General Welding Guidelines

National Certified Pipe Welding Bureau

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The National Certified Pipe Welding Bureau (NCPWB) gratefully acknowledges the permission from ASTM to use their data on copper tube sizes in this publication.

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TABLES

FORWARD

These General Welding Guidelines are intended to provide background information and supplementary instructions to contractors and their welders who are using National Certified Pipe Welding Bureau Welding Procedures Specifications (WPSs).

This document is divided into two sections: Mandatory Practices and Recommended Practices.

The “Mandatory Practices” are in addition to the instructions provided on the WPS and are considered part of the requirements stated on the WPS.

The “Recommended Practices” provides additional information to the welder on variables, which are not covered in the WPS. These practices are recommended to be followed unless other direction is provided by the welder’s supervisor.

MANDATORY PRACTICES

General

All ASME Section IX variables are covered in the Welding Procedure Specifications (WPSs). The welder shall follow the instructions in the WPS when making Code welds.

In addition to the instructions in the WPSs, the following portion of the General Welding Guidelines shall be followed during all welding.

Joints

Unless specifically required by the WPS or by details on the engineering drawings, the use of nonmetallic backing and nonfusing metal retainers is not permitted. When backing is shown as "Required" on the WPS, the backing shall be backing ring or strip, or it shall be weld metal deposited by another process or electrode type or the joint shall be made from both sides of the joint (i.e., backwelded). Fillet welds are considered welding on backing, and all sizes of fillet welds may be made using any NCPWB WPS on any thickness or diameter base metal.

Filler Metal

Welding without the addition of filler metal, such as might be used for tight-butt welds on schedule 10 pipe or for wash passes made on the cover to improve surface appearance, is not permitted unless the WPS specifically permits welding without the use of filler metal (i.e. the column "ROOT" on the WPS has "NONE" for the filler metal.)

Postweld Heat Treatment

The required postweld heat treatment temperature range indicated on the engineering drawing shall govern when using a Welding Procedure Specification, which permits the weld to be made either with or without heat treatment.

Postweld heat treatment holding time and heating and cooling rates shall be in accordance with the applicable code or contract requirements.

RECOMMENDED PRACTICES

General

The instructions contained in this portion of the guidelines provide additional information to the welder concerning variables, which are not usually addressed by the Welding Procedures. The direction provided by the Welding Procedure Specification and the "Mandatory Practices" in this document constitute the minimum requirements for code welding. The above requirements may not be changed by the following "Recommended Practices" provided in this document.

Joints

End preparations shall be in accordance with the details provided in the construction drawing(s), or as provided on the WPS. All groove welds shall be prepared and fit up in such a way that a full penetration weld can be made except where partial penetration welding is shown on the construction or engineering drawing. This includes both butt and branch connection welds on piping.

Care shall be taken when cutting the pipe to make the plane of the cut square to the axis of the pipe, so that the flat land and root spacing will be uniform all the way around the pipe.

End preparations shall be made by mechanical cutting or flame cutting. Irregularities should be removed by grinding. The bevel shall be uniform so that the resulting land is uniform around the pipe. The finished surface shall be reasonably smooth and suitable for welding.

The surfaces to be welded and the inside and outside surfaces of the base metal shall be cleared of all contamination for one inch back from the bevel before the pipe is aligned and tack welded. Special cleaning methods shall be used when specified in the Welding Procedure Specification.

Remove grease, oil and cutting fluid using appropriate solvents. After removing grease, oil or cutting fluid residue, remove paint, varnish, rust, dirt or oxide using a wire brush or grinding wheel. Paint which is designed to be welded over, such as “Deoxaluminite” may be welded over without removal. Brushing with a power wire brush to remove excess build-up (i.e., runs) of weldable coatings is recommended.

When wire brushing stainless steel, use only austenitic stainless steel wire brushes. Brushes for use on stainless steel or other corrosion-resistant metals should be segregated and not be used on carbon or low alloy steel. These ordinary steel will contaminate the brush and result in surface rusting of the corrosion-resistant metal if the brush is used on corrosion-resistant metals.

The components being joined shall be aligned to provide the root gap spacing given in the WPS. The inside surfaces shall be aligned to within 1/16", or as shown in the WPS. When the inside surfaces do not match within the required tolerance, the surfaces shall be ground or weld metal shall be added to bring the surfaces into alignment. When the surfaces are ground or weld metal is added, the taper from the original surface shall not exceed 30° maximum on internal original surfaces and 3:1 (about 18°) maximum on external surfaces. The minimum wall thickness required by engineering calculations shall be present after proper

alignment has been achieved. This may require the addition of weld metal to outside pipe wall. It is recommended that alignment be verified by using "Hi-Lo" gauges after has been fit-up and tack welded.

When backing is shown as "Required" on the WPS, the backing shall be backing ring or strip or other material shown above, or it shall be weld metal deposited by another process or electrode type for welds made from one side. Welds which are made from both sides of a joint and fillet welds are considered as welding "on backing," in which case the same process and electrode may be used on both sides.

Alignment shall be done using external alignment clamps or by tack welding the ends. The use of welded lugs or attachments and wedges to bring pipe into alignment is permitted. If the base metal is alloy steel, the preheat required by the WPS shall be used for tack welding and for attachment of alignment materials. Lugs should be removed by cutting and grinding followed by visually inspecting the pipe surface for defects. Care should be taken not to grind into the base metal when removing temporary welds

Tack welds, which will be incorporated into the final weld, shall be tapered on both ends to facilitate proper fusion. Any defective tack welds shall be removed by grinding. Tack welds, which have been removed, shall be replaced if necessary to maintain alignment or to prevent closing of the root opening during root pass welding.

Fillet weld sizes, as shown on the Welding Procedure Specification shall be used unless otherwise detailed on the engineering drawing. Fillet welds shall be made so that they penetrate fully into the root.

Electrodes and Filler Metals
Low hydrogen welding electrodes, such as E7015, E7018, E8018, E9018 and E308-16 shall be purchased in vacuum-sealed plastic wrappers or hermetically sealed containers. After removal from the containers, these electrodes shall be stored in holding ovens at 200 to 300°F. Welders shall not take more electrodes than can be consumed in the time permitted as shown in Table 1 when using leather rod pouches or other unheated containers. These electrodes are not permitted to be stored in pockets of clothing, since they will absorb body moisture. The use of portable holding ovens is recommended. Electrodes that have been exposed to the atmosphere for more time than permitted by Table 1 shall be destroyed or baked at 700 ± 50°F for 2-hour minimum.

TABLE 1
Low-Hydrogen Electrode Exposure Time Limits

Electrode Class	Exposure Time*
E7018	8 hours
E8018	4 hours
E9018, E502	2 hours
E10018, E11018	2 hours
E308-16	8 hours

* For electrodes designated as moisture resistant (e.g., E7018R), the exposure times may be doubled.

Note: In the above examples, the electrode classes E7018, E8018, etc. are intended to include all other low-hydrogen classes of electrodes, such as E7015, E7016, E8015, E9016, etc. The electrode class E308-16 is intended to include all

E3XX-15 and E3XX-16 electrodes. The electrode E502 is intended to include all E4XX, E5XX and E7Cr electrodes.

When portable heated rod containers are used, there is no time limit provided the containers are kept hot.

Electrodes other than the low-hydrogen type shall be stored in a dry place, sheltered from the elements, preferably at normal room temperature and humidity. E6010 and E6011 electrodes shall never, ever be stored in heated holding ovens.

The use of low-hydrogen welding electrodes is recommended for all Shielded Metal Arc Welding (SMAW), except that the use of EXX10 or EXX11 classification is recommended for root passes in order to assure full penetration.

Preheating and Interpass Temperature

Preheating and interpass temperature shall be as indicated in the Welding Procedure Specification. When higher preheat is required by the applicable construction code (i.e. B31.1, B31.9, etc.), that preheat shall be used for production welding. Welding on metal that is wet is strictly prohibited; wet metal shall be heated until it is at least warm to the touch to assure removal of moisture.

The following additional preheat is recommended for P-1, Group 2 materials (e.g, thick A-105 flanges):

TABLE 2

Recommended Supplemental Preheat

Thickness (in.)	Preheat (°F)
Over 1/4 to 3/4	150
Over 3/4 to 1-1/4	200
Over 1-1/4 to 2-1/2	250
Over 2-1/2	300

Preheat and interpass temperature measurement shall be made using temperature measuring crayons, contact pyrometers or infrared thermometers. Preheat temperature shall be measured on the base metal on the outside surface of the pipe or on the beveled edge near the outside surface. Interpass temperature shall be measured on the weld metal or on the base metal near the weld metal prior to beginning the subsequent weld bead pass. When using temperature measuring crayons, any residual crayon shall be removed before welding over the marked area.

Shielding and Backing Gas

When welding with a gas-shielded welding process, the area in which welding is being done shall be protected from drafts which can cause loss of the gas shield. Wind velocities in excess of 5 mph are high enough for this to happen, resulting in surface oxidation of the weld metal, oxide contamination in the deposit, porosity, and loss of mechanical properties. The use of tent-like enclosures is recommended in unsheltered areas.

Proper gas coverage is indicated on most materials by a silver or light gold color of the weld bead. After breaking the arc, keep the torch over the weld bead long enough to prevent it from oxidizing. Filler metal and tungsten should also be kept under the protection of the inert gas until it has cooled to well below the temperature at which it was glowing. Purging of the hose and torch assembly is recommended if the equipment has not been used for several hours.

When sharpening a tungsten electrode by grinding, make a small flat on the pointed end about 1/16" across. Final grinding of tungsten electrodes should be done parallel to the axis of the electrode so that the grinding marks go in the direction of the point. Use of a diamond wheel is highly recommended.

Purging shall be done using the purge gas specified in the Welding Procedure Specification. The use of hard, removable or inflatable type dams is recommended when the end of the pipe is open so that the dam can be removed after making the weld. The use of water soluble paper dams is recommended for welds when removable dams cannot be used. When backing flux is used, the acceptability of these should be approved by the customer since the residual material may contaminate the product stream.

Hard, removable purge dams can be made from wood, hardboard or metal disks which are slightly smaller that the pipe inside diameter. The edges of the disks should be wrapped with a rubber gasket or foam material so the dam is held in place by friction, yet is not so firmly held that is difficult to remove. The dams should be far enough back from the weld area so that the heat from welding does not

damage them. The dams should be connected to ropes or wires that can be used to pull them out after welding is complete. Do not remove dams until at least three weld passes are complete, and the weld is cool enough to avoid damaging the dam material. Purge dams are also commercially available.

When using dams or when purging entire assemblies of pipe, the welder should keep in mind that Argon is slightly heavier than air, and that it will displace the air upward, somewhat in the same manner as if the pipe were being filled with water. The argon entry port should be located at the physically lowest part of the piping, and the air discharge port should be located at the physically highest part of the piping.

The purge time may be established using Table 6 (page 25). Alternatively, the displaced gas may be monitored using an oxygen meter. Welding may begin when the oxygen level is below 2% for stainless steel and 1% for nickel alloys. A flow rate of 50 CFH is recommended for all purging until the desired purge time or oxygen level is achieved. Once this is complete, the purge gas flow rate should be reduced to maintain a slight positive pressure inside the pipe while the root pass and a few additional passes are being welded. This practice will prevent the aspiration of oxygen into the inside of the pipe by the shielding gas from the torch.

After the joint is aligned, including internal alignment and root spacing, the groove(s) should be taped shut except that an air discharge gap may be left open on the top of the pipe when the pipe is in the horizontal position. Tack welds should be made after purging is complete by peeling back 1 to 2 inches of tape, reducing the gas flow rate until there is a

slight gas flow outward from the opening, then making the tack. Replace the tape after the tack is made. Repeat this process at each location at which a tack is desired. After tacking, turn the purge gas flow rate up, remove that tape and grind, feather and inspect each tack, then replace the tape, and reestablish the purge. Make the initial weld by peeling back about 2 inches of tape on one side of a tack weld, reduce the purge gas flow rate until there is a slight outward flow, and begin welding. Peel the tape back no more than a couple of inches at a time to be sure that the purge is maintained and to preclude aspiration of air into the inside of the pipe.

Tack welding of consumables inserts may be done without first purging the pipe provided that very small tack welds are made which do not fuse the internal portion of the insert.

Cleaning

Initial cleaning shall be performed using the methods described in the Welding Procedure Specification. Surfaces to be welded shall be free of grease, oil, paint, rust mill scale and cutting oxides for at least 1/2 inch along the pipe from the end preparation bevel.

Interpass cleaning shall be done using the methods described in the Welding Procedure Specification. All slag, silica deposits and other residual deposits from the welding process on the surface of the weld and the surrounding base metal shall be removed. The weld surface shall be inspected and ground as necessary after each pass to be sure that the contour of the weld is sound and that the geometry is suitable for depositing the next layer of weld metal.

The completed weld shall be cleaned using the method described in the Welding Procedure Specification for interpass cleaning.

Environmental Requirements

Welding shall not be done when the air temperature is below zero degrees F.

When welding with Gas Tungsten Arc Welding (GTAW), the area in which welding is being done shall be protected from drafts which can cause loss of the gas shield. Wind velocities in excess of 5 mph are high enough to cause this to happen, resulting in surface oxidation on the weld metal, oxide contamination in the deposit, porosity, and loss of mechanical properties. The use of tent-like enclosures is recommended when welding outside or if there is wind. When welding pipe which is vertical or near vertical, the ends of the pipe should be capped off during welding to prevent loss of shielding or backing gas due to the "chimney effect." When using SMAW, the welding area shall be similarly protected when the wind velocity exceeds 20 MPH.

Welding Technique

The arc shall be struck on the face of the bevel or on previously deposited weld metal, not on the external surface of the pipe. When continuing the same bead around the pipe, it is preferred that the arc be struck on metal about 3/8" ahead of the previous bead then drawn back on to the previous bead before continuing forward progress.

The welder shall visually inspect each weld bead for defects. Any defects, including significant slag and porosity and all

cracks shall be removed by grinding or by carbon arc gouging following by grinding.

Beads not more than 3/4 inches wide are permitted for any welding process when the WPS permits weaving. When stringer beads are required by the WPS, the weld shall be made without significant motion of the electrode transverse to the direction of travel.

Prior to depositing the next weld bead, any weld metal build-up which may have been left at any weld stop or re-start locations shall be ground to blend uniformly with the surrounding deposit and base metal contour.

Welding from Two Sides

When the inside surface of a weld is accessible, it shall be visual examined by the welder for full fusion, adequate penetration, convexity and concavity. Any defects shall be removed by grinding to sound metal and welded from the inside, if necessary, to bring the weld metal flush with the surrounding base metal. On joints that are designed to be welded from both sides, the root pass shall be ground or carbon-arc gouged and ground to sound metal before depositing weld metal from the inside surface

The inside surface of a production joint may be backgouged using methods given in the Welding Procedure Specification and welded from the inside of the pipe, as necessary. Before welding the inside surface, that surface shall be visually inspected for defects, and additional grinding shall be done as needed to reach sound metal. When the WPS indicates that backgouging is “none,” it means that the procedure is not intended for use with backwelding; in these cases, use a

WPS which allows backwelding to make repairs from the second side.

Visual Examination

The completed weld shall be cleaned using the methods described in the Welding Procedure Specification for interpass cleaning. The welder shall visually inspect the finished weld surface for contour, reinforcement, undercut and surface appearance as required by the applicable Code.

As-welded surfaces are permitted; however, the surface of the welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys to avoid stress risers. Undercuts shall not exceed 1/32 in. or 10% of the wall thickness, whichever is less, and shall not encroach on the required section thickness. The surfaces of the finished weld shall be suitable to permit proper interpretation of radiographic and other required nondestructive examinations. If there is a question regarding the surface condition of the weld, the nondestructive testing technician shall determine whether or not the surface is suitable.

The weld metal for butt welds shall fill the groove until the weld metal is at least flush with the surrounding base metal. There is no minimum reinforcement required for groove welds, although welders should aim for approximately 1/16 inch of reinforcement in order to avoid conflicts with inspection personnel over adequacy of fill. Reinforcement shall merge smoothly into the surrounding base metal, and it shall not exceed the values given in Tables 3 and 4. Where the root side of a weld is accessible, it shall also be examined.

TABLE 3

ASME/ANSI B31.1 PIPING

Maximum Reinforcement (in.) at Design Temperature

Base Metal Thickness	Over 750°F	350/750°F	Less Than 350°F
Up to 3/16	1/16	1/8	3/16
Over 3/16-1/2	1/16	5/32	3/16
Over ½-1	3/32	3/16	3/16
Over 1	1/8	1/4	1/4

TABLE 4

ASME/ANSI B31.3 PIPING

Maximum Reinforcement Limits

Base Metal Thickness (in)	Maximum Reinforcement (in)
1/4 and thinner	1/16
Over 1/4 to 1/2	1/8
Over ½ to 1	5/32
Over 1	3/16

Concavity on the root side of a single welded circumferential butt weld is permitted when the resulting thickness of the weld is at least equal to the thickness of the thinner member of the two sections being joined and the contour of the concavity is smooth without sharp edges. The following

indications on surfaces that are accessible for visual examination are unacceptable:

- Cracks
- Lack of fusion
- Incomplete penetration when inside surface is readily accessible. (Note: For B31.3 Normal Fluid Service (i.e., where random radiography is required) and all B31.9 work, incomplete penetration up to 1-1/2 inches long in any 6 inches of weld length is acceptable.)
- Surface porosity having dimensions greater than 1/8 in. (5.0 mm) or four or more rounded indications of any size separated by 1/16 in. (2.0 mm) or less edge to edge in any direction.

Repairs

Defects found during inspections shall be removed as required to satisfy weld quality requirements. After defect removal, the section to be repaired shall be arc gouged and/or ground to make the repair cavity adequately open to allow easy access with the electrode to the bottom of the cavity. The surface to be welded shall be clean and smooth to ensure fusion. Repair welds may be made using the same WPS as was used to make the original weld or any other WPS appropriate for the combination of base metals, heat treatment, thickness, etc. to be welded. The repair cavity and surrounding base metal shall be preheated as required by the WPS or the governing code. When the base metal is a corrosion resistant alloy such as stainless steel, a backing gas should be used if the remaining base metal is less than

3/16" thick and when backing gas is required for the original construction.

Stamping of Welds

Each welder shall apply his identification at each weld using a steel die stamp. He shall stamp the base metal within one inch of the edge (toe) of the weld or on a flat spot ground on the weld metal. The welder may, when so directed, record his stamp number on permanent documentation at the reference to the weld(s) that he made, or he may mark the weld with appropriate identification using a vibratory etcher. Use of a permanent marker is acceptable for pipe that is less than 1/4 inch thick.

Safety

To ensure a safe workplace the welder or welding operator shall read and understand the safety policies of his employer. There are also certain inherent dangers that the welder needs to always keep in mind when engaged in welding operations. These can be reduced through safe work procedures and practices, some of which are listed below:

1. Keep your head out of the smoke plume when welding.

2. Wear proper eye and face protection (welding helmets, safety glasses with side shields, or goggles) with correct filter plates/lenses to avoid flash burns and to keep objects from hitting the eye. Make certain that others working around welding are adequately protected.

3. Wear flame resistant clothing, gauntlets and aprons to protect arms from heat, radiation and sparks. Avoid

pant cuffs or folds where hot metal can lodge while welding.

4. Make sure there is adequate ventilation to keep fumes from your breathing area. Before striking the arc, make sure area is free of dust, flammable liquid and fumes that could ignite or cause an explosion.

5. Do not enter confined spaces without first checking that there is sufficient good quality air available inside the confined space. Make sure continuous ventilation is provided when welding or cutting in confined spaces. Never use oxygen for ventilation.

6. Maintain welding equipment in a condition that prevents fire and electric shock.

For additional safety pointers read the MCAA publication "Safety Manual for the Mechanical Trades."

Welding Hazards

The OSHA Hazard Communication Standard requires that all workers be provided information on workplace hazards, and how, through proper work practices, exposure to these hazards can be reduced or minimized. Similar requirements may be enforced by state agencies.

During the welding process certain gases and fumes are generated which could be dangerous to your health. Before the start of welding read the warning labels on material containers to find out what hazards are associated with the use of the material.

Know the base metals being welded and know the type of hazardous fumes that may be created when the metal is heated to welding temperatures.

If you need more information on the material than is provided on the container label ask your supervisor to go over the "Material Safety Data Sheet" (MSDS) with you.

Welding Lens Shades

The following welding shades are recommended:

TABLE 5
Welding Lens Shade Selections

Application	Shade Number
Gas Cutting up to 1 inch thick	3 or 4
Gas Cutting over 1 inch thick	4 or 5
SMAW up to 5/32 inch electrodes	10
SMAW over 5/32 inch electrodes	12
GMAW or FCAW up to 250 amps	11
GMAW or FCAW over 250 amps	12
GTAW	12
Carbon Arc up to 250 amps	12
Carbon Arc over 250 amps	14
Plasma Cutting up to 300 amp	9
Plasma Cutting over 300 amps	12

TABLE 6
Determining Purge Time

This table calculates time for various pipe or tube sizes based on the flow rate and volume changes specified

Use of pipe diameter as either NPS or OD is inconsequential and does not affect the efficacy of the calculations

Volume Changes: 5 Flow Rate CFH: 50

Pipe Diameter or Size	Purge Time (Minutes Per Foot of Pipe Length)
3	0.3
3-1/2	0.4
4	0.5
4-1/2	0.7
5	0.8
6	1.2
8	2.1
10	3.3
12	4.7
14	6.4
16	8.4
18	10.6
20	13.1
24	18.8
30	29.4
36	42.4
48	75.4

Basis: seconds will it take to purge 1 foot of pipe 5 volume changes

sec/ft = 5 X π X radius^2 (in^2) X (ft^3/1728 in^3) X (3600 s/hr) X (hr/50ft^3) X 12 in/ft

To calculate the prepurge time for any length of pipe, multiply the value obtained from the Table by the length of pipe measured in feet.

Example: Find time required for prepurging of 200 ft. of NPS 5. pipe. From Table for NPS 5 pipe size, the purge time is .8 min. per 1 ft. of pipe, hence, 200 ft. x .8 = 160 minutes or 2 hours, 40 minutes.

Caution: Inert gases displace air and settle in low places. They can cause death by oxygen deprivation.

ASME P-Numbers

The ASME P-number system groups metals according to comparable characteristics such as composition, weldability and mechanical properties. The reason for grouping base metals in this manner is to reduce the number of welding procedure and welder performance qualifications that would otherwise be required. The following is a listing of piping and pressure vessel materials by base metal P-number. Materials that are not listed here can be found in QW/QB-422 of ASME Section IX and in the allowable stress tables of the B31 Code Sections.

Carbon Steel and Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
1	A-36		Structural Shapes, Plate
	A-53	All	Seamless and Welded Pipe
	A-105		Forgings
	A-106	A,B,C	Seamless Pipe
	A-108	1015,1018,	Bars, Tube
	A-181	C1.60,70	Pipe, Flanges
	A-216	WCA,B,C	Castings
	A-234	WPB, WBC	Pipe Fittings
	A-285	All	Plate
	A-333	1,6	Seamless and Welded Pipe
	A-334	1,6	Seamless and Welded Pipe
	A-350	LF1,2	Forgings
	A-352	LCA, B	Castings
	A-420	WPL	Forgings
	A-515	All	Plate
	A-516	All	Plate

	A-519	1018, 1020	Bar, Tube
	A-671	CA,CB,CC	Fusion Welded Pipe
	A-672	A,B,C,E	Fusion Welded Pipe
	API-5L	All	Seamless and Welded Pipe

Carbon Molybdenum Steel and Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
3	A-209	All	Seamless Tube
	A-213	T2	Seamless Tube
	A-387	Gr.2	Plate
	A-691	CM65/76	Fusion Welded Pipe

Chromium molybdenum Steel and Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
4	A-182	F11,12	Pipe Flanges, Forgings
	A-213	T11	Seamless Tube
	A-234	WP11	Pipe Fittings
	A-335	P11,12	Seamless Pipe
	A-387	Gr.11,12	Plate
	A-691	1-1/4CR	Fusion Welded Pipe

Chromium Molybdenum Steel and Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
5A	A-182	F21,22	Pipe Flanges, Forgings
	A-213	T22	Seamless Tube
	A-234	WP22	Pipe Fittings
	A-335	P21,22	Seamless Pipe
	A-387	Gr.21,22	Plate
	A-691	2-1/4Cr.	Fusion Welded Pipe

P No.	Spec. Numbers	Type or Grade	Product Type
5B	A-182	F5,7,9,91	Pipe Flanges, Forgings
	A-213	T5,7,9.91	Seamless Tube
	A217	C12A	Casting
	A-234	WP5,7,9,19	Pipe Fittings
	A-335	P-5,7,9,91	Seamless Pipe
	A-387	Gr. 5,7,9,91	Plate
	A-691	5,7,9 Cr.	Fusion Welded Pipe

Steels Alloyed with Nickel

P No.	Spec. Numbers	Type or Grade	Product Type
9A	A-182	FR	Pipe Flanges, Forgings
	A-203	A,B	Plate
	A-234	WPR	Pipe Fittings
	A-333	7,9	Seamless Pipe
	A-334	7,9	Welded Pipe and Tube
	A-350	LF2, 5, 9	Forging
	A-352	LC2	Castings
	A420	WPL9	Fittings
	A-714	V (Yolloy)	Seamless and Welded Pipe

P No.	Spec. Numbers	Type or Grade	Product Type
9B	A-203	D,E,F	Plate
	A-333	3	Seamless Pipe
	A-334	3	Welded Pipe and Tube
	A-350	LF3	Forging
	A-352	LC3	Castings
	A420	WPL3	Fittings

Stainless Steel and Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
8	A-182	F3XX	Pipe Flanges, Forgings
	A-213	TP3XX	Seamless Tube
	A-240	Type3XX	Plate
	A-312	TP3XX	Seamless or Welded Pipe
	A-403	WP 3XX	Pipe Fittings
10H	A-182	F50,51	Pipe Flanges, Forgings
	A-789	All	Seamless and Welded Tube
	A-790	All	Seamless and Welded Tube

Creep-strength Enhanced Ferritic Steel

P No.	Spec. Numbers	Type or Grade	Product Type
15E	A-182	F91, F92	Pipe Flanges, Forgings
	A-213	TP91, TP92	Seamless Tube
	A-217	C12A	Casting
	A-234	WP91, 92	Pipe Fittings
	A-335	P-91, P-92	Seamless Pipe
	A-336	F91	Forging
	A-369	FP91, FP92	Forged Pipe
	A-387	Gr 91, Cl 2	Plate
	A-691	Gr 91	Fusion Welded Pipe

Aluminum and Aluminum Base Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
21	B-209	1100,3003	Sheet, Plate
	B-210	1100,3003	Tube
	B-211	1100,3003	Bar, Rod, Shapes, Pipe, Tube
	B-221	1100,3003	Bar, Rod, Shapes, Tube
	B-234	1100,3003	Seamless Tube
	B-241	1100,3003	Seamless Pipe, Extruded Tube
23	B-209	6061,6063	Sheet, Plate
	B-210	6061,6063	Tube
	B-211	6061,6063	Bar, Rod, Shapes, Pipe, Tube
	B-221	6061,6063	Bar, Rod, Shapes, Tube
	B-234	6061,6063	Seamless Pipe, Extruded Tube
	B-241	6061,6063	Seamless Pipe, Extruded Pipe
	B-247	6061	Forgings

Copper and Copper Base Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
31	B-111	All	Seamless Pipe
32	B-111	Brass	Seamless Pipe
	B-171	C44300	Seamless Pipe
	B-359	C44300	Seamless Pipe
34	B-111	Cu-Ni	Seamless Pipe

Nickel and Nickel Base Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
41	B-161	N02200,1	Pipe, Tube
42	B-165	N04400	Seamless Pipe and Tube Monel 1
43	B-163	N06600	Seamless Pipe and Tube Inconel 600
	B-167	N06690	Seamless Pipe and Tube Inconel 690
	B-443	N06625	Seamless Pipe and Tube Inconel 625
	B-516	N06600	Seamless Pipe and Tube
	B-517	N06600	Seamless Pipe and Tube
	B-564	N06600	Seamless Pipe and Tube
	B-564	N06625	Seamless Pipe and Tube
	B-564	N10276	Forgings, Smls and Welded Pipe Hastelloy 276
	B-619	N06022	Forgings, Smls and Welded Pipe Hastelloy 22
45	B-163	N08020	Seamless and Welded Pipe Alloy 20
	SB-407	N08800	Seamless Pipe and Tube Incoloy 800
	B-423	Alloy 825	Seamless and Welded Pipe Incoloy 825
	B-462	N08020	Forgings Alloy 20
	B-463	N08020	Forgings, Smls and Welded Pipe
	B-464	N08020	Seamless and Welded Pipe

[1]Trade name is listed below Type/Grade the first time it appears.

	B-464	NO 8020	Forgings, Smls and Welded Pipe
	B-464	N08026	Forgings, Smls and Welded Pipe
	B-468	N08020	Forgings, Smls and Welded Pipe
	B-468	N08026	Forgings, Smls and Welded Pipe

Titanium and Titanium Base Alloys

P No.	Spec. Numbers	Type or Grade	Product Type
51	B-337	1,2,7	Seamless and Welded Pipe
	B-338	1,2,7	Seamless and Welded Tube
	B-363	WPT1,2	Seamless and Welded Fittings
52	B-337	3,12	Seamless and Welded Pipe
	B-338	3,12	Seamless and Welded Tube
	B-363	WPT3	Seamless and Welded Fittings

Item PW4

MCAA

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