Allegheny Ludlum
An Allegheny Technologies Company

Technical Data BLUE SHEET

Allegheny Ludlum Corporation ◆ Pittsburgh, PA

Stainless Steels

Type 201 and Type 201L

(UNS Designation S20100 and S20103)

GENERAL PROPERTIES

Allegheny Ludlum types 201 and 201L are austenitic chromium-nickel-manganese grades (see the following table) representing an entirely separate group within the family of austenitic stainless steels. Types 201 and 201L account for the greatest tonnage of the Cr-Ni-Mn steels (200 series), which are a smaller group than the Cr-Ni stainless steels (300 series).

Chemical Analysis - Weight Percent

Elements	Composition Range Per ASTM A240	
	Type 201	Type 201L
Carbon	0.15 Max.	0.03 Max.
Manganese	5.50/7.50	5.50/7.50
Silicon	1.00 Max.	0.75 Max.
Chromium	16.00/18.00	16.00/18.00
Nickel	3.50/5.50	3.50/5.50
Nitrogen	0.25 Max.	0.25 Max.
Iron	Balance	Balance

Types 201 and 201L are comparable to chromium - nickel types 301, 304, 304L in many respects, but they can provide some advantages over the 18-8 grades in certain applications. Lower cost manganese and nitrogen additions are partial substitutes for nickel in types 201 and 201L, making them more economical alloys. Because they possess a very desirable combination of economy plus good mechanical properties and corrosion resistance properties, they have been used in a wide variety of consumer and transportation applications, as illustrated in the following table.

Typical Applications For Types 201 and 201L

Formability	Structural Strength
Cookware Bodies/Lids Hose Clamps Piston Rings Washing Machine Basket	Transit Car Structural Member Transit Car Roofing/ Siding Thermal Window Spacers Air Bag Containers Truck Trailer Posts and Door Frames

Allegheny Ludlum types 201 and 201L are available in plate, sheet, and strip product forms and are listed in ASTM A240 as types 201-1 and 201-2.

Type 201 has properties similar to type 301, providing excellent mechanical properties in the annealed condition (i.e., strength and formability). Because of its high work hardening rate, it exhibits a high uniform elongation for improved stretchability for severe forming applications such as washing machine baskets.

Type 201L is a low carbon version of type 201 and maintains satisfactory intergranular corrosion resistance in applications involving welding particularly heavier gage material.

Balancing of alloying elements (austenitizers versus ferritizers) in types 201 and 201L produces an austenitic structure in the annealed condition even at sub-zero temperatures. This austenitic structure achieves significant strengthening through cold working of the material to produce the transformation to a stronger martensitic structure.

Thus types 201 and 201L can display a wide range of mechanical strengths starting from the annealed condition and increasing with increasing degrees of cold working to levels of strength which are necessary

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for several applications such as transit cars or truck trailer components.

CORROSION PROPERTIES

Allegheny Ludlum stainless steel type 201 is resistant to a wide variety of mild to moderately corrosive media. Generally speaking, type 201 has proven to be entirely adequate for many applications where type 301 has been satisfactory and has been successfully substituted for type 304 in a variety of mild environments.

General Corrosion

Types 201, 301, and 304 exhibit comparable corrosion behavior in an organic acid environment.

Corrosion Resistance in Boiling Solution

Boiling Test Solution	Corrosion Rate in Mils/Year (mm/y)		
	Type 201	Type 301	Type 304
20 % Acetic Acid	0.11 (.0028)	0.06 (.0016)	0.07 (.0018)

* Annealed material tested as duplicate samples for five 48-hour test periods.

The low carbon in type 201L contributes to its resistance to precipitation of chromium carbides as well as degradation of intergranular corrosion behavior.

Unlike the standard carbon grades, the low-carbon types 201L and 304L did not show increased corrosion rates or cracking in the sensitized condition when compared to an annealed version or as-welded version of that grade.

Intergranular Corrosion Tests

Tests Per ASTM A262	Corrosion Rate Mils Per Year (mm/y)				
	Type 201	Type 201L	Type 301	Type 304	Type 304L
Practice B	**Boiling Ferric Sulfate 50% Sulfuric Acid**				
Annealed	56.6 (1.439)	68.2 (1.733)	31.7(0.805)	20.8 (0.527)	20.4 (0.518)
As Welded*	59.1 (1.501)	66.5 (1.689)	32.2 (0.813)	22.4 (0.570)	20.5 (0.521)
Sensitized**	dissolved	70.5 (1.791)	**6105 (155.)**	**1654 (42.0)**	26.6 (0.675)
Practice C	**65% Nitric Acid, Boiling**				
Annealed	13.3 (0.337)	23.9 (0.607)	13.1 (0.332)	10.2 (0.259)	9.12 (0.232)
As Welded*	12.6 (0.321)	23.3 (0.593)	13.8 (0.350)	10.0 (0.253)	7.44 (0.189)
Sensitized**	**2379 (35.0)**	38.7 (0.982)	**1717 (28.4)**	**441 (11.20)**	17.3 (0.439)
Practice E	**Copper/16% Copper Sulfate/Sulfuric Acid, Boiling**				
Annealed	no cracks	no cracks	no cracks	no cracks	no cracks
As Welded*	no cracks	no cracks	no cracks	no cracks	no cracks
Sensitized**	cracked	no cracks	cracked	cracked	no cracks

* TIG welded material

** Samples heat treated at 1250°F(677°C) for one hour and air cooled. Results in bold letters are for tests that were discontinued because of high corrosion rates.

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Localized Corrosion

The crevice corrosion behavior of types 201, 301, and 304 in a sodium chloride solution are comparable. Susceptibility to crevice corrosion in chlorides increases with increases in temperatures.

Chloride Crevice Corrosion Resistance*

Grade	Test Temperature °F (°C)	Average Corrosion Weight Loss g/cm²
Type 201	100 (38)	0.0000
Type 301	100 (38)	0.0000
Type 304	100 (38)	0.0000

* Based on ASTM G48 Test Method, modified by testing duplicate samples in a 3.5% sodium solution with an adjusted pH of 4.0.

OXIDATION RESISTANCE

Allegheny Ludlum Stainless Steel type 201 possesses good resistance to oxidation and is comparable to type 301 up to about 1550°F (840°C); but it scales more rapidly above this temperature. For intermittent service, particularly when rapid cooling is involved, type 201 is not recommended for service conditions where temperature conditions above 1500°F (815°C) are encountered. Since the rate of oxidation is affected by the atmosphere to which the metal is exposed, by the heating and cooling cycle, and by the structural design, it is impossible to present data which would be applicable to all service conditions.

PHYSICAL PROPERTIES

Melting Range, °F (°C)
2550-2650 (1400-1455)

Density, lbs. per cu. in. (g/cm³)
0.284 (7.86)

Specific Gravity
7.86

Electrical Resistivity, (microhm-cm)
67 @ 68°F (20°C)

Coefficient of Thermal Expansion

Temperature Range		Mean Coefficient of Thermal Expansion	
°C	°F	cm/cm/°C	in./in./°F
20-100	68- 212	16.6×10^{-6}	9.2×10^{-6}
20-316	68- 600	18.0×10^{-6}	10.0×10^{-6}
20-538	68-1000	19.6×10^{-6}	10.9×10^{-6}
20-871	68-1600	20.3×10^{-6}	11.3×10^{-6}

Thermal Conductivity

Temperature Range			
°C	°F	W/m·K	Btu/(hr·ft·°F)
20-100	68-212	16.3	9.4

Specific Heat

Temperature Range			
°C	°F	J/kg·K	Btu/lb./°F
0-100	32-212	502	0.12

Magnetic Permeability

Properly annealed types 201 and 201L are fully austenitic materials and have a magnetic permeability generally less than 1.02. Cold working promotes the formation of martensite which results in an increase in magnetic permeability. This increase is dependent upon the exact alloy composition within the specified range, as well as on percent cold reduction. The data below illustrates the increase in magnetic permeability with cold rolling.

Magnetic Permeability

Percent Cold Reduction	D. C. Permeability (μ at 200 H)	
	Type 201	Type 201L
Annealed	1.004	1.008
5	1.014	1.008
10	1.048	1.235
20	1.96	3.42
30	3.95	9.61
40	7.07	22.0
50	13.8	30.0
60	16.0	36.0

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MECHANICAL PROPERTIES

Types 201 and 201L are used both in the fully annealed condition and in the cold rolled (temper rolled) condition. The mechanical properties of types 201 and 201L vary considerably depending upon the amount of cold work introduced. The response to cold work can be controlled to a certain extent by a balance of alloying elements. These grades develop higher tensile strengths than other more stable austenitic grades and for this reason have found a wide field of application in structural assemblies. Types 201 and 201L may be cold rolled to very high strength levels as indicated in the tables below and the graphs on Page 5.

Cold Reduction on Room Temperature Mechanical Properties of Sheet

Longitudinal

Percent Cold Reduction	Tensile Ksi(MPa)		0.2% Yield Strength Ksi (MPa)		Elongation Percent in 2" (51mm)		Hardness HRB & HRC	
	Type 201	Type 201L	Type 201	Type 201L	Type 201	Type 201L	Type 201	Type 201L
Annealed	101.0 (696)	114.0 (785)	43.6 (301)	57.5 (396)	56.0	56.0	85.0 HRB	93.0 HRB
5	118.0 (814)	125.4 (865)	78.8 (543)	84.0 (579)	42.5	43.3	99.5 HRB	25.0
10	130.8 (902)	138.8 (957)	98.3 (678)	97.4 (672)	32.5	33.0	28.5	31.0
20	156.4 (1044)	165.3 (1140)	121.4 (837)	122.2 (843)	22.3	22.3	34.5	38.0
30	176.2 (1214)	178.1 (1228)	152.3 (1050)	160.7 (1108)	14.0	17.3	39.0	41.0
40	183.3 (1264)	212.8 (1467)	158.3 (1091)	205.8 (1419)	13.3	8.3	42.5*	44.5
50	216.9 (1495)	235.7 (1625)	198.4 (1368)	223.5 (1541)	3.8	3.0	45.5*	48.5*
60	246.7 (1701)	256.2 (1766)	239.2 (1649)	246.1 (1697)	3.5	3.5	47.0*	49.0*

* Samples from cold rolled sheet were tested at ambient temperature
** HR30N test values were converted to HRC values per ASTM E140

Transverse

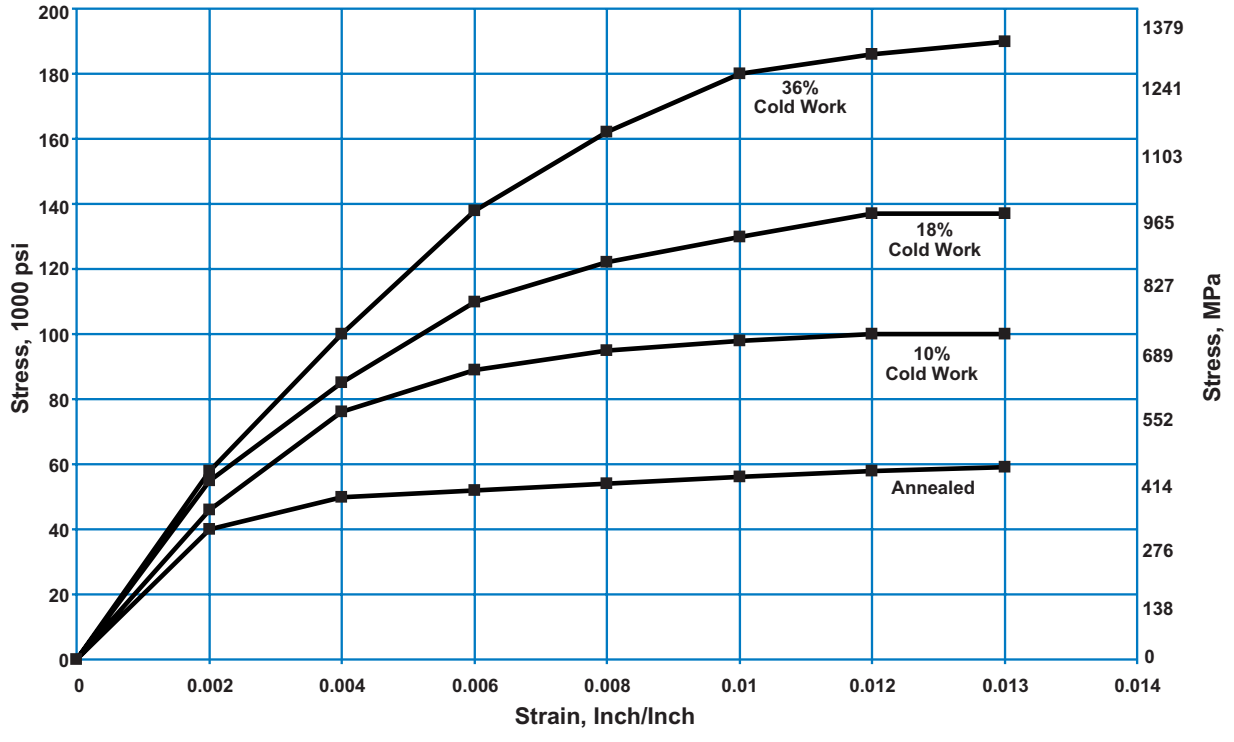
Percent Cold Reduction	Tensile Ksi(MPa)		0.2% Yield Strength Ksi (MPa)		Elongation Percent in 2" (51mm)		Hardness HRB & HRC	
	Type 201	Type 201L	Type 201	Type 201L	Type 201	Type 201L	Type 201	Type 201L
Annealed	99.4 (685)	—	42.4 (292)	—	62.5	—	85.0 HRB	—
5	113.6 (783)	124.1 (856)	82.5 (569)	86.7 (598)	38.0	43.0	99.5 HRB	25.0
10	124.1 (856)	136.1 (938)	93.5 (645)	103.8 (716)	31.3	32.8	28.5	31.0
20	151.5 (1045)	162.8 (1123)	115.3 (795)	132.7 (915)	17.5	18.0	34.5	38.0
30	177.5 (1224)	181.7 (1253)	144.5 (996)	158.5 (1093)	11.5	14.3	39.0	410
40	188.5 (1300)	217.4 (1499)	156.4 (1078)	187.4 (1292)	11.3	78.0	42.5*	44.5
50	220.7 (1522)	236.6 (1631)	180.2 (1242)	200.3 (1381)	4.8	35.0	45.5*	48.5*
60	252.7 (1742)	255.5 (1762)	251.0 (1731)	235.4 (1623)	1.5	3.3	47.0*	49.0*

* HR30N test values were converted to HRC values per ASTM E140.

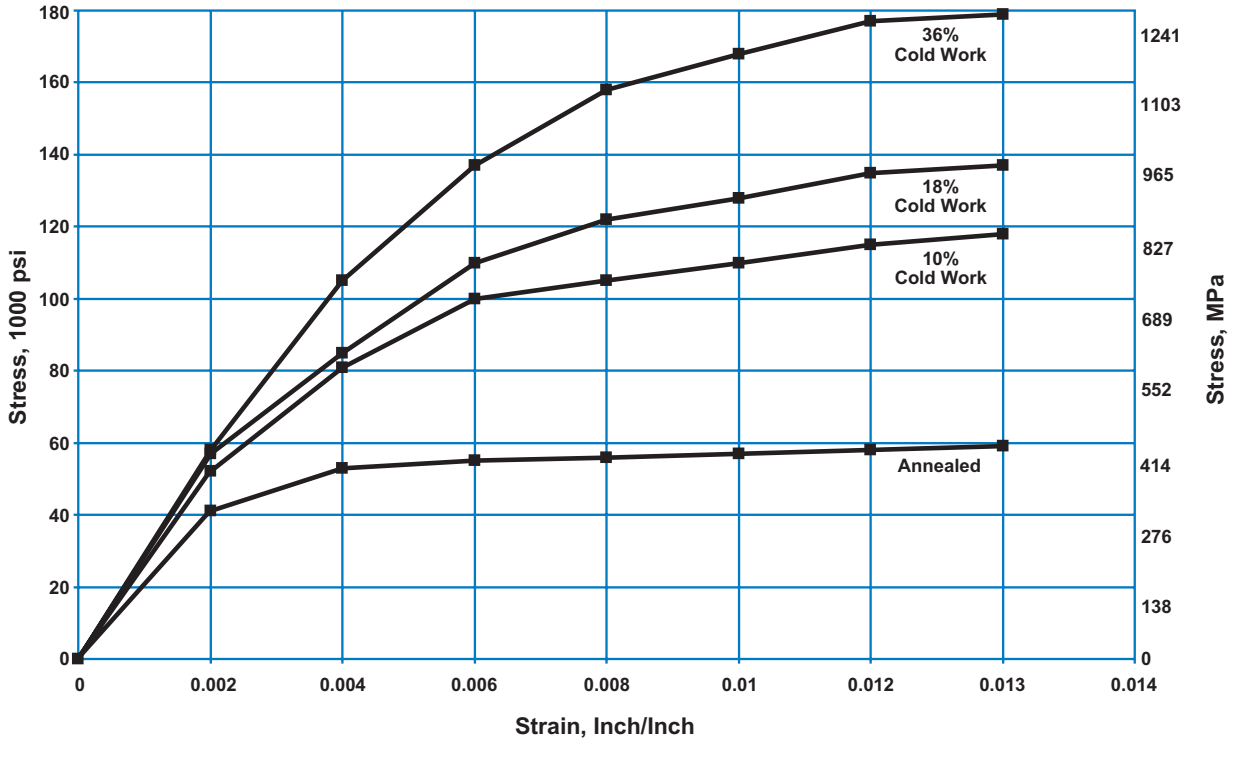
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Longitudinal Tension



Transverse Tension



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Like other austenitic stainless steels, type 201 does not exhibit a well defined transition from the elastic to the plastic range. For this reason, its yield strength is conventionally defined as the stress at which a line drawn with the initial slope of the stress-strain curve and the offset 0.2% on the abscissa intercepts the stress-strain curve.

Cold rolled type 201 shows slightly different properties in the direction of rolling and at right angles to this direction. There is also a considerable difference in yield strength in compression and in tension as is shown in the following data.

Transverse Mechanical Properties in Tension and Compression of Type 201

Percent Cold Reduction	Tension		Compression	
	Yield Strength 0.2% Offset psi (MPa)	E x 10^{-6} psi (GPa)	Yield Strength 0.2% Offset psi (MPa)	E x 10^{-6} psi (GPa)
Annealed	50,000 (345)	30.0 (207)	53,000 (365)	30.0 (207)
10	90,000 (621)	30.4 (210)	64,000 (441)	28.3 (195)
20	121,700 (839)	27.8 (192)	73,000 (503)	27.5 (190)
40	164,000 (1131)	26.6 (183)	86,700 (598)	26.8 (185)

The data shown below illustrates the effect of stress relieving at 800°F (427°C) on material from the same heat used to obtain the preceding data. Stress relieving in the range of 600 to 900°F (315-482°C) can reduce the differences in modulus induced by cold rolling, increase the yield strength, and minimize the differences in longitudinal and transverse properties.

This tendency increases with increasing cold reduction as a general rule. Compressive yield strength in the longitudinal direction is most affected by such stress relief treatments.

Effect of Stress Relieving on Type 201 Transverse Mechanical Properties

Percent Cold Reduction	Tension		Compression	
	Yield Strength 0.2% Offset psi (MPa)	E x 10^{-6} psi (GPa)	Yield Strength 0.2% Offset psi (MPa)	E x 10^{-6} psi (GPa)
10	100,000 (689)	29.5 (203)	92,800 (640)	29.8 (205)
20	130,200 (898)	27.6 (190)	123,250 (850)	29.0 (200)
40	181,800 (1253)	28.4 (196)	154,500 (1065)	30.0 (207)

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ELEVATED TEMPERATURE STRENGTH PROPERTIES

Typical Short Time Tensile Properties

Test Temperature °F	(°C)	Yield Strength 0.2% Offset psi(MPa)		Tensile Strength psi(MPa)		Elongation Percent in 2" (51mm)
70	(21)	53,050	(365.8)	117,275	(808.6)	55.5
200	(93)	38,890	(268.1)	97,645	(673.2)	62.5
400	(204)	30,895	(213.0)	81,370	(561.0)	46.5
600	(315)	27,360	(188.6)	79,040	(545.0)	44.0
800	(427)	26,210	(180.7)	76,530	(527.7)	45.5
1000	(538)	23,405	(161.4)	69,530	(479.4)	33.0
1200	(649)	20,480	(141.2)	47,625	(328.3)	28.5
1400	(760)	18,190	(125.4)	27,210	(187.6)	27.5
1600	(871)	14,020	(96.66)	18,925	(130.5)	55.0

The short time high temperature properties of a representative heat of type 201 in the annealed condition are shown. Above 800°F (427°C), design should be based on creep and stress-rupture properties.

Typical Stress Rupture Properties

Test Temperature		Rupture Stress, psi (MPa)						Elongation Percent in 2" (51"mm)	
°F	(°C)	100 hrs		1,000 hrs		10,000 hrs		100 hrs	1,000 hrs
1200	(649)	29,000	(200)	22,000	(152)	16,500	(114)	14	14
1350	(734)	15,000	(103)	10,000	(69)	6,600	(45)	16	22
1500	(816)	7,400	(51)	4,000	(28)			35	42

HEAT TREATMENT

Types 201 and 201L are annealed between 1850-2000°F (1010-1093°C). Annealing practices applied to type 301 are, in general, suitable for types 201 and 201L, although it is recommended that annealing temperatures do not exceed 2000°F (1093°C) to avoid excessive oxidation. The primary purposes of annealing are to relieve strain, recrystallize the material if it has been cold worked, and take carbides into solution. For type 201, rapid cooling through the carbide precipitation range is necessary to keep carbides in solution. For thin sections, air cooling is usually sufficient, while heavier sections should be water quenched. If the work can be cooled to “black” within 3 minutes by air cooling, this practice is preferred.

When properly annealed, types 201 and 201L are predominantly austenitic, however, they may contain small amounts of delta ferrite. Cold rolling promotes the formation of martensite. Exposure to the temperature range 800-1500°F (427-816°C) results in grain boundary carbide precipitation.

FABRICATION

Welding

Types 201 and 201L can be welded by all conventional methods applied to 18 percent chromium, 8 percent nickel steels. Filler wire or electrodes of the conventional chromium-nickel analyses can be used. Like other chromium-nickel 300 series austenitic stainless steels where carbon is not controlled below 0.03%, type 201 is sensitive to intergranular corrosion in the weld heat affected zone.

Hot Working

Types 201 and 201L have hot working characteristics similar to that of 300 series stainless steels. The normal hot working range for types 201 and 201L is 2100-2250°F (1150-1230°C).

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Cold Forming

In most applications where types 201 and 201L have been used, bending, forming and drawing operations have been successfully carried out following essentially the same practice as employed for type 301.

References for Additional Details

ASTM A240- Heat Resisting Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.

ASTM A480- General Requirements for Flat-Rolled Stainless and Heat Resisting Steel Plate, Sheet, and Strip.

ASTM A666- Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

ASTM A262- Standard Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels.

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