ASME B18.13.1M-2011
[Revision of ASME B18.13.1M-1998 (R2008)]

Screw and Washer Assemblies: SEMS (Metric Series)

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Three Park Avenue • New York, NY • 10016 USA

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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. Periodically certain actions of the ASME B18 Committee may be published as Cases. Cases and interpretations are published on the ASME Web site under the Committee Pages at http://cstools.asme.org as they are issued.

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

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FOREWORD

American National Standards Committee B27 for the Standardization of plain and lock washers was organized in March 1926 as Sectional Committee B27 under the aegis of the American Standards Association (later the United States of America Standards Institute and, as of October 6, 1969, the American National Standards Institute, Inc.) with the Society of Automotive Engineers and The American Society of Mechanical Engineers as joint sponsors. (Since 1950, this Committee has also been assigned responsibility for standardization of washers and machine rings.) The Committee was reorganized in May 1928, at which time two subcommittees were established to carry on development work: Subcommittee 1* on plain washers and Subcommittee 2 on lock washers.

In 1940, the B27 Committee was reactivated, and Subcommittee 2 proceeded to draft a proposal covering helical spring lock washers. It was further amended in 1943 and, following approval by the B27 Committee and sponsor organizations, accepted as an American Standard under the designation ASA B27.1-1994.

A draft proposal completed by Subcommittee 2 in September 1949 incorporated requirements applicable to helical spring lock washers made from materials other than carbon steel and included specifications for tooth lock washers, both helical spring and tooth lock washers, and machine screw assemblies. Subsequent to approval by the B27 Committee and sponsors, the proposal was forwarded to the American Standards Association and declared an American Standard on May 22, 1950.

During the years of 1951 through 1956, Subcommittee 2 considered numerous refinements to the coverage of helical spring lock washers and heat-treated machine screw and lock washer assemblies. A formal draft dated June 1957 was approved by letter ballot of the B27 Committee and the sponsor organization and submitted to the American Standards Association for designation as an American Standard. This was granted on November 3, 1958.

In 1961, a study group comprised of members of the B18 and B27 Committees recommended that the screw and washer assemblies, commonly known as SEMS, be published as a separate document under the jurisdiction of the B18 Committee but subject to approval of both Sectional Committees and the affected Subcommittees thereof. This recommendation was accepted by the B27 and B18 Committees, respectively, on the 28th and 30th of November 1961. Subcommittee 27† of Committee B18 was subsequently appointed.

At the initial meeting of Subcommittee 27 on February 1, 1962, a proposal was submitted consisting of a pertinent date for lock washer SEMS extracted from ASA B27.1-1958 and for plain washer SEMS proposed for inclusion in ASA B27.2, plus information gleaned from SAE Standard J773, Conical Spring Washers. It was agreed that the proposal should be extended to include tapping screw SEMS. Consequently, additional meetings of the subcommittee were held at which new drafts incorporating data for these products were reviewed, and further changes and corrections were recommended. On February 15, 1963, a formal proposal was circulated for comment to Subcommittees 3, 9, and 27 of the B18 Committee and Subcommittees 1 and 2 of the B27 Committee. On November 15, 1963, a revised draft incorporating resolutions to the comments received and additional refinements was letter balloted to Sectional Committees B18 and B27. The resulting comments and disapprovals were resolved at a meeting of Sectional Committee B18 on June 4, 1964 and by circulation of the recommended dispositions to Sectional Committee B27 on February 12, 1965. Subsequent to approval by the sponsor organization and the American Standards Association, the document was formally designated an American Standard, ASA B18.13-1965, on September 29, 1965.

Over the next 18 years, attempts were made to update and refine the document. However, due to extended vacancies in the chairmanship and continual shifts in membership of Subcommittee 13, none of these efforts proved successful, and the Standard was reaffirmed for the three review periods. At the December 5, 1984 meeting of Subcommittee 13, it was agreed the Standard should be revised to incorporate those changes necessary to bring it into agreement with the latest versions of the referenced B18 document covering the screw and washer components and for possible additional refinements. Recommendations for changes were reviewed and discussed further at a meeting held on May 18, 1985, and task groups were established to prepare detailed

* As of April 1, 1966, Subcommittee 1 was redesignated Subcommittee 2 on plain washers; Subcommittee 2 was redesignated Subcommittee 1 on lock washers under American National Standards Committee B27. As of March 16, 1972, Subcommittees 1 and 2 became Subcommittees 22 and 21, respectively, of American National Standards Committee B18.

† As of April 1, 1966, Subcommittee 3 was redesignated Subcommittee 6, Subcommittee 9 was redesignated Subcommittee 6, Subcommittee 9 was redesignated Subcommittee 3, and Subcommittee 27 was redesignated Subcommittee 13 of American National Standards Committee B18.

proposals relative to specific product lines. A proposed revision was drafted that relegated the coverage for round and truss head SEMS and Types A and C tapping screw SEMS to appendices under "Not recommended for new design" status. The revision included dimensional coverage for smaller sizes where applicable, changes to the helical spring lock washer sections and hardness, plus other technical and editorial updating previously accepted. This proposal was reviewed at the December 3, 1985 meeting of Subcommittee 13. Numerous editorial refinements were considered and adopted.

A formal proposal dated February 1986 was circulated to Subcommittees 3, 6, 13, 21, and 22 of the B18 Committee. A revised proposal incorporating resolutions to the comments received was given letter ballot approval by Standards Committee B18 in March 1987. Following its acceptance by ASME and the American National Standards Institute, this revision was granted recognition as an American National Standard on January 12, 1996.

A metric equivalent to the Standard was identified in 1998; thus, B18 approved a metric series SEMS standard. The document was accepted by ASME, and the American National Standards Institute granted approval on February 15, 1991.

With draft International Standards for screw and washer assemblies nearing completion in ISO/TC 2, and due to national or regional differences in production methods used, some revisions to this Standard, and an addition of an explanation of the alternative manufacturing practices in Nonmandatory Appendix A, became desirable. This revision was accepted by ASME and approved as an American National Standard on September 9, 1998.

In 2009, a formal proposal was made by the new chairman with a view to update and harmonize the Standard with ISO 898, incorporate information of importance to end users, and recognize manufacturing practices. The proposal was received, and a task force was formed. A final draft was submitted by the chairman for ballot in October 2010.

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

This revision was approved as an American National Standard on September 2, 2011.

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, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B18 Standards Committee
The American Society of Mechanical Engineers
Three 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 for the purpose of providing 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, 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 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.

The request for 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.
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. 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 this format 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 that are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B18 Standards Committee.

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SCREW AND WASHER ASSEMBLIES: SEMS (METRIC SERIES)

1 INTRODUCTION

1.1 Scope

This Standard covers the general, dimensional, material, and mechanical requirements for metric through-hardened (property classes 8.8, 9.8, and 10.9) machine screws and case-hardened tapping screws from 5 mm to 12 mm captivated washer assemblies (SEMS). The covered washer types are helical, plain, conical, and toothed.

This Standard describes two different methods of SEMS manufacturing. It also covers standard and modified hardness requirements for machine screw SEMS.

The inclusion of dimensional data in this Standard is not intended to imply that all of the products described herein are stock production items. Consumers should consult with respective suppliers concerning the availability of products.

In addition, this Standard includes Nonmandatory Appendices that contain information considered of significant importance to both purchaser and manufacturer.

1.2 Use and Application

The SEMS covered by this Standard are general purpose fasteners intended for mass production and other assembly operations where speed and convenience are paramount factors. Further attributes of the various washers, recognized herein, are given in detail for each type of SEMS.

1.3 ISO Comparison

See Nonmandatory Appendix C.

1.4 Types of SEMS

Included in this Standard are SEMS comprised of the following types of screws and washers:

(a) helical spring lock washers and
- *(1)* socket head cap screws (see Table 1)
- *(2)* hex cap screws (see Table 1)
- *(3)* machine screws (see Table 1)
- *(4)* tapping screws (see Tables 1 and 2)

(b) tooth lock washers and
- *(1)* machine screws (see Tables 3 and 4)
- *(2)* tapping screws (see Tables 3 and 4)
- *(3)* hex cap screws (see Tables 3 and 4)

(c) conical spring washers and
- *(1)* hex cap screws (see Table 5)
- *(2)* machine screws (see Table 5)
- *(3)* tapping screws (see Table 5)

(d) plain washers and
- *(1)* machine screws (see Table 6)
- *(2)* tapping screws (see Table 6)
- *(3)* hex cap screws (see Table 6)

1.4.1 Relevant Information

(a) Hexagon SEMS may be supplied as hex cap screws or as formed hex heads at the option of the manufacturer.

(b) Products having washers of styles and shapes not shown in this Standard may be considered SEMS; however, these products must be covered by the purchaser's drawing or standard or the supplier's standard.

(c) These products are made of carbon or alloy steel material compositions as required by the ISO 898 and ISO 2702 Standards. Purchasers of self-tapping screw SEMS are alerted to Nonmandatory Appendix B.

(d) Where the term low carbon steel is used, this indicates steels with a carbon content < 0.28% carbon. Where high carbon is shown, this indicates steels with a carbon content > 0.47%. When not specified, the material grade employed is at the option of the manufacturer.

(e) Except where shown in Table 7 (Parts A through C) or other places within this Standard, the marking protocol with regard to property class, manufacturer's identification markings, etc., shall be as stated in the referenced standard.

1.5 Screw Heads

The head styles applicable to the various types of SEMS shall be as depicted in the illustrations and designated in the tables for each type. Where only the slotted head SEMS are illustrated, it should be understood that this Standard also applies to other head and recess style SEMS.

1.6 Dimensions

All dimensions in this Standard are given in millimeters.

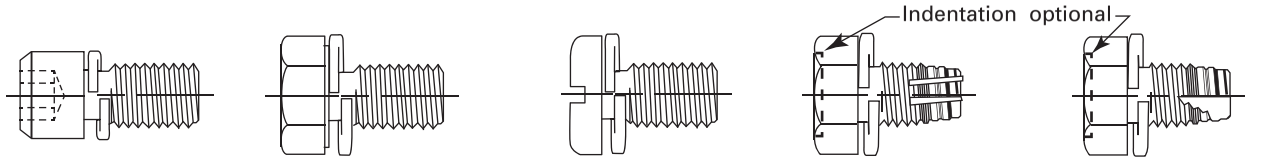
1.7 Options

Options, where permitted by this Standard, shall be at the discretion of the manufacturer, unless otherwise specified by the purchaser.

1.8 Responsibility for Modification

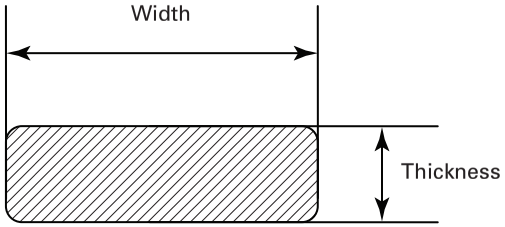
Parts made to this specification can be subjected to the effects of hydrogen embrittlement, either from electroplating operations or exposure in the environment.

Table 1 Dimensions of Helical Spring Lock Washers for SEMS With Machine and Tapping Screws Having Machine Screw Thread Diameter–Pitch Combinations



Socket Head Cap Screw | Hex Cap Screw | Pan Head Machine Screw | Hex Head [Note (1)] Type F Tapping Screw | Hex Flange Head Type T Tapping Screw

Representative Examples of Helical Spring Lock Washer SEMS

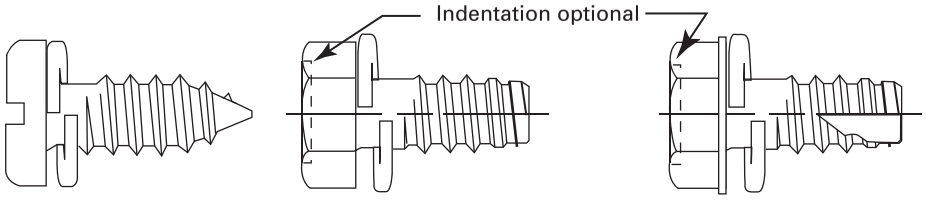


Washer Section Detail

Nominal Size or Basic Screw Diameter	Washer Inside Diameter		Pan Head Screw				Socket Head Cap and Hex Cap Screws				Hex Head Screw				Hex Flange Head Screw			
			Washer Section		Washer Outside Diameter		Washer Section		Washer Outside Diameter		Washer Section		Washer Outside Diameter		Washer Section		Washer Outside Diameter	
	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.
M2.5	2.22	2.35	1.19	0.79	4.60	4.81	0.86	0.73	3.94	4.15	1.02	0.64	4.26	4.47	1.19	0.79	4.60	4.81
M3	2.69	2.84	1.40	1.02	5.49	5.73	1.08	0.92	4.85	5.09	1.19	0.79	5.07	5.31	1.40	1.02	5.49	5.73
M3.5	3.15	3.30	1.40	1.02	5.95	6.19	...	...	...	...	1.19	0.79	5.53	5.77	1.40	1.02	5.95	6.19
M4	3.60	3.76	1.57	1.19	6.74	7.00	1.33	1.13	6.26	6.52	1.40	1.02	6.40	6.66	1.57	1.19	6.74	7.00
M5	4.52	4.67	1.78	1.42	8.08	8.34	1.57	1.33	7.66	7.92	1.57	1.19	7.66	7.92	1.78	1.42	8.08	8.34
M6	5.44	5.62	2.79	1.96	11.02	11.30	1.82	1.55	9.08	9.36	2.77	1.57	10.98	11.26	2.79	1.96	11.02	11.30
M8	7.36	5.75	3.30	2.46	13.96	14.29	2.32	1.97	12.00	12.33	3.18	1.98	13.72	14.05	3.30	2.46	13.96	14.29
M10	9.17	9.41	...	...	...	...	2.78	2.36	14.73	15.10	3.58	2.39	16.33	16.70	...	...	...	...
M12	11.08	11.33	...	...	...	...	2.78	2.36	16.64	17.05	4.34	3.18	19.76	20.17	...	...	...	...

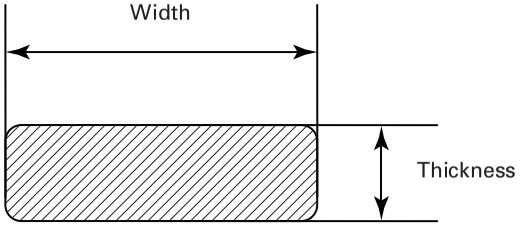
NOTE:
(1) For additional requirements, refer to sections 2 and 3.

Table 2 Dimensions of Helical Spring Lock Washers for SEMS With Screws Having Tapping Screw Thread Diameter–Pitch Combinations



Pan Head Type AB Tapping Screw | Hex Head Type B Tapping Screw | Hex Flange Head Type BT Tapping Screw

Representative Examples of Helical Spring Lock Washer SEMS

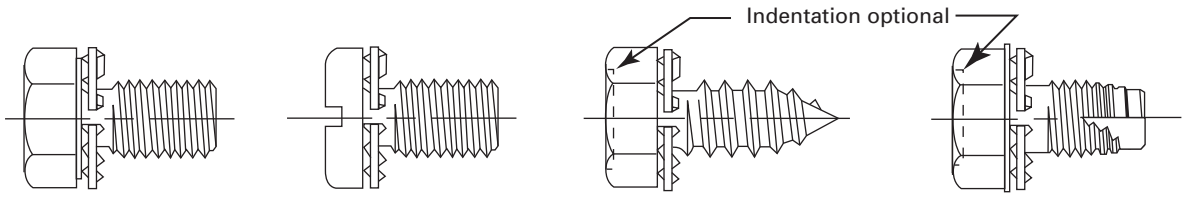


Washer Section Detail

Nominal Size or Basic Screw Diameter	Washer Inside Diameter		Pan Head Screw				Hex Head Screw				Hex Flange Head Screw			
			Washer Section		Washer Outside Diameter		Washer Section		Washer Outside Diameter		Washer Section		Washer Outside Diameter	
	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.	Min. Width	Min. Thickness	Min.	Max.
2.9	2.44	2.57	1.19	0.79	4.83	5.10	1.02	0.64	4.48	4.75	1.19	0.79	4.83	5.10
3.5	2.95	3.08	1.57	0.86	6.09	6.43	1.19	0.79	5.33	5.66	1.57	0.86	6.09	6.43
4.2	3.50	3.66	1.98	0.79	7.47	7.82	1.40	1.02	6.30	6.65	1.98	0.79	7.47	7.82
4.8	3.96	4.11	2.05	1.42	8.07	8.43	1.57	1.19	7.10	7.47	2.05	1.42	8.08	8.43
5.5	4.60	4.78	2.05	1.42	8.71	9.09	1.78	1.42	8.16	8.54	2.05	1.42	8.71	9.09
6.3	5.31	5.52	3.05	1.57	11.41	11.82	2.77	1.57	10.85	11.26	3.05	1.57	11.41	11.82
8.0	6.86	7.06	3.17	1.98	13.21	13.61	3.18	1.98	13.22	13.63	3.17	1.98	13.21	13.61
9.5	8.38	8.59	3.58	2.39	15.54	15.95	3.58	2.39	15.54	15.95	3.58	2.38	15.54	15.95

GENERAL NOTE: For additional requirements, refer to sections 2 and 3.

Table 3 Dimensions of Internal Tooth Lock Washers for SEMS



Hex Cap Screw | Pan Head Machine Screw | Hex Head Type AB Tapping Screw | Hex Flange Head [Note (1)] Type T Tapping Screw

Representative Examples of Internal Tooth Lock Washer SEMS

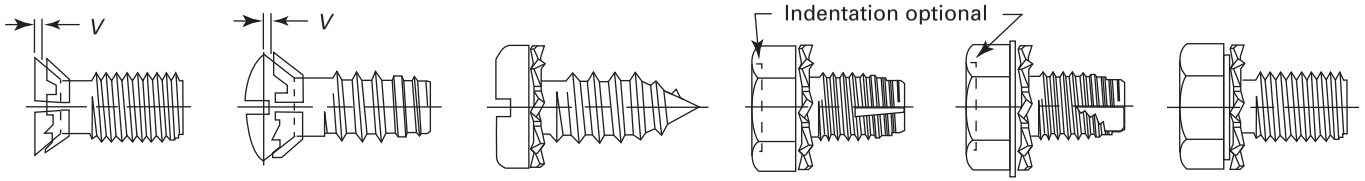
Nominal Size or Basic Screw Diameter	Pan, Hex, and Hex Flange Head Screws			
	Washer Outside Diameter		Washer Thickness	
	Min.	Max.	Min.	Max.
2.9	6.50	7.00	0.30	0.45
3.0	6.85	7.35	0.30	0.45
3.5	7.00	7.50	0.40	0.55
4.0	8.25	8.75	0.45	0.60
4.2	8.25	8.75	0.45	0.60
4.8	9.20	9.70	0.45	0.60
5.0	10.00	10.50	0.50	0.65
5.5	10.00	10.50	0.50	0.65
6.0	11.65	12.15	0.60	0.75
6.3	11.65	12.15	0.60	0.75
8.0	14.75	15.50	0.70	0.85
9.5	16.95	17.70	0.80	1.00
10.0	16.95	17.70	0.80	1.00

GENERAL NOTE: For additional requirements, refer to sections 2 and 4.

NOTE:

(1) Hex flange head SEMS are not available in sizes smaller than 3.5.

Table 4 Dimensions of External Tooth Lock Washers for SEMS



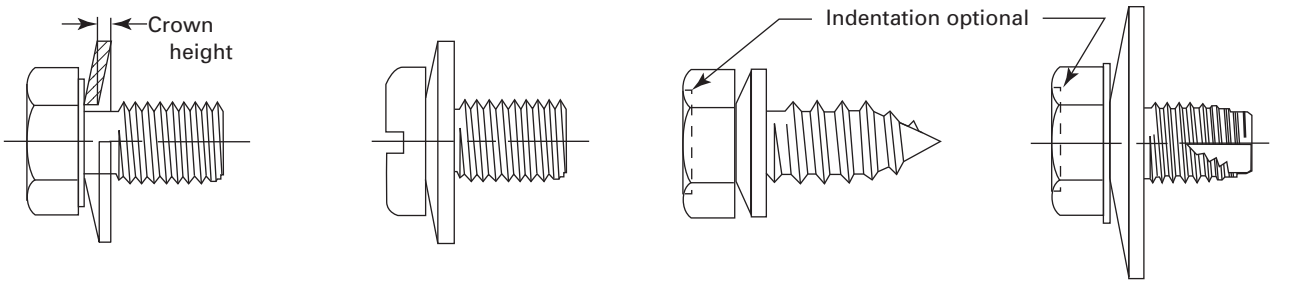
Flat Head Machine Screw | Oval Head Type B Tapping Screw | Pan Head Type AB Tapping Screw | Hex Head Type D Tapping Screw | Hex Flange Head Type T Tapping Screw | Hex Cap Screw

Representative Examples of External Tooth Lock Washer SEMS

Nominal Screw Size	Flat and Oval Head Screws			Pan Head and Hex Head Screws				Hex Flange Head Screws			
	Washer Thickness		Flush-to-Minus Tolerance, *V*	Washer Outside Diameter		Washer Thickness		Washer Outside Diameter		Washer Thickness	
	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
2.9	...	...	...	5.45	5.85	0.30	0.45	5.45	5.85	0.30	0.45
3.0	...	...	...	5.45	5.85	0.30	0.45	5.45	5.85	0.30	0.45
3.5	0.40	0.55	0.75	6.85	7.35	0.40	0.55	6.85	7.35	0.30	0.55
4.0	0.40	0.55	0.50	7.75	8.25	0.45	0.60	7.75	8.25	0.45	0.60
4.2	0.40	0.55	0.75	7.75	8.25	0.45	0.60	7.75	8.25	0.45	0.60
4.8	0.50	0.65	0.50	9.20	9.70	0.45	0.60	10.00	10.50	0.45	0.60
5.0	0.50	0.65	0.75	10.00	10.50	0.50	0.65	10.00	10.50	0.50	0.65
5.5	0.50	0.65	0.50	10.00	10.50	0.50	0.65	10.00	10.50	0.50	0.65
6.0	0.50	0.65	0.50	11.60	12.10	0.60	0.75	14.30	14.80	0.60	0.75
6.3	0.50	0.65	0.50	11.60	12.10	0.60	0.75	14.30	14.80	0.60	0.75
8.0	0.55	0.70	0.50	15.25	16.00	0.70	0.85	16.25	17.00	0.70	0.85
9.5	0.65	0.80	1.50	18.55	19.30	0.80	1.00	18.55	19.30	0.80	1.00
10	0.65	0.80	0.65	18.55	19.30	0.80	1.00	18.55	19.30	0.80	1.00

GENERAL NOTE: For additional requirements, refer to sections 2 and 4.

Table 5 Dimensions of Conical Spring Washers for SEMS



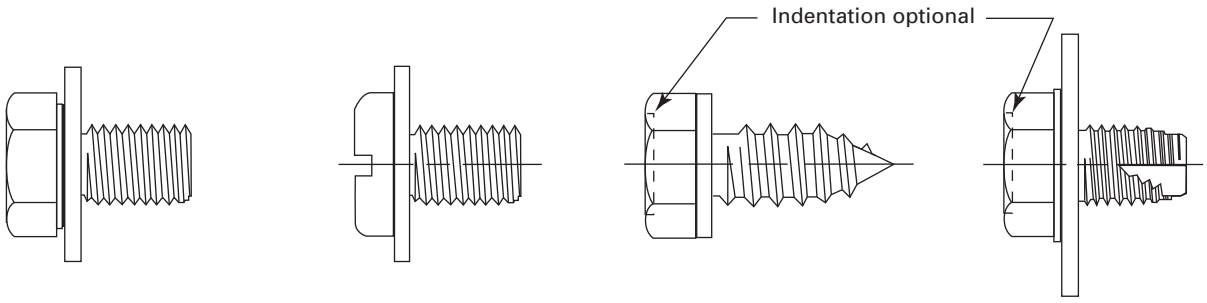
Hex Cap Screw and Type L Regular Washer | **Pan Head Machine Screw and Type H Regular Washer** | **Hex Head Type AB Tapping Screw and Type H Narrow Washer** | **Hex Flange Head Type T Tapping Screw and Type H Wide Washer**

Representative Examples of Conical Spring Washer SEMS

Nominal Size or Basic Screw Diameter	Pan, Hex, and Flange Head Screws										
				Type L Washer				Type H Washer			
	Washer Series	Washer Outside Diameter		Thickness		Crown Height		Thickness		Crown Height	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
3.5	Narrow	8.64	9.00	0.65	0.80	0.38	0.63	0.95	1.10	0.38	0.63
	Regular	9.64	10.00	0.70	0.85	0.38	0.63	0.95	1.10	0.38	0.63
	Wide	14.57	15.00	0.75	0.90	0.53	0.78	0.95	1.15	0.48	0.74
4.0	Narrow	9.64	10.00	0.95	1.15	0.38	0.63	1.05	1.25	0.38	0.63
	Regular	11.57	12.00	0.80	0.95	0.50	0.75	1.00	1.20	0.40	0.65
	Wide	15.57	16.00	0.80	0.95	0.70	0.95	1.00	1.20	0.78	1.04
4.2	Narrow	9.64	10.00	0.95	1.15	0.38	0.63	1.05	1.25	0.38	0.63
	Regular	11.57	12.00	0.80	0.95	0.50	0.75	1.00	1.20	0.40	0.65
	Wide	15.57	16.00	0.80	0.95	0.70	0.95	1.00	1.20	0.78	1.04
4.8	Narrow	10.57	11.00	0.85	1.05	0.38	0.63	1.30	1.50	0.38	0.63
	Regular	14.57	15.00	0.95	1.15	0.43	0.68	1.30	1.55	0.40	0.65
	Wide	19.48	20.00	1.00	1.20	0.67	0.92	1.30	1.50	0.63	0.88
5.0	Narrow	10.57	11.00	0.85	1.05	0.38	0.63	1.30	1.50	0.38	0.63
	Regular	14.57	15.00	0.95	1.15	0.43	0.68	1.30	1.55	0.40	0.65
	Wide	19.48	20.00	1.00	1.20	0.67	0.92	1.30	1.50	0.63	0.86
5.5	Narrow	10.57	11.00	0.95	1.15	0.38	0.63	1.35	1.60	0.38	0.63
	Regular	18.28	18.80	1.05	1.25	0.58	0.84	1.35	1.60	0.41	0.66
	Wide	21.48	22.00	1.05	1.25	0.84	1.10	1.50	1.80	0.58	0.84
6.0	Narrow	12.57	13.00	1.05	1.25	0.38	0.63	1.55	1.85	0.38	0.63
	Regular	18.28	18.80	1.30	1.50	0.56	0.82	1.90	2.25	0.54	0.79
	Wide	24.88	25.40	1.30	1.55	0.75	1.00	1.95	2.30	0.71	0.96
6.3	Narrow	12.57	13.00	1.05	1.25	0.38	0.63	1.55	1.85	0.38	0.63
	Regular	18.28	18.80	1.30	1.50	0.56	0.82	1.90	2.25	0.54	0.79
	Wide	24.88	25.40	1.30	1.55	0.75	1.00	1.95	2.30	0.71	0.96
8.0	Narrow	18.28	18.80	1.35	1.60	0.43	0.68	2.00	2.35	0.43	0.68
	Regular	24.88	25.40	1.55	1.85	0.80	1.05	2.40	2.75	0.48	0.75
	Wide	31.38	32.00	1.50	1.80	0.90	1.15	2.25	2.60	0.80	1.05
9.5	Narrow	19.48	20.00	1.70	2.00	0.40	0.65	2.25	2.60	0.38	0.63
	Regular	27.48	28.00	1.70	2.00	0.83	1.08	2.80	3.15	0.58	0.83
	Wide	38.38	39.00	1.80	2.15	1.01	1.26	2.75	3.10	0.93	1.18
10	Narrow	19.48	20.00	1.70	2.00	0.40	0.65	2.25	2.60	0.38	0.63
	Regular	27.48	28.00	1.70	2.00	0.83	1.08	2.80	3.15	0.58	0.83
	Wide	38.38	39.00	1.80	2.15	1.01	1.26	2.75	3.10	0.93	1.18
12	Narrow	24.88	25.40	1.95	2.30	0.48	0.73	3.20	3.55	0.42	0.68
	Regular	33.38	34.00	2.30	2.65	0.84	1.09	3.15	3.50	0.75	1.01
	Wide	43.38	44.00	2.30	2.65	1.30	1.55	3.30	3.65	1.04	1.30

GENERAL NOTE: For additional requirements, refer to sections 2 and 5.

Table 6 Dimensions of Plain Washers for SEMS



Hex Cap Screw and Regular Washer

Pan Head Machine Screw and Regular Washer

Hex Head Type AB Tapping Screw and Narrow Washer

Hex Flange Head Type T Tapping Screw and Wide Washer

Representative Examples of Plain Washer SEMS

Nominal Size or Basic Screw Diameter	Pan, Hex, and Hex Flange Head Screws					Nominal Size or Basic Screw Diameter	Pan, Hex, and Hex Flange Head Screws				
	Washer Series	Washer Outside Diameter		Washer Thickness			Washer Series	Washer Outside Diameter		Washer Thickness	
		Min.	Max.	Min.	Max.			Min.	Max.	Min.	Max.
2.2	Narrow	4.70	5.00	0.60	0.90	5.0	Narrow	10.57	11.00	1.00	1.40
	Regular	5.70	6.00	0.60	0.90		Regular	14.57	15.00	1.20	1.75
	Wide	7.64	8.00	0.60	0.90		Wide	19.48	20.00	1.60	2.30
2.5	Narrow	5.70	6.00	0.60	0.90	5.5	Narrow	10.57	11.00	1.00	1.40
	Regular	7.64	8.00	0.60	0.90		Regular	18.28	18.80	1.20	1.75
	Wide	9.64	10.00	0.80	1.20		Wide	21.48	22.00	1.60	2.30
2.9	Narrow	6.64	7.00	0.60	0.90	6.0	Narrow	12.57	13.00	1.20	1.75
	Regular	9.64	10.00	0.80	1.20		Regular	18.28	18.80	1.20	1.75
	Wide	11.57	12.00	1.00	1.40		Wide	24.88	25.40	1.60	2.30
3.0	Narrow	8.64	7.00	0.60	0.90	6.3	Narrow	12.57	13.00	1.20	1.75
	Regular	9.64	10.00	0.80	1.20		Regular	18.28	18.80	1.20	1.75
	Wide	11.57	12.00	1.00	1.40		Wide	24.88	25.40	1.60	2.30
3.5	Narrow	8.64	9.00	0.80	1.20	8.0	Narrow	18.28	18.80	1.60	2.30
	Regular	9.64	10.00	1.00	1.40		Regular	24.88	25.40	1.60	2.30
	Wide	14.57	15.00	1.20	1.75		Wide	31.38	32.00	2.00	2.80
4.0	Narrow	9.64	10.00	0.80	1.20	9.5	Narrow	19.48	20.00	1.60	2.30
	Regular	11.57	12.00	1.00	1.40		Regular	27.48	28.00	2.00	2.80
	Wide	15.57	16.00	1.60	2.30		Wide	38.38	39.00	2.50	3.50
4.2	Narrow	9.64	10.00	0.80	1.20	10	Narrow	19.48	20.00	1.60	2.30
	Regular	11.57	12.00	1.00	1.40		Regular	27.48	28.00	2.00	2.80
	Wide	15.57	16.00	1.60	2.30		Wide	38.38	39.00	2.50	3.50
4.8	Narrow	10.57	11.00	1.00	1.40	12	Narrow	24.88	25.40	2.00	2.80
	Regular	14.57	15.00	1.20	1.75		Regular	33.38	34.00	2.50	3.50
	Wide	19.48	20.00	1.60	2.30		Wide	43.38	44.00	2.50	3.50

GENERAL NOTE: For additional requirements, refer to sections 2 and 6.

Table 7 Through-Hardened and Tempered SEMS

Part A Method 1 Manufacturing — Screw Hardness and Draw Temperature

Screw								Washer					Mfg.
Product Identification Code	Property Class	Standard or Modified Hardness	Hardness		Material	Property Class Markings	Tempering Temperature of Screw, °C	Washer		Hardness		Material	Tempering Temperature of Assembly, °C
			HRC	HV				Name	Reference	HRC	HV		
1	8.8	Standard	22–32	248–318	Steel per ISO 898-1	As shown in ISO 898-1	Screw tempered with washer 425 minimum	Plain and flat	Table 6	None		Low carbon steel	425 minimum
2	9.8		28–37	286–363									
3	10.9		32–39	318–382									
4	8.8A		22–32	248–318		8.8A	Screw tempered with washer 340 minimum	Plain and flat	Table 6	30–40	302–392	High carbon steel	340 minimum
5	9.8A		28–37	286–363		9.8A				36–44	354–434		
6	10.9A		32–39	318–382		10.9A				39–47	382–471		
7	8.8A		22–32	248–318		8.8A		Conical spring	Table 5	30–40	302–392		
8	9.8A		28–37	286–363		9.8A				36–44	354–434		
9	10.9A		32–39	318–382		10.9A				39–47	382–471		

Table 7 Through-Hardened and Tempered SEMS (Cont'd)

Part B Method 1 Manufacturing — Modified Screw Hardness and Draw Temperature

Screw								Washer					Mfg.
Product Identification Code	Property Class	Standard or Modified Hardness	Hardness		Material	Property Class Markings	Tempering Temperature of Screw, °C	Washer		Hardness		Material	Tempering Temperature of Assembly, °C
			HRC	HV				Name	Reference	HRC	HV		
I	8.8A modified	Modified	24–36	260–354	Steel per ISO 898-1	8.8m	Screw tempered with washer 340 minimum	Conical spring	Table 5	36–44	354–434	High carbon steel	340 minimum
II	9.8A modified		28–39	286–382		9.8m				39–47	382–471		

Part C Method 2 Manufacturing — Standard Screw Hardness

A	8.8	Standard	22–32	248–318	Steel per ISO 898-1	8.8	425 minimum	Helical spring	Table 1 or 2	38–48	372–484	High carbon steel	Screw and washer heat treated separately
B	9.8		28–37	286–363									
C	10.9		32–39	318–382									
D	8.8		22–32	248–318		9.8		Tooth lock	Table 3 or 4	40–50	392–513		
E	9.8		28–37	286–363									
F	10.9		32–39	318–382									
G	8.8		22–32	248–318		10.9		Conical spring	Table 5	40–48	392–484		
H	9.8		28–37	286–363									
I	10.9		32–39	318–382									

The manufacturer shall not be held responsible for modifications, such as plating (done by the purchaser to unplated SEMS supplied in the original order), when these modifications are not made under his control, nor shall any certification be issued by the party making the modification unless it is accompanied by a written statement noting the original lot number, disclosing the modification, and warning that such modification may affect the dimensional and/or physical characteristics of the fastener.

1.9 Terminology

In addition to the term defined below, other terms used in this Standard are defined in ASME B18.12.

lock washer: appearing in the names of products in this Standard, a generic term historically associated with their function and not intended to imply an indefinite permanency of fixity in attachments where the fasteners are used.

1.10 Referenced Standards

This Standard does not duplicate those general and dimensional data pertaining to components of SEMS as found in the following. Unless otherwise specified, the standards referenced shall be the latest edition at the time of order.

ASME B1.13M, Metric Screw Threads — M Profile
ASME B18.2.3.1M, Metric Hex Cap Screws
ASME B18.3.1M, Socket Head Cap Screws (Metric Series)
ASME B18.6.5M, Metric Thread Forming and Thread Cutting Tapping Screws
ASME B18.6.7M, Metric Machine Screws
ASME B18.12, Glossary of Terms for Mechanical Fasteners
ASME B18.18, Quality Assurance for Fasteners
ASME B18.21.2M, Lock Washers (Metric Series)
ASME B18.22M, Metric Plain Washers
ASME B18.24, Part Identifying Number (PIN) Code System Standard for B18 Fastener Products

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 (www.asme.org)

ISO 898-1, Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread[1]
ISO 1478, Tapping screws thread[1]
ISO 2702, Heat-treated steel tapping screws — Mechanical properties[1]

Publisher: International Organization for Standardization (ISO), Central Secretariat, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Genève 20, Switzerland/Suisse (www.iso.org)

SAE J773, Conical Spring Washers

Publisher: Society of Automotive Engineers (SAE International), 400 Commonwealth Drive, Warrendale, PA 15096 (www.sae.org)

1.11 Designation

1.11.1 Description. SEMS products conforming to this Standard shall be designated by the following data in the sequence shown below. Points used shall be per the relevant requirements shown in the applicable standards in para. 1.10 (see also examples 1 through 4 in Table 8).

(a) product name (type of screw and type of washer)
(b) product standard
(c) nominal diameter size (as required by the applicable standard)
(d) thread pitch
(e) nominal length
(f) screw type
(g) point (any point in the applicable standard)
(h) head style and driving provision
(1) Table 1 with spring lock washers
(a) socket head/hex cap/pan head slotted/hex head/hex flange
(2) Table 2 with helical lock washers
(a) pan head/hex head/hex flange
(3) Table 3 with internal tooth washers
(a) hex cap/pan head/hex head (tapping)/hex flange (tapping)
(4) Table 4 with external tooth lock washers
(a) flat head (machine)/oval head (tapping)/pan head (tapping)/hex head (tapping)/hex flange (tapping)/hex cap (machine)
(5) Table 5 with conical spring washers
(a) hex cap/pan head/hex head/hex flange
(6) specify indented or nonindented hexagon heads
(7) specify head recess drive (slotted or other)
(i) property class and hardness
(1) through hardened and tempered
(a) Method 1 manufacturing method (see para. 1.12.1)
(1) ISO 898-1 with plain and flat low carbon washers [per Table 7 (Part A)]
– 8.8
– 9.8
– 10.9
(2) ISO 898-1 with modified tempering temperature, with plain and flat heat-treated washers [per Table 7 (Part A)]
– 8.8A
– 9.8A

[1] May also be obtained from American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036.

Table 8 Examples of SEMS Product Data

SEMS Product Data in Sequence	Example 1	Example 2	Example 3	Example 4
Product name and screw type	Hexagon head machine screw SEMS	Pan head tapping screw SEMS	Flat head machine screw SEMS	Flange head machine screw SEMS
Product standard	ASME B18.13.1M	ASME B18.13.1M	ASME B18.13.1M	ASME B18.13.1M
Nominal diameter	M10	6.3	M8	M6
Thread pitch	1.5	1.81	1.25	1
Nominal length	55 mm	25 mm	35 mm	40 mm
Point	Header point	AB	Plain end	Dog point
Head style and driving provision	Hexagon head (ASME B18.6.7M)	Pan head Type 1 C/R (ASME B18.6.5M)	Flat head Type 1A C/R (ASME B18.6.7M)	Flange head (ASME B18.6.7M)
Property class and hardness	8.8A [material and hardness, Table 7 (Part A)] — conical Type L narrow washer [material and hardness, Table 7 (Part A)]	ISO 2702 — flat regular washer	9.8 — external tooth lock washer	10.9 — helical spring lock washer
Protective finish	Phosphate and oil	Zinc plated (as applicable)	Plain finish	Zinc nickel (as applicable)

– 10.9A

(3) ISO 898-1 with modified tempering temperature, with conical spring washers [per Table 7 (Part A)]

– 8.8A

– 10.9A

(4) ISO 898-1 with modified screw hardness, modified tempering temperature, with conical spring washers [per Table 7 (Part A)]

– 8.8m

– 10.9m

(b) Method 2 manufacturing method (see para. 1.12.2)

(1) ISO 898-1 with helical spring washer [per Tables 1, 2, and 7 (Part C)]

– 8.8

– 9.8

– 10.9

(2) ISO 898-1 with tooth lock washer [per Tables 3, 4, and 7 (Part C)]

– 8.8

– 9.8

– 10.9

(3) ISO 898-1 with conical spring washer [per Table 5, Type L or Type H, and Table 7 (Part C)]

– 8.8

– 9.8

– 10.9

(2) case hardened and tempered

(a) ISO 2702 or other ASME/ISO Standard

(1) Specify Method 1 or Method 2 with manufacturer agreement.

(2) Washer

– helical spring lock washer (per Tables 1 and 2)

– tooth lock washer (per Tables 3 and 4)

– plain washer (per Table 6)

– conical spring washer (per Table 5, Type L or Type H)

(j) protective finish as required

1.11.2 PIN Code. When the PIN numbering system in ASME B18.24 is used to describe the SEMS, either Method 1 or Method 2 may be used at the manufacturer's discretion. When the specific method of manufacturing is required by the purchaser, the PIN system cannot be used.

1.12 Manufacturing

SEMS can be made of any screw type with any washer type; however, the method of manufacture is affected by the materials used for the screw and washer and the properties required in the finished part.

SEMS are made using two methods of production:

(a) washer assembly and thread rolling before heat treat

(b) washer assembly and thread rolling after heat treat

This Standard acknowledges these two methods of SEMS manufacture. The material choice in the first method requires skilled selection of the screw and washer materials, since the properties of each have to be realized by a single set of heat treat conditions. The selection of materials depends on the heat treat system involved, the size and shape of the washer and screw, and the austenitizing and quenching of the SEMS unit in oil. The second method is used when the desired properties of screw and washer cannot be made by the first method of heat treating the screw and washer at the same time.

1.12.1 Method 1 — Roll Thread Before Heat Treat. In this process, a nonheat-treated bolt or screw is assembled

with a nonheat-treated washer and then roll threaded as an assembly. Following threading, the assembly is heat treated simultaneously as a single unit. Since two different sets of properties must be achieved using a single heat treat process, the choice of material chemistries for both the screw and washer requires careful evaluation and selection.

1.12.2 Method 2 — Roll Thread After Heat Treat. In this process, a fully heat-treated bolt or screw blank is assembled with a fully heat-treated washer and then roll threaded to form an assembly. Following threading, no further heat treatment of the assembly is required. SEMS manufactured using Method 2 may not be reheat treated as a corrective action.

Unless determined and stated otherwise at the time of order agreement, Method 1 processing is used.

NOTES:

(1) Due to work hardening, screws thread rolled after heat treatment increase in core and surface hardness. This may cause the screws to have hardnesses greater than that allowed by the material specification after thread rolling. To keep the finished screws within hardness requirements, the hardness of the screws before thread rolling will have to be somewhat lower than the final product desired hardness. This can only be determined through experimentation.

(2) Method 1 is considered the default method and used where possible. However, if hardness requirements are unattainable with available materials using Method 1, Method 2 automatically applies. It should be noted also that Method 1 SEMS in Table 7 utilizes a minimum tempering temperature that is lower than that specified in ISO 898 for a non-SEMS screw of the shown property class due to the material choices that can be employed. In the event that the ISO 898 minimum temperatures must be required, then Method 2 production is automatically required.

The manufacturer of SEMS must consider several conditions related to the manufacturing processes used that may affect the final product. A discussion of some of these is covered in Nonmandatory Appendix D.

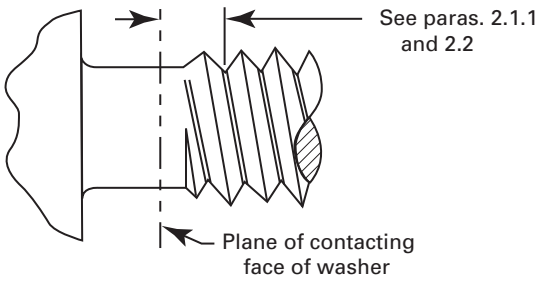
1.13 Lot

For all inspections referenced in this Standard, the SEMS lot shall consist of screws of one type, grade, washer style, finish, and size fabricated by the same productions process; made from the same heat number of metal provided by the metal manufacturer for the screw portion; and submitted for inspection and testing at the same time. The SEMS manufacturer shall keep records of the lot or lots of washers, and their associated material heats, assembled with a given lot of screws.

1.14 Quality Assurance

Products shall conform to the requirements of this and other standards as referred to in the applicable sections and be inspected in accordance with ASME B18.18, category 2.

Fig. 1 Unthreaded Length on Screws With Machine Screw Thread Diameter–Pitch Combinations



2 GENERAL DATA

2.1 Machine Screw SEMS

2.1.1 General. The machine screw component of SEMS shall conform to the specifications for machine screws published in ASME B18.6.7M, except for the following:

(a) The maximum diameter of the unthreaded shank shall be less than the major diameter of the thread by an amount sufficient to prevent disassembly of the washer from the screw.

(b) On screws threaded full length, the unthreaded length is the distance measured parallel to the axis of the screw from the underside of the washer to the face of a special nonchamfered or noncounterbored class 6g GO ring gage before plating or coating and a class 6h GO ring gage after plating or coating. The unthreaded length is a maximum of one thread pitch (see Fig. 1). A two-pitch allowance may be required on longer lengths. This shall be subject to agreement between the manufacturer and purchaser.

(c) The minimum underhead fillet radius shall be equivalent to 5% of the basic screw diameter on protruding head styles and 20% of the basic screw diameter for countersunk head styles.

(d) If so specified, the SEMS for greater strength shall be heat treated in accordance with para. 2.1.2.

2.1.2 Methods of Tests for Machine Screw SEMS

(a) The strength level applicable to these parts is shown in Table 7 as conveyed through the standard shown and the grade marking.

(b) Methods of Test. Tests for hardness and tensile strength shall conform to the tests specified in ISO 898-1, except the wedge tensile tests shall be conducted using a 6-deg wedge.

(c) Ductility Test. Whereas the wedge tensile test shall be considered the referee method, the following test for ductility of through-hardened screws may be used:

(1) The test for ductility of screw with protruding heads requires a test block with a hole approximately 5% larger in diameter than the basic diameter of the screw to be tested and having a top surface that is at

an angle of 70 deg to the axis of the hole. The hole shall be countersunk 100 deg to 120 deg including angle on the surface to a diameter 0.8 mm larger than the whole diameter. The screw and washer assembly shall be inserted into the hole, and the head shall be hammered or pressed down until the underhead surface bears on the angular surface of the block. Washers may be removed prior to testing. For referee testing, the washer shall be removed.

(2) Flat and oval countersunk head screws shall be held in a vise and shall be capable of taking a 20-deg bend when the head is hammered to one side.

(3) The screws so tested shall exhibit no sign of failure.

2.1.3 Identification. Unslotted hexagon and hexagon flange head SEMS shall be permanently and legibly marked on the top of the head for all sizes M5 or larger, with the manufacturer's identification, and heat-treated SEMS must also have the appropriate property class marking, which are shown in Table 7.

2.2 Tapping Screw for SEMS

The tapping screw component of SEMS shall conform to the specifications for the respective types of tapping screws published in ASME B18.6.5M, ISO 2702, and/or ISO 1478, except for the following:

(a) The maximum diameter of the unthreaded shank shall be less than the major diameter of the thread by an amount sufficient to prevent disassembly of the washer from the screw.

(b) On the screw threaded full length, the unthreaded length is the distance measured parallel to the axis of the screw from the underside of the washer to the point where the minor diameter is at the maximum dimension specified in ASME B18.6.5. The unthreaded length is a maximum of one pitch.

(c) The minimum underhead fillet radius shall be equivalent to 5% of the basic screw diameter on protruding head styles and 20% of the basic screw diameter on countersunk head styles.

(d) Tapping screw and washer materials must be able to be heat treated after thread rolling because case-hardened screws cannot be thread rolled after heat treatment.

(e) In cases where the washer thickness is equal to or smaller than the thread pitch, the manufacturer may use additional practices to ensure washer captivation. These practices may include the use of an annular ring to assist in captivating the washer. If these methods affect the final product dimensions or performance, they must be agreed upon with the purchaser.

2.3 SEMS Washers

The washer components of SEMS shall conform to the dimensions and specifications given for the various types in this Standard.

The compatibility of screw and washer materials shall be taken into account prior to manufacturing to determine the appropriate production method.

It should be noted that the washers for SEMS differ dimensionally from the equivalent over-the-thread washers.[2] With the exception of helical spring lock washers where the inside diameters are included for manufacturing purposes, the inside diameter of SEMS washer holes are not specified, provided the washer shall be assembled onto the screw blanks before the threads are rolled. The edge contour of the hole on the head side of the washer and the size relationship between the inside diameter and the diameter of the unthreaded shank on the screw shall be such that the washer will be retained on the screw after the threads are rolled, and shall be free to rotate after assembly.

2.3.1 Post-Heat Treatment Testing

2.3.1.1 Table 7 (Part C) SEMS

(a) Blanks shall be tested for hardness before rolling.

(b) Washers shall be tested for hardness before assembly.

2.3.1.2 Washer Testing — Table 7 (Parts A and B) SEMS

(a) Parts shall be tested full-size, unless indicated otherwise herein for referee testing.

(1) Routine Hardness. The washer shall have hardness as specified in Table 7 (Parts A and B). After heat treatment of the SEMS, the washers shall be removed, undamaged, from the fastener for testing.

In the event that the size of the washer is large enough that a testable area exists on its surface while still in place on the screw, then the hardness may be tested without removal of the washer.

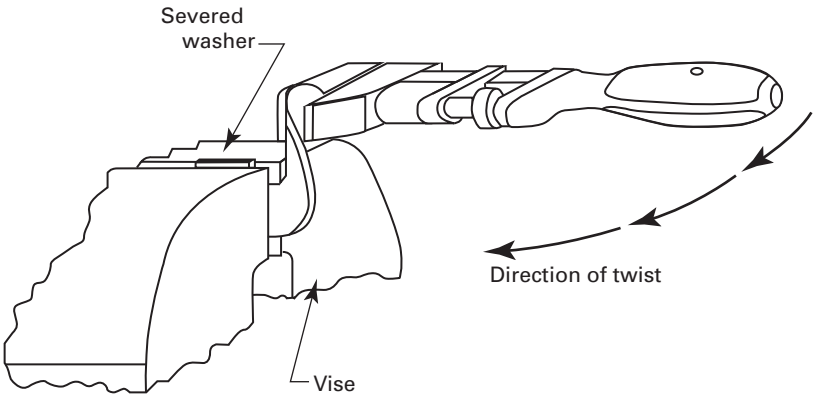
In the event of a referee test being required, the washer shall be removed. Hardness shall be checked by grinding or filing a flat spot on the top side of the washer to permit seating on an anvil with the reading to be taken on the undisturbed inner face of the washer. On conical washers, the hardness may be taken on the inner curvature of the washer.

(2) Referee Testing.[3] The washer shall have hardness as specified in Table 7 (Parts A and B). If the hardness

[2] These are washers that have an internal hole diameter that is larger than the major diameter of a screw, thus enabling the screw to be inserted through the washer prior to the screw thread performing its assembly function.

[3] Due to differences in exposure of the head-to-shank region to the threaded regions, to the quenching effect, certain factors must be satisfied. The hardness in the head-to-shank junction shall be sufficient to permit the specified wedge tensile strength to be attained. In the case of short screws or thread forms that do not enable them to be tensile tested, the torsional test shall prevail within the specifications provided by the screws' respective standard. Questions regarding microstructure in the head-to-shank junction within the washer area and wedge tensile shall prevail for acceptance.

Fig. 2 Conical Spring Washer Twist Test



as obtained routinely is not within specified limits, the washer is qualified by checking the hardness on a cut-out section of the washer on which both sides have been ground flat. However, an excessively decarburized surface, especially on lighter gage materials, shall be grounds for rejection if the performance of the washer is adversely affected.

(3) Metallurgical mounting may be required to address difficulties in testing small or difficult to handle samples. Such shall be used only when using light load Vickers or Knoop hardness testing methods.

2.3.1.3 Embrittlement Testing — Table 7 (Parts A Through C) Washers exposed to acid cleaning and/or electroplating processes shall be subjected to an embrittlement test (see para. 2.4).

2.3.2 Conical Washers — Table 7 (Parts A Through C)

2.3.2.1 Conical Washers

(a) Recovery Test. Regular and wide series washers shall be capable of retaining at least one-third of their original crown height after flattening between two hardened plates and then released. Narrow series washers shall be capable of retaining a minimum of 0.082 mm crown height.

(b) Twist Test. The rim of the washer shall be cut, and the ends shall be gripped by pliers, vise and pliers, or wrench, whichever is most suitable for the washer section under test. Separation of the severed ends in the form of a helix to a distance equal to the inside diameter of the washer shall not result in fracture (see Fig. 2). When, at a greater degree of twist, the washer fractures, the structure at the point of fracture shall exhibit a fine grain, and the washer up to the instant of fracture shall deliver a tough springy reaction.

2.4 Post-Heat Treatment Processing — Table 7 (Parts A Through C)

2.4.1 Finishes. Unless otherwise specified by the purchaser, SEMS shall be supplied with a plain (as-processed) finish, not plated or coated. Where corrosion preventative treatment is required, SEMS shall be plated or coated as specified by the purchaser unless otherwise agreed to at the time of initial order.

2.4.1.1 Post-Finishing Testing

(a) Coatings. The application of heavy coating deposits or supplemental treatments entailing organic compounds may result in a bonding of the SEMS components at points that abut. In such instances, the washers shall turn freely on the screw after breaking of the initial bond. See Nonmandatory Appendix D.

(b) Platings. Should the purchaser specify an electroplated finish on hardened product and either the specified hardness of screw or the washer is in excess of 38 HRC, then it shall be baked and an embrittlement test conducted. Sample sizes in ASME B18.18, category 2, will apply at inspection level C for the embrittlement test. The embrittlement test requires that a minimum of five samples from each lot be torqued to failure in hardened nuts or test plates having 6H threads. The average failure torque shall be determined. The samples to be tested shall then be torqued at 80% of the previously determined average failure torque with the head against a 90-deg surface. The fasteners shall then be retorqued to the original test value after 24 h and examined. No partial or complete fracture failure of either component is permitted.

3 HELICAL SPRING LOCK WASHER SEMS

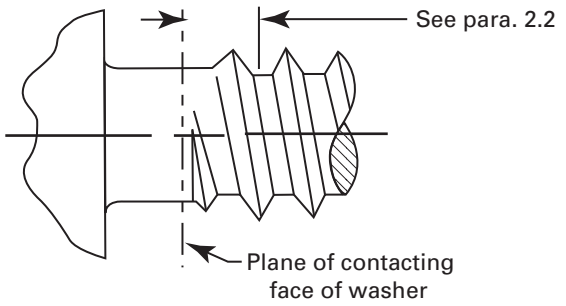
3.1 Specifications

The washer shall conform to the specifications shown in Table 7, except for modifications contained herein.

3.2 Washer Components

3.2.1 Dimensions. The dimensions of helical spring lock washers shall be specified in Tables 1 and 2. The corners at the outer and inner peripheries of the washer may be slightly rounded. However, the extent of the rounding shall be such that the bearing width of the

Fig. 3 Unthreaded Length on Tapping Screws With Spaced Thread Diameter–Pitch Combinations



washer section is not reduced to less than the equivalent of 70% of the specified minimum section width. See Fig. 3 for the check method.

3.2.2 Tests. The washers shall have hardness per Table 7 and shall meet all other test requirements for over-the-thread washers specified.

3.3 Screw Components

3.3.1 Tapping screws and machine screws having machine thread diameter–pitch combinations in the head styles indicated shall be assembled with washers shown in Table 1.

3.3.2 Tapping screws having Type B spaced thread diameter–pitch combinations in the head styles indicated shall be assembled with washers shown in Table 2.

4 TOOTH LOCK WASHER SEMS

4.1 Specifications

The washer shall conform to the specifications shown in Table 7, except for modifications contained herein.

4.2 Washer Components

4.2.1 Dimensions. The dimensions of internal tooth lock washers shall be as specified in Tables 4 and 5. Extrusion of a slight collar at the inside diameter of countersunk external tooth washers for use on flat or oval head screws shall be optional.

4.2.2 Tooth Design. Type A or Type B tooth design shall be optional. Refer to ASME B18.21.2M or a comparable ISO standard for details pertaining to tooth design.

4.2.3 Tests. The washers shall have hardness per Table 7 and shall meet all other tests for standard over-the-head washers specified.

4.3 Screw Components

Machine and tapping screws of the sizes and head styles shown in Tables 3 and 4 shall be assembled with the internal or external washers specified.

5 CONICAL WASHER SEMS

5.1 Specification

The washer shall conform to the specifications shown in Table 7, except for modifications contained herein.

5.2 Washer Components

5.2.1 Dimensions. The dimensions of Types L and H conical washer components of SEMS are given in Table 5.

5.2.2 Tests. The washers shall have hardness per Table 7 and shall meet all other tests for standard over-the-thread washers specified.

5.3 Screw Components

Machine and hex cap screws of the sizes and head styles indicated in this Standard shall be assembled with the conical washers shown in Table 5.

6 PLAIN WASHER SEMS

6.1 Specification

The washer shall conform to the specifications shown in Table 7, except for modifications contained herein.

6.2 Washer Components

6.2.1 Dimensions. The dimensions of plain washer components of SEMS are given in Table 6. The tolerances specified are intended to apply to metal washers but do not preclude the use of other materials. Washers shall conform to specifications for plain washers published in ASME B18.22M or a comparable ISO standard, except for the modifications contained herein.

(a) Concentricity. The inside and outside diameters of the washers shall be concentric within 0.013 mm for M5 and smaller sizes and within 0.25 mm for larger sizes.

(b) Flatness. The washers shall be flat within 0.13 mm for washers having outside diameters up to and including 22.6 mm and within 0.25 mm for washers having larger outside diameters.

6.2.2 Tests. The washers shall have hardness per Table 7 and shall meet all other tests for standard over-the-thread washers specified.

6.2.3 Material. Unless otherwise required by the purchaser, the carbon content of flat washers assembled on case-hardened screws shall not exceed 0.13% to avoid brittleness. See Nonmandatory Appendix B.

6.3 Screw Components

Machine screws, hex cap screws, and tapping screws of the sizes, point styles, and head styles identified in the applicable standards shall be assembled with washers specified in Table 6.

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NONMANDATORY APPENDIX A
REFERENCE INFORMATION FOR USERS OF THIS STANDARD

A-1 HELICAL SPRING LOCK WASHER SEMS

The helical spring lock washers covered herein are intended for general applications. Helical spring lock washers provide a hardened bearing surface.

A-2 TOOTH LOCK WASHER SEMS

The tooth lock washer SEMS covered herein is intended for general applications. When suitably plated, tooth lock washers assist electrical path continuity. Internal tooth lock washer SEMS are preferred where it is desirable to provide a smooth periphery.

A-3 CONICAL SPRING WASHER SEMS

The conical spring washer SEMS covered herein is intended for general application where it is desirable to

(a) compensate for loss of screw tension due to such factors as smoothing out or wearing of parts, thermal expansion, or compression set of gaskets

(b) distribute load over larger areas

(c) span large or elongated clearance holes

A-3.1 Conical Washer Types and Series

A-3.1.1 Types. Conical spring washers are available in a light series (Type L) and heavy series (Type H) for use with screws as described in the following:

(a) Type L conical spring washers are intended for use on machine screw SEMS with screw components of materials having a specified minimum ultimate tensile strength of 520 MPa or less. They shall also be used on tapping screw SEMS capable of safely accommodating these tensile requirements.

(b) Type H conical spring washers are intended for use on heat-treated SEMS with screw components of materials having a specified minimum ultimate tensile strength of 800 MPa or greater.

(c) Conical tooth washers having the same dimensions and characteristics as those defined above may also be used on SEMS for nonslip or positive electrical grounding purposes. Unless designated otherwise by the purchaser, when spur tooth conical washers are specified, they shall be furnished with six sharp-edged teeth equally spaced about the outer periphery on the bottom face of the washer conforming with the dimensions shown in Fig. A-1.

A-3.1.2 Series. Both the Types L and H conical spring washers for each screw size are specified in narrow, regular, and wide series having proportions designed to fulfill the purpose of distributing load over larger areas. Where used in conjunction with large clearance holes, it is recommended that the hole relationship be such as to permit washers to be in contact over at least 70% of their bearing area.

A-3.1.3 Assembly Considerations

(a) Assembly. The washers shall be assembled with the convex side adjacent to the screw head.

(b) Installation. The desired installed position shall be with the washer compressed to completely flat.

(c) Load Conditions. Since it is intended that the washers in the Standard be loaded beyond the elastic limit of their material, they should not be used in applications involving dynamic loading of the washer.

A-4 PLAIN WASHER SEMS

The plain washer SEMS covered herein are intended for general application where it is desirable to

(a) increase the area of bearing under the head of the screw when used against soft materials, such as aluminum, plastic, wood, etc.

(b) span large or elongated clearance holes

(c) provide uniform bearing surfaces on rough workpiece surfaces

A-4.1 Plain Washer Series and Material

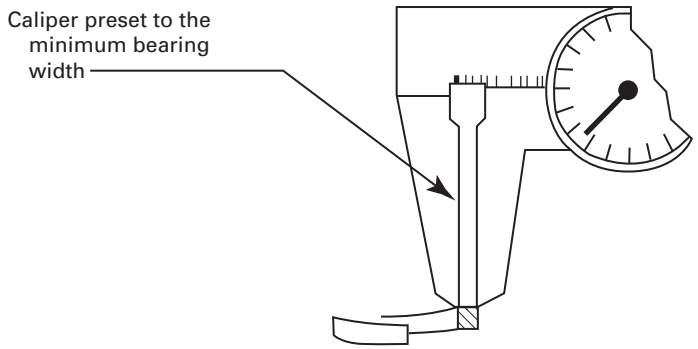
A-4.1.1 Series. The plain washers for each screw size are specified in narrow, regular, and wide series having proportions designed to fulfill the purpose of distributing load over larger areas.

A-4.1.2 Materials Plain washers for SEMS may be steel, soft or hardened; nonferrous metals; or other suitable materials as specified by the purchaser.

(a) Soft steel washers, where no hardness requirement is specified, shall normally be made from low carbon steel. See Nonmandatory Appendix B.

(b) Hardened steel washers, where specified by the purchaser, shall be quenched and tempered to a hardness shown in Table 7 or an equivalent hardness.

Fig. A-1 Verification of Bearing Width on Helical Spring Lock Washers



NONMANDATORY APPENDIX B
PLAIN WASHERS ON TAPPING SCREWS

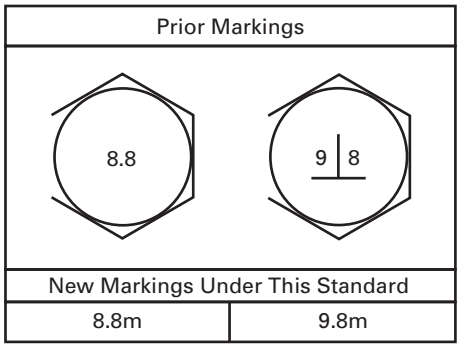
If the purchaser requires a carbon content of flat washers assembled on tapping screws that exceeds 0.13%, the washers should be copper plated at least 0.075 mm to prevent the potential of washer embrittlement. This may necessitate stripping the copper after case hardening prior to the surface finishing of the completed assembly. Acid stripping of copper is a significant environmental concern and should be avoided where possible.

NONMANDATORY APPENDIX C
THE RELATIONSHIP OF THIS REVISION TO PREVIOUS REVISIONS OF THIS STANDARD AND TO ISO STANDARDS

The previous edition of this Standard made various references to North American metric standards regarding dimensional, material, and mechanical properties. In a move to bring the document up to date, this Standard makes references to both American standards and ISO equivalents for dimensional requirements, for material and mechanical requirements in addition to new detail arriving through the natural process of standards management and committee work. In acknowledging increased scope of this Standard under ISO 898-1, 8.8 SEMS made by rolling before heat treatment of low carbon steel has been added.

Under the previous edition of this Standard, 9.8 and 10.9 were made with the low carbon option for the screw under SAE J1199. That practice is continued here but under ISO 898-1 and with a modified minimum carbon. In this Standard, minor departures to ISO are present, as an accommodation to preferences in industry to specific washer hardnesses. Where minor departures are involved, they are shown either in the text or in this Nonmandatory Appendix. With regard to head markings, the presence of the lowercase letter "m" next to the property class on the 8.8 and 9.8 head shown in Fig. C-1 denotes a modification for hardness. The "m" next to the 9.8 and 10.9 is also used to denote equivalency to the markings in the previous edition of this Standard. The "m" also denotes the modified carbon. Users are cautioned to review both this Standard and the previous edition to ensure continued equivalency for their applications. For small screws where space is limited for the presence of markings, the presence of a dot, "·", to the far right of the 8.8 will serve as an indication of the manufacture of that part under this Standard.

Fig. C-1 Relationship With Prior Head Markings



Attention is drawn to ISO 10644, which covers SEMS with plain washers of two different hardness classes (200Hv and 300Hv). It should be noted that, although there is some coverage between this Standard and ISO 10644, ISO 10644 does not recognize all the head styles that are used in SEMS industry and includes unique head design features that have not been commonly specified in North America.

NONMANDATORY APPENDIX D
MANUFACTURING

D-1 INTRODUCTION

In the course of SEMS manufacture, various, normally expected effects of manufacturing need to be considered.

D-2 BURRS

To ensure safe handling by operators and permit smooth washer flow in manufacturing feeder systems, washers are required to be free of burrs and sharp edges as much as possible. Such burrs and sharp edges remaining from stamping must be minimized by a suitable treatment. If not specified at the time of original order, such treatment processes are at the option of the washer manufacturer.

Even with the lightest handling treatment, the potential exists that the dimensional size of certain washer features may be affected by cleaning and deburring operations.

The permissible effects of deburring and handling should be agreed to between the SEMS producer and purchaser. For instance, in the case of teeth on toothed washers, no more than a specified number of teeth per washer are reduced in tooth height by more than a specified amount below the minimum tooth height requirement.

An example would be to state that no more than two teeth per washer can be reduced more than 0.05 mm below the minimum required tooth height.

D-3 HEAVY COATINGS THAT REQUIRE CURING PROCESSES

During coating treatments commonly used in industry (particularly dip-spin organic coatings), a bond between the contacting surfaces of washer and head is likely. Unless otherwise agreed to between the supplier and purchaser, the adhesion torque value is acceptable, provided the head breaks loose from the washer at a value equal to or less than 3% the torque value required to fail the screw when tested as described in the embrittlement test in para. 2.4.

D-4 THREAD-TO-HEAD DISTANCES

When the purchaser requires a thread-to-head distance less than two thread pitches, thread rolling dies with sharp top edges are necessary. This leads to premature die chipping and/or potential scraping of washer features on the underside of the washer. When washer scraping is objectionable to the purchaser, agreements shall be made between the manufacturer and purchaser to define acceptance criteria for such occurrences. Where such scraping is unacceptable, washers with an inside diameter greater than the screw thread may be assembled onto the threaded screws to provide a possible solution. A suitable means of retention to prevent washer loss will be necessary. This method of manufacturing SEMS cannot be designated using the PIN system in ASME B18.24.

NONMANDATORY APPENDIX E
STATISTICAL EXPRESSION OF HARDNESS

Computations of C_{pk}[1] are not recommended for Method 1 product hardnesses due to the normal variation between heats of steel (washers or screw materials) and the concurrent results of heat treating screws and washers simultaneously. In producing SEMS from components made to other standards, caution shall be exercised on any screw or washer where the hardness cannot be targeted to the mean of the hardness range and/or if the core hardness range is less than 6 HRC.

[1] C_{pk} is an index used to assess the statistical capability of a particular measured part or process feature in meeting the applicable specification tolerances established for it.

NONMANDATORY APPENDIX F
RECOVERY TEST

Crown height requirements, following recovery test, apply to washers with a specified minimum hardness of 40 HRC or greater. Agreement of crown heights, following recovery test, between supplier and purchaser would be required for washers with specified hardnesses lower than 40 HRC. Any lowering of washer hardness from that hardness, where desired recovery is already established, would cause this recovery ability to be voided and require reestablishment of recovery performance at the new hardness.

NONMANDATORY APPENDIX G
HOW SEMS FUNCTION

G-1 INTRODUCTION

The use of the SEMS design enables users to have an integral washer available to them at the moment they use the part. Various washer types bring to the application the ability to augment the screw and the job it performs, such as the following:

(a) Plain washers exert clamp loads over a wide area.

(b) Conical washers exert force up under the head of a fastener, as it attempts to maintain its original pretightened shape after being compressed during tightening.

(c) Toothed washers prevent the washer from turning during application of torque or to prevent the screw head from loosening after seating.

G-2 DESIGN OF SEMS

The design of SEMS generally incorporates the following:

(a) A means of retaining the washer from becoming separated from the screw. (The method chosen must consider whether the washer is kept in very close proximity to the fastener bearing surface.)

(b) A washer that has a hole diameter that is large enough to permit it to be assembled onto the screw blank at production thread rolling speeds and small enough to be retained by the retaining feature.

(c) The screw and washer must be combined so that the screw freely rotates during installation and seats against the captivated, stationary washer.

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