ASME B18.16.6-2017

(Revision of ASME B18.16.6-2014)

Prevailing Torque Locknuts (Inch Series)

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: June 19, 2017

This Standard will be revised when the Society approves the issuance of a new edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the Committee Web page and under go.asme.org/InterpsDatabase. Periodically certain actions of the ASME B18 Committee may be published as Cases. Cases are published on the ASME Web site under the B18 Committee Page at go.asme.org/B18committee as they are issued.

Errata to codes and standards may be posted on the ASME Web site under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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FOREWORD

ASME B18.16.6-2008 was balloted and approved by the B18 Standards Committee and B18 Subcommittee 16 on April 29, 2008. The proposal was submitted to the American National Standards Institute and designated as an American National Standard on August 25, 2008.

At the B18 meeting in the fall of 2011, Subcommittee 16 decided to expand this Standard to include all styles of locking nuts. B18.16.6 now contained dimensional and performance requirements for nonmetallic insert and all-metal locking nuts in a variety of grades. This Standard was intended to replace IFI-100/107, which the Industrial Fasteners Institute agreed to withdraw after the publication of this Standard. ASME B18.16.6-2014 was balloted and approved by the B18 Standards Committee and B18 Subcommittee 16 on March 12, 2014.

At the B18 meeting in the spring of 2015, Subcommittee 16 decided to revise this Standard based on several technical and editorial updates. Updates to this Standard include lowering the proof and clamp load values of thin nuts from 60% to 45% of regular hex nuts; harmonizing proof loads with SAE J995 2012, resulting in lower proof loads for fine and 8-UN series nuts; correcting hex height values on style NTM locknuts; clarifying corner fill requirements; increasing the proof load requirement for style NU locknuts; and correcting various table references.

This revision was approved as an American National Standard on June 1, 2017.

Suggestions for improvement of this Standard are welcome. They should be sent to Secretary, B18 Committee, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B18 COMMITTEE
Standardization of Bolts, Nuts, Rivets, Screws, Washers, and Similar Fasteners

(The following is the roster of the Committee at the time of approval of this Standard.)

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B18 Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

Interpretations. Upon request, the B18 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B18 Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the B18 Standards Committee at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a “yes” or “no” reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of “Yes” or “No,” with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B18 Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the B18 Standards Committee. Future Committee meeting dates and locations can be found on the Committee Page at go.asme.org/B18committee.

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PREVAILING TORQUE LOCKNUTS (INCH SERIES)

1 INTRODUCTION

1.1 Scope

This Standard covers the complete general, dimensional, mechanical, and performance requirements (proof load, prevailing torque, and torque-tension) for carbon steel, inch series nylon insert locknuts of grades N2, N5, and N8 in styles NE (1/4 in. to 1 1/2 in.), NTE (1/4 in. to 1 1/2 in.), NU (1/4 in. to 3 in.), NTU (1/4 in. to 3 in.), NM (#2 to #12), NTM (#2 to #12), and hex flange (1/4 in. to 3/4 in.). This Standard also includes all-metal hex (#4 to 1 1/2 in.) and hex flange (1/4 in. to 3/4 in.) locking nuts of grades A, B, C, F, and G. These nut designs are designated as American National Standards.

1.2 Comparison to ISO Standards

There is no ISO inch standard for these products.

2 REFERENCE STANDARDS

The following is a list of publications referenced in this Standard. Unless otherwise specified, the reference standard(s) shall be the most recent issue at the time of order placement.

ASME B1.1, Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.3, Screw Thread Gaging Systems for Acceptability: Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ)

ASME B1.15, Unified Inch Screw Threads (UNJ Thread Form)

ASME B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

ASME B18.12, Glossary of Terms for Mechanical Fasteners

ASME B18.18, Quality Assurance for Fasteners

ASME B18.21.1, Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ASTM F436, Standard Specification for Hardened Steel Washers

ASTM F606/F606M, Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

ASTM F788, Standard Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

ASTM F812, Standard Specification for Surface Discontinuities of Nuts, Inch and Metric Series

ASTM F1137, Standard Specification for Phosphate/Oil Corrosion Protective Coatings for Fasteners

ASTM F1470, Standard Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

ASTM F1941/F1941M, Standard Specification for Electrodeposited Coatings on Mechanical Fasteners, Inch and Metric

Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

IFI-101, Torque-Tension Requirements for Prevailing-Torque Type Steel Hex and Hex Flange Nuts

Publisher: Industrial Fasteners Institute (IFI), 6363 Oak Tree Boulevard, Independence, OH 44131 (www.indfast.org)

SAE J409, Product Analysis — Permissible Variations from Specified Chemical Analysis of a Heat or Cast of Steel

Publisher: SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 (www.sae.org)

3 TERMINOLOGY

For definitions of terms relating to fasteners or component features thereof used in this Standard, refer to ASME B18.12.

4 DIMENSIONS

Unless otherwise specified, all dimensions in this Standard are inches and shall be as specified in the tables and sections 6 through 9. All dimensions apply before coating.

5 NUT DESIGNS AND PROPERTY GRADES

5.1 Nylon Insert Locknuts

Nylon insert locknuts are two-piece construction hex nuts and hex flange nuts that derive their prevailing torque characteristics from a full ring of nylon material, located and retained in the nut under its top surface. These are designated in Table 1 as property grades N2, N5, and N8 with hardness requirements in Table 2. The configuration styles are NE (Table 3), NTE (Table 4), NU (Table 5), NTU (Table 6), NM (Table 7), NTM (Table 8), and hex flange (Table 9).

5.2 All-Metal Locknuts

All-metal locknuts are one-piece construction hex and hex flange nuts that derive their prevailing torque performance from controlled distortion of the nut threads and/or body. Hex locknuts are designated as grades A, B, and C. The dimensions are located in Table 10. Hex flange locknuts are designated as grades F and G. The dimensions are in Table 11. Table 1 identifies the material requirements for the various grades, and Table 2 identifies sizes and hardness requirements for the various grades.

6 CORNER FILL

A rounding or lack of fill at the location where the hex corners intersect with the chamfer shall be permissible, provided the width across corners is within specified limits in the area extending from a distance equal to 17.5% of the basic thread diameter from the chamfered bearing face to 85% of the specified minimum hex height.

7 CHAMFERS AND BEARING CIRCLES

7.1 Chamfer Length on Bearing Side of Nuts

The length of chamfer at hex corners shall be from 5% to 15% of the nominal thread diameter. The surface of the chamfer may be convex or rounded.

7.2 Bearing Surface Diameter

The diameter of bearing circle on chamfered nuts and washer-faced nuts shall be within the limits of the maximum width across flats and 95% of the minimum width across flats.

8 COUNTERSINKS

Unless otherwise specified in this Standard, tapped holes shall be countersunk on the bearing faces. The maximum countersink diameter shall be the nominal thread diameter plus 0.030 in. for $\frac{3}{8}$ in. nominal size nuts and smaller, and 1.08 times the nominal thread diameter for nuts larger than $\frac{3}{8}$ in. No part of the threaded portion shall project beyond the bearing surface.

Table 1 Chemical Composition Requirements

Nut Grade	C, Max.	Mn, Min.	P, Max.	S, Max.
N2, A	0.47	. . .	0.12 [Note (1)]	0.15 [Note (2)]
N5, B, F	0.55	0.30	0.05 [Notes (3), (4)]	0.15 [Notes (2), (4)]
N8, C, G	0.55	0.30	0.04	0.05 [Note (5)]

GENERAL NOTE: All values are for ladle analysis (percent by weight) and are subject to standard variations for check analysis as given in SAE J409.

NOTES:

(1) Resulfurized and rephosphorized material is not subject to rejection based on check analysis for sulfur.
(2) If agreed between purchaser and producer, sulfur content may be 0.23 max.
(3) Phosphorus content may be 0.13 max. for acid bessemer steel only.
(4) If agreed between purchaser and producer, sulfur content may be 0.35 max. and phosphorus content may be 0.12 max., provided that manganese content is 0.70 min.
(5) If agreed between purchaser and producer, sulfur content may be 0.33 max., provided that manganese content is 1.35 min.

Table 2 Hardness Requirements

Nut Grade [Note (1)]	Locknut Size [Note (2)]	Rockwell Hardness
N2, N5, A, B, and F	$\frac{1}{4}$–$1\frac{1}{2}$	C28, max.
N8, C, and G	$\frac{1}{4}$–$\frac{5}{8}$	C24–C32
	$\frac{3}{4}$–1	C26–C34
	$1\frac{1}{8}$–$1\frac{1}{2}$	C26–C36

NOTES:

(1) For grade N2 sizes over $1\frac{1}{2}$, the minimum hardness shall be HRB 68.
(2) For values on sizes not listed in Table 2, agreement shall be reached between purchaser and supplier.

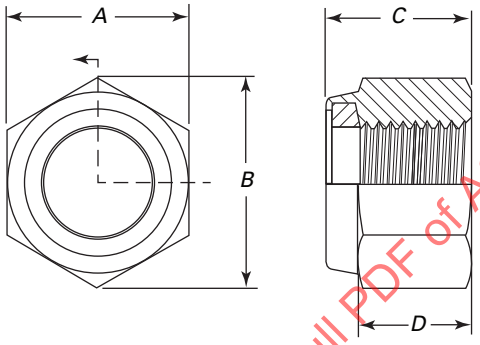
9 THREADS

Threads shall be unified thread form coarse, fine, or 8 thread series (UNC, UNF, or 8-UN) Class 2B in accordance with ASME B1.1 or UNJ thread form (UNJC, UNJF, or UNJ8 series) either Class 2B or 3B in accordance with ASME B1.15 provided all performance requirements of the final parts are in compliance.

Inspection shall be in accordance with System 21 of ASME B1.3. Inspection shall be conducted prior to nut deformation or nylon ring captivation.

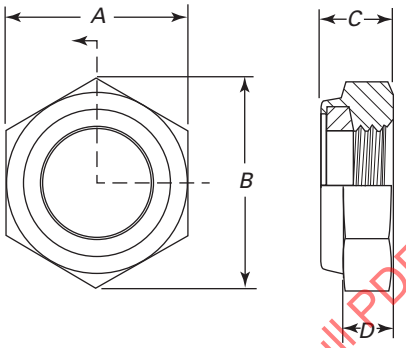
After deformation or nylon captivation, the GO threaded plug gage must enter $\frac{3}{8}$ in. and smaller nuts at least one-half turn, and for $\frac{7}{16}$-in. nuts and above one full turn from the bearing surface side of the nut.

Table 3 Style NE Nylon Insert Locknut Dimensions



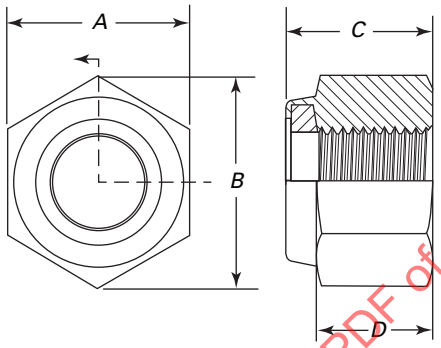
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
1/4	0.2500	0.439	0.430	0.482	0.328	0.298	0.225	0.010
5/16	0.3125	0.502	0.489	0.552	0.359	0.329	0.250	0.011
3/8	0.3750	0.564	0.551	0.622	0.468	0.438	0.335	0.012
7/16	0.4375	0.627	0.616	0.698	0.468	0.438	0.324	0.013
1/2	0.5000	0.752	0.736	0.837	0.609	0.579	0.464	0.014
9/16	0.5625	0.877	0.861	0.978	0.656	0.626	0.469	0.015
5/8	0.6250	0.940	0.922	1.051	0.765	0.735	0.593	0.016
3/4	0.7500	1.064	1.052	1.191	0.890	0.860	0.742	0.018
7/8	0.8750	1.252	1.239	1.403	0.999	0.969	0.790	0.020
1	1.0000	1.440	1.427	1.615	1.078	1.016	0.825	0.022
1 1/8	1.1250	1.627	1.614	1.826	1.203	1.141	0.930	0.025
1 1/4	1.2500	1.815	1.801	2.038	1.422	1.360	1.125	0.028
1 3/8	1.3750	2.008	1.973	2.232	1.609	1.547	1.282	0.031
1 1/2	1.5000	2.197	2.159	2.444	1.640	1.578	1.313	0.034

Table 4 Style NTE Nylon Insert Locknut Dimensions



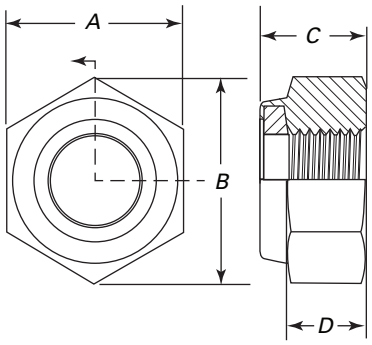
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
1/4	0.2500	0.439	0.430	0.482	0.218	0.188	0.125	0.010
5/16	0.3125	0.502	0.492	0.552	0.265	0.235	0.158	0.011
3/8	0.3750	0.564	0.553	0.622	0.281	0.251	0.150	0.012
7/16	0.4375	0.627	0.615	0.694	0.328	0.298	0.225	0.013
1/2	0.5000	0.752	0.741	0.837	0.328	0.298	0.190	0.014
9/16	0.5625	0.877	0.865	0.978	0.374	0.344	0.225	0.015
5/8	0.6250	0.940	0.928	1.051	0.406	0.376	0.265	0.016
3/4	0.7500	1.064	1.052	1.191	0.421	0.391	0.288	0.018
7/8	0.8750	1.252	1.239	1.403	0.484	0.454	0.340	0.020
1	1.0000	1.440	1.427	1.615	0.578	0.516	0.405	0.022
1 1/8	1.1250	1.627	1.614	1.826	0.672	0.610	0.500	0.025
1 1/4	1.2500	1.815	1.801	2.038	0.765	0.703	0.523	0.028
1 3/8	1.3750	2.008	1.973	2.249	0.821	0.759	0.493	0.031
1 1/2	1.5000	2.197	2.159	2.416	0.828	0.766	0.565	0.034

Table 5 Style NU Nylon Insert Locknut Dimensions



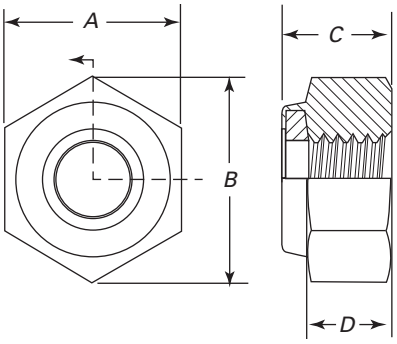
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
1/4	0.2500	0.506	0.489	0.556	0.390	0.360	0.290	0.010
5/16	0.3125	0.566	0.551	0.624	0.453	0.423	0.335	0.011
3/8	0.3750	0.691	0.675	0.763	0.562	0.532	0.392	0.012
7/16	0.4375	0.754	0.736	0.829	0.609	0.579	0.464	0.013
1/2	0.5000	0.879	0.861	0.969	0.718	0.688	0.544	0.014
9/16	0.5625	0.942	0.922	1.037	0.812	0.782	0.655	0.015
5/8	0.6250	1.067	1.045	1.175	0.874	0.844	0.677	0.016
3/4	0.7500	1.255	1.231	1.382	1.015	0.985	0.790	0.018
7/8	0.8750	1.444	1.417	1.589	1.140	1.110	0.883	0.020
1	1.0000	1.632	1.602	1.796	1.312	1.250	1.000	0.022
1 1/8	1.1250	1.820	1.788	2.002	1.469	1.407	1.096	0.025
1 1/4	1.2500	2.008	1.973	2.209	1.672	1.610	1.250	0.028
1 3/8	1.3750	2.197	2.159	2.416	1.828	1.766	1.376	0.031
1 1/2	1.5000	2.384	2.344	2.622	1.953	1.891	1.413	0.034
1 5/8	1.6250	2.572	2.530	2.886	2.172	2.110	1.637	0.038
1 3/4	1.7500	2.762	2.715	3.035	2.376	2.250	1.830	0.041
1 7/8	1.8750	2.950	2.901	3.242	2.422	2.296	1.875	0.044
2	2.0000	3.137	3.086	3.449	2.469	2.343	1.750	0.047
2 1/4	2.2500	3.514	3.457	3.862	2.876	2.750	2.063	0.052
2 1/2	2.5000	4.015	3.875	4.618	3.204	3.078	2.475	0.058
2 3/4	2.7500	4.015	3.875	4.618	3.204	3.078	2.350	0.064
3	3.0000	4.640	4.500	5.102	3.704	3.578	2.750	0.070

Table 6 Style NTU Nylon Insert Locknut Dimensions



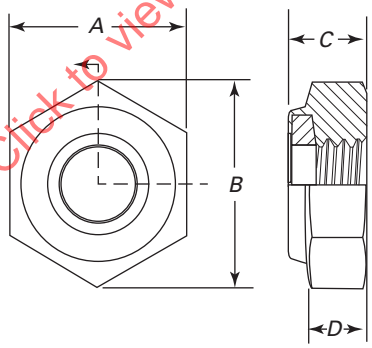
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
1/4	0.2500	0.502	0.492	0.552	0.296	0.266	0.194	0.010
5/16	0.3125	0.564	0.553	0.622	0.328	0.298	0.212	0.011
3/8	0.3750	0.690	0.679	0.766	0.421	0.391	0.251	0.012
7/16	0.4375	0.752	0.741	0.837	0.453	0.423	0.316	0.013
1/2	0.5000	0.877	0.865	0.978	0.546	0.516	0.360	0.014
9/16	0.5625	0.940	0.928	1.051	0.578	0.548	0.421	0.015
5/8	0.6250	1.064	1.052	1.191	0.624	0.594	0.428	0.016
3/4	0.7500	1.252	1.239	1.403	0.718	0.688	0.488	0.018
7/8	0.8750	1.440	1.427	1.615	0.796	0.766	0.535	0.020
1	1.0000	1.627	1.614	1.826	0.922	0.860	0.600	0.022
1 1/8	1.1250	1.814	1.801	2.038	1.000	0.938	0.627	0.025
1 1/4	1.2500	2.008	1.973	2.232	1.140	1.078	0.720	0.028
1 3/8	1.3750	2.197	2.159	2.444	1.219	1.157	0.767	0.031
1 1/2	1.5000	2.384	2.344	2.622	1.344	1.282	0.810	0.034
1 3/4	1.7500	2.762	2.715	3.075	1.532	1.406	0.986	0.041
2	2.0000	3.137	3.086	3.497	1.735	1.609	1.016	0.047
2 1/4	2.2500	3.514	3.457	3.918	2.001	1.875	1.179	0.052
2 1/2	2.5000	4.015	3.875	4.393	2.250	2.124	1.523	0.058
2 3/4	2.7500	4.015	3.875	4.393	2.250	2.124	1.523	0.064
3	3.0000	4.640	4.500	5.102	2.788	2.662	2.075	0.070

Table 7 Style NM Nylon Insert Locknut Dimensions



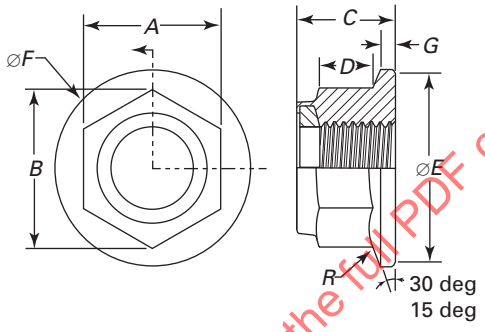
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
#2	0.0860	0.251	0.243	0.268	0.153	0.133	0.081	0.004
#4	0.1120	0.251	0.243	0.268	0.153	0.133	0.081	0.004
#6	0.1380	0.313	0.305	0.339	0.188	0.168	0.103	0.004
#8	0.1640	0.345	0.336	0.374	0.239	0.219	0.140	0.004
#10	0.1900	0.376	0.367	0.410	0.249	0.229	0.140	0.004
#12	0.2160	0.439	0.430	0.482	0.328	0.298	0.225	0.005

Table 8 Style NTM Nylon Insert Locknut Dimensions



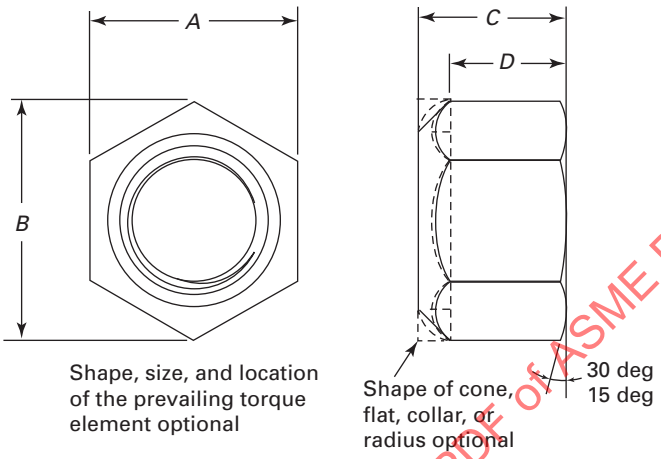
Designation		Width Across Flats, *A*		Minimum Width Across Corners, *B*	Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.		Max.	Min.		
#2	0.0860	0.251	0.243	0.268	0.124	0.094	0.075	0.004
#3	0.0990	0.251	0.243	0.268	0.124	0.094	0.075	0.004
#4	0.1120	0.251	0.243	0.268	0.124	0.094	0.075	0.004
#5	0.1250	0.251	0.243	0.268	0.124	0.094	0.075	0.004
#6	0.1380	0.313	0.305	0.339	0.140	0.110	0.090	0.004
#8	0.1640	0.345	0.336	0.374	0.187	0.157	0.110	0.004
#10	0.1900	0.376	0.367	0.410	0.187	0.157	0.110	0.004
#12	0.2160	0.439	0.430	0.482	0.218	0.188	0.125	0.005

Table 9 Dimensions of Nylon Insert Hex Flange Nuts



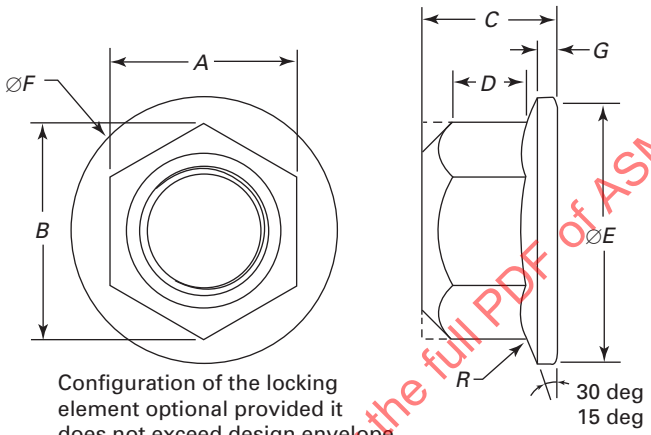
Size	Nominal Diameter	Width Across Flats, *A*		Width Across Corners, *B*		Maximum Thickness, *C*	Min. Hex Height, *D*	Minimum Diameter of Bearing Surface, *E*	Minimum Flange Thickness, *G*	Max. Flange Top Radius, *R*	Maximum Flange Diameter, *F*	Maximum Runout of Bearing Surface With Thread P.D. FIM
		Max.	Min.	Max.	Min.							
1/4	0.2500	0.4385	0.4280	0.505	0.488	0.300	0.140	0.484	0.040	0.010	0.560	0.011
5/16	0.3125	0.5020	0.4890	0.577	0.557	0.365	0.170	0.602	0.050	0.010	0.680	0.013
3/8	0.3750	0.5645	0.5510	0.650	0.628	0.425	0.200	0.730	0.060	0.020	0.810	0.015
7/16	0.4375	0.6895	0.6750	0.794	0.768	0.495	0.230	0.846	0.070	0.020	0.930	0.016
1/2	0.5000	0.7520	0.7360	0.866	0.840	0.555	0.260	0.982	0.080	0.020	1.070	0.018
9/16	0.5625	0.8770	0.8610	1.010	0.982	0.625	0.290	1.101	0.090	0.030	1.190	0.019
5/8	0.6250	0.9395	0.9220	1.083	1.051	0.690	0.320	1.230	0.100	0.030	1.330	0.021
3/4	0.7500	1.1270	1.0880	1.299	1.240	0.825	0.380	1.472	0.110	0.030	1.585	0.023

Table 10 Dimensions of Prevailing Torque All-Metal Type Hex Nuts



Designation		Width Across Flats, *A*		Width Across Corners, *B*		Thickness, *C*		Minimum Hex Height, *D*	Maximum Runout of Bearing Surface With Thread P.D. FIM
Size	Nominal Diameter	Max.	Min.	Max.	Min.	Max.	Min.		
#4	0.1120	0.251	0.241	0.289	0.275	0.163	0.087	0.066	0.008
#6	0.1380	0.313	0.302	0.361	0.344	0.171	0.102	0.075	0.008
#8	0.1640	0.345	0.332	0.397	0.378	0.191	0.117	0.083	0.009
#10	0.1900	0.376	0.362	0.433	0.413	0.241	0.117	0.083	0.009
#12	0.2160	0.438	0.423	0.505	0.482	0.241	0.148	0.103	0.010
1/4	0.2500	0.4385	0.428	0.505	0.488	0.288	0.212	0.145	0.010
5/16	0.3125	0.5020	0.489	0.577	0.557	0.336	0.258	0.166	0.011
3/8	0.3750	0.5645	0.551	0.650	0.628	0.415	0.320	0.198	0.012
7/16	0.4375	0.6895	0.675	0.794	0.768	0.463	0.365	0.223	0.013
1/2	0.5000	0.7520	0.736	0.866	0.840	0.573	0.427	0.262	0.014
9/16	0.5625	0.8770	0.861	1.010	0.982	0.621	0.473	0.286	0.015
5/8	0.6250	0.9395	0.922	1.083	1.051	0.731	0.535	0.329	0.016
3/4	0.7500	1.1270	1.088	1.299	1.240	0.827	0.617	0.382	0.018
7/8	0.8750	1.3145	1.269	1.516	1.447	0.922	0.724	0.450	0.020
1	1.0000	1.5020	1.450	1.732	1.653	1.018	0.831	0.513	0.022
1 1/8	1.1250	1.6895	1.631	1.949	1.859	1.176	0.939	0.576	0.025
1 1/4	1.2500	1.8770	1.812	2.165	2.066	1.272	1.030	0.628	0.028
1 3/8	1.3750	2.0645	1.994	2.382	2.273	1.399	1.138	0.681	0.031
1 1/2	1.5000	2.2520	2.175	2.598	2.480	1.526	1.245	0.757	0.034

Table 11 Dimensions of Prevailing Torque All-Metal Type Hex Flange Nuts



Configuration of the locking element optional provided it does not exceed design envelope of "*A*," "*B*," "*C*," and "*D*"

Size	Nominal Diameter	Width Across Flats, *A*		Width Across Corners, *B*		Maximum Thickness, *C*	Min. Hex Height, *D*	Minimum Diameter of Bearing Surface, *E*	Minimum Flange Thickness, *G*	Max. Flange Top Radius, *R*	Maximum Flange Diameter, *F*	Maximum Runout of Bearing Surface With Thread P.D. FIM
		Max.	Min.	Max.	Min.							
1/4	0.2500	0.4385	0.4280	0.505	0.488	0.300	0.140	0.484	0.040	0.010	0.560	0.011
5/16	0.3125	0.5020	0.4890	0.577	0.557	0.365	0.170	0.602	0.050	0.010	0.680	0.013
3/8	0.3750	0.5645	0.5510	0.650	0.628	0.425	0.200	0.730	0.060	0.020	0.810	0.015
7/16	0.4375	0.6895	0.6750	0.794	0.768	0.495	0.230	0.846	0.070	0.020	0.930	0.016
1/2	0.5000	0.7520	0.7360	0.866	0.840	0.555	0.260	0.982	0.080	0.020	1.070	0.018
9/16	0.5625	0.8770	0.8610	1.010	0.982	0.625	0.290	1.101	0.090	0.030	1.190	0.019
5/8	0.6250	0.9395	0.9220	1.083	1.051	0.690	0.320	1.230	0.100	0.030	1.330	0.021
3/4	0.7500	1.1270	1.0880	1.299	1.240	0.825	0.380	1.472	0.110	0.030	1.585	0.023

10 MATERIAL, MECHANICAL, AND PERFORMANCE PROPERTIES

10.1 Material and Processes

10.1.1 Material. Locknuts shall be made of carbon steel and shall conform to the requirements of Table 1.

Alternate material may be used with prior agreement between the purchaser and supplier on material selection, all performance characteristics, and nut markings.

10.1.1.1 Nylon Rings. The nylon insert material shall be manufactured of nylon sufficient to meet the prevailing torque requirements of Tables 12, 13, and 14 when tested as specified in para. 10.3.1. Nylon rings are only functional up to 250°F.

10.1.2 Heat Treatment. Nut grades N2 and A shall not be heat treated. Other locknut grades may be through-hardened at the discretion of the manufacturer (see Table 2) to meet the mechanical and performance requirements of this Standard. Case hardening is not allowed on locknuts.

10.1.3 Finish. Nuts may be furnished plain (bare metal) or with a protective coating as specified by the purchaser. When selecting protective coatings, consideration should be given to the curing temperatures of the finishes on nylon insert locknuts.

10.1.4 Locknut Lubrication. All nuts may be provided with an additional supplementary lubricant that shall be clean and dry to the touch as defined in ASTM F1137.

10.2 Mechanical Requirements

10.2.1 Proof Load. Locknuts shall withstand the proof load specified for the applicable grade and thread series in Tables 12, 13, and 14 when tested as specified in para. 11.1.

10.2.2 Hardness. Nuts shall have a hardness conforming to the limits specified for the applicable grade in Table 2 when tested as specified in para. 11.2.

10.3 Performance Requirements for Steel Locknuts

All performance requirements in Tables 12, 13, and 14 apply to all steel locknuts as they are supplied to the end user regardless of finish.

10.3.1 Prevailing Torque. The prevailing torque developed by nuts during their first installation, or any subsequent installation or removal, shall not exceed the maximum first installation torque specified for the applicable grade in Tables 12, 13, and 14 when tested as specified in para. 11.3. In addition, minimum prevailing torque generated by nuts during their first and third removals shall not be less than the respective removal torque values specified for the applicable grade in Tables 12, 13, and 14.

11 TEST METHODS

11.1 Proof Load Test

The test sample nut shall be assembled on a test bolt (see para. 11.5.4) or on a hardened mandrel (see para. 11.5.5) with a minimum of three threads projecting through the nut. The proof load test may be performed prior to the prevailing torque feature being added to the nut. For referee test purposes, the hardened mandrel shall be used and the prevailing torque feature present. The maximum prevailing torque occurring during the assembly of the nut on the test bolt or mandrel shall be recorded.

The specified proof load in Tables 12, 13, and 14 shall be applied in tension or compression through the test bolt or mandrel against the nut bearing surface in an axial direction and held for 10 sec. For referee purposes, the load shall be applied in tension. The nut shall resist this load without thread stripping or rupture. The prevailing torque necessary to remove the nut from the test bolt or mandrel shall not exceed the maximum torque occurring during assembly.

11.2 Rockwell Hardness Test

Rockwell hardness tests shall be conducted in accordance with the procedures in ASTM F606/F606M.

11.3 Prevailing Torque Test

The prevailing torque test shall be conducted at room temperature using a load-measuring device (see para. 11.5.2). A test bolt (see para. 11.5.4) and/or hardened mandrel (see para. 11.5.6) shall be inserted in the load-measuring device and hardened washer (see para. 11.5.3) placed on the bolt or mandrel and the sample nut then assembled on the bolt or mandrel. The nut shall be advanced until a minimum of three and a maximum of five full bolt or mandrel threads protrude through the top of the nut. At that time, the maximum torque shall be recorded. This torque shall not exceed the first installed prevailing torque value as specified for the applicable grade and thread series in Tables 12, 13, and 14. The torque-measuring device shall be in accordance with para. 11.5.1.

Tightening shall be continued until the nut is seated against the hardened washer. The length of the test bolt or mandrel should be such that seating of the nut shall occur at or before a length equivalent to a maximum of nine thread pitches of the test bolt or mandrel protruding through the top of the nut, as measured from the end of the bolt or mandrel. The nut shall then be tightened until a tensile load equal to the clamp load, as specified for the applicable grade and thread series in Tables 12, 13, and 14, is developed in the bolt or mandrel. The hardened washer shall be prevented from turning during nut tightening. The nut shall then be backed off by the application of reverse torque until the tensile load in the bolt or mandrel has been reduced to zero. The

Table 12 Proof Loads, Clamp Loads, and Prevailing Torques for Coarse Thread Locknuts (Regardless of Finish)

Nut Size and Threads Per Inch	Grade N2 and A Nuts		Grade N5, B, and F Nuts		Grade N8, C, and G Nuts		Prevailing Torque		
	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Max. First Install, in.-lb	Min. First Removal, in.-lb	Min. Third Removal, in.-lb
No. 4–40	540	250	720	380	910	550	4.0	1.0	0.2
No. 6–32	820	370	1,100	580	1,350	810	8.0	1.5	0.5
No. 8–32	1,250	580	1,700	900	2,100	1,250	12.0	2.0	0.5
No. 10–24	1,550	720	2,100	1,100	2,600	1,550	17	2.5	1.0
No. 12–24	2,200	1,000	2,900	1,550	3,650	2,200	27	3.5	1.0
1/4–20	2,900	1,300	3,800	2,000	4,750	2,850	40	5.0	1.5
5/16–18	4,700	2,150	6,300	3,350	7,850	4,700	80	8.0	2.5
3/8–16	7,000	3,200	9,300	4,950	11,600	6,950	110	12.0	4.0
7/16–14	9,550	4,400	12,800	6,800	15,900	9,600	135	17.0	5.0
1/2–13	12,800	5,850	17,000	9,050	21,300	12,800	204	22.0	7.5
9/16–12	16,400	7,550	21,800	11,600	27,300	16,400	300	30.0	10.0
5/8–11	20,300	9,300	27,200	14,500	33,900	20,300	420	39.0	12.5
3/4–10	30,000	13,800	40,100	21,300	50,100	30,100	540	58.0	20.0
7/8–9	41,600	12,400	55,400	29,500	69,300	41,600	840	88.0	30.0
1–8	54,500	15,000	72,700	38,700	90,900	54,600	1,080	120.0	40.0
1 1/8–7	68,700	18,900	80,100	42,100	115,000	69,000	1,200	150.0	50.0
1 1/4–7	87,200	24,000	101,700	53,500	145,000	87,000	1,320	188.0	60.0
1 3/8–6	104,000	28,700	121,300	63,800	173,000	104,000	1,620	220.0	70.0
1 1/2–6	126,000	34,800	147,500	77,600	211,000	127,000	1,800	260.0	90.0

GENERAL NOTE: For styles NTE, NTU, and NTM, the proof load and clamp load values shall be 45% of those shown in this Table.

NOTES:

(1) For values on sizes not listed in Table 12, agreement shall be reached between purchaser and supplier.

(2) For style NU, the proof load values shall be 110% of those shown in this Table.

(3) The supplier shall report the torque range to achieve the clamp load values in this Table.

Table 13 Proof Loads, Clamp Loads, and Prevailing Torques for Fine Thread Locknuts (Regardless of Finish)

Nut Size and Threads Per Inch	Grade N2 and A Nuts		Grade N5, B, and F Nuts		Grade N8, C, and G Nuts		Prevailing Torque		
	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Note (1)]	Clamp Load, lb [Notes (1), (3)]	Max. First Install, in.-lb	Min. First Removal, in.-lb	Min. Third Removal, in.-lb
No. 4–48	530	270	720	420	990	600	4.0	1.0	0.2
No. 6–40	800	420	1,100	640	1,500	900	8.0	1.5	0.5
No. 8–36	1,200	610	1,600	930	2,200	1,300	12.0	2.0	0.5
No. 10–32	1,600	840	2,200	1,300	3,000	1,800	17	2.5	1.0
No. 12–28	2,100	1,050	2,800	1,650	3,900	2,350	27	3.5	1.0
1/4–28	2,900	1,500	4,000	2,300	5,450	3,250	40	5.0	1.5
5/16–24	4,650	2,400	6,350	3,700	8,700	5,200	80	8.0	2.5
3/8–24	7,000	3,600	9,550	5,600	13,200	7,900	110	12.0	4.0
7/16–20	9,500	4,900	13,000	7,550	17,800	10,700	135	17.0	5.0
1/2–20	12,800	6,550	17,400	10,200	24,000	14,400	204	22	7.5
9/16–18	16,200	8,350	22,100	13,000	30,400	18,300	300	30	10.0
5/8–18	20,500	10,500	27,900	16,300	38,400	23,000	420	39	12.5
3/4–16	29,800	15,400	40,700	23,800	56,000	33,600	540	58	20
7/8–14	40,800	12,600	55,500	32,400	76,400	45,800	840	88	30
1–14	54,400	16,800	74,100	43,300	101,900	61,100	1,080	120	40
1–12	53,000	16,400	72,300	42,300	99,500	59,700	1,080	120	40
1 1/8–12	68,500	21,200	80,400	47,500	128,000	76,800	1,200	150	50
1 1/4–12	85,800	26,600	100,900	59,700	161,000	96,600	1,320	188	60
1 3/8–12	105,200	32,500	123,600	72,900	197,000	118,000	1,620	220	70
1 1/2–12	126,500	39,100	148,600	87,700	237,000	142,000	1,800	260	90

GENERAL NOTE: For styles NTE, NTU, and NTM, the proof load and clamp load values shall be 45% of those shown in this Table.

NOTES:

(1) For values on sizes not listed in Table 13, agreement shall be reached between purchaser and supplier.

(2) For style NU, the proof load values shall be 110% of the values shown in this Table, excluding grades N8, C, and G.

(3) The supplier shall report the torque range to achieve the clamp load values in this Table.

Table 14 Proof Loads, Clamp Loads, and Prevailing Torques for 8-UN Series Thread Locknuts (Regardless of Finish)

Nut Size and Threads Per Inch	Grade N2 and A Nuts		Grade N5, B, and F Nuts		Grade N8, C, and G Nuts		Prevailing Torque		
	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Proof Load, lb [Notes (1), (2)]	Clamp Load, lb [Notes (1), (3)]	Max. First Install, in.-lb	Min. First Removal, in.-lb	Min. Third Removal, in.-lb
1 1/8–8	71,150	19,600	83,000	44,200	118,600	71,200	1,200	150	50
1 1/4–8	90,000	24,800	105,000	55,900	150,000	90,000	1,320	188	60
1 3/8–8	111,000	30,600	129,500	68,900	185,000	111,100	1,620	220	70
1 1/2–8	134,250	37,000	156,600	83,400	223,750	134,300	1,800	260	90

GENERAL NOTE: For styles NTE, NTU, and NTM, the proof load and clamp load values shall be 45% of those shown in this Table.

NOTES:

(1) For values on sizes not listed in Table 14, agreement shall be reached between purchaser and supplier.

(2) For style NU, the proof load values shall be 110% of those shown in this Table.

(3) The supplier shall report the torque range to achieve the clamp load values in this Table.

lowest numerical torque occurring while the nut is being backed off throughout the next 360 deg of rotation shall be recorded as the minimum first removal torque. This minimum torque shall not be less than the first removal prevailing torque value as specified in Tables 12, 13, and 14. The nut shall then be backed off until the prevailing torque element is disengaged from the bolt or mandrel thread. The nut shall be reassembled and removed two more times. On each reassembly, the nut shall be assembled to the initial first removal position, but no clamp load shall be induced in the bolt or mandrel. The test washer shall not be removed during these additional cycles.

At no time during the two additional installations and removals should the prevailing torque exceed the maximum, first install prevailing torque value as specified for the applicable grade and thread series in Tables 12, 13, and 14. During the third removal, the minimum torque occurring while the nut is being backed off throughout the first 360 deg of rotation shall be recorded. The minimum torque shall not be less than the third removal value as specified in Tables 12, 13, and 14. Sufficient time shall elapse between installation and removal cycles to prevent overheating of the test assembly.

The speed of installation and removal of the nut shall not exceed 30 rpm and shall be continuous and uniform.

11.4 Optional Torque-Tension Test

When torque-tension data are desired by the purchaser, refer to IFI-101.

11.5 Test Devices, Washers, Bolts, and Mandrels

11.5.1 Torque-Measuring Device. The torque-measuring device, handheld or automatic, shall be capable of measuring the torque while the test locknut is rotating on a test bolt. The measuring devices and/or system shall be accurate within ±2% of the device scale from 20% through 100% of the full scale. Devices should not be used in the lower 20% of their full-scale capability.

11.5.2 Load-Measuring Device. The load-measuring device used in the prevailing torque test shall be capable of measuring the actual tension induced in the test bolt as the nut is tightened. The measuring devices and/or system shall be accurate within ±5% of the device scale from 20% through 100% of the full scale. The bolt clearance hole in the backing plate behind the washer shall have the same diameter and tolerance as the test washer.

11.5.3 Test Washer. Washers or multiple-hole test strips shall be plain finished and hardened to HRC 38 minimum. The washer's outside diameter or strip width shall be larger than the maximum across corners or flange diameter, whichever is greater, of the locknuts being tested. The inside diameter of the through hole shall conform to the inside hole diameters specified in either ASME B18.21.1, Type A, or ASTM F436 for sizes through 1 in. in diameter. Washers for sizes over 1 in. shall have an inside diameter of 108% of the nominal bolt or mandrel diameter with a +0.032 tolerance.

Washers and strips shall not be used for more than one test per hole on each side.

11.5.4 Test Bolt. The test bolt may be used for proof load and prevailing torque testing for all sizes.

The bolt shall have threads conforming to Class 2A tolerances as specified in ASME B1.1. Threads on all bolts 1 in. in diameter and smaller shall be produced by thread rolling. Bolt length shall be such that a minimum length equivalent to six thread pitches, as measured from the end of the bolt, will protrude through the nut when the nut is seated against the test washer. Thread length shall be such that a minimum of two full threads are within the grip after the nut is seated. The bolt shall be pointed in accordance with the dimensional requirements for hex cap screws as given in ASME B18.2.1. The thread surface shall be free of burrs or other contamination that might affect an accurate determination of the prevailing torque developed by the nut.

The test bolt shall have a minimum specified tensile strength not less than the specified proof load of the nut to be tested. The test bolts shall have a zinc phosphate and oil finish according to grade D of ASTM F1137.

The bolts shall conform to the surface discontinuity requirements of ASTM F788. When test bolts less than $\frac{3}{4}$ in. in diameter are used, a new bolt shall be used for testing each nut. Bolts $\frac{3}{4}$ in. and larger in diameter may be reused if upon nonmagnified (except for personal corrective lenses) visual inspection, the thread does not show thread flank deformation or grooving.

11.5.5 Proof Load Testing Mandrel. Proof load testing mandrels may be used for proof load testing all nut sizes.

The threaded mandrel used for proof load testing of nuts shall have threads conforming to Class 3A tolerances as specified in ASME B1.1, except that the major diameter shall be the minimum major diameter with a plus tolerance of 0.002 in. The mandrel shall be quenched and tempered to a hardness range of HRC 45–HRC 50.

Test mandrels may be reused if upon nonmagnified (except for personal corrective lenses) visual inspection the thread flanks are not visibly deformed or grooved.

11.5.6 Prevailing Torque Testing Mandrel. Prevailing torque testing mandrels may be used for all nut sizes.

The threaded mandrel used for prevailing torque testing of nuts shall have threads conforming to Class 2A tolerances for both the pitch diameter and major diameter as specified in ASME B1.1. The mandrel shall be quenched and tempered to a hardness range of HRC 45–HRC 50.

Test mandrels may be reused if upon nonmagnified (except for personal corrective lenses) visual inspection the thread flanks are not visibly deformed or grooved.

NOTE: Threaded mandrels with a pitch diameter size between the low limit of Class 3A and the high limit of Class 2A, and a major diameter size within the limits of low limit 3A with a tolerance of minus zero plus 0.002 in., can be used for testing both proof load and prevailing torque.

12 GRADES AND MANUFACTURING MARKING

12.1 Grade and Source Markings

Markings may be on the top or the wrench flats of locknuts or on the top of flanges for flange nuts. Markings on the top of locknuts or on flanges may be raised or depressed at the option of the manufacturer. Markings on the wrench flats and bearing surfaces of locknuts shall be depressed. Locknuts must conform to all locknut dimensions when measurements are made over the marks. For nuts larger than $1\frac{1}{2}$ in., the nature and location of markings shall be based on an agreement between the purchaser and supplier.

12.2 Grade Marking Requirements and Options

Nut grades N5, B, and F locknuts shall be marked with three equally spaced (120 deg) identical symbols on the top side of the nut.

Nut grades N8, C, and G locknuts shall be marked with six equally spaced (60 deg) identical symbols on the top side of the nut.

Alternatively, grades F and G may be marked on the tops of the flange.

Alternatively, when grades N5, N8, B, and C locknuts are machined from bar stock, grades N5 and B locknuts may be identified with one set of circumferential notches cut into the corners of the nut and grades N8 and C locknuts with two sets of circumferential notches cut into the corners of the nut.

12.3 Source Marking and Options

All grade N5, N8, B, F, C, and G locknuts shall be uniquely marked or color coded to identify the manufacturer. Such markings may be separate from the grade markings or may be incorporated into one or more of the three or six grade marking symbols.

Insert color may be used as a manufacturer's identification on nylon insert locknuts provided the color is registered to the manufacturer on the U.S. Department of Commerce list of registered FQA Insignias, http://www.uspto.gov/trademarks/law/fastener/fqa.jsp.

13 QUALITY ASSURANCE

13.1 Dimensional Inspection Sampling

Sampling and procedures for dimensional inspections shall be in accordance with ASME B18.18.

13.2 Performance and Mechanical Testing Sampling

Sampling for performance and mechanical requirements shall be done in accordance with ASTM F1470.

13.3 Modification After Delivery

The supplier shall not be responsible for nonconformances resulting from any modification of the parts after delivery to the purchaser.

14 WORKMANSHIP

Nuts shall be free of surface irregularities (e.g., burrs, seams, laps, loose scale) that might affect their serviceability. When control of surface irregularities is important for the intended application, ASTM F812 shall be specified by the purchaser.

15 DESIGNATION

15.1 Nylon Insert Nuts

Nylon insert locknuts shall be designated by the following data preferably in the sequence as follows:

(a) product name
(b) designation of standard (i.e., ASME B18.16.6)
(c) nominal diameter and threads per inch
(d) style of locknut (NM, NU, etc.)
(e) steel property grade or material identification
(f) protective coating, if required
(g) torque-tension data per IFI-101, if required

EXAMPLE: Nylon insert locknut, ASME B18.16.6, $\frac{1}{2}$–13, NE, grade N8, zinc plated per ASTM F1941/F1941M, Fe/Zn 5C.

15.2 All-Metal Locknuts

All-metal locknuts shall be designated by the following data preferably in the sequence as follows:

(a) product name and type
(b) designation of standard (i.e., ASME B18.16.6)
(c) nominal diameter and threads per inch
(d) steel grade or material identification
(e) protective coating, if required
(f) torque-tension data per IFI-101, if required

EXAMPLE: All-metal hex flange locknut, ASME B18.16.6, $\frac{5}{8}$–11, grade F, zinc plated per ASTM F1941/F1941M, Fe/Zn 5C.

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B18 AMERICAN NATIONAL STANDARDS FOR BOLTS, NUTS, RIVETS, SCREWS, WASHERS, AND SIMILAR FASTENERS

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Essais de corrosion en atmosphères artificielles - Essais aux brouillards salins (ISO/FDIS 9227:2022)

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European foreword

This document (EN ISO 9227:2022) has been prepared by Technical Committee ISO/TC 156 "Corrosion of metals and alloys" in collaboration with Technical Committee CEN/TC 262 “Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2023, and conflicting national standards shall be withdrawn at the latest by May 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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Any feedback and questions on this document should be directed to the users’ national standards body/national committee. A complete listing of these bodies can be found on the CEN website.

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Endorsement notice

The text of ISO 9227:2022 has been approved by CEN as EN ISO 9227:2022 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262, *Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition cancels and replaces the fourth edition (ISO 9227:2017), which has been technically revised.

The main changes are as follows:

— the arrangement of test specimens has been added;

— the arrangement of collecting devices has been changed; examples of arrangement of collecting devices have been added as Annex E;

— DC04, DC05 and UNS G10080 have been added for steel reference specimens as an alternative of CR4-grade steel, and interlaboratory comparison for reference specimens has been added as Annex F;

— the diluted acetic acid for preparing the test solution of AASS and CASS has been added;

— the allowed limit of copper concentration when the cabinet once used for CASS is re-used for NSS or AASS has been specified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

There is seldom a direct relation between resistance to the action of salt spray and resistance to corrosion in other media, because several factors influencing the progress of corrosion, such as the formation of protective films, vary greatly with the conditions encountered. Therefore, the test results should not be regarded as a direct guide to the corrosion resistance of the tested metallic materials in all environments where these materials can be used. Also, the performance of different materials during the test should not be taken as a direct guide to the corrosion resistance of these materials in service.

Nevertheless, the method described gives a means of checking that the comparative quality of a metallic material, with or without corrosion protection, is maintained.

Different metallic substrates (metals) cannot be tested in direct comparison in accordance to their corrosion resistances in salt spray tests. Comparative testing is only applicable for the same kind of substrate.

Salt spray tests are generally suitable as corrosion protection tests for rapid analysis for discontinuities, pores and damage in organic and inorganic coatings. In addition, for quality control purposes, comparison can be made between specimens coated with the same coating. As comparative tests, however, salt spray tests are only suitable if the coatings are sufficiently similar in nature.

When interpreting test results (e.g. minimum time until appearance defects or protection defects) for product quality control or acceptance specifications, it is important to recognize that the salt spray test can have a low level of reproducibility, especially with production parts tested in different laboratories.

It is often not possible to use results gained from salt spray testing as a comparative guide to the long-term behaviour of different coating systems, since the corrosion stress during these tests differs significantly from the corrosion stresses encountered in practice.

INTERNATIONAL STANDARD **ISO 9227:2022**

Corrosion tests in artificial atmospheres — Salt spray tests

1 Scope

This document specifies the apparatus, the reagents and the procedure to be used in conducting the neutral salt spray (NSS), acetic acid salt spray (AASS) and copper-accelerated acetic acid salt spray (CASS) tests for assessment of the corrosion resistance of metallic materials, with or without permanent or temporary corrosion protection.

It also describes the method employed to evaluate the corrosivity of the test cabinet environment.

It does not specify the dimensions or types of test specimens, the exposure period to be used for a particular product, or the interpretation of results. Such details are provided in the appropriate product specifications.

The salt spray tests are particularly useful for detecting discontinuities, such as pores and other defects, in certain metallic, organic, anodic oxide and conversion coatings.

The NSS test is particularly applicable to:

— metals and their alloys;

— metallic coatings (anodic and cathodic);

— conversion coatings;

— anodic oxide coatings;

— organic coatings on metallic materials.

The AASS test is especially useful for testing decorative coatings of copper + nickel + chromium, or nickel + chromium. It has also been found suitable for testing anodic and organic coatings on aluminium.

The CASS test is useful for testing decorative coatings of copper + nickel + chromium, or nickel + chromium. It has also been found suitable for testing anodic and organic coatings on aluminium.

The salt spray methods are all suitable for checking that the quality of a metallic material, with or without corrosion protection, is maintained. They are not intended to be used for comparative testing as a means of ranking different materials relative to each other with respect to corrosion resistance or as means of predicting long-term corrosion resistance of the tested material.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3574, *Cold-reduced carbon steel sheet of commercial and drawing qualities*

ISO 4623-2:2016, *Paints and varnishes — Determination of resistance to filiform corrosion — Part 2: Aluminium substrates*

ISO 8044, *Corrosion of metals and alloys — Vocabulary*

ISO 8407, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*

ISO 17872, *Paints and varnishes — Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
reference specimen
portion of the reference material that is to be exposed with the intention to check the reproducibility and repeatability of the test results for the test cabinet in use

Note 1 to entry: The reference material is the material with known test performance.

3.2
test specimen
specific portion of the samples upon which the testing is to be performed

3.3
substitute specimen
inert materials (such as plastic or glass) used for the substitute of a *test specimen* (3.2)

4 Principle

WARNING — This document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

The NSS test is the test method in which a neutral approximate 5 % sodium chloride solution is atomized under a controlled environment.

The AASS test is the test method in which an approximate 5 % sodium chloride solution acidified by the addition of acetic acid is atomized under a controlled environment.

The CASS test is the test method in which an approximate 5 % sodium chloride solution acidified by the addition acetic acid and with the addition of copper(II) chloride is atomized under a controlled environment.

5 Test solutions

5.1 Preparation of the sodium chloride solution

Dissolve a sufficient mass of sodium chloride in distilled or deionized water with a conductivity not higher than 20 µS/cm at 25 °C to produce a concentration in a range between 45 g/l and 55 g/l. The sodium chloride concentration of the sprayed solution collected shall be 50 g/l ± 5 g/l. The specific gravity range for a 50 g/l ± 5 g/l solution is 1,029 to 1,036 at 25 °C.

The sodium chloride shall not contain a mass fraction of the heavy metals copper (Cu), nickel (Ni) and lead (Pb) in total more than 0,005 %. It shall not contain a mass fraction of sodium iodide more than 0,1 % and a mass fraction of total impurities more than 0,5 %, calculated for dry salt.

NOTE Anti-caking agents added to the sodium chloride can act as corrosion inhibitors or accelerators. A useful sodium chloride salt grade is a grade named Ph. Eur/USP or JIS, ACS.

5.2 Preparation of each test solution with pH adjustment

5.2.1 pH of the salt solution

Adjust the pH of the salt solution to the desired value on the basis of the pH of the sprayed solution collected.

5.2.2 Neutral salt spray test

Adjust the pH of the salt solution (see 5.1) so that the pH of the sprayed solution collected within the test cabinet (6.2 and 6.5) is 6,5 to 7,2 at 25 °C ± 2 °C. Check the pH using electrometric measurement. Measurements of pH shall be done using electrodes suitable for measuring in weakly buffered sodium chloride solutions in distilled or deionized water. Make any necessary corrections by adding hydrochloric acid, sodium hydroxide or sodium bicarbonate solution of analytical grade.

WARNING — Hydrochloric acid (CAS Registry Number®[1] 7647-01-0) solution is toxic, corrosive, irritating and very toxic to aquatic life. Refer to the safety data sheet for details. Handling of hydrochloric acid solution shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

WARNING — Sodium hydroxide (CAS 1310-73-2) solution is toxic, corrosive and irritating. Refer to the safety data sheet for details. Handling of sodium hydroxide solution shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

NOTE Possible changes in pH can result from loss of carbon dioxide in the solution when it is sprayed. Such changes can be avoided by reducing the carbon dioxide content of the solution by, for example, heating it to a temperature above 35 °C before it is placed in the apparatus, or by making the solution using freshly boiled water.

5.2.3 Acetic acid salt spray test

Add a sufficient amount of glacial acetic acid not less than 99,7 % of mass fraction or diluted acetic acid more than 10 % of mass fraction to the salt solution (see 5.1) to ensure that the pH of samples of sprayed solution collected in the test cabinet (6.2 and 6.5) is between 3,1 and 3,3 at 25 °C ± 2 °C. Take the added volume of acetic acid into account when making up the initial sodium chloride solution. If the pH of the solution initially prepared is 3,0 to 3,1, the pH of the sprayed solution is likely to be within the specified limits. Check the pH using electrometric measurement. Measurements of pH shall be done using electrodes suitable for measuring in weakly buffered sodium chloride solutions in distilled or deionized water. Make any necessary corrections by adding acetic acid, sodium hydroxide, or sodium bicarbonate of analytical grade.

WARNING — Glacial acetic acid (CAS 64-19-7) is a flammable liquid, toxic, corrosive and irritating. Refer to the safety data sheet for details. Handling of glacial acetic acid shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

1) CAS Registry Number® is a trademark of CAS corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

5.2.4 Copper-accelerated acetic acid salt spray test

Dissolve a sufficient mass of copper(II) chloride dihydrate ($CuCl_2 \cdot 2H_2O$) not less than 99,0 % of mass fraction in the salt solution (5.1) to produce a concentration of 0,26 g/l ± 0,02 g/l [equivalent to (0,205 ± 0,015) g of $CuCl_2$ per litre].

WARNING — Copper(II) chloride dihydrate (CAS 10125-13-0) is toxic, corrosive, irritating and very toxic to aquatic life. Refer to the safety data sheet for details. Handling of copper(II) chloride dihydrate shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

Adjust the pH using the procedures described in 5.2.3.

5.3 Filtration

If necessary, filter the solution before placing it in the reservoir of the apparatus, to remove any solid matter which can block the apertures of the spraying device.

6 Apparatus

6.1 Component protection

All components in contact with the spray or the test solution shall be made of, or lined with, materials resistant to corrosion by the sprayed solution and which do not influence the corrosivity of the sprayed test solutions.

The supports for the test specimen shall be constructed such that different substrate types do not influence each other. It shall also be constructed so that the supports themselves do not influence the test specimens.

6.2 Spray cabinet

The cabinet shall be such that the conditions of homogeneity and distribution of the spray are met. Due to the limited capacity of cabinets smaller than 0,4 m^3, the effect of the loading of the cabinet on the distribution of the spray and temperature shall be carefully considered. The solution shall not be sprayed directly onto test specimens but rather spread throughout the cabinet so that it falls naturally down to them. The upper parts of the cabinet shall be designed so that drops of sprayed solution formed on its surface do not fall on the test specimens.

The size and shape of the cabinet shall be such that the collection rate of solution in the cabinet is within the limits specified in 10.3.

Preference shall be given to apparatus that has a means for properly dealing with fog after the test, prior to releasing it from the building for environmental conservation, and for diluting salt solution prior to discharging it to the drainage system.

NOTE A schematic diagram of one possible design of spray cabinet is shown in Annex A (see Figures A.1 and A.2).

6.3 Heater and temperature control

The test cabinet shall be maintained at the specified temperature (see 10.1) in the zone where the test specimens are placed by the appropriate system.

6.4 Spraying device

The device for spraying the salt solution comprises a supply of clean air, of controlled pressure and humidity, a reservoir to contain the solution to be sprayed, and one or more atomizers.

The compressed air supplied to the atomizers shall be passed through a filter before introduction into the air humidifier to remove all traces of oil or solid matter, and the atomizing pressure shall be at an overpressure of 70 kPa to 170 kPa. The pressure is typically 98 kPa ± 10 kPa but can vary depending on the type of cabinet and atomizer used.

In order to prevent the evaporation of water from the sprayed droplets (aerosol), the air shall be humidified before entering the atomizer by passing through a suitable humidifier. The humidified air shall be saturated such that the concentration of the fallout solution falls within the specifications of 5.1. The humidified air shall also be heated such that when mixed with the salt solution and after the adiabatic expansion at the atomizer, there is no significant disturbance of the temperature in the cabinet. The appropriate temperature depends on the pressure used and on the type of atomizer. Temperature, pressure or humidification, or a combination thereof, shall be adjusted so that the rate of collection of the spray in the cabinet and the concentration of the collected spray are kept within the specified limits (see 10.3). A commonly used humidifier is the saturation tower where temperature and pressure are controllable. Table 1 gives guiding values on temperature and pressure combinations for the saturation tower.

Table 1 — Guiding values for the temperature of the hot water in the saturation tower

Atomizing overpressure kPa	Guiding values for the temperature, in °C, of the hot water in the saturation tower when performing the different salt spray test	
	NSS and AASS	CASS
70	45	61
84	46	63
98	48	64
112	49	66
126	50	67
140	52	69
160	53	70
170	54	71

The atomizers shall be made of inert material. Baffles made of inert material may be used to prevent direct impact of the spray on the test specimens, and the use of adjustable baffles is helpful in obtaining uniform distribution of the spray within the cabinet. For this purpose, a dispersion tower equipped with an atomizer may also be helpful.

The salt solution supplied to the atomizer shall be kept stable to ensure a continuous and uniform fall out as described in 10.3. A stable level of spraying can be achieved by either controlling the level of salt solution in the reservoir or restricting the flow of salt solution to the atomizer such that a continuous spray is achieved.

Distilled or deionized water with a conductivity not higher than 20 µS/cm at 25 °C shall be used for humidification of spray air.

6.5 Collecting devices

At least two collecting devices shall be used to check the homogeneity of the spraying of the cabinet. Suitable funnels shall be made of chemically inert material, with the stems inserted into graduated cylinders or other similar containers and have a diameter of 100 mm, which corresponds to a collecting area of approximately 80 cm^2. The collecting devices shall be placed in the zone of the cabinet where the test specimens are placed. They shall be placed so that only mist, and not liquid falling from specimens or from parts of the cabinet, is collected.

The collecting devices shall be placed as follows.

a) During the test, two collecting devices should be placed at central points in the zone (see Annex E for an example).

b) For calibration purposes, the collection rate of the cabinet shall be verified with at least six collecting devices, which are placed at the four corners and two central points of the zone (see Annex E for an example). This verification is done without test specimens in the cabinet, but preferably with substitute specimens (see also 10.2). It is recommended to perform it after installation, a move, modifications, adjustments or repair of the cabinet, after detecting nonconformities of the spray collection rate during running tests [see a)], and after idle periods longer than four weeks.

c) If the collecting devices cannot be placed at four corners and/or at the central two points in the zone, they may be placed at another point by agreement between the interested parties. The number of collecting devices placed may also be changed according to the size of the cabinet by the agreement between the interested parties. In those cases, it shall be stated in the test report.

NOTE During permanent operation, a reasonable time period of the verification of the collection rate of the cabinet is generally considered to be three months.

When nonconforming spray collection rates are found during verification [see b)], the cabinet shall be adjusted or the test specimens shall not be placed in the nonconforming area.

6.6 Re-use

If the cabinet has been used once for an AASS or CASS test, or has been used for any other purpose with a solution differing from that specified for the NSS test, it shall not be used for the NSS test until a thorough cleaning procedure has been completed and the pH of collected solution has been verified by the method in 5.2.2 and the corrosivity of the cabinet verified by the method in Clause 7 to not be significantly affected by previous tests.

Additionally, it is recommended to check that the copper concentration in the collected solution is below the allowed limit of 2,5 mg/l (see 5.1), better below 0,5 mg/l, when the cabinet was previously used for CASS, but should now be used for AASS or NSS.

NOTE It is very difficult to clean a cabinet sufficiently that was once used for AASS or CASS testing so that it can be used for an NSS test.

7 Method for evaluating cabinet corrosivity

7.1 General

To determine the corrosivity of the cabinet, reference specimens made of steel shall be used. It is necessary to verify the cabinet at regular intervals as described in 7.2 to 7.4.

NOTE 1 During permanent operation, a reasonable time period between two checks of the corrosivity of the cabinet is generally considered to be three months.

As a complement to the reference specimens made of steel, high-purity zinc reference specimens may also be exposed in the tests in order to determine the corrosivity against this metal as described in Annex B.

NOTE 2 The corrosivity of the cabinet verified with steel or high-purity zinc reference specimens via their mass loss does not guarantee reproducible times to the occurrence of certain corrosion products on coated specimens from industrial production.

7.2 Reference specimens

To verify the apparatus, use at least four reference specimens of 1,0 mm ± 0,2 mm thickness and 150 mm × 70 mm of CR4-grade steel in accordance with ISO 3574 with an essentially faultless surface and a matt finish (arithmetical mean deviation of the profile Ra = 0,8 µm ± 0,3 µm). Cut these reference specimens from cold-rolled plates or strips. Alternatively to CR4-grade steel, the following steel grades

can be used, DC04 and DC05 according to EN 10130 and UNS G10080 according to SAE HS-1086 with reference to the results of the interlaboratory comparison (see Annex F).

NOTE 1 "Essentially faultless" means free from pores, marks, scratches and any light colouration.

Clean the reference specimens carefully, immediately prior to testing. Besides the specifications given in 8.2 and 8.3, cleaning shall eliminate all those traces (dirt, oil or other foreign matter) that can influence the test results.

Thoroughly clean the reference specimens with an appropriate organic solvent (such as a hydrocarbon with a boiling point between 60 °C and 120 °C) using a clean soft brush or a soft cloth, a non-woven lint-free cloth, that does not leave any remains, or an ultrasonic cleaning device. Carry out the cleaning in a vessel full of solvent. After cleaning, rinse the reference specimens with fresh solvent and then dry them.

NOTE 2 Cleaning with isopropanol can lead to a film of residues on the specimen surface.

WARNING — Most organic solvents are flammable liquids, toxic and irritating. Refer to the safety data sheet for details. Handling of organic solvents shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of these solvents.

Determine the mass of the reference specimens to ±1 mg. Protect one face of the reference specimens with a removable coating, e.g. an adhesive plastic film. The edges of the reference specimens may be protected by the adhesive tape as well.

7.3 Arrangement of the reference specimens

Position at least four steel reference specimens in four quadrants (if six specimens are available, place them in six different positions including four quadrants) in the zone of the cabinet where the test specimens are placed, with the unprotected face upwards, and at an angle of 20° ± 5° from the vertical. The support for the reference specimens shall be made of, or coated with, inert materials such as plastics. The top of the collecting device should be in level with lower edge of the reference specimens or at the mean reference specimen exposure height.

The cabinet should be verified during the testing of test specimens. If this is the case, great care shall be taken that the specimens do not affect each other. Otherwise, the cabinet shall be filled with substitute specimens to maintain the homogeneity of the cabinet. The verification procedure shall be performed using the same settings as for the test runs.

7.4 Determination of mass loss (mass per area)

At the end of the test with duration according to Table 2, immediately take the reference specimens out of the test cabinet and remove the protective coating. Remove the corrosion products by mechanical and chemical cleaning, as described in ISO 8407. As one possibility of chemical cleaning, use a solution of diammonium hydrogen citrate [$(NH_4)_2HC_6H_5O_7$] (recognized analytical grade) in water with a concentration of 200 g/l for 10 min at 23 °C.

After each stripping, thoroughly clean the reference specimens at ambient temperature with water, then with ethanol, followed by drying.

Weigh the reference specimens to the nearest 1 mg. Divide the determined mass loss by the area of the exposed surface area of the reference specimen in order to assess the metal mass loss per square metre of the reference specimen.

It is recommended that freshly prepared solution be used during each procedure for the removal of corrosion products.

7.5 Satisfactory performance of cabinet

The cabinet has not performed satisfactorily if the mass loss of steel reference specimen is outside the allowed ranges given in Table 2.

Table 2 — Allowed range of mass loss of the steel reference specimens[14] during verification of the corrosivity of the cabinet

Test method	Test duration h	Allowed range of mass loss g/m^2
NSS	48	70 ± 20
AASS	24	40 ± 10
CASS	24	55 ± 15

NOTE See Annex B for the use of a zinc reference specimen.

8 Test specimens

8.1 The number and type of test specimens, their shape and their dimensions shall be selected in accordance with the specification for the material or product being tested. When not specified, these parameters shall be mutually agreed between the interested parties. Unless otherwise specified or agreed, test specimens with an organic coating to be tested shall be made from burnished steel conforming to ISO 1514, and of approximate dimensions 150 mm × 100 mm × 1 mm. Annex C describes how test specimens with organic coatings shall be prepared for testing. Annex D gives supplementary information needed for testing test specimens with organic coatings.

8.2 The test specimens shall be thoroughly cleaned before testing, if not otherwise specified. The cleaning method employed shall depend on the nature of the material, its surface and the contaminants and shall not include the use of any abrasives or solvents which can attack the surface of the specimens.

Care shall be taken that test specimens are not re-contaminated after cleaning by careless handling.

8.3 If the test specimens are cut out from a larger coated article, cutting shall be carried out in such a way that the coating is not damaged in the area adjacent to the cut. Unless otherwise specified, the cut edges shall be adequately protected by coating them with a suitable material which remains stable under the conditions of the test, such as paint, wax or adhesive tape.

9 Arrangement of the test specimens

9.1 The test specimens shall be placed in the zone fulfilling the operating condition of Table 3.

9.2 The test specimens shall be placed in the cabinet so that they are not in the direct line of travel of the spray from the atomizer.

9.3 The angle at which the surface of the test specimen is exposed in the cabinet is very important. The test specimen shall, in principle, be flat and placed in the cabinet facing upwards at an angle as close as possible to 20° to the vertical. This angle shall, in all cases, be within the limits of 15° to 25°. In the case of irregular surfaces (e.g. entire components), these limits shall be adhered to as closely as possible.

9.4 The test specimens shall be arranged so that they do not come into contact with the cabinet and so that surfaces to be tested are exposed to free circulation of spray. The test specimens may be placed at different levels within the cabinet as long as the solution does not drip from test specimens or their supports at one level onto other test specimens placed below. However, for a new examination or for tests with a total duration exceeding 96 h, location permutation of test specimens is permitted.

9.5 The supports for the test specimens shall be made of an inert non-metallic material or coated with an inert non-metallic material. If it is necessary to suspend test specimens, the material used shall not be metallic but shall be synthetic fibre, cotton thread or other inert insulating material.

10 Operating conditions

10.1 Operating conditions are summarized in Table 3.

Table 3 — Operating conditions

Test method item	NSS	AASS	CASS
Temperature	35 °C ± 2 °C	35 °C ± 2 °C	50 °C ± 2 °C
Average collection rate for a horizontal collecting area of 80 cm^2	1,5 ml/h ± 0,5 ml/h		
Concentration of sodium chloride (collected solution)	50 g/l ± 5 g/l		
pH (collected solution)	6,5 to 7,2	3,1 to 3,3	3,1 to 3,3
The ± tolerances given are the allowable operational fluctuations, which are defined as the positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions. This does not mean that the set value may vary by plus/minus the amount indicated from the given value.			

10.2 Check the collection rate and other test conditions in the test cabinet, filled to a similar extent as during the test. An empty or a completely filled cabinet behaves differently. After it has been confirmed that the test conditions are within a specified range, stop spraying the salt solution, fill the test cabinet with test specimens and start the test.

Evaporation of collected solution inside the cabinet can have an effect on the concentration and pH. Care should be taken to only measure solution that has not been subject to significant evaporation.

10.3 The solution collected in each of the collecting devices (6.5) shall have a sodium chloride concentration and a pH value within the ranges given in Table 3.

The average rate of collection of solution in each device shall be measured over a minimum period of 24 h (including inspection time) of continuous spraying. A daily checking of the collection rate during the operation of the cabinet is recommended.

10.4 The test solution which has been sprayed shall not be re-used.

10.5 During operation, the tank for the salt solution shall be covered by a lid to prevent dust or other contaminants from influencing the solution and to prevent the concentration of sodium chloride and the pH from fluctuating.

11 Duration of tests

11.1 The period of test shall be as designated by the specification covering the material or product being tested. When not specified, this period shall be agreed upon by the interested parties.

Recommended periods of exposure are 2 h, 6 h, 24 h, 48 h, 96 h, 168 h, 240 h, 480 h, 720 h and 1 008 h.

11.2 Interruptions of the test shall be minimized. The cabinet shall be opened only for brief visual inspections of the test specimens in position, for changing the collecting devices, and for replenishing the salt solution in the reservoir, if such replenishment cannot be carried out from outside the cabinet.

The total opening time per day shall not exceed 1 h and the cabinet should be opened not more than once per day, when the specified test duration exceeds 24 h.

11.3 If the end-point of the test depends on the appearance of the first sign of corrosion, the test specimens shall be inspected frequently with the requirements of 11.2.

11.4 A periodic visual examination of specimens under test for a predetermined period may be carried out, but the surfaces under test shall not be disturbed, and the period for which the cabinet is open shall be the minimum necessary to observe and record any visible changes.

12 Treatment of test specimens after test

12.1 General

How to treat test specimens after testing should be included in the test specification or material specification given by the customer. It shall be agreed with the test parties before starting the test.

12.2 Non-organic coated test specimens: metallic and/or inorganic coated

At the end of the test period, remove the test specimens from the cabinet and allow them to dry for 0,5 h to 1 h before rinsing, in order to reduce the risk of removing corrosion products. Before they are examined, carefully remove the residues of spray solution from their surfaces. A suitable method is to rinse the test specimens gently in clean running water, at a temperature not exceeding 40 °C, and then to dry them immediately in a stream of air, at an overpressure not exceeding 200 kPa and at a distance of approximately 300 mm.

NOTE ISO 8407 can be used for treatment of the specimen after the test.

12.3 Organic coated test specimens

12.3.1 Scribed organic coated test specimens

Clean the surface of the organic coated test specimens under running tap water at a temperature not exceeding 40 °C directly after removing the test specimens out of the salt spray cabinet. A soft sponge may be used to remove dirt and salt rests out of the scribed area but not to remove evaluable corrosion phenomena. Remove the delaminated area around the scribe by one of the following methods:

a) using a knife: carefully remove the loose coating using a knife blade held at an angle, positioning the blade at the interface between the coating and the substrate and forcing the coating away from the substrate;

b) using an adhesive tape.

Removing the organic coating (paint coating) depends on the kind of coating (paint) and its behaviour in wet conditions. If agreed by the interested parties, let the test specimens dry in room atmosphere for 24 h and then treat them as described under a) and b).

12.3.2 Organic coated but not scribed test specimens

Coated but not scribed test specimens shall be cleaned under running tap water so that corrosion products and/or corrosion phenomena which have to be evaluated are not influenced by cleaning.

13 Evaluation of results

Many different criteria for the evaluation of the test results may be applied to meet particular requirements, for example:

a) appearance after the test;

b) appearance after removing superficial corrosion products;

c) number and distribution or corrosion defects (i.e. pits, cracks, blisters, rusting or creep from scratches in the case of organic coatings) to be assessed by methods described in ISO 8993,

ISO 8994 or ISO 10289 and, for organic coatings, in ISO 4628-1, ISO 4628-2, ISO 4628-3, ISO 4628-4, ISO 4628-5 and ISO 4628-8 (see Annex D);

d) time elapsed before the appearance of the first signs of corrosion;

e) change in mass;

f) alteration revealed by micrographic examination;

g) change in mechanical properties;

h) colorimetry.

NOTE It is good engineering practice to define the appropriate criteria in the specification for a coating or a product to be tested.

14 Test report

14.1 The test report shall indicate the outcome of the test according to the criteria for evaluation of results prescribed for the test. Report the result obtained for each test specimen tested and, when appropriate, the average result for a group of replicate test specimens. Photographic records of the tested test specimens may, if required, accompany the report.

14.2 The test report shall contain information about the test procedure. This information may vary according to the purpose of the test and the guidelines prescribed, but a general list of the details likely to be required is as follows:

a) a reference to this document, i.e. ISO 9227:2022, and the test performed (NSS, AASS or CASS);

b) type and purity of salt and water used;

c) description of the material or product tested;

d) dimensions and shape of the test specimen, and nature and area of the surface tested;

e) preparation of the test specimen, including any cleaning treatment applied and any protection given to edges or other special areas;

f) known characteristics of any coating, with an indication of the surface area;

g) number of test specimens subjected to the test representing each material or product;

h) method used to clean test specimens after the test with, where appropriate, an indication of the loss in mass resulting from the cleaning operation;

i) angle at which the tested surfaces were inclined;

j) frequency and number of test specimen location permutations if required;

k) start and end date, duration of the test and results of any intermediate inspections;

l) properties of any reference specimens placed in the cabinet to check the stability of the operating conditions;

m) test temperature;

n) volume of the collected solution;

o) pH of the test solution and the collected solution;

p) salt concentration or density of the collected solution;