



Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding



American Welding Society®



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An American National Standard

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Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding

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Prepared by the
American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

The composition, soundness, and properties of weld metal from ten grades of flux cored electrodes are specified. Standard electrode sizes together with their package forms and package sizes are detailed.

This specification makes use of both U. S. customary units and the International System of Units (SI). Since these are not equivalent, each system must be used independently of the other.



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Foreword

This foreword is not part of AWS A5.34/A5.34M: 2013, *Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.

Flux cored arc welding (FCAW) has been a major welding process for the fabrication of carbon, low-alloy, and stainless steel for more than 40 years. Initially, application of the process was limited, to some extent, by: a) the size of the electrode that could be manufactured and b) compositions of weld metal that could be developed using mild steel strip. Manufacturing improvements now permit the manufacture of a much wider range of electrode diameters. Likewise, these improvements permit the use of strip compositions such as stainless steel, aluminum, cobalt, and nickel alloys.

This second edition of nickel-alloy flux cored electrodes specification represents the state-of-the-art. The AWS Subcommittee on Nickel and Nickel-Alloy Filler Metal recognizes that the recent rapid growth and development in nickel-alloy welding will continue. Revision of this specification before the normal five-year period may be necessary to keep abreast of developments.

This document makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore each system must be used independently of the other, without combining values in any way. In selecting rational metric units AWS A1.1, *Metric Practice Guide for the Welding Industry*, and ISO 544 *Consumables—Technical delivery conditions for welding filler materials—Type of product, dimensions, tolerances and markings* are used where suitable. Tables and figures make use of both U. S. Customary and SI units, which, with the application of the specified tolerances, provides for interchangeability of products in both the U.S. Customary and SI units.

Substantive changes in this revision include adding new filler metal classification ENiMo13Tx-y, and updating Clause 6 (Rounding-Off Procedure). These are shown in Italic font.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.

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Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	x
<i>List of Figures</i>	x
1. Scope	1
2. Normative References	1
3. Classification	2
4. Acceptance	4
5. Certification	4
6. Rounding-Off Procedure	4
7. Summary of Tests	4
8. Retest	6
9. Weld Test Assemblies	6
10. Chemical Analysis	12
11. Radiographic Test	12
12. Tension Test	13
13. Bend Test	13
14. Fillet Weld Test	13
15. Method of Manufacture	15
16. Standard Sizes	15
17. Finish and Uniformity	15
18. Standard Package Forms	15
19. Winding Requirements	15
20. Filler Metal Identification	16
21. Packaging	16
22. Marking of Packages	16
Annex A (Informative)—Guide to AWS Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding	17
Annex B (Informative)—Guidelines for the Preparation of Technical Inquiries	25
AWS Filler Metal Specifications by Material and Welding Process	27
AWS Filler Metal Specifications and Related Documents	29

List of Tables

Table		Page No.
1	Chemical Composition Requirements for Undiluted Weld Metal	3
2	Required Shielding Gas, Welding Current, and Welding Position	4
3	Required Tests	5
4	Required Base Metals	5
5	Base Metal Specifications	6
6	Tension Test Requirements	15
A.1	Comparison of Classifications	19

List of Figures

Figure		Page No.
1	Pad for Chemical Analysis of Undiluted Weld Metal	7
2	Groove Weld Test Assembly for Tension and Radiographic Tests	8
3	Groove Weld for Longitudinal Face-Bend Test	9
4	Fillet Weld Test Assembly	10
5	Fillet Weld Test Specimen and Dimensional Requirements	11
6	Radiographic Standards for 3/4 in [19 mm] Test Assembly in Figure 2	14
A.1	A5.34/A5.34M Classification System Utilizing the ISO Format	18
A.2	A5.34/A5.34M Classification System Utilizing the Traditional Format	18

Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of nickel-alloy electrodes for flux cored arc welding. It includes those compositions in which the nickel content exceeds that of any other element, but excludes nickel-base alloy compositions intended for the joining of cast irons.

1.2 Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully addressed herein. Some safety and health information can be found in the nonmandatory annex, Clauses A5 and A10. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and applicable federal and state regulations.

1.3 This specification makes use of both U.S. Customary Units and the International System of Units (SI), according to the guidelines in AWS A1.1. The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to material properties. The specification with the designation A5.34 uses U.S. Customary Units. The specification A5.34M uses SI Units. The latter are shown within brackets [] or in appropriate columns in tables and figures. Standard dimensions based on either system may be used for sizing of filler metal or packaging or both under the A5.34 or A5.34M specification.

2. Normative References

2.1 The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreement based on this AWS standard are encouraged to investigate the possibility of applying the most recent editions of the documents shown below. For undated references, the latest edition of the standard referred to applies.

2.2 The following AWS standards¹ are referenced in the mandatory clauses of this document:

AWS A1.1, *Metric Practice Guide for the Welding Industry*

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*

AWS A5.01M/A5.01 (ISO 14344 MOD), *Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes*

AWS A5.02/A5.02M, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*

AWS A5.32/A5.32M (ISO 14175 MOD), *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*

AWS B4.0 or AWS B4.0M, *Standard Methods for Mechanical Testing of Welds*

2.3 The following ANSI standard² is referenced in the mandatory clauses of this document:

ANSI Z49.1 *Safety in Welding, Cutting, and Allied Processes*

¹ AWS standards are published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166, USA.

² This ANSI standard is published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166, USA.

2.4 The following ASTM standards³ are referenced in the mandatory clauses of this document:

ASTM A131/A131M *Standard Specification for Structural Steel for Ships*

ASTM A240/A240M *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

ASTM A515/A515M *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate-, and Higher- Temperature Service*

ASTM A516/A516M *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A666 *Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*

ASTM B166 *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Rod, Bar, and Wire*

ASTM B168 *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip*

ASTM B333 *Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip*

ASTM B435 *Standard Specification for UNS N06002, N06230, UNS N12160, and R30556 Plate, Sheet, and Strip*

ASTM B443 *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip*

ASTM B446 *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Rod and Bar*

ASTM B575 *Spec for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet and Strip*

ASTM E29 *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E354 *Standard Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys*

ASTM E1019 *Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys*

ASTM E1032 *Standard Test Methods for Radiographic Examination of Weldments*

ASTM E1473 *Standard Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys*

2.5 The following ISO standards⁴ are referenced in the mandatory clauses of this document:

ISO 544, *Welding Consumables—Technical delivery conditions for welding filler materials—Type of product, dimensions, tolerances and markings*

ISO 80000-1, *Quantities and units—Part 1: General*

3. Classification

3.1 The flux cored electrodes covered by the A5.34/A5.34M specifications are classified using a system that is independent of U.S. Customary Units and the International System of Units (SI). Classification is according to the chemical composition of the undiluted weld metal, the shielding gas employed during welding, and the welding position usability, as specified in Tables 1 and 2.

³ ASTM standards are published by ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

⁴ ISO standards are published by the International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

Table 1
Chemical Composition Requirements for Undiluted Weld Metal

AWS Classifications ^c			Wt Percent ^{a,b}															
ISO Format	Traditional	UNS Number ^d	C	Mn	Fe	P	S	Si	Cu	Ni ^e	Co	Ti	Cr	Nb(Cb) plus Ta ^g	Mo	V	W	Other
TiNi 6082-xy	ENiCr3Ti-x-y	W86082	0.10	2.5–3.5	3.0	0.03	0.015	0.50	0.50	67.0 min.	(f)	0.75	18.0–22.0	2.0–3.0	—	—	—	0.50
TiNi 6062-xy	ENiCrFe1Ti-x-y	W86132	0.08	3.5	11.0	0.03	0.015	0.75	0.50	62.0 min.	—	—	13.0–17.0	1.5–4.0	—	—	—	0.50
TiNi 6133-xy	ENiCrFe2Ti-x-y	W86133	0.10	1.0–3.5	12.0	0.03	0.02	0.75	0.50	62.0 min.	(f)	—	13.0–17.0	0.5–3.0	0.5–2.5	—	—	0.50
TiNi 6182-xy	ENiCrFe3Ti-x-y	W86182	0.10	5.0–9.5	10.0	0.03	0.015	1.0	0.50	59.0 min.	(f)	1.0	13.0–17.0	1.0–2.5	—	—	—	0.50
TiNi 1013-xy	ENiMo13Ti-x-y	N10300	0.10	2.0–3.0	10.0	0.020	0.015	0.75	0.5	58.0 min.	—	—	4.0–8.0	—	16.0–19.0	—	2.0–4.0	0.50
TiNi 6002-xy	ENiCrMo2Ti-x-y	W86002	0.05–0.15	1.0	17.0–20.0	0.04	0.03	1.0	0.50	Rem.	0.50–2.50	—	20.5–23.0	—	8.0–10.0	—	0.2–1.0	0.50
TiNi 6625-xy	ENiCrMo3Ti-x-y	W86625	0.10	0.50	5.0 ^h	0.02	0.015	0.50	0.50	58.0 min.	(f)	0.40	20.0–23.0	3.15–4.15	8.0–10.0	—	—	0.50
TiNi 6276-xy	ENiCrMo4Ti-x-y	W80276	0.02	1.0	4.0–7.0	0.03	0.03	0.2	0.50	Rem.	2.5	—	14.5–16.5	—	15.0–17.0	0.35	3.0–4.5	0.50
TiNi 6022-xy	ENiCrMo10Ti-x-y	W86022	0.02	1.0	2.0–6.0	0.03	0.015	0.2	0.50	Rem.	2.5	—	20.0–22.5	—	12.5–14.5	0.35	2.5–3.5	0.50
TiNi 6117-xy	ENiCrCoMo1Ti-x-y	W86117	0.05–0.15	0.3–2.5	5.0	0.03	0.015	0.75	0.50	Rem.	9.0–15.0	—	21.0–26.0	1.0	8.0–10.0	—	—	0.50

^a The weld metal shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined, the total of which shall not exceed 0.50%.

^b Single values are maximum, except where otherwise specified. Rem. = Remainder.

^c Both designations shall be shown as described in Clause 22.1. The letter “x” stands for the numerals 0 or 1 which denotes the welding position for which the alloy is classified, as described in Table 2. The letter “y” stands for one of the numerals 1, 3 or 4 which denotes the particular shielding gas (or none at all) required when conducting the classification tests, as described in Table 2.

^d SAE HS-1086/ASTM DS-56 *Metals & Alloys in the Unified Numbering System*

^e Includes residual cobalt.

^f Cobalt is 0.10 maximum, when specified by the purchaser.

^g Tantalum is 0.30 maximum, when specified by the purchaser.

^h Iron is 1.0 maximum, when specified by the purchaser.

Table 2
Required Shielding Gas, Welding Current, and Welding Position

AWS Classifications ^a		External Shielding Gas Classification ^b	Current and Polarity	Welding Position ^c
ISO Format	Traditional			
TNi xxxx-01	ENiXXXXT0-1	AWS A5.32(ISO 14175)-C1-100	dcep	F & HF
TNi xxxx-11	ENiXXXXT1-1	AWS A5.32(ISO 14175)-C1-100	dcep	All
TNi xxxx-03	ENiXXXXT0-3	None	dcep	F & HF
TNi xxxx-04	ENiXXXXT0-4	AWS A5.32(ISO 14175)-M21-ArC-25	dcep	F & HF
TNi xxxx-14	ENiXXXXT1-4	or AWS A5.32(ISO 14175)-M21-ArC-20	dcep	All

^a The letters xxxx stand for numeric designators, and XXXX stand for the chemical symbol designators for the chemical composition.

^b See AWS A5.32M/A5.32 (ISO 14175 MOD). AWS A5.32 (ISO 14175)-C1-100 = CO₂; AWS A5.32 (ISO 14175)-M21-ArC-25 is nominally 25% CO₂, balance argon; AWS A5.32(ISO 14175)-M21-ArC-20 is nominally 20% CO₂, balance argon. The external shielding gas specified here is required when making welds for classification. This requirement is not intended to preclude the use of another shielding gas in the application of the electrode.

^c Welding position usability is determined by the Fillet Weld Test as required by Table 3.

F = flat; HF = horizontal fillet; All = flat, horizontal, overhead and vertical with upward progression.

3.2 Electrodes classified under one classification may be classified under any other classification of this specification provided they meet all the requirements for those classifications.

4. Acceptance

Acceptance⁵ of the electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD).

5. Certification

By affixing the AWS specification and classification designations to the packaging or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁶

6. Rounding-Off Procedure

For the purpose of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding-off rules of ASTM E29 or Rule A in Clause B.3 of ISO 80000-1 (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding off. If an average value is to be compared to the specified limit, rounding off shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1000 psi (1 ksi) for tensile strength for A5.34 or to the nearest 10 MPa for tensile strength for A5.34M; and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded-off results shall fulfill the requirements for the classification under test.

7. Summary of Tests

7.1 The tests required for each classification are specified in Table 3. The purpose of these tests is to determine the chemical composition, the mechanical properties, soundness of the weld metal, and the welding position usability characteristics of the electrode using the specified shielding gas.

7.2 The base metals for the weld test assemblies are as specified in Tables 4 and 5. The welding and testing procedures to be employed, and the results required are given in Clauses 9 through 14.

⁵ See Clause A3, Acceptance (in Annex A), for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01 (ISO 14344 MOD).

⁶ See Clause A4, Certification (in Annex A), for further information concerning certification and the testing called for to meet this requirement.

Table 3
Required Tests^a

AWS Classifications	Chemical	Radiographic	Tension	Longitudinal	Fillet
ISO Format	Analysis	Test	Test	Bend Test	Weld Test
TNi 6082-0y	ENiCr3T0-y	Required	Required	Required	Not Required
TNi 6082-1y	ENiCr3T1-y	Required	Required	Required	Required
<i>TNi 1013-0y</i>	<i>ENiMo13T0-y</i>	<i>Required</i>	<i>Required</i>	<i>Required</i>	<i>Not Required</i>
<i>TNi 1013-1y</i>	<i>ENiMo13T1-y</i>	<i>Required</i>	<i>Required</i>	<i>Required</i>	<i>Required</i>
TNi 6062-0y	ENiCrFe1T0-y	Required	Required	Required	Not Required
TNi 6062-1y	ENiCrFe1T1-y	Required	Required	Required	Required
TNi 6133-0y	ENiCrFe2T0-y	Required	Required	Required	Not Required
TNi 6133-1y	ENiCrFe2T1-y	Required	Required	Required	Required
TNi 6182-0y	ENiCrFe3T0-y	Required	Required	Required	Not Required
TNi 6182-1y	ENiCrFe3T1-y	Required	Required	Required	Required
TNi 6002-0y	ENiCrMo2T0-y	Required	Required	Required	Not Required
TNi 6002-1y	ENiCrMo2T1-y	Required	Required	Required	Required
TNi 6625-0y	ENiCrMo3T0-y	Required	Required	Required	Not Required
TNi 6625-1y	ENiCrMo3T1-y	Required	Required	Required	Required
TNi 6276-0y	ENiCrMo4T0-y	Required	Required	Required	Not Required
TNi 6276-1y	ENiCrMo4T1-y	Required	Required	Required	Required
TNi 6022-0y	ENiCrMo10T0-y	Required	Required	Required	Not Required
TNi 6022-1y	ENiCrMo10T1-y	Required	Required	Required	Required
TNi 6117-0y	ENiCrCoMo1T0-y	Required	Required	Required	Not Required
TNi 6117-1y	ENiCrCoMo1T1-y	Required	Required	Required	Required

^a The tests specified are required for each size of electrode to be classified.

Table 4
Required Base Metals^{a,b}

AWS Classification		Chemical Analysis ^c	Radiographic Test	Tension Test	Bend Test	Fillet Weld Test
ISO Format	Traditional					
TNi 6082-xy	ENiCr3Tx-y	Ni-Cr-Fe, Stainless, or Carbon Steels				
TNi 6062-xy	ENiCrFe1Tx-y					
TNi 6133-xy	ENiCrFe2Tx-y					
TNi 6182-xy	ENiCrFe3Tx-y					
<i>TNi 1013-xy</i>	<i>ENiMo13Tx-y</i>	<i>Ni-Mo, Stainless, or Carbon Steel</i>				
TNi 6002-xy	ENiCrMo2Tx-y	Ni-Cr-Mo, Stainless, or Carbon Steels				
TNi 6625-xy	ENiCrMo3Tx-y					
TNi 6276-xy	ENiCrMo4Tx-y					
TNi 6022-xy	ENiCrMo10Tx-y					
TNi 6117-xy	ENiCrCoMo1Tx-y	Ni-Cr-Co-Mo, Stainless, or Carbon Steels				

^a See Table 5 for specifications for the required base metals.

^b Where nickel alloy, carbon steel, or stainless steel is shown, any type or any combination of those may be used. When either or both members are carbon steel, two layers of buttering shall be applied to the face of the groove on the carbon steel member and, if the backing strip is also carbon steel, to the mating surface of that as well. The buttering shall be applied in the flat position using electrodes of the same classification as the one being tested prior to joint fit up.

^c For chemical analysis, carbon steel, stainless steel, or nickel alloy base metals other than those specified in tables may be used in preparation of the undiluted weld metal pad provided the minimum pad height (weld metal) is 3/4 in [20 mm] and the sample for analysis is taken at least 5/8 in [16 mm] from the nearest surface of the base metal.

Table 5
Base Metal Specifications^a

AWS Classification		Base Metal	ASTM Specification	UNS Number of Base Metal
ISO Format	Traditional			
TNi 6082-xy	ENiCr3Tx-y	Nickel-chromium Iron alloy	B 166, B 168	N06600
TNi 6062-xy	ENiCrFe1Tx-y			
TNi 6133-xy	ENiCrFe2Tx-y			
TNi 6182-xy	ENiCrFe3Tx-y			
TNi 1013-xy	ENiMo13Tx-y	Nickel-Molybdenum alloy	B333	N10001, N10665, and N10675
TNi 6002-xy TNi 6625-xy	ENiCrMo2Tx-y ENiCrMo3Tx-y	Nickel-chromium- molybdenum alloy	B 443, B 446, B 435	N06625 N06002
		Low carbon nickel-chromium- molybdenum alloy	B 575	N10276
		Low carbon nickel-chromium- molybdenum alloy	B 575	N10276, N06022
TNi 6276-xy	ENiCrMo4Tx-y	Nickel-chromium-cobalt- Molybdenum alloy	B 166, B 168	N06617
TNi 6022-xy	ENiCrMo10Tx-y			
TNi 6117-xy	ENiCrCoMo1Tx-y			
All		Carbon steel	A 131, A 285, A515, A516	—
All		Austenitic stainless steel	A 240, A 666	S301xx, S302xx, S304xx, S316xx

^a All base metals, except carbon steel, shall be in the annealed condition prior to welding.

8. Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet their requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

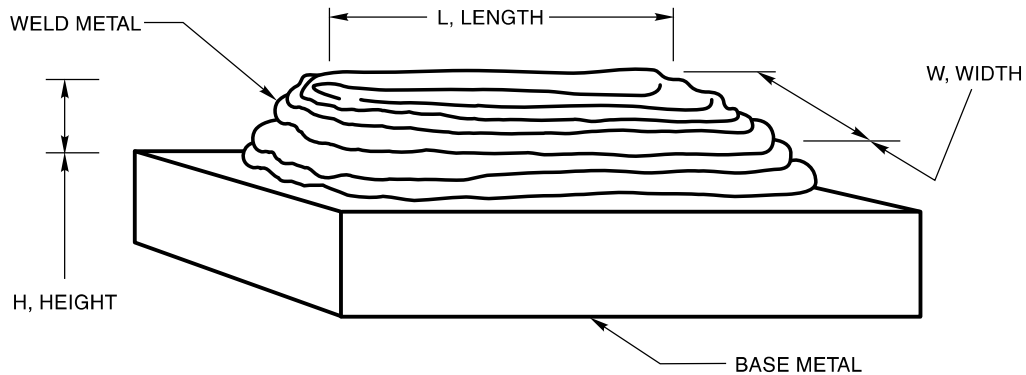
In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s) or in conducting the test, the test shall be considered invalid without regard to whether the test was actually completed, or whether test results met, or failed to meet, the requirement. That test shall be repeated, following prescribed procedures. In this case, the requirement for doubling of the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 Up to four weld test assemblies may be needed, depending upon the classification, as specified in Table 3. They are :

- (1) the weld pad in Figure 1 for chemical analysis of the undiluted weld metal
- (2) the groove weld in Figure 2 for mechanical properties and soundness of the weld metal
- (3) the groove weld in Figure 3 for longitudinal bend testing
- (4) the fillet weld in Figure 4 for welding position usability of the electrode.

The sample for chemical analysis may be taken from the reduced section of the fractured tension specimen, or from a corresponding location (or any location above it) in the weld metal of the groove weld in Figure 2, thereby avoiding the need to make the weld pad. In case of dispute, the weld pad shall be the referee method.



								Minimal Distance of Sample from Surface of Base Plate ^a	
Diameter		Weld Pad Size, Minimum							
		L		W		H ^a			
in	mm	in	mm	in	mm	in	mm	in	mm
0.035 0.040 0.045 —	0.9 1.0 — 1.2	3	75	3/4	20	1/2	13	3/8	10
0.052 — 1/16 5/64	— 1.4 1.6 2.0	3	75	3/4	20	5/8	16	1/2	13
3/32 7/64	2.4 2.8	3-1/2	90	1	25	3/4	20	5/8	16

^a Number of passes per layer is optional.

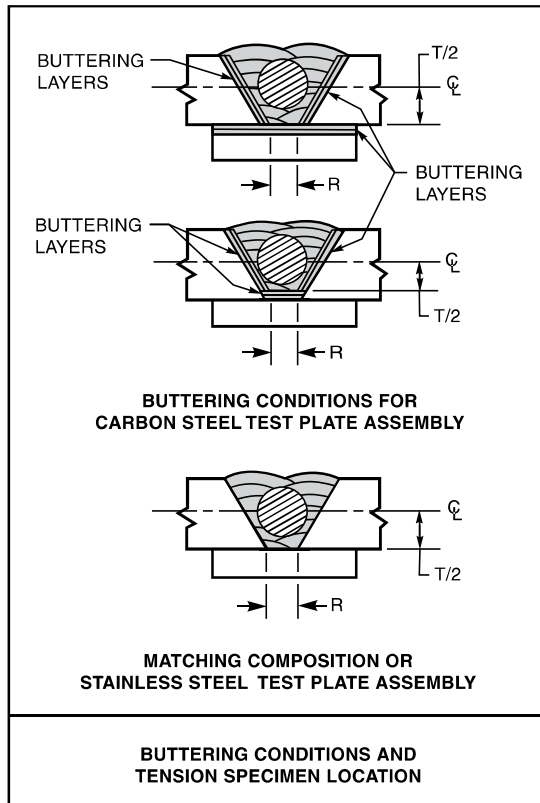
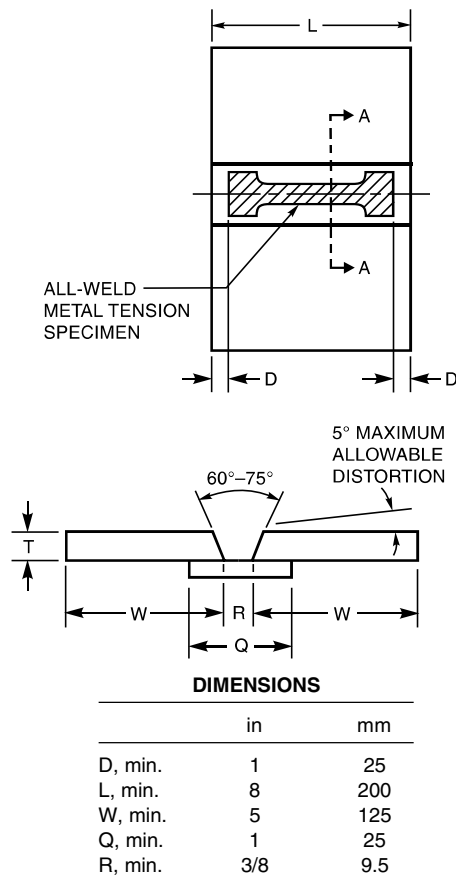
Notes:

1. Width and thickness of the base plate may be any dimensions suitable for the electrode diameter and current used.
2. The first and last inch [25 mm] of the weld length shall be disregarded. The top surface shall be removed and chemical analysis samples shall be taken from the top of the remaining deposited metal.
3. The use of copper chill bar is optional.
4. For chemical analysis, carbon steel, stainless steel, or nickel alloy base metals other than those specified in tables may be used in preparation of the undiluted weld metal pad provided the minimum pad height (weld metal) is 3/4 in [20 mm] and the sample for analysis is taken at least 5/8 in [16 mm] from the nearest surface of the base metal.

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal

9.2 Preparation of each weld test assembly shall be as prescribed in 9.3, 9.4, 9.5, and 9.6. The base metal for each assembly shall be as required in Table 4, according to the tests to be conducted, and shall meet the requirements of the appropriate ASTM specification shown in Table 5, or an equivalent specification. Testing shall be as prescribed in Clause 10: Chemical Analysis, Clause 11: Radiographic Test, Clause 12: Tension Test, Clause 13: Bend Test, and Clause 14: Fillet Weld Test.

9.3 Weld Pad. A weld pad shall be prepared as specified in Table 3 and shown in Figure 1, except when one of the alternatives in 9.1 (taking the sample from the weld metal in the groove weld or from the tension test specimen) is selected. Base metal of any convenient size, of the type specified in Tables 4 and 5, shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position, with multiple layers to obtain undiluted weld metal using the applicable shielding gas, if any. Welding



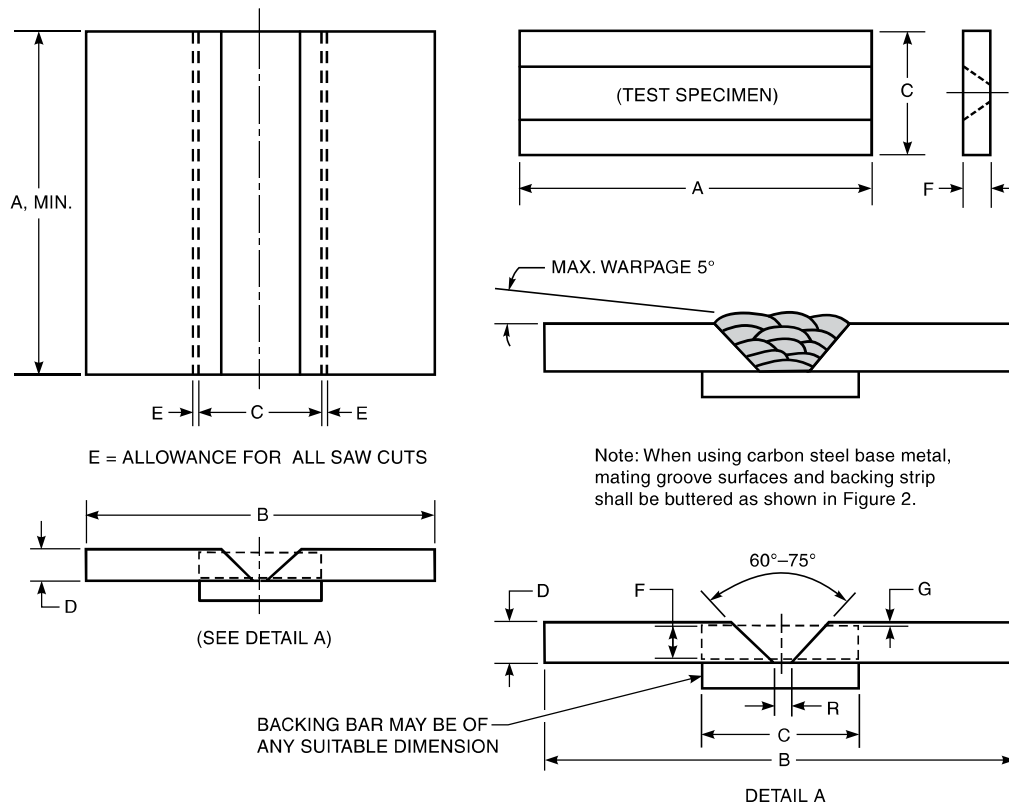
Electrode Diameter		(T) Plate Thickness		Recommended Passes per Layer		Recommended Number of Layers
in	mm	in	mm	Layer 1 and 2	Layer 3 to Top	
0.035	0.9	3/4	20	1 or 2	2, 3, or 4	8 to 12
0.040	1.0					
0.045	—					
—	1.2					
0.052	1.4	3/4	20	1 or 2	2 or 3 ^a	5 to 8
—	1.6					
1/16	1.6					
5/64	2.0					
3/32	2.4					4 to 6
7/64	2.8	3/4	20	1 or 2	2 or 3 ^a	

^a Final layer may be 4 passes.

Notes:

1. The assembly shall be as long as necessary to provide the specimens needed for the number and type of tests required.
2. The root opening (R) tolerance is $\pm 1/16$ in [1.5 mm].
3. The base metal shall be as specified in Table 4.
4. The surfaces to be welded shall be clean.
5. Prior to welding, the assembly may be preset so that the welded joint will be sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within five (5) degrees of plane. A test assembly that is more than five (5) degrees out of plane shall be discarded. Straightening of the test assembly is prohibited.
6. Welding shall be performed in the flat position, using welding parameters and technique recommended by the electrode manufacturer.
7. The preheat temperature shall be 60 °F [15 °C] minimum. The interpass temperature shall not exceed 300 °F [150 °C].
8. The tests shall be conducted without a postweld heat treatment.

Figure 2—Groove Weld Test Assembly for Tension and Radiographic Tests

**Electrode Diameter****Passes per layer**

in	mm	Layer 2			Number of Layers
		Layer 1	to top		
0.035	0.9				
0.040	1.0				
0.045	—				
—	1.2				
0.052	—				
—	1.4				
1/16	1.6	1	2 to 3 ^a		3 to 5
5/64	2.0				
3/32	2.4				
7/64	2.8				

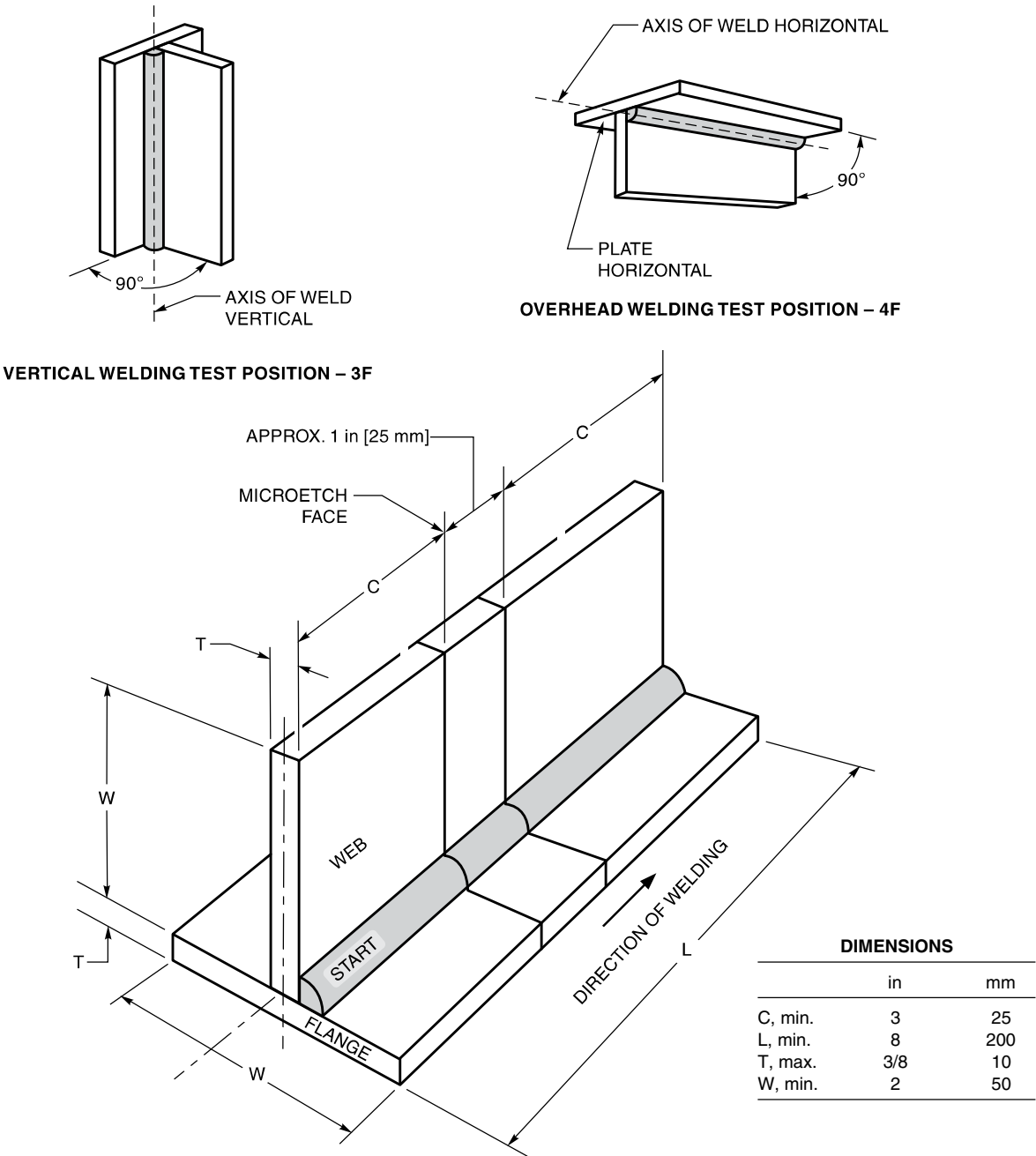
	in	mm
A	6 min.	150 min.
B	6	150
C	2	50
D	1/2	13
E	1/8	3
F	3/8	9.5
G	1/16	1.6
R	3/8	10

Notes:

- The assembly shall be as long as necessary to provide the specimens needed for the number and type of tests required.
- The root opening (R) tolerance is $\pm 1/16$ in [1.6 mm].
- The base metal shall be as specified in Table 4.
- The surfaces to be welded shall be clean.
- Prior to welding, the assembly may be preset so that the welded joint will be sufficiently flat to facilitate removal of the test specimen. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within five (5) degrees of plane. A welded test assembly that is more than five (5) degrees out of plane shall be discarded. Straightening of the test assembly is prohibited.
- Welding shall be performed in the flat position, using welding parameters and technique recommended by the electrode manufacturer.
- The preheat temperature shall be 60°F [15°C] minimum. The interpass temperature shall not exceed 300°F [150°C].
- The tests shall be conducted without a postweld heat treatment.

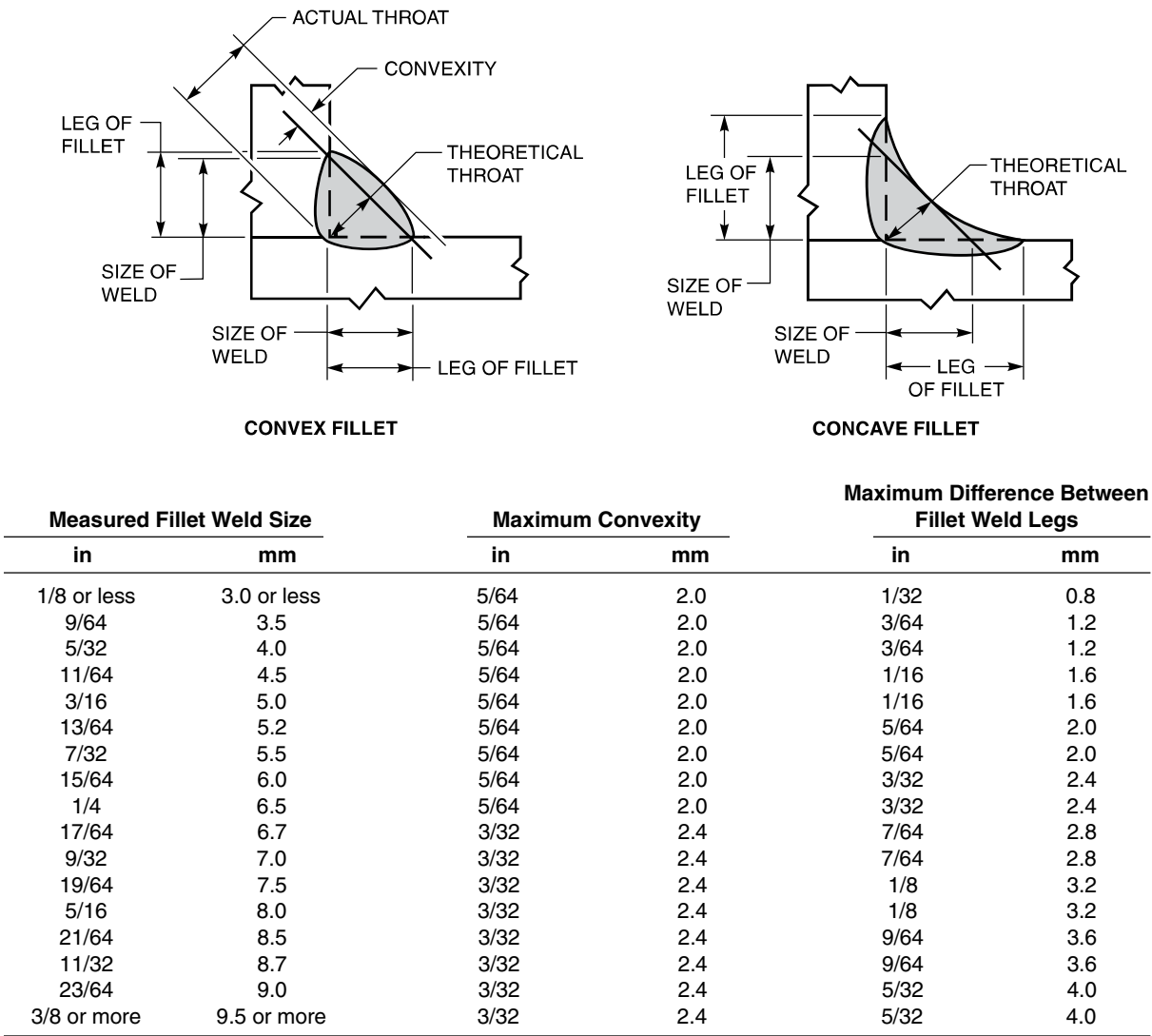
^a. Top layer must be 3.

Figure 3—Groove Weld for Longitudinal Face-Bend Test



- Notes:
1. The base metal shall be as specified in Table 4.
 2. The surface to be welded shall be clean.
 3. The assembly shall be at room temperature at the start of the welding pass.
 4. Weld cleaning shall be limited to slag chipping , brushing, and needle scaling. Grinding or filing of the weld face is prohibited.

Figure 4—Fillet Weld Test Assembly



Notes:

1. Size of fillet weld = leg length of largest inscribed isosceles right triangle.
2. Fillet weld size, convexity, and leg lengths of fillet welds shall be determined by actual measurement (nearest 1/64 in [0.5 mm]) on a section laid out with scribed lines shown.

Figure 5—Fillet Weld Test Specimen and Dimensional Requirements

conditions shall be those recommended by the manufacturer. The preheat temperature shall be not less than 60°F [15°C], and the interpass temperature shall not exceed 300°F [150°C]. The slag shall be removed after each pass. The pad may be quenched in water between passes. Dimensions of the completed weld pad shall be as shown in Figure 1. Testing of this assembly shall be as specified in Clause 10, Chemical Analysis.

9.4 Groove Weld. A test assembly shall be prepared and welded as specified in Table 3 and Figure 2, using base metal of the appropriate type specified in Tables 4 and 5. Testing of this assembly shall be as specified in Clause 11, Radiographic Test, and Clause 12, Tension Test. The assembly shall be tested in the as-welded condition.

9.5 Longitudinal Face Bend

The test assembly shall be prepared and welded as specified in Table 3 and Figure 3, using base metal of the appropriate type as specified in Tables 4 and 5. Testing of this assembly shall be as specified in Clause 13, Bend Test.

9.6 Fillet Weld

9.6.1 Fillet weld tests, when required by Table 3, shall be performed in the vertical and overhead positions. A test assembly shall be prepared and welded as shown in Figure 4 using base metal of the appropriate type as specified in Tables 4 and 5, the shielding gas, current and polarity specified in Table 2, and the amperage or wire feed speed and arc voltage recommended by the manufacturer. Testing of the assembly shall be as specified in Clause 14, Fillet Weld Test.

9.6.2 In preparing the two plates forming the test assembly, the standing member (web) shall have one edge prepared so that when the web is set upon the base plate (flange), which shall be straight and smooth, there will be intimate contact along the entire length of the joint.

9.6.3 A single-pass fillet weld shall be deposited on one side of the joint. When welding in the vertical position, the welding shall progress upward.

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal produced with the filler metal and the shielding gas with which it is classified. The top surface of the pad described in 9.3 and shown in Figure 1 shall be removed and discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag. The sample shall be taken at least 3/8 in [10 mm] from the nearest surface of the base metal (see Table 4, Note c, for sample removal when base metals other than those specified are used). Samples from the reduced section of the fractured tension specimen or from a corresponding location (or any location above it) in the groove weld in Figure 2 shall be prepared for chemical analysis by any suitable mechanical means.

10.2 The sample shall be analyzed by accepted analytical methods. The primary referee method shall be ASTM Method E1473, supplemented by ASTM Method E1019 for carbon and ASTM Method E354 for phosphorus.

10.3 The results of the analysis shall meet the requirements of Table 1 for the classification of electrode under test.

11. Radiographic Test

11.1 The groove weld described in 9.4 and shown in Figure 2 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed and both surfaces of the weld shall be machined or ground smooth and flush with the original surfaces (except as noted) of the base metal or with a uniform reinforcement not exceeding 3/32 in [2.5 mm]. It is permitted on both sides of the test assembly to remove base metal to a depth of 1/16" [1.5 mm] nominal below the original base metal surface in order to facilitate backing and/or buildup removal. Thickness of the weld metal shall not be reduced by more than 1/16" [1.5 mm] less than the nominal base metal thickness. Both surfaces of the test assembly, in the area of the weld, shall be smooth enough to avoid difficulty in interpreting the radiograph.

11.2 The weld shall be radiographed in accordance with ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*. The quality level of inspection shall be 2-2T.

11.3 The soundness of the weld metal meets the requirements of this specification if the radiograph shows:

- (1) no cracks, no incomplete fusion, and no incomplete penetration, and
- (2) no rounded indications in excess of those permitted by the radiographic standard in Figure 6

In evaluating the radiograph one inch [25 mm] of the weld on each end of the test assembly shall be disregarded.

11.3.1 The alternative method of evaluation involves calculation of the total area of the rounded indications as they appear on the radiograph. This total area shall not exceed 1 percent of the thickness of the test assembly multiplied by the length of the weld used in evaluation (length of the weld in the test assembly minus 1 in [25 mm] on each end). The value given in Note 3 of the Figure 6 has been calculated for 6 in [150 mm] of weld (an 8 in [200 mm] long test assembly). The value for weld lengths other than this will differ on a linearly proportional basis.

11.3.2 A rounded indication is an indication on the radiograph whose length is no more than three times its width. Rounded indications may be circular or irregular in shape, and they may have tails. The size of a rounded indication is the largest dimension of the indication, including any tail that may be present. The indication may be of porosity or slag.

11.3.3 Indications whose largest dimension does not exceed 1/64 in [0.4 mm] shall be disregarded. Test assemblies with indications larger than the large indications permitted in the radiographic standard (Figure 6) do not meet the requirements of this specification.

12. Tension Test

12.1 One all-weld-metal tension test specimen, as specified in the Tension Test clause of AWS B4.0 or AWS B4.0M, shall be machined from the groove weld described in 9.4 and shown in Figure 2. The all-weld-metal tensile specimen shall have a nominal diameter of 0.500 in [12.5 mm] and a nominal gage length-to-diameter ratio of 4:1.

12.2 The specimen shall be tested in the manner described in the Tension Test clause of AWS B4.0 or AWS B4.0M.

12.3 The results of the tension test shall meet the requirements specified in Table 6.

13. Bend Test

13.1 One longitudinal face bend specimen, as required in Table 3, shall be machined from the groove weld test assembly shown in Figure 3, as described in AWS B4.0 or AWS B4.0M. The dimensions of the specimen shall be as shown in Figure 3. The backing strip and weld reinforcement shall be removed by machining.

13.2 The specimen shall be tested in the manner described in the Bend Test clause of AWS B4.0 or AWS B4.0M by bending it uniformly through 180 degrees over a 3/4 in [19 mm] radius. Any suitable jig, as specified in the Bend Test clause of AWS B4.0 or AWS B4.0M may be used.

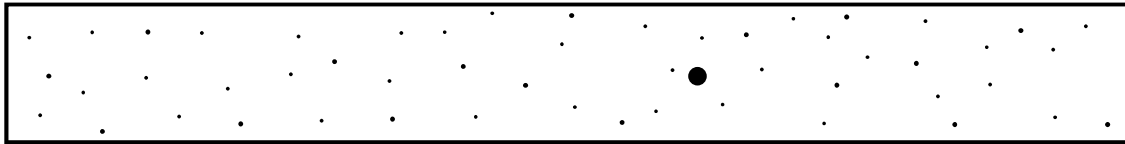
13.3 The specimen, after bending, shall conform to the 3/4 in [19 mm] radius, with appropriate allowance for spring back, and the weld metal shall show no defects on the tension face greater than 1/8 in [3 mm].

14. Fillet Weld Test

14.1 The fillet weld test, when required by Table 3, shall be made in accordance with the requirements of 9.6 and Figure 4. The entire face of the completed fillet shall be examined visually, and shall show no cracks and be reasonably free of undercut. After the visual examination, a specimen containing approximately 1 in [25 mm] of weld (in the lengthwise direction) shall be prepared as shown in Figure 4. One cross-sectional surface of the specimen shall be polished and etched, then examined as required in 14.2.

14.2 Scribe lines shall be placed on the prepared surface, as shown in Figure 5, and the leg lengths and convexity of the fillet shall be determined to the nearest 1/64 in [0.5 mm] by actual measurement (see Figure 5). These dimensions shall meet the requirements in Figure 5 for fillet size, convexity, and permissible difference in the length of the legs.

14.2.1 The fillet shall have penetration to or beyond the junction of the edges of the plates.



(A) ASSORTED ROUNDED INDICATIONS

SIZE PERMITTED IS 0.125 in [3.2 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 53, WITH THE FOLLOWING RESTRICTIONS:

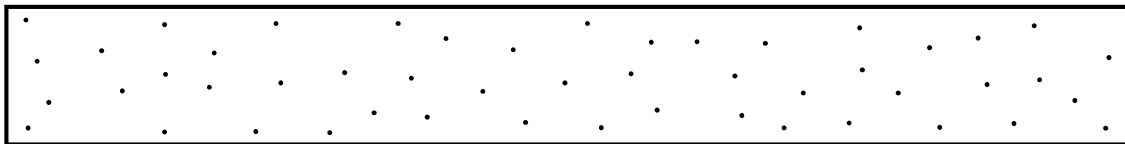
- LARGE: UP TO 0.125 in [3.2 mm] – 1 PERMITTED
- MEDIUM: UP TO 0.034 in [0.9 mm] – 17 PERMITTED
- SMALL: UP TO 0.024 in [0.6 mm] – 35 PERMITTED



(B) LARGE ROUNDED INDICATIONS

SIZE PERMITTED IS 0.125 in [3.2 mm] MAXIMUM.

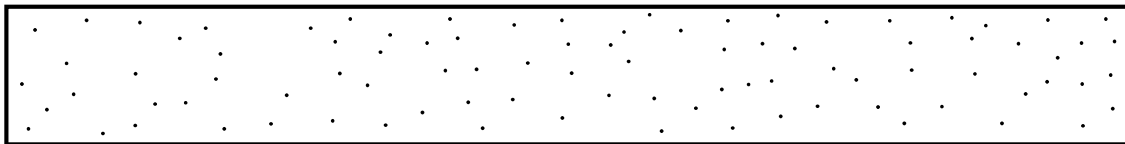
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 4.



(C) MEDIUM ROUNDED INDICATIONS

SIZE PERMITTED IS 0.034 in [0.9 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 50.



(D) SMALL ROUNDED INDICATIONS

SIZE PERMITTED IS 0.024 in [0.6 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 90.

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in [0.4 mm] and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those normally encountered in general fabrication.
3. When using the alternative method of evaluation described in 11.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.045 in² [29.0 mm²] in any 6 in [150 mm] of weld.
4. The acceptance standard for slag inclusions in this assembly is the following:
 - (a) Length of each individual slag indication: 5/16 in [8 mm] maximum
 - (b) Total length of all slag indications: 15/32 in [12 mm] maximum

Figure 6—Radiographic Standards for 3/4 in [19 mm] Test Assembly in Figure 2

Table 6
Tension Test Requirements^a

AWS Classification		Tensile Strength, min.		Elongation ^b
ISO Format	Traditional	psi	MPa	Percent, min.
TNi 6082-xy	ENiCr3Tx-y	80 000	550	25
TNi 6062-xy	ENiCrFe1Tx-y			
TNi 6133-xy	ENiCrFe2Tx-y			
TNi 6182-xy	ENiCrFe3Tx-y			
TNi 6002-xy	ENiCrMo2Tx-y	90 000	620	25
<i>TNi 1013-xy</i>	<i>ENiMo13Tx-y</i>	100 000	690	25
TNi 6625-xy	ENiCrMo3Tx-y			
TNi 6276-xy	ENiCrMo4Tx-y			
TNi 6022-xy	ENiCrMo10Tx-y			
TNi 6117-xy	ENiCrCoMo1Tx-y	90 000	620	25

^a As-welded condition.

^b The elongation shall be determined from gage length equal to 4 times the gage diameter.

14.2.2 The legs and convexity of the fillet weld shall be within the limits prescribed in Figure 5.

14.2.3 The fillet weld shall show no evidence of cracks.

14.2.4 The weld shall be reasonably free from undercutting, overlap, trapped slag, and porosity.

15. Method of Manufacture

The electrodes classified according to this specification may be manufactured by any method that will produce material that meets the requirements of this specification.

16. Standard Sizes

Standard sizes for electrode in the different package forms (coils with support, coils without support, spools and drums) are as specified in AWS A5.02/A5.02M.

17. Finish and Uniformity

17.1 Finish and uniformity shall be as specified in 4.2 of AWS A5.02/A5.02M.

18. Standard Package Forms

18.1 Standard package forms are coils with support, coils without support, spools, and drums. Standard package dimensions and weights and other requirements for each form shall be as specified in 4.3 of AWS A5.02/A5.02M

19. Winding Requirements

19.1 Winding requirements shall be as specified in 4.4.1 of AWS A5.02/A5.02M

19.2 The cast and helix of filler metal shall be as specified in 4.4.2 of AWS A5.02/A5.02M

20. Filler Metal Identification

20.1 Filler metal identification including product information and the precautionary information shall be as specified in 4.5 of AWS A5.02/A5.02M.

21. Packaging

Filler metal shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.

22. Marking of Packages

22.1 The product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package shall be as specified in 4.6.1 of AWS A5.02/A5.02M.

22.2 The appropriate precautionary information as given in ANSI Z49.1 (as a minimum) or its equivalent, shall be prominently displayed in legible print on all packages of electrodes, including individual unit packages enclosed within a larger package.

Annex A (Informative)

Guide to AWS Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding

This annex is not part of AWS A5.34/A5.34M: 2013, *Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.

A1. Introduction

The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively. Reference to appropriate base metal specifications is made whenever that can be done and when it would be helpful. Such references are intended only as examples rather than complete listings of the base materials for which each filler metal is suitable.

A2. Classification System

A2.1 An international system for designating filler metals (Figure A.1) is being adopted for nickel filler metals by the International Standards Organization (ISO). In order that the AWS filler metal specifications can easily conform to international standards, this specification adopts the new system along with that of the traditional designations. Both designations are to be employed for identification of the filler metal.

A2.1.1 The international, or ISO, designation system for nickel flux cored wire starts with “T” for tubular, followed by “Ni” for nickel. Four numeric digits based upon the UNS numbers are then assigned according to the composition.

A2.1.2 The composition designation is followed by two digits, marked x and y in Table 1. As defined in Table 1, the “x” stands for the welding position, and the “y” stands for the shielding gas (if any) with which the filler metal was classified by the manufacturer.

A2.2 The traditional designation system (Figure A.2) is also shown in a parallel column in Tables 1 to 6.

A2.2.1 The letter E at the beginning of each classification stands for electrode. The chemical symbol Ni appears right after the E as a means of identifying the electrodes as nickel base alloys. The other symbols (Cr, Fe, Mo, Co) in the designation are intended to group the electrodes according to their major alloying elements. The individual members of each family are designated by a numeral. These numerals are used only once in each family of compositions.

A2.2.2 Following the chemical symbols and their numeric designator comes the letter “T”, which is used to designate the filler metal as a flux cored electrode. As in the ISO system, two numeric digits, marked x and y, are appended. As defined in Table 1, the “x” stands for the welding position, and the “y” stands for the shielding gas (if any) with which the filler metal was classified by the manufacturer.

A2.3 In both systems “x” in Table 1 stands for the capability of the electrode for use out of position. As shown in Table 2, “0” is for flat and horizontal fillet positions only, and “1” for all position capability.

A2.4 In both systems the symbol “y” in Table 1 stands for the external shielding gas, if any: “1” for carbon dioxide [AWS A5.32(ISO 14175)-C1-100] as the shielding gas, “3” for no external shielding gas, or “4” for 75% to 80% argon, balance carbon dioxide [{AWS A5.32(ISO 14175)-M21-ArC-25} or {AWS A5.32 (ISO 14175)-M21-ArC-20}] shielding gas.

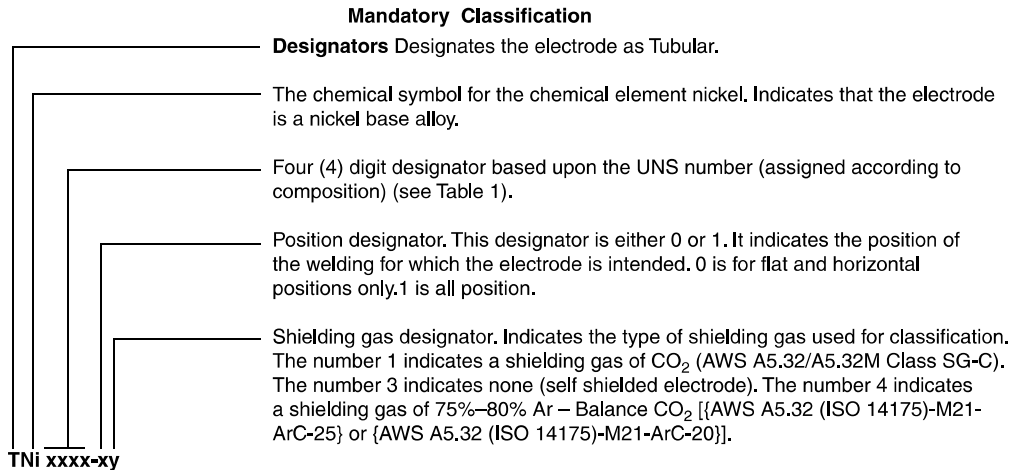


Figure A.1—A5.34/A5.34M Classification System Utilizing the ISO Format

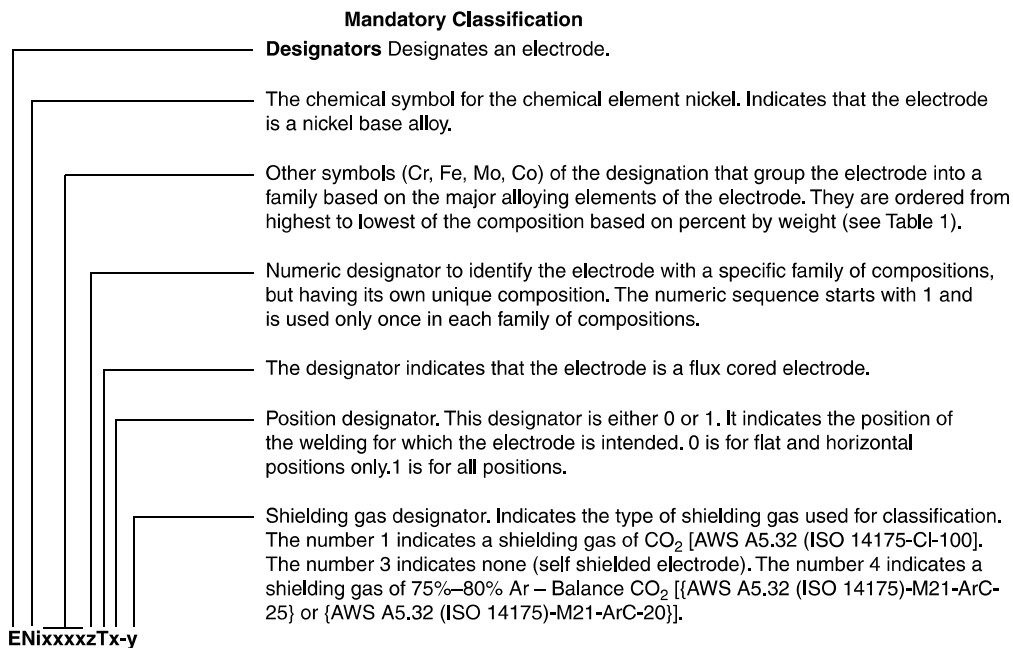


Figure A.2—A5.34/A5.34M Classification System Utilizing the Traditional Format

A2.5 Many of the classifications in this specification correspond with classifications having the same composition in AWS A5.11 and A5.14. Where the composition of weld metal from the flux cored electrodes in this specification is similar to that of the covered electrodes in A5.11 and the bare wire in A5.14, an effort has been made to maintain the same composition designators for the corresponding electrode in this specification. A comparison of the classifications is given in Table A.1.

A2.6 Request for Filler Metal Classification

- (1) A request to establish a new (filler metal) classification must be submitted in writing. The request needs to provide sufficient detail to permit the Committee on Filler Metals and Allied Materials and the relevant Subcommittee to determine whether a new classification or the modification of an existing classification is more appropriate, or if neither is necessary. In particular, the request needs to include:
- (a) A declaration that the new classification will be offered for sale commercially.
 - (b) All classification requirements as given for existing classifications, such as, chemical composition ranges, mechanical property requirements, and usability test requirements.
 - (c) Any conditions for conducting the tests used to demonstrate that the filler metal meets the classification requirements. (It would be sufficient, for example, to state that welding conditions are the same as for other classifications.)
 - (d) Information on Descriptions and Intended Use, which parallels that for existing classifications (for that clause of the Annex).
 - (e) For all A5 filler metal specifications, other than A5.8M/A5.8 and A5.10/A5.10M: Actual test data for all tests required for classification according to the requirements of the specification for a minimum of two production heats/lots must be provided. In addition, if the specification is silent regarding mechanical properties, test data submitted shall include appropriate weld metal mechanical properties from a minimum of two production heats/lots.
 - (f) A request for a new classification without the above information will be considered incomplete. The Secretary will return the request to the requester for further information.

Table A.1
Comparison of Classifications^a

AWS Classification in A5.34/A5.34M ISO Format ^b	Traditional	Corresponding Classification in A5.11/A5.11M	Corresponding Classification in A5.14/A5.14M
TNi 6082-xy	ENiCr3Tx-y	—	ERNiCr-3
TNi 6062-xy	ENiCrFe1Tx-y	ENiCrFe-1	ERNiCrFe-5
TNi 6133-xy	ENiCrFe2Tx-y	ENiCrFe-2	ERNiCrFe-6
TNi 6182-xy	ENiCrFe3Tx-y	ENiCrFe-3	—
TNi 1013-xy	ENiMo13Tx-y	—	—
TNi 6002-xy	ENiCrMo2Tx-y	ENiCrMo-2	ERNiCrMo-2
TNi 6625-xy	ENiCrMo3Tx-y	ENiCrMo-3	ERNiCrMo-3
TNi 6276-xy	ENiCrMo4Tx-y	ENiCrMo-4	ERNiCrMo-4
TNi 6022-xy	ENiCrMo10Tx-y	ENiCrMo-10	ERNiCrMo-10
TNi 6117-xy	ENiCrCoMo1Tx-y	ENiCrCoMo-1	ERNiCrCoMo-1

^a This comparison is based on chemical composition only. Mechanical properties may not necessarily be the same.

^b The ISO format is based on the generic designations system set forth in the annex of ISO 12153:2011: *Welding Consumables—Tubular Cored Electrodes for Gas Shielded and Non-Gas Shielded Metal Arc Welding of Nickel and Nickel Alloys—Classification*. Table 10.B of that document applies to flux-cored nickel alloys. The four-digit number is intended to relate to the designations used for the corresponding covered electrodes and solid wire filler metals designated TNi in this specification, ENi in A5.11 and ERNi in A5.14.

(2) *In order to comply with the AWS Policy on Patented Items, Trademarks, and Restraint of Trade, if the proposed new classification is patented, if a patent is pending for it, or if there is any intention to apply for a patent, the requester shall disclose this. The affected classification shall be identified in all drafts and eventually the published standard identifying the patent owner. The requester shall also provide written assurance to AWS that:*

i. No patent rights will be enforced against anyone using the patent to comply with the standard;

or

ii. The owner will make licenses available to anyone wishing to use the patent to comply with the standard, without compensation or for reasonable rates, with reasonable terms and conditions demonstrably free of any unfair competition.

The status for the patent shall be checked before publication of the document and the patent information included in the document will be updated as appropriate.

Neither AWS, the Committee on Filler Metals and Allied Materials, nor the relevant Subcommittee are required to consider the validity of any patent or patent application.

The published standard shall include a note as follows:

NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with AWS A5.01M/A5.01 (ISO 14344 MOD), as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD). In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing he normally conducts on material of that classification, as specified in Schedule F, Table 1, of AWS A5.01M/A5.01 (ISO 14344 MOD). Testing in accordance with any other Schedule in that Table must be specifically required by the purchase order. In such cases, acceptance of the material shipped will be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations on the packaging enclosing the product, or the classification on the product itself, constitutes the supplier's (manufacturer's) certification that the product meets all of the requirements of the specification.

The only testing requirement implicit in this "certification" is that the manufacturer has actually conducted the tests required by the specification on material that is representative of that being shipped and that the material met the requirements of the specification. Representative material, in this case, is any production run of that classification using the same formulation. "Certification" is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may, or may not, have been made. The basis for the "certification" required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance System" in AWS A5.01M/A5.01 (ISO 14344 MOD).

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fumes in the atmosphere to which welders and welding operators are exposed during welding. These are as follows:

- (1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling)
- (2) Number of welders and welding operators working in that space
- (3) Rate of evolution of fumes, gases, or dust, according to the materials and processes involved
- (4) The proximity of the welder or welding operator to the fumes as they issue from the welding zone, and to the gases and dusts in the space in which they are working
- (5) The ventilation provided to the space in which the welding is done

A5.2 American National Standard ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes* (published by the American Welding Society), discusses the ventilation that is required during welding and should be referred to for details. Attention is drawn particularly to the clause of that document on Ventilation. Further details about ventilation can be found in AWS F3.2 Ventilation Guide for Welding Fume.

A6. Welding Considerations

A6.1 Before welding or heating any nickel-base alloy, the material must be clean. Oil, grease, paint, lubricants, marking pencils, temperature indicating materials, threading compounds, and other such materials frequently contain sulfur, lead, phosphorus, or other surface contaminants, which may cause cracking (embrittlement) of the base metal or the weld metal if present during welding or heating.

A6.2 Electrodes of some of the classifications are used for dissimilar metal welds. When making such welds it is important to obtain as little dilution as possible from the dissimilar metal member (steel, for example). This can be done by traveling slowly to deposit a thicker bead and to dissipate the energy of the arc against the molten weld metal or the nickel-base metal rather than the steel member.

A6.3 Flux cored electrodes can absorb significant moisture if stored in a humid environment in damaged or open packages, especially if unprotected for a long period of time. In the case of excessive exposure, weldability and weld integrity can be adversely affected. In the event the electrode has been exposed, the manufacturer should be consulted regarding possible reconditioning of the electrode.

A7. Description and Intended Use of Electrodes

A7.1 Nickel-Chromium Classifications

A7.1.1 TNi 6082-xy and ENiCr3Tx-y. The nominal composition (wt %) of the weld metal of this classification is 72 Ni, 20 Cr, 3 Mn, 2.5 Nb (+Ta). Electrodes of this classification are used for welding nickel-chromium-iron alloys, for dissimilar welding of nickel-based alloys, for the clad side of joints in steel clad with nickel-chromium alloy, for surfacing steel with nickel-chromium-iron weld metal, and for joining carbon and low-alloy steels to nickel-base alloys and to austenitic stainless steels. Typical specifications for the nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number N06600.

A7.2 Nickel-Chromium-Iron Classifications

A7.2.1 TNi 6062-xy and ENiCrFe1Tx-y. The nominal composition (wt %) of the weld metal of this classification is 73 Ni, 15 Cr, 8 Fe, 2.5 Mn, 2.5 Nb (+ Ta). Electrodes of this classification are used for welding nickel-chromium-iron alloys, for the clad side of joints in steel clad with nickel-chromium-iron alloy, and for surfacing steel with nickel-chromium-iron weld metal. This electrode is also suitable for joining steel to nickel-base alloys. Typical specifications for the nickel-chromium-iron base metal are ASTM B 163, B 166, B 167, and B 168, all of which have UNS Number N06600.

A7.2.2 TNi 6133-xy and ENiCrFe2Tx-y. The nominal composition (wt %) of the weld metal of this classification is 70 Ni, 15 Cr, 8 Fe, 2 Mn, 2 Nb (+ Ta), 1.5 Mo. Electrodes of this classification are used for welding nickel-chromium-iron alloys, 9 percent nickel steel and a variety of dissimilar metal joints (involving carbon steel, low-alloy steels, stainless steel, nickel and nickel-base alloys). The base metal can be wrought or cast (welding grade), or both. Typical specifications for the nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number N06600. Weld metal of this classification is more resistant to fissuring than weld metal of the TNi6062-xy and ENiCrFe1Tx-y classification.

A7.2.3 TNi 6182-xy and ENiCrFe3Tx-y. The nominal composition (wt %) of the weld metal of this classification is 67 Ni, 15 Cr, 7 Fe, 7.5 Mn, 2 Nb (+ Ta). Electrodes of this classification are used for welding nickel-chromium-iron and nickel-iron-chromium alloys, for welding the clad side of joints in steel clad with nickel-chromium-iron alloy and steel clad with ferritic chromium steel, and for surfacing steel with nickel-chromium-iron weld metal, when comparatively high manganese content in the weld metal is not detrimental for the intended service. This electrode is frequently used for welding carbon steel and low-alloy steels to austenitic stainless steels and nickel-base alloys. Typical specifications for nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number 06600. Typical specifications for nickel-iron-chromium base metals are ASTM B407, B409, B512, and B564, all of which have UNS Number N08800. Weld metal of this classification is more resistant to fissuring than weld metal of the TNi6062-xy (ENiCrFe1Tx-y) and TNi6133-xy (ENiCrFe2Tx-y) classifications.

A7.3 Nickel-Chromium-Molybdenum Classifications

A7.3.1 TNi 6002-xy and ENiCrMo2Tx-y. The nominal composition (wt %) of weld metal produced by electrodes of this classification is 47 Ni, 22 Cr, 18 Fe, 9 Mo, 1.5 Co. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B435, B572, B619, B622, and B626, all of which have UNS Number N06002.

A7.3.2 TNi 6625-xy and ENiCrMo3Tx-y. The nominal composition (wt %) of the weld metal of this classification is 60 Ni, 22 Cr, 9 Mo, 3 Fe, 3.6 Nb (+ Ta). Electrodes of this classification are used for welding nickel-chromium-molybdenum and nickel-iron-chromium alloys to themselves and to steel, and for surfacing steel with nickel-chromium-molybdenum weld metal. This electrode can be used also for welding other nickel-base alloys to steel. Typical specifications for the nickel-chromium-molybdenum base metal are ASTM B443, B444, and B446, all of which have UNS Number N06625. Typical specifications for nickel-iron-chromium base metal are ASTM B407, B409, B514, and B564, all of which have UNS Number N08800.

A7.3.3 TNi 6276-xy and ENiCrMo4Tx-y. The nominal composition (wt %) of the weld metal of this classification is 57 Ni, 16 Mo, 15.5 Cr, 5.5 Fe, 4 W, low C. Electrodes of this classification are used for welding low carbon nickel-chromium-molybdenum alloy to steel or to other nickel-base alloys, and for clad side of joints in steel clad with low carbon NiCrMo alloys. Typical specifications for the nickel-chromium-molybdenum base metals are B574, B575, B619, B622, and B626, all of which have UNS Number N10276.

A7.3.4 TNi 6022-xy and ENiCrMo10Tx-y. The nominal composition (wt %) of weld metal produced by electrodes of this classification is 56 Ni, 22 Cr, 13 Mo, 4 Fe, 3 W. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for the clad side of joints in steel clad with nickel-base alloys; and for joining nickel-chromium-molybdenum alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B574, B575, B619, B622, and B626, all of which have UNS Number N06022.

A7.4 Nickel-Chromium-Cobalt-Molybdenum Classifications

A7.4.1 TNi 6117-xy and ENiCrCoMo1Tx-y. The nominal composition (wt %) of weld metal produced by electrodes of this classification is 52 Ni, 23 Cr, 12 Co, 9 Mo, 2 Fe, 1.5 Mn. Electrodes of this classification are used for welding nickel-chromium-cobalt-molybdenum alloys (UNS No. N06617) to themselves and to steel and for surfacing steel with nickel-chromium-cobalt-molybdenum weld metal. The electrodes are used for applications where optimum strength and oxidation resistance are required above 1500°F [820°C] up to 2100°F [1150°C], especially when welding on base metals of nickel-iron-chromium alloys.

A7.5 Nickel-Molybdenum Classification

A7.5.1 TNi 1013-xy and ENiMo13-Tx-y. *The nominal composition (wt %) of the weld metal of this classification is 65 Ni, 17 Mo, 7 Fe, 6 Cr, 3 W. Electrodes of this classification are used for welding 9 percent nickel steel, but they can be used in other applications as well. Typical specifications for the 9 percent nickel steel base metal are ASTM A333, A334, A353, A522, and A553, all of which have UNS Number K81340.*

A8. Mechanical Tests

The mechanical tests required for classification of an electrode in this specification measure the strength and ductility of the weld metal. These properties are sometimes less important than the corrosion and heat resistance of these weld metals. The mechanical tests (tension and bend tests), as well as the radiographic test, however, do provide an indication of the weld metal defects which, if present, may cause or contribute to premature failure in service.

A9. Special Tests

It is recognized that supplementary tests may be required for certain applications. In such cases, tests to determine specific properties such as corrosion resistance, scaling resistance, or strength at elevated or cryogenic temperatures may be required. AWS A5.01M/A5.01 (ISO 14344 MOD), contains provisions for ordering such tests. This clause is included for the guidance of those who desire to specify such tests which may be conducted as agreed upon between supplier and purchaser.

A9.1 Corrosion or Scaling Tests. Although welds made with electrodes in this specification are commonly used in corrosion and heat-resisting applications, tests for those properties are not included in the specification. When required for a particular application, tests can be conducted on specimens taken from either a weld pad or a welded joint. Specimens from a joint are suitable for qualifying the welding procedure (for a specific application involving corrosion or oxidation resistance) but not for qualifying the electrode. Tests on specimens from a joint have the disadvantage of being a combined test of the properties of the weld metals, the heat-affected zone and the unaffected base metal. With them, it is more difficult to obtain reproducible data (when a difference exists in the properties of the metal in the various parts of the specimen). Specimens taken from a joint have the advantage of being able to duplicate the joint design and the welding sequence planned for fabrication.

A9.1.1 Specimens for testing corrosion or oxidation resistance of the weld metal alone are prepared by following the procedure outlined in 9.3 of the specification. The pad size should be at least 3/4 in [20 mm] in height, 2-1/2 in [65 mm] in width, and $1 + 5/8n$ in [$25 + 16n$ mm] in length where n is a multiplier for the number of specimens required from the pad. Specimens measuring $1/2 \times 2 \times 1/4$ in [$13 \times 50 \times 6$ mm] are machined from the top of the pad in a manner such that the 2 in [50 mm] dimension of the specimen is parallel to the 2-1/2 in [65 mm] dimension of the pad and the 1/2 in [13 mm] dimension is parallel with the length of the pad.

A9.1.2 The heat treatment, surface finish, and marking of the specimens prior to testing should be in accordance with standard practices for tests of similar alloys in the wrought or cast forms. The testing procedures should correspond to ASTM G4, *Standard Practice for Conducting Plant Corrosion Tests*, or ASTM G31, *Recommended Practice for Laboratory Immersion Corrosion Testing of Metals*, as the case may be.

A10. General Safety Considerations

A10.1 Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully addressed herein. Some safety and health information can be found in annex Clause A.5. Safety and health information is available from other sources, including, but not limited to Safety and Health Fact Sheets listed in A10.3, ANSI Z49.1 Safety in Welding, Cutting and Allied Processes,⁷ and applicable federal and state regulations.

A10.2 Safety and Health Fact Sheets. The Safety and Health Fact Sheets listed below are published by the American Welding Society (AWS). They may be downloaded and printed directly from the AWS website at <http://www.aws.org>. The Safety and Health Fact Sheets are revised and additional sheets added periodically.

⁷ ANSI Z49.1 is published by the American welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166, USA.

A10.3 AWS Safety and Health Fact Sheets Index (SHF)⁸

No.	Title
1	<i>Fumes and Gases</i>
2	<i>Radiation</i>
3	<i>Noise</i>
4	<i>Chromium and Nickel in Welding Fume</i>
5	<i>Electrical Hazards</i>
6	<i>Fire and Explosion Prevention</i>
7	<i>Burn Protection</i>
8	<i>Mechanical Hazards</i>
9	<i>Tripping and Falling</i>
10	<i>Falling Objects</i>
11	<i>Confined Spaces</i>
12	<i>Contact Lens Wear</i>
13	<i>Ergonomics in the Welding Environment</i>
14	<i>Graphic Symbols for Precautionary Labels</i>
15	<i>Style Guidelines for Safety and Health Documents</i>
16	<i>Pacemakers and Welding</i>
17	<i>Electric and Magnetic Fields (EMF)</i>
18	<i>Lockout/Tagout</i>
19	<i>Laser Welding and Cutting Safety</i>
20	<i>Thermal Spraying Safety</i>
21	<i>Resistance Spot Welding</i>
22	<i>Cadmium Exposure from Welding & Allied Processes</i>
23	<i>California Proposition 65</i>
24	<i>Fluxes for Arc Welding and Brazing: Safe Handling and Use</i>
25	<i>Metal Fume Fever</i>
26	<i>Arc Welding Distance</i>
27	<i>Thoriated Tungsten Electrodes</i>
28	<i>Oxyfuel Safety: Check Valves and Flashback Arrestors</i>
29	<i>Grounding of Portable and Vehicle Mounted Welding Generators</i>
30	<i>Cylinders: Safe Storage, Handling, and Use</i>
31	<i>Eye and Face Protection for Welding and Cutting Operations</i>
33	<i>Personal Protective Equipment (PPE) for Welding & Cutting</i>
34	<i>Coated Steels: Welding and Cutting Safety Concerns</i>
36	<i>Ventilation for Welding & Cutting</i>
37	<i>Selecting Gloves for Welding & Cutting</i>

⁸ AWS standards are published by the American welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166, USA.

Annex B (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.34/A5.34M:2013, *Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding*, but is included for informational purposes only.

B1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

B2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
8669 Doral Blvd., Suite 130
Doral, FL 33166

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

B2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

B2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

B2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

B3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

B4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

B5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The AWS *Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

B6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

AWS Filler Metal Specifications by Material and Welding Process

	OFW	SMAW	GTAW GMAW PAW	FCAW	SAW	ESW	EGW	Brazing
Carbon Steel	A5.2	A5.1	A5.18, A5.36	A5.36	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28, A5.36	A5.36	A5.23	A5.25	A5.26	A5.8, A5.31
Stainless Steel		A5.4	A5.9, A5.22	A5.22	A5.9	A5.9	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11	A5.14	A5.34	A5.14	A5.14		A5.8, A5.31
Aluminum Alloys		A5.3	A5.10					A5.8, A5.31
Copper Alloys		A5.6	A5.7					A5.8, A5.31
Titanium Alloys			A5.16					A5.8, A5.31
Zirconium Alloys			A5.24					A5.8, A5.31
Magnesium Alloys			A5.19					A5.8, A5.31
Tungsten Electrodes			A5.12					
Brazing Alloys and Fluxes								A5.8, A5.31
Surfacing Alloys	A5.21	A5.13	A5.21	A5.21	A5.21			
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

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AWS Filler Metal Specifications and Related Documents

Designation	Title
FMC	<i>Filler Metal Comparison Charts</i>
IFS	<i>International Index of Welding Filler Metal Classifications</i>
UGFM	<i>User's Guide to Filler Metals</i>
A4.2M (ISO 8249:2000)	<i>Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal</i>
A4.3	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding</i>
A4.4M	<i>Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings</i>
A4.5M/A4.5 (ISO 15792-3 MOD)	<i>Standard Methods for Classification Testing of Positional Capacity and Root Penetration of Welding Consumables in a Fillet Weld</i>
A5.01M/A5.01 (ISO 14344 MOD)	<i>Procurement guidelines for consumables—Welding and allied processes—Flux and Gas Shielded Electrical Welding Processes</i>
A5.02/A5.02M	<i>Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes</i>
A5.1/A5.1M	<i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i>
A5.2/A5.2M	<i>Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding</i>
A5.3/A5.3M	<i>Specification for Aluminum-Alloy Electrodes for Shielded Metal Arc Welding</i>
A5.4/A5.4M	<i>Specification for Stainless Steel Welding Electrodes for Shielded Metal Arc Welding</i>
A5.5/A5.5M	<i>Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding</i>
A5.6/A5.6M	<i>Specification for Covered Copper and Copper-Alloy Arc Welding Electrodes</i>
A5.7/A5.7M	<i>Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes</i>
A5.8/A5.8M	<i>Specification for Filler Metals for Brazing and Braze Welding</i>
A5.9/A5.9M	<i>Specification for Bare Stainless Steel Welding Electrodes and Rods</i>
A5.10/A5.10M (ISO 18273 MOD)	<i>Welding Consumables – Wire Electrodes, Wires and Rods for Welding of Aluminum and Aluminum-Alloys – Classification</i>
A5.11/A5.11M	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>
A5.12M/A5.12 (ISO 6848:2004 MOD)	<i>Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting</i>
A5.13/A5.13M	<i>Specification for Surfacing Electrodes for Shielded Metal Arc Welding</i>
A5.14/A5.14M	<i>Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods</i>
A5.15	<i>Specification for Welding Electrodes and Rods for Cast Iron</i>
A5.16/A5.16M (ISO 24034 MOD)	<i>Specification for Titanium and Titanium-Alloy Welding Electrodes and Rods</i>
A5.17/A5.17M	<i>Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding</i>
A5.18/A5.18M	<i>Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.19	<i>Specification for Magnesium-Alloy Welding Electrodes and Rods</i>
A5.21/A5.21M	<i>Specification for Bare Electrodes and Rods for Surfacing</i>
A5.22/A5.22M	<i>Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes</i>
A5.23/A5.23M	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>

A5.24/A5.24M	<i>Specification for Zirconium and Zirconium-Alloy Welding Electrodes and Rods</i>
A5.25/A5.25M	<i>Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding</i>
A5.26/A5.26M	<i>Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding</i>
A5.28/A5.28M	<i>Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.30/A5.30M	<i>Specification for Consumable Inserts</i>
A5.31	<i>Specification for Fluxes for Brazing and Braze Welding</i>
A5.32/A5.32M (ISO 14175 MOD)	<i>Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes</i>
A5.34/A5.34M	<i>Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding</i>
A5.36/A5.36M	<i>Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding</i>

