ in [6 mm]	$E \leq 2$ in [50 mm]
	$< 3/8$ in [10 mm]	$E > 2$ in [50 mm]
C ₁	$\geq 3L$	(A) ONE DISCONTINUITY ROUNDED, THE OTHER ROUNDED OR ELONGATED ^a (B) $L \geq 3/32$ in [2.5 mm]

* The elongated discontinuity may be located in either weld "A" or "B." For the purposes of this illustration the elongated discontinuity "B" was located in weld "B."

Case I—Discontinuity at Weld Intersection

Figure 6.1 (Continued)—Discontinuity Acceptance Criteria for Statically Loaded Nontubular and Statically or Cyclically Loaded Tubular Connections (see 6.12.1)

Chapter 10

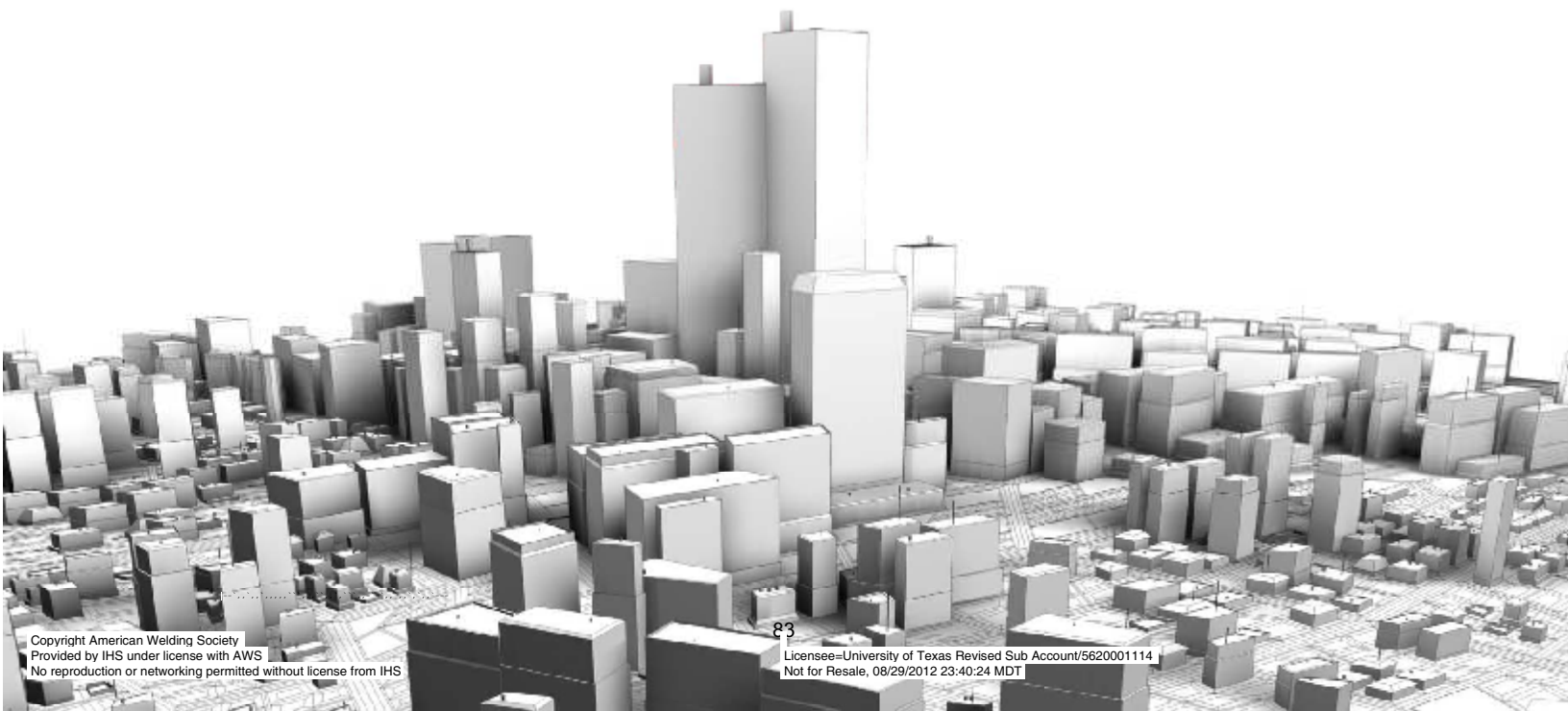
Clause 7: Stud Welding

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

According to D1.1, clause 7 “contains general requirements for welding of steel studs to steel.” The clause has provisions that pertain to the welding of studs to steel which includes: workmanship, reproduction testing, operator qualification, application qualification testing, in-process fabrication, inspection, mechanical properties of the studs, requirements for qualification of stud bases, and the stud manufacturer’s certification of stud base metal weldability.

Clause 7 is the next to last clause in the code. It is situated between the clause concerning fabrication (clause 6) and the clause concerning repair (clause 8). Repairing and strengthening of welds is of course, the last step in the construction after all welding (including stud welding) is finished. It is therefore the last clause. Stud welding is the clause immediately preceding clause 8 which suits the order of the code because stud welding is differentiated from the other welding process covered in the first six clauses such as SAW, SMAW, and FCAW. Most importantly, all questions dealing with stud welding will be found in clause 7.

TEXT

The text portion of Clause 7 is the biggest section of the clause. It runs from page 281 to 285 and is distributed amongst 22 sub clauses. At five pages long, it is larger than the figures and tables portion which means the clause is relatively small. This section covers the general structure of the text in clause 7 and reviews some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents.

7. Stud Welding	281
7.1 Scope	281
7.2 General Requirements	281
7.3 Mechanical Requirements	282
7.4 Workmanship/Fabrication	282
7.5 Technique	282
7.6 Stud Application Qualification Requirements	283
7.7 Production Control	284
7.8 Fabrication and Verification Inspection Requirements	285
7.9 Manufacturers' Stud Base Qualification Requirements	285

Clause 7 like clause 1 and 8 is a short clause without any major subdivision. Each sub clause is relatively short and concise. In the following section important sub clauses from clause 7 are reviewed.

7.2 General Requirements

7.2.1. Specifies that while studs can be of almost any shape, the general form is as shown in Figure 7.1 with typical dimensions shown in the accompanying table.

7.3 Mechanical Requirements

7.3-1. The mechanical properties shall conform to the provisions of Table 7.1.

7.4 Workmanship/Fabrication

- 7.4.1. States that studs shall be clean, free of rust, rust pits, oil, moisture, and other deleterious matter.
- 7.4.2. Studs shall not be painted, galvanized, or cadmium-plated prior to welding.
- 7.4.3. The area where studs are to be applied shall be clean and free of injurious material to the extent necessary to obtain satisfactory welds and to prevent objectionable fumes. Cleaning may be by brushing, scaling, prick-punching or grinding.
- 7.4.5. Allows a longitudinal and lateral variance of up to 1" in the placement of studs from the locational requirements shown in the applicable drawings. Although 1-1/2 inches (40 mm) is the recommended minimum distance from the edge of a stud base to the edge of a flange, the absolute minimum shall be the stud diameter plus 1/8 inch.
- 7.4.6. Requires that for studs to be encased in concrete, and preferably in the case of all other studs, arc shields (ferrules) shall be broken and removed after welding.
- 7.4.7. Requires that all welds shall exhibit a full 360° of flash and be free of any discontinuities or substances that would interfere with the intended function. However, the fillet weld profile provisions of Figure 5.4 do not apply to the flash of automatically timed stud.

7.5 Technique

- 7.5.1. States that for stud welding direct current electrode negative power is required, with voltage, current, time, and gun settings for lift and plunge set at optimum values. Parameters are typically based on past experience or the stud manufacturer's recommendations.
- 7.5.2. States that if two or more guns are connected to a single power source, they shall be interlocked to prevent simultaneous welding.
- 7.5.3. Requires the gun to be held in position without movement during welding.
- 7.5.4. States that welding shall not be done when the base metal temperature is below 0°F (-18°C) or when the surface is wet or exposed to falling rain or snow. However, when the base metal temperature is < 32°F (0°C), one additional stud per hundred (1 per 100 studs) shall be tested as per subparagraphs 7.7.1.3 and 7.7.1.4, but with bending limited to 15°.
- 7.5.5. At the contractor's option, prequalified SMAW, GMAW, or FCAW may be used, in which case fillet weld sizes are governed by the larger of either Table 5.8 or Table 7.2.

7.6 Stud Application Qualification Requirements

- 7.6.1. Provides that, in general, studs that are applied in the flat position are deemed prequalified when the stud manufacturer has qualified the stud base.

7.8- Fabrication and Verification Inspection Requirements

- 7.8.1. Provides that if visual inspection shows less than 360° of flash, all such studs plus any stud that has been repaired by welding shall be bent approximately 15°. In the case of threaded studs, each such stud shall be torque tested.
-

TABLES

The 2 tables in clause 7 are found on page 287 and are listed in the List of Tables by their respective titles and page numbers. Additionally a brief review of one important table in clause 7 is discussed. Below is the list of tables for clause 7.

7.1	Mechanical Property Requirements for Studs	287
7.2	Minimum Fillet Weld Size for Small Diameter Studs	287

Table 7.1 – Mechanical Property Requirements for Studs. Sub clause 7.3.1 refers to this table by stating that “...studs shall conform to the standard {mechanical} properties shown in table 7.1.”¹ This table provides the ranges and thresholds for the different mechanical properties that studs in conformance with D1.1 require, which include: tensile strength, yield strength, elongation, and reduction of area. For example type A studs must have a minimum tensile strength of 61,000 psi (420 MPa). Below is table 7.1.

Table 7.1 Mechanical Property Requirements for Studs (see 7.3.1)				
		Type A ^a	Type B ^b	Type C ^c
Tensile strength	psi min.	61 000	65 000	80 000
	MPa min.	420	450	552
Yield strength (0.2% offset)	psi min.	49 000	51 000	—
	MPa min.	340	350	—
(0.5% offset)	psi min.	—	—	70 000
	MPa min.	—	—	485
Elongation	% in 2 in min.	17%	20%	—
	% in 5x dia. min.	14%	15%	—
Reduction of area	% min.	50%	50%	—

^a Type A studs shall be general purpose of any type and size used for purposes other than shear transfer in composite beam design and construction.

^b Type B studs shall be studs that are headed, bent, or of other configuration in 3/8 in [10 mm], 1/2 in [12 mm], 5/8 in [16 mm], 3/4 in [20 mm], 7/8 in [22 mm], and 1 in [25 mm] diameter that are used as an essential component in composite beam design and concrete anchorage design.

^c Type C studs shall be cold-worked deformed steel bars manufactured in conformance with specification ASTM A 496 having a nominal diameter equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire. ASTM A 496 specifies a maximum diameter of 0.628 in [16 mm] maximum. Any bar supplied above that diameter shall have the same physical characteristics regarding deformations as required by ASTM A 496.

¹ D1.1 84 *emphasis added*

FIGURES

The 5 figures in clause 7 are found in pages 288-290 and listed in the List of Figures by their respective titles and page numbers. Additionally a brief review of two important figures in clause 7 are discussed. Below is the list of figures for clause 7.

7.1	Dimension and Tolerances of Standard-Type <u>Headed Studs</u>	288
7.2	Typical Tension Test Fixture	288
7.3	Torque Testing Arrangement and Table of Testing Torques	289
7.4	Bend Testing Device	290
7.5	Suggested Type of Device for Qualification Testing of Small Studs	290

Figure 7.1 – Dimensions and Tolerances of Standard- Type Headed Studs. Sub clause 7.2 states that although studs can be of almost any shape, the general form is shown in figure 7.1 with standard dimensions and tolerances. Below is Figure 7.1.

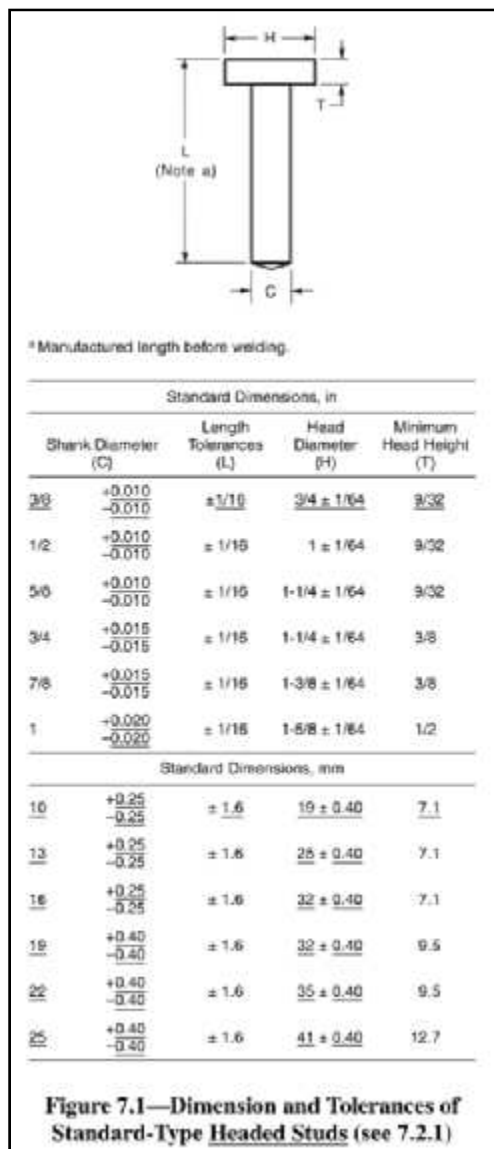
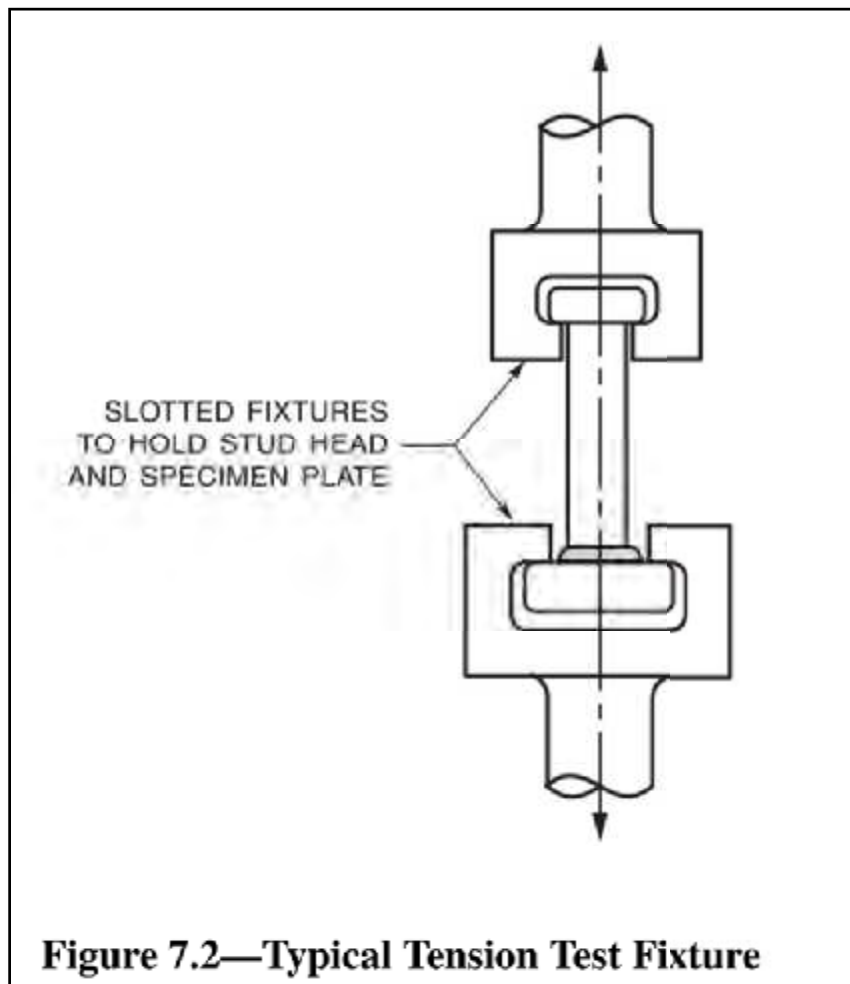


Figure 7.2 – Typical Tension Test Figure. This table is referred to by 7.3.2 as an example of a typical test fixture for a stud test. Other variations may be acceptable as long as they conform to ASTM 370 *Mechanical Testing of Steel Products*. Below is figure 7.2.



Chapter 11

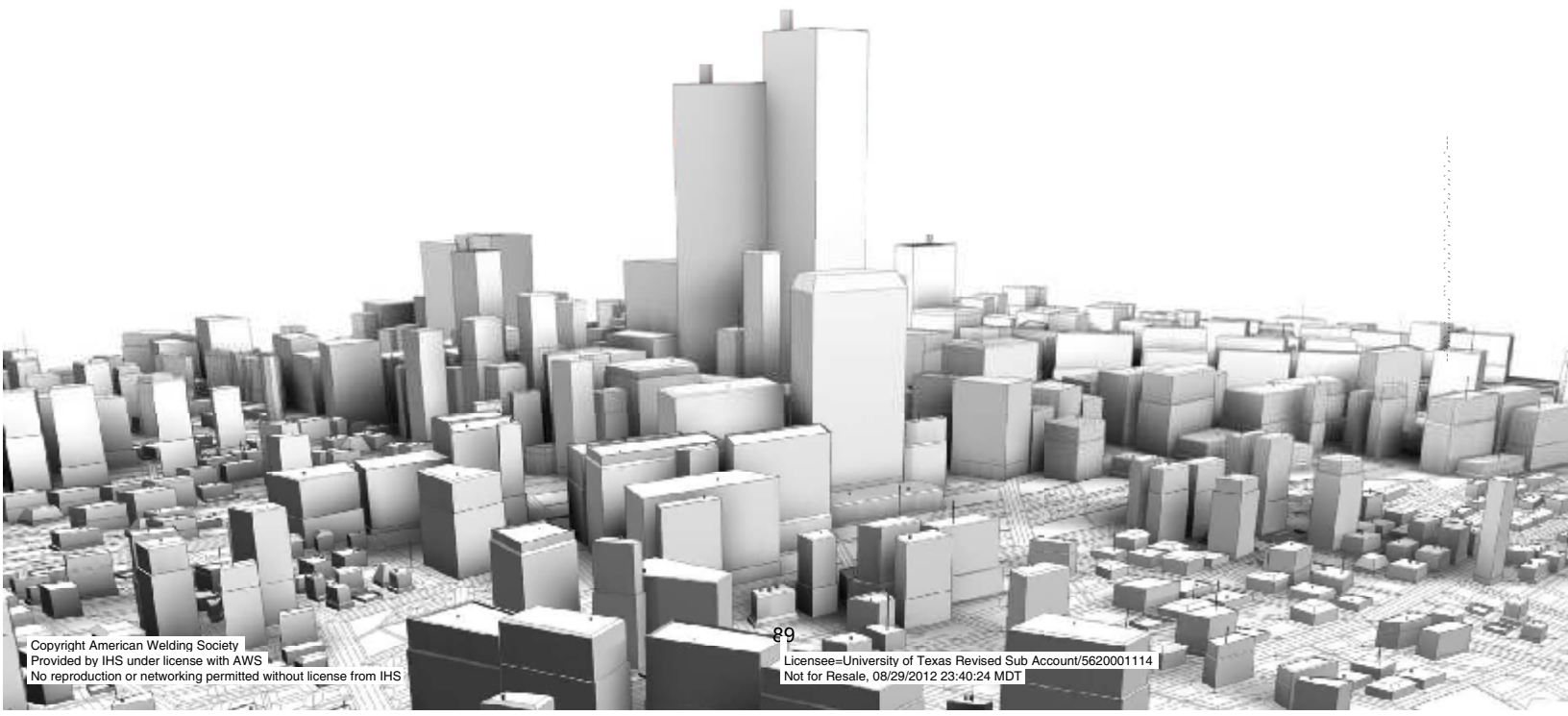
Clause 8: Strengthening and Repairing Existing Structures

Introduction.....

Text.....

Tables

Figures



INTRODUCTION

Clause 8 “applies equally to the strengthening *and* the repair of existing structures....”¹ The code defines ‘strengthening’ and ‘repairing’ of an existing structure as any change and modification necessary to meet the engineer’s design requirements. Effectively, the engineering must prepare a plan for modification of a weld in order to bring the weld into the standards that the engineer has designed. Strengthening and repairing, in this sense, can include design, workmanship, inspection, and documentation.

Clause 8 is the last section of the main parts of the D1.1. It is the last clause because any modification to a weld, *after the process of welding*, is the last step in the construction sequence. Provision concerning changes that can be made to the weld *during welding* is not to be found within this clause. The code defines strengthening and repair using the term “modification.” Which means any allowable changes, after the fabrication of the weld, should be found in this clause.

TEXT

The text portion of Clause 8 is the only section of the clause. It is found in pages 291-292 and is distributed amongst 6 sub clauses. Clause 8 has no tables and figures and is only two pages long making it the smallest clause in the code. This section covers the general structure of the text in clause 8 and reviews some of the important sub clauses that are in the clause. The following is a list of all the sub clauses as listed in the table of contents.

8. Strengthening and Repairing Existing Structures	291
8.1 General	291
8.2 Base Metal.....	291
8.3 Design for Strengthening and Repair.....	291
8.4 Fatigue Life Enhancement	291
8.5 Workmanship and Technique	292
8.6 Quality.....	292

Clause 8 like clause 1 and 7 is a short clause without any major sub divisions. Each sub clause is rather short in length. The following section reviews important provisions contained in clause 8 accompanied by the sub clauses they fall under.

8.2	Base Metal
8.2.1.	Requires that contract plans and specifications specify the base metal designation, and the location, type, size and extent of all welds.
8.2.2.	Requires that the suitability of welding be established.
8.2.3.	Stipulates that In the event the base metal is found to be other than one of those listed in Table 3.1 or Table 4.9 the Engineer must give special consideration to the filler metal to be used and the WPSs, as applicable.

¹ D1.1 pg 291 emphasis added

8.3 Design for Strengthening and Repair

- 8.3.2. Requires that stresses in the areas affected by strengthening or repair be established and the possibility of accumulated damage be considered.
- 8.3.3. Requires that the previous loading history be considered in designing strengthening and repair.
- 8.3.4. Requires consideration for repairing or replacing corroded or otherwise damaged parts.

8.4 Fatigue Life Enhancement

- 8.4.1. Permits the use of the following five fatigue life enhancement techniques:
 - Profile Improvement
 - Toe Grinding
 - Peening
 - TIG Dressing
 - Toe Grinding plus Hammer Peening
- 8.4.2. Requires that any resulting increase in stress range due to fatigue life enhancement be established by the engineer.

8.5 Workmanship and Technique

- 8.5.1. Requires existing base metal to be in contact with new base metal shall be cleaned and free of dirt, rust, and foreign matter. However, adherent paint films as per SSPC SP2 (Surface Preparation Specification #2-Hand Tool Cleaning) may remain. All portions of old and new base metal to receive welding shall be cleaned for at least 2 inches in each direction from the weld root.
- 8.5.2. Stipulates that, if required by the engineer, existing discontinuities shall be repaired prior to heat application for straightening, curving or welding.
- 8.5.3. Weld repairs, when required, are to be made in accordance with subclause 5.26.
- 8.5.5. Requires that the temperature in heat straightening shall not exceed the limits set out elsewhere in the code, nor shall accelerated cooling take place from above 600°F.
- 8.5.6. Requires that the sequence of welding and of welds made during strengthening or repair welding shall result in a balanced heat input around the neutral axis with a view to minimizing distortion and distortion.

8.6 Quality

- 8.6.1. Requires that all members and welds affected by the work shall be visually inspected according to the Engineer's requirements.
-

Chapter 12

Attacking the Question

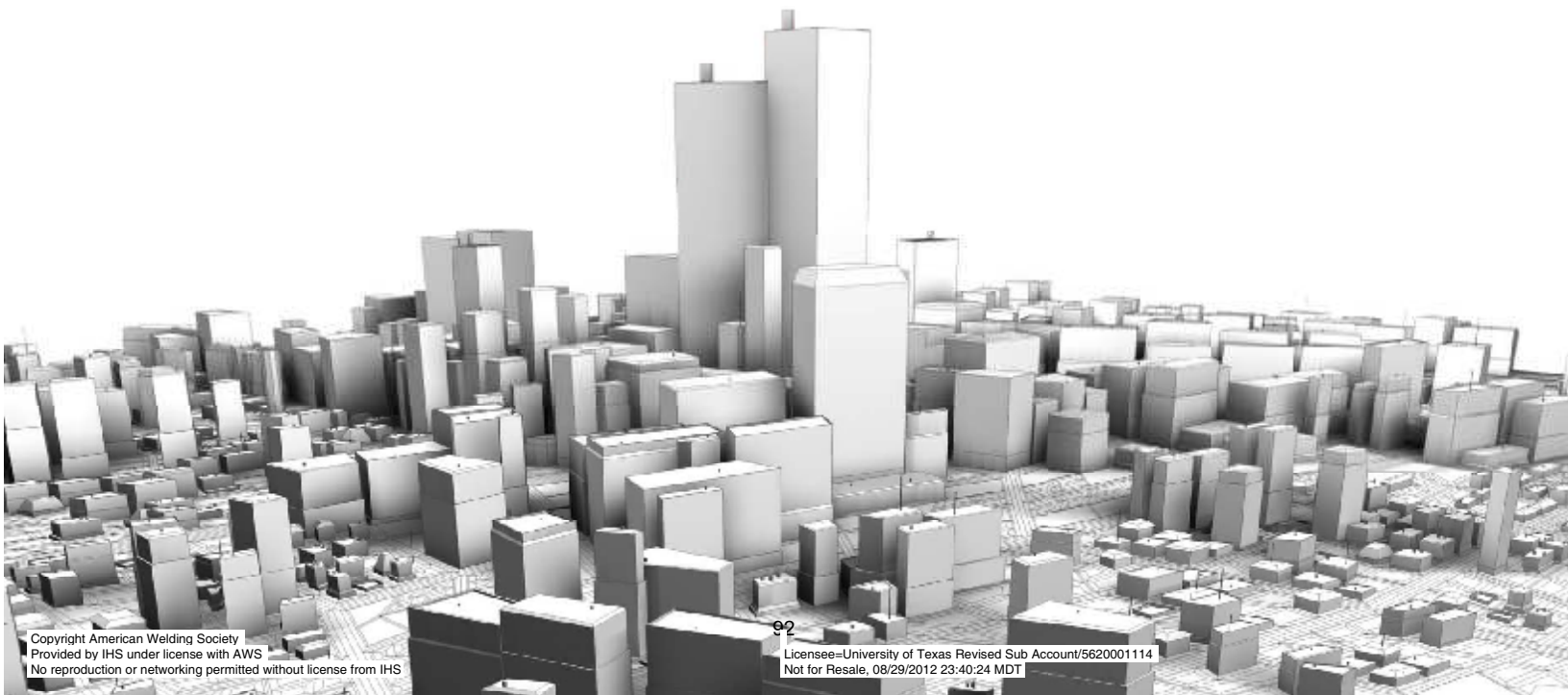
Attacking the Question

Keywords

Primary vs. Secondary Keywords

Keywords in the Answer

What is the Question really asking for?



ATTACKING THE QUESTION

Each question in the D1.1 code book exam will test the ability to navigate through vast amounts of information. Test takers are not expected to answer questions from their own knowledge or memories, but rather they are expected to dive into the code book itself to locate the answer.

“Attacking the Question” means to take an offensive, proactive approach to finding answers. The first step in this approach is mental; Test takers must understand that every answer to the D1.1 exam is inside their code book. There is no need to be nervous or anxious. Following this simple approach will ensure that test takers have enough time to complete the exam and obtain a passing score.

Before starting the search for the answer to any question, test takers must ask themselves two important questions that if answered correctly, will point them towards the correct answer:

1. What are the keywords in the question (and answers)?
2. What is the question asking for?

Attacking the question begins with this simple step. Once those questions have been answered, your understanding of the code, familiarity with the clauses, and some simple strategies that are covered in the coming chapters will combine to make the answer quite apparent. Your next step (which will be addressed later in the book) is to answer more specific follow up questions:

3. Should my answer be in a text, table, or figure?
4. What clause should I expect my answer to be in?
5. Should I start by using the Index? Table of Contents? List of Tables? or List of Figures?

All questions on the D1.1 exam can be addressed by going through this process. As test takers practice utilizing this system, their speed and accuracy in locating specific information will increase, allowing for more efficient test taking.

KEYWORDS

There are specific words in each question that give you a clue as to where to search for your answer. All questions have a few important words that were intended to point you to a specific part of the code. These crucial words are called keywords. Keywords are words or phrases that act as a road map through the question. Let’s look at a few examples:

- | |
|---|
| 1. What is the lowest ambient temperature at which welding may be done according to AWS D1.1?
a) Less than 0°F
b) Less than 18°F
c) All the above
d) 0°F
e) 18°F |
|---|

In the example above “ambient” and “temperature” are the two keywords.

Some might be tempted to highlight “welding” and “AWS D1.1” as keywords as well. However, in the context of the exam, all questions will be related to welding and AWS D1.1 one way or another. Knowing these terms will not help to narrow the search. In fact concentrating too much on those terms might have a detrimental effect- they might broaden the scope of the search unnecessarily. Therefore it would be counterproductive to choose “welding” or “AWS D1.1” as key words.

Note: If one were to index the word “temperature” and look for the subheading “ambient,” this will lead straight to sub clause 5.12 on page 198 (see image 1).

The answer which is ‘d’ is contained in paragraph (1) and in the note (see image 2).

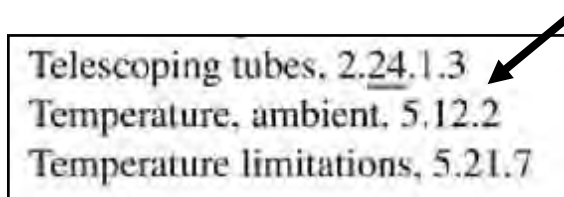


Image 12.1

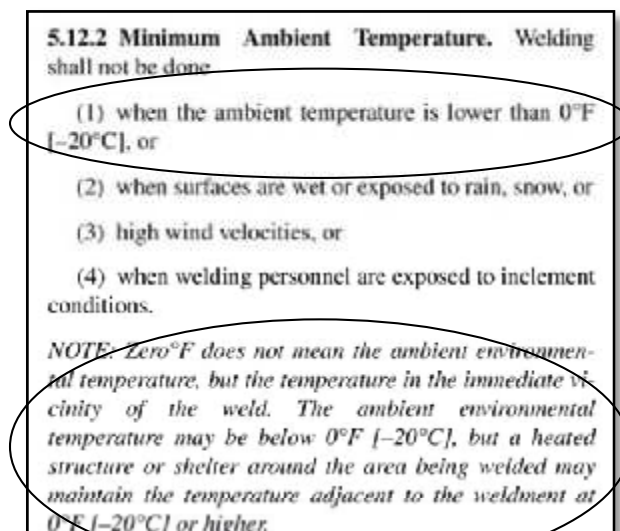


Image 12.2

PRIMARY VS SECONDARY KEYWORDS

Let's consider another example:

2. What is the proper width of a root bend test coupon from a 6 inch, Schedule 40 pipe?

 - a) 1 inch
 - b) 1-1/2 inches
 - c) 1-1/4 inches
 - d) 2 inches
 - e) None of the above

In this example there are five keywords: “width,” “root,” “bend test,” “6 inch,” and “Schedule 40 pipe.”

Sometimes, as in the above example, it becomes necessary, for the sake of efficiency and speed to differentiate between primary and secondary keywords.

- **Primary Keywords** are words or phrases that can be starting points for the search with the navigation tools in the D1.1 code book: index, table of contents, list of tables, and list of figures.
- **Secondary Keywords** are words or phrases that cannot be utilized as starting points for a search, but that are nonetheless necessary to answer the question. Secondary keywords add further details that build upon the information provided by the primary keyword.

In the above example “width”, “6 inch” and “Schedule 40 pipe” are secondary keywords. Test takers will not find these words as main entries in the index, table of contents, list of tables, or list of figures. Nevertheless, once you find the sections of the code that have the provision for root bend tests, test takers *will* need these words to answer the question.

“Root” and “bend test” are the primary words in this question. It is with these two words that test takers must start their search. If you start with the index, look up “bend test requirements” (see image 3). This will lead to 4.9.3.1, 4.9.3.2, and 4.9.3.3. Only the first sub-clause (4.9.3.1, see image 4) has provisions for root bend specimens. The text will directly to figure 4.12.

Bearing at points of loading, 5.23.10
bearing stiffeners, 5.23.10, 5.23.11.3
tolerances, 5.22.2, 5.23.11
Bend test requirements, 4.9.3.1, 4.9.3.2,
4.9.3.3
Bend jig, 4.9.3.1, Figs. 4.15–4.17

Image 12.1

4.9.3.1 Root, Face, and Side Bend Specimens (see Figure 4.12 for root and face bends, Figure 4.13 for side bends). Each specimen shall be bent in a bend test jig that meets the requirements shown in Figures 4.15 through 4.17 or is substantially in conformance with those figures, provided the maximum bend radius is not exceeded. Any convenient means may be used to move the plunger member with relation to the die member.

Image 12.2

At this point secondary keywords come into play. Figure 4.12 has a table that includes schedule 40 pipes above 4 inches (see image 5), and specifies a 1- ½ in. test specimen. The problem specifies a schedule 40 pipe which is 6 inches, thus greater 4 inches. The answer is ‘b.’

Dimensions	
Test Weldment	Test Specimen Width, W in [mm]
Plate	1-1/2 [40]
Test pipe or tube ≤ 4 in [100 mm] in diameter	1 [25]
Test pipe or tube > 4 in [100 mm] in diameter	1-1/2 [40]

Image 12.5

Another option is to use those keywords and start the search in the list of figures. The most appropriate entry for our search is “Face and Root Bend Specimens” (see image 6) which will also lead you to figure 4.12 on page 168.

4.11	Location of Test Specimens on Welded Test Plate 3/8 in [10 mm] Thick and Under—	
	WPS Qualification	167
4.12	Face and Root Bend Specimens	168
4.13	Side Bend Specimens	169

Image 12.3

KEYWORDS IN THE ANSWERS

Let's look at another example:

3. Steel backing for welds in statically loaded structures:
- Need not be welded full length or removed
 - Need not be welded full length or removed unless specified by the Engineer
 - Need not be welded full length or removed unless specified by the Contractor
 - Shall be removed prior to inspection
 - Shall be welded full length, need not be removed

In the above example there are primary keywords in both the question stem and in the answer choices. Often times, test takers will find that the starting point of their search will not be in the question but in the answers. In this case there are two primary keywords (“backing” and “removal”) and one secondary keyword (“statically loaded”).

If a test taker references the index “backing, removal of” they will find two sub clauses that are referenced: 5.10.5 and 6.17.5. Sub clause 5.10.5 states that:

5.10.5 Statically Loaded Connections. Steel backing for welds in statically loaded structures (tubular and non-tubular) need not be welded full length and need not be removed unless specified by the Engineer.

Image12.4

According to 5.10.5 the answer is “b”: “Need not be welded full length or removed unless specified by the Engineer.”

The secondary keyword “statically loaded” structures was not necessary in order to find the information. However, it is important to verify that 5.10.5 is a provision for “statically loaded structures” which is the reason why it can be considered a secondary keyword in this example. 5.10.5 is a provision for statically loaded structures because it is specified in the bold letters at the beginning of the paragraph (see image 7).

WHAT IS THE QUESTION *really* ASKING FOR?

The D1.1 exam may contain questions where merely identifying the keywords will not be enough. Instead test takers are going to have to ask themselves “What is this question *really* asking for?” For example:

1. The maximum weld reinforcement permitted for a procedure qualification test on 6G pipe having a wall thickness of 1-1/2 inches is:
- a) 1/32 inch
 - b) 1/16 inch
 - c) 1/8 inch
 - d) 3/16 inch
 - e) 5/16 inch

The primary keywords are “reinforcement” and “procedure qualification test.” (Note: For the purpose of explaining this concept, the answer is in sub clause 4.9.1 paragraph 3).

Notice that if either “reinforcement” or “procedure qualification test” are searched for in the index, neither leads to 4.9.1 (3). (see images 2. 9 and 2.10)

Reinforcement, 2.12.2.1, 5.24.3,
5.24.3.1, 6.17.3, C-6.17.3
removal of, 5.24.3.2, 6.17.3.3
not removed, 6.17.3.3, C-6.17.3.3

Image 12.8

Prequalified joint details, 2.3.5.4,
2.24.1.2, 3.9.2, 3.13.4, Figs. 3.3–
3.6, 3.8–3.11
Procedure qualification record (PQR),
4.7, Annex N
Processes, 3.2.1, 3.2.2, 3.2.3

Image 12.9

The next step is to ask “What is this question *really* asking for?” A question about maximum allowable reinforcement for a procedure qualification test is an issue that can often arise out in the field. In other words, this is an issue that would come up for a Welding Inspector as he/she is verifying if the procedure qualification test is acceptable or not. The core issue in the question is “acceptance criteria” for a “visual inspection” of a procedure qualification test, not “reinforcement” although it is a keyword.

Now search the index for these words (see images 10 and 11). Note that both have references to sub clause 4.9.1.

Acceptance criteria, 5.15.1.1, 7.4.7 alternate, 6.8
 bend tests, 4.9.3.3, 4.31.4.1, C-4.9.3.3
 fillet weld, 4.31.4.1
 macroetch test, 4.9.4.1, 4.31.2.3
 MT, 6.10, 6.12.2
 nontubular structures, 6.11.2.1, 6.12.2, 6.13.1, 6.13.2
 PT, 6.10, 6.11
 reduced section tension test, 4.9.3.5
 RT, 6.12, 6.12.1
 stud welding, 7.7
 tack welds, 4.32
 tubular structures, 6.12.1, 6.13.3
 UT, 6.13
 visual, 4.9.1, 4.31.1, 6.9, Table 6.1

Image 12.10

Visual inspection, 4.9.1, 5.15.1.2, 6.5.3, 6.9, 7.5.5.7, 7.7.1.3, 7.7.1.4, 7.7.1.5, 7.8.1, C-5.15.1.2, C-6.9, C-7.7.1.4, Table 6.1

Image 12.5

4.9.1 Visual Inspection of Welds. The visual acceptable qualification for qualification of groove and fillet welds (excluding weld tabs) shall conform to the following requirements, as applicable:

4.9.1.1 Visual Inspection of Groove Welds. Groove welds shall meet the following requirements:

- (1) Any crack shall be unacceptable, regardless of size.
- (2) All craters shall be filled to the full cross section of the weld.
- (3) Weld reinforcement shall not exceed 1/8 in [3 mm]. The weld profile shall conform to Figure 5.4 and shall have complete fusion.
- (4) Undercut shall not exceed 1/32 in [1 mm].
- (5) The weld root for CJP grooves shall be inspected, and shall not have any cracks, incomplete fusion, or inadequate joint penetration.
- (6) For CJP grooves welded from one side without backing, root concavity or melt through shall conform to the following:
 - (a) The maximum root concavity shall be 1/16 in [2 mm], provided the total weld thickness is equal to or greater than that of the base metal.
 - (b) The maximum melt-through shall be 1/8 in [3 mm] except for tubular T-, Y-, and K-connections, where melt through is not limited.

Image 6.12

Now consider subclause 4.9.1:

Paragraph (3) states that weld reinforcement shall not exceed 1/8 inch. The answer is therefore “c.”

It is important to reiterate how crucial it is to ask oneself “what is the question *really* asking for?” this will allow test takers to answer questions whose keywords are not necessarily directly related to an entry in the index or in the table of contents. Instead, they can use their welding knowledge to make an indirect connection from the keywords to other words that are more intimately related to what the test maker’s intent was in formulating the question.

Chapter 13

Using the Index and Table of Contents

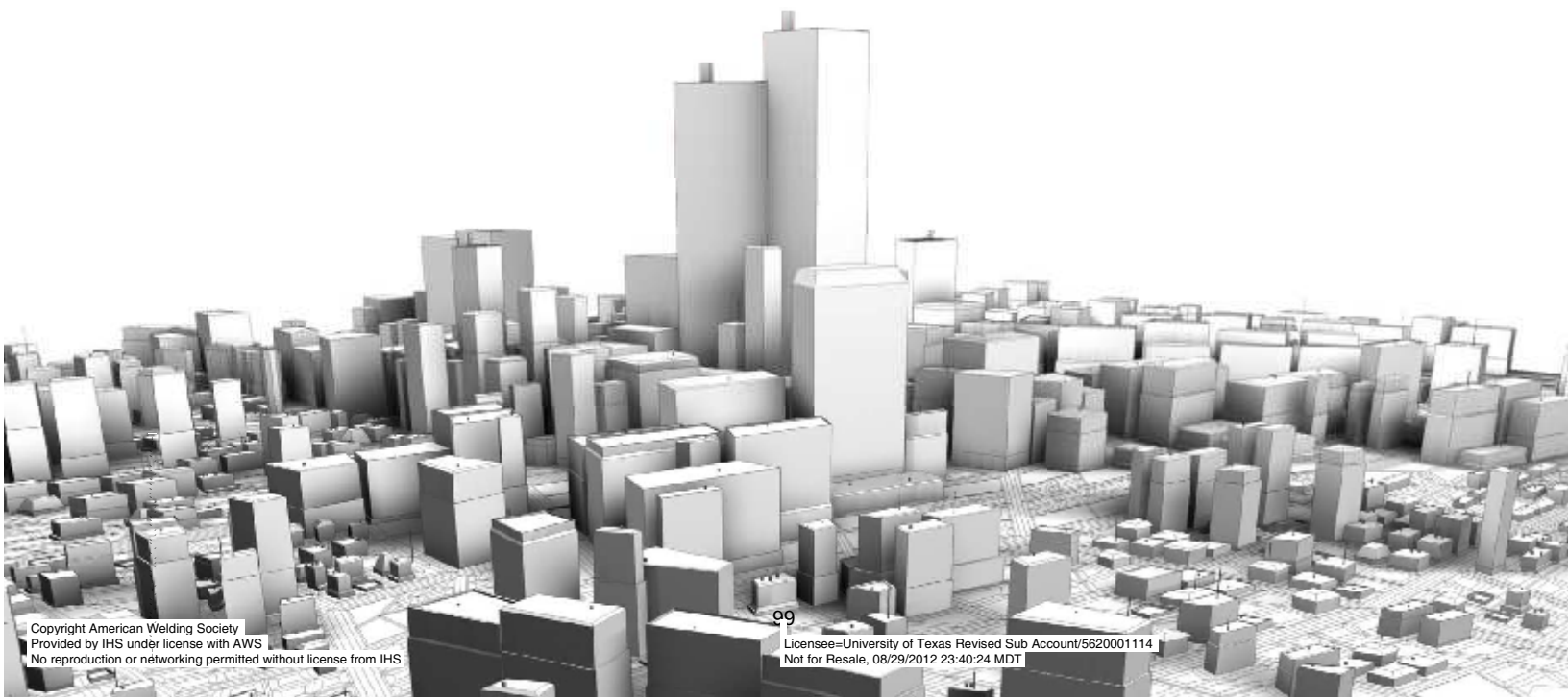
Using the Index

Headings and Sub Headings

Synonyms and Repeated References

Differences between the Index and the Table of Contents

Using the Table of Contents



USING THE INDEX

The index is the most effective and speedy tool that you have to look for information in the D1.1. A large percentage of the inquiries that you have into the code will force you to start by flipping directly to the index. If you know what you are looking for, the index will take you there.

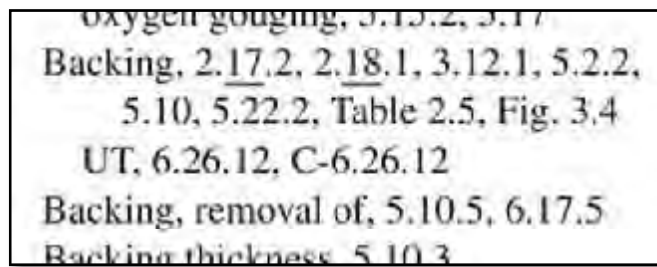
Remember though most everyday tests require you to actually memorize and absorb the content of the book, the D1.1 exam does not follow this pattern. The D1.1 exam will test your ability to navigate, not to memorize. It is perfectly normal, indeed expected, for you not to know in what clause and sub-clause a specific piece of information is found. The index serves as that map that helps you narrow your search for the desired information. Learn to use it often. Learn to use it well.

Let's look at a sample test question:

1. Steel backing for welds in statically loaded structures:
 - a) Need not be welded full length or removed
 - b) Need not be welded full length or removed unless specified by the Engineer
 - c) Need not be welded full length or removed unless specified by the Contractor
 - d) Shall be removed prior to inspection
 - e) Shall be welded full length, need not be removed

Backing is mentioned in four (4) clauses within the code: clause 2, 3, 5 and 6. Therefore, instead of searching through all four clauses, it is much more time efficient to use the index in order to narrow your search.

Go to the index to section "B" and find what is listed for 'Backing.' See image 1.

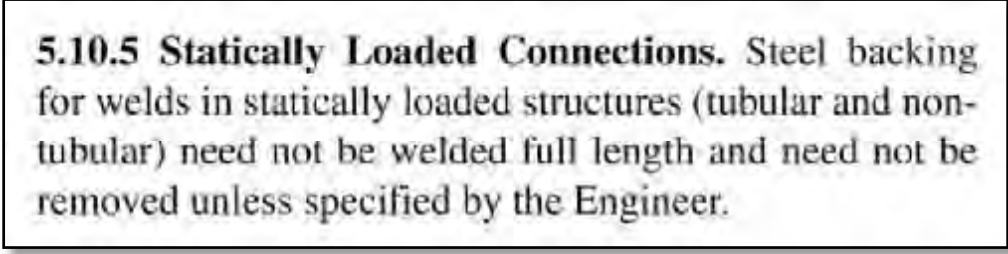


oxygen gouging, 3.13.2, 3.17
Backing, 2.17.2, 2.18.1, 3.12.1, 5.2.2,
5.10, 5.22.2, Table 2.5, Fig. 3.4
UT, 6.26.12, C-6.26.12
Backing, removal of, 5.10.5, 6.17.5
Backing thickness, 5.10.3

Image 13.1

The index should list all of the section numbers where the code references backing. However, because there are so many references we need a little more information to narrow our search. If you look at the possible answers for our question, the word "removal" is referenced in all the answers, making it an important keyword. Instead of the entry "backing", it is better to look at the entry "backing, removal of."

Now refer back to the index (image 1) and notice that there are two separate sub-clauses under “Backing, removal of”: 5.10.5, and 6.17.5. You can choose either reference to begin your search. We will begin with the first one, 5.10.5 (see image 13.2).



5.10.5 Statically Loaded Connections. Steel backing for welds in statically loaded structures (tubular and non-tubular) need not be welded full length and need not be removed unless specified by the Engineer.

Image 13.2

Sub-clause 5.10.5 is almost verbatim the answer choice ‘B’ in the question. We don’t need to look any further.

As you can see with the use of the index, we have just saved time by avoiding searching clause 2, 3, and 6 which also refer to backing. We have just avoided sifting through more than 100 pages of text, tables, and figures, and nevertheless found the right answer.

As you continue to practice using the index, you will begin to notice that though it is a great tool, it does have its share of kinks and nuances. The following is a set of tips that will help you make better use of the index as you navigate the code.

HEADINGS AND SUB-HEADINGS

There are two types of entries in the index: headings and sub headings. All the headings in the index are arranged in alphabetical order and divided by each of the letters in the alphabet. The sub-headings are arranged in alphabetical order *within* each sub heading. Sub headings can be recognized because they are indented farther to the left than their respective headings.

In the example below “film” is the heading and “length,” “overlapping cassette,” and “width,” are the sub headings (see image 13.3).

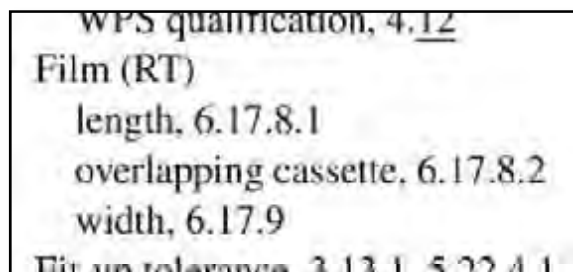


Image 13.3

When looking up information in the D1.1 you will often look up a word that is a heading, and then look up another keyword to determine what sub-heading to look up. Take a look at the following sample test question:

1. Per AWS D1.1, what is the maximum fillet weld size for a statically loaded lap joint on 1/4 inch thick steel?
 - a) 1/8 inch
 - b) 3/16 inch
 - c) 1/4 inch
 - d) 5/16 inch
 - e) 3/5 inch

Image 33.4

CLAUSE NUMBERS vs. PAGE NUMBERS

The D1.1 code book, unlike most indexes, references clause numbers instead of page numbers.

For example, the entry for “Fillet Weld, minimum size” refers you to sub-clauses 2.18.3, 3.9, 3.9.3.2, 5.14, and 7.5.5.4 instead of pages 15, 61, 61, 198, and 283 respectively.

Naturally, the lack of page numbers creates a delay of a few seconds when trying to find a sub-clause because the index does not point you to a specific page.

However there is an advantage to having the clause number. In the above example, clauses 2, 3, 5 and 6 are referenced. We know clause 2 deals with design of welded connections, clause 3 with prequalification of WPSs, clause 5 with fabrication, and clause 6 with inspection. With that in mind you can be selective about which reference to go to first. If you wanted to know the minimum fillet weld size depending on the thickness of the metal then you should most likely check fabrication (clause 5) first. If you wanted to know the absolute minimum size of any fillet weld according to the code then you would more than likely find that information in design (clause 2).

Combining your knowledge of the general contents of each clause with the clause references in the index will enable you to find information quicker.

Fatigue, cont'd
 increase in, 2.6.5, 2.21.6.4
 behavior improvement, 2.21.6.6
 categories, 3.13.5, Tables 2.5, 2.8
 critical members, 2.21.6.5
 cumulative damage, 2.21.6.4
 cyclically loaded structures, 2.16.2, Table 2.5
 history, 8.3.3
 life enhancement, 8.4
 loading, 8.3.5
 peening, 2.21.6.6(3)
 size and profile effects, 2.21.6.7
 stress categories, 2.21.6.2, Table 2.7, Fig. 2.13
 stress cycles, 2.21.6.1
 stress range, 2.21.6.1, Figs. 2.11, 2.13
 tubular structures, 2.21.6.6, Tables 2.7, 2.8
 Faying surfaces, 2.4.5.3, 5.22.1, 5.24.3.2
 FCAW (Flux cored arc welding), 3.2.1, 3.10
 backing, 5.10, C-5.10
 electrodes, 5.3.1.5, 5.3.4, 5.3.4.1
 layer thickness, Table 3.7
 limitations, 3.13, 3.2.4
 power sources, 3.2.4, C-3.2.4
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 protection, 5.12.1
 shielding gas, 5.3.1.3, C-5.3.1.3
 WPS qualification, 4
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 FCAW-G, FCAW-S, Annex K
 Ferrules, 7.4.4
 Fiber stresses, 2.21.3
 Field welds, 2.3.1
 Fillers (nonmetallic), C-5.28
 Filler metals
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 hydrogen control, Annex I6.2
 matching requirements, 3.3, Tables 2.3, 2.6
 powdered, Table 4.5(9)
 properties, Annex V
 storage, 5.3.1.4, 5.3.2.1, C-5.3.2.1
 strength level match, Table 2.3
 welder group designation, 4.2.31, 4.23, C-4.23, Table 4.13
 Filler plates, 2.11, 2.11.1, 2.11.2, Figs. 2.1, 2.9
 Filler welds, 2.4.2
 allowable stresses, 2.6.4.2, 2.6.4.3, Tables 2.3, 2.6
 along an edge, 2.4.2.9, Fig. 2.1
 assembly tolerances, 5.22, 5.22.3.1
 break test, 4.12.2, 4.31.4, 4.31.4.1
 combination with PIP weld, Annex A
 concavity, 5.24.1
 convexity, 5.24.1, 5.24.3, Fig. 5.4
 curved, effective length, 2.4.2.2
 details, 3.9.2, Figs. 2.1, 3.2
 effective area, 2.4.2.10, 2.24.1.1
 effective length, 2.4.2.1, 2.4.2.2
 effective throat, Annex B
 end connections, 2.9.2, C-2.9.2
 energy input, Annex I, Table I.2, Fig. 1.4
 holes, 2.9.4
 intermittent, 2.4.2.4, 2.9.4, 2.9.5
 interrupted, 2.9.3.2
 lap joints, 2.24.1.3, Fig. 2.4
 longitudinal, 2.9.2
 macroetch test for, 4.9.4, 4.31.2
 maximum size, 2.4.2.9, Fig. 2.1
 tolerance, 5.13
 minimum size, 2.18.3, 3.9, 3.9.3.2, 5.14, 7.5.5.4, Table 5.8
 tolerance, 5.13
 opposite sides, of common plane, 2.9.3.2, Fig. 2.8
 pipe positions, 4.3.4, Fig. 4.6
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 reinforcing, 2.4.2.7, 2.7.4, 2.7.5, Annex A
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 transverse, 2.9.1.1
 undersize, 5.13, C-5.13
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 overlapping cassette, 6.17.8.2
 width, 6.17.9
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 Flare-groove welds, 2.4.1.4, 4.11.5, Table 2.1
 Flat position, 5.25.1.1, Figs. 4.1–4.6
 Fluorescent screens, 6.17.4
 Flux, 5.4.3, 7.2.3
 condition, 5.3.3.2, 5.4.3
 damaged packages, 5.3.3.2
 drying, 5.3.3.2, 5.4.3
 electrode combination, 5.3.3.1

Image 13.5

The first keyword is “fillet weld.” Once you index the word “fillet weld” you will realize that there is close to a third of a page of sub-headings under that term (see image 13.4). Now you have to look below the heading “fillet weld” to all the sub-headings that are between “fillet weld” and the next heading which is “film.”

Now we have to determine what sub-heading to look up in order to find the information we desire. In this case “maximum size” is what we are looking for, on lap joints in particular.

Scan to the middle of the second column and find “maximum size, 2.4.2.9, Fig. 2.1.” Now, go to sub clause 2.4.2.9 which is on page 7. The code states that “The maximum fillet weld size detailed along the edges of base metal in lap joints shall be ...1/16 in [2 mm] less than the thickness of the base metal, for metal 1/4 in [6 mm] or more in thickness” (see image 13.6).

2.4.2.9 Maximum Weld Size in Lap Joints. The maximum fillet weld size detailed along the edges of base metal in lap joints shall be the following:

(1) the thickness of the base metal, for metal less than 1/4 in [6 mm] thick (see Figure 2.1, Detail A).

(2) 1/16 in [2 mm] less than the thickness of the base metal, for metal 1/4 in [6 mm] or more in thickness (see Figure 2.1, Detail B), unless the weld is designated on the shop drawing to be built out to obtain full throat thickness for a leg size equal to the base metal thickness. In the as-welded condition, the distance between the edge of the base metal and the toe of the weld may be less than 1/16 in [2 mm] provided the weld size is clearly verifiable.

Image 13.6

In this case the maximum fillet weld size is 3/16in (1/4 in. less 1/16 in. = 3/16 in.). The correct answer is b.

SYNONYMS AND REPEATED REFERENCES

Look at the following sample test question:

1. What are the drying requirements for an AWS A5.5 low hydrogen electrode?
 - a) Bake at 400°F for at least four hours
 - b) Bake at 500°F for at least one hour
 - c) Bake at 500° - 800°F for at least two hours
 - d) Bake at 700° - 800°F for at least one hour
 - e) None of the above

In order to look up the answer to this question in the index you have to identify the key words. The keywords in the question above are “drying” and “electrode.” Look up the word drying in the index (see image 13.7) and you will see the sub-heading “electrodes” which will lead you to 5.3.2.4 (hint: the location of the answer).

However, there are more ways to find the same answer. The first alternate route is to look up “electrode” as a heading and “drying” as a subheading instead of “drying” as a heading and “electrode” as a sub heading (see image 13.8).

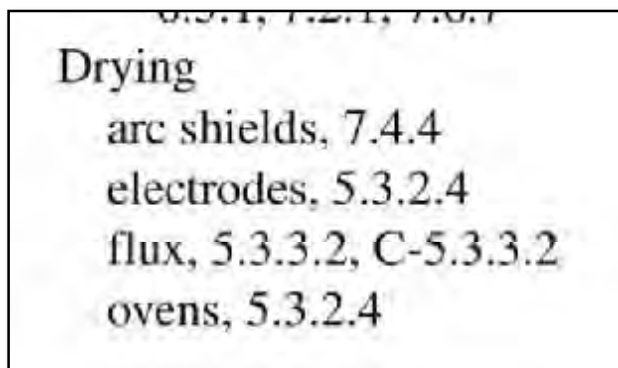


Image 13.7

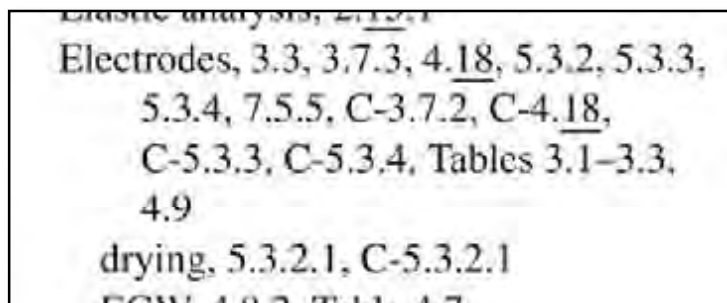


Image 13.8

Notice that one reference leads you to clause 5.3.2.4 and the other 5.3.2.1. In fact, both will lead you to the right answer; one will take a bit longer than the other. Clause 5.3.2.4 states (see image 13.9):

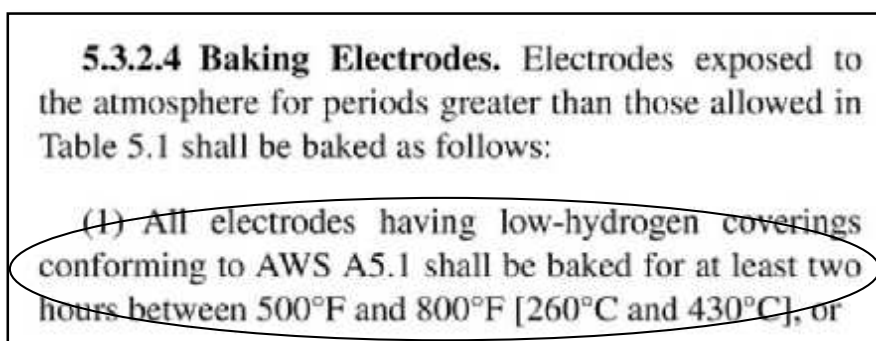


Image 13.9

If you refer back to the sample test question you will notice answer choice 'c' is exactly congruent with 5.3.2.4. Therefore if you referred first to 5.3.2.4 you would need to search no further. The question now comes up: "What happens if I search for 5.3.2.1?" Let's take a look at what that clause states (see image 13.10):

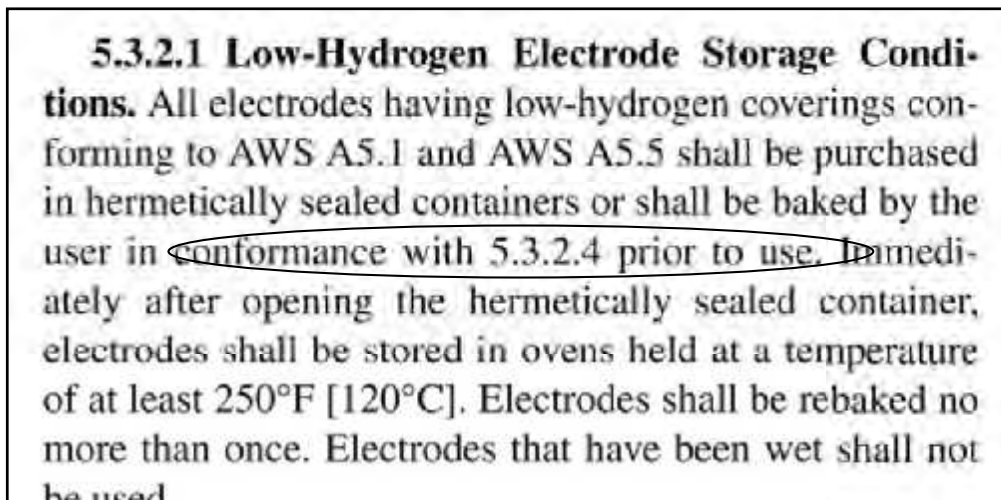


Image 13.10

Notice sub clause 5.3.2.1 refers back to 5.3.2.4 for the provisions on electrode drying. However, this route is precisely one step longer and more time consuming than going directly to 5.3.2.4. Nevertheless, it is inevitable that you will often not select the shortest route to the information you are seeking. Regardless the route you choose, it is important to know that there are multiple routes to the same information.

There is yet a third route to get the same answer which is relevant to the concept of synonyms. A synonym is a word having the same or nearly the same meaning as another word or other words.¹ You may have noticed that neither of the clauses used the word "drying." The actual technical term for keeping electrodes dry in the oven is called "baking."

The index has the word "baking" as a heading (see image 13.11).

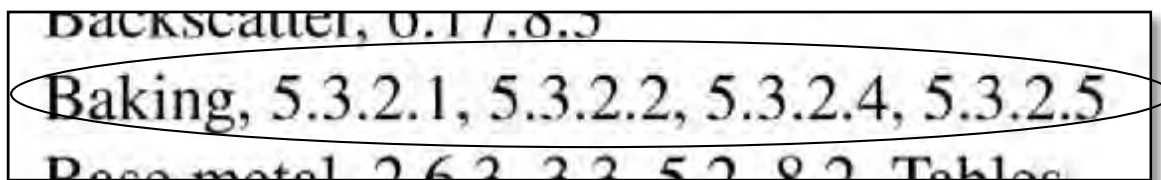


Image 13.11

¹ <http://www.answers.com/topic/synonym>

Notice that the references include 5.3.2.1 and 5.3.2.4 as well as two other references in clause 5. Out of the headings we have looked at so far (“drying” and “electrode”) “baking” is the more complete one because it includes the whole section on drying electrodes (see image 13.12).

5.3.2.1 Low-Hydrogen Electrode Storage Conditions. All electrodes having low-hydrogen coverings conforming to AWS A5.1 and AWS A5.5 shall be purchased in hermetically sealed containers or shall be baked by the user in conformance with 5.3.2.4 prior to use. Immediately after opening the hermetically sealed container, electrodes shall be stored in ovens held at a temperature of at least 250°F [120°C]. Electrodes shall be rebaked no more than once. Electrodes that have been wet shall not be used.

5.3.2.2 Approved Atmospheric Time Periods. After hermetically sealed containers are opened or after electrodes are removed from baking or storage ovens, the electrode exposure to the atmosphere shall not exceed the values shown in column A, Table 5.1, for the specific electrode classification with optional supplemental designators, where applicable. Electrodes exposed to the atmosphere for periods less than those allowed by column A, Table 5.1 may be returned to a holding oven maintained at 250°F [120°C] min.; after a minimum hold period of four hours at 250°F [120°C] min, the electrodes may be reissued.

5.3.2.3 Alternative Atmospheric Exposure Time Periods Established by Tests. The alternative exposure time values shown in column B in Table 5.1 may be used provided testing establishes the maximum allowable time. The testing shall be performed in conformance with AWS A5.5 for each electrode classification and each electrode manufacturer. Such tests shall establish that the maximum moisture content values of AWS A5.5 are not exceeded. Additionally, E70XX or E70XX-X (AWS A5.1 or A5.5) low-hydrogen electrode coverings shall be limited to a maximum moisture content not exceeding 0.4% by weight. These electrodes shall not be used at relative humidity-temperature combinations that exceed either the relative humidity or moisture content in the air that prevailed during the testing program.

For proper application of this subclause, see Annex F for the temperature-moisture content chart and its examples. The chart shown in Annex F, or any standard psychrometric chart, shall be used in the determination of temperature-relative humidity limits.

5.3.2.4 Baking Electrodes. Electrodes exposed to the atmosphere for periods greater than those allowed in Table 5.1 shall be baked as follows:

- (1) All electrodes having low-hydrogen coverings conforming to AWS A5.1 shall be baked for at least two hours between 500°F and 800°F [260°C and 430°C], or
- (2) All electrodes having low-hydrogen coverings conforming to AWS A5.5 shall be baked for at least one

hour at temperatures between 700°F and 800°F [370°C and 430°C].

All electrodes shall be placed in a suitable oven at a temperature not exceeding one half the final baking temperature for a minimum of one half hour prior to increasing the oven temperature to the final baking temperature. Final baking time shall start after the oven reaches final baking temperature.

5.3.2.5 Electrode Restrictions for ASTM A 514 or A 517 Steels. When used for welding ASTM A 514 or A 517 steels, electrodes of any classification lower than E100XX-X, except for E7018M and E70XXH4R, shall be baked at least one hour at temperatures between 700°F and 800°F [370°C and 430°C] before being used, whether furnished in hermetically sealed containers or otherwise.

5.3.3 SAW Electrodes and Fluxes. SAW may be performed with one or more single electrodes, one or more parallel electrodes, or combinations of single and parallel electrodes. The spacing between arcs shall be such that the slag cover over the weld metal produced by a leading arc does not cool sufficiently to prevent the proper weld penetration of a following electrode. SAW with multiple electrodes may be used for any groove or fillet weld pass.

5.3.3.1 Electrode-Flux Combination Requirements. The bare electrodes and flux used in combination for SAW of steels shall conform to the requirements in the latest edition of AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*, or to the requirements of the latest edition of AWS A5.23, *Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*.

5.3.3.2 Condition of Flux. Flux used for SAW shall be dry and free of contamination from dirt, mill scale, or other foreign material. All flux shall be purchased in packages that can be stored under normal conditions for at least six months without such storage affecting its welding characteristics or weld properties. Flux from damaged packages shall be discarded or shall be dried at a minimum temperature of 500°F [260°C] for one hour before use. Flux shall be placed in the dispensing system immediately upon opening a package, or if used from an opened package, the top one inch shall be discarded. Flux that has been wet shall not be used.

5.3.3.3 Flux Reclamation. SAW flux that has not been melted during the welding operation may be reused after recovery by vacuuming, catch pans, sweeping, or other means. The welding fabricator shall have a system for collecting unmelted flux, adding new flux, and welding with the mixture of these two, such that the flux com-

Image 13.12

Note: Although “baking” appears as a heading in the index, it does not appear as a sub-heading under electrodes. This is why synonyms are so important to finding the correct information. If you look under the heading “electrodes” for “baking” and find that it does not appear, then you can look for the sub-heading “drying” instead.

Other examples of synonyms include “Oxygen cutting” and “Thermal cutting” as well as “Cyclical loading” and “Fatigue.” The importance of synonyms is that 1) If you cannot find a word as a heading look it up as its synonym, 2) There is more than one way to reference information in the index.

TABLE OF CONTENTS

The Table of Contents (TOC) is another efficient and speedy tool at your disposal to look up information in the D1.1 code book. On the exam you may find that you will use the table of contents to a lesser degree in comparison with the index. However, understanding how to use the TOC will provide you with another great tool to find information within the code.

There are some important differences between the TOC and Index that changes the way we use the TOC to navigate through the code.

- The TOC is divided into three parts. There is a Table of Contents (image 13.13) which contains references to text only. Additionally there is a List of Tables (image 13.14) which corresponds to tables only. Finally, there is a List of Figures (image 13.15) which corresponds to figures only. On the other hand, the entries in the Index contain references to text, tables, and figures.

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- *Chronological Order vs. Alphabetical Order:* The entries in the TOC are organized according to the order of appearance of the content in the D1.1 while in the Index they are organized in alphabetical order. Notice that in the Table of Contents all the entries are under eight (8) headings which correspond to the eight (8) clauses in the code. Additionally, notice that all the clauses and sub clauses are arranged in numerical order according to the order that they appear in the code.

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HOW TO USE THE TABLE OF CONTENTS

The differences between the Table of Contents and index are significant enough to call for a different strategy when using the TOC. When looking up information in the TOC it is helpful (though not entirely necessary) to have more than just a keyword. When using the index, a keyword is enough because you can look up any word or phrase alphabetically using the first letter of the word or phrase. Because the TOC is arranged in order of clauses and because it is divided up in three parts (text, table, and figure), there is additional information required when using it as a starting point in your search.

When looking up the answer to a question in the TOC ask yourself two questions:

1. What clause should I expect the answer to be in?
2. Should I expect the answer to be a text, table, or figure?

Let's look at an example:

2. What is the maximum convexity permitted on a 3/8 inch fillet weld having an actual face width of 9/16 inch?

a) 1/16 inch
b) 3/32 inch
c) 1/8 inch
d) 3/16 inch

The primary keywords are “maximum convexity” and “fillet weld.” The question is *really* asking for the permissible tolerances in convexity that a welder can deem acceptable on the weld during its fabrication. Essentially, the question is targeting the amount of “wobble room” a welder has in the convexity of a fillet weld.

Now let's go back and answer the two questions.

Q: What clause should I expect the answer to be in?

A: The answer should be in clause 5 that deals with fabrication. Allowable tolerances in convexity variations is an issue that comes up during the actual welding process. The welder has to know what are the limits of convexity while fabricating the fillet weld.

Q: Should I expect the answer to be a text, table, or figure?

A: You should expect the answer to be in a table. If you take a look at the possible answer choices in the question, they are all different fractions of an inch. It is therefore probable that the information we are looking for has formulas in order to determine the allowable tolerances for weld profiles in general, convexity in particular. This is probably too much information to be in text, and too numerical to be in a figure. It is most probably in a table.

With this in mind let's take a look at the List of Tables in Clause 5.

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As you can see, tables 5.9 and 5.10 are tables dealing with weld profiles and weld profile schedules. The reference refers to page 210. Let's look at page 210.

Table 5.9 Weld Profiles ^a (see 5.24)						
Weld Type	Joint Type					
	Butt	Corner—Inside	Corner—Outside	T-Joint	Lap	Butt with Shelf Bar
Groove (CJP or PJP)	Figure 5.4A	Figure 5.4B ^b	Figure 5.4C	Figure 5.4D ^b	N/A	Figure 5.4G
	Schedule A	Schedule B	Schedule A	Schedule B	N/A	See Note c
Fillet	N/A	Figure 5.4E	Figure 5.4F	Figure 5.4E	Figure 5.4E	N/A
	N/A	Schedule C	Schedule C or D ^d	Schedule C	Schedule C	N/A

^a Schedules A through D are given in Table 5.10.
^b For reinforcing fillet welds required by design, the profile restrictions apply to each weld, butt, and fillet, separately.
^c Welds made using shelf bars and welds between horizontal bars of unequal thickness are exempt from R and C limitations.
^d See Figure 5.4F for a description of where Schedule C and D apply.

Table 5.9 and 5.10 are tables concerned with weld profiles. For fillet welds you go table 5.9 and notice that you are referred to table 5.10 schedule C. The question is asking about a face width of 9/16 in which means we have to look at the second line for face widths greater than 5/16 of an inch. The "C Max" which is an abbreviation for "allowable convexity" is 1/8 in which means the answer to our question is 'C'.

Table 5.10
Weld Profile Schedules (see 5.24)

Schedule A	(t = thickness of thicker plate joined for CJP; t = throat size for PJP)				
	t	R min.	R max.		
	≤ 1 in [25 mm]	0	1/8 in [3 mm]		
	> 1 in [25 mm], ≤ 2 in [50 mm]	0	3/16 in [5 mm]		
	> 2 in [50 mm]	0	1/4 in [6 mm] ^a		
Schedule B	(t = thickness of thicker plate joined for CJP; t = throat size for PJP; C = allowable convexity or concavity)				
	t	R min.	R max.	C min.	C max.
	< 1 in [25 mm]	0	unlimited	0	1/8 in [3 mm]
	≥ 1 in [25 mm]	0	unlimited	0	3/16 in [5 mm]
Schedule C	(W = width of weld face or individual surface bead; C = allowable convexity)				
	W	C min.	C max. ^b		
	≤ 5/16 in [8 mm]	0	1/16 in [2 mm]		
	> 5/16 in [8 mm], < 1 in [25 mm]	0	1/8 in [3 mm]		
	≥ 1 in [25 mm]	0	3/16 in [5 mm]		
Schedule D	(t = thickness of thinner of the exposed edge dimensions; see Figure 5.4F)				
	t	C min.	C max.		
	any value of t	0	t/2		

^a For cyclically loaded structures, R max. for materials > 2 in [50 mm] thick is 3/16 in [5 mm].

^b C shall not exceed R.

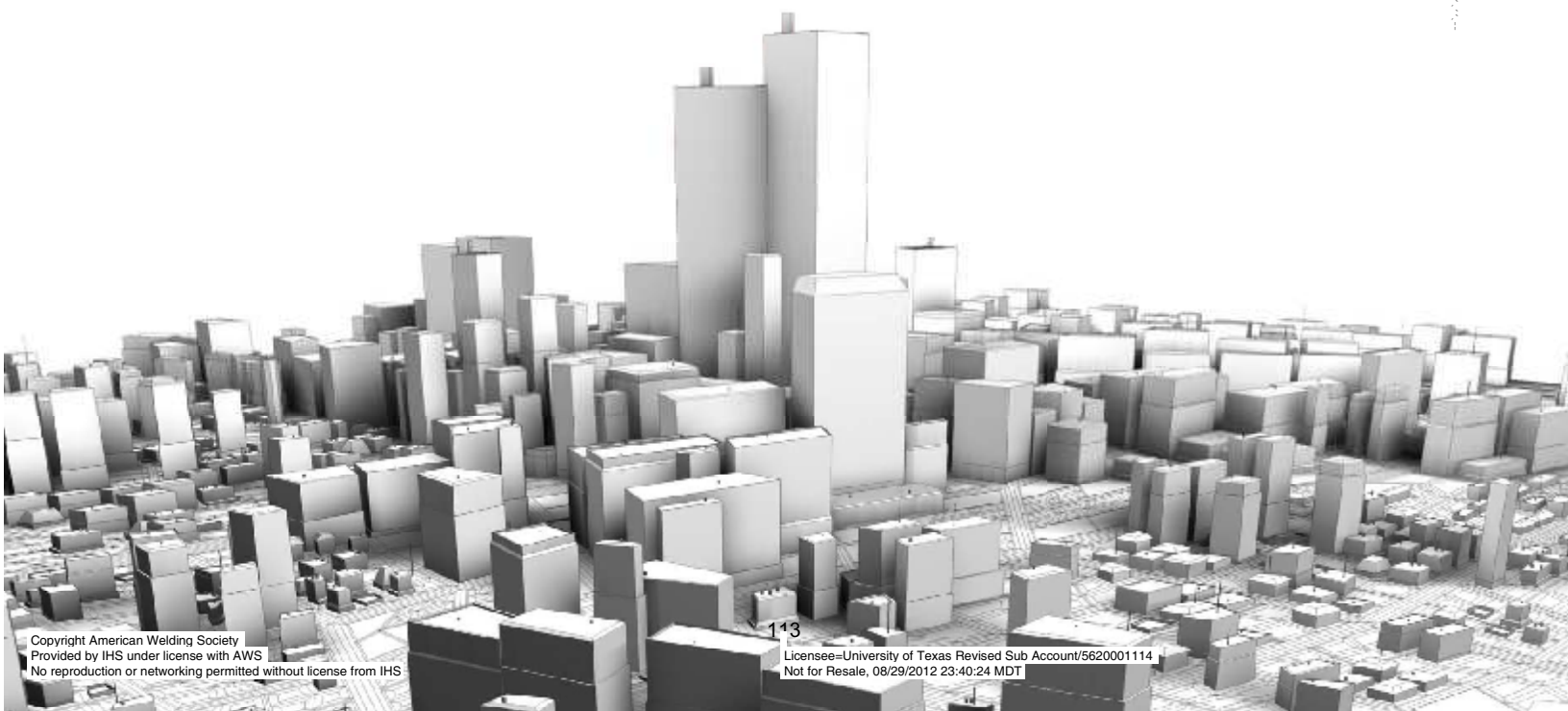
Chapter 14

Text, Tables, and Figures

Text.....

Tables

Figures



INTRODUCTION

1.1 Scope

This code contains the requirements for fabricating and erecting welded steel structures. When this code is stipulated in contract documents, conformance with all provisions of the code shall be required, except for those provisions that the Engineer (see 1.4.1) or contract documents specifically modifies or exempts.

The following is a summary of the code clauses:

1. General Requirements. This clause contains basic information on the scope and limitations of the code, key definitions, and the major responsibilities of the parties involved with steel fabrication.

The D1.1 code book presents information in three distinct formats: text, tables, and figures. Learning to properly read the information and understanding what type of information each format contains is vital to efficiently navigating the code. Each information format- text, tables, and figures- has its own structure and nuances. Becoming familiar with these differences will facilitate locating pertinent information, whether you are in the field or taking the certification exam.

TEXT

The D1.1 code book is a voluntary consensus standard, developed in accordance with the rules of the American National Standard Institute (ANSI). The stipulations contained therein are written in an extremely precise manner. Phrases and paragraphs are thoughtfully chosen and carefully constructed in order to maximize clarity and minimize the need for interpretation.

“Shall,” “Should,” and “May”

The D1.1 code uses the words “shall”, “should”, and “may” to signify different standards of enforcement as stipulated in sub clause 1.3.6 on Page 2.

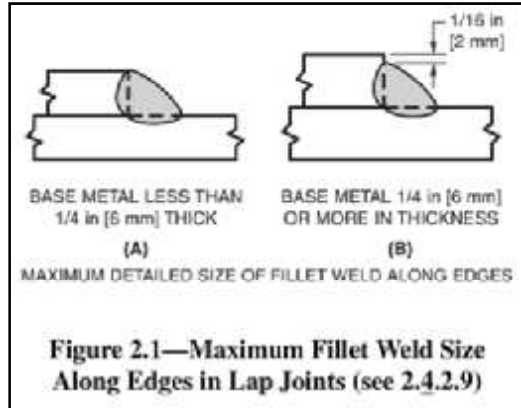
Any provision that is prefixed by the word “shall” is mandatory unless modified by the Engineer in the contract documents. The word “should” highlights practices that are not required though they are recommended. The word “may” signifies procedures or practices that are optional, and that may be used as a supplement.

<i>Shall</i> = Mandatory
<i>Should</i> = Recommended
<i>May</i> = Optional

Some provisions may contain any combination of the words “shall”, “should” and “may” in the same clause or sub clause. As such, some sections of the sub clause may be mandatory, some may be optional, others may simply be recommendations. Please examine the following example:

Welding Process	Flare-Bevel-Groove	Flare-V-Groove
SMAW and FCAW-S	5/16 R	5/8 R
GMAW* and FCAW-G	5/8 R	3/4 R
SAW	5/16 R	1/2 R

* Except GMAW-S
Note: R = radius of outside surface.





4.8.4 Preheat and Interpass Temperature. The minimum preheat and interpass temperature **should** be established on the basis of steel composition as shown in Table 3.1. Alternatively, recognized methods of prediction or guidelines such as those provided in Annex I, or other methods **may** be used. Preheat and Interpass temperatures lower than required per Table 3.2 or calculated per Annex I **may** be used provided they are approved the Engineer and qualified by WPS testing.

Clauses, Sub Clauses, and Parts

There are eight clauses in the D1.1:2010 code. Each of the clauses has a varying number of sub clauses, which are organized numerically by topic. In the example below, Clause 4, which outlines requirements for “Qualification”, is divided into thirty-nine (39) sub-clauses. Sub-clause 3 “Common Requirements for WPS and Welding Personnel Performance Qualification” has four (4) additional sub-clauses, of which, sub-clause 2 is named “Aging”.



Clauses two (2), four (4) and six (6) are organized in a slightly different manner than the other clauses. In addition to sub clauses, these three clauses have “parts.” Clause two (2) for example, which details the design of welded connections, starts with the scope and then divides the rest of the clause into Parts A, B, C, and D.

Part A	2.2 – 2.4	Nontubular and Tubular
Part B	2.5 – 2.12	Statically Loaded or Cyclically Loaded
Part C	2.13 – 2.19	Cyclically Loaded
Part D	2.20 – 2.27	Statically and Cyclically Loaded

These divisions are utilized to further organize the information. Even though these four clauses are divided into parts, they are still numerated using the same system as the rest of the document.

The importance of knowing what each part contains lies in the growing ease you will develop for referencing necessary information.

For example, consider the following question:



What is the minimum length of a fillet weld?

- a) 3 inches
- b) Twice the base metal thickness
- c) 4 times the normal size of the fillet weld
- d) 6 inches
- e) Size shall be specified on the drawing

Realizing that the question is related to the design of welds would lead to clause 2, but knowing that the question is specifically asking about welded connections, would lead directly to Part A, whereby reducing the length of time necessary to find the information. In this case, the answer is 'C' and is referenced in 2.4.2.3 on page 7 of the D1.1:2010.

TABLES

A table presents information in a visual manner, generally through the use of rows and columns. After the text section of each clause you will find the tables corresponding to that clause. The most time efficient means of locating a specific table is to search the 'List of Tables' on page xxiv of the D1.1:2010, which lists each table by its title and page number.

The D1.1 code book utilizes tables as a means of organizing large amounts of data into a finite amount of space. Subjects that inherently have many variables, properties, or standards of measurements are prime candidates to be organized in a table.

Some tables contain information that is quantitative. Table 3.1 for example contains all the prequalified combinations of base metal and filler metals.

Table 3.1 Prequalified Base Metal—Filler Metal Combinations for Matching Strength (see 3.3)						
G r a d e P	Steel Specification Requirements				Filler Metal Requirements	
	Steel Specification	Minimum Yield Point/Strength		Tensile Range	AWS Electrode Specification	Electrode Classification
		ksi	MPa			
	ASTM A 36	≤3/4 in [20 mm]	36	250	58–80	400–550
	ASTM A 53	Grade B	35	240	60 min.	415 min.
	ASTM A 106	Grade B	35	240	60 min.	415 min.
					SMAW	A5.1
						E60XX, E70XX

Other tables organize information that can be more qualitative in nature. Table 6.1 details the acceptability of different criterion when visually inspecting welds.

Table 6.1 Visual Inspection Acceptance Criteria (see 6.9)			
Discontinuity Category and Inspection Criteria	Statically Loaded Nontubular Connections	Cyclically Loaded Nontubular Connections	Tubular Connections (All Loads)
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X	X	X

As test takers review the tables in each clause they will become familiar with the type of information that each contains. The more familiar they become with each clause's tables, the easier it will be to recognize that a test question references a particular table. Sample tests and practice questions will help test takers identify the tables that are most often utilized. These study tools will help build speed in answering questions and reading tables.

Types of Tables

Although all tables are organized in rows and columns, not all tables share the same structural form. It is important to become acquainted with the different types of tables and learn how to read them properly. The following are four (4) different types of tables with directions on how to read them.

Table 3.1 Prequalified Base Metal—Filler Metal Combinations for Matching Strength (see 3.3)						
G T C H P	Steel Specification Requirements				Filler Metal Requirements	
	Steel Specification	Minimum Yield Point/Strength		Tensile Range	Process	AWS Electrode Specification Electrode Classification
		ksi	MPa			
	ASTM A 36 (≤34 in [20 mm])	36	250	38–50	SMAW	A5.1 E60XX, E70XX
	ASTM A 53 Grade B	35	240	60 min. 415 min.		
	ASTM A 106 Grade B	35	240	60 min. 415 min.		
	ASTM A 131 Grades A, B, CS, D, DS, E	34	235	58–75	SAW	A5.17 E60XX-EXXX, E60XX-ECXXXX, E70XX-EXXX, E70XX-ECXXXX
	ASTM A 170 Grade B	35	240	60 min. 415 min.		
	ASTM A 381 Grade Y35	35	240	60 min. 415 min.		
	ASTM A 500 Grade A	33	230	45 min. 310 min.		
	ASTM A 500 Grade B	42	290	58 min. 400 min.		
	ASTM A 500 Grade C	46	315	62 min. 425 min.		
	ASTM A 501	36	250	58 min. 400 min.		
	ASTM A 516 Grade 55	50	345	55–75 380–515		

To read the table above, one must first look to the left column and identify a steel specification. Then read directly across in a horizontal line to match up the minimum yield strength and/or the tensile range. The column on the right of the table applies to all of the steel specifications on the left. For example, if a welder were welding API 2H Grade 50 using the SMAW process, all the selected information in the above table would apply.

Table 5.9
Weld Profiles^b (see 5.24)

Weld Type	Joint Type					
	Butt	Corner—Inside	Corner—Outside	T-Joint	Lap	Butt with Shelf Bar
Groove (CJP or PJP)	Figure 5.4A	Figure 5.4B ^b	Figure 5.4C	Figure 5.4D ^b	N/A	Figure 5.4G
	Schedule A	Schedule B	Schedule A	Schedule B	N/A	See Note c
Fillet	N/A	Figure 5.4E	Figure 5.4F	Figure 5.4E	Figure 5.4E	N/A
	N/A	Schedule C	Schedule C or D ^d	Schedule C	Schedule C	N/A

^a Schedules A through D are given in Table 5.10.

^b For reinforcing fillet welds required by design, the profile restrictions apply to each weld, butt, and fillet, separately.

^c Welds made using shelf bars and welds between horizontal bars of unequal thickness are exempt from R and C limitations.

^d See Figure 5.4F for a description of where Schedule C and D apply.

Table 5.10
Weld Profile Schedules (see 5.24)

Schedule A	(t = thickness of thicker plate joined for CJP; t = throat size for PJP)				
	t	R min.	R max.		
	≤ 1 in [25 mm]	0	1/8 in [3 mm]		
	> 1 in [25 mm], ≤ 2 in [50 mm]	0	3/16 in [5 mm]		
	> 2 in [50 mm]	0	1/4 in [6 mm] ^a		
Schedule B	(t = thickness of thicker plate joined for CJP; t = throat size for PJP; C = allowable convexity or concavity)				
	t	R min.	R max.	C min.	C max.
	< 1 in [25 mm]	0	unlimited	0	1/8 in [3 mm]
	≥ 1 in [25 mm]	0	unlimited	0	3/16 in [5 mm]
	Schedule C	(W = width of weld face or individual surface bead; C = allowable convexity)			
W		C min.	C max. ^b	}	
≤ 5/16 in [8 mm]		0	1/16 in [2 mm]		
> 5/16 in [8 mm], < 1 in [25 mm]		0	1/8 in [3 mm]		
≥ 1 in [25 mm]		0	3/16 in [5 mm]		

The two tables above differ from many of the other tables found in D1.1 in that they work in conjunction with one another, and are of little use on their own. To read the table one must first know the type of weld, the type of joint, and the weld profile. For example, if an engineer needed to find the allowable convexity of a Fillet weld on a T-joint with a weld face that is 1 inch wide for a statically loaded structure, then the first step is to find Fillet under weld type in table 5.9. Next, he/she must read directly across the row under T-joint and see schedule C.

He/she would then need to move to table 5.10 and find schedule C in the left hand column and look under W to find the appropriate width which is “≥ 1in.” Looking across that row under C max, he/she would see that the maximum allowable convexity is 3/16 of an in.

Table 6.1
Visual Inspection Acceptance Criteria (see 6.9)

Discontinuity Category and Inspection Criteria	Statically Loaded Nontubular Connections	Cyclically Loaded Nontubular Connections	Tubular Connections (All Loads)
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X	X	X
(2) Weld/Base-Metal Fusion Complete fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X	X	X
(3) Crater Cross Section All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X	X	X
(4) Weld Profiles Weld profiles shall be in conformance with 5.24.	X	X	X
(5) Time of Inspection Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Acceptance criteria for ASTM A 514, A 517, and A 709 Grade 100 and 100 W steels shall be based on visual inspection performed not less than 48 hours after completion of the weld.	X	X	X
(6) Undersized Welds The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): L specified nominal weld size, in [mm] $\leq 3/16$ [5] $1/4$ [6] $\geq 5/16$ [8] U allowable decrease from L, in [mm] $\leq 1/16$ [2] $\leq 3/32$ [2.5] $\leq 1/8$ [3] In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, under-run shall be prohibited at the ends for a length equal to twice the width of the flange.	X	X	X
(7) Undercut (A) For material less than 1 in [25 mm] thick, undercut shall not exceed 1/32 in [1 mm], with the following exception: undercut shall not exceed 1/16 in [2 mm] for any accumulated length up to 2 in [50 mm] in any 12 in [300 mm]. For material equal to or greater than 1 in [25 mm] thick, undercut shall not exceed 1/16 in [2 mm] for any length of weld.	X		

As already mentioned, the information in table 6.1 is more qualitative than quantitative. The criteria for visual inspection of welds are on the left side of the table. The X's and grey shaded areas differentiate this table from others by indicating whether or not the variables on the left of the graph apply. For example, under number (7) undercut, part A applies only to statically loaded nontubular connections but neither cyclically loaded nontubular connections nor to tubular connections.

Table 3.7
Prequalified WPS Requirements¹ (see 3.7)

Variable	Position	Weld Type	SMAW	SAW ^d			GMAW/ FCAW ^e
				Single	Parallel	Multiple	
Maximum Electrode Diameter	Flat	Filler ^a	5/16 in [8.0 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove ^b	1/4 in [6.4 mm]				
		Root pass	3/16 in [4.8 mm]				
	Horizontal	Fillet	1/4 in [6.4 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove	3/16 in [4.8 mm]	Requires WPS Qualification Test			
	Vertical	All	3/16 in [4.8 mm] ^h				3/32 in [2.4 mm]
	Overhead	All	3/16 in [4.8 mm] ^h				5/64 in [2.0 mm]
Maximum Current	All	Fillet	Within the range of recommended operation by the filler metal manufacturer	1000 A	1200A	Unlimited	Within the range of recommended operation by the filler metal manufacturer ^c
	All	Groove weld root pass with opening		600A	700A		
		Groove weld root pass without opening			900A		
		Groove weld fill passes			1200A		
		Groove weld cap pass		Unlimited			

Table 3.7 may be tedious to read because of the combination of grey shaded areas and incomplete rows and columns. The key to read this table is to follow the horizontal lines straight across the table even when they are cut off by the grey areas.

For example, the darkened horizontal line above should help identify the major divisions in the table. All the area above the line refers to maximum electrode diameter. If a test taker were searching for the maximum electrode diameter for GMAW welding in the vertical position, he would have to look under “vertical” in the position column in the maximum electrode diameter row. Then look straight across through the grey shaded area to the GMAW column, and you will see the maximum of 3/32 in.

Text, Table, or Figure?

Due to the instances of duplicated information, some answers on the D1.1 test can be found in a portion of text, in a table, and/or in a figure. Conversely, you may see a question in which the answer can only be found in a small paragraph, in one row or column, or in a specific diagram. For this reason it is important to develop the skill of being able to predict whether the answer will appear as a text, table, or figure, or in any combination of the three.

FIGURES

Figures, like tables, are visual tools that use diagrams to present information graphically. After the tables in each clause you will find the figures for that clause. To find a specific figure you can flip towards the final pages of a clause, or you can go to the 'List of Figures' on page xxvi which lists each figure by its title and page number.

The D1.1 code book uses figures in order to present information that is best understood through a visual representation, like a diagram or drawing. Information that refers to the parts, tolerances, and measurements of a weld connection, for example, can be expected to be found as a figure within the code book.

Some figures can be composed exclusively of diagrams and drawings that refer to different parts of the subject. Figure 3.5 for example contains the prequalified joint details for PJP T-, Y-, and K- Tubular connections. Other figures may have a combination of diagrams, formulas, and tables. Figures 3.3 and 3.4 for example, are diagrams that provide the details for prequalified joints, but they also use tables in order to show the different maximum and minimum standards and measurements.

As with tables, becoming familiar with the types of figures is important in order to help you build speed in referencing the information you need, whether in the field or on the test. As you take sample tests and review each clause, take note of the information contained in each figure and which figures may be most often utilized.

TYPES OF FIGURES

There are three basic types of figures: labeled graphs, labeled diagrams, and mixed figures.

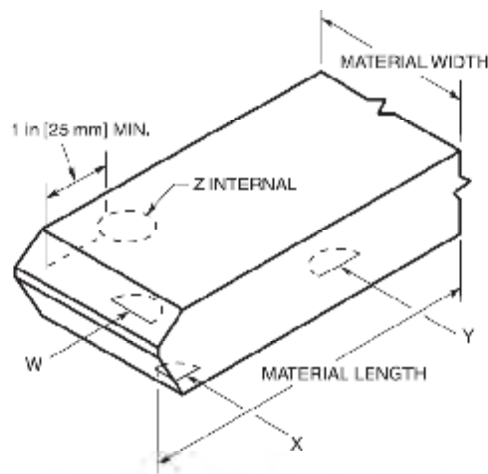
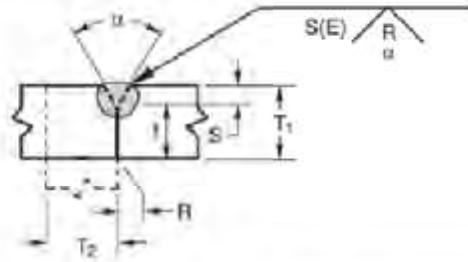
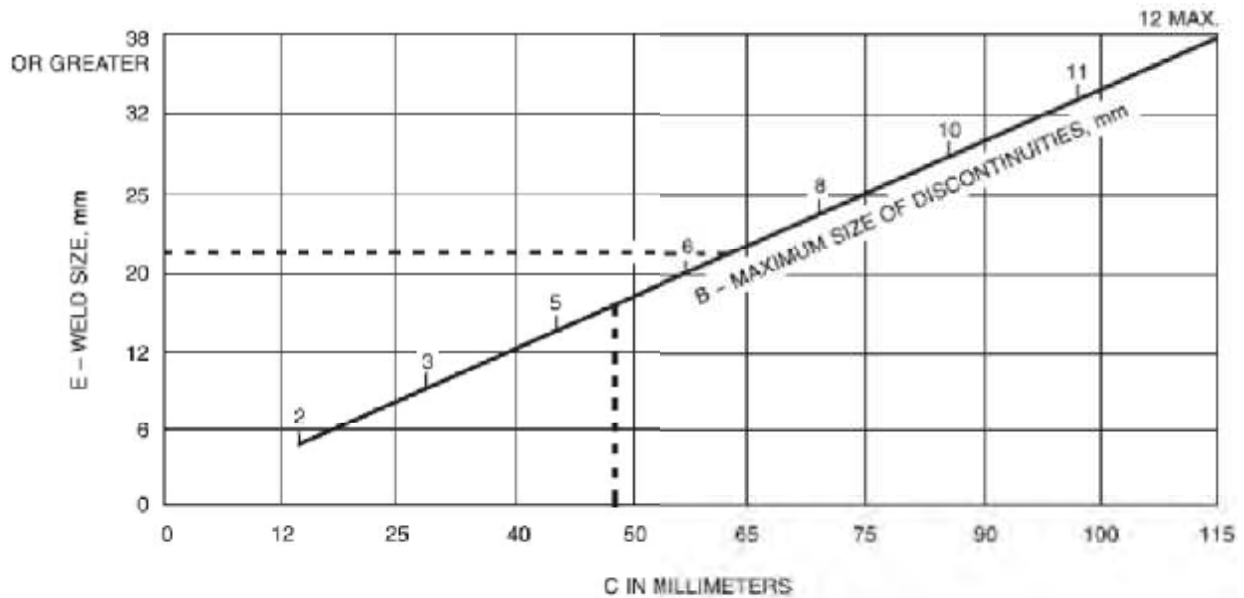


Figure 5.1—Edge Discontinuities in Cut Material (see 5.15.1.1)

Single-V-groove weld (2)
Butt joint (B)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness: (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (E)	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T ₁	T ₂		As Detailed (see 3.12.3)	As Fit-Up (see 3.12.3)			
SMAW	BC-P2	1/4 min.	U	R = 0 f = 1/32 min. α = 60°	+1/16, -0 +U, -0 +10°, -0°	+1/8, -1/16 ±1/16 +10°, -5°	All	S	b, c, f, j
GMAW FCAW	BC-P2-GF	1/4 min.	U	R = 0 f = 1/8 min. α = 60°	+1/16, -0 +U, -0 +10°, -0°	+1/8, -1/16 ±1/16 +10°, -5°	All	S	a, b, f, j
SAW	BC-P2-S	7/16 min.	U	R = 0 f = 1/4 min. α = 60°	±0 +U, -0 +10°, -0°	+1/16, -0 ±1/16 +10°, -5°	F	S	b, f, j



Notes:

1. To determine the maximum size of discontinuity allowed in any joint or weld size, project E horizontally to B.
2. To determine the minimum clearance allowed between edges of discontinuities of any size, project B vertically to C.
3. See Legend on page 246 for definitions.

Figure 6.2—Discontinuity Acceptance Criteria for Cyclically Loaded Nontubular Connections in Tension (Limitations of Porosity and Fusion Discontinuities)
(see 6.12.2.1)

FOOTNOTES

The majority of tables and figures in the code book have footnotes that provide further information about the table. The footnotes appear as a small letter called a “superscript,” often times near words or numbers. These superscripts refer to a sentence or paragraph at the end of the table or figure beginning with the same letter.

There are three types of footnotes found in the D1.1 code: global, regional, and local.

- Global footnotes are footnotes that apply to the whole table or figure. For example, in table 3.7 footnote ‘f’ (which is the superscript at the end of the title) is the only global footnote which you must read in order to understand the table. In this case footnote ‘f’ states that “the shaded area indicates nonapplicability”. The purpose of the footnote is a guide to how to interpret the grey shaded areas.

- Regional footnotes are footnotes that only apply to a section or region of the table or figure. For example, in table 3.7 footnote “g” applies to all of the information in the column furthestmost to the right which concerns ‘GMAW/FCAW’. It reads: “GMAW-S shall not be prequalified” signifying that all of the information under GMAW will not apply to the short circuiting process.
- Local footnotes are footnotes that only apply to a specific term, number, phrase, or paragraph in a table. For example, in Table 3.7 footnote “b” applies to the maximum electrode diameter for all weld types while welding in the vertical and overhead positions. The footnote modifies the maximum diameter to “5/32 in for EXX14 and low-hydrogen electrodes.” Notice that because it is a local footnote it must be placed on both ‘fillet’ and ‘groove’ in order for it to apply each weld type.

Table 3.7
Prequalified WPS Requirements[†] (see 3.7)

Variable	Position	Weld Type	SMAW	SAW ^d			GMAW/ FCAW ^e
				Single	Parallel	Multiple	
Maximum Electrode Diameter	Flat	Filler ^a	5/16 in [8.0 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove ^a	1/4 in [6.4 mm]				
		Root pass	3/16 in [4.8 mm]				
	Horizontal	Filler	1/4 in [6.4 mm]	1/4 in [6.4 mm]			1/8 in [3.2 mm]
		Groove	3/16 in [4.8 mm]	Requires WPS Qualification Test			
	Vertical	All	3/16 in [4.8 mm] ^b				3/32 in [2.4 mm]
Overhead	All	3/16 in [4.8 mm] ^b				5/64 in [2.0 mm]	
Maximum Current	All	Fillet	Within the range of recommended operation by the filler metal manufacturer	1000 A	1200A	Unlimited	Within the range of recommended operation by the filler metal manufacturer
	All	Groove weld root pass with opening		600A	700A		
		Groove weld root pass without opening			900A		
		Groove weld fill passes			1200A		
				Groove weld cap pass	Unlimited		
Maximum Root Pass Thickness ^d	Flat	All	3/8 in [10 mm]	Unlimited			3/8 in [10 mm]
	Horizontal		5/16 in [8 mm]				5/16 in [8 mm]
	Vertical		1/2 in [12 mm]				1/2 in [12 mm]
	Overhead		5/16 in [8 mm]				5/16 in [8 mm]
Maximum Fill Pass Thickness	All	All	3/16 in [5 mm]	1/4 in [6 mm]	Unlimited		1/4 in [6 mm]
Maximum Single Pass Fillet Weld Size ^c	Flat	Fillet	3/8 in [10 mm]	Unlimited			1/2 in [12 mm]
	Horizontal		5/16 in [8 mm]	5/16 in [8 mm]	5/16 in [8 mm]	1/2 in [12 mm]	3/8 in [10 mm]
	Vertical		1/2 in [12 mm]				1/2 in [12 mm]
	Overhead		5/16 in [8 mm]				5/16 in [8 mm]
Maximum Single Pass Layer Width	All (for GMAW/ FCAW) F & H (for SAW)	Root opening > 1/2 in [12 mm], or		Split layers	Laterally displaced electrodes or split layer	Split layers	Split layers
		Any layer of width w		Split layers if w > 5/8 in [16 mm]	Split layers with tandem electrodes if w > 5/8 in [16 mm]	If w > 1 in [25 mm], split layers	(Note c)

^a Except root passes.

^b 5/32 in [4.0 mm] for EXX14 and low-hydrogen electrodes.

^c See 3.7.3 for requirements for welding unpainted and exposed ASTM A 588.

^d See 3.7.2 for width-to-depth limitations.

^e In the F, H, or OH positions for nonbutt joints, split layers when the layer width w > 5/8 in [16 mm]. In the vertical position for nonbutt joints or the flat, horizontal, vertical, and overhead positions for butt joints, split layers when the width w > 1 in [25 mm].

[†] Shaded area indicates nonapplicability.

* GMAW-S shall not be prequalified.

SYMBOLS AND ABBREVIATIONS

In order to economize space, the tables in the code book use a set of symbols and abbreviations. Usually these are defined within the table in order to allow the reader to understand the formulas or phrases that the table employs. However there are some terms which are used repeatedly throughout the book and merit some attention. The following is a list of common symbols and abbreviations and their meanings.

<	Less Than
>	Greater Than
≤	Greater Than or equal to
≥	More Than
Incl.	Literally 'included' which means the provision includes the measurement or item immediately preceding the word. For example "1/8 to 3/32 inch" means that 3/32 of an inch is included.

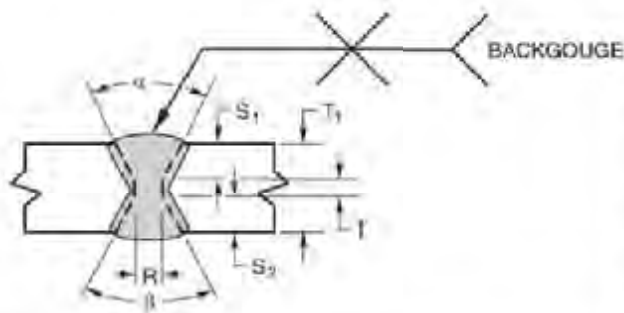
FORMULAS

In lieu of exact measurements, some tables have formulas or equations that are meant to be applied to a specific problem or situation. Formulas are mathematical expressions that utilize variables to stand for real life measurements. A figure, 3.3 & 3.4 for example, is a series of combined diagrams and tables which contain equations needed to derive various tolerances.

Below is a possible situation where you would need to apply the formula.

1. What is the maximum depth of bevel S_2 for joint designation B-U3c-S when welding $3\frac{1}{2}$ inch thick plate?
 - a) $1\frac{1}{4}$ inch
 - b) $1\frac{1}{8}$ inch
 - c) 1 inch
 - d) $\frac{7}{8}$ inch
 - e) $\frac{3}{4}$ inch

Double-V-groove weld (3)
Butt joint (B)



For B-U3c-S only		
T_1		S_1
Over	to	
2	2-1/2	1-3/8
2-1/2	3	1-3/4
3	3-5/8	2-1/8
3-5/8	4	2-3/8
4	4-3/4	2-3/4
4-3/4	5-1/2	3-1/4
5-1/2	6-1/4	3-3/4
For $T_1 > 6-1/4$ or $T_1 \leq 2$ $S_1 = 2/3 (T_1 - 1/4)$		

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening Root Face Groove Angle	Tolerances				
					As Detailed (see 3.13.1)	As Fit-Up (see 3.13.1)			
SMAW	B-U3b	U	—	R = 0 to 1/8 f = 0 to 1/8 $\alpha = \beta = 60^\circ$	+1/16, -0 +1/16, -0 +10°, -0°	+1/16, -1/8 Not limited +10°, -5°	All	—	d, e, h, j
GMAW FCAW	B-U3-GF			+1/16, -0 +10°, -0°	Not limited +10°, -5°	All	Not required	a, d, h, j	
SAW	B-U3c-S	U	—	R = 0 f = 1/4 min. $\alpha = \beta = 60^\circ$	+1/16, -0 +1/4, -0 +10°, -0°	+1/16, -0 +1/4, -0 +10°, -5°	F	—	d, h, j
To find S, see table above: $S_1 = T_1 - (S_2 + f)$									

METRICS vs. INCHES

The D1.1 codebook contains tables and figures both in metric and US Customary Units (SI). However, the D1.1 test is completely in SI. Therefore, test takers will not see any questions and answers in metric. Test takers will not need to utilize the tables and figures that are in metric within the code book (pg 86-93; pg 106-115) unless they are outside the United States. In order to facilitate navigating through the codebook, both in the field and taking the test, it could be beneficial to staple or paperclip these pages together in order to not confuse them with their SI versions (pg 77-85; pg 95-105).

LEGENDS

Several tables and figures in the code are preceded by a legend. A legend is a code or key for a table or figure that lists and explains the symbols that are used in that table or series of tables. Whenever it becomes necessary to compress a large amount of information into a table or

figure, the writers of the D1.1 utilize symbols and abbreviations. Therefore, without referring to the legend it will not be possible to interpret the corresponding table or figure.

Most of the time, legends are placed prior to the table or figure like figures 3.3, 3.4, 6.1, 6.2, and 6.3. Otherwise the legend may appear within or immediately after a table or figure such as tables 6.2, 6.3, and 6.7. Wherever the location, it is absolutely essential to read the legend carefully and thoughtfully prior to attempting to interpret the table or figure.

The legend for figures 3.3 and 3.4 on page seventy-seven (77) determines how to interpret the subsequent forty (40) pages of figures.

Legend for Figures 3.3 and 3.4

Symbols for joint types

- B — butt joint
- C — corner joint
- T — T-joint
- BC — butt or corner joint
- TC — T- or corner joint
- BTC — butt, T-, or corner joint

Symbols for base metal thickness and penetration

- P — PJP
- L — limited thickness—CJP
- U — unlimited thickness—CJP

Symbol for weld types

- 1 — square-groove
- 2 — single-V-groove
- 3 — double-V-groove
- 4 — single-bevel-groove
- 5 — double-bevel-groove
- 6 — single-U-groove
- 7 — double-U-groove
- 8 — single-J-groove
- 9 — double-J-groove
- 10 — flare-bevel-groove
- 11 — flare-V-groove

Symbols for welding processes if not SMAW

- S — SAW
- G — GMAW
- F — FCAW

Welding processes

- SMAW — shielded metal arc welding
- GMAW — gas metal arc welding
- FCAW — flux cored metal arc welding
- SAW — submerged arc welding

Welding positions

- F — flat
- H — horizontal
- V — vertical
- OH — overhead

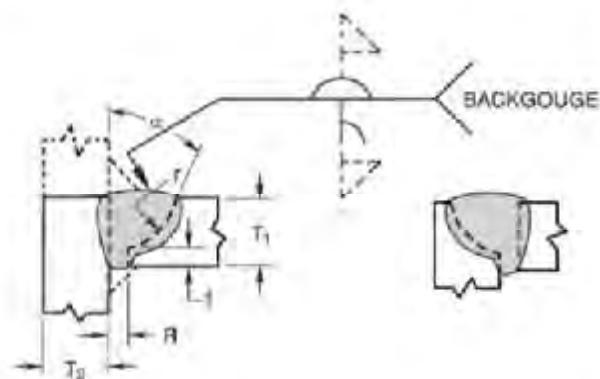
Dimensions

- R = Root Opening
- α, β = Groove Angles
- f = Root Face
- r = J- or U-groove Radius
- S, S₁, S₂ = PJP Groove Weld
- Depth of Groove
- E, E₁, E₂ = PJP Groove Weld
- Sizes corresponding to S, S₁, S₂, respectively

Joint Designation

The lower case letters, e.g., a, b, c, etc., are used to differentiate between joints that would otherwise have the same joint designation

Single-J-groove weld (B)
T-joint (T)
Corner joint (C)



Tolerances	
As Detailed (see 3.13.1)	As Fit-Up (see 3.13.1)
TC-U8a and TC-U8a-GF	
$R = +1/16, -0$	$+1/16, -1/8$
$\alpha = +10^\circ, -0^\circ$	$+10^\circ, -5^\circ$
$f = +1/16, -0$	Not Limited
$r = +1/4, -0$	$\pm 1/16$
TC-U8a-S	
$R = \pm 0$	$+1/4, -0$
$\alpha = +10^\circ, -0^\circ$	$+10^\circ, -5^\circ$
$f = +0, -1/8$	$\pm 1/16$
$r = +1/4, -0$	$\pm 1/16$

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	TC-U8a	U	U	$R = 0 \text{ to } 1/8$	$\alpha = 45^\circ$	$f = 1/8$	$r = 3/8$	All	—	d, e, g, j, k
				$R = 0 \text{ to } 1/8$	$\alpha = 30^\circ$	$f = 1/8$	$r = 3/8$	F, OH	—	d, e, g, j, k
GMAW FCAW	TC-U8a-GF	U	U	$R = 0 \text{ to } 1/8$	$\alpha = 30^\circ$	$f = 1/8$	$r = 3/8$	All	Not required	a, d, g, j, k

If a test taker needs to know the permissible range for the root opening, as fitup, for the prequalified joint TC-U8a-GF, first it would be necessary to find the diagram for a TC-U8a-GF prequalified joint on page 103 and search under 'Root Opening'. According to the figure, the maximum permissible range is " $R = 0 \text{ to } 1/8$." To verify this test takers could cross-reference the legend in page 77 which defines " R " and root opening.

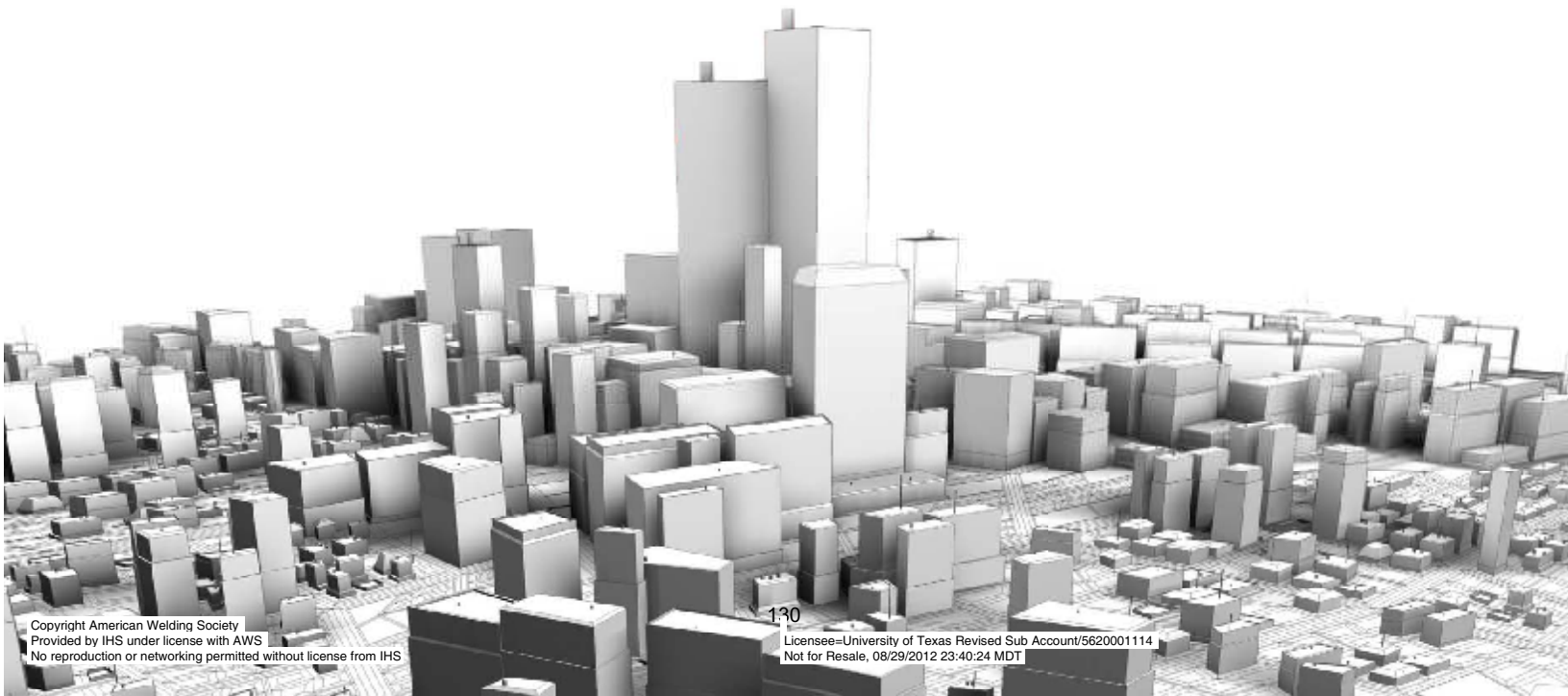
All of the diagrams for figures 3.3 and 3.4 will require cross-reference to the legend for symbols and abbreviations.

Chapter 15

Tabbing and Highlighting

Tabbing.....

Highlighting.....



TABBING AND HIGHLIGHTING

Tabbing and highlighting are two important tools that will help you create personalized ‘shortcuts’ in navigating the code. Tabbing makes flipping to important sections of the code easier and faster. Highlighting will help you go back and quickly identify portions of the code that you think are essential. Recall that the D1.1 is a *timed* test. The faster you can find information within the code, the greater your chances of passing the exam.

TABBING

What should you tab? Developing a balance between tabbing too little and over tabbing is important. When you are getting ready to tab, we recommend you start with the biggest sections of the code:

- Table of Contents
- List of tables
- List of figures
- Clauses 1 through 8
- Index

With those sections tabbed you will be able to flip to all the important places rather quickly; any additional tabbing is up to your discretion. Remember, over tabbing can make finding a specific part of the code complicated. You do not want to be shuffling through your tabs to find a spot in the book. Keep it simple.

What shouldn't I tab? There are three sections that are recommended for you not to tab.

- Annexes
- Commentary
- Tables and Figures in Metrics

There are two types of Annexes, normative and informative. Normative Annexes (pg 293-332) “contain information and requirements that are considered a part of the standard.”¹ Informative Annexes (pg 333-409) “are not considered part of the standard and are provided for informational purposes only.”² The commentary is prepared “to generate better understanding in the application of the code to welding in steel construction.”³ The tables and figures that are in metric (instead of SI) is of no use to you outside of the United States. Do not expect test questions on these. We therefore recommend for you not to tab these sections of the code.

¹ AWS D1.1/D1.1 M:2010 pg 293

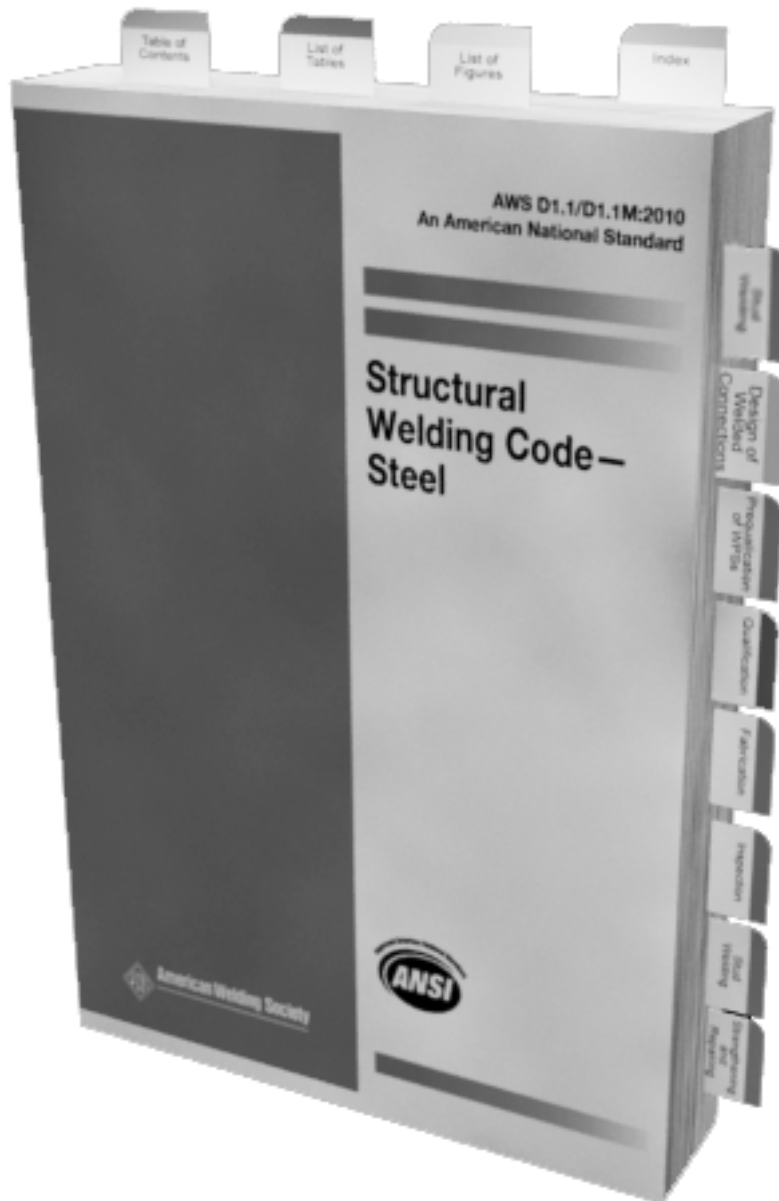
² AWS D1.1/D1.1 M:2010 pg 293

³ AWS D1.1/D1.1 M:2010 pg 413

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How should I tab? There is, believe it or not, a right and wrong way to place your tabs on the code book.

The recommended way to tab is to place the tabs for “Table of Contents”, “List of tables”, and “List of Figures” and “Index” on the top of the code book. The tabs for all the individual clauses we recommend you place on the right side of the code book.



The following is a step by step explanation to help you tab your code book in the most efficient way:

1. Open the code book to the first page of the clause that you want to tab. Let's say you want to tab clause 1. You should have the first page of clause 1 on your right hand side and a blank page on your left hand side. See image 1.
2. Now, lift the page immediately prior to the first page of clause 1 which is the blank page. (On the other side of the blank page you will find the last part of the List of Figures section). Now place the tab labeled "clause 1" on the top right hand corner of the last page of the List of Figures section. See image 2.
3. Now let's practice flipping to clause 1. Close the code book. Now grab the tab and open to clause 1. Notice that although you tabbed the page previous to clause 1, you are in fact looking at the first page of clause 1. See image 3.



Image 1



Image 3



Image 2

HIGHLIGHTING

Highlighting is a great skill to have in order to refer back to those parts of the code you thought were important. However, there is a danger of doing too much. The golden rule for highlighting is “do not over do it.” The following are a few tips to keep in mind when highlighting the code:

Get the big picture. Before you highlight anything within each clause make sure you have read the scope and the summaries of all the major sections. This way you have a better understanding of what is and what is not important in that particular clause.

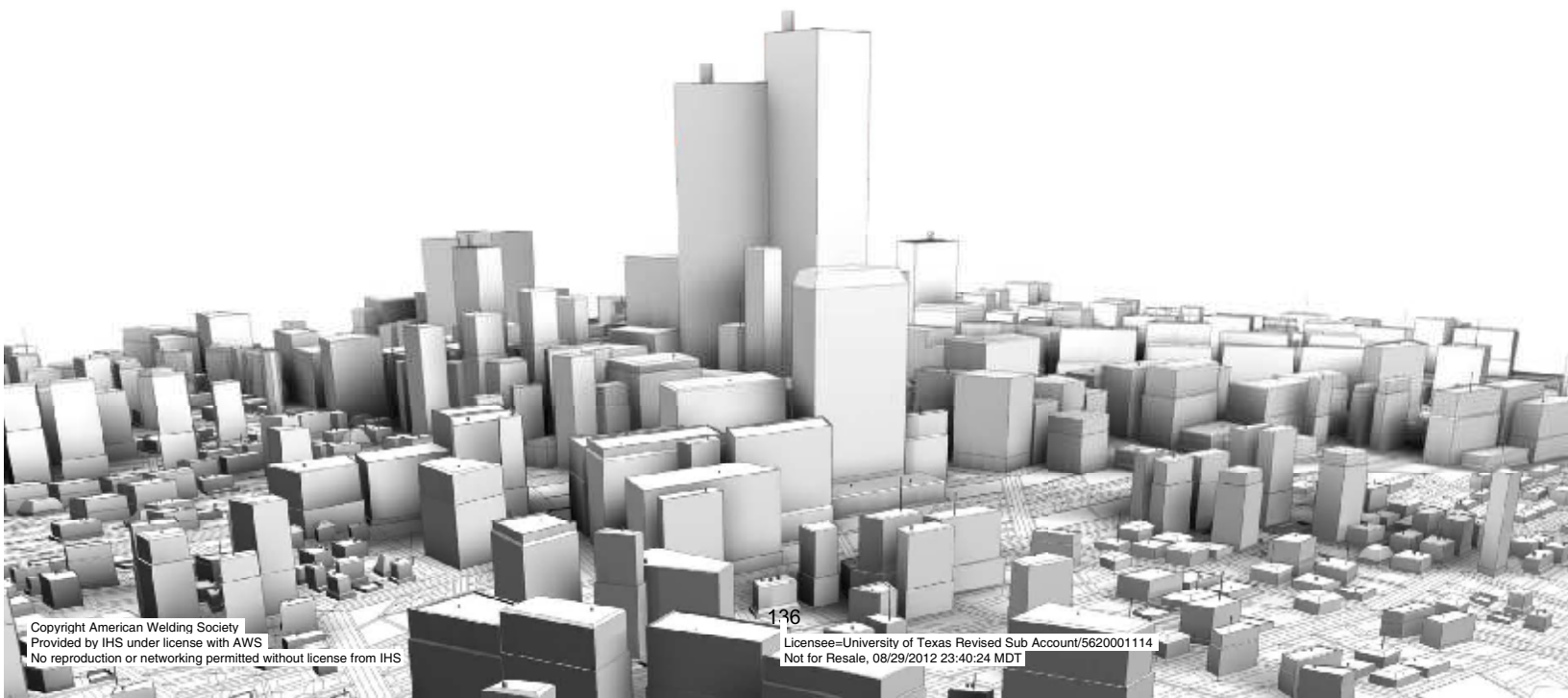
Do the practice exams first. The practice exams give you a general idea of what types of information is tested on more often than others. If you see yourself revisiting a table, figure, or portion of the text two or three times in a sample test, it’s a good idea to highlight that table, figure, or portion of the text.

Inspection vs. Engineering. The D1.1 test is made for Certified Welding Inspector’s, not for engineers. The parts of the D1.1 that delve into subject matter that are more engineer oriented in nature (“z-loss factor” for example) you should avoid highlighting. On the other hand, sections that are central to an inspector’s responsibilities (“acceptance criteria” for example) are very important to highlight.

Chapter 16

Test Taking Tips

Introduction	
Multiple Choice Exams.....	
Attitude	
Understanding the Question	
Process of Elimination.....	
Time Management.....	
Trust Your Gut.....	
Using Scrap Paper	
Simulate the Test Environment	
Relax.....	
The Day Before.....	
Pre-Flight Checklist	



MULTIPLE CHOICE EXAMS

The D1.1 Certification Exam is comprised entirely of multiple choice questions. All the questions, without exception, will be multiple choice problems. Becoming familiar with the structure of this type of question is paramount to acquiring the critical thinking habits necessary to tackle each question.

Each multiple choice problem begins with a prompt, question, or incomplete sentence, followed by several answer choices to choose from, only one of which is correct. The D1.1 test will provide five (5) answer choices for each problem which means four (4) choices will be incorrect. You should think of these as distractions meant to lure you away from the right answer.

A good way to think about choosing the right answer is treating each answer choice as a true and false question. When you read each answer choice say to yourself 'does this choice answer the problem in a way that is true or false?'

1. A CJP groove weld qualification on $\frac{1}{2}$ inch thick plate qualifies a procedure for what range of thickness?
- | | |
|---|-------|
| a) 0 to 1 inch | FALSE |
| b) 0 to $\frac{3}{4}$ inch | FALSE |
| c) $\frac{1}{8}$ to 1 inch | TRUE |
| d) $\frac{1}{8}$ inch to $\frac{3}{4}$ inch | FALSE |
| e) None of the above | FALSE |

Only B can answer the problem in a way that is true.

As you take the sample tests at the end of this book you will begin to develop your own intuitive way of quickly deciphering which is the correct answer. However, there are general strategies that can be used for multiple choice tests and applied specifically for the D1.1 exam that will quicken your ability to read the problem and find the right answer.

ATTITUDE

Keep in mind that the D1.1 exam will test your ability to navigate, not to memorize. Furthermore, the exam will be an open book test. You will be allowed to take your D1.1 code with you into the test. It is expected that you will have your book prepared in order to make it easier to find the right answers. *The vast majority of the questions will require you to dive into the code.*

Therefore, as you practice do not panic if you do not know the correct answer upon your first reading of the problem. Instead, learn to use the keywords in the problem and the answer choices to your advantage to find the answer in the code book. Learning to glean each question to pick out the keywords is the most crucial skill you need to pass this test.

UNDERSTANDING THE QUESTION

Getting a firm grasp of what the question is actually asking for is the most important tool you need to answer any question on the D1.1. Test takers commonly make the mistake of choosing an answer that may present good information, but does not address what is really being asked. The key is taking the time to read, think, and understand the question.

Read the question. D1.1 is a timed test. You will experience pressure in trying to keep a good pace throughout the test. However, you should not rush through your first reading of the question. Go through the question at a speed that allows you to determine what is being asked.

Re-read the question. If you do not understand the question in your first reading, do not skip to reading the answers. Instead, re-read the question. It is better to skip over a question you don't understand, than to try to answer a question under false assumptions.

Important keywords. Words such as “none”, “only”, “except”, “all”, “always”, and “every” often alter the meaning of a problem. Underlining or circling these words may help you keep them in mind when answering the question.

Answer the actual question. It is a good idea to check that are you are answering the actual question *before* you bubble in you answer. You will be more confident that you made the right choice.

PROCESS OF ELIMINATION

Eliminating wrong answers is one of the surest ways to increase the probability of choosing the right answer. If you cannot determine what the correct answer is, you can work backwards by crossing out the ones you are sure to be incorrect.

For example if you are able to eliminate one (1) wrong answer you have increased odds from 20% to 25% of getting the right answer. Eliminate two (2) and that number jumps to 33%. If you are able to reduce the answers to two possible choices, you have a 50% chance of getting the right answer.

Read all of the answer choices carefully before crossing out answers or even choosing your answer. This way you will avoid eliminating answers that may appear to be incorrect but are in fact correct. For example, phrases like “all of the above” , “none of the above” and others that include two or three answers like “both A and C” will necessarily be inclusive of other answers that are only partially correct.

Often the correct answer may be very similar to another answer but only have a small difference. In these cases it is important to look back at each answer and identify what is the key distinction. Then go back to the question and determine which option best answers the question.

Finally, do not be afraid to guess. However, it is important to make educated guesses. If you cannot determine the right answer, try to narrow your choices down to 3 or 2 answers. This way you will have increased your chances of getting the right answer.

TIME MANAGEMENT

D1.1 is a timed test. You will have two (2) hours to answer approximately 50 questions which means you will have an average of 2.4 minutes per question. Practicing your timing and pacing is a major component of preparation for the test. There several important tips to help you get a handle on your ability to manage your time during the test.

Don't get stuck. If you cannot find the answer to a question that has become difficult for you, skip it, mark it, and come back to it latter. You cannot afford the luxury of investing 5-6 minutes on any one question. It is preferable to answer the questions that are easy first, and then come back to the more difficult ones later.

Refer to your watch sparingly. In can become counterproductive to look at your watch every few minutes. This may slow down your pace as well as make you feel like you need to rush. A good strategy is to put markers on your test so that you remind yourself to check the time every ten (10) questions.

Pace yourself. Being hasty can be a roadblock to reading the test and the code book carefully. The more your practice taking the test, the more you will begin to feel comfortable with an appropriate rhythm for answering questions.

Take a few breathers. If you feel yourself tightening up or getting too jittery, its recommended to take a few seconds to take a few deep breathes and settle down. You should see this as an investment to help you remain focused and apt to answer questions with precision.

Save your last 3-5 minutes. You should use your last few minutes to erase any stray marks and bubble in any answers you left blank. The D1.1 test does not penalize you for guessing. A question that is left blank is as equally incorrect as one that has a wrong answer. Therefore you should make sure that no question is left unanswered.

TRUST YOUR GUT

Studies have shown that your initial answer choice is usually correct. Although for most of the answers in the D1.1 exam you will have to search for in the code book, you should trust your gut instincts as to what are the keywords, where to look for the answer, and what is the correct answer choice. If you have

prepared well for the exam, and gone through this work book, you should walk in to the test with a certain degree of confidence to tackle each question.

There are no answer patterns. Do not be weary if you have answered 'C' for five questions in a row. It may very well be the correct answer. Test makers do not usually create patterns for the answers. If you believe to have answered each question to the best of your ability, do not second guess yourself.

It's ok to change an answer. Sometimes some information you read on a question will trigger your memory and make you recall an answer to a previous question you know to be wrong. This is very common. Do not be afraid to go back and make a change on your test. The key is to trust your gut and make the change.

USING SCRAP PAPER

Several questions on the D1.1 exam will require that you apply a formula found in the code book to the specifications given in a question. These questions might require the use of scrap paper to calculate the answer. If you are not careful this extra work may make room for careless errors. When using scrap paper you want to follow two important tips: 1) Double check that you write the accurate formula on your scrap paper, and 2) double check that you transfer the right answer from the scrap paper to your test. It can be very frustrating to calculate the right answer, but get the question wrong because of a misspelling, a stray mark, or a simple mistake. This way you will have skirted any possibility of careless errors.

SIMULATE THE TEST ENVIRONMENT

Taking sample tests in a similar test environment is the most effective way to predict your outcome on the test. If you score 85% when you are taking the sample test, *while recreating test day conditions*, you can expect to do close to the same on the test. Therefore it is important to follow a few guidelines when taking sample tests.

Timing. Set aside two hours of time, no more and no less, to take the test. If you finish early, go back and erase stray marks, bubble in unanswered questions, and check your answers just like you would on the test. Additionally, try to discipline yourself not to go over the two hours. If you see yourself running out of time, speed up your pace just like you would on test day.

Testing Conditions. Make sure that you can take the sample test uninterrupted. Find a quiet room with adequate lighting. Do not take the sample test while you are tired or sleepy as this will not be an adequate indication of how well you will do on the test.

The code book. Take the sample tests with your code book tabbed and highlighted like on the day of the test. In addition to simulating the test environment, this will allow you to assess the effectiveness of your particular style of tabbing and highlighting.

RELAX

Studies have shown that being anxious or too excited can decrease your effectiveness as a test taker. It is important to try to relax and breathe easy. This way your performance will not be hampered by extra emotional weight.

Some stress is ok. Stress and performance are related in such a way that you do need some stress to do great. Expect to have stress before and during the test. However, prepare yourself to accept it as part of the process. Positive self reinforcement is a part of any good test taker.

Be aware of your posture. Be conscious about your comfort levels. Try to sit as comfortably and loosely as possibly without slouching or hunching over. It is a two hour test, so sitting in an awkward manner may give you pains in the latter half of the test. If you find yourself too stiff, take a small break to breathe and fix your posture, then continue.

THE DAY BEFORE

How you prepare for the test the night before is often underappreciated and taken for granted. There are several important tips that will help you be in the right state of mind for the test.

Do not cram the night before. There is a way to over-study that fatigues your mind and does not allow it to recuperate for the test the next day. The day of the test you want to feel fresh. Do not over work the night before.

Get a good night's rest. Studies have shown that without rest the brain cannot recall information quickly and accurately. At the same time, do not oversleep. Your best bet is to sleep the average amount of hours that you sleep every night.

Eat a sound breakfast. Your brain cannot think properly without proper nutrition. A good balanced breakfast is crucial to having a fresh mind that can access your critical thinking skills.

PRE-FLIGHT CHECKLIST

The following is a list of all the important steps that are recommended prior to taking the D1.1 exam. The same way a pilot has to run through a check list prior to takeoff, this list contains all the steps that will guarantee adequate preparation for the D1.1 test.

Pre-Flight Checklist	✓
Review Clauses 1-8	
Practice Identifying keywords – chapter 12	
Practice using the Index – chapter 13	

Practice using the Table of Contents – chapter 13	
Practice predicting answers as Text, Table, or Figure – chapter 14	
Tab the code book – chapter 15	
Highlight the code book – chapter 15	
Take Sample Test 1	
Review and correct wrong answers	
Take Sample Test 2	
Review and correct wrong answers	
Take Sample Test 3	
Review and correct wrong answers	
Review Test Day Instructions	
The Day of the Test	✓
Eat a good breakfast	
Arrive 10-15 minutes early to test site	
Take your tabbed and highlighted D1.1 code book	

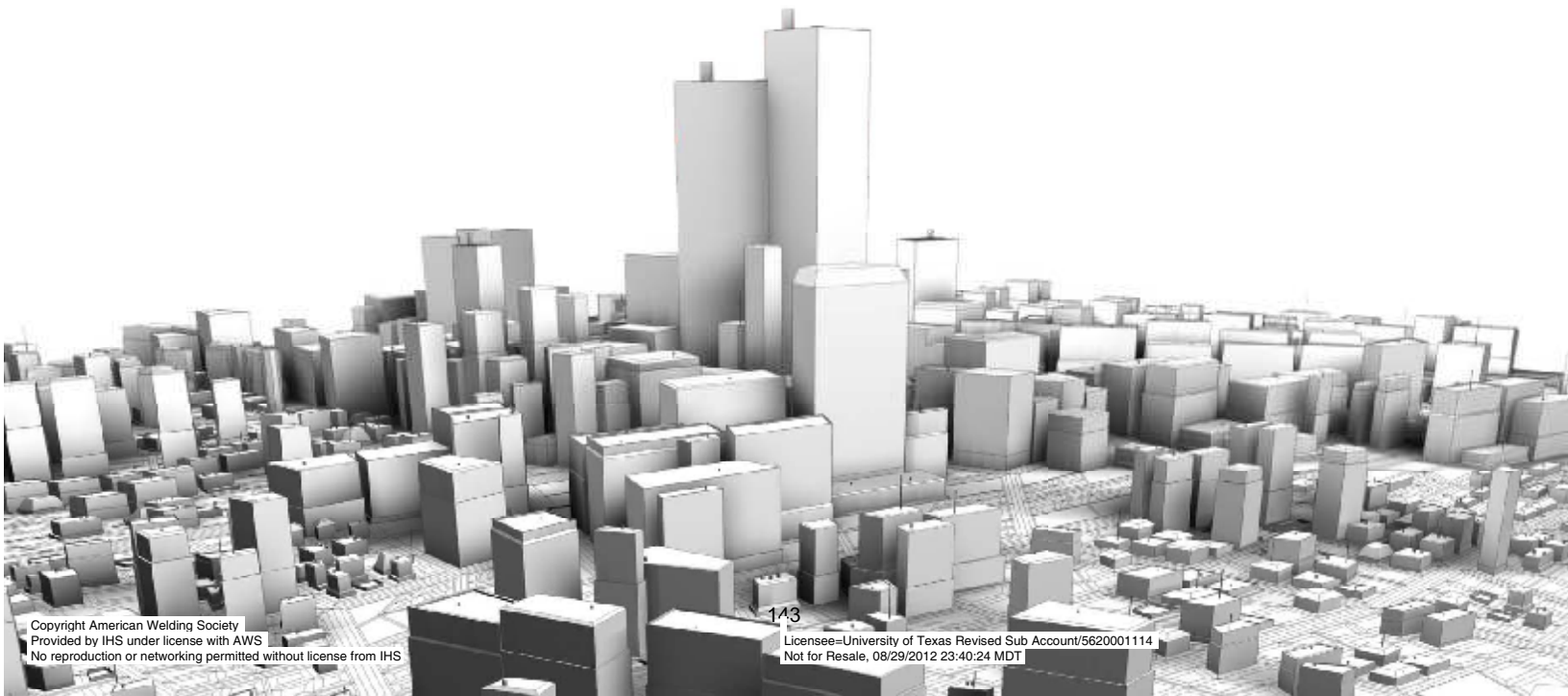
Chapter 17

Sample Tests

Sample Test 1.....

Sample Test 2.....

Sample Test 3.....



AWS D1.1 Practice Examination Sample Test 1

Read each question carefully and select the one best answer. It is helpful for you to write down the clause and subclause number(s) and page number(s) where you found the answer. The exam should be completed within a one hour period.

1. What is the suggested filler metal classification for welding ASTM A131 Grade DH32 steel with GMAW?
 - a) E7015
 - b) ER70S-X
 - c) AWS A5.1
 - d) AWS A5.5
 - e) AWS A5.18
2. When fillet welding a 3/8 inch stud in the flat position with an E7018 electrode, what diameter electrode must be used?
 - a) 1/8 inch
 - b) 3/16 inch
 - c) 5/16 inch
 - d) 3/8 inch
 - e) 7/16 inch
3. How long does welder certification last per AWS D1.1?
 - a) 3 months
 - b) 6 months
 - c) 1 year
 - d) Indefinitely
 - e) Indefinitely, unless not engaged in the process for more than 6 months at a time
4. With a single electrode for SAW, what is the maximum size single pass fillet weld that can be deposited in the horizontal welding position when using a prequalified procedure?
 - a) 5/32 inch
 - b) 3/8 inch
 - c) 5/16 inch
 - d) 1/4 inch
 - e) 1/2 inch
5. How often are visual examinations required for inspectors under AWS D1.1?
 - a) Once, within last 3 months of CWI certification
 - b) Once each year
 - c) Once each 3 years
 - d) Once every three years or less if necessary
 - e) None of the above

6. When stress relieving a weldment at a temperature of 150° F below the minimum specified temperature, what is the minimum holding time per inch of thickness?
- a) 1 hour
 - b) 2 hours
 - c) 3 hours
 - d) 4 hours
 - e) 10 hours
7. Steel backing for welds in statically loaded structures:
- a) Need not be welded full length or removed
 - b) Need not be welded full length or removed unless specified by the Engineer
 - c) Need not be welded full length or removed unless specified by the Contractor
 - d) Shall be removed prior to inspection
 - e) Shall be welded full length, need not be removed
8. The maximum weld reinforcement permitted for a welding procedure qualification on pipe or tubing having a wall thickness of 0.208 inch is:
- a) none permitted
 - b) 1/16 inch
 - c) 3/16 inch
 - d) 3/32 inch
 - e) 1/8 inch
9. What is the difference between the AWS A5.1 and AWS A5.5 specifications?
- a) One is for electrodes and the other one is for base metals
 - b) One is for SMAW electrodes and the other one is for FCAW electrodes
 - c) One is for plain carbon steel base metals and the other one is for low-alloy steel base metals
 - d) One is for plain carbon steel electrodes and the other one is for low-alloy steel electrodes
 - e) None of the above
10. Tack welds incorporated into SAW welds shall also meet the following:
- a) Fillet tack welds shall not produce objectionable changes in the weld surface appearance
 - b) Electrodes for tack welds shall meet the requirements of the final welds
 - c) Preheat is not required for single pass tack welds
 - d) Fillet tack welds shall not exceed 3/8 inch in size
 - e) All of the above
11. For GMAW, which is not considered to be an essential variable for procedure qualification?
- a) a change in the number of electrodes used
 - b) a change from a single shielding gas to a mixture of gases
 - c) a change of 5% above the mean amperage for each filler metal diameter used
 - d) a change in the position of welding
 - e) a change in the type of groove
12. Which of the following SMAW electrodes is not included in the F2 group?
- a) E6012
 - b) E6010
 - c) E6013
 - d) E6014
 - e) none of the above

13. How much overlap is allowed on a procedure qualification test coupon?
- a) None, the weld shall merge smoothly with the base metal
 - b) 5% of base metal thickness
 - c) 1/32 inch
 - d) 1/16 inch for lengths less than 2 inches in any 12 inches of weld, otherwise 1/32 inch
 - e) 1/8 inch
14. What is the maximum root opening for welder qualification testing on CJP tubular butt joints without backing?
- a) no limit
 - b) 1/16 inch
 - c) 1/8 inch
 - d) 3/32 inch
 - e) 3/16 inch
15. What is the lowest temperature at which welding can be done without preheating a 1/2 inch thick ASTM A36 carbon steel?
- a) 0°F
 - b) Below 32°F
 - c) 32°F
 - d) 70°F
 - e) None of the above
16. What is the classification of a suitable FCAW filler material for joining ASTM A516 Grade 55 steel?
- a) AWS A5.17
 - b) AWS A5.23
 - c) AWS A5.18
 - d) AWS A5.20
 - e) None of the above
17. What plate repair is required when a 3/4 inch long laminar discontinuity is discovered in an oxygen-cut edge?
- a) Remove and reweld
 - b) Grind to determine depth and reweld if deeper than 1/8 inch
 - c) Grind to determine depth and reweld
 - d) Inspect with ultrasonic testing and remove and reweld if deeper than 1/8 inch
 - e) None, need not be explored
18. Welding shall not be done when the ambient temperature is:
- a) less than -20° F
 - b) less than 32° F
 - c) less than 0° C
 - d) less than 0° F
 - e) none of the above

19. For the prequalified joint B-L2c-S, what is the range of root face dimensions, as fit-up, permitted for a base metal thickness of 1 inch?
- a) 3/16 to 5/16 inch
 - b) 1/4 to 5/16 inch
 - c) 1/4 inch maximum
 - d) Not limited
 - e) 0 to 5/16 inch
20. What is the minimum preheat and interpass temperature for FCAW on 1/2 inch thick ASTM A500, Grade A steel, when the base metal temperature is less than 32° F?
- a) none
 - b) 150° F
 - c) 70° F
 - d) 225° F
 - e) 300° F
21. For a fillet weld joining 1/2 inch thick statically loaded nontubular members, what maximum length of 1/16 inch deep undercut is allowed in any 12 inch length of weld?
- a) 1 inch
 - b) 1-1/2 inches
 - c) 2 inches
 - d) 2-1/2 inches
 - e) none
22. When rounding the corners of the finished bend test specimen, the maximum allowable radius is :
- a) None
 - b) 1/16 inch
 - c) 3/32 inch
 - d) 1/8 inch
 - e) Dependent on the thickness of the bend test coupon
23. How much depth of undercut does AWS D1.1 allow on 3/8 inch thick plate for a procedure qualification?
- a) No more than 1/32 inch on test coupons less than 1 inch
 - b) Up to 1/16 inch for lengths less than 2 inches in any 12 inches of weld on test coupons less than 1 inch thick
 - c) No more than 1/16 inch on test coupons more than 1 inch thick
 - d) Combination of a), b), and c), above
 - e) No more than 1/32 inch for any thickness of test coupon
24. What is the maximum time an E7018R electrode may be exposed to the atmosphere if established by testing?
- a) 1/2 hour
 - b) 1 hour
 - c) 4 hours
 - d) 9 hours
 - e) 10 hours

25. What is the test position where the axis of the pipe is at 45 degrees and the pipe is not rotated while welding?

- a) 1G
- b) 2G
- c) 5G
- d) 6G
- e) 3G

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Sample Test 1

Answer Key

Question	Index	Text		Table		Figure		Answer
		Subclause	Page	Number	Page	Number	Page	
1	Filler metals, matching requirements	3.3	59	3.1	65			b
2	SMAW, of studs	7.5.5.6	283					b
3	Welder Qualification, period of effectiveness	4.2.3.1	126					e
4		3.7.3.2	60	3.7	73			c
5	Eye Examination	6.1.4.4	220					d
6		5.8.2	196	5.3	208			e
7	Backing, removal of	5.10.5	197					b
8		4.9.1.1 (3)	127					e
9	Electrodes, shielded metal arc	5.3.2	193					d
10	Tack welds	5.18.4; 5.18.5	200- 201					e
11		4.8.1	127	4.5	142-144			c
12				4.13	155			b
13	Visual inspection	4.9.1.1 (3)	127			5.4	214	a
14		4.27 (2)	134			4.24 (A)	178	c
15	Preheat	3.5	60	3.2 note a	68-70			c
16	Filler metals, matching requirements	3.3	59	3.1	64			e
17	Discontinuities, repair	5.15.1.2	199	5.4	208			e
18		5.12.2(1)	198					d
19	Prequalified joint details					3.4	96	e
20		3.5; 4.8.4	60; 125	3.2 note a	70			c
21		6.9	221	6.1 (7)(A)	239			c
22	Bend Test Requirements	4.9.3.1	128			4.13 & 4.12	169	d
23	Undercut	4.9.1.1 (4)	127					e
24	Atmospheric exposure time periods	5.3.2.3	194	5.1	208			e
25	Test Weld Positions	4.3.4	126			4.4	160	d

AWS D1.1 Practice Examination Sample Test 2

Read each question carefully and select the one best answer. It is helpful for you to write down the clause and subclause number(s) and page number(s) where you found the answer. The exam should be completed within a one hour period.

1. What is the maximum permitted separation between the back side of a butt joint and its backing bar?
 - a) 1/32 inch
 - b) 1/16 inch
 - c) 3/32 inch
 - d) 1/8 inch
 - e) 3/16 inch

2. Which of the following methods cannot be used to remove unacceptable work on quenched and tempered steels?
 - a) oxygen gouging
 - b) machining
 - c) chipping
 - d) grinding
 - e) c and d

3. If a welding operator qualifies in the 2G position, for what groove weld positions is that welding operator qualified?
 - a) 2G plate
 - b) 1G pipe over 24 inches in diameter
 - c) 1F plate
 - d) 2F pipe over 24 inches in diameter
 - e) Both a) and b)

4. If a CJP groove welding procedure is qualified in the 6G position, what positions are qualified for production?
 - a) F, H, and V groove welds only
 - b) All position fillet and groove welds, except for T- Y- K- CJP groove welds
 - c) F and V groove welds only
 - d) H, V, and OH groove and fillet welds only
 - e) All position groove welds only

5. What does AWS D1.1 say about interpass weld cleaning?
 - a) Nothing, AWS D1.1 does not cover cleaning
 - b) Interpass cleaning may be done using a needle scaler or a hand chipping hammer and a power brush
 - c) Slag shall be removed from the weld crater before resuming welding after any interruption
 - d) b) and c) above
 - e) None of the above

6. The groove welding position where the inclination of axis is 35 degrees and the rotation of face is 200 degrees is:
- a) Flat
 - b) Horizontal
 - c) Vertical
 - d) Overhead
 - e) Both a) and b)
7. What is the specification of a suitable FCAW filler metal for joining ASTM A516, Grade 55 steel?
- a) AWS A5.17
 - b) AWS A5.23
 - c) AWS A5.18
 - d) AWS A5.20
 - e) none of the above
8. Tack welds and construction aid welds shall meet visual inspection requirements if:
- a) the tack welds are not incorporated into the final weld
 - b) preheat is required
 - c) the construction aid welds are not removed
 - d) a) and b) above
 - e) a) and c) above
9. What are the storage conditions required for a low hydrogen electrode after removal from its hermetically sealed container?
- a) At least 250°F in an oven
 - b) At least 450°F in an oven for AWS A5.1 electrodes
 - c) At least 500°F in an oven for AWS A5.5 electrodes
 - d) b) and c) above
 - e) None of the above
10. When strengthening or repairing an existing building, the portions of surfaces that are to receive welds shall be:
- a) cleaned of dirt and rust except adherent paint need not be removed
 - b) cleaned thoroughly of all foreign matter including paint for a distance of 1 inch from each side of the weld
 - c) cleaned thoroughly of all foreign matter including paint for a distance of 2 inches from the root of the weld
 - d) inspected by dye penetrant prior to welding
 - e) visually inspected for a distance of 1 inch from each side
11. What is the minimum preheat temperature for welding 1 inch thick ASTM A36 plate with an E7018 electrode?
- a) 0°F
 - b) 32°F
 - c) 50°F
 - d) 70°F
 - e) 150°F

12. What is the proper width of a root bend test coupon from a 6 inch, Schedule 40 pipe?
- a) 1 inch
 - b) 1-1/2 inches
 - c) 1-1/4 inches
 - d) 2 inches
 - e) None of the above
13. For the prequalified joint B-L2c-S, what is the maximum root face dimension permitted, as fitup, for a base metal thickness of 1-1/4 inches?
- a) 0 - 1/8 inch
 - b) 1/4 inch maximum
 - c) 1/2 inch maximum
 - d) 9/16 inch maximum
 - e) 5/8 inch maximum
14. What is the maximum prequalified size a single pass, 2F weld on ASTM A36 plate could possibly be, according to AWS D1.1, if welded with an E7018 electrode?
- a) 5/32 inch
 - b) 5/16 inch
 - c) 3/8 inch
 - d) 1/2 inch
 - e) None of the above
15. In welding ASTM A514 and ASTM A517 steels, how long must the inspector wait before performing visual inspection for acceptance?
- a) when it is cool enough
 - b) 4 hours
 - c) 48 hours
 - d) 10 hours
 - e) not specified
16. When welding 2 inch thick ASTM A588 steel for exposed, bare, unpainted applications using the SMAW process with a prequalified procedure, which electrode suffixes will produce a deposited weld metal having similar corrosion resistance and color matching as the base metal?
- a) B2
 - b) no suffix
 - c) B3
 - d) B2L
 - e) G
17. When fillet welding a 1 inch stud in the overhead position with an E7018 electrode, which of the following electrode diameters may be used?
- a) 1/8 inch
 - b) 3/16 inch
 - c) 5/16 inch
 - d) 3/8 inch
 - e) 7/16 inch

18. What is the lowest temperature at which welding may be done according to AWS D1.1?
- a) Less than 0°F
 - b) Less than 18°F
 - c) All the above
 - d) 0°F
 - e) 18°F
19. Per AWS D1.1, what is the maximum fillet weld size for a statically loaded lap joint on 1/4 inch thick steel?
- a) 1/8 inch
 - b) 3/16 inch
 - c) 1/4 inch
 - d) 5/16 inch
 - e) 3/5 inch
20. When the weld is transverse to the direction of tensile stress in a cyclically loaded primary member, what is the maximum allowable depth of undercut for material under 5/8 inches thick?
- a) 0.01 inch
 - b) 1/32 inch
 - c) 0.0625 inch
 - d) 1/8 inch
 - e) not specified
21. An E6020 electrode would be included in which group?
- a) F1
 - b) F2
 - c) F3
 - d) F4
 - e) F5
22. Can a WPS using GMAW-S be qualified under AWS D1.1?
- a) No, GMAW-S is the exception, and therefore is not prequalified
 - b) Yes, GMAW-S is a code approved process and is therefore a prequalified process
 - c) No, under no circumstances can the short-circuiting GMAW process be used on structural steel under AWS D1.1
 - d) Yes, provided the WPSs are qualified in conformance with the requirements of Clause 4
 - e) Both a) and c)
23. What plate repair is required when a 3/4 inch long laminar discontinuity is discovered in an oxygen-cut edge?
- a) remove and reweld
 - b) grind to determine depth and reweld if deeper than 1/8 inch
 - c) grind to determine depth and reweld
 - d) inspect with ultrasonic testing, remove and reweld if deeper than 1/8 inch
 - e) none; need not be explored
24. Could OFW-A be used to weld on a job that required AWS D1.1 code conformance?

- a) Yes, if the procedure was qualified per Clause 4
- b) No, AWS D1.1 does not recognize oxy-fuel as a welding process
- c) No, only arc welding processes may be used to weld structural steel
- d) Yes, OFW-A is a prequalified process under AWS D1.1
- e) Both b) and c)

25. When may studs be furnished without flux?

- a) Studs used for arc welding to steel members with the use of automatically timed stud welding equipment
- b) Alternative head configurations shall be permitted with proof of mechanical testing
- c) 5/16 inch diameter studs
- d) All of the above
- e) Studs smaller than 5/16 inch diameter

Sample Test 2

Answer Key

Question	Index	Text		Table		Figure		Answer
		Subclause	Page	Number	Page	Number	Page	
1		5.22.1.1	199					b
2		5.26; 5.15.2	205-206; 199					a
3	Welding Operation Qualification	4.19.1.1	132	4.11	151			e
4	Qualification, WPS	4.4	126	4.1	138			b
5	Cleaning	5.30.1	207					c
6	Test Weld Positions	4.3.4	126			4.1	157	c
7		3.3; 5.3.4	59; 195	3.1	65			d
8		5.18.1 (2)	200					e
9	Low hydrogen electrodes, storage	5.3.2.1	194					a
10		8.5.1	292					c
11	Preheat	3.5	60	3.2	68-70			c
12	Bend Test Requirements	4.9.3.1	128			4.12	168	b
13		3.13	62			3.4	96	d
14	Maximum root pass thickness	3.7.3.2	61	3.7	73			b
15		6.9	221	6.1 (5)	239			c
16		3.7.3	61	3.3 note 1; 3.1 note b	71; 65; 67			d
17	SMAW, of studs	7.5.5.6	283					b
18	Temperature, ambient	5.12.2 (1) & note	198					d
19	Fillet welds, maximum size	2.4.2.9	7			2.1	43	b
20		6.9	221	6.1 (7) (B)	239			a
21	Filler metals, welder			4.13	155			a
22	GMAW (Gas Metal Arc Welding)	3.2.2	59					d
23		5.15.1	198	5.4	208			e
24	Processes	3.2.3	59					a
25	Stud welding, flux	7.2.3	281					e

AWS D1.1 Practice Examination Sample Test 3

Read each question carefully and select the one best answer. It is helpful for you to write down the clause number(s) and page number(s) where you found the answer. The exam should be completed within a two hour period.

1. What is the range of thickness of base metals that AWS D1.1 covers?
 - a) All thicknesses
 - b) All thicknesses exceeding 1/8 inch
 - c) Only thicknesses between 1/8 inch and 1 inch
 - d) Thicknesses of 1/8 inch and greater
 - e) Only thicknesses between 5/16 inch and 1 inch
2. Per AWS D1.1, what is the maximum fillet weld size for a lap joint on 1/4 inch thick steel?
 - a) 1/8 inch
 - b) 3/16 inch
 - c) 1/4 inch
 - d) 5/16 inch
 - e) 3/8 inch
3. All welds are to be inspected by which of the following nondestructive methods?
 - a) MT
 - b) VT
 - c) PT
 - d) UT
 - e) paint film thickness measurement
4. For a CJP groove weld procedure qualification on a 1/2 inch thick test plate, what is the maximum thickness for which that procedure will be qualified?
 - a) 1/2 inch
 - b) 3/4 inch
 - c) 1 inch
 - d) 1-1/2 inches
 - e) 2 inches
5. For the prequalified joint TC-U8a-GF, what is the permissible range for the root opening, as fit-up?
 - a) 0 - 1/8 inch
 - b) 0 - 3/16 inch
 - c) 0 - 1/4 inch
 - d) 1/16 - 3/16 inch
 - e) None of the above
6. When two 3/8 inch thick plates are joined in a lap joint configuration, what is the maximum size fillet weld that can be specified on the plate edges?
 - a) 3/8 inch
 - b) 1/4 inch
 - c) 3/16 inch
 - d) 5/16 inch
 - e) none of the above

7. If a welding procedure is being qualified for a CJP groove weld using 6 inch schedule 120 pipe, what range of wall thicknesses will that procedure cover?
- a) no limit
 - b) 3/16 inch to unlimited
 - c) 1/8 to 3/4 inch
 - d) 0 to 2T
 - e) none of the above
8. For RT of 1-1/2 inch thick plate, which hole-type IQI designation is required (Source Side)?
- a) 20
 - b) 25
 - c) 30
 - d) 35
 - e) 40
9. What is the specification of a suitable SAW filler material for joining ASTM A572 Grade 60 steel?
- a) AWS A5.17
 - b) AWS A5.23
 - c) AWS A5.18
 - d) AWS A5.20
 - e) None of the above
10. How many times may a low-hydrogen electrode be rebaked?
- a) Electrodes cannot be rebaked
 - b) 4 maximum
 - c) 9 maximum
 - d) 10 maximum
 - e) Once
11. What is the suggested minimum backing thickness for SMAW?
- a) 1/8 inch
 - b) 3/16 inch
 - c) 3/8 inch
 - d) Backing thickness will be determined by the metal thickness and amperage used
 - e) All of the above
12. What are the minimum preheat and interpass temperatures for welding 1/2 inch thick ASTM A709 Grade 36 steel with an E6013 electrode when the base metal temperature is less than 32°F?
- a) 0°F preheat, 32°F interpass
 - b) 32°F preheat, 32°F interpass
 - c) 50°F preheat, 50°F interpass
 - d) 70°F preheat, 32°F interpass
 - e) 70°F preheat, 70°F interpass
13. Who is responsible for conducting qualification tests?
- a) The manufacturer
 - b) The manufacturer or contractor
 - c) The engineer
 - d) The manufacturer, contractor, or an independent testing agency
 - e) The American Welding Society

14. Using a standard guided bend test jig to bend specimens of a material having minimum yield strength of 75,000 psi, what is the diameter of the plunger about which it is bent?
- a) 1 inch
 - b) 2 inches
 - c) 1-1/2 inches
 - d) 2-1/2 inches
 - e) 1-1/4 inches
15. What is the minimum number of plate test(s) required to qualify a fillet welding procedure in all positions?
- a) 4 tests, 1F, 2F, 3F, and 4F
 - b) 3 tests, 2F, 3F, 4F will qualify in all positions
 - c) 2 tests, 3F, 4F will qualify in all positions
 - d) 1 test, 4F will qualify in all positions
 - e) 1 test, 3F will qualify in all positions
16. The maximum size of porosity permitted in RT of a 1/2 inch thick groove weld subject to tensile stress for a cyclically loaded nontubular structure is:
- a) 1/16 inch
 - b) 1/8 inch
 - c) 5/32 inch
 - d) 3/16 inch
 - e) 7/32 inch
17. How much melt-through is allowed on T, K, or Y connections on procedure qualification tests?
- a) None
 - b) 1/32 inch
 - c) 1/16 inch
 - d) 1/8 inch
 - e) Unlimited
18. What is the minimum thickness groove weld a welder may weld in production if the welder was successfully qualified using a 1 inch thick groove weld plate test coupon?
- a) unlimited
 - b) 1 inch
 - c) 1/2 inch
 - d) 1/8 inch
 - e) none of the above
19. A drawing specifies a 3/8 inch fillet weld for a particular weld joint. What size fillet weld is necessary if a 1/8 inch root opening exists between the two pieces prior to welding?
- a) 3/4 inch
 - b) 3/8 inch
 - c) 1/2 inch
 - d) 1/4 inch
 - e) none of the above
20. Individuals performing nondestructive testing other than visual shall be qualified in accordance with:
- a) AWS D1.1 requirements
 - b) API 1104 requirements
 - c) ASME Section IX requirements
 - d) ASME Section V requirements
 - e) ASNT SNT-TC-1A requirements

21. When utilizing parallel SAW electrodes for a prequalified groove weld procedure, what is the maximum current permitted for the final pass?
- a) 1000 A
 - b) 700 A
 - c) 900 A
 - d) 1200 A
 - e) unlimited
22. When a CJP groove weld procedure is successfully qualified on a pipe in the 5G test position, for what positions is it qualified?
- a) H, V grooves on pipe
 - b) F, H, V, OH fillets on plate
 - c) F, V, OH fillets and grooves on plate
 - d) F, H, V, OH fillets and grooves on plate
 - e) none of the above
23. A welder qualified to weld with the FCAW process is also qualified to weld using:
- a) SMAW
 - b) GMAW
 - c) SAW
 - d) ESW
 - e) None of the above
24. If a new welding process was invented, how could it be used to weld in accordance with AWS D1.1?
- a) It could not be used. Only SMAW, SAW, GMAW, and FCAW are qualified processes under AWS D1.1
 - b) It could not be used. Only SMAW, SAW, GMAW, FCAW, ESW, EGW, and GTAW are approved by AWS D1.1
 - c) It could be used by qualifying it under clause 3 as a prequalified process
 - d) It could be used by qualification of the WPSs under clause 4
 - e) None of the above
25. Welding shall not be done when the ambient temperature is:
- a) less than 0°F
 - b) 32°F
 - c) 16°F
 - d) Minimum temperature depends on the metal type, thickness, and electrode type
 - e) None of the above
26. What is the required minimum preheat for welding 2-1/2 inches thick ASTM A572 steel, Grade 42, using the GMAW process with a prequalified procedure?
- a) 50° F
 - b) 150° F
 - c) 225° F
 - d) 300° F
 - e) none of the above

27. Individuals performing nondestructive testing (other than visual) shall be qualified in accordance with:
- a) AWS QC-1 requirements
 - b) AWS QC-5 requirements
 - c) ASNT SNT-TC-1A requirements
 - d) Both a) and b) above
 - e) None of the above
28. When may Cobalt 60 be used as a radiographic source?
- a) For X-ray units, 600kvp maximum
 - b) When the steel is 2.5 inches thick or less
 - c) When the steel is over 2.5 inches thick
 - d) Only when testing cobalt
 - e) Never
29. What is the minimum fillet weld size allowed for shielded metal arc welding a 1/4 inch stud onto a 3/4 inch thick plate?
- a) 1/8 inch
 - b) 3/16 inch
 - c) 1/4 inch
 - d) 5/16 inch
 - e) None of the above
30. For procedure qualification using a 3/8 inch thick plate, what test specimens are required or allowed for a CJP groove weld?
- a) 1 tensile, 2 face bends, 2 root bends
 - b) 2 tensiles, 1 face bend, 1 root bend
 - c) 2 tensiles, 4 side bends
 - d) 2 tensiles, 2 side bends
 - e) 2 face bends, 2 root bends
31. For a 1/2 inch groove weld subject to compressive stress in a cyclically loaded, nontubular structure, what is the minimum spacing between pores permitted by RT?
- a) approximately 5/16 inch
 - b) approximately 1 inch
 - c) approximately 1-1/2 inches
 - d) approximately 2 inches
 - e) approximately 1/4 inch
32. What is the largest diameter E7018 electrode that may be used to weld a V-groove joint in the overhead position using a prequalified SMAW WPS?
- a) 5/16 inch
 - b) 3/16 inch
 - c) 5/32 inch
 - d) 1/8 inch
 - e) Electrode diameter is a non-essential variable for WPS qualification

33. What is the largest E7015 electrode permitted for prequalified procedures by AWS D1.1 for welding in the overhead position?
- a) 5/32 inch
 - b) 3/16 inch
 - c) 1/4 inch
 - d) 5/16 inch
 - e) None of the above
34. How must a crack be corrected?
- a) remove and reweld
 - b) grind and reweld
 - c) remove crack and sound metal 2 inches beyond each end of the crack and reweld
 - d) reweld with deep penetrating process to assure complete fusion of crack
 - e) none of the above
35. If a welder is successfully qualified on a fillet weld test in the 3F test position, for what welding positions are they qualified?
- a) flat and overhead fillets
 - b) flat grooves and fillets
 - c) flat and horizontal grooves
 - d) flat, horizontal, and vertical fillets
 - e) none of the above
36. A welder who is successfully qualified to weld with the FCAW process is also qualified to weld using:
- a) SMAW
 - b) GMAW
 - c) SAW
 - d) ESW
 - e) none of the above
37. When must edge blocks be used for radiographic testing?
- a) When radiographing butt welds 1/2 inch thick
 - b) When radiographing butt welds less than 1/2 inch thick
 - c) When radiographing butt welds greater than 1/2 inch thick
 - d) When radiographing butt welds 1 inch or greater thick
 - e) When radiographing butt welds 2 inches or greater thick
38. Other than root passes, what is the maximum thickness of passes in a prequalified horizontal SMAW groove weld?
- a) 5/16 inch
 - b) 3/32 inch
 - c) 1/8 inch
 - d) 5/32 inch
 - e) 3/16 inch
39. How much depth of undercut does AWS D1.1 allow on a 3/8 inch thick test plate for a welder qualification?
- a) None allowed
 - b) 5% of base metal thickness
 - c) 1/32 inch
 - d) 1/16 inch for lengths less than 2 inches in any 12 inches of weld, otherwise 1/32 inch
 - e) 5/16 inch

40. What does AWS D1.1 require for visual acuity for all Inspectors?
- a) Near vision acuity of Snellen English, or equivalent, at no less than 12 inches
 - b) Near vision acuity of Jaeger J-2 at a distance of 12 to 17 inches
 - c) Near vision acuity of Jaeger J-2 at a distance of 12 to 17 inches, with or without corrective lenses
 - d) Far vision acuity of 20/40, or better.
 - e) Far vision acuity of 30/40, or better.
41. What is the maximum convexity permitted on a 3/8 inch fillet weld having an actual face width of 9/16 inch?
- a) 1/16 inch
 - b) 3/32 inch
 - c) 1/8 inch
 - d) 3/16 inch
 - e) none of the above
42. What is the baking requirement for an AWS A5.5 low hydrogen electrode?
- a) Bake at 400°F for at least four hours
 - b) Bake at 500°F for at least one hour
 - c) Bake at 500° - 800°F for at least two hours
 - d) Bake at 700° - 800°F for at least one hour
 - e) None of the above
43. If a welding procedure is qualified in the 4G position, for what groove weld positions is that procedure qualified?
- a) F
 - b) F, H, and OH
 - c) F, H, V, and OH
 - d) H and OH only
 - e) OH only
44. For the prequalified joint B-U2-GF, the maximum root opening as fit-up is:
- a) 0 - 1/8 inch
 - b) 0 - 3/16 inch
 - c) 1/16 - 1/4 inch
 - d) Not limited
 - e) 3/16 inch
45. When the fit-up of a T-joint for fillet welding reveals a 1/16 inch root opening, what should be done?
- a) No corrective action is necessary because joints having members of any thickness may have up to a 5/16 inch opening
 - b) Close the joint to as tight as practicable
 - c) Open the joint to a maximum of 3/16 inch except in cases involving either shapes or plates 3 inches or greater in thickness
 - d) increase the leg of the fillet weld by 1/16 inch
 - e) increase the leg of the fillet weld by 3/16 inch
46. What is the maximum diameter E7018 electrode that can be used for a weld in the vertical welding position when using a prequalified procedure?
- a) 3/32 inch
 - b) 1/8 inch
 - c) 5/32 inch
 - d) 3/16 inch
 - e) 7/32 inch

47. The maximum weld reinforcement permitted for a procedure qualification test on 6G pipe having a wall thickness of 1-1/2 inches is:
- a) 1/32 inch
 - b) 1/16 inch
 - c) 1/8 inch
 - d) 3/16 inch
 - e) 5/16 inch
48. Which of the following is not considered to be an essential variable for the qualification of a WPS for SMAW?
- a) a decrease in the groove angle
 - b) an increase in the groove angle
 - c) a decrease in the root opening of the groove
 - d) an increase in the root face of the groove
 - e) the omission of backing material
49. Which of the following processes is not considered prequalified?
- a) SMAW
 - b) FCAW
 - c) GMAW (short circuiting transfer)
 - d) SAW
 - e) GMAW (non-short circuiting transfer)
50. For a 40 foot long horizontally curved welded girder, what is the permissible variation in specified sweep at the midpoint?
- a) (+/-) 1/4 inch
 - b) (+/-) 3/8 inch
 - c) (+/-) 1/2 inch
 - d) (+/-) 5/8 inch
 - e) (+/-) 3/4 inch

Sample Test 3

Answer Key

Question		Text		Table		Figure		Answer
		Subclause	Page	Number	Page	Number	Page	
1	Base metal, limitations (general)	1.2	1					d
2		2.4.2.9	7			2.1	43	b
3		6.9	221					b
4		4.5	126	4.2	139			c
5	Prequalified joint details	3.13.1	62			3.4	103	b
6		2.4.2.9 (2)	7			2.1	43	d
7		4.5	126	4.2	139			b
8		6.17.1	225-226	6.4	242			c
9	Base metal, filler metal combinations	3.3	59	3.1	64-67			b
10	Baking	5.3.2.1	194					e
11	Backing Thickness	5.10.3	197					b
12	Preheat	3.5; 5.6	60; 196	3.2 note a & note 2	68-70			d
13	Qualification, responsibility	4.2.1.1; 4.2.2.2	125					b
14		4.9.3.1	128			4.15	171	b
15	Qualification, WPS	4.3	126	4.1	138			b
16		6.12.2.1	222			6.2	252	c
17	Melt-through	4.9.1.1 (6b)	127					e
18		4.19.2.1	132	4.11	151-154			d
19		5.22.1	201-202					c
20		6.14.6.1	225					e
21		3.7	60	3.7	73			e
22		4.4	126	4.1	138			c
23	Welder qualification, essential variables	4.23	133	4.12 (1)	155			e
24	Processes	3.2.3	59					d
25	Temperature, ambient	5.12.2 (1)	198					a
26		3.5	60	3.2	68-70			b
27	Qualification, NDT	6.14.6.1	225					c
28	RT, Sources	6.17.6	226					c
29	Studs, fillet weld size	7.5.5.4	283	5.8; 7.2	209; 287			c
30		4.5	126	4.2 note i	139			c
31		6.12.2.2	223			6.3	257	c
32	Maximum electrode diameter	3.7	60	3.7 note b	73			c
33	Maximum electrode diameter	3.7	60	3.7 note b	73			a
34		5.26.1.4	206					c

35		4.19.1.1	132	4.10	150			d
36		4.23	133	4.12 (1)	155			e
37	Edge blocks	6.17.13	227					c
38		3.7	60	3.7	73			e
39	Welder qualification, test results	4.20.1 (1); 4.9.1.1 (4)	132; 127					c
40	Eye examination	6.1.4.4	220					c
41		5.24	205	5.9; 5.10	210			c
42	Baking	5.3.2.1; 5.3.2.4 (2)	194	5.1	208			d
43	WPS, qualification	4.4	126	4.1	138			e
44	Prequalified joint details					3.4	95	e
45	Fillet welds, assembly tolerances	5.22.1	201					b
46		3.7	60	3.7 footnote b	73			c
47	Visual Inspection	4.9.1 (3)	127					c
48		4.8.1	127	4.5 item 33	142- 144			b
49		3.2	59					c
50		5.23.5	203					c