ASTM Material Standards under the jurisdiction of Committee A01 on Steel, Stainless Steel and Related Alloys and the European Union Pressure Equipment Directive

Executive Summary

The European Union Pressure Equipment Directive (EU PED) has been discussed in relation to ASTM A01 material standards for steel by an ad hoc task group for the past several meetings of ASTM Committee A01. The discussions have lead to the following understanding of the situation as to technical and non-technical issues.

Technical issues include broader chemical limitations of ASTM standards; design criteria differences between the European Union Pressure Equipment Directive (EU PED) and the ASME Boiler Code (Boiler Code); mechanical property requirements differences; alloying systems used in the United States and Europe; different size limitations to standards; and differences in American and European design methods.

Non-technical issues include the requirement of using European Union (EU) based auditors known as Notified Bodies; no ability to have any material standard or standards other than those promulgated in Europe accepted under the EU PED; a method exists to approve as each individual case specific material but not the ASTM standard under which it was produced; and the fact that the EU PED is actually an international law promulgated by a government as opposed to the consensus ASTM material standards and the ASME Boiler Code (allowing that the Boiler Code has been adopted by many local governments).

ASTM material standards for steel need to be modified to bring them up to date and more reflective of the state of the art in steel manufacturing and processing and more consistent with the products actually in the marketplace under such ASTM material standards. Other modifications to make those standards more comparable to the EN material standards should also be considered because such modifications may be useful in the market.

However, no matter what ASTM does with the material standards involved in this discussion, as there is no method to secure acceptance or approval of such standards under the EU PED, any improvements will not secure adoption of ASTM standards by the PED.

We are discussing a situation involving a government and ASTM, and that does leave us at a disadvantage. Involvement by the United States government is undoubtedly necessary to achieve some understanding leading to acceptance of ASTM material standards under the EU PED.

Conclusions of the Task Group

ASTM material standards do not always represent the state of technology within the steel industry and the marketplace. Often, our ASTM A01 standards have not been updated with more restrictive limits on chemical elements or mechanical properties. Many companies within the USA have purchasing standards usually more restrictive, with respect to properties and composition, than ASTM material standards. This shows that the market recognizes that the current standards do not meet the requirements of some users. Further, some common mechanical properties and other requirements are contained in supplementary requirements rather than within the normal requirements of the standard. Material standards should represent the state of the art but not necessarily the leading edge of manufacturing technology. Without question, many of our material standards need to be updated to meet what is in the market and not kept so broad as to cover for the errors made in manufacturing operations. Failures caused by poorly controlled manufacturing processes are a cost of doing business and those who can not control their processed sufficiently should not dictate broad acceptance criteria to the rest of the industry. Without question, we do need to examine our material standards and improve the world view of the quality of our standards.

At the same time, regarding the EU PED, there is no existing method to have material produced to any standard other than one from the EU accepted under the EU PED. It doesn't matter how good they might be, the ASTM standards are not accepted so it does not matter. There must be governmental involvement in the situation and without it, there will never be an ASTM material standard accepted under the EU PED.

Yes, we can clean up our act and we should do that. However, without a lot of outside help, tightening of ASTM material standards is an exercise which, while important to the world view of ASTM standards as technically pertinent and up to date, will have no impact on the acceptance of ASTM material standards by the EU PED.

Background

Approximately six years ago, Mr. James Thomas, ASTM President, brought to the attention of Committee A01 problems with the acceptance of the ASTM Material Standards for Steel by users of the European Union Pressure Equipment Directive (EU PED). Committee A01 was asked to investigate the situation and determine steps to be taken to alleviate the concern. An ad hoc group has been meeting semi-annually since May 2007 and this report is to summarize the results of these meetings and to recommend further activities.

Problems between ASTM A01 Material Standards and the EU PED

As background information, it is useful to understand the relationship between ASTM and ASME material standards. There are several concerns between the ASTM material standards and the resulting American Society of Mechanical Engineers (ASME) Boiler Code which in general adopts the ASTM material standards as written. For steel, ASTM material standards are

of the 'A' designation while ASME Ferrous Material Standards use the 'SA' designation. In both cases, the ASTM number is the number used. Not all ASTM A01 material standards have been accepted by the Boiler Code, but many have been.

ASTM material standards do not deal with design issues which are under the jurisdiction of the Boiler Code but only with the materials to be supplied to meet certain design criteria set forth by the Boiler Code and the engineers who design the equipment covered under the Boiler Code. Issues between ASTM material standards and EU PED material standards consist of both technical and non-technical issues.

On the technical side, the issues appear to be mainly

- 1. Chemistry differences between ASTM and EN Material Standards;
- 2. Mechanical property differences at elevated temperatures which are specified in the EN material standards but not the ASTM material standards;
- 3. Charpy impact tests are specified in the EN material standards but not in the ASTM material standards except as supplementary requirements;
- 4. Different alloying systems are reported to be in use in the European Union as compared to the North American steel industry which uses the ASTM material standards;
- 5. ASTM material standards often cover a much wider range of material thickness than the European material standards;
- 6. ASME Boiler Code design practices and criteria are different than the EU PED methods and this means different properties are specified by the two different material standard systems.

On the non-technical side, the issues appear to be mainly:

- 1. Certification of materials or production methods for the EU PED materials must be performed by an organization with European presence (Notified Bodies);
- 2. There is no method within the EU PED to allow for the approval of material standards other than EN material standards as a complete set of material standards;
- 3. Individual materials may be approved by a Notified Body for a particular application by the method known as the Particular Material Appraisal, but this is by single application and not an overall approval of the standard under which the material was produced;
- 4. The EU PED is created and administered as a governmental statute, as compared to the ASTM and ASME standards which are consensus standards which may be accepted by individual political entities as law, but there is no overall body within the United States which dictates that the Boiler Code is the law of the land.

Discussion of Technical Issues

Chemistry Issues

In general, the chemical differences between ASTM Standards and EN Product Standards for PED applications rest with tabled limits on phosphorus and sulfur. ASTM Standards are considerably more lax than the EN Standards for these two elements although there is general agreement within the ASTM community of producers that the ASTM limits are not typically representative of the products in the marketplace. There is agreement that the vast majority of the materials in USA commercial production and use easily fit the EN limits.

Most of the opposition to tightening the ASTM limits on such material rests with manufacturing concerns. What happens if the tighter limits are not met? Further, the American concept is to supply material of appropriate properties and chemistry to perform properly in the application. The EN concept is that meeting the material standard satisfies the contract for the material. The bottom line is that the ASTM material standards do not represent what is typically in the USA marketplace for pressure vessel plates while the EN standards would be considered more representative of acceptable limits while still being broader than typical products for this pressure vessel use.

The effect of phosphorous and sulfur on certain mechanical properties, particularly impact properties, is well known. Lower levels of these elements help to improve impact properties which are included in the EN material standards but are typically supplemental in ASTM material standards for these pressure vessel materials.

There is an opportunity for ASTM material standards to tighten their chemical composition limits to more appropriately represent the material in the USA marketplace supplied under those standards.

It should be recognized that the EN standards may have different limits on certain elements than the ASTM standards and some EN standards may allow for the use of microalloys (Nobium (Columbium), Vanadium, or Titanium, for example) while the ASTM standards are carbon steels without such additions. These differences can lead to greater differences in mechanical properties and responses to temperature than might be expected based on examination of the standards.

It is important to take into account the changes in chemistry with material thickness and how this affects weldability. Many ASTM material standards carry supplementary requirements for Carbon Equivalent (CE) which relates the effect of Carbon, Manganese, and other elements, in combination and is often applied to welding criteria such as preheat, postheat, and other practices. EN standards may contain these requirements within the standard.

Mechanical Properties at Elevated Temperatures

This difference between the EN and ASME systems, and the effect on ASTM material standards

for pressure vessel applications is extremely significant. The EN design criteria are different to those of ASME and the resulting strength requirements are different. EN design, and subsequently material standards, is based on minimum strength levels at various elevated temperatures. The ASME design criteria makes use of nominal strength levels with consideration for a safety factor in design criteria. The ASME strength levels and temperature charts are contained in the Boiler Code. The EN higher temperature (above room temperature) requirements for strength are contained in the material standards. It should be noted that, in general, the buyer must specify the need for the higher temperature requirements at the time of ordering. Further, it appears that testing at the higher temperatures in not required but that the producer must guarantee the stated results within the material standard.

While there is general agreement that steel chemistry and processing are the determinants of strength response to elevated temperatures, and whether the steel is produced in the United States to an ASTM material standard or in Europe to an EN material standard is immaterial to such response. The difficulty arises in that the ASME values are nominals and the EN values are minimums and we have not conducted any testing programs to adequately define the temperature-strength curves to fully guarantee the products.

While it is assumes that similar materials will respond similarly, there is concern that due to certain chemical composition differences between ASTM and EN material standards, we may not be always comparing 'apples and apples' but may be comparing 'apples and oranges' and that simply inserting the EN higher temperature strength tables may be technically inappropriate. At the same time, it is recognized that the development of the temperature-strength tables would be extremely time consuming and expensive.

Impact Properties

ASTM material standards for pressure vessel applications typically specify impact properties, usually Charpy V-Notch, as supplementary requirements. While not uncommon, this method of specification development means additional steps in the ordering process. Often, the exact level of the requirements is left to the buyer and seller as part of the ordering negotiation process. EN material standards, on the other hand, contain impact requirements at various temperatures within the standard. In general, the buyer must specify the impact requirement at the time of order but the values are contained in the material standard.

The interaction of impact requirements and phosphorous and sulfur levels cannot be understated. Lower levels of such non-metallic materials generally lead to improved impact results, all else being equal. The impact requirements seen in the EN material standards are not considered unreasonable for the chemistry specified and material with the lower levels of phosphorous and sulfur generally in the marketplace in the United States should meet the impact requirements. However, there is general agreement that material with the higher levels of phosphorous and sulfur allowed by the existing ASTM material standards would not meet the impact requirements of the EN standards and likewise would not meet the typically required supplemental impact requirements of ASTM material standards for this product.

It also has to be understood that other chemical elements can affect the impact properties of the

material. Carbon steels and micro-alloy steels cannot be compared as there can be significant differences in response to temperature of these two types of steel. So, we again come back to the manufacturing philosophies of the USA and Europe because some material we produce as carbon steel can be produced as micro-alloy steel in Europe and this can lead to an improper comparison of these two materials.

Thickness Differences

It is well recognized that thickness of the plate product is significant in the choice of chemistry and alloying system, as well as processing system, to meet for example specific strength, impact, and temperature response requirements. Many ASTM material standards cover greater thickness ranges than some EN material standards and thus allow for higher levels of Carbon and perhaps Manganese to provide the needed strength in the thicker plates. As the strength is a function of chemistry and processing, especially rolling and coiling practices, the thicker plates cool more slowly and thus can require more alloying elements to achieve a given strength level. EN standards often contain different strength levels for different thickness ranges or different chemical requirements for different thickness ranges as compared to a 'one size fits all' model within the ASTM material standards chemical limits with restrictions in chemistry levels generally controlled by the producer.

It must also be recognized that as the alloy content increases, particularly the carbon, concerns about welding practices emerge and the Carbon Equivalent concept previously noted becomes an issue.

The wider range of thickness and chemistry allowed by ASTM standards can, in the eye of someone not familiar with those standards, cause concern about strength and welding response as compared to EN material standards. Again, a philosophical difference between meeting the customer needs and meeting a specification is seen.

ASME Boiler Code vs. EU PED Design

While clearly a technical issue and we have discussed some of the concerns previously, this is not an ASTM concern. The ASME Boiler Code adopts ASTM material standards, often as written but sometimes with modifications, for materials which meet the needs of the ASME community and process. Current ASTM material standards meet the design needs and criteria of the ASME Boiler Code and many ASTM members are active within both organizations. However, the ASTM standards being discussed are material standards and not design standards so we leave this discussion to ASME.

General Comments on Technical Issues

Under the direction of this working group, a few representative ASTM material standards have been examined for possible modification to meet the EN requirements. Examples of such modifications are attached for ASTM A516A516M, A105/A105M, A106/A106M, and A414/A414M.

We have a fairly complete consensus that reduction in phosphorous and sulfur is an important consideration and that ASTM material standards should represent the product currently in the marketplace and not that which was produced many years ago with very different production and processing methods. It should be both our short and long term goals to bring our material standards up to date and make them more reflective of today's material actually being bought and sold. It must be understood that the chemistry used in any product is a function of customer needs and producer capabilities. Higher limits on any given alloying element may be beneficial to all in certain applications and perhaps we need to recognize that in our material standards and move away from the 'one size fits all' with modifications or restrictions within the standard to meet the more critical requirements for a certain applications. Perhaps we need multiple material standards for multiple typical end uses and develop such standards with appropriate limits of chemistry, mechanical properties, thickness, etc.

What makes many of the technical issues complex is that it appears the Americans and Europeans took different approaches to design and material production over the years and those differences have become imbedded in the EN material standards and the EN Pressure Equipment Directive.

Discussion of Non-Technical Issues

Certification of Products and Facilities

The EU PED requires the products and facilities be examined and certified by an approved Notified Body. The EU PED also requires that such Notified Bodies have a presence in the EU. Organizations with only a North American or even Japanese presence are not considered acceptable to certify products and facilities. As many premier Notified Bodies have offices in both EU countries and the United States, other than the added cost of additional inspection, auditing, and certification of such efforts, there are not major problems. It is inconvenient for a producer to arrange for multiple certification and qualification contractors, but could be considered a cost of doing business. US certifying bodies such as the US DOT and ASME permit inspection bodies from other countries to be qualified, via education followed by an audit or examination, to inspect and certify DOT and ASME, as examples, items in their own country. Only an EU Notified Body is acceptable for PED certification.

Approval of Material Standards Other than EN

Only the EN Material Standards are approved for application to EU PED end uses. There are no provisions in the EU PED, based on our examination and comments from Notified Bodies within the EU, to approve either individual material standards or entire groups of such standards such as ASTM or the resulting ASME material standards.

Thus, while it would be possible to modify ASTM material standards to meet or exceed the requirements of similar EN material standards, there is no mechanism to have such standards accepted under the EU PED. We can do whatever we want to modify ASTM standards but there

is currently no method to allow acceptance of our standards by the European Community for pressure equipment. Within the United States, we have procedures to accept EN material standards but there is nothing of a reciprocal nature as far we have been able to determine.

Approval of Individual Materials

While there is no mechanism to approve material standards other than EN, individual materials may be approved for use under a method known as Particular Material Appraisal (PMA). Under the exception for a specific material by the PMA method, an appropriate Notified Body with EU presence approves the material through appropriate testing and facilities certification and auditing to meet the EN material requirements.

One American company takes material purchased under ASTM or DOT material standards and has it retested at a laboratory certified by their Notified Body, and then recertifies the material for EU use. This is an on going process and not a one shot situation. It goes back to the inability to have material produced to other than an EN material standard approved because there is no procedure to allow the approval of other than the EN material standards.

Governmental vs. Non-governmental Standards

The EU PED is a legislative action by the European Parliament. The EU PED is thus a legal document promulgated by a government. We do not have a similar legal situation within the United States. ASTM material standards are consensus documents which may or may not be adopted by any regulatory entity. Likewise, the ASME Boiler Code is not a legal document unless adapted by some political entity. Interestingly, it is reported that one of the frustrations Europeans have with our system is that the Boiler Code is not a National Law and therefore one set of standards. Legal activities appear outside of the scope of the ASTM standards' development process.

Additionally, it seems that negotiations between a non-governmental organization, ASTM and ASME, and a government, the EU Parliament, are not being played on an even playing field. Negotiations involving governments would seem best between governments!

General Comments on Non-technical Issues

We are confronted with a governmental administered program in the EU PED with no method provided to allow acceptance of any non-European material standard. We can make any modifications to ASTM material standards we want, including making them mirror the various EN material standards, and there is still no way to have them accepted within the existing EU PED system. As making the ASTM material standards mirror EN material standards might not adequately service the usual users of our standards in North America and elsewhere, that approach seems not worthwhile.

It is the opinion of many members of the task group on this subject that we have a legal situation which should be handled between governments hidden by the EU as a technical issue. Steel is

steel and it does not matter where it is manufactured. Material with similar chemistry and process will react similarly anywhere in the world. ASTM material standards can be contrived to match EN material standards and they would still not be acceptable to the EU. This is not a technical issue!

Note: This report was reviewed and approved unanimously by the Executive Subcommittee, A01.90, of Committee A01 on Steel, Stainless Steel, and Related Alloys, at the meeting of September 28, 2009, in Nashville, TN. 10/19/2009

			.≝∴Modified :::
Carbon	Max	0.35	5020
Manganese		0.60 - 1.05	150.90-150
Phosphorus	Max	0.035	0.025
Sulfur	Max	0.040	010115
Silicon		0.10 - 0.35	≶ 0.40
Chrome	Max	0.30	≤ 0.30
Copper	Max	0.40	≤ 0.30
Molybdenum	Max	0.12	≤ 0.08
Nickel	Max	0.40	≤0.30
Vanadium	Max	0.08	≤ 0.02
Niobium	Max	NS	≤ 0.01

Chemistry taken from EN 10222 Pt 2 - P280GH

TABLE 1 CHEMICAL REQUIREMENTS

Element	Composition, %
Carbon	0.35 max.
Manganese	0.60-1.05
Phosphorus	0.035 max
Sulfur	0.040 max.
Silicon	0.10-0.35
Copper	0.40 max, [Note (1)]
Nickel	0.40 max. [Note [1]]
Chromium	0.30 max. [Notes (1), {2}]
Molybdenum	0.12 max. [Notes (1), (2)]
Vanadium	0.08 max.

GENERAL NOTE: For each reduction of 0.01% below the specified carbon maximum (0.35%), an increase of 0.06% manganese above the specified maximum (1.05%) will be permitted up to a maximum of 1.35%.

NOTES:

TABLE 2 MECHANICAL REQUIREMENTS (NOTE (1))

Tensile strength, min., psi IMPaJ	70 000 [485]
Yield strength, min., psi [IAPa] ENote (2)]	36 000 C250J
Elongation in 2 in. or 50 mm, min., %:	
Basic minimum elongation for walls 1/16 in.	30
[7.9 mm] and over in thickness, strip tests.	
When standard round 2 in. or 50 mm gage	\$2
length or smaller proportionally sized	
specimen with the gage length equal to 4D	
Is used	
For strip tests, a deduction for each 1/32 in.	1.50 [Note (3)]
[0.8 mm] decrease in wall thickness below	
1/46 In. 17.9 mmI from the basic minimum	
elongation of the percentage points of	
Table 3	
Reduction of area, min., % [Note (4)]	30
Hardness, HB, max	167

NOTES:

ATTACHMENT 4
Page 1 of 3

(1) The sum of copper, nickel, chromium, molybdenum and vanadium (1) For small forgings, see 7.3.4.

Smal desig	medon			Chrenis	al competiti	on (cast ana	lysis) % ¹⁾				Mechanic	g Good action	om temp	श्यांसक				
Name	Number	С	Si muc.	Ми	P max	5 mex	Cr	Мо	Others	fe to the rule-g the rule-g	Fig. 30	Tensile strength R _a	first first	i a) Spec Spec Spec Spec Spec Spec Spec Spec	im	otch pact	gåmper gåmper	Pamperent C
										rer	Karra ²	Mmm²	1	in % tr.t	î	≦≘J £e.t		
P245GH	1.0352	0,08 16 0,20	0.40	0,50 to 1,30	0,025	9,015	-	-	-	n₂ ≤35 35<2₂≤160	245 220	410 m 530 410 m 530	25 25	23 23	32 ⁷⁾	27 ⁷ ? 27 ⁷ ?	A N Mor OT	890 to 930 890 to 930 890 to 930
P280GH	1.042/5	0,08 to 0,20	0,40	0,90 .tc 1,30	0,025	0.015	-	-	-	12 ≤ 35 35 < 4 ≤ 169	250 255	460 to 580 460 to 580	23 23	21 21	48 ⁰	27 ⁷⁹	N NT or QT	850 to 920 880 to 920 880 to 920
P305GH	1.0436	0,15 to:	0.43	0,90 te	0,025	0,015	-	-	-	6 ≤ 35 35 < 2 ≤ 160	305 280	490 to 530 490 to 530	222 222	20 20	43 ¹⁾	27 th 27 th	N NT	880 to 920 880 to 920
		0,20		1,50						to ≤70	285	510 to 630	22	20	48,0	2710	QT	8\$0 to 920
163663	1.5415	0,12 10 0,29	0.35	0,40 o.00 0,00	0,025	D,015	-	0,25 50 0,35	-	15 ≤ 33 33 < 15 ≤ 30 70 < 25 ≤ 300	255 265 275	440 to 570	33	21	30 ³⁾	347	N QT	850 to 950 850 to 960
										1 ₂ ≤ 250 250 < 4 ₂ ≤ 560	265 250	#40 to \$70 420 to \$50	23	21	20 _g	3471	QT	390 to 960
3-5eMn2/61	1.7335	0,08 to-	0,35	0,40 16	0,025	0,015	0,70 to	0,40 ca	-	t ₂ ≤35 35 < t ₆ ≤ 70	295 235	440 to 59∙0	20	18	4471	27%	NT	890 to 950
		0.18		1,00			1.15%	0,8)		$70 < t_0 \le 100$ $100 < t_0 \le 250$ $250 < t_0 \le 500$	273 265 240	440 to 1940 440 to 1940 420 to 5780	20	IS:	440	27%	MI or QT	850 to:950

¹⁸ Elements not listed in this wide shall not be introducedly added to the stead without the approval of the partition except for finishing the cert. All appropriate measures shall be taken to prove the solution from street or other materials used in size the

ATTACHMENT Page 2 of 3

ATTACHMENT 4 Page 3 of 3



Czrken	egifralise eultv	គ	*	×	t	14.16 14.11			0,43		1000		ı	£	1	ı	Ŀ	ومزيمها احتاسه
	cing	Cooling in			1	ŀ	2, f	1	L.f	1	ı, İ	ን ተ	ı	ž ž	2, f	۲. ۲.	4	A tributa afficial th
	Tempering	Fernitarina 2	0		1	1	600 to 540	1	600 కా ప్రశ్	1	620 to 560	670 to 560	1	620 to 700	<u>අවූම</u> සං 700	630 to 740	630 to 730	er franklingeren mit der eiter er fange er menen de bid in en menen fan menel bin en mei it oante mei
Hour treetment	that the solution	Cooling in			*3+3	rz	3, a, w	מ	3, 0, 1%	102	3, 0, 77	ኒሲ ንኃ	KZ	ŭ. ŭ.	¢, w	n	a, a, 78	
	s or gaintings	eratura	r,,		936	930	936	920	920 928	.920	916	.920	930	999		956	063g	



Designation: A 106/A 106M

Used in USDOE-NE standards

Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service¹

This standard is issued under the fixed designation A 106/A 106M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (a) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification² covers seamless carbon steel pipe for high-temperature service (Note 1) in NPS 1/2 to NPS 48 [DN 6 to DN 1200] (Note 2) inclusive, with nominal (average) wall thickness as given in ASME B 36.10M. It shall be permissible to furnish pipe having other dimensions provided such pipe complies with all other requirements of this specification. Pipe ordered under this specification shall be suitable for bending, flanging, and similar forming operations, and for welding. When the steel is to be welded, it is presupposed that a welding procedure suitable to the grade of steel and intended use or service will be utilized.

Note 1-It is suggested, consideration be given to possible graphitization

Note 2-The dimensionless designator NPS (nominal pipe size) [DN (diameter nominal)] has been substituted in this standard for such traditional terms as "nominal diameter," "size," and "nominal size."

- 1.2 Supplementary requirements of an optional nature are provided for seamless pipe intended for use in applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order.
- 1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.
- 1.4 The following precautionary caveat pertains only to the test method portion, Sections 11, 12, and 13 of this specification: This standard 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 standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards: 3

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

2.2 ASME Standard:

ASME B 36.10M Welded and Seamless Wrought Steel Pipe4

2.3 Military Standards: MIL-STD-129 Marking for Shipment and Storage⁵

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage⁵

2.4 Federal Standard:

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)⁵ Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products5

2.5 Other Standards:

SSPC-SP 6 Surface Preparation Specification No. 66

3. Ordering Information

- 3.1 The inclusion of the following, as required will describe the desired material adequately, when ordered under this specification:
 - 3.1.1 Quantity (fect, metres, or number of lengths),
 - 3.1.2 Name of material (seamless carbon steel pipe),
 - 3.1.3 Grade (Table 1),

¹ This specification is under the jurisdiction of Committee ADI on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

Current edition approved July 15, 2008, Published August 2008, Originally approved in 1926. Last previous edition in 2006 as A 106/A 106M - 06a.

For ASME Bolter and Pressure Vessel Code applications see related Specifi-

cations SA-106 in Section II of that Code.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://

⁵ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

	(Composition, %					
	Grade A	Grade B	Grade Co/				
Carbon, max	0.25 0.13	10.30 0.16	10.35× 0.21				
Manganese, MRX	(0.27-0.93)	(0.29-1.06) 1, 20	(0.29-1.06) / 40				
Phosphorus, max	0.035	0.035 0,025	0.035 0.025				
Sullur, max	0.035 0.020	10.035 0.026	0.035 0.020				
Silicon, Mill max	0.10 0.35	0.10 0.35	0.10 0.40				
Chrome, max A	0.40 0.30	0.40 0,30	0.40 0.30				
Copper, max	0.40 0.30	0.40 0.30	0.40 0.30				
Molybdenum max®	0.15 0.08	0.15 D. OB	0.15 0.08				
Nickel, max 1	0.40/0.30	10.40/0.30	0.40 0 30				
Vanadium, max	0.08/0.02	0.08 0.02	(0.08/0,02				

For each reduction of 0.01% below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

Because II was elements combined shall not exceed 1 %.

A These four elements combined shall not sice ad 0.70%.

- 3.1.4 Manufacture (hot-finished or cold-drawn),
- 3.1.5 Size (NPS [DN] and weight class or schedule number. or both; outside diameter and nominal wall thickness; or inside diameter and nominal wall thickness),
 - 3.1.6 Special outside diameter tolerance pipe (16.2.2),
- 3.1.7 Inside diameter tolerance pipe, over 10 in. [250 mm] ID (16.2.3),
 - 3.1.8 Length (specific or random, Section 17),
 - 3.1.9 Optional requirements (Section 9 and S1 to S8),
- 3.1.10 Test report required (Section on Certification of Specification A 530/A 530M),
- 3.1.11 Specification designation (A 106 or A 106M, including year-date),
 - 3.1.12 End use of material,
- 3.1.13 Hydrostatic test in accordance with Specification A 530/A 530M or 13.3 of this specification, or NDE in accordance with Section 14 of this specification.
 - 3.1.14 Special requirements.

4. Process

- 4.1 The steel shall be killed steel, with the primary melting process being open-hearth, basic-oxygen, or electric-furnace, possibly combined with separate degassing or rehning. If secondary melting, using electroslag remelting or vacuum-arc remelting is subsequently employed, the heat shall be defined as all of the ingots remelted from a single primary heat.
- 4.2 Steel cast in ingots or strand cast is permissible. When steels of different grades are sequentially strand east, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.
- 4.3 For pipe NPS 11/2 [DN 40] and under, it shall be permissible to furnish hot finished or cold drawn.
- 4.4 Unless otherwise specified, pipe NPS 2 [DN 50] and over shall be furnished hot finished. When agreed upon between the manufacturer and the purchaser, it is permissible to furnish cold-drawn pipe.

5. Heat Treatment

5.1 Hot-finished pipe need not be heat treated. Cold-drawn pipe shall be heat treated after the final cold draw pass at a temperature of 1200 °F (650 °C) or higher.

All pipe shall be furnished in the mormalized condition by heeting into the 2 temperature range of 1625 to 1725 of [880 to 940°C]

6. General Requirements

6.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A 530/A 530M unless otherwise provided herein.

7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

on heat analysis

8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified in Section 7. If the secondary melting processes of 5.1 are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the manufacturer, if the latter has not manufactured the steel, shall be reported to the purchaser or the purchaser's representative, and shall conform to the requirements specified in Section 7.

9. Product Analysis

9.1 At the request of the purchaser, analyses of two pipes from each lot (see 20.1) shall be made by the manufacturer from the finished pipe. The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section D Table 1A.

9.2 If the analysis of one of the tests specified in 9.1 does 9 not conform to the requirements specified in Section 7 Table 1# analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to requirements specified.

10. Tensile Requirements Mechanical Properties

C|10.1 The material shall conform to the requirements as to

tensile properties given in Table 2.
10.2 Elovated Temperature Yield Strength -

11. Bending Requirements

11.1 For pipe NPS 2 [DN 50] and under, a sufficient length of pipe shall stand being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter (as shown in ASME B 36.10M) of the pipe, without developing cracks. When ordered for close coiling, the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the outside diameter (as shown in ASME B 36.10M) of the pipe, without failure.

11.2 For pipe whose diameter exceeds 25 in. [635 mm] and whose diameter to wall thickness ratio, where the diameter to wall thickness ratio is the specified outside diameter divided by the nominal wall thickness, is 7.0 or less, the bend test shall be conducted. The bend test specimens shall be bent at room temperature through 180° with the inside diameter of the bend being 1 in. [25 mm] without cracking on the outside portion of the bent portion.

Example: For 28 in. [711 mm] diameter 5.000 in. [127 mm] thick pipe the diameter to wall thickness ratio = 28/5 = 5.6 [711/127 = 5.6].

> D) The material shall be capable of meeting the yield strength values in Table 24 when tested at the temporature is took in Table 24

TABLE 2 (Tensile Requirements	W-1	Demoute 21
TABLE 2 /Tensile Requirements	MECHEUMICAN	1 halist 1143

. 0/	Gn	ade A	Gra	ade B	Gre	ide C	
Tensile strength, (nin) psi [MPa] 45 000 - 65000 [320] Yield strength, min, psi [MPa]	-4407@0	00(205)9 L340 00(205)9 L340 1940	3-5001 35 0		85000 00		
Impact Energy, CharAl V-Motch, Aimman average at + 320 FC oc], At 16[T]	Longitu- dinal	Transverse	Longitu- dinal	Transverse	Longitu- dinal	Transverse	
Elongation in 2 in. [50 mm], min, %: Basic minimum elongation transverse strip tests, and for all small	35	25	30	16.5	30	16.5	
sizes tested in full section When standard round 2-in. [50-mm] gage length test specimen is	28	20	22	12	20	12	
used For longitudinal strip tests	A		A		A		
For transverse strip tests, a deduction for each ½2-in. [0.8-mm] decrease in wall thickness below ¾1. [7.9 mm] from the basic minimum elongation of the following percentage shall be made		1.25		1,00		1.00	

A The minimum elongation in 2 in. [50 mm] shall be determined by the following equation: e = 625 000A02 / U 0.8

for inch-pound units, and

= 1 940A02/U0.9

for SI units,

where:

minimum elongation in 2 in. [50 mm], %, rounded to the pearest 0.5 %, cross-sectional area of the tension test specimen, in.² [min²], based upon specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 0.01 in.² [1 mm²]. (If the area thus calculated is equal to or greater than 0.75 in.² [500 mm²], then the value 0.75 in.² [500 mm²] shall be used.), and

specified tensile strength, psi [MPa].

Longitudinal 30[40] Transverse 20[27]

30[40]

12. Flattening Tests

12.1 Although testing is not required, pipe shall be capable of meeting the flattening test requirements of Supplementary Requirement S3, if tested.

13. Hydrostatic Test

- 13.1 Except as allowed by 13.2, 13.3, and 13.4, each length of pipe shall be subjected to the hydrostatic test without leakage through the pipe wall.
- 13.2 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order, it shall be permissible for the full body of each pipe to be tested with a nondestructive electric test described in Section 14.
- 13.3 Where specified in the purchase order, it shall be permissible for pipe to be furnished without the hydrostatic test and without the nondestructive electric test in Section 14; in this case, each length so furnished shall include the mandatory marking of the letters "NH." It shall be permissible for pipe meeting the requirements of 13.1 or 13.2 to be furnished where pipe without either the hydrostatic or nondestructive electric test has been specified in the purchase order; in this case, such pipe need not be marked with the letters "NH." Pipe that has failed either the hydrostatic test of 13.1 or the nondestructive electric test of 13.2 shall not be furnished as "NH" pipe.
- 13.4 Where the hydrostatic test and the nondestructive electric test are omitted and the lengths marked with the letters "NH," the certification, where required, shall clearly state "Not Hydrostatically Tested," and the letters "NH" shall be appended to the product specification number and material grade shown on the certification.

14. Nondestructive Electric Test

- 14.1 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order as an alternative or addition to the hydrostatic test, the full body of each pipe shall be tested with a nondestructive electric test in accordance with Practice E 213, E 309, or E 570. In such cases, the marking of each length of pipe so furnished shall include the letters "NDE." It is the intent of this nondestructive electric test to reject pipe with imperfections that produce test signals equal to or greater than that produced by the applicable calibration standard.
- 14.2 Where the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE." The certification, where required, shall state "Nondestructive Electric Tested" and shall indicate which of the tests was applied. Also, the letters "NDE" shall be appended to the product specification number and material grade shown on the certification.
- 14.3 The following information is for the benefit of the user of this specification:
- 14.3.1 The reference standards defined in 14.4 through 14.6 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.
- 14.3.2 The ultrasonic testing referred to in this specification is capable of detecting the presence and location of significant longitudinally or circumferentially oriented imperfections: however, different techniques need to be employed for the detection of such differently oriented imperfections. Ultrasonic testing is not necessarily capable of detecting short, deep imperfections.

4 A 106/A 106M - 08

- 14.3.3 The eddy current examination referenced in this specification has the capability of detecting significant imperfections, especially of the short abrupt type.
- 14.3.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented imperfections: however, different techniques need to be employed for the detection of such differently oriented imperfections.
- 14.3.5 The hydrostatic test referred to in Section 13 has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. Hydrostatic testing is not necessarily enpable of detecting very tight, through-the-wall imperfections or imperfections that extend an appreciable distance into the wall without complete penetration.
- 14.3.6 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific applications of these examinations is directed to discuss this with the manufacturer of the tubular product.
- 14.4 For ultrasonic testing, the calibration reference notches shall be, at the option of the producer, any one of the three common notch shapes shown in Practice E 213. The depth of notch shall not exceed 12½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.
- 14.5 For eddy current testing, the calibration pipe shall contain, at the option of the producer, any one of the following discontinuities to establish a minimum sensitivity level for rejection:
- 14.5.1 Drilled Hole—The calibration pipe shall contain depending upon the pipe diameter three holes spaced 120° apart or four holes spaced 90° apart and sufficiently separated longitudinally to ensure separately distinguishable responses. The holes shall be drilled radially and completely through the pipe wall, care being taken to avoid distortion of the pipe while drilling. Depending upon the pipe diameter the calibration pipe shall contain the following hole:

NPS	DN	Diameter of Drilled Hole
≤ 1/2	≤ 15	0.039 in. [1 mm]
> 1/2 \leq 11/4	> 15 ≤ 32	0.055 in. [1.4 mm]
> 1¼ ≤ 2	> 32 ≤ 50	0.071 in. [1.8 mm]
> 2 ≤ 5	> 50 ≤ 125	0.087 in. [2.2 mm]
>5	> 125	0.106 in. (2.7 mm)

- 14.5.2 Transverse Tangential Notch—Using a round tool or file with a ¼-in. [6-mm] diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. The notch shall have a depth not exceeding 12 ½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.
- 14.5.3 Longitudinal Notch—A notch 0.031 in. [0.8 mm] or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe, to have a depth not exceeding 12 ½ % of the specified wall thickness of the tube or 0.004 in. [0.1 mm], whichever is greater. The length of the notch shall be compatible with the testing method.
- 14.5.4 Compatibility—The discontinuity in the calibration pipe shall be compatible with the testing equipment and the method being used.
- 14.6 For flux leakage testing, the longitudinal calibration reference notches shall be straight-sided notches machined in a radial plane parallel to the pipe axis. For wall thicknesses under ½ in. [12.7 mm], outside and inside notches shall be used; for wall thicknesses equal to and above ½ in. [12.7 mm], only an outside notch shall be used. Notch depth shall not exceed 12½% of the specified wall thickness, or 0.004 in. [0.1 mm], whichever is greater. Notch length shall not exceed 1 in. [25 mm], and the width shall not exceed the depth. Outside diameter and inside diameter notches shall be located sufficiently apart to allow separation and identification of the signals.
- 14.7 Pipe containing one or more imperfections that produce a signal equal to or greater than the signal produced by the

calibration standard shall be rejected or the area producing the signal shall be reexamined.

14.7.1 Test signals produced by imperfections which cannot be identified, or produced by cracks or crack-like imperfections shall result in rejection of the pipe, unless it is repaired and retested. To be accepted, the pipe must pass the same specification test to which it was originally subjected, provided that the remaining wall thickness is not decreased below that permitted by this specification. The OD at the point of grinding may be reduced by the amount so reduced.

14.7.2 Test signals produced by visual imperfections such as those listed below may be evaluated in accordance with the provisions of Section 18:

14.7.2.1 Dinges,

14.7.2.2 Straightener marks,

14.7.2.3 Cutting chips,

14.7.2.4 Scratches,

14.7.2.5 Steel die stamps,

14.7.2.6 Stop marks, or

14.7.2.7 Pipe reducer ripple.

14.8 The test methods described in this section are not necessarily capable of inspecting the end portion of pipes, a condition referred to as "end effect." The length of such end effect shall be determined by the manufacturer and, when specified in the purchase order, reported to the purchaser.

15. Nipples

15.1 Nipples shall be cut from pipe of the same dimensions and quality described in this specification.

16. Dimensions, Mass, and Permissible Variations

16.1 Mass—The mass of any length of pipe shall not vary more than 10 % over and 3.5 % under that specified. Unless otherwise agreed upon between the munufacturer and the purchaser, pipe in NPS 4 [DN 100] and smaller may be weighed in convenient lots; pipe larger than NPS 4 [DN 100] shall be weighed separately.

16.2 Diameter—Except as provided for thin-wall pipe in paragraph 11.2 of Specification A 530/A 530M, the tolerances for diameter shall be in accordance with the following:

16.2.1 Except for pipe ordered as special outside diameter tolerance pipe or as inside diameter tolerance pipe, variations in outside diameter shall not exceed those given in Table 3.

16.2.2 For pipe over 10 in. [250 mm] OD ordered as special outside diameter tolerance pipe, the outside diameter shall not vary more than 1 % over or 1 % under the specified outside diameter.

16.2.3 For pipe over 10 in. [250 mm] ID ordered as inside diameter tolerance pipe, the inside diameter shall not vary more than 1 % over or 1 % under the specified inside diameter.

16.3 Thickness—The minimum wall thickness at any point shall not be more than 12.5 % under the specified wall thickness.

17. Lengths

17.1 Pipe lengths shall be in accordance with the following regular practice:

17.1.1 The lengths required shall be specified in the order, and

TABLE 3 Variations in Outside Diameter

			e Variations in e Diameter	
NPS [DN Designator]	evO		Unde	r
	in.	mm	in.	mm
% to 1 ½ [6 to 40], incl	V84 (0.015)	0.4	V64 (0.015)	0.4
Over 11/2 to 4 [40 to 100], incl	1/32 (0.031)	8.0	1∕a₂ (0.031)	8.0
Over 4 to 8 [100 to 200], incl	1/1e (0.062)	1.6	1/32 (0.031)	8.0
Over 8 to 18 [200 to 450], incl	3/ 32 (0.093)	2.4	1/22 (0.031)	8.0
Over 18 to 26 [450 to 650], Incl	1/6 (0.125)	3.2	1/22 (0.031)	8.0
Over 26 to 34 [650 to 850], incl	⁵⁄a₂ (0.156)	4.0	1/32 (0.031)	8.0
Over 34 to 48 [850 to 1200], Incl	¥18 (0.187)	4.8	1/32 (0.031)	8.0

17.1.2 No jointers are permitted unless otherwise specified. 17.1.3 If definite lengths are not required, pipe may be ordered in single random lengths of 16 to 22 ft [4.8 to 6.7 m] with 5 % 12 to 16 ft [3.7 to 4.8 m], or in double random lengths with a minimum average of 35 ft [10.7 m] and a minimum length of 22 ft [6.7 m] with 5 % 16 to 22 ft [4.8 to 6.7 m].

18. Workmanship, Finish and Appearance

18.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable assurance that they have been properly evaluated with respect to depth. Exploration of all surface imperfections is not required but consideration should be given to the necessity of exploring all surface imperfections to assure compliance with 18.2.

18.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with such defects shall be given one of the following dispositions:

18.2.1 The defect shall be removed by grinding, provided that the remaining wall thickness is within the limits specified in 16.3

18.2.2 Repaired in accordance with the repair welding provisions of 18.6.

18.2.3 The section of pipe containing the defect may be cut off within the limits of requirements on length.

18.2.4 Rejected.

18.3 To provide a workmanlike finish and basis for evaluating conformance with 18.2 the pipe manufacturer shall remove by grinding the following noninjurious imperfections:

18.3.1 Mechanical marks and abrasions—such as cable marks, dinges, guide marks, roll marks, ball scratches, scores, and die marks—and pits, any of which imperfections are deeper than V_{16} in. [1.6 mm].

18.3.2 Visual imperfections commonly referred to as scabs, seams, laps, tears, or slivers found by exploration in accordance with 18.1 to be deeper than 5 % of the nominal wall thickness.

18.4 At the purchaser's discretion, pipe shall be subjected to rejection if surface imperfections acceptable under 18.2 are not scattered, but appear over a large area in excess of what is

4 106/A 106M - 08

considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

- 18.5 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. The outside diameter at the point of grinding is permitted to be reduced by the amount so removed.
- 18.5.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical caliper shall govern.
- 18.6 Weld repair shall be permitted only subject to the approval of the purchaser and in accordance with Specification A 530/A 530M.
 - 18.7 The finished pipe shall be reasonably straight.

19. End Finish

- 19.1 The Pipe shall be furnished to the following practice, unless otherwise specified.
- 19.1.1 NPS 1½ [DN 40] and Smaller—All walls shall be either plain-end square cut, or plain-end beveled at the option of the manufacturer.
- 19.1.2 NPS 2 [DN 50] and Larger—Walls through extra strong weights, shall be plain-end-beveled.
- 19.1.3 NPS 2 [DN 50] and Larger—Walls over extra strong weights, shall be plain-end square cut.
- 19.2 Plain-end beveled pipe shall be plain-end pipe having a bevel angle of 30°, +5° or -0°, as measured from a line drawn perpendicular to the axis of the pipe with a root face of $V_{16} \pm V_{22}$ in. [1.6 \pm 0.8 mm]. Other bevel angles may be specified by agreement between the purchaser and the manufacturer.

20. Sampling

- 20.1 For product analysis (see 9.1) and tensile tests (see 21.1), a lot is the number of lengths of the same size and wall thickness from any one heat of steel; of 400 lengths or fraction thereof, of each size up to, but not including, NPS 6 [DN 150]; and of 200 lengths or fraction thereof of each size NPS 6 [DN 150] and over.
- 20.2 For bend tests (see 21.2), a lot is the number of lengths of the same size and wall thickness from any one heat of steel, of 400 lengths or fraction thereof, of each size.
- 20.3 For flattening tests, a lot is the number of lengths of the same size and wall thickness from any one heat of steel, of 400 lengths or fraction thereof of each size over NPS 2 [DN 50], up to but not including NPS 6 [DN 150], and of 200 lengths or fraction thereof, of each size NPS 6 [DN 150] and over.

21. Number of Tests

- 21.1 The tensile requirements specified in Section 10 shall be determined on one length of pipe from each lot (see 20.1).
- 21.2 For pipe NPS 2 [DN 50] and under, the bend test specified in 11.1 shall be made on one pipe from each lot (see 20.2). The bend test, where used as required by 11.2, shall be made on one end of 5 % of the pipe from each lot. For small lots, at least one pipe shall be tested.

21.3 If any test specimen shows flaws or defective machining, it shall be permissible to discard it and substitute another test specimen.

22. Retests

22.1 If the percentage of elongation of any tension test specimen is less than that given in Table 1 and any part of the fracture is more than ¼ in. [19 mm] from the center of the gage length of a 2-in. [50-mm] specimen as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

23. Test Specimens and Test Methods

- 23.1 On NPS 8 [DN 200] and larger, specimens cut either longitudinally or transversely shall be acceptable for the tension test. On sizes smaller than NPS 8 [DN 200], the longitudinal test only shall be used.
- 23.2 When round tension test specimens are used for pipe wall thicknesses over 1.0 in. [25.4 mm], the mid-length of the longitudinal axis of such test specimens shall be from a location midway between the inside and outside surfaces of the pipe.
- 23.3 Test specimens for the bend test specified in Section 11 and for the flattening tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.
- 23.4 Test specimens for the bend test specified in 11.2 shall be cut from one end of the pipe and, unless otherwise specified, shall be taken in a transverse direction. One test specimen shall be taken as close to the outer surface as possible and another from as close to the inner surface as possible. The specimens shall be either ½ by ½ in. [12.5 by 12.5 mm] in section or 1 by ½ in. [25 by 12.5 mm] in section with the corners rounded to a radius not over ½ in. [1.6 mm] and need not exceed 6 in. [150 mm] in length. The side of the samples placed in tension during the bend shall be the side closest to the inner and outer surface of the pipe respectively.
- 23.5 All routine check tests shall be made at room temperature.

24. Certification

24.1 When test reports are requested, in addition to the requirements of Specification A 530/A 530M, the producer or supplier shall furnish to the purchaser a chemical analysis report for the elements specified in Table 1.

25. Product Marking

25.1 In addition to the marking prescribed in Specification A 530/A 530M, the marking shall include heat number, the information as per Table 4, an additional symbol "S" if one or

TABLE 4 Marking

Hydro	NDE	Marking
Yes	No	Test Pressure
No	Yes	NDE
No	No	NH
Yes	Yes	Test Pressure/NDE

∰ A 106/A 106M - 08

more of the supplementary requirements apply; the length, OD 1 %, if ordered as special outside diameter tolerance pipe; ID 1 %, if ordered as special inside diameter tolerance pipe; the schedule number, weight class, or nominal wall thickness; and, for sizes larger than NPS 4 [DN 100], the weight. Length shall be marked in feet and tenths of a foot [metres to two decimal places], depending on the units to which the material was ordered, or other marking subject to agreement. For sizes NPS 11/2, 11/4, 1, and 3/4 [DN 40, 32, 25, and 20], each length shall be marked as prescribed in Specification A 530/A 530M. These sizes shall be bundled in accordance with standard mill practice and the total bundle footage marked on the bundle tag individual lengths of pipe need not be marked with footage For sizes less than NPS 3/4 [DN 20], all the required markings shall be on the bundle tag or on each length of pipe and shall include the total footage; individual lengths of pipe need not be marked with footage. If not marked on the bundle tag, all required marking shall be on each length.

25.2 When pipe sections are cut into shorter lengths by a subsequent processor for resale as material, the processor shall transfer complete identifying information, including the name or brand of the manufacturer to each unmarked cut length, or to metal tags securely attached to bundles of unmarked small diameter pipe. The same material designation shall be included with the information transferred, and the processor's name, trademark, or brand shall be added.

25.3 Bar Coding—In addition to the requirements in 25.1 and 25.2, bar coding is acceptable as a supplementary identification method. The purchaser may specify in the order a specific bar coding system to be used.

26. Government Procurement

26.1 When specified in the contract, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for the shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 or Fed. Std. No. 183 if continuous marking is required for military agencies.

26.2 Inspection—Unless otherwise specified in the contract, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the producer shall use his own, or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that the material conforms to the prescribed requirements.

27. Keywords

27.1 carbon steel pipe; seamless steel pipe; steel pipe

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

\$1.1 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical composition requirements shall be rejected.

S2. Transverse Tension Test

S2.1 A transverse tension test shall be made on a specimen from one end or both ends of each pipe NPS 8 [DN 200] and over. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails to meet the required tensile properties (tensile, yield, and elongation), that length shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest.

S3. Flattening Test, Standard

S3.1 For pipe over NPS 2 [DN 50], a section of pipe not less than 2½ in. [63.5 mm] in length shall be flattened cold between parallel plates until the opposite walls of the pipe meet. Flattening tests shall be in accordance with Specification A 530/A 530M, except that in the formula used to calculate the "H" value, the following "e" constants shall be used:

0.08 for Grade A

0.07 for Grades B and C

S3.2 When low *D*-to-*t* ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve o'clock locations, cracks at these locations shall not be cause for rejection if the *D*-to-*t* ratio is less than ten.

S3.3 The flattening test shall be made on one length of pipe from each lot of 400 lengths or fraction thereof of each size over NPS 2 [DN 50], up to but not including NPS 6 [DN 150], and from each lot of 200 lengths or fraction thereof, of each size NPS 6 [DN 150] and over.

S3.4 Should a crop end of a finished pipe fail in the flattening test, one retest is permitted to be made from the failed end. Pipe shall be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

S4. Flattening Test, Enhanced

S4.1 The flattening test of Specification A 530/A 530M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be

4 106/A 106M - 08

specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness, that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

S5. Metal Structure and Etching Test

S5.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate sections of Method E 381. Etching tests shall be made on a cross section from one end or both ends of each pipe and shall show sound and reasonably uniform material free from injurious laminations, cracks, and similar objectionable defects. If this supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

S6. Carbon Equivalent

S6.1 The steel shall conform to a carbon equivalent (CE) of 0.50 maximum as determined by the following formula:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15}$$

S6.2 A lower CE maximum may be agreed upon between the purchaser and the producer.

S6.3 The CE shall be reported on the test report.

S7. Heat Treated Test Specimens

S7.1 At the request of the purchaser, one tensile test shall be performed by the manufacturer on a test specimen from each heat of steel furnished which has been either stress relieved at 1250 °F or normalized at 1650 °F, as specified by the purchaser. Other stress relief or annealing temperatures, as

appropriate to the analysis, may be specified by agreement between the purchaser and the manufacturer. The results of this test shall meet the requirements of Table 1.

S8. Internal Cleanliness-Government Orders

S8.1 The internal surface of hot finished ferritic steel pipe and tube shall be manufactured to a free of scale condition equivalent to the visual standard listed in SSPC-SP 6. Cleaning shall be performed in accordance with a written procedure that has been shown to be effective. This procedure shall be available for audit.

S9. Requirements for Carbon Steel Pipe for Hydrofluoric Acid Alkylation Service

- \$9.1 Pipe shall be provided in the normalized heat-treated condition.
- S9.2 The carbon equivalent (CE), based upon heat analysis, shall not exceed 0.43 % if the specified wall-thickness is equal to or less than 1 in. [25.4 mm] or 0.45 % if the specified wall thickness is greater than 1 in. [25.4 mm].
- S9.3 The carbon equivalent (CE) shall be determined using the following formula:
 - CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15
- S9.4 Based upon heat analysis in mass percent, the vanadium content shall not exceed 0.02 %, the niobium content shall not exceed 0.02 %, and the sum of the vanadium and niobium contents shall not exceed 0.03 %.
- S9.5 Based upon heat analysis in mass percent, the sum of the nickel and copper contents shall not exceed 0.15 %.
- S9.6 Based upon heat analysis in mass percent, the carbon content shall not be less than 0.18 %.
- S9.7 Welding consumables of repair welds shall be of low hydrogen type. E60XX electrodes shall not be used and the resultant weld chemical composition shall meet the chemical composition requirements specified for the pipe.
- S9.8 The designation "HF-N" shall be stamped or marked on each pipe to signify that the pipe complies with this supplementary requirement.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 106/A 106M - 06a, that may impact the use of this specification. (Approved July 15, 2008)

(1) Revised 16.2 to permit OD tolerance for thin-wall pipe to default to Specification A 530/A 530M.

EN 10216-2:2002+A2:2007 (E)

1A

Table & Permissible deviations of the product analysis from specified limits on cast analysis given in Table & 1

Element	Limiting value for the cast analysis in accordance with Table	Permissible deviation of the produc analysis
·	% by mass	% by mass
С	≤ 0,29	± 0,02
SI	≤ 0,40	± 0,05
	> 0,40 to < 1,00	± 0,06
Mn	. ≤ 1,00	± 0,05
	> 1,00 to ≤ 1,50	± 0,10
Р	≤ 0,030	+ 0,005
S	≤ 0,010	+ 0,003
3	>0,010 to ≤0,020	+ 0,005
Al	≤ 0,060	. ± 0,005
В	≤ 0,007	± 0,001
	≤ 1,00	± 0,05
Cr	> 1,00 to ≤ 10,00	± 0,10
	> 10,00 to ≤ 12,50	± 0,15
Си	≤ 0,80	± 0,05
· Mo	≤ 0,35	± 0,03
· IND	> 0,35 to ≤ 1,20	± 0,04
N	≤ 0,070	± 0,01
Nb	≤ 0,10	± 0,005
NII.	≤ 0,35	± 0,05
NI	> 0,35 to ≤ 1,30	± 0,07
T	≤ 0,060	+ 0,010
V	≤ 0,10	+ 0,01
V	> 0,10 to ≤ 0,55	± 0,03
W	. ≤ 2,00	± 0,10

8.3 Mechanical properties

8.3.1 Mechanical properties at and below room temperature

The mechanical properties at and below room temperature of the tubes shall conform to the requirements in Table 4 and in clauses 11.3, 11.4, 11.5 and 11.6.

8.3.2 Proof strength at elevated temperature

The minimum proof strength $R_{p0,2}$ values at elevated temperature are given in Table 5.

15

24

Table Minimum proof strength R_{p0,2} at elevated temperature

				1											
	Steel grad	Wall	hickness				Mini	mum pro	of streng	gth R _{p0,2}	MPa a				
	Grade		mm					at a te	emperatu	re of °C					
	Steel name	Steel comber			100	150	200	250	300	350	400	450	500	550	600
^	P195GH A	1.0348		≤16	175	165	150	130	113	102	94	-	-	-	•
3	€235GH) B	1.0345		≤ 60	1 9 8	187	170	150	132	120	112	108	-	-	-
9	P265GH)	1.0425		≤60	226	213	192	171	154	141	134	128	-	-	
6	20MnNb6	1.0471		≤60	312	292	264	241	219	200	186	174.	-	. 0	-
	16Mo3	1.5415		≤ 60	243	237	224	205	173	159	156	150	146		-
	8MoB5-4	1.5450		≤ 16	368	368	368	368	368	3 68	368	- .		-	•
	14MoV6-3	1.7745		≤ 60	282	276	267	241	225	216	209	203	200	197	-
	10CrMo5-5	1.7338		<u>≼60</u>	240	228	219	208	165	156	148	144	143	-	-
	13CrMo4-5	1.7335		≤60	264	253	245	236	192	182	174	168	166	-	-
	10CrMo9-10	1.7380		≤ 60	249	241	234-	224	219	212	207	193	180	-	-
	11CrMo9-10	1.7383		≤60	323	312	304	296	289	280	275	257	239	-	-
	25CrMo4	1.7218		≤ 50	-	315	305	295	285	265	225	185	-	-	
	20CrMoV13-5-5	1.7779		≤60	-	575	570	560	550	510	470.	420	370	-	, -
	15NiCuMoNb5-6-4	1.6368		≤80	422	412	402	392	382	373	343	304	-	-	-
	7CrWVMoNb9-6	1.8201		≤ 60	379	370	363	361	359	351	345	338	330	299	266
	7CrMoVTiB10-10	1.7378		≤ 50	397	383	373	366	359	352	345	336	324	301	245
	X11CrMo5±l	1.7362+1		≤ 100	156	150	148	147	145	142	137	129	116	-	-
	X11CrMo5+NT1	1.7362+NT1		≤ 100	245	237	230	223	216	206	196	18†	167	-	-
	X11CrMo5+NT2	1.7362+NT2		≤ 100	366	350	334	332	309	299	289	280	265	-	-

ATTACHMENT 4 - PAGE 1 OF 5

This standard is under consideration for revision within an ASTM International technical committee. The revisions proposed have not received all approvals required to become an ASTM International standard. It shall not be reproduced or circulated or quoted, in whole or part, outside of ASTM International Committee activities except with the approval of the Chairman of the Committee having jurisdiction and the President of the Society. Copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. All rights reserved.

A01.19 SS 395 Rev. 1 05/18/09

ITEM

To:

ASTM A01.19 Members

From:

John K. Mahaney, Jr., TG Chairman

Subject:

Revision to ASTM A 414/A 414 Standard Specification for Steel, Sheet,

Carbon, for Pressure Vessels with title change

WK #:

20854

Rationale: The proposal is to add a grade of high-strength low-alloy steel to this standard which has been exclusively carbon steel to this point. The new grade, Grade H, will have the same strength level as the current Grade G and can be substituted for that grade upon agreement of the buyer and seller. The new grade will fit European Union (EN) Pressure Equipment Directive (PED) and Transportable Pressure Vessel Regulations (TPV) requirements for impact properties and higher temperature, beyond room temperature, properties, if specified at the time of purchase. More restrictive chemical requirements will be noted for the new grade. The new grade would be usable for propane tanks and other US DOT applications which are now excluded from this standard.

Table 1, Chemical Requirements has been revised to include both elements in the current Table 1 and Table 2. As A 568/A 568M contains limits for product analysis, there is no reason for Table 2 and it has been removed. The chemistry table and tensile requirements table have been revised to the format used in other A01.19 standards.

Note there are two work items involving this standard, 20853 and 20854. The changes suggested in each are independent of the other so approving one should not negate the other.

Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy for Pressure Vessels¹

This standard is issued under the fixed designation A 414/A 414M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (c) indicates an editorial change since the last revision or reapproval.

1.2 The following grades are included in this specification:

in Ö N PAGE 1 4 ATTACHMENT

Aechanical Requirements

Grade	Yield St	rength, min	Tensile Strength, min			
	ksi	MPs	ksi	MPa		
A	25	170	45	310		
B	30	205	50	345		
C	33	230	55	380		
D	35	240	60	415		
E	38	260	65	450		
F	42	290	70	485		
G	45	310	75	515		
н	45	310	75	515		

2. Referenced Documents

- 2.1 ASTM Standards:1
- A 370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

 A 568/A 568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
- A 635/A 635M Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for

3. Ordering Information

- 3.1 Orders for material under this specification shall include the following information, as required, to describe the material adequately:
 - 3.1.1 Designation or specification number, date of issue, and grade,
 - 3.1.1.1 Grade H may be substituted for Grade G upon agreement between the purchaser and producer,
 - 3.1.2 Copper bearing steel, when required,
 - 3.1.3 Special requirements, if required,
 - 3.1.3.1 Charpy impact properties may be specified for Grade H at the time of order,
- 3.1.3.2 Strength levels at other than room temperature may be specified for Grade H at the time of
- 3.1.4 Condition—pickled (or blast cleaned), if required (material so ordered will be oiled unless ordered dry), and
 - 3.1.5 Dimensions, including type of edges.
- 3.1.5.1 As agreed upon between the purchaser and the producer, material ordered to this specification will be supplied to meet the appropriate standard or restricted thickness tolerance table shown in Specification A 568/A 568M or Specification A 635/A 635M.

NOTE 1-Not all producers are capable of meeting all of the limitations of the thickness tolerance tables in Specification A 568/A 568M or Specification A 635/A 635M. The purchaser should contact the producer regarding possible limitations prior to placing an order.

3.1.6 Cast or heat analysis, or test report request, or both, if required.

For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

NOTE 2-A typical ordering description is as follows: "ASTM A 414, Grade A, Hot-Rolled Sheet, 0.100 in. [2.54 mm] by 36 in. [914.4 mm] by 96 in. [2438 mm], cut edges."

4. Chemical Requirements

- 4.1 Cast or Heat Analysis-The analysis of the steel shall conform to the requirements prescribed in
- 4.1.1, Each of the elements listed in Table 1 shall be included in the report of the heat analysis. When the amount of an element present is less than 0.02 %, the analysis may be reported as "<0.02 %."
- 4.2 Product, Check, or Verification Analysis -- Analyses may be made by the purchaser from finished material representing each heat.
 - 4.3 Deoxidation—For all grades, killed steel is required. See Table 1 and footnote, B.

Deleted: 4.1.1 Unspecified elements may be present. Limits on elements shall be as stated in Table 2.¶ Deleted: .1 Deleted: 2 Deleted: s Deleted: A Deleted: and B **Formatted Table**

	TABLE 1 Chemical Requirements ^A														
	% Heat Analysis, Element Maximum Unless Otherwise Shown														
Grad e	c	Mn	Þ	S	AL ^B	Si ⁸	Cur	Ni ^e	C _f F.	Mo F. S	V H	Cb ^H	Ti ^D	N	В
Δ	0.1 5.2 0.2 5.2 5.2 5.2 7.3	0.9 0.9 0.9 0.9 1.2 0.1 1.2	0.03 <u>5</u> 0.03	0.03 <u>5</u> 0.03	0.02- 0.08 0.02-	303030303030303030	0.40	0.4 Q 0.4	0.30	0.1 2 0.1	0.03	0.02	0.025	عشد	444
₿	0.2	0.9	<u>5</u> 0.03	<u>5</u>	<u>0.08</u> 0.02-	0.3	0.40	0.4 Q 0.4	0.30	0.1 2 0.1	0.03	0.02	0.025	244	***
<u>c</u>	5 0.2	<u>0</u> 1.2	5 0.03	0.03 <u>5</u> 0.03	0.08 0.02-	<u>0</u> 0.3	0.40	0.4 0 0.4	0.30	0.1 2 0.1	0.03	0.02	0.025	***	4:1
₫	<u>5</u> 0.2	<u>0</u> 1,2	5 0.03	5 0.03	0.08 0.02-	0.3	0.40	0.4 0 0.4	0.30	0.1 2 0.1	0.03	0.02	0.025	<u></u>	شد
E	7 0.3	<u>0</u> 1.2	<u>5</u> 0.03	5 0.03	0.08 0.02- 0.08	0.3	0.40	0.4 0.4 0.4	0.30	0.1 2 0.1	0.03	0.02	0.025	255	444
Ē	1 0.3 1	0 1.3	5.03 5.03 0.03 5.03 5.03 5.03 5.03	5 0.03	0.08	0.3	0.40	0	0.30	0.1 2 0.1	0.03	0.02	0.025	هند	***
<u>G</u>	1 0.1	0 1.3 5 1.2	5 0.02	5 0.01	0.08	0 0.3	0.40	0.4 0 0.2	0.30	0.1 2 0.0	<u>0.03</u> 0.005	0.02 0.005/	0.025 0.005	Ó.Ö	***
H E.T When	4 e an eli	5	0	5	0.08 s table, th		0.20 o require	0	0.15 oul the	<u>6</u>	min	0.05	min	09	***
	s shall		orted.												

The steel shall be considered aluminum-silicon killed when the silicon is between

0.15% and 0.30%, otherwise it

shall be considered aluminum

killed.
When copper is specified, a minimum of 0,20% is required. When copper

is a maximum requirement.

Titanium is permitted for Grades A through G, at the producer's option, to the lesser of 3.4N + 1.55 or 0.025%.

For each reduction of 0.01% below the specified carbon maximum, an increase of 0.06% manganese

above the specified maximum will be permitted up to a maximum of 1.50%.

The sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00% on heat

analysis. When one or more of these elements are specified, the sum does not apply,

in which case, only the individual limits on the remaining unspecified elements will apply.

The sum of chromium and molybdenum shall not exceed

0.32% on heat analysis.

When one or more of these elements are specified, the sum does not apply, in which case,

only the individual limits on the remaining unspecified elements will apply.

By agreement, the heat analysis limits for vanadium or

colubium or both, may be

increased up to 0.10% and 0.05% respectively.

Grade H contains the strengthening elements columbium

(niobium), vanadium, titanium and

molybdenum added singly or in combination. The minimum requirements only apply to

Formatted Table

Formatted Table

Formatted Table

Formatted Table

Formatted Table

Formatted Table

S Р ന PAGE ी 4 ATTACHMENT

the microalloy elements selected for strengthening of the steel.

5. Mechanical Property Requirements

- 5.1 Tensile Strength:
- 5.1.1 Requirements—Material as represented by the test specimen shall conform to the tensile requirements specified in Table 2.

5.1.4 Test Method—Yield strength shall be determined by either the 0.2 % offset method or by the 0.5 % extension under load method, unless otherwise specified. per ASTM A 370.

			Tal	ble 2 Ter	<u>nsile Require</u>	<u>ments</u>			4
-	Designati on	<u>Yleid</u> Strength *	Tensile	Strength	Elongation in 2 in.			Elongation in 8 in,	
			<u>Minimum</u>	Maximum	Under 0.270 in. [7,0 mm] to 0.145 in.	Under 0.145 in. [3,8 mm] to 0.089 in.	<u>Under 0.089</u> <u>in,</u> [2.2 mm] to 0.057 in,	[200 mm], min. %	4
			ksi[MP	ksi{MP	[3.8 mm]	[2.2 mm]	[1.5 mm]		
		ksi[MPa]	<u>a]</u>	<u>raj</u>					
-	Grade A	<u>25 [170]</u>	<u>45</u> [310] <u>50</u>	60 [415] 65	<u>26</u>	<u>24</u>	<u>23</u>	<u>20</u>	_
	Grade B	30 [205]	[<u>345]</u> <u>55</u>	[450] 70	<u>24</u>	<u>22</u>	<u>21</u>	<u>18</u>	
	<u>Grade C</u>	33 [230]	[<u>380]</u> 60	[485] 75	<u>22</u>	<u>20</u>	<u>19</u>	<u>16</u>	
	Grade D	35 [240]	[<u>415]</u> 65	[<u>515]</u> <u>85</u>	<u>20</u>	<u>18</u>	17	<u>14</u>	
	Grade E	38 [260]	[<u>450]</u> 70	[585]	<u>18</u>	<u>16</u>	<u>15</u>	<u>12</u>	
	<u>Grade F</u> <u>Grade</u>	42 [290]	[485] 75	90 [620] 95	<u>16</u>	14	<u>13</u>	<u>10</u>	
	G	45 [310]	[<u>515]</u> 75	<u> 16551</u> 90	<u>16</u>	14	<u>13</u>	<u>10</u>	
	Grade H	45 [310]	[515]	[620]	<u>25</u>	<u>24</u>	<u>23</u>	<u>20</u>	

A Yield Strength determined by the 0.2% offset or 0.5% extension under load methods.

5	7	lmoc	eret b	D	***	tion.
J.	4	HHIDL	$I \subseteq I$	- 1 Oi	VE1 1	163

- 5.2.1 Requirements At the time of order. Charpy impact properties may be specified by the purchaser for Grade H only.
- 5.2.1.1 Impact energy minimums and testing temperatures shall be agreed upon between the producer and the purchaser.
- 5.2.2 Number of Tests Three samples taken in the transverse direction shall be taken at mid-length (middle) of each coil to be certified.
- 5.2.3 Testing shall be in accordance with ASTM A 370.

Deleted: ¶

Deleted: 3

Deleted: .
Formatted Table

Formatted Table

Formatted: Font: Italic
Formatted: Font: Italic

ATTACHMENT 4 - PAGE 4 OF 5

Р PAGE! ATTACHMENT 4-

Summary of Changes

- Title changed to include High-Strength, Low-Alloy
- 2. Grade H added to 1.2 table
- 3. A 370 added to referenced documents
- 4. 3.1.1.1 added regarding Grades H and G
- 5. 3.1.3.1 added to allow impact testing of Grade H
- 6. 3.1.3.2 added to allow strength requirements at other than room temperature for
- 7. 4.1.1 deleted with consolidation of chemical requirements to one table
- 8. 4.1.1.1 becomes 4.1.1 and reference to Table 2 deleted
- 9. New Table 1 Chemical Requirements
- 10. 5.1.1 change reference to Table 2
- 11. 5.1.4 reference to A 370 added
- 12. New Table 2 Tensile Requirements
 13. 5.2 added on impact properties

Formatted: Indent: Left: 0.25"

Formatted: Bullets and Numbering

Standard Specification for

Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service¹

This standard is issued under the fixed designation A 516/A 516M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

- 1.1 This specification² covers carbon steel plates intended primarily for service in welded pressure vessels where improved notch toughness is important.
 - 1.2 Plates under this specification are available in four grades having different strength levels as follows:

Grade U.S. [SI] 55 [380] 60 [415] 65 [450]	Tensile Strength, ksl [MPa]
55 [380]	55-75 [380-515]
60 [415]	60-80 [415-550]
65 [450]	65-85 [450-585]
70 [485]	70-90 [485-620]

1.3 The maximum thickness of plates is limited only by the capacity of the composition to meet the specified mechanical property requirements; however, current practice normally limits the maximum thickness of plates furnished under this specification as follows:

Grade U.S. [SI]	Maximum Thickness, in. [mm]
55 (380)	12 [305]
60 [415]	8 [205]
85 [450]	8 [205]
70 [485]	8 [205]

- 1.4 For plates produced from coil and furnished without heat treatment or with stress relieving only, the additional requirements, including additional testing requirements and the reporting of additional test results of Specification A 20/A 20M apply.
- 1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 ASTM Standards:3

A 20/A 20M Specification for General Requirements for Steel Plates for Pressure Vessels

A 435/A 435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A 577/A 577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates

A 578/A 578M Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications

¹This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.11 on Steel Plates for Boilers and Pressure Vessels.

Current edition approved March 1, 2006. Published March 2006. Originally approved in 1964. Last previous edition approved in 2005 as A 516/A 516M - 05^{e1}.

²For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-516/SA-516M in Section II of that Code.

³For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

3. General Requirements and Ordering Information

- 3.1 Plates supplied to this product specification shall conform to Specification A 20/A 20M, which outlines the testing and retesting methods and procedures, permissible variations in dimensions and mass, quality and repair of defects, marking, loading, and so forth.
- 3.2 Specification A 20/A20M also establishes the rules for ordering information that should be complied with when purchasing plates to this specification.
- 3.3 In addition to the basic requirements of this specification, certain supplementary requirements are available where additional control, testing, or examination is required to meet end use requirements.
- 3.4 The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specification A 20/A20M.
- 3.5 Coils are excluded from qualification to this specification until they are processed into finished plates. Plates produced from coil means plates that have been cut to individual lengths from coil. The processor directly controls, or is responsible for, the operations involved in the processing of coils into finished plates. Such operations include decoiling, leveling, cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

Note 1—For plates produced from coil and furnished without heat treatment or with stress relieving only, three test results are reported for each qualifying coil. Additional requirements regarding plate produced from coil are described in Specification A 20/A 20M.

3.6 If the requirements of this specification are in conflict with the requirements of Specification A 20/A20M, the requirements of this specification shall prevail.

4. Materials and Manufacture

4.1 Steelmaking Practice—The steel shall be killed and shall conform to the fine austenitic grain size requirement of Specification A 20/A 20M.

5. Heat Treatment

- 5.1 Plates 1.50 in. [40 mm] and under in thickness may be supplied in the as-rolled condition or normalized.
- 5.2 Plates over 1.50 in. [40 mm] in thickness shall be normalized.
- 5.3 If approved by the purchaser, cooling rates faster than those obtained by cooling in air are permissible for improvement of the toughness, provided the plates are subsequently tempered in the temperature range 1100 to 1300 °F [595 to 705 °C].

6. Chemical Composition

6.1 The steel shall conform to the chemical requirements given in Table 1

7. Mechanical Properties

- 7.1 Tension Test—The plates, as represented by the tension test specimens, shall conform to the requirements given in Table 2.
- 7.2 Impact Tests The material shall be capable of meeting the Charpy V-notch tests in Table 2 of this specification. Impact testing shall be in accordance with specification A 20/A 20M.
- 7.3 Elevated Temperature Yield Strength The material shall be capable of meeting the yield strength values in Table 3 when tested at the temperatures listed in Table 3. The values at temperatures not listed in Table 3 may be obtained by interpolation.

8. Keywords

8.1 carbon steel; carbon steel plate; pressure containing parts; pressure vessel steels; steel plates for pressure vessels

TABLE 1 Chemical Requirements

Elements		Compos	ition, %	
	Grade 55 [Grade 380]	Grade 60 [Grade 415]	Grade 65 [Grade 450]	Grade 70 [Grade 485]
Carbon, max ^{A, B} ;				
1/2 in. [12,5 mm] and under	0.18	0.21	0.24	0.25
Over 1/2 in. to 2 in. [12.5 to 50 mm], incl	0,20	0.23	0.25	0.25
Over 2 in. to 4 in. [50 to 100 mm], incl	0.22	0.25	0.25	0.25
Over 4 to 8 in. [100 to 200 mm], incl	0,24	0.25	0.25	0.25
Over 8 in. [200 mm]	0.25	0.25	0.25	0.25
Manganese ^a :				
1/2 in. [12.5 mm] and under:				
Heat analysis	0,60-0.90	0.60-0.90 5	0.85-1.20	0.85-1,20
Product analysis	0.55-0.98	0.55-0.98 ^c	0.79–1.30	0.79-1.30
Over 1/2 in. [12.5 mm]:				
Heat analysis	0.60-1.20	0.85-1.20	0,85-1,20	0.85-1.20
Product analysis	0.55–1.30	0.79-1.30	0.79-1.30	0.79-1.30
Phosphorus,max ^A	0.025	0.025	0.025	0.025
Sulfur, max ^A	0.025	0,025	0.025	0.025
Silicon:				
Heat analysis	0.15-0.40	0.150.40	0.15-0.40	0.15-0.40
Product analysis	0.13-0.45	0.13-0.45	0.13-0.45	0.13-0.45

^A Applies to heat analyses. Product analysis, when specified, shall not be more thn0.02 % greater for carbon and 0.005 % for phosphorus and sulfur than the values listed in Table 1.

^B For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.05 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50 % by heat analysis and 1.60 % by product analysis.

TABLE 2 Mechanical Properties Requirements

	Grade						
,	55 [380]	60 [415]	65 [450]	70 [485]			
Tensile strength, ksi [MPa]	55-75 [380-515]	60-80 [415-550]	65–85 [450–585]	70-90 [485-620]			
Yield strength, min, Aksi [MPa]	30 [205]	32 [220]	35 [240]	38 [260]			
Eiongation in 8 in. [200 mm], min, % 8	23	21	19	17			
Elongation in 2 in. [50 mm], min, % ^a	27	25	23	21			
Impact Energy, Charpy V-notch, minimum average, ft-lb [J] at +88 °F [+20°C], or at a lower test temperature, as specified in the purchase order.	20 [27]	20 [27]	20 [27]	20 [27]			

 $^{^{\}rm A}$ Determined by either the 0.2 % offset method or the 0.5 % extension-under-load method. $^{\rm B}$ See Specification A 20/A20M for elongation adjustment.

^c Grade 60 plates 1/2 in. [12.5 mm] and under in thickness may have 0.85–1.20 % manganese on heat analysis, and 0.79–1.30 % manganese on product analysis. ^DThe sum of the percentages of the elements chromium, copper, and molybdenum shall not exceed 0.45 %.

ATTACHMENT 2 - PAGE 4 OF 6

Table 3 Yield Strength at Elevated Temperatures

	Yield Strength, ksi [MPa] at Temperature, °F [°C]											
Grade	150 [65]	200 [95]	250 [120]	300 [150]	400 [205]	500 [260]	600 [315]	700 [370]	800 [425]			
55	28.2 [195]	27.5 [190]	27.0 [186]	26.5 [183]	25.6 [177]	24.4 [168]	23.0 [159]	21.5 [148]	20.1 [139]			
60	30.1 [208]	29.3 [202]	28.8 [199]	28.3 [195]	27.3 [188]	26.1 [180]	24.5 [169]	22.9 [158]	21.5 [149]			
65	32.9 [227]	32.1 [221]	31.5 [217]	31.0 [214]	29.9 [206]	28.5 [197]	26.8 [185]	25.1 [173]	23.5 [162]			
70	35.7 [246]	34.8 [240]	34.2 [236]	33.6 [232]	32.5 [224]	31.0 [214]	29.1 [201]	27.2 [188]	25.5 [176]			

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the purchase order.

A list of standardized supplementary requirements for use at the option of the purchaser is included in ASTM Specification A 20/A 20M. Those that are considered suitable for use with this specification are listed below by title.

Vacuum S1. Treatment,

Product S2. Analysis,

Simulated S3. Post-Weld Heat Treatment of Mechanical Test Coupons,

Additional S4.1 Tension Test,

Charpy V-Notch S5. Impact Test,

Drop Weight Test (for Material 0.625 in. S6. [16 mm] and over in Thickness),

High-Temperature S7. Tension Test,

Ultrasonic S8. Examination in accordance with Specification A 435/A 435M,

Magnetic S9. Particle Examination,

Ultrasonic S11. Examination in accordance with Specification A 577/A 577M,

Ultrasonic S12. Examination in accordance with Specification A 578/A 578M, and

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or serviceastm.org (e-mail); or through the ASTM website (www.astm.org).