

شرکت فولاد امیرکبیر کاشان

اسناد مناقصه اصلاح پل، خرید و تامین و نصب شین و متعلقات به همراه نصب و راه اندازی جرثقیل سقفی دو پل مستعمل سوله طرح توسعه

بسمه تعالی

کلیات و شرایط شرکت در مناقصه عمومی (دو مرحله‌ای)

شرکت فولاد امیرکبیر کاشان در نظر دارد تا از طریق برگزاری مناقصه عمومی دو مرحله ای نسبت به "اصلاح پل، خرید و تامین و نصب شین و متعلقات به همراه نصب و راه اندازی جرثقیل سقفی دو پل مستعمل سوله طرح توسعه" شرکت فولاد امیرکبیر کاشان واقع در کاشان، کیلومتر ۱۴ جاده اردستان اقدام نماید.

موضوع مناقصه:

عبارت است از مناقصه عمومی "اصلاح پل، خرید و تامین و نصب شین و متعلقات به همراه نصب و راه اندازی جرثقیل سقفی دو پل مستعمل سوله طرح توسعه"

چگونگی ارائه پیشنهادات:

متقاضیان باید پیشنهادات خود را در سه پاکت جداگانه، در بسته، مهر و امضاء شده تهیه کرده و هر سه پاکت را در یک پاکت اصلی، لاک و مهر شده به شرح ذیل ارائه نمایند:

۱- پاکت الف (سپرده شرکت در مناقصه)

- سپرده شرکت در مناقصه به مبلغ ۵٪ مبلغ کل برآورد مناقصه گر بصورت ضمانت نامه بی قید و شرط بانکی با اعتبار حداقل سه ماه و قابل تمدید به نام شرکت فولاد امیر کبیر کاشان ارائه گردد.

۲- پاکت ب (اسناد مناقصه، رزومه و مدارک فنی با مهر و امضا پیشنهاد دهنده)

- کلیه صفحات اسناد مناقصه، نقشه‌ها و پیوست‌ها باید در کادر مربوطه (در پایین هر صفحه) مهر و امضاء شده باشد.

۳- پاکت ج (فرم پیشنهاد قیمت طبق جدول پیوست شماره یک)

- پیشنهاد قیمت باید از هر حیث خوانا، بدون ابهام، بدون قید و شرط و با لحاظ کلیه کسورات قانونی ارائه گردد.

توجه: روی تمام پاکت‌ها ذکر عبارت "مناقصه عمومی اصلاح پل، خرید و تامین و نصب شین و متعلقات به همراه نصب و راه اندازی جرثقیل سقفی دو پل مستعمل سوله طرح توسعه" صراحتاً قید شده باشد و نیز ذکر شناسه پاکت (الف-ب-ج) ضروری است.

ماده ۱: شرایط عمومی مناقصه:

- ۱- کارفرما در قبول یا رد یک یا کلیه پیشنهادات مختار است.
- ۲- شرکت در مناقصه به منزله پذیرش کلیه اختیارات، صلاحیت‌ها و تصمیمات دستگاه کارفرما است.
- ۳- کارفرما حق دارد در مدت قرارداد، موضوع قرارداد را از نظر مبلغ و حجم موضوع مناقصه به میزان ۲۵٪ به نسبت مقدار مندرج در شرایط مناقصه بدون تغییر در نرخ واحد، کاهش و یا افزایش دهد.
- ۴- در صورت انصراف برنده مناقصه از مناقصه یا تاخیر بیش از دو هفته در ارسال تضامین مندرج در اسناد مناقصه، تضمین شرکت در مناقصه برنده به نفع کارفرما ضبط و وصول خواهد شد و کارفرما مختار است نسبت به تجدید مناقصه یا معرفی نفر دوم بعنوان برنده مناقصه اقدام نماید.
- ۵- هرگونه توضیح یا تجدید نظر یا حذف و اضافه نمودن اسناد و مدارک مناقصه و نحوه تغییر و تسلیم آن‌ها در مهلت مقرر به صورت کتبی از سوی کارفرما اعلام و جزء اسناد و مدارک مناقصه منظور خواهد شد.
- ۶- شرکت در مناقصه هیچگونه حقی برای مناقصه گر ایجاد نمی‌کند.
- ۷- مناقصه گر موظف است در کادر تعبیه شده پایین همه صفحات اسناد، "عبارت خوانده شد و مورد قبول می‌باشد" را مهر و امضا نماید در غیر اینصورت مناقصه گر از مناقصه کنار گذاشته خواهد شد.
- ۸- کمیسیون معاملات کارفرما مرجع تصمیم‌گیری و حل اختلاف در خصوص کلیه مراحل برگزاری مناقصه می‌باشد و شرکت کردن مناقصه گر در مناقصه به منزله پذیرش این موضوع بوده و حق هرگونه اعتراض را از خود سلب می‌نماید.
- ۹- کارفرما حق تغییر، اصلاح یا تجدید نظر در اسناد و مشخصات را قبل از انقضای مهلت تسلیم پیشنهادها برای خود محفوظ می‌دارد و اگر چنین موردی پیش آید، مراتب به مناقصه گران ابلاغ می‌شود و در صورتی که پیشنهادی قبل از ابلاغ مراتب مزبور تسلیم شده باشد پیشنهاد دهنده حق دارد تقاضای استرداد آن را بنماید. از آنجا که ممکن است تجدید نظر یا اصلاح در اسناد و مشخصات موجب تغییر مقادیر یا قیمت‌ها باشد، در این صورت کارفرما می‌تواند به تشخیص خود آخرین مهلت دریافت پیشنهادها را با اعلام کتبی به پیشنهاد دهندگان به نحوی که آنان فرصت کافی برای اصلاح و تجدید نظر در پیشنهاد خود را داشته باشند به تعویق اندازد.
- ۱۰- به پیشنهادهای مبهم، مشروط و پیشنهادهایی که بعد از تاریخ مقرر یا به صورت ناقص تحویل شود ترتیب اثر داده نخواهد شد.
- ۱۱- مناقصه گر موظف است در صورت مشاهده هرگونه مغایرت در شرح خدمات موضوع مناقصه، قبل از ارسال پاکات، موارد را بصورت کتبی از طریق دبیرخانه کارفرما به اطلاع کارفرما رساند. در غیر این صورت مسئولیت هرگونه مغایرت بر عهده مناقصه گر بوده و ملاک و مرجع تصمیم‌گیری در خصوص مغایرت (های) احتمالی در کلیه مراحل برگزاری مناقصه و عقد قرارداد، نظر کارفرما می‌باشد و مناقصه گر موظف به تمکین نظر کارفرما خواهد بود.

۱۲- متقاضی شرکت در مناقصه اظهار می نماید که مشمول ممنوعیت مذکور در قانون مداخله کارمندان دولت در معاملات دولتی مصوب دی ماه ۱۳۳۷ نمی باشد و چنانچه خلاف این موضوع به اثبات برسد کارفرما حق دارد، قرارداد را فسخ و نسبت به وصول تضامین شرکت نزد خود اقدام نماید.

۱۳- شرکت برنده مکلف است حداکثر ظرف مدت یک هفته پس از ابلاغ نتیجه به وی نسبت به ارائه تضمین انجام تعهدات به صورت ضمانت نامه بانکی بی قید و شرط و یا وجه نقد حداقل معادل ۱۰٪ مبلغ پیشنهادی مناقصه و متعاقباً انعقاد قرارداد اقدام نماید.

۱۴- در صورت تعلق مالیات بر ارزش افزوده به قرارداد، مبلغ مربوطه، صرفاً در قبال ارائه گواهی معتبر ثبت نام در نظام مالیات بر ارزش افزوده به صورت حساب های طرف قرارداد اضافه و پرداخت خواهد شد.

۱۵- مناقصه گرموظف به تحویل و صورتجلسه کلیه اقلام و تجهیزات پروژه در محل انبار کارفرما در محل شرکت فولاد امیرکبیر واقع در کاشان، کیلومتر ۱۴ جاده اردستان می باشد.

۱۶- هیچگونه تعدیل به مبالغ پیشنهادی تعلق نمی گیرد.

۱۷- بکارگیری اتباع بیگانه به هر شکل ممکن (با یا بدون مجوز) ممنوع می باشد و در صورت مشاهده، کارفرما می تواند نسبت به فسخ یکطرفه قرارداد اقدام نموده و کلیه تضامین پیمانکار نزد کارفرما به نفع کارفرما ضبط و وصول خواهد شد و پیمانکار حق هرگونه اعتراض را از خود سلب می نماید.

۱۸- پرداخت هزینه های اگهی های مناقصه (کل نوبت ها) برعهده پیمانکار خواهد بود.

۱۹- در صورتی که کارفرما ثبت قرارداد در دفاتر اسناد رسمی را ضروری تشخیص دهد، هزینه های مربوطه برعهده پیمانکار خواهد بود.

۲۰- نشانی اعلام شده توسط مناقصه گران به استناد ماده ۱۰۱۰ قانون مدنی، اقامتگاه قراردادی - انتخابی وی بوده و هرگونه اعلام به آن نشانی (واقعی یا دیجیتالی) معتبر و دریافت شده تلقی و کلیه اعلامات اداری، قراردادی و قضایی تا وقتی که نشانی جدید اعلام نشده است به نشانی سابق اعلام خواهد شد.

ماده ۲: شرایط خصوصی

۱-۲- دامنه کار مناقصه گر

هدف از اجرای پروژه، اصلاح و تکمیل جرثقیل سقفی مستعمل شامل افزایش طول پل موجود (دو پل طولی) به همراه ریل عرضی از وضعیت فعلی به طول مورد نیاز (مطابق فاصله محور به محور ریل از ۲۳ متر به ± ۲۴ متر)، طراحی و اجرای وصله ها و تقویت های لازم و همچنین تهیه و تامین و نصب شین، جاروبک و کلیه متعلقات برقی و مکانیکی مرتبط با آن و نصب پل بر روی ریل های مربوطه، و همچنین اصلاح سیستم محدود کننده ارتفاع و تنظیم تعداد رشته های ریوینگ از ۶/۱ به ۴/۱ جهت افزایش کورس قلاب به نحوی که جرثقیل پس از پایان عملیات، دارای ظرفیت عملیاتی ایمن حداقل ۱۸ تن و قابل بهره برداری مطابق استانداردهای معتبر (طبق DIN, FEM, CMAA) باشد:

- ارائه نقشه‌های اجرایی (Shop Drawings) برای پل های جرثقیل، وصله‌ها، صفحات تقویتی و کلیه جزئیات اجرایی و انجام محاسبات سازه‌ای و تحلیل نرم افزاری قبل از اجرا به منظور اطمینان از کفایت مقاومت پل ها پس از افزایش طول و تعیین ظرفیت عملیاتی مجاز جرثقیل حداقل ۱۸ تن و ارائه گزارش نهایی همراه نقشه ازبیلت نهایی پل ها به کارفرما
- اجرای عملیات اصلاحی شامل دمونتاز و افزایش طول پل جرثقیل و مونتاژ و تنظیم چرخ های طولی و نصب پل روی ریل ها
- ارائه MILL Certificate معتبر برای کلیه متریکال مصرفی شامل ورق ها، پروفیل ها، الکترودها و ...
- تنظیم و رگلاژ نهایی چرخ ها و کنترل هم محوری با ریل ها همراه با برداشت ابعادی و ارائه نقشه دویدگی پل و چرخ ها (diagonal) پس از نصب روی ریل.

- اجرای تست‌های کنترل کیفیت شامل بازرسی چشمی و تست‌های غیرمخرب و ارائه گزارش کامل QC و NDT (VT, UT) و MT و ... توسط آزمایشگاه معتبر و مورد تایید کارفرما.
تبصره: کلیه هزینه های مربوطه برعهده پیمانکار میباشد.
- رنگ آمیزی و حفاظت سطح بخش های افزایش یافته مطابق دستورالعمل پیوست و مطابق با رال رنگ فعلی پل.
- اجرای راهرو و هندریل به میزان افزایش طول پل همراه با رنگ آمیزی
- اجرا و نصب ریل (چهار پهلو ۴۰*۶۰) جهت حرکت کالسکه (وینچ عرضی) همراه با رنگ آمیزی (۳ متر طول) مطابق با افزایش طول پل

- انجام عملیات نقشه برداری بمنظور انطباق span چرخها نسبت به span ریل های موجود قبل از شروع پروژه توسط پیمانکار الزامیست .

- کلیه مسولیت های پروژه از صفر تا صد و تبعات احتمالی هرگونه خطا در کلیه محاسبات پروژه ، برعهده پیمانکار می باشد.
- انجام تست بار ایستا معادل ۱۲۰٪ ظرفیت نامی (ظرفیت نامی ۱۸ تن) و بار دینامیک معادل ۱۱۰٪ ظرفیت نامی (طبق

(DIN,FEM,CMAA

- ارائه گزارش تست های جوش، دویدگی پل و چرخ ها (diagonal)، کنترل کیفیت، مواد مصرفی و گزارش تست بار. خرید و تامین و نصب شین، جاروبک و متعلقات شامل مونتاژ، تراز کردن، محکم کاری و انجام تست‌های الکتریکی و مکانیکی مطابق با مشخصات زیر:

- کلیه تجهیزات باید نو، سالم، بدون هرگونه زدگی، شکستگی، ترک، تغییر رنگ و اثرات خوردگی تحویل شوند.
- کالاهای کارکرده، بازسازی شده یا دست دوم به هیچ عنوان پذیرفته نمی شوند.
- شین‌ها و متعلقات باید مطابق با استانداردهای معتبر (DIN, IEC)، یا استاندارد معادل سازنده اصلی) باشند.
- ارائه گواهی سازنده (Factory Test Certificate / Mill Certificate) شامل مشخصات فنی، جریان نامی، جنس متریکال، شماره سری ساخت و تأییدیه کیفیت الزامی است.
- شین‌ها باید دارای ظرفیت ۴۵۰ آمپر با کاور PVC باشند.
- جاروبک‌ها باید ۱۰۰ آمپر با علمک و کاور PVC باشند.
- نیم درز انبساط، منبع تغذیه و سایر متعلقات باید برای جریان نامی قید شده طراحی و تأیید شده باشند.

- به منظور اطمینان از نصب صحیح و عملکرد ایمن سیستم شین باز، کلیه متعلقات شامل ساپورت‌ها، نیم درزهای انبساط، ثابت‌کننده‌ها، درپوش‌ها و سایر لوازم جانبی مرتبط می‌بایست از یک سیستم طراحی شده واحد (برند یا سری مشخص) تأمین گردند. تأمین متعلقات متفرقه یا غیرسازگار که موجب بروز اشکال در نصب، بهره‌برداری یا کاهش ایمنی گردد، به هیچ عنوان مورد تأیید کارفرما نبوده و کالا به صورت کامل مرجوع خواهد شد.
 - مناقصه گر موظف است کاتالوگ فنی، نقشه نصب، دستورالعمل مونتاژ و نگهداری تجهیزات را ارائه دهد.
 - کالا پیش از ارسال می‌بایست از جانب کارفرما بازدید و بازرسی گردد.
 - محل تحویل، انبار شرکت فولاد امیرکبیر کاشان می‌باشد.
 - کالا باید به صورت کامل بسته بندی استاندارد و مقاوم در برابر رطوبت و ضربه حمل گردد.
 - کلیه هزینه‌ها و مسئولیت‌های حمل، بیمه باربری، بارگیری و تخلیه کالا در محل انبار کارفرما بر عهده مناقصه گر است.
 - در صورت وجود مغایرت یا عدم انطباق با مشخصات فنی، مناقصه گر موظف به تعویض کالا ظرف ۱۰ روز کاری خواهد بود.
 - تنها مرجع تأیید یا عدم تأیید فنی کالاها، واحد فنی شرکت کارفرما و یا نماینده قانونی وی می‌باشد و هیچ مرجع ثالثی برای تأیید کیفیت پذیرفته نخواهد بود.
 - مناقصه گر مسئول سلامت و ایمنی کالا تا زمان تحویل در انبار کارفرما است.
 - در صورت بروز خسارت یا آسیب در حمل کل تجهیزات و ماشین آلات موضوع مناقصه در کل زمان پروژه، مسئولیت و هزینه جبران بر عهده مناقصه گر خواهد بود.
- ۲-۲- انجام عملیات جوشکاری می‌بایست مطابق با استانداردهای معتبر (AWS D1.1 یا معادل) انجام پذیرد و جوشکاران باید دارای گواهینامه معتبر باشند.
- ۳-۲- کلیه عملیات حمل، بارگیری، تخلیه و جابجایی کلیه اجزاء و تجهیزات پروژه (پل، ریل و ...) چه در داخل سایت و چه انتقال به کارگاه مناقصه گر و بازگشت به سایت کارفرما با هزینه و مسئولیت مناقصه گر است.
- ۴-۲- کلیه جوش‌ها باید به صورت ۱۰۰٪ تحت آزمون NDT قرار گیرند.
- ۵-۲- مناقصه گر موظف است WPS (روش جوشکاری) را قبل از اجرا ارائه و به تأیید کارفرما برساند.
- ۶-۲- مناقصه گر موظف است طرح بازرسی و آزمون (ITP) را قبل از اجرا تهیه و به تأیید کارفرما / ناظر برساند.
- ۷-۲- تحویل نهایی منوط به ارائه و تأیید کتبی کامل مدارک شامل: نقشه‌های ازبیلت، گزارش بار ایستا و دینامیک، گزارش تست‌های الکتریکی، مکانیکی و NDT، گزارش نقشه دویدگی پل (diagonal)، گواهی متریکال مصرفی و گزارش‌های QC و ITP خواهد بود.
- ۸-۲- کلیه متریکال‌ها باید با گرید معادل یا بالاتر از فولاد پل موجود در شرکت کارفرما تأمین گردد.
- ۹-۲- رعایت کلیه اصول ایمنی کار در ارتفاع و کار با تجهیزات سنگین در محیط کار الزامی است.
- ۱۰-۲- کلیه عملیات برداشت ابعادی و کنترل هندسی میبایست توسط نقشه بردار واجد صلاحیت انجام شود. نقشه بردار پیشنهادی مناقصه گر قبل از شروع عملیات باید به تأیید کتبی کارفرما برسد. کلیه هزینه‌های مربوطه برعهده مناقصه گر می‌باشد.

- ۱۱-۲- مسئولیت هرگونه خسارت ناشی از نقص طراحی، ساخت یا نصب بر عهده مناقصه گر خواهد بود.
- ۱۲-۲- تأخیرات ناشی از عدم هماهنگی یا نواقص مناقصه گر، هزینه‌ای متوجه کارفرما نخواهد نمود.
- ۱۳-۲- مناقصه گر موظف به تامین کلیه تجهیزات، ماشین آلات، ابزار، متریا، داربست، سکوی کار در ارتفاع، بالابرها، تجهیزات ایمنی و ابزار دقیق تراز و اندازه گیری، کابل برق، تابلو سیار و ... می باشد.
- ۱۴-۲- مناقصه گر موظف است برنامه زمانبندی تفصیلی شامل مراحل ساخت، حمل و نصب را ارائه و به تایید کارفرما برساند.
- ۱۵-۲- کلیه تست‌های الکتریکی اعم از آزمون پیوستگی، تست عایقی، بررسی صحت اتصال ارت، کنترل عملکرد مکانیکی جاروبک‌ها و اطمینان از حرکت روان تجهیزات و ... است. تحویل نهایی پس از انجام موفق این تست‌ها و تأیید دستگاه نظارت انجام خواهد شد.
- ۱۶-۲- مناقصه گر موظف است پس از ابلاغ قبولی پیشنهاد، کلیه اطلاعات فنی مورد نیاز و برنامه زمانبندی خود را به کارفرما ارائه نماید و نسبت به اخذ تاییدیه آن اقدام نماید.
- ۱۷-۲- محل اجرای خدمات، شرکت فولاد امیرکبیر کاشان واقع در کیلومتر ۱۴ جاده اردستان-کاشان می باشد و کلیه هزینه های پروژه موضوع مناقصه اعم از خرید قطعات و ابزار آلات و حمل و ... بر عهده مناقصه گر می باشد. لذا اطلاع از شرایط کار در شرکت فولاد امیرکبیر کاشان و کمیت و کیفیت کارها برای مناقصه گر الزامی می باشد.
- ۱۸-۲- نظارت در اجرای تعهداتی که برنده مناقصه بر طبق مفاد این مناقصه آن را تقبل نموده است، به عهده دستگاه نظارت معرفی شده از سوی شرکت فولاد امیرکبیر و یا نمایندگان قانونی وی خواهد بود اما عدم نظارت کافی، رافع مسئولیت مناقصه گر در قبال انجام صحیح کار طبق مشخصات فنی نخواهد بود و مسئولیت کلیه خسارات وارده به دلیل عدم انجام صحیح کار به عهده مناقصه گر خواهد بود.
- ۱۹-۲- مدت زمان اجرای پروژه سه ماه شمسی از تاریخ ابلاغ قرارداد می باشد.
- ۲۰-۲- مبلغ مبنای پیمان بصورت قیمت مقطوع بوده و هیچگونه تعدیلی به آن تعلق نمیگیرد.
- ۲۱-۲- برنده استعلام مکلف به رعایت مسائل و ضوابط ایمنی کار در رابطه با بارگیری، حمل، تخلیه و سایر مواردی است که در اجرای عملیات نقش خواهد داشت می باشد و در صورت بروز هر گونه حادثه ای، مسئولیت عواقب احتمالی بر عهده مناقصه گر خواهد بود و هیچ گونه مسئولیتی متوجه کارفرما نمی باشد و برنده استعلام نیز مکلف به پرداخت خسارت وارده می باشد.
- ۲۲-۲- در صورتیکه هر یک از پیشنهاد دهندگان نسبت به مفهوم اسناد و مدارک استعلام، ابهامی داشته باشند باید بلافاصله پس از دریافت اسناد و مدارک استعلام و قبل از تسلیم پیشنهاد قیمت، مراتب را کتبا به دستگاه مناقصه گذار اطلاع داده و تقاضای توضیح کتبی نمایند.
- ۲۳-۲- مناقصه گر موظف است هماهنگی های لازم با دستگاه نظارت کارفرما در مراحل مختلف کار را داشته باشد در غیر اینصورت، کلیه خسارات وارده به عهده مناقصه گر خواهد بود.
- ۲۴-۲- پیمانکار باید به اندازه کافی امکانات نیروی کار و ماشین آلات مورد نیاز پروژه را فراهم نماید به نحوی که در برنامه زمان اتمام عملیات اجرایی تاخیری ایجاد نشود، در صورتیکه بنا به تشخیص دستگاه نظارت، پیمانکار از برنامه پیشرفت کار

- عقب ماندگی داشته باشد، پیمانکار باید با توجه به دستورات دستگاه نظارت نسبت به افزایش اکیپ های اجرایی و یا افزایش شیفیت کاری و یا ساعات کاری و بدون هیچ عذر و بهانه ای اقدام نماید و هزینه ناشی از آن بعهده پیمانکار می باشد. تاخیرات ناشی از عدم تامین تجهیزات و نیروی انسانی ماهر و کافی جزء تاخیرات غیر مجاز خواهد بود.
- ۲-۲۵- استفاده از هر گونه وسایل، ابزار آلات و تجهیزات و ماشین آلات متعلق به کارفرما بدون مجوز ممنوع بوده و باید از قبل مجوز استفاده از آن را اخذ نمایند.
- ۲-۲۶- استهلاک و یا معیوب شدن تجهیزات مناقصه گر حین اجرا رافع مسئولیتهای مناقصه گر نبوده و وی موظف به تامین فوری ابزار آلات و ماشین آلات جایگزین در صورت خرابی تجهیزات می باشد.
- ۲-۲۷- مناقصه گر موظف است قبل از هر گونه استفاده از امکانات تأسیساتی کارفرما (مانند آب، برق و ..) هماهنگی لازم را با دستگاه نظارت کارفرما بعمل آورده و در غیر اینصورت مسئولیت و خسارات وارده و عواقب احتمالی آن، متوجه مناقصه گر خواهد بود.
- ۲-۲۸- بکارگیری اتباع بیگانه به هر شکل ممکن (با یا بدون مجوز) ممنوع می باشد.
- ۲-۲۹- در صورت هر گونه مغایرت بین پیشنهاد ارائه شده از طرف مناقصه گر با اسناد مناقصه شرکت فولاد امیرکبیر کاشان، اسناد مناقصه شرکت فولاد امیرکبیر کاشان تعیین کننده شرایط خواهد بود.
- ۲-۳۰- مناقصه گر مکلف است قبل از ارائه پیشنهاد، با انجام بازدید حضوری از محل پروژه و مطالعه دقیق نقشه‌ها، مدارک، لیست تجهیزات، متریکال، احجام، نفر-ساعت و سایر اسناد پیوست (شماره ۱ الی ۴)، نسبت به بررسی کامل موارد و رفع هرگونه ابهام اقدام نموده و در صورت مشاهده هرگونه مغایرت یا کمبود، موضوع را به اطلاع کارفرما برساند.
- ۲-۳۱- مناقصه گر موظف است پس از بازدید، صورتجلسه بازدید حضوری پروژه را به عنوان گواهی اطلاع از کلیات اسناد و شرایط مناقصه تهیه و در پاکت «ب» درج نماید. بدیهی است در صورت عدم انجام بازدید حضوری یا عدم ارائه صورتجلسه بازدید در پاکت «ب»، مناقصه گر از ادامه فرایند مناقصه کنار گذاشته خواهد شد و هیچ گونه اعتراض یا ادعایی در این خصوص پذیرفته نخواهد بود. علاوه بر این، در صورت قصور مناقصه گر در اعلام مغایرت‌ها یا کمبودها، کلیه مسئولیت‌ها بر عهده وی بوده و هرگونه ادعا یا درخواست پرداخت اضافه در آینده از سوی مناقصه گر مورد پذیرش قرار نخواهد گرفت.
- ۲-۳۲- با توجه به اینکه بازدید میدانی از محل پروژه، بررسی شرایط موجود و مطالعه نقشه‌ها و مدارک مرتبط توسط مناقصه گر، پیش از ارائه پیشنهاد انجام شده است، مناقصه گر نسبت به نحوه اجرای آیتم‌ها و فعالیت‌های مندرج در جدول پیوست شماره یک اشراف کامل دارد. لذا هرگونه ادعا یا درخواست پرداخت اضافی در آینده، با استناد به عدم اطلاع از شرایط پروژه، قابل پذیرش نخواهد بود.
- ۲-۳۳- تهیه وسایل و تجهیزات ایمنی و HSE بعهده مناقصه گر می باشد و مناقصه گر ملزم به رعایت اصول HSE کارفرما بوده و عواقب ناشی از عدم اجرای آن به عهده مناقصه گر خواهد بود.
- ۲-۳۴- مناقصه گر متعهد است نماینده ایمنی خود (مورد تایید اداره کار) را به کارفرما معرفی نماید.

- ۳۵-۲- مناقصه گر موظف است کلیه نیروهای عملیاتی خود را به کارفرما بصورت کتبی معرفی نماید. بعلاوه یک نفر نیز به عنوان نماینده تام الاختیار خود، بصورت کتبی به کارفرما معرفی شود. بدیهی است کلیه مواردی که کتبا از طریق کارفرما و دستگاه نظارت به این مناقصه گر ابلاغ می گردد جزء تعهدات مناقصه گر محسوب می گردد.
- ۳۶-۲- مناقصه گر مکلف است بر اساس دستورالعمل های ابلاغ شده از جانب دستگاه نظارت نسبت به اجرای عملیات و تحویل موضوع قرارداد به دستگاه نظارت اقدام نماید.
- ۳۷-۲- مناقصه گر موظف است ساعات کاری و ایام تعطیل خود را با کارفرما هماهنگ کرده و برنامه های کاری مورد نظر کارفرما و جدول محدودیت زمانی را دقیقاً رعایت نماید.
- ۳۸-۲- هزینه و تهیه وسایل نقلیه جهت ایاب ذهاب و اسکان پرسنل به طور کامل بر عهده مناقصه گر می باشد. تامین غذا فقط یک وعده غذای گرم جهت نهار در زمان حضور پرسنل مناقصه گر درون شرکت (به تعداد پرسنل حاضر) بر عهده کارفرما خواهد بود و بقیه وعده های غذایی بر عهده مناقصه گر می باشد.
- تبصره: در ایام ماه مبارک رمضان، تهیه وعده غذایی نهار برعهده پیمانکار خواهد بود که لیست و تعداد پس از صورتجلسه با دستگاه نظارت کارفرما و ارائه صورتحساب رسمی با تایید دستگاه نظارت کارفرما قابل پرداخت خواهد بود.
- ۳۹-۲- حفظ تاسیسات در طول مسیر و جلوگیری از آسیب به آنها بعهدہ مناقصه گر بوده و هرگونه هزینه خسارت ناشی از اهمال مناقصه گر، به عهده ایشان می باشد.
- ۴۰-۲- موضوع مناقصه تا ۲۵٪ قابل افزایش یا کاهش می باشد و مناقصه گر می بایست با توجه به مبالغ اولیه پیمان نسبت به انجام آن طبق دستور کار کارفرما اقدام نماید.
- ۴۱-۲- مناقصه گر می بایست قیمت های پیشنهادی را بر اساس نقشه ها و احجام اجرایی (پیوست ۱) و بازدید از محل اجرای پروژه و اطلاع کامل از نوع و جنس متریکال بکار رفته اعلام نماید و دعاوی پس از اجرا در این خصوص پذیرفته نخواهد بود.
- ۴۲-۲- مناقصه گر موظف است نسبت به حفاظت از نقاط نقشه برداری اطراف پروژه تا انتهای کار اقدام نماید.
- ۴۳-۲- مناقصه گر میبایست با توجه به نیاز کارفرما، جهت اجرای برخی از فعالیت های متفرقه خارج از تعهدات قرارداد، نسبت به آنالیز قیمت روز نیروی انسانی، ماشین آلات و مصالح اقدام نماید.
- ۴۴-۲- مناقصه گر میبایست قبل از شروع عملیات اجرایی، نسبت به معرفی سرپرست کارگاه و مسئول دفتر فنی، نقشه بردار و HSE به کارفرما اقدام نماید.
- ۴۵-۲- هزینه های تجهیز و برچیدن کارگاه مناقصه گر (کانکس، ملزومات مربوطه و...) در قیمت های پیشنهادی مناقصه گر لحاظ گردیده است.
- ۴۶-۲- جریمه تاخیر در اجرای موضوع قرارداد به ازای هر روز دیرکرد غیر مجاز معادل یک درصد ارزش کل مبلغ قرارداد و تا سقف ۲۰ درصد، محاسبه و از محل مطالبات مناقصه گر اعم از نقدی و یا غیر نقدی (تضامین) کسر خواهد شد.
- ۴۷-۲- در صورت تأخیر بیش از سقف تعیین شده، کارفرما مجاز به فسخ قرارداد و ضبط تضامین خواهد بود.
- ۴۸-۲- شرکت برنده مکلف است حداکثر ظرف مدت یک هفته پس از ابلاغ نتیجه به وی نسبت به ارائه تضمین انجام تعهدات به صورت ضمانت نامه بانکی بی قید و شرط و یا وجه نقد حداقل معادل ۱۰٪ مبلغ پیشنهادی مناقصه و متعاقباً انعقاد قرارداد

اقدام نماید. ضمانت نامه فوق پس از تحویل موقت قرارداد چنانچه موجبی برای ضبط و وصول آن نباشد با تایید کارفرما به مناقصه گر عودت داده می شود.

۲-۴۹- مدت زمان دوره تضمین، ۲۴ ماه از تاریخ تحویل موقت موضوع پیمان می باشد.

۲-۵۰- مناقصه گر مکلف است نسبت به ارائه گزارشات روزانه و ماهیانه اقدام نماید و در صورت عدم ارائه گزارشات فوق مطابق با نظر کارفرما، دستگاه نظارت به تهیه گزارشات فوق اقدام نموده و هزینه اجرای کار از صورت وضعیت های مناقصه گر کسر خواهد گردید.

۲-۵۱- یک هفته پس از ابلاغ قرارداد، مناقصه گر موظف است نسبت به ارائه ساختار شکست پروژه بهمراه اوزان فیزیکی اقدام نماید.

۲-۵۲- مناقصه گر موظف است نسبت به ارسال صورت وضعیت به صورت ماهیانه با ارائه فاکتور رسمی اقدام نماید و مبنای محاسبات صورت وضعیت، بر اساس کار انجام شده و درصد پیشرفت فیزیکی، مطابق ساختار شکست پروژه می باشد.

۲-۵۳- تاخیرات غیر مجاز حادث شده از جانب مناقصه گر بر اساس جدول شماره ۳ محاسبه و از صورت وضعیت های مناقصه گر کسر می گردد.

۲-۵۴- تامین کلیه ابزار آلات سرمایه ای، ابزار آلات مصرفی (شامل انواع الکترو، صفحه سنگ ساب و برش، شارژر کپسول اکسیژن و گاز و...) لوازم و تجهیزات، ماشین آلات و نیروی انسانی مورد نیاز برعهده مناقصه گرمیباشد و قبل از اجراء بایستی نسبت به اخذ تأییدیه دستگاه نظارت اقدام نماید.

۲-۵۵- هزینه و تهیه کلیه اتصالات مورد نیاز شامل انواع پیچ و مهره، پرچ، بولت، متریا ل لازم جهت رنگ آمیزی، پلیتھا، آهن آلات و ... به طور کامل مطابق مشخصات فنی اسناد مناقصه برعهده مناقصه گر می باشد و در کلیه ردیف های قیمت پیشنهادی لحاظ شده است.

۲-۵۶- تأمین و هزینه کلیه ماشین آلات مانند بالابر، انواع جرثقیل و لیفتراک با ظرفیت مورد نیاز برعهده مناقصه گر می باشد و در کلیه ردیف های قیمت پیشنهادی مناقصه گر لحاظ گردیده است.

۲-۵۷- تأمین و هزینه وسیله نقلیه جهت حمل مصالح و جابجایی نفرات، داربست یا کفراژ بندی و نردبان بلند به عهده پیمانکار بوده و در کلیه ردیف های قیمت پیشنهادی لحاظ شده است.

۲-۵۸- درخواستهایی که نیاز به نصب در محل دارند، بررسی معارضات نصب و سوراخکاری و برشکاری های مورد نیاز پیش از نصب و دریافت تایید از کارفرما به عهده مناقصه گر بوده و در صورت دوباره کاری و اصلاحات، هزینه ای به وی پرداخت نخواهد شد. ضمناً تاخیرات ناشی از قصور مناقصه گر در پیش بینی معارضات جزء تاخیرات مجاز شناخته نخواهد شد.

۲-۵۹- پیمانکار باید به اندازه کافی امکانات نیروی کار و ماشین آلات مورد نیاز پروژه را فراهم نماید به نحوی که در برنامه زمان اتمام ساخت و نصب مد نظر کارفرما تاخیری ایجاد نشود، در صورتیکه بنا به تشخیص دستگاه نظارت، پیمانکار از برنامه پیشرفت کار عقب ماندگی داشته باشد، پیمانکار باید با توجه به دستورات دستگاه نظارت نسبت به افزایش اکیپ های اجرایی و یا افزایش شیفیت کاری و یا ساعات کاری و بدون هیچ عذر و بهانه ای اقدام نماید و هزینه ناشی از آن برعهده پیمانکار می باشد. تاخیرات ناشی از عدم تامین تجهیزات و نیروی انسانی ماهر و کافی جزء تاخیرات غیر مجاز خواهد بود.

۶۰-۲- در صورتیکه عملیات اجرائی موضوع خدمات در داخل محوطه ای انجام شود که پیمانکاران دیگری نیز شاغل باشند، پیمانکار متعهد است برنامه ریزی های خود را بگونه ای انجام دهد که از ایجاد هر گونه مزاحمتی خصوصاً در روند فعالیت‌های جاری جلوگیری نماید. بدیهی است در صورت هر گونه خسارت احتمالی از ناحیه عدم توجه پیمانکار به این مقررات، جبران آن به عهده پیمانکار خواهد بود. همچنین پیمانکار موظف است کلاه، لباس کار و وسایل ایمنی و کارت شناسائی پرسنل را در محدوده کارگاه تأمین نماید و بطور خلاصه مناقصه گرموظف به اجرای مقررات بیمه های اجتماعی و درمانی، مقررات و دستورالعمل‌های حفاظت فنی و بهداشت کار در خصوص کارکنان خود می باشد.

۶۱-۲- جمع آوری کامل ضایعات و انتقال از سایت، به محل ضایعات اعلامی از جانب شرکت فولاد امیرکبیر بر عهده مناقصه گر می باشد.

۶۲-۲- مناقصه گر موظف است به هزینه خویش کلیه کارکنانی را که در اجرای عملیات موضوع قرارداد بکار می گمارد تحت پوشش بیمه تأمین اجتماعی و خدمات درمانی، تکمیلی و کل عملیات موضوع قرارداد را به هزینه خویش تحت پوشش بیمه های حوادث، مسئولیت مدنی و تمام خطر (صادره از شرکت ها معتبر بیمه) قرار دهد.

۶۳-۲- حفظ و حراست متریکال اولیه و مصالح دریافتی از انبارهای شرکت به صورت امانی در تعهد مناقصه گر می باشد.

۶۴-۲- کلیه مسولیت ها و هزینه های پروژه اعم از خرید ، ساخت ، حمل ، نصب ، راه اندازی ، تجهیزات ، نقشه برداری ، تست ها و ... عهده مناقصه گر می باشد.

۶۵-۲- در صورت نیاز، تهیه کلیه لوازم و ابزار آلات خاص در هر دو بخش تامین و اجرا مانند دوربین نقشه برداری و ... جهت تعیین دقیق موقعیتهای انجام عملیات و یا تهیه گزارش بطور کامل به عهده مناقصه گر می باشد.

۶۶-۲- هرگونه بازرسی، نظارت، تایید مدارک مهندسی و غیره توسط کارفرما رافع مسئولیتهای مناقصه گر نبوده و مناقصه گر در قبال عملکرد صحیح سیستم مسئولیت کامل دارد.

۶۷-۲- مناقصه گر نمی تواند بدون موافقت کتبی کارفرما موضوع خدمات را به غیر واگذار نماید.

۶۸-۲- مناقصه گر متعهد می گردد که نسبت به اعمال کلیه تغییراتی که در اثر پیشنهاد یا سفارش یا دستور کار در اجرای عملیات حادث می شود اقدام نماید.

۶۹-۲- در صورت عدم تأیید متریکال و مصالح خریداری شده توسط مناقصه گر از جانب کارفرما، هزینه های حمل و نقل و همچنین هزینه های متاثر از آن بر عهده مناقصه گر خواهد بود که از مطالبات ایشان کسر میگردد.

۷۰-۲- مناقصه گر موظف است نسبت به اخذ تأییدیه های کیفی لازم به صورت مقطعی جهت اجرا موضوع قرارداد از دستگاه نظارت اقدام نماید.

۷۱-۲- مناقصه گر موظف است قبل از ارسال لیست بیمه کارکنان شاغل در پروژه به سازمان تامین اجتماعی، نسخه اولیه لیست مزبور را جهت بررسی و تأیید به دستگاه نظارت ارائه نماید. در صورت عدم رعایت این بند، کلیه مسئولیت های ناشی از مغایرت یا عدم تأیید لیست بر عهده مناقصه گر خواهد بود.

ماده ۳: نحوه پرداخت

پیش پرداخت به میزان ۵۰ درصد مجموع ردیفهای یک و دو جدول دو پیوست یک که قبل از انجام تجهیز کارگاه در قبال ارائه ضمانت نامه بی قید و شرط بانکی قابل پرداخت خواهد بود که مبالغ مذکور متناسباً از صورت وضعیت های مناقصه گر کسر خواهد شد. ۳۰ درصد مجموع ردیفهای یک و دو جدول دو پیوست یک پس از تخلیه کل تجهیزات پروژه در محل انبار کارفرما و با تایید دستگاه نظارت کارفرما و ۲۰ درصد مابقی به اضافه کل هزینه ردیف سه جدول دو پیوست یک، پس از نصب و راه اندازی جرثقیل و تحویل موقت پروژه و با تایید دستگاه نظارت کارفرما پرداخت خواهد شد.

مناقصه گر موظف است نسبت به ارسال صورت وضعیت به صورت ماهیانه به انضمام مستندات کامل و ارائه فاکتور رسمی اقدام نماید و مبنای محاسبات صورت وضعیت، بر اساس کار انجام شده و درصد پیشرفت فیزیکی، مطابق ساختار شکست پروژه می باشد.

تبصره: پس از تحویل موقت موضوع قرارداد و استهلاك کل مبلغ پیش پرداخت از صورت وضعیت های ارسالی پیمانکار، تضمین واریز پیش پرداخت با تأیید دستگاه نظارت به پیمانکار مسترد می گردد. در صورت تمدید زمانی موضوع مناقصه، ضمانت مذکور نیز می بایست تمدید گردد.

ماده ۴: نظارت بر اجرای کار

نظارت در اجرای تعهداتی که مناقصه گر بر طبق مفاد این درخواست انجام خدمات و اسناد و مدارک آن تقبل نموده است از طرف کارفرما به عهده واحد طرح و توسعه/ نماینده مورد تأیید شرکت فولاد امیرکبیر کاشان واگذار شده است. لازم به ذکر است کلیه مکاتبات بدو با دستگاه نظارت صورت خواهد گرفت.

ماده ۵: تضمین انجام تعهدات

برای ضمانت انجام تعهدات، مناقصه گر موظف است به میزان ۱۰٪ مبلغ کل پیشنهاد مالی خود در زمان انعقاد قرارداد، بصورت ضمانت نامه بانکی معتبر در وجه شرکت فولاد امیرکبیر کاشان به کارفرما ارائه دهد. بدیهی است ضمانت مذکور پس از تحویل موقت موضوع مناقصه، با تأیید دستگاه نظارت کارفرما به مناقصه گروودت داده می شود. در صورت تمدید زمانی موضوع مناقصه، ضمانت مذکور نیز می بایست تمدید گردد.

تبصره: در صورت عدم تامین یا انصراف یا امتناع انجام کار توسط برنده مناقصه، ضمانت مذکور به نفع شرکت فولاد امیر کبیر کاشان ضبط و وصول خواهد شد.

ماده ۶: تضمین حسن انجام کار:

برای حصول اطمینان از حسن انجام کار و تکالیف مناقصه گر، به اندازه کل مبلغ قرارداد چک صیادی ثبت روز در وجه کارفرما به‌همراه سفته به‌همان میزان تواما، بعنوان تضمین حسن انجام کار، کسر و نگهداری می شود و در صورت عدم انجام

تعهدات مناقصه گر و یا فسخ قرارداد بعثت قصور مناقصه گر در انجام تکالیف یا در صورت عدول مناقصه گر از انجام قرارداد، وجه الضمان مذکور بنفع کارفرما ضبط خواهد شد.

تضمین حسن انجام کار پس از پایان دوره تضمین و گارانتی قرارداد چنانچه موجبی برای ضبط و وصول آن نباشد با تایید دستگاه نظارت به مناقصه گر مسترد خواهد شد.

ماده ۷: کسورات قانونی:

کلیه کسورات قانونی بر عهده مناقصه گر می باشد.

در خصوص کسورات مربوط به سازمان تامین اجتماعی، ۷/۸٪ کل مبلغ پیشنهادی، بعنوان تضمین اخذ مفاصا حساب تامین اجتماعی کسر شده که این تضمین پس از تحویل موقت موضوع مناقصه و پس از ارائه مفاصا حساب مربوطه، با تایید دستگاه نظارت کارفرما، به مناقصه گر عودت خواهد شد. لازم بذکر است کسورات مذکور در صورت تایید دستگاه نظارت کارفرما قابل تبدیل به تضمین مورد قبول کارفرما خواهد بود.

ماده ۸: تحویل موقت

پس از اصلاح و نصب پل روی ریل و پس از تائید کلیه مدارک و مستندات مورد نیاز مطابق با اسناد مناقصه و انجام تست های عملیاتی شامل حرکت طولی جرثقیل در کل مسیر سالن بصورت روان و انطباق span چرخها با span ریل و تست جاروبک ها و شین و سایر تست های مربوطه موضع مناقصه با تایید دستگاه نظارت کارفرما طی صورتجلسه، تحویل موقت می گردد. در صورتیکه به تشخیص دستگاه نظارت کارفرما، عملیات موضوع مناقصه آماده بهره برداری نباشد و یا نواقصی در کار مشاهده شود، کارفرما نواقص و کارهایی را که باید پیش از تحویل تکمیل شود، به اطلاع مناقصه گر می‌رساند و مناقصه گر موظف به رفع نواقص مورد نظر در بازه زمانی تعیین شده کارفرما می باشد.

ماده ۹: دوره تضمین

- مدت زمان دوره تضمین، ۲۴ ماه از تاریخ تحویل موقت موضوع مناقصه می باشد.
- مناقصه گر موظف است به ارائه خدمات پس از فروش ۵ سال پس از دوران گارانتی می باشد که تضمین حسن انجام کار پس از بازه خدمات پس از فروش در صورتی که موجبی برای ضبط یا وصول آن نباشد با تایید دستگاه نظارت کارفرما عودت می گردد.
- چنانچه در زمان تست عملیاتی یا دوره تضمین، معایب و نواقصی در کار مشهود شود که ناشی از عدم رعایت مشخصات و مفاد قرارداد باشد، مناقصه گر مکلف است معایب و نواقص مذکور را با هزینه خود رفع کرده و برای این منظور کارفرما مراتب را با ذکر معایب و نواقص و محل آنها کتباً به پیمانکار ابلاغ می نماید و پیمانکار می بایست ظرف حداکثر ۴۸ ساعت بعد از ابلاغ، شروع به رفع معایب و نواقص نموده و آنها را طی مدتی که با رضایت کارفرما معین می شود رفع نماید.
- در صورت قصور مناقصه گر در اجرای تعهدات (به تشخیص دستگاه نظارت کارفرما)، کارفرما مجاز می باشد راساً یا به هر طریقی که صلاح بداند نسبت به رفع عیوب یا نواقص مذکور اقدام و هزینه های آن را به اضافه ۱۵٪ به عنوان بالاسری از محل اسناد تعهد آور مناقصه گر و یا هر نوع مطالبات و سپرده ای که پیمانکار نزد کارفرما دارد، برداشت نماید.

ماده ۱۰: حل اختلاف

در مرحله اول کلیه اختلافات در تفسیر و تعبیر شرایط و مسائل اجرایی قرارداد، به داور مرضی الطرفین ارجاع داده شده و حل و فصل می گردد و در صورت عدم نتیجه گیری در مرحله اول (عدم تراضی در انتخاب داور و یا عدم پذیرش رای داور توسط هر یک از طرفین) در مرحله دوم، موضوع به مدیریت امور حقوقی و قراردادهای شرکت سرمایه گذاری شسستان یا نماینده معرفی شده توسط این مدیریت ارسال شده و نظر مکتوب این مدیریت برای طرفین قرارداد لازم الاجرا و غیر قابل اعتراض میباشد و طرفین حق هرگونه مراجعه به محاکم قضایی را از خود سلب و ساقط می نمایند.

تبصره ۱: مناقصه گر ملزم است تا زمان حل نهائی اختلاف، تعهداتی را که به موجب قرارداد مربوطه بعهده دارد، اجرا نماید و در غیر این صورت کارفرما به هر طریقی تعهدات مربوطه را انجام داده و هزینه های آن به اضافه ۱۵ درصد بالاسری از مطالبات و یا تضامین مناقصه گر کسر میگردد و مناقصه گر حق طرح هیچگونه ادعایی نخواهد داشت.
تبصره ۲: مفاد این ماده مستقل از قرارداد جاری می باشد.

ماده ۱۱: تعهدات کارفرما:

پرداخت به موقع صورت حساب مناقصه گر مطابق با شرایط موافقت نامه

ماده ۱۲: نحوه و زمان ارسال پاکات :

۱. شماره تلفن های ۷-۳۸۴۱۰۳۸۵۵-۰۳۱ داخلی ۳۶۵ واحد بازرگانی و ۱۵۵ واحد طرح و توسعه برای هرگونه سوالات و نمابر ۵۵۵۰۳۸۶۵-۰۳۱ آماده پاسخگویی می باشد.

۲. کارفرما در روزهای پنج شنبه و جمعه تعطیل بوده و از پذیرش پاکتها معذور است.

۳. مهلت ارسال پیشنهادات حداکثر تا ساعت ۱۲ مورخ ۱۴۰۵/۰۳/۲۶ می باشد.

۴. تذکر: کارفرما به پیشنهادهاتی که بعد از مهلت مقرر در فوق، ارائه و یا از طریق پست ارسال شده باشد به هیچ وجه ترتیب اثر نخواهد داد.

۵. محل تحویل پیشنهادات دبیرخانه شرکت فولاد امیر کبیر کاشان (۵۵۰۳۸۲۴۵-۰۳۱) میباشد.

تذکر: چنانچه پاکات پیشنهاد قیمت سهوا یا عمدا و به هر دلیل به غیر از آدرس مندرج در این بند ارسال و تسلیم گردد پیشنهادات مذکور تحویل نشده تلقی خواهد شد و هیچگونه مسئولیتی در این خصوص متوجه دستگاه مناقصه گزار نخواهد بود.

۶. شرکت کنندگان در مناقصه می توانند، جهت دریافت پاسخ سوالات احتمالی خود (در ارتباط با مسایل فنی - اجرائی) و یا کسب اطلاعات بیشتر از شرایط اجرای کار، حداکثر ظرف مدت یک هفته پس از دریافت اسناد مناقصه (به جزء پنجشنبه و ایام تعطیل) با شماره تماس و فاکس مندرج در بند ۱ مکاتبه نمایند.

۷. مسئولیت عملکرد کامل تجهیزات بعهده مناقصه گر بوده و پیشنهاد دهندگان میبایست کلیه تجهیزات لازم جهت عملکرد کامل و صحیح تجهیز را حتی اگر در لیست تجهیزات و اسناد مناقصه آورده نشده است در پیشنهاد خود لحاظ نمایند. به هر حال هیچگونه هزینه ای از این بابت به مناقصه گر پرداخت نخواهد شد.

۸. اینجانب/اینجانبن دارنده/دارندگان امضای مجاز شرکت ثبت شده به شماره که دارای سمت می باشم/ می باشیم حق امضاء اسناد تعهدآور را دارا بوده و شرایط شرکت در مناقصه و پیوست آن را به دقت مطالعه نموده و از کم و کیف معامله و تمامی جزئیات آن آگاهی پیدا نموده و عالمأ و عاملاً در مناقصه شرکت می نمایم / می نمائیم.

آدرس :

تلفن :

کدپستی:

تاریخ امضاء صاحبان امضای مجاز و مهر شرکت

صاحبان امضاء مجاز براساس روزنامه رسمی			
ردیف	نام و نام خانوادگی	سمت	نمونه امضاء

پیوست یک

(احجام عملیات اجرایی و مبلغ پیشنهادی)

جدول شماره ۱: احجام عملیات اجرایی و مبلغ پیشنهادی

ردیف	شرح	واحد	مقدار	قیمت واحد	مبلغ پیشنهادی (ریال)	توضیحات
۱	تهیه و تامین کلیه مترپال لازم مطابق با افزایش طول پل شامل (وصله ها و تقویت ها، ریل چهار پهلو، راهرو و هندریل و...)	مقطوع	۱			شامل کلیه مترپال (وصله ها و تقویت ها و...)
۲	عملیات اصلاحی شامل دمونتاژ و افزایش طول پل جرثقیل و مونتاژ، نصب ریل (چهار پهلو) جهت حرکت کالسکه، راهرو و هندریل و تنظیم چرخ های طولی و نصب پل روی ریل ها	مقطوع	۱			جوشکاری، مونتاژ و دمونتاژ، آماده سازی برای نصب و تست حرکتی و برداشت ابعادی جهت تهیه نقشه دویدگی پل و چرخ ها
۳	تهیه و تامین شین باز ۴۵۰ آمپر کاور PVC با اتصالات	متر طول	۲۰۰			
۴	تهیه و تامین ساپورت جوشی با پیچ و ریل ۲۰ سانتی و تسمه ۴ سوراخ	مجموعه	۱۵۵			
۵	تهیه و تامین درز انبساط ۴۵۰ آمپر کاور PVC	مجموعه	۲			
۶	تهیه و تامین جاروبک ۱۰۰ آمپر کاور PVC با علمک	مجموعه	۲			
۷	تهیه و تامین ورودی برق نصب شده (منبع تغذیه)	مجموعه	۲			
۸	تهیه و تامین ثابت کننده کاور PVC	عدد	۲۴			
۹	تهیه و تامین درپوش انتهایی کاور PVC	عدد	۸			
۱۰	عملیات نصب شین، جاروبک و متعلقات برقی و مکانیکی	متر طول	۲۰۰			شامل تست های الکتریکی
۱۱	کلیه عملیات حمل، بارگیری، تخلیه و جابجایی کلیه اجزاء و تجهیزات پروژه (پل و...) چه در داخل سایت یا انتقال به کارگاه مناقصه گر و بازگشت به سایت	مقطوع	۱			شامل بیمه باربری
۱۲	انجام کلیه تست ها اعم از تست های جوش مطابق با اسناد و ارائه گزارش QC، تست بار ایستا و داینامیک و تست الکتریکی و تهیه و تحویل مدارک نهایی، نقشه برداری، گزارش تست ها، نقشه دویدگی پل و چرخ ها، گواهی مترپال، As-built و کلیه اقداماتی که براساس اسناد مناقصه و قرارداد، پیمانکار موظف به اجرا می باشد	مقطوع	۱			تحویل نهایی منوط به تایید کتبی کارفرما بر اساس مدارک
مجموع مبلغ کل بدون احتساب مالیات بر ارزش افزوده (ریال) به عدد						
با احتساب کلیه هزینه های بالاسری اعم از بیمه، مالیات و ...						
مجموع مبلغ کل بدون احتساب مالیات بر ارزش افزوده (ریال) به حروف						
با احتساب کلیه هزینه های بالاسری اعم از بیمه، مالیات و ...						

تاریخ:

مدت اعتبار:

جدول ۲ - مبلغ پیشنهادی مناقصه اصلاح پل، خرید و تامین و نصب شین و متعلقات به همراه نصب و راه اندازی جرثقیل سقفی دو پل مستعمل سوله طرح توسعه		
ردیف	شرح خدمات	قیمت (ریال)
۱	خرید متعلقات پل و سازه	
۲	خرید متعلقات شین و سیستم برق رسانی	
۳	هزینه های اصلاح ، نصب و راه اندازی و ... کل پروژه	
مجموع مبلغ کل بدون احتساب مالیات بر ارزش افزوده (ریال) به عدد با احتساب کلیه هزینه های بالاسری اعم از بیمه ، مالیات و ...		
مجموع مبلغ کل بدون احتساب مالیات بر ارزش افزوده (ریال) به حروف با احتساب کلیه هزینه های بالاسری اعم از بیمه ، مالیات و ...		

- کلیه قیمت ها باید ریالی باشند .

پیوست دو

(وندور لیست)

جدول شماره ۲: وندور لیست

ردیف	شرح	تامین کننده
۱	شین باز ۴۵۰ آمپر کاور PVC با اتصالات	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۲	ساپورت جوشی با پیچ و ریل ۲۰ سانتی و تسمه ۴ سوراخ	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۳	درز انبساط ۴۵۰ آمپر کاور PVC	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۴	جاروبک ۱۰۰ آمپر کاور PVC با علمک	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۵	ورودی برق نصب شده (منبع تغذیه)	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۶	ثابت کننده کاور PVC	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
۷	درپوش انتهایی کاور PVC	پویا الکتریک بهاران- رافد صنعت-مهندسی و تحقیقات صنعتی RMN
	الکتروود E7018	اما- یزد
	آهن آلات ST37 (وصله ها و تقویت ها)	فولاد مبارکه ، فولاد اکسین ، کاویان
	ریل ST52 (چهار پهلو ۴۰*۶۰)	فولاد مبارکه ، فولاد اکسین ، کاویان
	رنگ اپوکسی	نگین زره - الوند - اورانوس

پیوست سه

(جدول جرائم)

جدول شماره ۳- میزان جرائم متعلقه به تخلفات انجام شده توسط مناقصه گر

ردیف	موارد عدم اجرای تعهدات	جرائم در نظر گرفته شده
۱	عدم اطلاع مدیر پروژه و سرپرست کارگاه مناقصه گر از بندهای قرارداد	هر مورد مشاهده یا گزارش ۵۰,۰۰۰,۰۰۰ ریال
۲	عدم تسلط سرپرست کارگاه بر عملکرد نیروها و عدم پیگیری جهت رفع موانع و مشکلات	هر مورد مشاهده یا گزارش ۲۰,۰۰۰,۰۰۰ ریال
۳	عدم وجود هر یک از ابزارهای موردنیاز مطابق با قرارداد	هر ردیف ناقص روزانه ۲۰,۰۰۰,۰۰۰ ریال
۴	عدم استفاده از لباس کار متحدالشکل مناقصه گر	هر مورد مشاهده یا گزارش ۱۰,۰۰۰,۰۰۰ ریال
۵	عدم استفاده یا استفاده غیر صحیح از لوازم حفاظت فردی	هر مورد مشاهده یا گزارش ۳۰,۰۰۰,۰۰۰ ریال
۶	عدم تأمین متریا ل موردنیاز جهت ساخت	هر دستور کار، روزانه ۱۰۰,۰۰۰,۰۰۰ ریال
۷	مشاهده رفتارهای غیر ایمن در محیط کار	هر مورد مشاهده یا گزارش ۱۰۰,۰۰۰,۰۰۰ ریال
۸	عدم رعایت اصول 5S در محیط کار، کارگاه، اداری، انبار، رختکن و ...	هر مورد مشاهده یا گزارش ۳,۰۰۰,۰۰۰ ریال
۹	غیبت سرپرست کارگاه مناقصه گر و یا جانشین معرفی شده ایشان در روزهای کاری و یا عدم حضور بدون هماهنگی جهت روزهای تعطیل	هر نفر روز ۲۰,۰۰۰,۰۰۰ ریال
۱۰	غیبت کارکنان در روزهای کاری و یا عدم حضور کارکنان معرفی شده بدون هماهنگی در روزهای تعطیل.	هر نفر روز ۱۵,۰۰۰,۰۰۰ ریال
۱۱	تأخیر و یا عدم ارسال گزارشات روزانه و هفتگی، و یا موردی خواسته شده	هر گزارش هرروز ۵,۰۰۰,۰۰۰ ریال
۱۲	عدم ارائه برنامه زمان بندی در موعد مقرر مطابق با مفاد قرارداد	هرروز تأخیر ۲۰,۰۰۰,۰۰۰ ریال
۱۳	تأخیر در زمان شروع دستور کار ابلاغی	هر دستور کار روزانه ۱۰,۰۰۰,۰۰۰ ریال
۱۴	عدم اخذ مجوزهای لازم جهت شروع و یا ایجاد توقف در حین اجرای عملیات	هر مورد مشاهده یا گزارش ۳۰,۰۰۰,۰۰۰ ریال
۱۵	اخطار کتبی به مناقصه گر	هر مورد ۴۰,۰۰۰,۰۰۰ ریال
۱۶	معرفی اتباع بیگانه	هر نفر روز ۵۰۰,۰۰۰,۰۰۰ ریال
۱۷	استفاده از تجهیزات کارفرما بدون اخذ مجوز	هر مورد مشاهده یا گزارش ۲۰۰,۰۰۰,۰۰۰ ریال
۱۸	عدم حضور نماینده HSE مناقصه گر در کارگاه	هر روز مبلغ ۳۰,۰۰۰,۰۰۰ ریال

پیوست چهار

(دستورالعمل رنگ آمیزی و جوشکاری)

Section 7) Surfaces Protection

All metallic surfaces of equipment shall be protected against atmospheric and / or service corrosion as specified below.

• PAINTING SYSTEMS

DESCRIPTION	RAL NO.	TABLE
Outside Surfaces of Steel Framed buildings, sheds, pipe racks, conveyor, towers, inside buildings, pults, platforms and ancillary Structural steel works in general, Stairs and gangways, supporting structure	(Green) 6011	1
Floor plates:		
- Floor Side	(Grey) 7038	1
- Ceiling side	(Green) 6011	
Stairs and gangways: supporting structure	(Green) 6011	1
Steps and footpaths	(Black) 9005	
Railing: Handrails and treads	(Black) 9005	1
Uprights and Legboards	(Yellow) 1021	
Gratings (Deck, Stairs, etc.), Bolts, Nuts, washers	(Green) 6011	1
Machined Surfaces ⁽¹⁾	Rust Preventive Oil	----

NOTES:

(1) Items listed below need no paint;

Weight Elements (in take-up assembly), High strength fasteners (10.9 and above), parts in contact with concrete (e.g. base-plates), Rubber and parts made of stainless steel, copper and aluminum alloys, **tanks rubber lined surfaces.**

Table 1

- The painting shall be applied according to following table.

Process		Paint Name or Treatment *	No. of Coats	Painting Method	Dry Film Thickness of each Coat (microns)	Interval Min. Max. (hrs.)**	
At Shop	Surface Preparation	SIS SA 2 $\frac{1}{2}$					
At Shop	Primer Coat	2-Component Epoxy(P9)	1	Airless	70	48	---
At Shop	Intermediate Coat	Epoxy(P14)	1	Airless	70	16	---
At Shop	Final coat	Epoxy(P20)	1	Airless	80	16	---

* : For detail specification of painting cycles refer to pages 11~16 of "packing instruction & painting cycles & welding inspection" attached.

** : Up to paint manufacturer instruction.

Painting cycles

P.9 Epoxy consisting of two-elements Primer

Painting Product characteristics

-TYPE:	Two-components	
-COLOUR:	Brown-red	
- PIGMENT: percentage :	40÷45	
Chemical composition:	Zinc-chromate,Zinc-phosphates,synthetic red-iron-oxide,alluminium and magnesium silicates.	
	Pigments and extenders shall not be water-soluble.Carbonates must be avoided .	
-VEHICLE: percentage:	50÷55	
Chemical composition:	Epoxy resin solid solution.	
-HARDENER:	Amino or polyamides to be mixed at the time of use.	
-SPECIFIC WEIGHT:	1,30 ÷ 1,40	(regarding the
-VISCOSITY AT 25° C.:	130" ÷ 150" FORD Cup 4(product	mixed and
		ready for use.)

Application Field and characteristics

- SURFACE ON WHICH THE PRIMER IS TO BE APPLIED :

Rust grade A-B-C-D Steel

Surface : Sa 2.1/2 Minimum grade blast cleaning

-PAINTING PRODUCTS WHICH CAN BE RECOATED:

(P.14) Epoxy intermediate coat or any others according to the "Compatibility Table"(Parag.6.6.)

- APPLICATION: Brush, Spray, Airless, Roller
- DRYING TIME: 6 hours to the touch

-MINIMUM INTERVAL FOR RECOATING: 24 Hours

RECOATING:

- DRIED COAT LOOKS: Semi-Gloss

-MINIMUM THICKNESS OF

DRIED FILM: 40÷50 microns

- AVERAGE YELD sq.m/kg: 5 ÷ 7

Resistance Characteristics:

- SALT-SPRAY CHAMBER TEST (According to ASTM B-117)

350 Hours exposure

- HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)

350 Hours exposure.

P.14 Epoxy Intermediate Coat

Painting Products characteristics

- TYPE: Two-components
- COLOUR: Grey, Yellow, Green (Upon request)
- PIGMENT: percentage: 45 ÷ 50
 Chemical composition: Grey:
 Titanium dioxide, Black Ferric oxide,
 Alluminium and Magnesium silicates.
Yellow:
 Lead-Chromate, Yellow Ferric oxide,
 Alluminium and Magnesium silicates.
Green:
 Green Chromium oxide, Titanium
 dioxide, Alluminium and Magnesium
 silicates.
 Pigments and extenders shall not be
 water-soluble. Carbonates must be
 avoided.
- VEHICLE: percentage: 55 ÷ 50
 Chemical composition: Epoxy resin solid solution.
 Among solvents, chlorinated and
 benzene must be avoided.
- HARDENER: Amino and polyamides or any others to
 be mixed at the time of use.
- SPECIFIC WEIGHT: 1,20 ÷ 1,40 (regarding the
- VISCOSITY at 25 °C.: 50" ÷ 70" FORD Cup 4 (product mixed
 and ready for use.)

Application Field and characteristics

- SURFACE ON WHICH THE PRODUCT IS TO BE APPLIED :
- (P.9.) Epoxy consisting of two-elements primer or any others according
 to the "Compatibility Table" (Parag. 6.6.)

- PAINTING PRODUCTS WHICH CAN BE RECOATED:

(P.20) Epoxy Finish Coat or any others according to the "Compatibility Table" (Parag.6.6.)

- APPLICATION: Brush, Spray, Airless, Roller.

- DRYING TIME: 4 ÷ 6 hours to the touch

- MINIMUM INTERVAL FOR RECOATING: 24 hours

-DRIED COAT LOOKS: Semi-Gloss

-MINIMUM THICKNESS OF DRIED FILM: 40 ÷ 45 microns

AVERAGE YIELD sq.m/kg: 5 - 6

Resistance Characteristics :

-SALT-SPRAY CHAMBER TEST (According to ASTM B-117)
350 Hours exposure

-HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)
350 Hours exposure

P.20 Epoxy Finish Coat

Painting Product characteristics

- TYPE: Two components
- COLOUR: (Upon request)
- PIGMENT: percentage: Black Colour: 12 ÷ 15
Other Colours: 25 ÷ 35
- Chemical composition: According to the colour .
Pigments and extenders shall have strong corrosion-proof characteristics.
Furthermore they shall not undergo any colour's degradation and/or alteration.
Pigments and extenders shall not be water-soluble. Carbonates must be avoided.
- VEHICLE: percentage: Black Colour: 88 ÷ 85
Other Colours: 75 ÷ 65
- Chemical composition: Epoxy resin solid solution.
Among solvents, chlorinated and benzene must be avoided .
- HARDENER: Amino and polyamides or any others to be mixed at the time of use.
- SPECIFIC WEIGHT: 1,10 ÷ 1,40 (regarding the
- VISCOSITY at 25 °C.: 50" ÷ 70" FORD Cup 4 (product mixed and ready for use.)

Application Field and characteristics

- SURFACE ON WHICH THE PRODUCT IS TO BE APPLIED :
(P.14) Epoxy Intermediate Coat or any others according to the "Compatibility Table" (Parag. 6.6.)
- APPLICATION: Brush, Spray, Airless, Roller.
- DRYING TIME: 2 hours to the touch
- DRIED COAT LOOKS: Gloss

-MINIMUM THICKNESS OF 30 ÷ 40 microns

DRIED FILM:

AVERAGE YELD sq.m/kg: Black Colour: 7÷8

Other Colours: 6÷7

Resistance Characteristics :

-SALT-SPRAY CHAMBER TEST (According to ASTM B-117)

350 Hours exposure.

-HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)

350 Hours exposure.

For the performance of both tests, the steel samples shall be given two coats of the painting product_

AWS D14.1/D14.1M:2005
An American National Standard



Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment



American Welding Society



Key Words—Cranes, industrial cranes, lifting devices, material handling equipment, mill cranes

AWS D14.1/D14.1M:2005
An American National Standard

Approved by
American National Standards Institute
February 24, 2005

Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

4th Edition

Supersedes ANSI/AWS D14.1-97

Prepared by
AWS D14 Committee on Machinery and Equipment

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

Requirements are presented for the design and fabrication of constructional steel weldments that are used in industrial and mill cranes, lifting devices and other material handling equipment. Requirements are also included for modification, weld repair, and postweld treatments of new and existing weldments. Filler metal and welding procedure guidelines are recommended for the applicable base metals, which are limited to carbon and low-alloy steels. Allowable unit stresses are provided for weld metal and base metal for various cyclically loaded joint designs.



American Welding Society

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International Standard Book Number: 0-87171-736-0

American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126

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Printed in the United States of America

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Foreword

(This Foreword is not a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, but is included for informational purposes only.)

This specification was prepared for the overhead crane and material handling industries to continue the advancement of welding and to increase product reliability. This 4th edition provides revisions to ANSI/AWS D14.1-97, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, under the direction of the AWS Machinery and Equipment Committee.

The participating committee, representing manufacturers, users, and government, joined in the preparation of this document. It will provide all concerned, including the general public, with high quality, reliable products and an economical approach to production, consistent with the industry's capabilities.

This specification will be reviewed periodically to assure its success in serving all parties concerned with its provisions. Revisions will be issued when warranted.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D14 Committee on Machinery and Equipment, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures (see Annex C).

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Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

1. Scope and General Provisions

1.1 Scope. This specification applies to the welding of all principal structural weldments and all primary welds used in the manufacture of cranes for industrial, mill, power house, and nuclear facilities. Furthermore, the specification applies to other overhead material handling machinery and equipment that support and transport loads within the design rating, vertically or horizontally, during normal operations, and, when agreed upon between the Owner and Manufacturer, to loading caused by abnormal operations or environmental events, such as seismic loading.

Secondary welds that will be subjected to tensile stresses of less than 5000 psi [34.5 MPa] need only meet the requirements of Section 7, Workmanship, and Section 10, Weld Quality and Inspection. The engineering drawings shall specify the joint detail, type, and size of weld. This specification is not intended for application to construction- or crawler-type cranes. For the welding of rails, refer to AWS D15.2, *Recommended Practice for the Welding of Rails and Related Rail Components for Use by Rail Vehicles*.

All provisions of this specification are equally applicable to the strengthening and repairing of existing overhead cranes and material handling equipment as described above.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements may not be exact equivalents; therefore each system shall be used independently of the other without combining in any way. The specification with the designation D14.1 uses U.S. Customary Units. The specification D14.1M uses SI Units. The latter are shown in appropriate columns in tables and figures or within brackets []. Detailed dimensions on figures are in inches. A separate tabular form that relates the U.S. Customary Units with SI Units may be used in tables and figures.

Safety and health issues and concerns are beyond the scope of this standard, and therefore are not fully

addressed herein. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* and applicable federal and state regulations. Some other sources of safety and health information can be found in Annex D.

1.2 General Provisions. The Manufacturer's¹ adherence to this specification shall include responsibility for the following:

- (1) Welding, as defined in the Scope, in accordance with this specification;
- (2) Producing the welds designated on the drawings by appropriate welding symbols and notes containing sufficient detail to show joint preparations compatible with the designated welding processes;
- (3) Providing written welding procedures;
- (4) Recording results of all procedure and welder qualification tests;
- (5) Controlling the use of designated base metals and consumables; and
- (6) Inspecting the welds to the requirements of this specification.

1.2.1 Acceptance. Acceptance shall be as agreed upon between the Manufacturer and the Owner (purchaser). The fundamental premise of this specification is to provide general stipulations applicable to most situations. Acceptance criteria for production welds different from those stated in this specification may be used for a particular application, provided they are suitably documented by the proposer and approved by the Engineer. These alternate acceptance criteria can be based upon evaluation of suitability for service using past experience, experimental evidence or engineering analysis considering material type, service-load effects, and environmental factors.

¹ Manufacturer refers to the organization responsible for the performance of the work covered by this specification (see definition in Section 3).

1.2.2 Welding Symbols. Welding symbols used on shop drawings shall be those shown in AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special requirements shall be fully explained by added notes or details.

1.2.3 Mechanical Testing of Welds. Methods used in the mechanical testing of welds shall be those described in AWS B4.0 or B4.0M, *Standard Methods for Mechanical Testing of Welds*. When there is a conflict between this specification and AWS B4.0 or B4.0M, the provisions of this specification shall govern.

1.2.4 Filler Metal Specifications. All welding consumables shall meet the requirements of the applicable AWS filler metal specifications, except for specific requirements of this specification.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

2.1 American Welding Society (AWS) Standards²

- (1) AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*
- (2) AWS A3.0, *Standard Welding Terms and Definitions*
- (3) AWS A5.01, *Filler Metal Procurement Guidelines*
- (4) AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
- (5) AWS A5.5, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
- (6) AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
- (7) AWS A5.18, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
- (8) AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
- (9) AWS A5.23, *Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
- (10) AWS A5.25, *Specification for Carbon and Low Alloy Steel Electrodes and Fluxes for Electroslag Welding*
- (11) AWS A5.26, *Specification for Carbon and Low Alloy Steel Electrodes for Electrogas Welding*
- (12) AWS A5.28, *Specification for Low-Alloy Steel Filler Metals for Gas Shielded Arc Welding*

2. AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

(13) AWS A5.29, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*

(14) AWS A5.32, *Specification for Welding Shielding Gases*

(15) AWS B2.1, *Specification for Welding Procedure and Performance Qualification*

(16) AWS B4.0, *Standard Methods for Mechanical Testing of Welds* (U.S. Customary Units only)

(17) AWS B4.0M, *Standard Methods for Mechanical Testing of Welds* (SI Units only)

(18) AWS C4.1, *Oxygen Cutting Surface Roughness Gauge*

(19) AWS QC1, *Standard for AWS Certification of Welding Inspectors*

2.2 American Society of Mechanical Engineers (ASME) Standards³

(1) ASME B 46.1, *Surface Texture (Surface Roughness, Waviness, and Lay)*

2.3 American Society for Testing and Materials (ASTM) Standards⁴

(1) ASTM E 23, *Test Methods for Notched Bar Impact Testing of Metallic Materials*

(2) ASTM E 94, *Standard Guide for Radiographic Examination*

(3) ASTM E 164, *Practice for Ultrasonic Contact Examination of Weldments*

(4) ASTM E 165, *Test Method for Liquid Penetrant Examination*

(5) ASTM E 317, *Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems without the Use of Electronic Measurement Instruments*

(6) ASTM A 435, *Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

(7) ASTM E 709, *Guide for Magnetic Particle Examination*

(8) ASTM E 1316, *Standard Terminology for Non-destructive Examinations*

2.4 American Society for Nondestructive Testing (ASNT) Standards⁵

(1) SNT-TC-1A, *Recommended Practice No. SNT-TC-1A*

3. ASME standards are published by the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10017.

4. ASTM standards are published by the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

5. ASNT standards are published by the American Society for Nondestructive Testing, Inc., P.O. Box 28518, 1711 Arlington Lane, Columbus, OH 43228-0518.

3. Definitions

The terms that follow are defined for the purposes of this specification. Other terms used in this specification are defined in AWS A3.0, *Standard Welding Terms and Definitions*.

Engineer. The responsible technical authority.

Manufacturer. The organization responsible for the performance of the work covered by this specification.

Owner. The person, company, or agency that purchases the equipment.

principal structural weldments. Those weldments that carry the main working loads during normal operations.

primary welds. Welds, the failure of which would result in (1) a carried load being dropped in excess of 4 in. [100 mm] or (2) an increase of stress beyond the allowable stress limits, as defined in Section 5, Allowable Stresses, in other welds or base metal. Any welds subject to only compressive stresses are not considered primary.

secondary welds. Welds not covered by the requirements of primary welds; secondary welds shall be noted as such on the drawings. Secondary welds only need to meet the requirements of Section 7, Workmanship, and Section 10, Weld Quality and Inspection.

tensile strength of the weld metal. The minimum tensile strength specified for the filler metal classification as published in the applicable filler metal specification.

4. Base Metals

4.1 Specifications. All ferrous and nonferrous metals, structural steel, steel castings, forgings, and any other metals used in the fabrication by welding of all components for overhead material handling machinery and equipment shall be identified by a specification. Common industry-wide specifications from organizations such as the American Society for Testing and Materials (ASTM), the American Iron and Steel Institute (AISI), the American Petroleum Institute (API), and the Society of Automotive Engineers (SAE), or written proprietary specifications developed by an individual equipment manufacturer, may be used.

4.2 Proprietary Base Metals. The weldability of and the procedure for welding (1) base metals covered by a specific equipment manufacturer's proprietary specifica-

tion, (2) steels not listed in Table 1, or (3) base metals not covered by accepted national specifications, shall be established by qualification, except as provided for in 4.4.

4.3 Tensile and Yield Strengths of a Base Metal. The minimum specified tensile and yield strengths for base metals are listed in Table 1. When Table 1 or the base metal specification does not establish the minimum tensile and yield strengths for acceptance, the Manufacturer shall establish the minimum tensile and yield strengths for design purposes. The documentation may be in the form of references to published data or compilations of test data. In the establishment of minimum tensile and yield strengths for design purposes, due regard shall be made for size effects, thermal or mechanical treatments, and the effect of the welding process on the base material in the heat-affected zone (HAZ).

4.4 Weldability. Steel base metals listed in Table 1 (including combinations thereof) shall be considered weldable without separate qualification, except base metals with a minimum yield strength of 90 ksi [620 MPa] or higher (see 9.1.1). The steels listed in Table 1 are classified into groups according to the degree of difficulty encountered during welding related to chemical composition, rolling condition, or heat treatment. Steels in the higher classifications require greater precautions during welding, such as preheat, limited heat input, or other precautions to ensure sound weldments. When welding combinations of these steels, precautions related to the steel with the higher classification number should be observed.

4.5 Quenched and Tempered Steels. Quenched and tempered steels may be used where design and other factors permit or require them. Their use shall be compatible with their mechanical properties and the design requirements as documented by the equipment manufacturer. Documentation may be in either of two forms:

- (1) An acceptable service history proving reliability, or
- (2) Welding procedure development and qualification data establishing the expected service life of the steel according to accepted engineering criteria for the application.

4.6 Nonferrous Metals. Nonferrous metals that meet the requirements of an accepted specification, as described in 4.1, may be used in the fabrication of components by welding. Proper documentation in the form of qualified welding procedures and other experimental data shall be provided by the Manufacturer using such metals.

Table 1
Weldability Classification of Steels

Material Class ⁽¹⁾	Steel Specification and Grade		Minimum or Range of Tensile Strength ksi [MPa]	Minimum Yield Strength ksi [MPa]
I	AISI/SAE		See Notes (2), (3), & (4)	See Notes (2) & (4)
	1005	Sheet, Plate	Hot Rolled 42 [290]	23.5 [162]
	1006	Bar or Casting	Hot Rolled 43 [295]	24 [165]
	1008	(Usually specified by composition	Hot Rolled 44 [305]	24.5 [170]
	1010	only—without mechanical properties)	Hot Rolled 47 [325]	26 [180]
	1012		Hot Rolled 48 [330]	26.5 [183]
	1013		Hot Rolled 49 [338]	27 [186]
	1015		Hot Rolled 50 [345]	27.5 [190]
	1016		Hot Rolled 55 [380]	30 [205]
	1017		Hot Rolled 53 [365]	29 [200]
	1018		Hot Rolled 58 [400]	32 [220]
	1020		Hot Rolled 55 [380]	30 [205]
	1021		Hot Rolled 61 [420]	33 [230]
	1025		Hot Rolled 58 [400]	32 [220]
II	ASTM		See Note (5)	See Note (5)
	A27	Grade N-1 Castings Chemistry Only	Not Specified—See 4.3	Not Specified—See 4.3
		Grade 60-30	60 [415]	30 [205]
		Grade 65-35	65 [450]	35 [240]
	A36	Shapes, Plate, Bar	58–80 [400–550]	36 [250]
	A53	Grade B Pipe	60 [415]	35 [240]
	A106	Grade B Pipe	60 [415]	35 [240]
	A131	Grade A, B, D, CS, DS	58–75 [400–520]	34 [235]
		Ship Building Shapes, Plate, Bars		
	A139	Grade A Pipe	48 [330]	30 [205]
		Grade B	60 [415]	35 [240]
		Grade C	60 [415]	42 [290]
		Grade D	60 [415]	46 [315]
		Grade E	66 [455]	52 [360]
	A283	Grade C, ≤ 2 in. [50 mm] Plate	55–75 [380–515]	30 [205]
		Grade D, ≤ 1 in. [25 mm]	60–80 [415–550]	33 [230]
	A381	Grade Y35 Pipe	60 [415]	35 [240]
	A500	Grade A Tubing	45 [310]	33 [288]
		Grade B	58 [400]	42 [290]
	A501	Tubing	58 [400]	36 [250]
	A515	Grade 55, ≤ 8 in. [200 mm] Plate <i>Grade no longer listed in A515-2003</i>	55–75 [380–515]	30 [205]
	A516	Grade 55, ≤ 8 in. [200 mm] Plate	55–75 [380–515]	30 [205]
		Grade 60, ≤ 8 in. [200 mm] Plate	60–80 [415–550]	32 [220]
A524	Grade I, ≤ 0.375 in. [10 mm] Pipe	60–85 [414–586]	35 [240]	
	Grade II, > 0.375 in. [10 mm] Pipe	55–80 [380–550]	30 [205]	
A570— <i>Withdrawn in 2000</i>	Grade 36 Sheet, ≤ 0.229 in. [6 mm]	53 [365]	36 [250]	
A573	Grade 58 Plate, ≤ 1.5 in. [40 mm]	58–71 [400–490]	32 [220]	
	Grade 65 Plate, ≤ 1.5 in. [40 mm]	65–77 [450–530]	35 [240]	
A662	Grade A Plate, ≤ 1.5 in. [40 mm]	58–78 [400–540]	40 [275]	
	Grade B Plate, ≤ 1.5 in. [40 mm]	65–85 [450–585]	40 [275]	
A709	Grade 36 Shapes, Plate, Bar	58–80 [400–550]	36 [250]	
API ⁽⁶⁾				
5L	Grade B Pipe	60 [410]	35 [240]	

(continued)

Table 1 (Continued)
Weldability Classification of Steels

Material Class ⁽¹⁾	Steel Specification and Grade		Minimum or Range of Tensile Strength ksi [MPa]	Minimum Yield Strength ksi [MPa]
III	AISI/SAE			
	1030	Sheet, Plate, Bar, or Casting (Usually specified by composition only— without mechanical properties)	See Notes (2) & (7) 68 [470]	See Notes (2) & (4) 37.5 [260]
III	ASTM			
	A27	Grade N-2 Castings Heat Treated	See Note (5) Not Specified—See 4.3	See Note (5) Not Specified—See 4.3
		Grade 70-36	70 [485]	36 [250]
		Grade 70-40	70 [485]	40 [275]
	A106	Grade C Pipe	70 [485]	40 [275]
	A131	Grade AH32, DH32, EH32	64–85 [440–590]	46 [315]
		AH36, DH36, EH36	71–90 [490–620]	51 [355]
		Ship Building Shapes, Plate, Bars		
	A283	Grade C, > 2 in. [50 mm] to ≤ 4 in. [100 mm] Plate	55–75 [380–515]	30 [205]
		Grade D, > 2 in. [50 mm] to ≤ 4 in. [100 mm] Plate	60–80 [415–550]	33 [230]
	A500	Grade C Round Tubing	62 [427]	46 [317]
		Grade C Shaped Tubing	62 [427]	50 [345]
	A515	Grade 60, ≤ 2 in. [50 mm] Plate	60–80 [415–550]	32 [220]
		Grade 65, ≤ 2 in. [50 mm] Plate	65–85 [450–585]	35 [240]
	A516	Grade 60, ≤ 2 in. [50 mm] Plate	60–80 [415–550]	32 [220]
		Grade 65, ≤ 2 in. [50 mm] Plate	65–85 [450–585]	35 [240]
	A537	Class 1, ≤ 2.5 in. [65 mm] Plate	70–90 [485–620]	50 [345]
	A572	Shapes, Plate, Sheet, & Bar		
		HSLA Cb-V Steels		
		Grade 42, ≤ 2 in. [50 mm]	60 [415]	42 [290]
		Grade 50, ≤ 0.5 in. [13 mm]	65 [450]	50 [345]
		Grade 50, > 0.5 [13 mm] to ≤ 2 in. [50 mm]		
		Type 1 or 2 Killed Steel	65 [450]	50 [345]
	A588	Grades A, B, C, & K Shapes, Plate, & Bar ≤ 4 in. [100 mm]	70 [480]	50 [340]
	A606	Type 2 & 4 Sheet ≤ 0.180 in. [5 mm]		
		Weathering Steel—As Rolled Cut Lengths All Other Coils & Cut Lengths	70 [480] 65 [450]	50 [340] 45 [310]
	A607— <i>Withdrawn in 2000</i>	Type 1 Class 2 Sheet ≤ 0.180 in. [5 mm] HSLA Non-Weathering	Grade 45 Grade 50	60 [410] 65 [450]
	A618	HSLA Structural Tubing		
		Wall ≤ 3/4 in. [19 mm]	Grade II	70 [485]
		Wall > 3/4 in. [19 mm] to ≤ 1.5 in. [38 mm]	Grade II Grade III	67 [460] 65 [450]
	A633	HSLA Normalized Structural		
		Plate, ≤ 4 in. [100 mm]	Grade A	63–83 [430–570]
		Plate, ≤ 2.5 in. [65 mm]	Grades C & D	70–90 [485–620]
		Plate, > 2.5 in. [65 mm] to ≤ 4 in. [100 mm]	Grades C & D	65–85 [450–590]
	A662	Grade B PV Plate Moderate & Low Temp. Applications		65–85 [450–585]
				40 [275]

(continued)

Table 1 (Continued)
Weldability Classification of Steels

Material Class ⁽¹⁾	Steel Specification and Grade		Minimum or Range of Tensile Strength ksi [MPa]	Minimum Yield Strength ksi [MPa]	
III (Cont'd)	A709	Structural Shapes, Plate, Bars—Bridges Non-Weathering	Grade 50	65 [450]	50 [345]
		Weathering	Grade 50W	70 [485]	50 [345]
	API ⁽⁶⁾ 5LX	Grade 42 High-Strength Pipe		60 [410]	42 [290]
IV	ASTM A283	Grade C, > 4 in. [100 mm] to ≤ 12 in. [300 mm] Plate		See Note (5)	See Note (5)
		Grade D, > 4 in. [100 mm] to ≤ 8 in. [200 mm] Plate		55–75 [380–515]	30 [205]
	A515	Grade 60, > 2 in. [50 mm] Plate		60–80 [415–550]	33 [230]
		Grade 65, > 2 in. [50 mm] Plate		60–80 [415–550]	32 [220]
	A516	Grade 60, > 2 in. [50 mm] Plate		65–85 [450–585]	35 [240]
		Grade 65, > 2 in. [50 mm] Plate		60–80 [415–550]	32 [220]
	A537 ⁽⁸⁾	Class 2, ≤ 2.5 in. [65 mm] Plate		65–85 [450–585]	35 [240]
	A572	Shapes, Plate, Sheet & Bar		80–100 [550–690]	60 [415]
		Grade 60, ≤ 1.25 in. [32 mm]		75 [520]	60 [415]
		Grade 65, ≤ 1.25 in. [32 mm]		80 [550]	65 [450]
	A607— <i>Withdrawn in 2000</i>	HSLA Non-Weathering	Grade 60 Grade 65	75 [520] 80 [550]	60 [410] 65 [450]
	A633 ⁽⁸⁾	HSLA Normalized Structural Plate			
		≤ 4 in. [100 mm]	Grade E	80–100 [550–690]	60 [415]
		> 4 in. [100 mm] to ≤ 6 in. [150 mm]	Grade E	80–100 [550–690]	55 [380]
V ⁽⁸⁾	ASTM			See Note (5)	See Note (5)
	A514	HSLA Q&T Plate, ≤ 2.5 in. [65 mm]		110–130 [760–895]	100 [690]
		> 2.5 in. [65 mm] to ≤ 6 in. [150 mm]		100–130 [690–895]	90 [620]
	A517	HSLA Q&T PV Plate, ≤ 2.5 in. [65 mm]		115–135 [795–930]	100 [690]
		> 2.5 in. [65 mm] to ≤ 6 in. [150 mm]		105–135 [725–930]	90 [620]
A709	HSLA Q&T Plate, ≤ 2.5 in. [65 mm]		110–130 [760–895]	100 [690]	
	Grades 100 & 100 W, > 2.5 in. [65 mm] to ≤ 4 in. [100 mm]		100–130 [690–895]	90 [620]	

Notes:

- (1) Material Class I steels are the most weldable, and Material Class V steel the most difficult to weld of the steels listed.
- (2) All tensile and yield strength values for AISI/SAE steels are *estimated minimum values*.
- (3) Hardness is not to exceed 160 Brinell for the AISI/SAE steels listed under Weldability Class I. These same AISI/SAE steels should be placed in a higher Weldability Class when hardness exceeds 160 Brinell (ultimate strength greater than 80 ksi [550 MPa]).
- (4) See 4.3 for tensile-yield property determination for AISI/SAE steels.
- (5) All tensile and yield strength values listed for ASTM steels are specified by the ASTM Standard.
- (6) API = American Petroleum Institute.
- (7) Hardness is not to exceed 180 Brinell for the AISI/SAE steel listed under Weldability Class III. This same AISI/SAE steel should be placed in a high Weldability Class when hardness exceeds 180 Brinell (ultimate strength greater than 90 ksi [620 MPa]).
- (8) Qualification is required due to the upper limit of the tensile strength range or the entire range exceeding 90 ksi [620 MPa].

5. Allowable Stresses

5.1 General. The allowable stresses for base metal and weld metal and the type of fatigue analysis to be used shall conform to the requirements of the design specifications from organizations such as the American Institute of Steel Construction (AISC), the American Society of Mechanical Engineers (ASME), the Crane Manufacturers Association of America (CMAA), or the Monorail Manufacturers Association (MMA). In the absence of other requirements, the allowable stresses in the base metal and the weld metal shall conform to the following requirements.

5.1.1 Base Metal. Unless otherwise specified by the design specifications in 5.1, the allowable tensile or compressive stress in the base metal shall be 50% of the yield strength, and the allowable shear stress in the base metal shall be 40% of the yield strength for members not controlled by buckling.

5.1.2 Weld Metal. Allowable stresses in the weld metal shall conform to Table 2.

5.2 Fatigue. The maximum stress in welded joints subject to repeated stress fluctuations or reversals shall not exceed:

- (1) The allowable tensile or compressive stress in 5.1; or
- (2) The allowable fatigue stress as defined in the design specifications indicated in 5.1.

In the absence of other requirements, fatigue loading shall be addressed as follows:

5.2.1 Members subject to repeated loading shall be designed so that the maximum stress does not exceed that allowed by 5.1 and the stress range does not exceed the value given in Table 3 for the applicable stress category and nominal number of loading cycles. Stress categories for weld joint configurations are described in Table 4 and illustrated in Figure 1.

5.2.2 The stress range is the maximum stress minus the minimum stress. The minimum stress is considered negative if it is opposite in direction to the maximum stress. The nominal number of loading cycles shall be the number defined in the design specification for the duty cycle class or determined by the Engineer for the duty cycle and life specified in the purchase contract.

6. Weld Joint Design

6.1 General Requirements. Complete information regarding location, type, size, and extent of all welds and welded joints shall be shown on the drawings. Any special inspection requirements shall be noted on the draw-

ings or other appropriate documents. In general, design details should minimize restraint, avoid undue concentration of welding, and afford ample access for depositing the weld metal.

6.2 Groove Welds

6.2.1 The effective area of a weld shall be the effective weld length multiplied by the effective throat.

6.2.2 The effective length of any groove weld is the length throughout which the correctly proportioned weld cross section exists.

6.2.3 The effective throat is the minimum distance from the root of a weld to its face, less any reinforcement. For a complete joint penetration weld, this shall be the nominal thickness of the thinner part joined.

6.2.4 The effective throat of a partial penetration weld is joint penetration below the surface of the member (see Table 5 for the minimum effective throat required).

Shop or working drawings shall specify the groove depths (S) applicable for the weld size (E) required for the welding process and position of welding to be used.

6.2.5 Groove welds made from one side only, except in secondary members, are prohibited unless they are completely fused to a backing strip, or qualified in accordance with the requirements of this specification (see 6.9).

6.2.6 A complete joint penetration groove weld is one that has been welded from both sides, or from one side, in which the weld metal completely fills the groove and is fused to the base metal throughout its total thickness (see 6.9).

6.3 Intermittent Groove Welds. Intermittent groove welds are prohibited, except in secondary members.

6.4 Fillet Welds (See Figures 2 and 3)

6.4.1 The minimum fillet weld size shall be as shown in Table 6, except where fillet welds are used to reinforce groove welds (see Figure 3).

6.4.2 The maximum fillet weld size permitted along the edges of members shall be:

- (1) The thickness of the base metal when the metal is less than 1/4 in. [6 mm] thick; or
- (2) The thickness of the base metal less 1/16 in. [2 mm] when the metal is 1/4 in. [6 mm] or more in thickness, unless the weld is designated on the drawing to be built out to obtain full throat thickness.

6.4.3 The effective weld area shall be the effective weld length multiplied by the effective throat. The shear stress in a fillet weld shall be considered as applied to this effective area regardless of the direction of applied

Table 2
Allowable Stress in Weld Metal

Type of Weld	Stress in Weld ⁽¹⁾		Allowable Stress	Required Weld Strength Level ⁽²⁾
Complete joint penetration groove welds (Joint Class I, II, III, or IV)	Tension normal to the effective area		Same as base metal	Matching weld metal shall be used. Weld metal with a strength level equal to or one classification (10 ksi [69 MPa]) less than matching weld metal may be used. Weld metal with a strength level equal to or less than matching weld metal may be used.
	Compression normal to the effective area		Same as base metal	
	Tension or compression parallel to the axis of the weld		Same as base metal	
	Shear on the effective area		0.27 times nominal tensile strength of weld metal, except shear stress on base metal shall not exceed 0.55 times yield strength of base metal.	
Partial joint penetration groove welds (Joint Class IV or V)	Compression normal to effective area	Joint not designed to bear	0.45 times nominal tensile strength of weld metal, except shear stress on base metal shall not exceed 0.55 times yield strength of base metal.	Weld metal with a strength level equal to or less than matching weld metal may be used.
		Joint designed to bear	Same as base metal	
	Tension or compression parallel to the axis of the weld ⁽³⁾		Same as base metal	
	Shear parallel to axis of metal		0.27 times nominal tensile strength of weld metal, except shear stress on base metal shall not exceed 0.55 times yield strength of base metal.	
	Tension normal to effective area		0.27 times nominal tensile strength of weld metal, except tensile stress on base metal shall not exceed 0.36 times yield strength of base metal.	
Fillet welds (Joint Class IV, V, or VI)	Shear on effective area		0.27 times nominal tensile strength of weld metal, except shear stress on base metal shall not exceed 0.36 times yield strength of base metal.	Weld metal with a strength level equal to or less than matching weld metal may be used.
	Tension or compression parallel to axis of weld ⁽³⁾		Same as base metal	
Plug and slot welds (Joint Class V or VI)	Shear parallel to faying surfaces (on effective area)		0.27 times nominal tensile strength of weld metal, except shear stress on base metal shall not exceed 0.36 times yield strength of base metal.	Weld metal with a strength level equal to or less than matching weld metal may be used.

Notes:

(1) For definitions of effective area, see 6.2, 6.4, and 6.7.

(2) For matching weld metal, see Table 9.

(3) Fillet welds and partial joint penetration groove welds joining the component elements of built-up members, such as flange-to-web connections, may be designed without regard to the tensile or compressive stress in these elements parallel to the axis of the welds.

Table 3
Allowable Stress Range⁽¹⁾

Stress Category (From Table 4)	Allowable Stress Range, ksi [MPa] per Nominal Number of Loading Cycles			
	20 000 to 100 000 ⁽²⁾	100 000 to 500 000	500 000 to 2 000 000	Over 2 000 000
A	63 [435]	37 [255]	24 [165]	24 [165]
B	49 [340]	29 [200]	18 [125]	16 [110]
B'	39 [270]	23 [160]	15 [100]	12 [80]
C	35 [240]	21 [145]	13 [90]	10 [70] ⁽³⁾
D	28 [190]	16 [110]	10 [70]	7 [50]
E	22 [150]	13 [90]	8 [55]	5 [34]
E'	16 [110]	9 [60]	6 [40]	3 [20]
F	15 [100]	12 [80]	9 [60]	8 [55]

Notes:

- (1) Stress range is defined as the algebraic difference between the maximum stress and the minimum stress. Tension stress is considered to have the opposite algebraic sign from the compression stress.
(2) For less than 20 000 loading cycles, use the allowable stress for static loading in accordance with 5.1.1.
(3) Flexural stress range of 12 ksi [80 MPa] permitted at toe of stiffener welds or flanges.

load. The effective length of a fillet weld shall be the overall length of the full size fillet, including boxing (end returns).

6.4.4 Fillet welds terminated at ends or sides of parts or members shall, wherever practicable, be returned continuously around the corners for a distance at least twice the nominal size of the weld where such return can be made in the same plane. Fillet welds deposited on the opposite sides of a common plane of contact between two parts shall be interrupted at a corner common to both welds.

Unless otherwise specified in the contract documents, fillet welds connecting attachments shall start or terminate a distance approximately equal to the weld size from the end of the joint. For girder stiffeners, the welds joining the stiffeners to the web shall start or terminate a distance approximately equal to two times the weld size from the end of the joint.

6.4.5 Fillet welds in holes or slots may be used to transmit shear in lap joints to prevent the buckling or separation of lapped parts, or to join components of built up members. Fillet welds in holes or slots are not to be considered plug or slot welds.

6.4.6 Fillet welds shall not be used in skewed T-joints that have an included angle of less than 60° or more than 135°. The edge of the abutting member shall be beveled, when necessary, to limit the root opening to 1/8 in. [3 mm] maximum.

6.5 Intermittent Fillet Welds

6.5.1 The length of any segment of intermittent fillet welds shall not be less than four times the weld size, with a minimum of 2 in. [50 mm]. Welds shall be made on both sides of the joint for at least 25% of its length. Maximum spacing permitted between welds shall be 12 in. [300 mm].

6.5.2 Intermittent fillet welds may be used to carry calculated loads except as prohibited in 6.5.4.

6.5.3 Intermittent fillet welds shall be no less than 2 in. [50 mm] in length at each end of the joint. (Note restriction in 6.4.4.)

6.5.4 Intermittent fillet welds on primary tension members are prohibited.

6.6 Staggered Intermittent Fillet Welds (See Figure 4)

6.6.1 When staggered intermittent fillet welds are used, the clear spacing shall be considered the distance between two consecutive welds on the same side of the plate.

6.6.2 When the total aggregate length of the staggered intermittent fillet weld is 90% or more of the joint length, any odd number of weld segments may be used provided:

- (1) Welds are placed at each end of the joint on one side, and
- (2) Clear spacing does not exceed 6 in. [150 mm].

6.6.3 Intermittent staggered fillet welds on primary tension members are prohibited.

Table 4
Stress Categories to Determine Allowable Stress Range

General Condition	Situation	Kind of Stress ⁽¹⁾	Stress Category (see Table 3)	Illustrative Example Numbers (See Figure 1) ⁽²⁾
Plain Material	Base metal with rolled or cleaned surface. Flame-cut edges with ANSI smoothness of 1000 or less.	T or Rev.	A	1, 2
Built-up Members	Base metal and weld metal in members without attachments, built-up plates, or shapes connected by continuous fillet welds parallel to the direction of applied stress.	T or Rev.	B	3, 4, 5, 6
	Base metal and weld metal in members without attachments, built-up plates, or shapes connected by complete joint penetration groove welds with backing bars not removed, or by partial joint penetration groove welds parallel to the direction of applied stress.	T or Rev.	B'	3, 4, 5, 6
	Base metal at toe of welds on girder webs or flanges adjacent to welded transverse stiffeners.	T or Rev.	C	7
	Base metal at ends of partial length welded cover plates narrower than the flange having square or tapered ends, with or without welds across the ends or wider than flange with welds across the ends. Flange thickness ≤ 0.8 in. [20 mm] Flange thickness > 0.8 in. [20 mm]	T or Rev. T or Rev.	E E'	5 5
	Base metal at end of partial length welded cover plates wider than the flange without welds across the ends.		E'	5
Groove Welds	Base metal and weld metal at complete joint penetration groove welded splices of parts of similar cross section ground flush, with grinding in the direction of applied stress and with weld soundness established by radiographic or ultrasonic inspection in accordance with the requirements of Section 10.	T or Rev.	B	10, 11
	Base metal and weld metal at complete joint penetration groove welded splices at transitions in width or thickness, with welds ground to provide slopes no steeper than 1 to 2-1/2 with grinding in the direction of applied stress, and with weld soundness established by radiographic or ultrasonic inspection in accordance with the requirements of Section 10. A514 base metal Other base metals	T or Rev. T or Rev.	B' B	12, 13 12, 13
	Base metal and weld metal at complete joint penetration groove welded splices, with or without transitions having slopes no greater than 1 to 2-1/2 when reinforcement is not removed but weld soundness is established by radiographic or ultrasonic inspection in accordance with the requirements of Section 10.	T or Rev.	C	10, 11, 12, 13
Partial Joint Penetration Groove Welds	Weld metal of partial joint penetration transverse groove welds, based on effective throat area of the weld or welds	T or Rev.	F ⁽³⁾	16

(continued)

Table 4 (Continued)
Stress Categories to Determine Allowable Stress Range

General Condition	Situation	Kind of Stress ⁽¹⁾	Stress Category (see Table 3)	Illustrative Example Numbers (See Figure 1) ⁽²⁾
Fillet-Welded Connections	Base metal at intermittent fillet welds	T or Rev.	E	
	Base metal at junction of axially loaded members with fillet-welded end connections. Welds shall be disposed about the axis of the member so as to balance weld stresses. b ≤ 1 in. [25 mm] b > 1 in. [25 mm]	T or Rev. T or Rev.	E E'	17, 18 17, 18
	Base metal at members connected with transverse fillet welds. b ≤ 1 in. [25 mm] b > 1 in. [25 mm]	T or Rev.	C ⁽³⁾	20, 21
Fillet Welds	Weld metal of continuous or intermittent longitudinal or transverse fillet welds.	S	F ⁽³⁾	15, 17, 18, 20, 21
Plug or Slot Welds	Base metal at plug or slot welds.	T or Rev.	E	27
	Shear on plug or slot welds.	S	F	27
Mechanically Fastened Connections	Base metal at cross section of high-strength bolted slip-critical connections, except axially loaded joints which induce out-of-plane bending in connected material.	T or Rev.	B	8
	Base metal at net section of other mechanically fastened joints.	T or Rev.	D	8, 9
	Base metal at net section of fully tensioned high-strength, bolted bearing connections.	T or Rev.	B	8, 9
Attachments	Base metal at details attached by complete joint penetration groove welds subject to longitudinal and/or transverse loading when the detail embodies a transition radius R with the weld termination ground smooth and for transverse loading, the weld soundness established by radiographic or ultrasonic inspection in accordance with Section 10.			
	Longitudinal Loading R > 24 in. [600 mm]	T or Rev.	B	14
	24 in. [600 mm] ≥ R > 6 in. [150 mm]	T or Rev.	C	14
	6 in. [150 mm] ≥ R > 2 in. [50 mm]	T or Rev.	D	14
	R ≤ 2 in. [50 mm]	T or Rev.	E	14
	Detail base metal for transverse loading: equal thickness and reinforcement removed. R > 24 in. [600 mm]	T or Rev.	B	14
	24 in. [600 mm] ≥ R > 6 in. [150 mm]	T or Rev.	C	14
	6 in. [150 mm] ≥ R > 2 in. [50 mm]	T or Rev.	D	14
	R ≤ 2 in. [50 mm]	T or Rev.	E	14, 15
	Detail base metal for transverse loading: equal thickness and reinforcement not removed. R > 24 in. [600 mm]	T or Rev.	C	14
	24 in. [600 mm] ≥ R > 6 in. [150 mm]	T or Rev.	C	14
	6 in. [150 mm] ≥ R > 2 in. [50 mm]	T or Rev.	D	14
R ≤ 2 in. [50 mm]	T or Rev.	E	14, 15	

(continued)

Table 4 (Continued)
Stress Categories to Determine Allowable Stress Range

General Condition	Situation	Kind of Stress ⁽¹⁾	Stress Category (see Table 3)	Illustrative Example Numbers (See Figure 1) ⁽²⁾
Attachments (Cont'd)	Detail base metal for transverse loading: unequal thickness and reinforcement removed. R > 2 in. [50 mm] R ≤ 2 in. [50 mm]	T or Rev. T or Rev.	D E	14 14, 15
	Detail base metal for transverse loading: unequal thickness and reinforcement not removed. All R	T or Rev.	E	14, 15
	Detail base metal for transverse loading. R > 24 in. [600 mm] 6 in. [150 mm] ≥ R > 2 in. [50 mm] R ≤ 2 in. [50 mm]	T or Rev. T or Rev. T or Rev.	C D E	19 19 19
	Base metal at detail attached by complete joint penetration groove welds subject to longitudinal loading. 2 in. [50 mm] < a ≤ 12b or 4 in. [100 mm] a > 12b or 4 in. [100 mm] when b ≤ 1 in. [25 mm] a > 12b or 4 in. [100 mm] when b > 1 in. [25 mm]	T or Rev. T or Rev. T or Rev.	D E E'	15 15 15
	Base metal at detail attached by fillet welds or partial joint penetration groove welds subject to longitudinal loading. a ≤ 2 in. [50 mm] 2 in. [50 mm] < a ≤ 12b or 4 in. [100 mm] a > 12b or 4 in. [100 mm] when b ≤ 1 in. [25 mm] a > 12b or 4 in. [100 mm] when b > 1 in. [25 mm]	T or Rev. T or Rev. T or Rev. T or Rev.	C D E E'	15, 23, 24, 25, 26 15, 23, 24, 26 15, 23, 24, 26 15, 23, 24, 26
	Base metal attached by fillet welds or partial joint penetration groove welds subjected to longitudinal loading when the weld termination embodies a transition radius with the weld termination ground smooth. R > 2 in. [50 mm] R ≤ 2 in. [50 mm]	T or Rev. T or Rev.	D E	19 19
	Fillet-welded attachments where the weld termination embodies a transition radius, weld termination ground smooth, and main material subject to longitudinal loading. R > 2 in. [50 mm] R ≤ 2 in. [50 mm]	T or Rev. T or Rev.	D E	19 19
	Base metal at stud-type shear connector attached by fillet weld or automatic end weld.	T or Rev.	C	22
	Shear stress on nominal area of stud-type shear connectors.	S	F	—

Notes:

- (1) "T" signifies range in tensile stress only; "Rev." signifies a range involving reversal of tensile or compressive stress; "S" signifies range in shear, including shear stress reversal.
- (2) These examples are provided as guidelines and are not intended to exclude other reasonably similar situations.
- (3) Allowable fatigue stress range for transverse partial joint penetration groove welds and transverse fillet welds is a function of the effective throat, depth of penetration, and plate thickness. See Frank and Fisher, *Journal of the Structural Division*, Vol. 105, N. ST9, Sept. 1979.

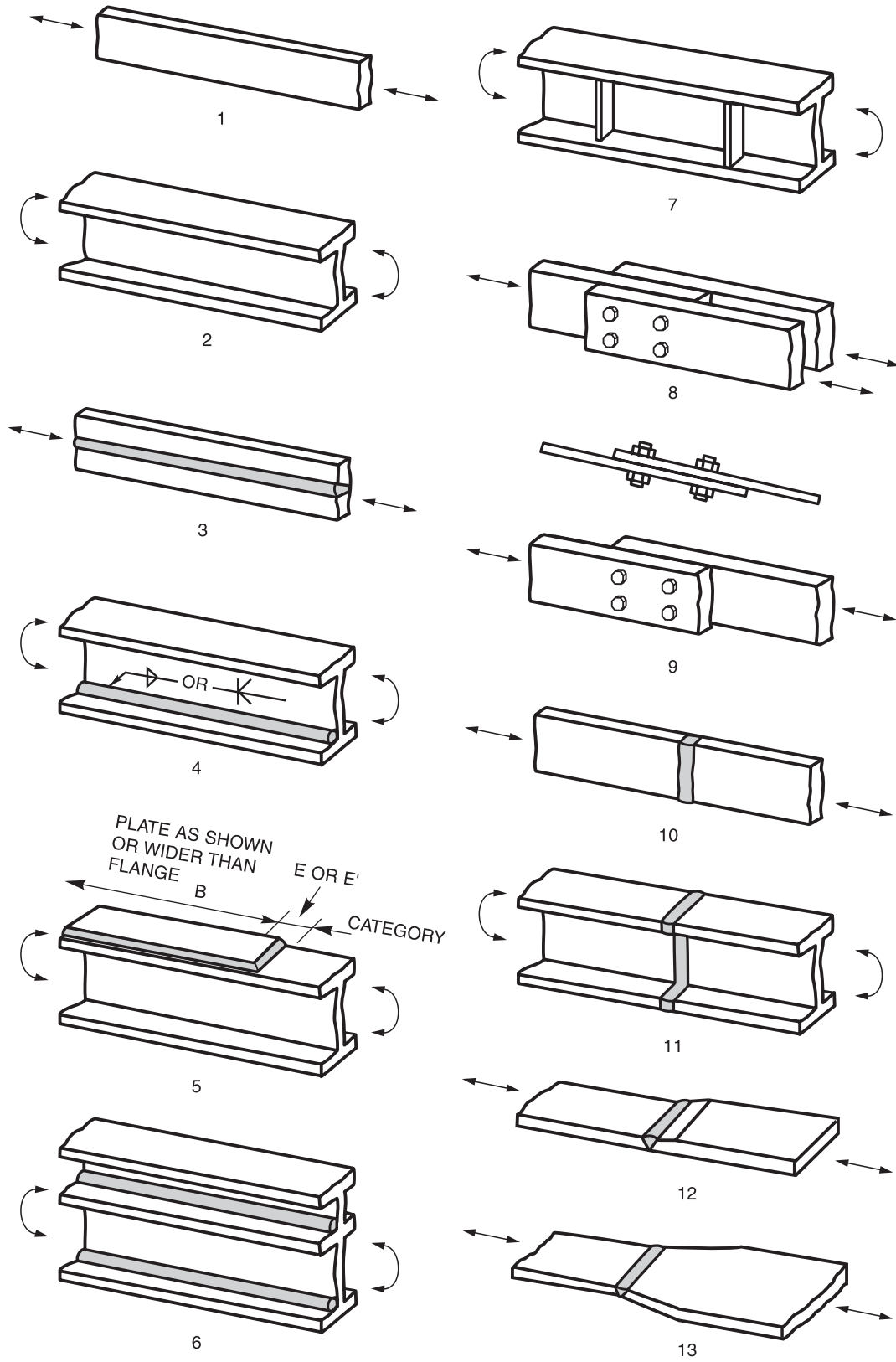


Figure 1—Illustrative Examples for Table 4

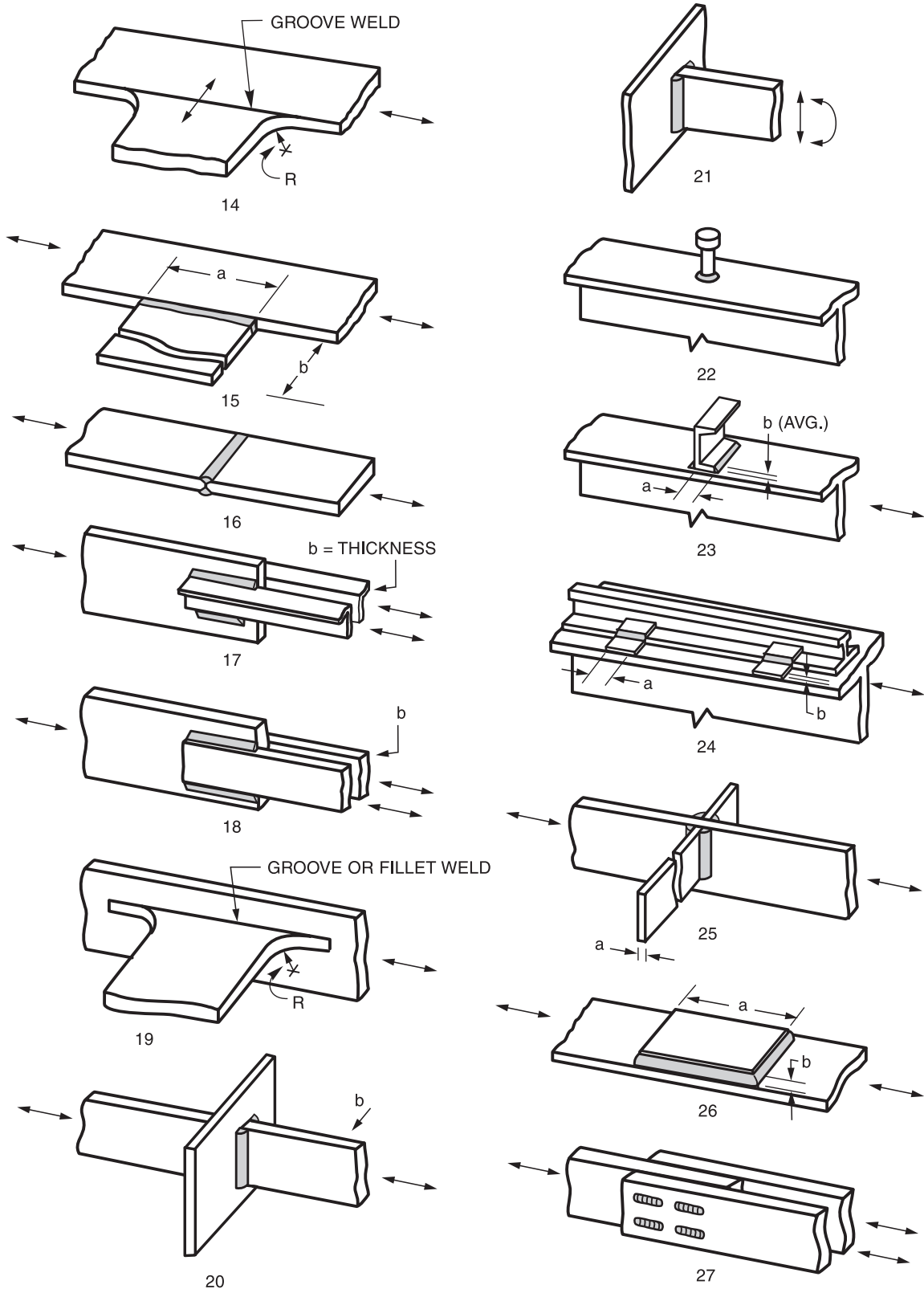
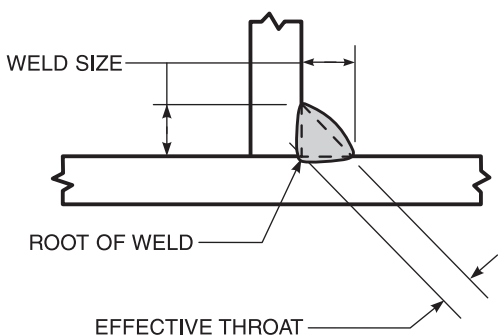


Figure 1 (Continued)—Illustrative Examples for Table 4

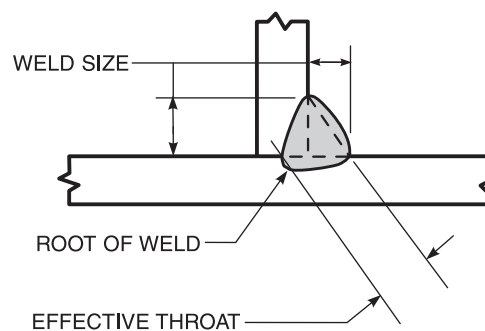
Table 5
Minimum Effective Throat for Partial Joint Penetration Groove Welds

Metal Thickness of Thicker Part Jointed		Minimum Effective Throat	
in.	mm	in.	mm
≤ 1/4	≤ 6	1/8	3
> 1/4 to ≤ 1/2	> 6 to ≤ 13	3/16	5
> 1/2 to ≤ 3/4	> 13 to ≤ 20	1/4	6
> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	5/16	8
> 1-1/2 to ≤ 2-1/4	> 40 to ≤ 55	3/8	10
> 2-1/4 to ≤ 6	> 55 to ≤ 150	1/2	13
> 6	> 150	5/8	16

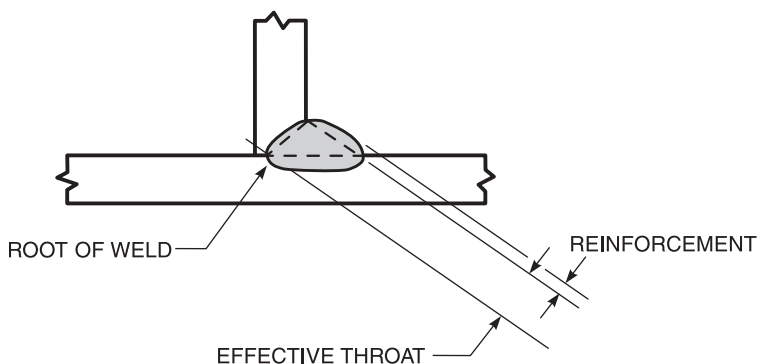
General Note: The effective throat does not need to exceed the thickness of the thinner part joined.



(A) STANDARD FILLET WELD

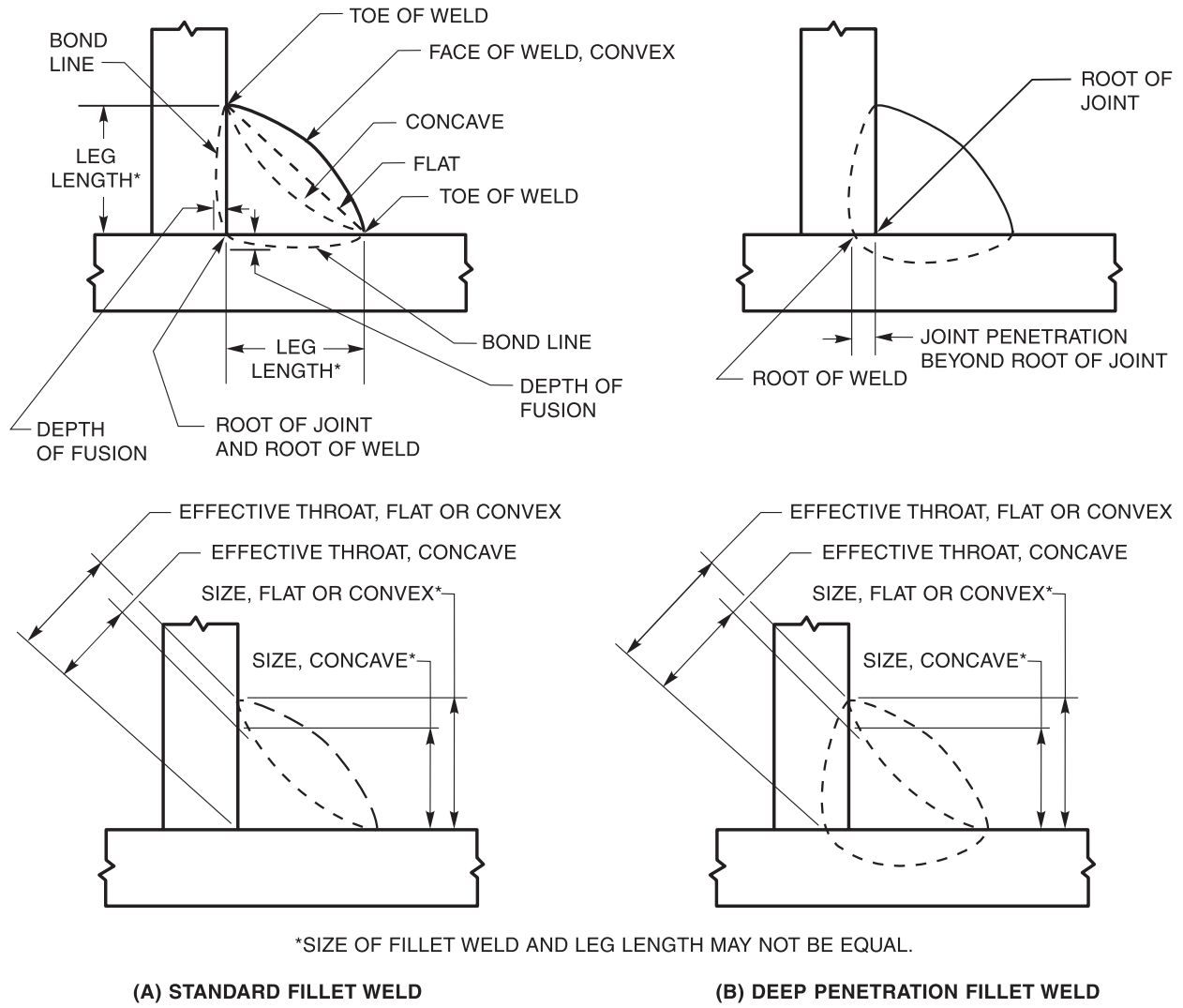


(B) DEEP PENETRATION FILLET WELD

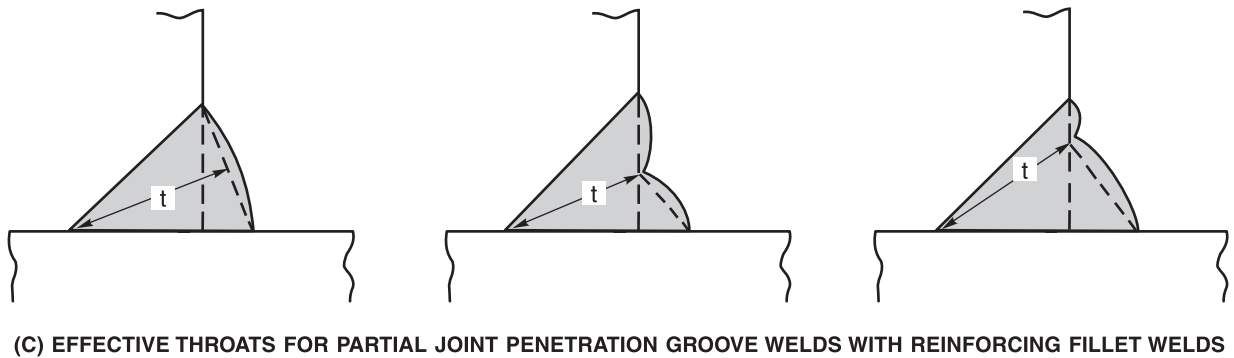


(C) ACTUAL THROAT OF A BEVEL GROOVE WELD REINFORCED WITH A FILLET WELD

Figure 2—Fillet and Combined Weld Dimension



Source: Figures 3(A) and 3(B) from AWS D14.5-97, Figures 2(A) and 2(B).



Source: Figure 3(C) from AWS A3.0:2001, Figure 25(I).

Figure 3—Size and Effective Throat Measurements for Fillet and Partial Penetration Groove Welds with Reinforcing Fillet Welds

Table 6
Minimum Fillet Weld Size

Metal Thickness of Thicker Part Joined		Weld Size ⁽¹⁾			
		Shielded Metal Arc Welding		Deep Penetration Process ⁽²⁾ for Single Pass Welds ⁽³⁾ Flat or Horizontal Positions	
in.	mm	in.	mm	in.	mm
≤ 1/4	≤ 6	1/8	3	1/8	3
> 1/4 to ≤ 1/2	> 6 to ≤ 13	3/16	5	1/8	3
> 1/2 to ≤ 3/4	> 13 to ≤ 20	1/4	6	3/16	5
> 3/4	> 20	5/16	8	1/4	6

Notes:

- (1) Weld size need not exceed thickness of thinner member. Minimum weld size for cyclically loaded structures is 3/16 in. [5 mm].
 (2) The intent of this table is not to establish the arc welding processes that provide deep penetration, but rather, to establish the typical allowable decrease of fillet weld size, provided the Manufacturer can demonstrate that the required effective throat can be obtained by the qualified welding procedure in accordance with Section 9.
 (3) Also applies to the root pass of a multiple pass weld.

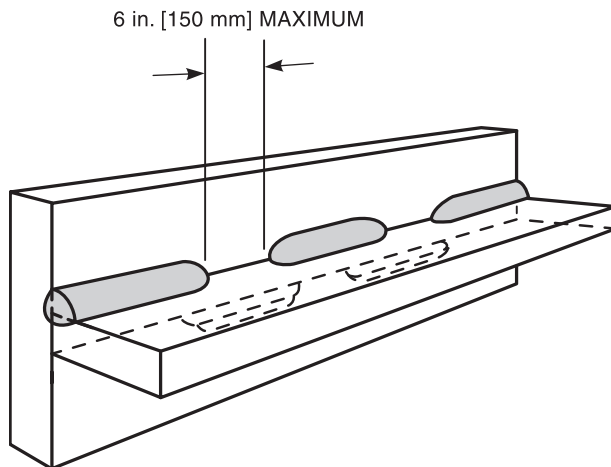


Figure 4—Staggered Intermittent Fillet Weld

6.7 Plug and Slot Welds

6.7.1 Plug or slot welds may be used to transmit shear loading in a lap joint to prevent buckling or separation of lapped parts, or to join component parts of built up members, except with quenched and tempered steels.

6.7.2 The effective area shall be the nominal area of the hole or slot in the plane of the faying surface.

6.7.3 The minimum diameter of the hole for a plug weld shall be no less than the thickness of the part con-

taining it plus 5/16 in. [8 mm], preferably rounded to the next greater odd 1/16 in. [2 mm]. The maximum diameter shall equal the minimum diameter plus 1/8 in. [3 mm] or 2 1/4 times the thickness of the member, whichever is greater. The minimum center-to-center spacing of plug welds shall be four times the diameter of the hole.

6.7.4 The length of the slot for a slot weld shall not exceed 10 times the thickness of the weld. The width of the slot shall not be less than the thickness of the part containing it plus 5/16 in. [8 mm], preferably rounded to the next greater odd 1/16 in. [2 mm]. The maximum width shall equal the minimum width plus 1/8 in. [3 mm] or 2 1/4 times the thickness of the member, whichever is greater. The ends of the slot shall be semicircular or shall have the corners rounded to a radius not less than the thickness of the part containing it, except those ends which extend to the edge of the part.

6.7.5 The depth of filling of plug or slot welds in metal 5/8 in. [16 mm] thick or less shall be equal to the thickness of the metal. In metal over 5/8 in. [16 mm] thick, it shall be at least one-half the thickness of the metal but no less than 5/8 in. [16 mm].

6.7.6 The minimum center-to-center spacing of plug welds shall be four times the diameter of the hole.

6.7.7 The minimum spacing of lines of slot welds in a direction transverse to their length shall be four times the width of the slot. The minimum center-to-center spacing in a longitudinal direction on any line shall be two times the length of the slot.

6.7.8 Plug and slot welds on primary tension members are prohibited.

6.8 Suggested Classification of Welded Joints

6.8.1 The classifications of welded joints for use in the design and manufacture of overhead material handling machinery and equipment are listed in 6.9 and illustrated in Figure 5.

6.8.2 These classifications can be used for qualification and examination of welded joints used in fabrication of equipment covered by this specification.

6.8.3 It is not the intent of these classifications to restrict the use of other proven methods and procedures that have achieved acceptable results, when agreed to in writing by the Manufacturer and Owner.


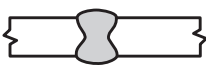
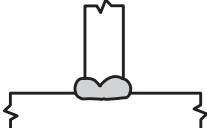
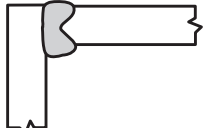

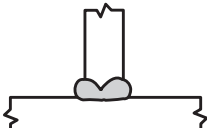
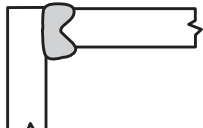
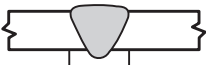
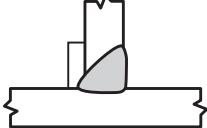
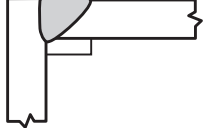
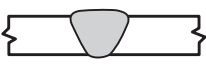
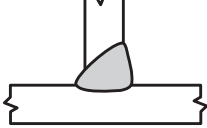

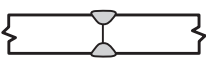
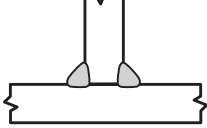
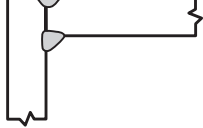
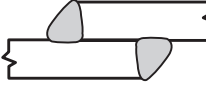
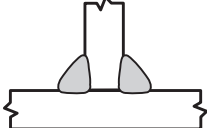
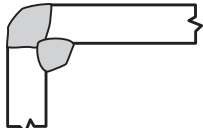
JOINT CLASS	CONFIGURATION OF WELDED JOINTS		
I			
II			
III			
			
IV			
			
			

Figure 5—Classification of Welded Joints

JOINT CLASS	CONFIGURATION OF WELDED JOINTS		
V			
VI			

General Note: Avoid loading the joint in the arrow direction.

Figure 5 (Continued)—Classification of Welded Joints

6.9 Weld Joint Classes

6.9.1 Joint Class I. Joints in this class are double-welded butt joints with complete joint penetration. The root of the first weld is chipped, gouged, or ground to sound metal before making the second weld, and the weld faces are ground or machined flush with the direction of metal removal parallel to the principle stress. Welded joints that are made using backing tape, fusible flux backing material, or a nonfusible backing bar, and are back welded to obtain a completely fused root, shall be qualified in accordance with Section 9, Qualification. Finished joints shall be nondestructively examined according to Section 10, Weld Quality and Inspection, and the results recorded.

6.9.2 Joint Class II. Joints in this class are double-welded butt, T-, and corner joints with complete joint penetration. The root of the first weld is chipped, gouged, or ground to sound metal before making the second weld. Welded joints that are made using backing tape, fusible flux backing material, or a nonfusible backing bar, and are back welded to obtain a completely fused root, shall be qualified in accordance with Section 9, Qualification. Finished joints shall be nondestructively examined according to Section 10, Weld Quality and Inspection, and the results recorded.

6.9.3 Joint Class III. Joints in this class are complete joint penetration butt, T-, and corner joints welded from both sides, or from one side using a backing strip that is not removed after welding.

6.9.4 Joint Class IV. Joints in this class are complete joint penetration butt, T-, and corner joints welded from one side without the use of backing; partial joint penetration butt, T-, and corner joints welded on both sides; and fillet welded lap, T-, and corner joints welded on both sides.

6.9.5 Joint Class V. Joints in this class are partial joint penetration butt, T-, and corner joints welded on one side; and fillet, plug, or slot welded lap, T-, and corner joints welded on one side only.

6.9.6 Joint Class VI. Joints in this class are joints which do not require special weld groove preparation, such as butt, T-, corner, lap, or edge joints; plug welds; welds of secondary importance in strength; and structural welded joints of secondary importance not subject to dynamic loading.

6.10 Joint Qualification

6.10.1 Joints meeting the following requirements are designated as prequalified:

(1) Conformance with the details of 6.2 through 6.7, and Figures I.1 or I.2 in Annex I; and

(2) Welded with one of the following processes in accordance with the requirements of Section 8, Processes and Filler Metals, as applicable: shielded metal arc, submerged arc, flux cored arc, and gas metal arc with other than short-circuiting transfer.

6.10.2 Other joint configurations may be used with proper qualification in accordance with Section 9, Qualification.

6.11 Transition of Thicknesses or Widths at Butt Joints

6.11.1 Butt joints between parts of unequal thicknesses and also subject to tensile stress shall have a smooth transition between the offset surfaces at a maximum slope of 1 in 2-1/2 with the adjacent surface of either part. The transition may be accomplished by sloping the weld face(s), by chamfering the thicker part, or by a combination of the two methods (see Figure 6).

6.11.2 Transition of thickness in butt joints between parts of unequal thickness, that are subject only to shear or compressive stress, shall be accomplished as specified in 6.11.1 when the offset between surfaces at either side of the joint is greater than the thickness of the thinner part connected. When the offset does not exceed the thickness of the thinner part connected, the face of the weld shall be sloped (1) no more than 1 in 2-1/2 from the surface of the thinner part or (2) to the surface of the thicker part if this requires a lesser slope. The exception is that truss member joints and beam and girder flange joints shall be made with a smooth transition of the type specified in 6.11.1.

6.11.3 Butt joints between parts of unequal width that are subject to tensile stress shall have either (1) a smooth slope between offset edges of no more than 1 in 2-1/2 with the edge of either part or (2) a 2.0 ft [600 mm] minimum radius tangent to the narrower part at the center of the butt joint, as shown in Figure 7. A radius transition is required for steels having yield strength greater than or equal to 90 ksi [620 MPa].

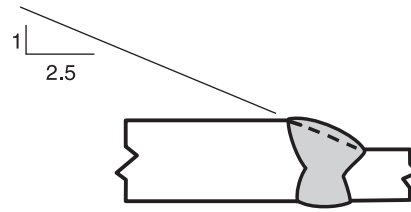
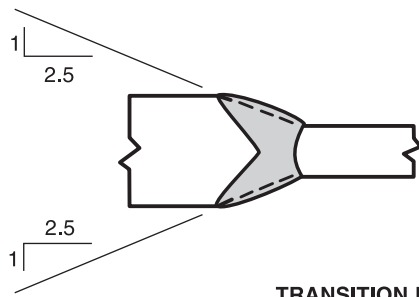
6.12 Material for Joint Extensions, Backing, and Spacers

6.12.1 Material for joint extensions and backing used in welding shall conform to the following requirements:

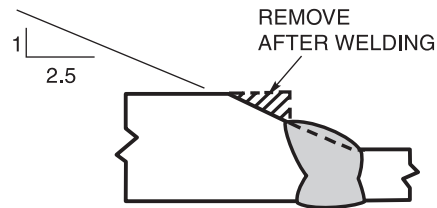
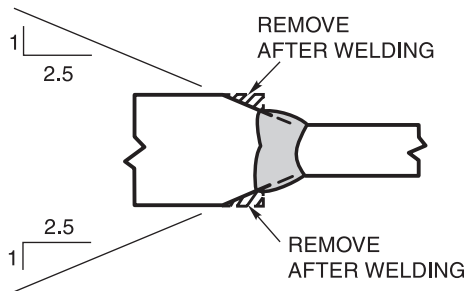
(1) When used for welding any prequalified steel listed in 4.4, they may be of any of the steels in the same list.

(2) When used for welding with a steel qualified in accordance with this specification, they shall be of the steel qualified.

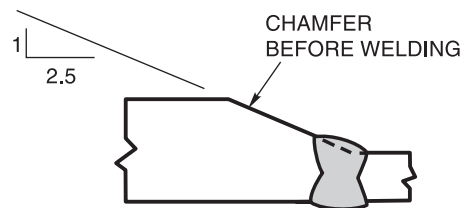
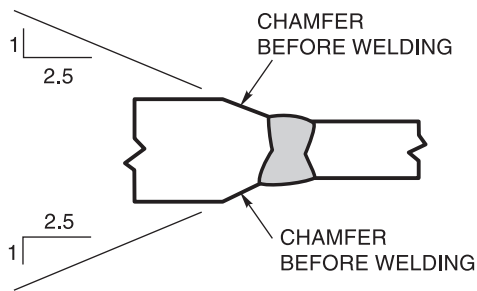
(3) Use 100 ksi [690 MPa] minimum yield strength steel when and only when welding 100 ksi [690 MPa] minimum yield strength steels.



TRANSITION BY SLOPING WELD SURFACE



TRANSITION BY SLOPING WELD SURFACE AND CHAMFERING



TRANSITION BY CHAMFERING THICKER PART

CENTERLINE ALIGNMENT
(PARTICULARLY APPLICABLE TO WEB PLATES)

OFFSET ALIGNMENT
(PARTICULARLY APPLICABLE TO FLANGE PLATES)

General Notes:

1. Groove may be of any permitted or qualified type and detail.
2. Transition slopes shown are the maximum permitted.

Figure 6—Transition of Butt Joints in Parts Having Unequal Thickness

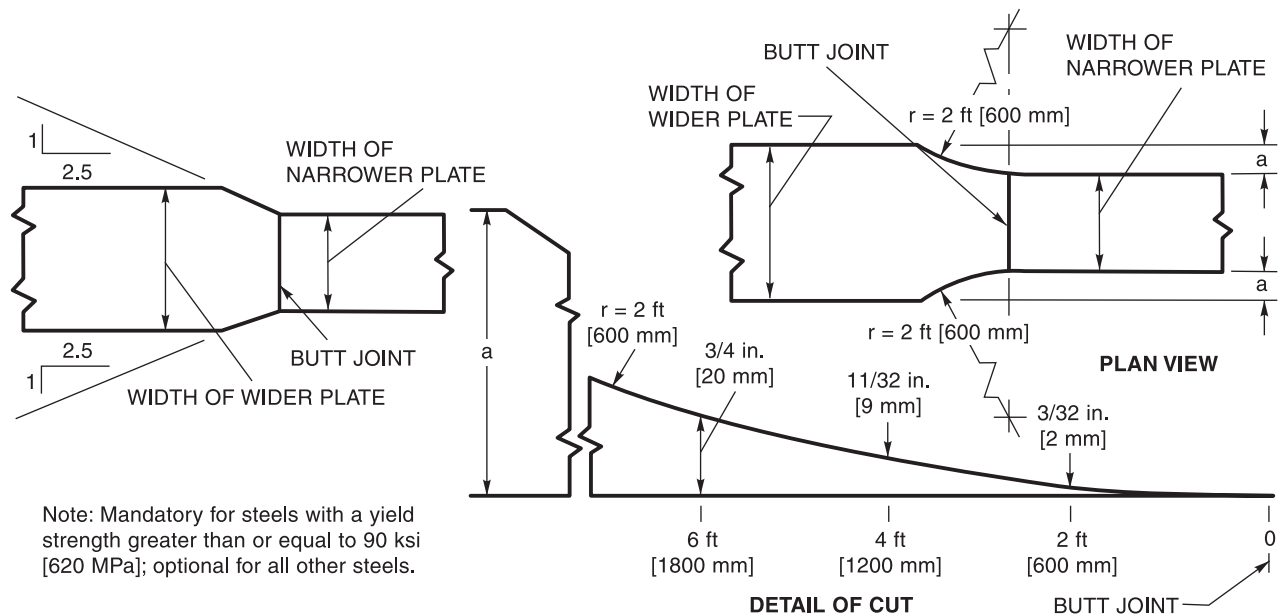


Figure 7—Transition of Width at Butt Joints of Parts Having Unequal Width (see 6.11.3)

6.12.2 Spacers shall be of the same material as the base metal.

6.13 Dimensional Tolerances. Dimensions of groove welds specified on design or detailed drawings may vary from the dimensions shown in Figures I.1 and I.2 only within the following limits:

6.13.1 The specified thickness of base metal or weld effective throat is the maximum nominal thickness that may be used.

6.13.2 The stated groove angle is the minimum; it may be detailed to exceed the dimensions shown by no more than 10° .

6.13.3 The stated radius of J and U grooves is the minimum. U grooves may be prepared before or after fit up.

6.13.4 Double groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than $1/4$ of the thickness of the thinner part joined, unless otherwise designated in Figures I.1 and I.2.

6.13.5 The root face of the joint shall be as shown in Figures I.1 and I.2 with the following variations permitted:

(1) For shielded metal arc, gas metal arc, and flux cored arc welding, it may not be detailed less than the specified dimension.

(2) For complete joint penetration submerged arc welding, the specified root face of the joint is the maximum.

6.13.6 The stated root opening of the joints is the minimum. It may be detailed to exceed the specified dimensions by no more than $1/16$ in. [2 mm], except that the root opening of joints for submerged arc welding shall be detailed as zero (no variation) when so specified.

6.14 Lap Joints

6.14.1 The minimum overlap of parts in stress carrying lap joints shall be five times the thickness of the thinner part. Unless lateral deflection of the parts is prevented, they shall be connected by at least two transverse lines of fillet, plug, or slot welds or by two or more longitudinal fillet or slot welds.

6.14.2 If longitudinal fillet welds are used alone in lap joints of end connections, the length of each fillet weld shall be no less than the perpendicular distance between the welds. The transverse spacing of the welds shall not exceed 16 times the thickness of the connected thinner part unless suitable provision is made (as by intermediate plug or slot welds) to prevent buckling or separation of the parts. The longitudinal fillet weld may be either at the edges of the member or in slots.

6.14.3 When fillet welds in holes or slots are used, the clear distance from the edge of the hole or slot to the adjacent edge of the part containing it, measured perpendicular to the direction of stress, shall be no less than five times the thickness of the part nor less than two times the width of the hole or slot. The strength of the part shall be determined from the critical net section of the base metal.

6.15 Corner and T-Joints. Corner and T-joints that are to be subjected to bending about an axis parallel to the joint shall have their welds arranged to avoid concentration of tensile stress at the root of any weld.

6.16 Welds in Combination with Rivets and Bolts. Rivets or bolts used in bearing-type connections shall not be considered as sharing the load in combination with welds. Welds, if used, shall be provided to carry the entire load in the connection. High-strength bolts properly installed as a slip-critical-type connection prior to welding may be considered as sharing the load with the welds. Bolts or rivets used in assembly may be left in place if their removal is not specified. If bolts are to be removed, the plans should indicate whether holes should be filled and in what manner.

6.17 Eccentricity of Connections

6.17.1 Eccentricity between intersecting parts and members shall be avoided insofar as practicable.

6.17.2 In designing welded joints, adequate provision shall be made for bending stresses due to eccentricity, if any, in the disposition and section of base-metal parts and in the location and types of welded joints.

6.17.3 For members having symmetrical cross sections, the connection welds shall be arranged symmetrically about the axis of the member, or proper allowance shall be made for unsymmetrical distribution of stresses.

6.17.4 For axially stressed angle members, the center of gravity of the connecting welds shall lie between the line of the center of gravity of the angle's cross section and the centerline of the connected leg. If the center of gravity of the connecting weld lies outside of this zone, the total stresses, including those due to the eccentricity from the center of gravity of the angle, shall not exceed those permitted by this specification.

7. Workmanship

7.1 General

7.1.1 All requirements of this section shall be observed in the production and inspection of welded

assemblies produced by any of the processes acceptable under this specification.

7.1.2 All welding and thermal-cutting equipment shall be so designed and manufactured, and shall be in such condition, as to enable designated personnel to follow the procedures and attain the results described elsewhere in this specification.

7.1.3 Welding shall not be done when the ambient temperature is lower than 0°F [-18°C], when surfaces are wet or exposed to rain, snow, or high wind velocities, or when welding personnel are exposed to inclement conditions. The maximum permissible wind velocity will vary with the welding process and procedure. Heating, local protection from the elements, or both, shall be used as necessary.

7.1.4 The size and length of welds shall not be less than those specified by design requirements and detail drawings, except as permitted by 10.6(6), nor shall they exceed those requirements by more than 25% without prior approval of the design change by the responsible Engineer. Also, the location of welds shall not be changed without prior approval of the Design Engineer.

7.2 Preparation of the Base Metal

7.2.1 Surfaces and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other visual defects that would adversely affect the quality of the weld. Surfaces to be welded and surfaces adjacent to a weld shall be free from loose or thick mill scale, slag, rust, paint, moisture, and other foreign material, or contaminants that will prevent proper welding or produce hazardous fumes. Thin mill scale (that can withstand vigorous wire brushing), thin rust-inhibitive coating, or antisplatter compound (that will not cause problems with welding) need not be removed.

7.2.2 When oxyfuel gas cutting is employed, the cutting torch shall be adjusted and manipulated to avoid cutting beyond (inside) the prescribed lines. The roughness of cut surfaces shall not be greater than Sample No. 2 of AWS C4.1, *Surface Roughness Gauge*, for material thicknesses up to 2 in. [50 mm], and Sample No. 1 for material 2 in. [50 mm] to 8 in. [200 mm] thick. Surfaces exceeding the above roughness values and occasional notches or gouges not exceeding 3/16 in. [5 mm] deep shall be corrected by machining or grinding. Notches or other sharp discontinuities exceeding 3/16 in. [5 mm] may be repaired by welding only with the approval of the Design Engineer. Approved weld repairs shall be made only by following a documented repair welding procedure that shall contain the following:

- (1) Discontinuity removal and joint preparation.
- (2) Welding process and filler metal to be used.

(3) Preheat and welding variables and also any postheat requirements necessary to comply with this specification.

(4) Procedures for grinding the completed weld smooth and flush to within the surface roughness acceptance criteria of 7.2.2. Weld repaired surfaces and edges that will not be subsequently incorporated into a welding joint shall be stress relieved by any approved method when determined necessary by the Design Engineer.

7.2.3 Machining, plasma arc cutting, air carbon arc cutting, oxyfuel gas cutting, oxygen gouging, chipping, or grinding may be used for joint preparation, back gouging, and the removal of unacceptable work or metal. One exception is that oxygen gouging shall not be used on quenched and tempered steel. Thermally cut surfaces should be ground as needed to proper contour. Preparation of nonferrous base metals by nontraditional methods shall be a matter of agreement between the Manufacturer and Owner.

7.2.4 Edges of built up beam and girder webs shall be cut to the prescribed camber with empirically developed manufacturing allowance for shrinkage due to cutting and welding. However, deviation from the specified camber tolerances may be corrected by carefully supervised application of a limited amount of localized heat or other suitable means of obtaining the specified camber.

The use of flame straightening of distorted members and camber correction by localized heating shall have the approval of the Design Engineer and follow an approved written procedure (see 12.4). When flame straightening is used, the temperature of the heated areas shall be accurately measured. The temperature shall not exceed 1100°F [590°C] for quenched and tempered steels or normalized and tempered steels, and 1200°F [650°C] for other steels.

7.2.5 Dimensional Tolerances. Dimensions of built up beams and girders shall be within the tolerance of the general specification governing the work, and also within the following special tolerances. All measurements shall be taken at the Manufacturer's plant prior to shipment, unless otherwise specified.

7.2.5.1 Maximum deviation from straightness, D_s , (referenced to the neutral axis) of welded beams or girders, where there is no specified sweep:

$$D_s, \text{ in.} = 0.0125 \times \text{total length, ft}$$

$$D_s, \text{ mm} = 1.04 \times \text{total length, m}$$

7.2.5.2 Maximum deviation from specified camber (in the service position), D_c , of welded beam or girders:

$D_c, \text{ in.} = \pm 0.003 \times \text{total length, ft, or } \pm 1/4 \text{ in, whichever is greater}$

$D_c, \text{ mm} = \pm 0.25 \times \text{total length, m, or } \pm 6 \text{ mm, whichever is greater}$

7.2.5.3 Lateral deviation between the centerline of the web and the centerline of the flange of buildup H or I members at the contact surface (referenced to neutral axis) shall be 1/4 in. [6 mm] maximum.

7.2.5.4 The maximum deviation from the specified depth for welded built up beams and girders, measured at the web centerline, shall be $\pm 1/2$ in. [13 mm] for depths up to 72 in. [1800 mm]. For depths over 72 in. [1800 mm], the maximum deviation shall be $+3/4$ in. [20 mm] to $-1/2$ in. [13 mm].

7.2.6 Re-entrant corners, except for the corners of weld-access cope holes adjacent to a flange, shall be filleted to a radius of no less than 3/4 in. [20 mm]. The fillet and its adjacent cuts shall meet without offset or cutting past the point of tangency.

7.3 Visual Inspection and Repair of Plate and Wrought Steel Products

7.3.1 In the repair and the determination of the limits of visible internal discontinuities on rolled, sheared, or oxygen cut edges, the amount of metal removed shall be the minimum necessary to remove the discontinuity, but not to exceed the permissible limit given in Table 7. Material cut edges may exist at any angle with respect to the rolling direction. All repairs of discontinuities by welding shall conform to the applicable provisions of this specification.

7.3.2 The limits of acceptability and the repair of visually observed edge discontinuities shall be in accordance with Table 7. The length of discontinuity is the visible length dimension on the material edge, and the depth is the distance that the discontinuity extends into the material from the edge.

7.3.3 Discontinuities over 1 in. [25 mm] in length and in depth, when discovered during either visual inspection of cut surfaces or nondestructive examination of welded joints, shall be evaluated further. The following procedures are recommended:

(1) Where discontinuities, such as W, X, or Y in Figure 8 are observed prior to completing the joint, the size and shape of discontinuity shall be determined by ultrasonic inspection. The area of the discontinuity shall be determined as the area of total loss of back reflection when examined in accordance with the procedure section of ASTM A 435.

(2) For acceptance of W, X, or Y discontinuities, the area of a single discontinuity or the aggregate area of

Table 7
Limits on Acceptability and Repair of Edge Discontinuities in Cut Surfaces (see 7.3.2)

Size of Discontinuity		
Length, in. [mm]	Depth, in. [mm]	Repair Required
≤ 1 [25]	Unspecified	None; need not be explored.
> 1 [25]	≤ 1/8 [3]	None; depth should be explored per Note (1).
> 1 [25]	> 1/8 [3] to ≤ 1/4 [6]	Remove; repair welding not required.
> 1 [25]	> 1/4 [6] to ≤ 1 [25]	Completely remove and repair weld as limited by Note (2).
> 1 [25]	> 1 [25]	Refer to 7.3.3.

Notes:

- (1) A spot check of 10% of the discontinuities on the edge in question should be explored by grinding to determine depth. If the depth of any one of the discontinuities explored exceeds 1/8 [3 mm], then all of the discontinuities remaining on that edge shall be explored by grinding to determine depth. If none of the discontinuities explored in the 10% spot check has a depth exceeding 1/8 in. [3 mm], then the remaining of the discontinuities on that edge need not be explored.
- (2) Aggregate length of welding shall not exceed 20% of the length of the plate edge being repaired.

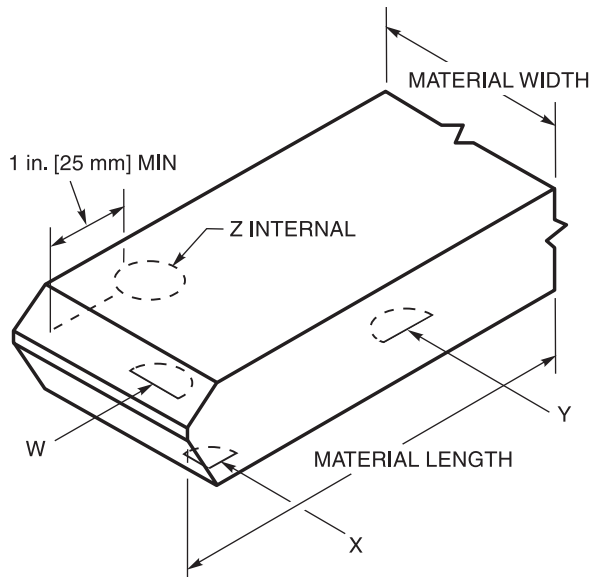


Figure 8—Edge Discontinuities in Cut Material (see 7.3.3)

multiple discontinuities shall not exceed 4% of the cut material area (length \times width) with the following exception: if the width of discontinuity or the aggregate width of discontinuities on any transverse section, as measured perpendicular to the cut material length, exceeds 20% of the cut material width, the maximum allowable area shall be reduced by the percentage amount of the width exceeding 20%. For example, if a discontinuity is 30% of the cut material width, the percentage area of discontinuity

cannot exceed $4 \text{ minus } 4 \times (0.30 - 0.20)$, or 3.6% of the cut material area. The discontinuity on the edge of the plate shall be gouged out to a depth of 1 in. [25 mm] beyond its intersection with the surface by chipping, air carbon arc gouging, or grinding, and then blocked off by welding in layers not exceeding 1/8 in. [3 mm] in thickness for at least the first four layers.

(3) Repair of an internal discontinuity, Z, in Figure 8 is not required if it does not exceed the allowable area in 7.3.3(2), is discovered after the joint has been completed, and is 1 in. [25 mm] or more from the toe of the weld as measured on the cut material surface. If a Type Z discontinuity is less than 1 in. [25 mm] from the face of the weld, it shall be removed to a distance of 1 in. [25 mm] from the fusion zone of the weld by chipping, gouging or grinding. It shall then be blocked by welding in layers not exceeding 1/8 in. [3 mm] in thickness for at least the first four layers.

(4) If the area of the discontinuity W, X, Y, or Z exceeds the allowable in 7.3.3(2), the cut material or sub-component shall be either rejected and replaced or repaired at the discretion of the Design Engineer.

(5) The aggregate length of weld repair shall not exceed 30% of the length of the cut surface without approval of the Design Engineer.

(6) All repairs shall be in accordance with this specification. Gouging of a discontinuity may be done from either the cut material surface or the edge.

7.4 Assembly

7.4.1 Parts to be joined by fillet welds shall be brought as close together as practicable at the joint. Root cracking may occur in a fillet weld if there is no root opening between the parts (e.g., surfaces machined to

bear). It may be necessary to provide a small root opening, in such cases, prior to welding. In any case, the root opening between parts shall not exceed 1/8 in. [3 mm] for sections up to 2 in. [50 mm] in thickness. When the root opening between shapes or plates of 2 in. [50 mm] or more in thickness cannot be closed to meet this tolerance, a maximum root opening of 3/16 in. [5 mm] is acceptable if a sealing weld or suitable backing material⁶ is used. If the root opening is 1/16 in. [2 mm] or greater, the leg of the fillet weld shall be increased by the amount of the separation, or the contractor shall demonstrate that the required effective throat has been obtained.

The separation between the faying surfaces of lap joints and butt joints with a backing shall not exceed 1/16 in. [2 mm]. Deviations from these limits shall be approved by the Design Engineer.

7.4.2 Parts to be joined by partial joint penetration groove welds parallel to the length of the member (bearing joints excepted) shall be brought as close together as practicable. The root opening between parts shall not exceed 1/8 in. [3 mm]. If the root opening between rolled shapes or plates of 2 in. [50 mm] or greater in thickness cannot be closed sufficiently to meet this tolerance, a maximum gap of 3/16 in. [5 mm] is acceptable provided (1) a sealing weld or suitable backing material is used and (2) the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specification or the Manufacturer's standard if no tolerances are included in the contract. Deviations from these limits shall be approved by the Design Engineer.

7.4.3 Parts to be joined at butt joints shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity in alignment, an offset not exceeding 10% of the thickness of the thinner part joined, but in no case more than 0.18 in. [4.5 mm], may be permitted as a departure from the theoretical alignment. In correcting misalignment in such cases, the slope of the drawn-in parts shall not exceed 1 to 24. Measurement of offset shall be based upon centerline of parts, unless otherwise shown on the drawing. Deviations from these limits shall be approved by the Design Engineer.

7.4.4 Dimensions of the cross section of groove weld joint preparations that vary from those shown on the detail drawings by more than the tolerances given in Table 8 shall be referred to the Design Engineer for acceptance. Exceptions are grooves for electroslag and electrogas welds.

6. Backing may be flux, glass tape, iron powder, or similar materials. Sealant (root) passes should be made with low-hydrogen covered electrodes or other arc welding processes.

Table 8
Tolerances for Groove Weld Joint
Preparations for Arc Welding (see 7.4.4)

	Root Not Gouged		Root Gouged	
	in.	mm	in.	mm
Root face	±1/16	±2	Not limited	
Root opening with other than steel backing	±1/16	±2	±1/16	±2
Root opening with steel backing	+1/4	+6	Not applicable	
Groove angle	+5°		+10°, -5°	

7.4.5 Grooves produced by gouging shall be in accordance with the requirements for processes and filler metals of Section 8.

7.4.6 Groove welds shall be terminated at the ends of a joint in a manner that will ensure sound welds. This should be done by the use of extension bars or run-off plates.

7.4.7 Extension bars and run-off plates shall be removed upon completion of the welding, and the ends of the weld shall be finished smooth and flush with the edges of the abutting parts.

7.4.8 The weld metal of groove welds made with steel backing strips shall be thoroughly fused with the backing. Steel backings shall be removed, where accessible, from welds that are transverse to computed stress, and the joints shall be ground or finished smooth.

7.4.9 Members to be welded shall be brought into correct alignment and held in position by clamps, wedges, guy lines, struts, tack welds, or other suitable devices until welding has been completed. The use of jigs and fixtures is recommended where practicable. Suitable allowances shall be made for warpage and shrinkage.

7.4.10 Steel backing shall be continuous for the full length of a weld. Welded butt joints in a fabricated steel backing shall have complete joint penetration, and the joints shall be welded prior to placement of the backing.

7.4.11 Caulking of welds is not permitted.

7.4.12 Tack Welds

7.4.12.1 Tack welds shall be subject to the same quality requirements as the final welds.

7.4.12.2 Tack welds which are incorporated into the final weld shall be made with electrodes meeting the requirements of the final weld. Multipass tack welds shall have cascaded ends. Tack welds shall be cleaned prior to depositing additional weld metal.

7.4.12.3 Tack welds not incorporated into final welds shall be removed.

7.4.13 Arc Strikes. Arc strikes outside the area of permanent welds should be avoided on any base metal. Cracks or blemishes caused by arc strikes shall be ground to a smooth contour and examined to ensure soundness (see 12.2.2).

7.5 Control of Distortion and Shrinkage Stresses

7.5.1 The procedure and welding sequence for assembling and joining parts of a structure or of built up members and for welding reinforcing parts to members, shall be designed to minimize distortion and shrinkage.

7.5.2 When practicable, all welds shall be deposited in a sequence that will balance the applied heat while welding progresses.

7.5.3 A program for welding sequence and distortion control shall be provided where shrinkage stresses or distortion are likely to affect the adequacy of the structure.

7.5.4 Joints that are expected to produce large shrinkage should usually be welded with as little restraint as possible before other joints that are expected to cause less shrinkage are welded.

7.5.5 Peening may be used on intermediate weld layers for control of shrinkage stresses in thick welds to prevent cracking (see 7.8). No peening shall be done on the root pass. Peening of the final weld layer shall be for fatigue enhancement purposes only and shall be done according to an approved written procedure (see 7.8.3).

7.5.6 In making welds under conditions of severe external shrinkage restraint, the welding shall be carried continuously to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum specified preheat temperature. Where preheat and interpass temperatures are not specified, welding shall continue to a point where freedom from cracking is assured.

7.6 Stress Relief. Where required by the contract drawings or specifications, welded assemblies shall be stress relieved.

7.6.1 All stress relief operations shall follow an approved written procedure.

7.6.2 Localized stress relieving may be employed, subject to approval by the Design Engineer, when it is

impractical to stress relieve the entire weldment. A written procedure shall address the variables given in 7.6.3.

7.6.3 The procedures for furnace stress relief shall address the following:

- (1) Temperature at the start of the thermal cycle.
- (2) Rate of heating to temperature.
- (3) Maximum allowable variation of temperature throughout the portion of the part being heated.
- (4) Maximum temperature tolerance at stress relief temperature.
- (5) Holding time at stress relief temperature.
- (6) Rate of cooling to a temperature suitable for removal of work from the furnace.
- (7) The thermocouples shall have surface contact with the weldment and be shielded from direct impingement of the heat source. The records shall include the location, calibration and thermal chart of each thermocouple, along with traceable weldment documentation. The records and data shall become part of the weldment documentation.
- (8) Support of the weldment to minimize sagging and distortion.
- (9) Spacing of multiple items so all pieces will heat uniformly.
- (10) Use of baffles or insulating material to protect the weldment from direct impingement of the heat source.

7.6.4 Stress relieving of weldments of A514, A517, A709 Grades 100 and 100W, and A710 steels is not recommended. Stress relieving may be necessary for those applications where weldments must retain dimensional stability during machining or where stress corrosion may be involved, neither condition being unique to weldments involving A514, A517, A709 Grades 100 and 100W, and A710 steels. However, the results of notch toughness tests have shown that stress relieving may actually impair weld metal toughness, and intergranular cracking may sometimes occur in the grain-coarsened region of the weld heat affected zone. Such steels should only be stress relieved after consultation with the steel producer and in strict accordance with the producer's recommendations.

Precautionary Note: Consideration must be given to possible distortion due to stress relief.

7.7 Vibratory Conditioning

7.7.1 Vibratory conditioning to obtain dimensional stability of the weldment may be employed with the approval of the Engineer. The conditioning shall be done in accordance with the recommendations of the manufacturer of the vibratory equipment. It shall not be substituted for thermal stress relief.

7.7.2 The conditioning process shall be covered by a written procedure.

7.8 Peening. Shot and mechanical peening provide for improved fatigue life in the weld joint as a result of the surface material being placed in compression.^{7,8,9} Mechanical peening can be applied to intermediate weld passes to reduce residual stresses, cracking, and distortion. All peening shall be done using an approved written procedure. These guidelines are based on experience with carbon steel.

7.8.1 Controlled Shot Peening. Controlled shot peening may be used on external surfaces to improve fatigue life. Controlled shot peening procedures shall include Almen intensity, shot size, pressure, and percent coverage.

7.8.2 Hammer Peening. Hammer peening may be used on external surfaces to improve fatigue life. Peening should be controlled to prevent introducing stress concentrations to, or cracking of, the weld or base metal. Controlled air hammer peening procedures shall specify hammer size, peening tool radius, air pressure, and extent and density of coverage (see 7.8.4).

7.8.3 Peening Applications

- (1) No peening shall be done on the root pass.
- (2) Hammer or needle peening may be used on intermediate weld layers for control of shrinkage stresses in thick welds to prevent cracking.
- (3) Peening of the surface layer of the weld and the base metal at the edges of the weld is permitted for fatigue life improvement. Under controlled conditions, both shot and mechanical peening places the exposed material in compression which reduces residual tensile stresses at the weld surface, the toe of the weld, and the base metal adjacent to the weld.

(4) All slag shall be removed prior to peening. The use of manual slag hammers, chisels, and lightweight tools such as needle descaling guns for the removal of slag and spatter is permitted, but is not considered peening.

7.8.4 Specification for Pneumatic Hammer Peening for Fatigue Life Improvement. Peening of weld toes shall be performed with the use of a small pneumatic hammer (Ingersoll #2 or equivalent) and peening tool as shown in Figure 9(A). All welds shall pass magnetic par-

ticle examination prior to peening, followed by a second magnetic particle examination after peening.

The peening tool shall be made from a chisel or other tool designed for the pneumatic hammer. The tool tip shall conform to the dimensions shown in Figure 9(A). All sharp edges and burrs shall be removed and the tool shape maintained in this geometric shape and condition.

Best peening results will be obtained by operating the pneumatic hammer at approximately 25 psi [1.7 bar] air pressure. The axis of the hammer shall be perpendicular to the longitudinal axis of the weld toe and inclined 60° to 70° above the weld toe plane as shown in Figure 9(B). Peening is done by slowly moving the peening tool of an operating hammer along the weld toe. Peening shall continue until the weld toe becomes smooth (absence of weld ripples), approximately three to four passes at 30 in./min [760 mm/min]. The depth of indentation due to peening should be approximately 1/32 in. [1 mm] to 1/16 in. [2 mm].

Peened welds, after passing the second magnetic particle examination, have increased fatigue strength equal to the next higher stress category (see Table 3) for the applicable detail (see Table 4 and Figure 1). However, the stress category for peened welds shall not exceed category B.

8. Processes and Filler Metals

8.1 General

8.1.1 Filler Metal Requirements

8.1.1.1 The electrode, electrode-flux combination, or other filler metal for making complete joint penetration groove welds shall be in accordance with Table 9 when matching weld metal is required by Table 2.

8.1.1.2 The electrode, electrode-flux combination, or other filler metal for complete joint penetration or partial joint penetration groove welds and for fillet welds may provide lower strength weld metal, as permitted in Table 2. The allowable stress in the weld metal shall not exceed that allowed in Table 2.

8.1.2 Preheat and Interpass Temperature Requirements. Preheat and interpass temperatures shall be in accordance with Table 10 for the welding process being used and for the higher strength base metals being welded.

8.1.3 Heat Input Control for Quenched and Tempered Steel. When quenched and tempered steels are welded, the heat input shall be restricted in conjunction with the maximum preheat and interpass temperatures permitted for the metal thickness. The heat input limitations shall be in accordance with the steel producer's rec-

7. Bremen, U., Smith, I. F. C., and Hirt, M. A., *Crack Growth Behavior in a Welded Joint Improved by Residual Stress Method*. International Conference: Fatigue of Welded Construction, Ed., Maddox, S. J. The Welding Institute: 1987.

8. Booth, G. S., *Improving the Fatigue Performance of Welded Joints*. The Welding Institute: 1983.

9. Metal Improvement Company, Inc. *Shot Peening Application, Seventh Edition*.

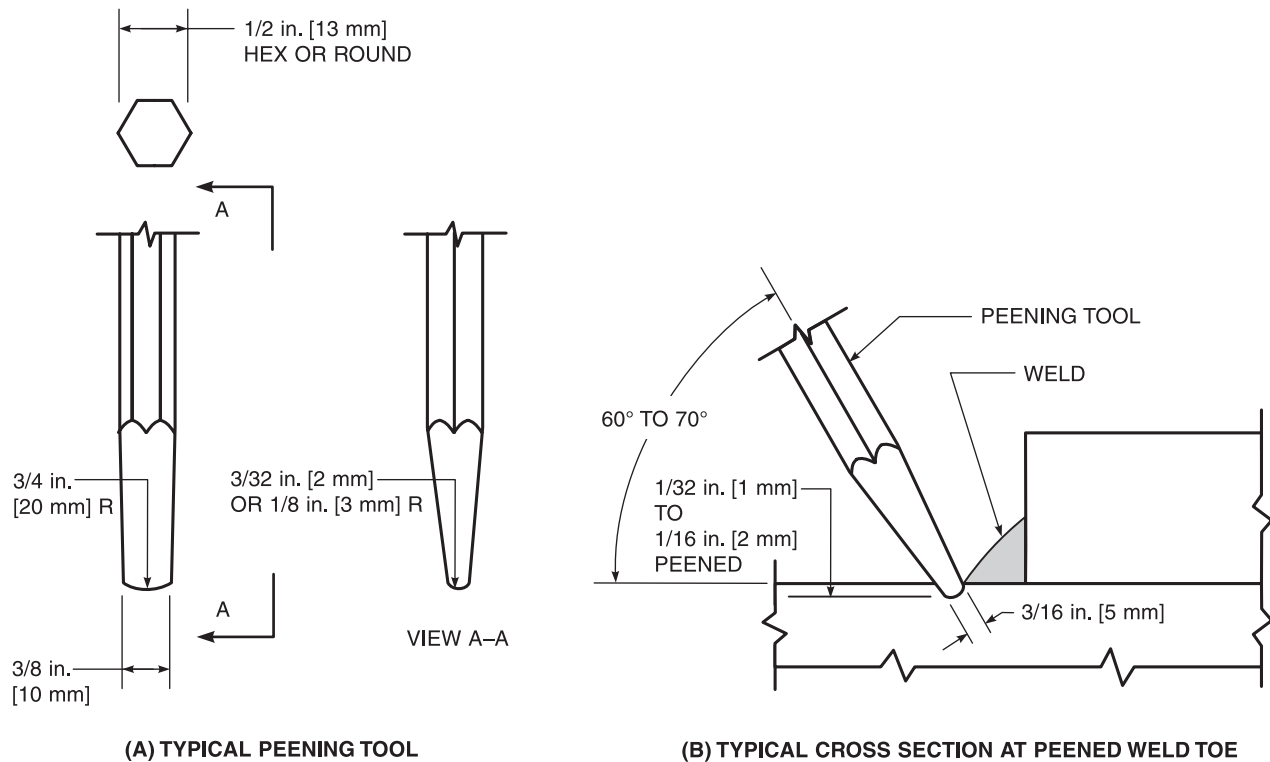


Figure 9—Pneumatic Hammer Peening (see 7.8.4)

ommendations. The use of stringer beads to avoid overheating is strongly recommended. Oxygen gouging of quenched and tempered steel is not permitted.

8.1.4 Backing for Groove Welds. Materials used for backing of groove welds may be steel, neutral submerged arc welding flux, nonfusible backup bars, or commercially available tapes made specifically for this purpose. The backing material employed shall not alter the weld metal composition, and the joints shall meet the requirements of Section 6, Weld Joint Design.

8.2 Shielded Metal Arc Welding (SMAW)

8.2.1 Electrodes for Shielded Metal Arc Welding

8.2.1.1 Electrodes for shielded metal arc welding shall conform to the requirements of either AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*, or AWS A5.5, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*, whichever is applicable.

8.2.1.2 All electrodes having low-hydrogen coverings conforming to AWS A5.1 shall be purchased in hermetically sealed containers, or shall be dried for at least

two hours between 500°F [260°C] and 800°F [425°C] before being used. Electrodes having low-hydrogen coverings conforming to AWS A5.5 shall be purchased in hermetically sealed containers, or shall be dried for at least one hour at a temperature of between 700°F [370°C] and 800°F [425°C] before being used, in accordance with the recommendations of AWS A5.5. Electrodes shall be dried prior to use if the hermetically sealed container shows evidence of damage.

Immediately after opening of hermetically sealed containers or removal from drying ovens, the low-hydrogen electrodes shall be consumed or stored in ovens held at a temperature of at least 250°F [120°C]. E70XX or E70XX-X electrodes that are not used within four hours, E80XX-X within two hours, E90XX-X within one hour, E100XX-X or E110XX-X within one half hour, and E70XXR, E7018M, or E70XXHZR within nine hours after removal from hermetically sealed containers or from a drying or storage oven shall be redried before use. Electrodes shall be redried not more than one time. Electrodes that are, or have been, wet shall not be used.

8.2.1.3 The classification and size of electrode, arc length, voltage, and amperage shall be suited to the

Table 9
Matching Filler Metal Requirements^{(1), (2), (3)}

Base Metal ⁽⁴⁾	Welding Process			
	SMAW	SAW	GMAW	FCAW
Class I	AWS A5.1 or A5.5	AWS A5.17 or A5.23	AWS A5.18	AWS A5.20 or A5.29
Class II	E60XX, E70XX E70XX-X	F6XX-EXXX F7XX-EXXX F7XX-EXX-XX	ER70S-X AWS A5.18 or A5.28 E70C-XX	E6XT-X, E6XTX-X, E7XT-X, or E7XTX-X (except -2, -3, -10, -13, -14, or GS) ⁽⁵⁾
Class III	AWS A5.1 or A5.5 ⁽¹⁾ E70XX ⁽⁶⁾ E70XX-X ⁽⁶⁾	AWS A5.17 or A5.23 F7XX-EXXX F7XX-EXX-XX	AWS A5.18 ER70S-X AWS A5.18 or A5.28 E70C-XX	AWS A5.20 or A5.29 E7XT-X or E7XTX-X (except -2, -3, -10, -13, -14, or GS) ⁽⁵⁾
Class IV	AWS A5.5	AWS A5.23	AWS A5.28	AWS A5.29
UTS > 70 ksi [485 MPa]	E80XX-X	F8XX-EXX-XX	ER80S-X E80C-XX	E8XTX-X
UTS ≤ 70 ksi [485 MPa]	AWS A5.1 or A5.5 E70XX-X ⁽⁶⁾ E70XX ⁽⁶⁾	AWS A5.17 or A5.23 F7XX-EXX F7XX-EXX-X	AWS A5.18 ER70S-X E70C-XX	AWS A5.20 E7XT-X or E7XTX-X (except -2, -3, -10, -13, -14, or GS) ⁽⁵⁾
Class V Thickness	AWS A5.5	AWS A5.23	AWS A5.28	AWS A5.29
< 2.5 in. [65 mm]	E110XX-X ⁽⁶⁾ E11018M	F11XX-EXX-XX	ER110S-X	E11XTX-X
≥ 2.5 in. [65 mm]	E100XX-X ⁽⁶⁾ E10018M	F10XX-EXX-XX	ER100S-X	E10XTX-X

Notes:

- (1) The use of the same type of filler metal having the next higher strength classification as listed in AWS filler metal specifications is permitted. A filler metal of a lower strength may be used where the Engineer has stipulated less than 100% joint efficiency.
- (2) When welds are to be thermally stress relieved, the deposited weld metal shall not exceed 0.05% vanadium.
- (3) Filler metals of alloy groups B3, B3L, B4L, B5, B6, B6L, B7, B7L, B8, B8L, or B9, in AWS A5.5, A5.23, A5.28, or A5.29, are not prequalified for use in the as-welded condition.
- (4) In joints involving base metals of different yield points or strengths, filler metals applicable to the lower strength metal may be used.
- (5) These electrode classifications do not have yield strength or elongation requirements specified in AWS A5.20. If E7XT-2 filler metals are qualified by prototype testing (see 9.5.3), this qualifies the use of these filler metals for production. However, it is recommended that these classifications and the E7XT-11 classification from AWS A5.20 be limited to weld thicknesses less than 1/2 in. [13 mm].
- (6) Low hydrogen classifications only (i.e., EXX15, EXX15-XX, EXX16, EXX16-XX, EXX18, EXX18-XX, EXX28, EXX48).

thickness of the base metal, type of groove, welding position, and other circumstances attending the work.

8.2.1.4 The maximum size of electrodes shall be as follows:

- (1) 5/16 in. [8 mm] for all welds made in the flat position, except for root passes;
- (2) 1/4 in. [6 mm] for horizontal fillet welds;
- (3) 1/4 in. [6 mm] for root passes of fillet welds made in the flat position and groove welds made in the flat position with a backing and a root opening of 1/4 in. [6 mm] or more;

(4) 5/32 in. [4 mm] for welds made with EXX14 and low-hydrogen electrodes in the vertical and overhead positions;

(5) 3/16 in. [5 mm] for root passes of groove welds and for all other welds not included under (1), (2), (3), and (4).

8.2.2 The minimum thickness of a root pass shall be large enough to avoid weld metal cracking.

8.2.3 The maximum thickness of layers of fillet welds, other than root passes, and all layers of groove welds shall be the following:

- (1) 1/4 in. [6 mm] for root passes of groove welds;

Table 10
Minimum Preheat and Interpass Temperatures

Weldability Classification of Base Metal	Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Temperature ^{(1),(2)}	
		in.	mm	°F	°C
I	Shielded metal arc welding with other than low-hydrogen electrodes	≤ 3/4	≤ 20	None ⁽¹⁾	
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	None ⁽¹⁾	
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	50	10
		> 2-1/2	> 65	200	95
	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	Up to 3/4	≤ 20	None ⁽¹⁾	
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	None ⁽¹⁾	
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	None ⁽¹⁾	
		> 2-1/2	> 65	150	65
II	Shielded metal arc welding with other than low-hydrogen electrodes	Up to 3/4	≤ 20	None ⁽¹⁾	
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	150	65
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	225	110
		> 2-1/2	> 65	300	150
II & III	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	Up to 3/4	≤ 20	None ⁽¹⁾	
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	50	10
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	150	65
		> 2-1/2	> 65	225	110
IV	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	≤ 3/4	≤ 20	50	10
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	150	65
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	225	110
		> 2-1/2	> 65	300	150
V	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding with carbon or alloy steel wire, neutral or active flux, ⁽³⁾ gas metal arc welding, flux cored arc welding	≤ 3/4	≤ 20	50	10
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	125	50
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	175	80
		> 2-1/2	> 65	225	110
	Submerged arc welding with carbon steel wire, alloy flux ⁽³⁾	≤ 3/4	≤ 20	50	10
		> 3/4 to ≤ 1-1/2	> 20 to ≤ 40	200	95
		> 1-1/2 to ≤ 2-1/2	> 40 to ≤ 65	300	150
		> 2-1/2	> 65	400	205

Notes:

- (1) When the base metal temperature is below 32°F [0°C], the base metal shall be preheated to at least 70°F [21°C] for a distance equal to the thickness of the part being welded, but not less than 3 in. [75 mm] both laterally and in advance of welding. This minimum temperature shall be maintained during welding. Preheat and interpass temperature shall be sufficient to prevent crack formation. Temperature above the minimum shown may be required for highly restrained welds. For quenched and tempered steel, the maximum preheat and interpass temperature should not exceed 400°F [250°C] for thicknesses up to 1-1/2 in. [40 mm] inclusive or 450°F [230°C] for greater thicknesses. When welding quenched and tempered steel, heat input should not exceed the producer's recommendation.
- (2) In joints involving combinations of base metals, preheat shall be as specified for the higher strength steel being welded.
- (3) Neutral flux: Flux whose primary purpose is to shield the weld metal.
Active flux: Flux whose primary purpose is to deoxidize the weld metal.
Alloy flux: Flux whose primary purpose is to alloy the weld metal. (See AWS A3.0 for complete definitions.)
AWS A5.17/A5.17M-97, Annex A6 contains more complete descriptions of these fluxes and their applications.

(2) 1/8 in. [3 mm] for subsequent layers of welds made in the flat position;

(3) 3/16 in. [5 mm] for subsequent layers of welds made in the vertical, overhead, and horizontal positions.

8.2.4 The maximum size of both single-pass and root-pass fillet welds shall be the following:

(1) 3/8 in. [10 mm] in the flat position;

(2) 5/16 in. [8 mm] in horizontal and overhead positions;

(3) 1/2 in. [13 mm] in the vertical position.

8.2.5 The progression of welding in the vertical position may be upward or downward, but only in the direction or directions for which the welder is qualified.

8.2.6 Complete joint penetration groove welds that are made without the use of steel backing shall have the root of the first weld gouged or ground to sound metal before the second weld is started on the opposite side.

8.3 Submerged Arc Welding (SAW)

8.3.1 General Requirements

8.3.1.1 Submerged arc welding (SAW) may be performed with one or more single electrodes, one or more parallel electrodes, or combinations of single and parallel electrodes. The spacing between multiple arcs shall be such that the slag cover over the weld metal produced by a leading arc does not cool sufficiently to prevent proper fusion of the weld metal deposit from a following electrode. SAW with multiple electrodes may be used for any groove or fillet weld pass.

8.3.1.2 The following subsections (8.3.1.3 through 8.3.1.7) governing the use of SAW are suitable for any steel included in Table 1, other than quenched and tempered steels. Concerning welding of quenched and tempered steels, it is necessary to comply with the steel producer's recommendations for maximum permissible heat input and preheat combinations. Such considerations shall include the additional heat input produced in simultaneous welding on two sides of a common member.

8.3.1.3 The size of the electrode shall not exceed 1/4 in. [6 mm] diameter.

8.3.1.4 Surfaces on which submerged arc welds are to be deposited and adjacent faying surfaces shall be clean and free of moisture and other contaminants that may have an adverse effect on weld quality.

8.3.1.5 Roots of groove or fillet welds may be backed with copper, flux, glass tape, iron powder, or similar materials to prevent melt-through, or be sealed by means of root passes deposited using a low-hydrogen welding procedure. Use caution to avoid letting the welding arc strike the copper backing.

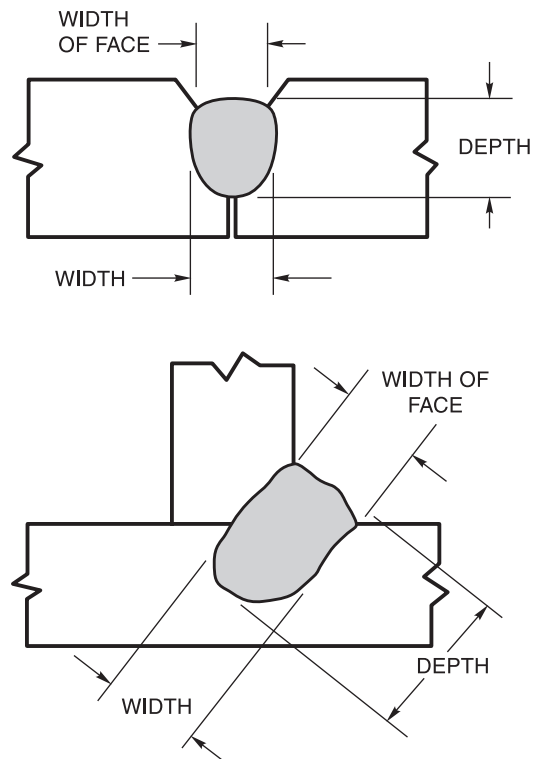


Figure 10—Unacceptable Submerged Arc Weld Pass where the Depth and Width Exceed the Face Width

8.3.1.6 Neither the depth nor the maximum width in the cross section of the weld metal deposited in each weld pass shall exceed the width of the face of that weld pass or throat cracking may occur (see Figure 10).

8.3.1.7 Tack welds located in the roots of joints requiring specific root penetration, or in the form of fillet welds 3/8 in. [10 mm] and under in size, shall not produce objectionable changes in appearance of the weld surface or result in decreased penetration. Tack welds that will cause unsatisfactory weld characteristics shall be reduced in size by any suitable means before welding. Tack welds in the root of a joint with steel backing of less than 5/16 in. [8 mm] thick shall either be reduced in size by any suitable means before welding or made continuous for the full length of the joint using a low-hydrogen welding procedure. After any tack weld is reduced in size, care shall be taken to clean the weld groove before proceeding.

8.3.2 Electrodes and Fluxes. The electrode and flux combination used for submerged arc welding of a steel

shall conform to the requirements of AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding* or of AWS A5.23, *Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*, whichever is applicable.

8.3.3 Condition of Flux. Flux used for SAW shall be dry and free of contamination from dirt, mill scale, or other foreign material. Flux shall be purchased in packages that can be stored under normal conditions for at least six months without affecting the welding characteristics of the flux or the weld properties. Flux from damaged packages shall be discarded or dried at a minimum temperature of 250°F [120°C] for one hour before use. Flux shall be placed in the dispensing system immediately upon opening a package. Before using flux that has been exposed to the atmosphere in an open package, the top 1 in. [25 mm] shall be discarded. Flux that has been wet shall not be used.

SAW flux that has not been melted during the welding operation may be reused after recovery by vacuuming, catch pans, sweeping, or other means. The welding fabricator shall have a system for collecting unmelted flux, adding new flux, and welding with the mixture of these two, such that the flux composition and particle size distribution at the weld puddle are relatively constant. Recrushed slag may be used provided it has its own marking, using the crusher's name and trade designation. In addition, each dry batch or dry blend (lot) of flux, as defined in AWS A5.01, *Filler Metal Procurement Guidelines*, shall be tested in conformance with Schedule I of AWS A5.01 and classified by the contractor or crusher per AWS A5.17 or A5.23, as applicable.

8.3.4 Procedures for SAW with a Single Electrode

8.3.4.1 Submerged arc welds may be made in either the flat or horizontal position. Single-pass fillet welds made in the horizontal position shall not exceed 5/16 in. [8 mm] in size.

8.3.4.2 The thickness of weld layers, except root and surface layers, shall not exceed 1/4 in. [6 mm]. When the root opening is 1/2 in. [13 mm] or greater, a multiple-pass stringer bead (split layer) technique shall be used. The stringer bead (split layer) technique shall also be used in making multiple-pass welds when the width of the layer will exceed 5/8 in. [16 mm].

8.3.4.3 The welding conditions, including current, arc voltage, and speed of travel, shall ensure that each weld pass will have complete fusion with the adjacent base and weld metals, and have no overlap or unacceptable undercut. The maximum welding current used to make any weld pass with fusion to both faces of a weld groove shall be 800 A, except that the final layer of weld metal may be made using higher welding current. The

maximum welding current to be used for fillet welds in the flat position shall be 1000 A.

8.3.5 Procedures for SAW with Multiple Electrodes

8.3.5.1 Submerged arc welds made with multiple electrodes may be made in either the flat or horizontal position. Single-pass, multiple-arc fillet welds made in the horizontal position shall not exceed 1/2 in. [13 mm] in size.

8.3.5.2 The thickness of weld layers is not limited. In making the root pass of a groove weld, either single or multiple electrodes may be used. Backing strips or root faces of the groove shall be of adequate thickness to prevent melt-through. When the width of a groove in which a layer of weld metal is to be deposited exceeds 1/2 in. [13 mm], multiple electrodes shall be displaced laterally, or a stringer bead (split layer) technique shall be used to assure complete fusion. A stringer bead (split layer) technique shall be employed when only two electrodes in tandem are used and the width of a previously deposited layer exceeds 1 in. [25 mm].

8.3.5.3 The welding conditions, including current, arc voltage, speed of travel, and relative location of electrodes, shall ensure that each pass will have complete fusion with the adjacent base and weld metals, and have no depressions or unacceptable undercut. Concavity of initial weld passes shall not be excessive to avoid cracking in roots of joints that are under restraint.

8.3.5.4 The maximum welding current used in making a groove weld shall be as limited by the allowable heat input for quenched and tempered materials. For other materials, the following limitations shall apply:

- (1) 700 A for any single electrode or for multiple electrodes when making a root pass of a multiple-pass weld in a groove having no root opening.
- (2) 750 A for any single electrode or 900 A for multiple electrodes when making a root pass in a groove having steel backing or a spacer bar.
- (3) 1000 A for any single electrode or 1200 A for multiple electrodes for all other passes except the root pass and the final layer.
- (4) Any suitable amperage for the final pass or layer.

8.3.5.5 The maximum welding current to be used when making a fillet weld shall be 1000 A for a single electrode or 1200 A for multiple electrodes or as limited by the allowable heat input for quenched and tempered materials.

8.3.5.6 Multiple electrodes may be used in the root of groove or fillet welds using a leading gas metal arc electrode with gas shielding followed by multiple submerged arc electrodes provided that (1) the gas metal arc welding conforms to the requirements of 8.4, and (2) the

spacing between the leading gas metal arc electrode and the first following submerged arc electrode is not more than 15 in. [375 mm].

8.4 Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)

8.4.1 Consumables

8.4.1.1 The electrodes and shielding medium for gas metal arc welding (GMAW) or flux cored arc welding (FCAW) for producing weld metal with a minimum specified yield strength of 60 ksi [415 MPa] or less shall conform to the requirements of AWS A5.18, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*, AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, or AWS A5.29, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*, as applicable.

8.4.1.2 Weld metal having a minimum specified yield strength greater than 60 ksi [415 MPa] shall conform to the following requirements:

(1) The electrodes and shielding gas for GMAW for producing weld metal with a minimum specified yield strength greater than 60 ksi [415 MPa] shall conform with AWS A5.28, *Specification for Low-Alloy Steel Filler Metals for Gas Shielded Arc Welding*.

(2) The electrodes and shielding gas for flux cored arc welding for producing weld metal with a minimum specified yield strength greater than 60 ksi [415 MPa] shall conform to AWS A5.29, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*.

8.4.1.3 When requested by the Design Engineer, the fabricator shall furnish the electrode manufacturer's certification that the filler metal product being used met the requirements for classification in accordance with the applicable AWS specifications. The electrode manufacturer's recommended welding process conditions and parameters including amperage, voltage and shielding gas (or lack of such) shall be followed.

8.4.2 Shielding Gas. When a gas or gas mixture is used for shielding in any gas shielded process, it shall be a welding grade having a dew point of -40°F [-40°C] or lower (see AWS A5.32, *Specification for Welding Shielding Gases*).

8.4.3 Prequalified Procedures for GMAW¹⁰ and FCAW. The requirements for prequalified procedures that are exempt from qualification testing are as follows:

10. Applies only when welding with the spray or globular modes of metal transfer. Prequalification does not apply to short-circuiting metal transfer.

8.4.3.1 Electrodes shall be dry and in suitable condition for use.

8.4.3.2 The maximum diameter of electrodes shall be 1/8 in. [3 mm] for the flat and horizontal positions, and 5/64 in. [2 mm] for the vertical and overhead positions.

8.4.3.3 The maximum size of a fillet weld made in one pass shall be 1/2 in. [13 mm] for the flat and vertical positions, 3/8 in. [10 mm] for the horizontal position, and 5/16 in. [8 mm] for the overhead position.

8.4.3.4 The maximum fill pass thickness shall be 1/4 in. [6 mm]. The maximum root pass thickness shall be 3/8 in. [10 mm] for the flat position, 5/16 in. [8 mm] for the horizontal and overhead positions, and 1/2 in. [13 mm] for the vertical position. The stringer bead (split layer) technique shall also be used in making all multipass welds (fillet or groove) when the width of the preceding layer exceeds 5/8 in. [16 mm].

8.4.3.5 The welding conditions used shall ensure that each pass will have complete fusion with adjacent base metal and weld metal, and there will be no excessive overlap, porosity, or undercutting.

8.4.3.6 Complete joint penetration groove welds made without the use of steel backing shall have the root of the first weld gouged to sound metal before the second weld is started from the opposite side of the joint.

8.4.3.7 Backing may be used to prevent melt-through at the roots of fillet welds and partial penetration groove welds.

8.4.3.8 Welding with external gas shielding shall not be done in a draft or wind having a velocity exceeding five miles per hour unless the weld is protected by a shelter. The shelter shall reduce the air velocity in the vicinity of the welding to that necessary to avoid loss of gas shielding.

8.5 Electroslag Welding (ESW) and Electrogas Welding (EGW)

8.5.1 General Requirements

8.5.1.1 Electroslag Welding (ESW) and electrogas welding (EGW) of quenched and tempered steels is not permitted unless the heat-affected zone (HAZ) and weld are heat treated subsequent to welding to obtain the required mechanical properties.

8.5.1.2 Prior to use, the Manufacturer shall prepare a welding procedure specification and qualify each procedure for the process to be used in accordance with the requirements of Section 9, Qualification. The welding procedure specification shall include the joint details, filler metal type and diameter, welding current and type,

voltage, speed of vertical travel (if not an automatic function of arc length or deposition rate), oscillation (traverse speed, distance, and dwell time), type of shielding (including flow rate and dew point of gas or type of flux), type of molding shoe, postweld heat treatment (if required), and other pertinent information.¹¹

8.5.2 Impact Test Requirements. Impact tests shall be included in the welding procedure qualification.

8.5.2.1 Five Charpy V-notch impact test specimens from the weld metal and five specimens from the HAZ shall be machined from the same weld test assembly made to determine weld joint properties.

8.5.2.2 The impact specimens shall be machined and tested in accordance with ASTM E 23, *Standard Methods for Notched Bar Impact Testing of Metallic Materials*, or AWS B4.0 or B4.0M, *Standard Methods for Mechanical Testing of Welds*, for Charpy impact specimens.

8.5.2.3 The longitudinal centerline of the specimens shall be transverse to the weld axis and shall be located as near as practicable to a point midway between the surface and center of thickness. The base of the notch shall be perpendicular to the surface. The standard 0.394 in. × 0.394 in. [10 mm × 10 mm] specimen shall be used where the thickness is 1/2 in. [13 mm] or greater.

8.5.2.4 When computing the average value of the impact properties, the lowest value and highest value obtained for each set of five specimens tested shall be disregarded.

8.5.2.5 The notched bar impact properties of the weld metal of the remaining three specimens shall be no less than the values in Table 11 when tested at 0°F [−18°C].

8.5.3 All-Weld-Metal Tension Tests. Prior to use, the fabricator shall demonstrate by appropriate tests that each combination of shielding media and filler metal will produce welds having the mechanical properties specified in the latest edition of AWS A5.25 or A5.26, or as listed in Table 12.

8.5.4 Electrodes and consumable guide tubes shall be dry, clean, and in suitable condition for use.

11. The resistance of an electroslag or electrogas weld to centerline hot cracking is related to the angle at which the dendritic grains meet as solidification of the weld metal proceeds. This angle is determined by the shape of the molten weld pool. Generally, if the angle is acute (<90°), the cracking resistance will be high. See the *AWS Welding Handbook*, Vol. 2, *Welding Processes*, Part 1, 9th Ed., pages 446–447 for more information.

Table 11
Impact Property Requirements
at 0°F [−18°C] for Electrogas
and Electroslag Welds

Specimen Size		Minimum Average Impact Energy		Minimum Impact Energy	
		ft-lb	J	ft-lb	J
in.	mm	ft-lb	J	ft-lb	J
0.394 × 0.394	10.0 × 10.0	15.0	20.3	10.0	13.6

8.5.5 A gas or gas mixture used as shielding for electrogas welding shall be of a welding grade and have a dew point of −40°F [−40°C], or lower (see AWS A5.32).

8.5.6 The flux used for electroslag welding shall be dry and free of contamination from dirt, mill scale, or other foreign material. Flux from packages damaged in transit or handling shall be discarded or dried at a minimum temperature of 250°F [120°C] for one hour before use.

8.5.7 Procedures for Electroslag and Electrogas Welding

8.5.7.1 When an externally supplied shielding gas is used, electrogas welding shall not be done in a draft or wind unless the weld area is protected by a shelter. This shelter shall be designed to reduce the wind velocity in the vicinity of the weld to conditions where the gas shielding is not disrupted.

8.5.7.2 The type and diameter of the electrodes used shall meet the requirements of the welding procedure specification.

8.5.7.3 Welds shall be started in such a manner as to permit sufficient heat buildup for complete fusion of the weld metal to the groove faces of the joint. Welds stopped at any point in the length of the joint shall be examined in accordance with Section 10, *Weld Quality and Inspection*, and repaired if necessary.

8.5.7.4 Preheating of base metals is not normally required. However, welding shall not be performed when the base metal at the point of welding is below 32°F [0°C].

8.5.7.5 Welds not meeting the quality requirements of Section 10 shall be repaired utilizing a qualified welding process.

Table 12
All-Weld-Metal Tension Test Requirements for Electrode Gas and Electroslag Welds

Base Metal	Minimum Tensile Strength		Minimum Yield Point		Minimum Elongation, % in 2 in. [50 mm]
	ksi	MPa	ksi	MPa	
ASTM A 36	60	415	36	250	24
ASTM A 242 or A 441, thickness:					
≤ 3/4 in. [20 mm]	70	485	50	345	22
> 3/4 in. [20 mm] to ≤ 1-1/2 in. [40 mm]	67	460	46	315	22
> 1-1/2 in. [40 mm] to ≤ 4 in. [100 mm]	63	435	42	290	24
> 4 in. [100 mm] to 8 in. [200 mm]	60	415	40	275	24
ASTM A 572:					
Grade 42	60	415	42	290	24
Grade 45	60	415	45	310	22
Grade 50	65	450	50	345	21
Grade 55	70	485	55	380	20
Grade 60	75	515	60	415	18
Grade 65	80	550	65	450	17
ASTM A 588, thickness:					
≤ 4 in. [102 mm]	70	485	50	345	21
> 4 in. [100 mm] to 5 in. [125 mm]	67	460	46	315	21
> 5 in. [125 mm] to 8 in. [200 mm]	63	435	42	290	21

9. Qualification

Part A *General Requirements*

9.1 Approved Procedures

9.1.1 Joint welding procedures that conform in all respects to the provisions of Section 4, Base Metals; Section 6, Weld Joint Design; Section 7, Workmanship; and Section 8, Processes and Filler Metals, shall be deemed prequalified and are exempt from tests or qualifications, except that all groove and fillet weld procedures for weld metal and base metal with a minimum specified yield strength of 90 ksi [620 MPa] or higher shall be qualified prior to use by tests as prescribed in 9.2 of this section to the satisfaction of the Engineer.

Note: The use of a prequalified joint welding procedure is not intended as a substitute for engineering judgment in the suitability of application of these joint welding procedures to a welded assembly or connection.

9.1.2 All prequalified joint welding procedure specifications (WPS) to be used shall be prepared by the Manufacturer, fabricator, or contractor, be in writing and

signed by an authorized individual, and be available to those authorized to examine them. A suggested form showing the information required in a welding procedure specification is shown in Annex A. The welding parameters set forth in (1) through (4) of this subsection shall be specified on the written welding procedure specifications within the limitations of variables prescribed in 9.5 for each applicable process. Changes in these parameters, beyond those specified on the written welding procedure specification, shall be considered essential changes and shall require a new or revised written prequalified welding procedure specification.

- (1) Amperage (wire feed speed),
- (2) Voltage,
- (3) Travel Speed, and
- (4) Shielding Gas Flow Rate.

9.1.3 A combination of qualified or prequalified joint welding procedures may be used without requalification, provided the limitations of essential variables applicable to each process are observed. This combination of joint welding procedures shall be written as a single welding procedure specification.

9.1.4 Procedures previously qualified under earlier editions of this specification, AWS D1.1, *Structural Welding Code—Steel*, AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or

Section IX of the ASME *Boiler and Pressure Vessel Code* for equivalent welding shall be acceptable under this specification, subject to the limitations of variables in Section 9. In addition, Standard Welding Procedure Specifications (WPSs) published by the AWS Committee on Welding Qualification are acceptable, subject to the limitations of variables in Section 9. New qualifications shall be made in accordance with the requirements of this specification, or the latest edition of B2.1, subject to the limitations of variables in Section 9.

9.2 Other Procedures. Except for those procedures exempted in 9.1.1, joint welding procedures that are employed in executing contract work under this specification shall be qualified prior to use by tests as prescribed in Part B of this section to the satisfaction of both the Owner's appointed representative and the Manufacturer's designated representative responsible for welding. The Owner's appointed representative should accept evidence of previous qualification of any joint welding procedures to be employed.

9.3 Welders, Welding Operators, and Tack Welders

9.3.1 All welders, welding operators, and tack welders to be employed to weld under this specification shall have been qualified by tests as prescribed in Parts C, D, and E, respectively, of this section or by AWS B2.1. Owner's representatives, at their discretion, should accept evidence of previous qualification (to other industry-recognized codes or specifications) of the welders, welding operators, and tack welders to be employed. A suggested form showing the information required is shown in Annex A.

9.3.2 Radiographic examination of a welder's or welding operator's qualification test plate, or test pipe, may be made in lieu of the guided bend test prescribed in Parts C and D of this section.

9.4 Qualification Responsibility. Each Manufacturer or contractor shall conduct the tests required by this specification to qualify the welding procedures and the welders, welding operators, and tack welders who will use these procedures.

Part B **Procedure Qualification**

9.5 Qualification of Welding Procedures. To qualify a welding procedure by test weldments, the Manufacturer shall choose testing according to 9.6 through 9.14 or prototype testing according to 9.5.3.

9.5.1 The following rules apply when it is necessary to establish a welding procedure by qualification as required by 9.2 or the contract specifications, and the procedure shall be recorded by the Manufacturer as a welding procedure specification.

9.5.1.1 Qualification of a welding procedure using a steel that is listed in Table 1, but not in 9.5.1.2, and has a minimum specified yield point of less than 50 ksi [345 MPa] shall qualify the procedure for welding any other steel or combination of steels listed in the table that have a minimum specified yield point equal to or less than that of the base metal used in the test.

9.5.1.2 Qualification of a welding procedure established with ASTM A 131, Grades AH, DH, or EH; A 515; A 537, Class 1; A 572, Grade 42 through 50; or API 5LX, Grade 42 shall be considered as procedure qualification for welding any other steel or combination of steels in this group, or other steels included in Table 1 that have a lower minimum specified yield point.

9.5.1.3 Qualification of a welding procedure established with a base metal included in Section 4, Base Metals, and having a minimum specified yield strength greater than 50 ksi [345 MPa] shall qualify the procedure for welding only base metals of the same material specification and grade or type that have the same minimum specified yield strength as the base metal tested, the permitted reduction in yield strength for increased material thickness being excepted. For example, a procedure qualified with a 1 in. [25 mm] thick, 100 ksi [690 MPa] yield strength base metal also qualifies for a 3 in. [75 mm] thick, 90 ksi [620 MPa] yield strength base metal of the same material specification.

9.5.1.4 Qualification of a welding procedure established with a combination of base metals included in Table 1 of different minimum specified yield strengths, one of which is greater than 50 ksi [345 MPa], shall qualify the procedure for welding that high yield strength base metal to any other of those base metals that have a minimum specified yield strength equal to or less than that of the lower strength base metal used in the test.

9.5.1.5 The variables listed in 9.5.2 are essential variables of a joint welding procedure. In preparing the procedure qualification record and the welding procedure specification, the Manufacturer or contractor shall report the specific values for the essential variables in 9.5.2. The suggested form for showing the information required is shown in Annex A.

9.5.2 Limitations of Variables. The changes set forth in 9.5.2.1 through 9.5.2.5 shall be considered essential changes in a welding procedure. Any changes exceeding the limitations thereof shall require establishment of a

new procedure incorporating those changes by qualification. When a combination of welding processes is used, the variables applicable to each process shall apply.

9.5.2.1 Shielded Metal Arc Welding (SMAW). A change in any of the following variables requires requalification of the WPS:

(1) A change increasing filler metal strength levels (for example, a change from E70XX(-X) to E80XX-X, but not vice versa).

(2) A change from a low-hydrogen electrode to a non-low-hydrogen electrode, but not vice versa.

(3) An increase in the diameter of the electrode used over that called for in the welding procedure specification.

(4) A change of more than 15% above or below the specified mean arc voltage or amperage for each size electrode used.¹²

(5) For a specified welding groove, a change of more than $\pm 25\%$ in the specified number of passes. If the area of the groove is changed, it is also permissible to change the number of passes in proportion to the change in area.

(6) A change in position in which welding is done, as defined in 9.8.

(7) For a change in groove type:

(a) A change in the type of groove (a change from a V-groove to U-groove for example), except qualification of a complete joint penetration groove weld qualifies for any groove detail which complies with the requirements of 6.10.1.

(b) A change in the type of groove to a square-groove or vice versa.

(8) A change in the shape of any one type of groove exceeding the tolerances given in Section 6, Weld Joint Design, involving the following:

(a) A decrease in the included angle of the groove.

(b) A decrease in the root opening of the groove.

(c) An increase in the root face of the groove.

(d) The omission, but not inclusion, of backing material.

(9) A decrease of more than 25°F [15°C] in the minimum specified preheat or interpass temperature.

(10) In vertical welding, a change in the progression specified for any pass from upward to downward, or vice versa.

(11) The omission, but not the inclusion, of backgouging.

(12) The addition or deletion of postweld heat treatment.

12. When welding quenched and tempered steel, any change within the limitation of variables shall not increase the heat input beyond the steel producer's recommendations.

9.5.2.2 Submerged Arc Welding (SAW)

(1) A change in the electrode-flux combination not covered by AWS A5.17 or A5.23.

(2) A change increasing the filler metal strength level (for example, from 80 ksi [550 MPa] to 90 ksi [620 MPa], but not vice versa).

(3) A change in electrode diameter when using an active or alloy flux.¹³

(4) A change in the number of electrodes used.

(5) A change in the type of current (ac or dc) or polarity when welding quenched and tempered steel, or when using an active or alloy flux.¹³

(6) A change of more than 10% above or below the specified mean amperage or wire feed speed for each electrode diameter used.¹²

(7) A change of more than 7% above or below the specified mean arc voltage for each diameter electrode used.¹²

(8) A change of more than 15% above or below the specified mean travel speed.¹²

(9) A change of more than 10%, or 1/8 in. [3 mm], whichever is greater, in the longitudinal spacing of multiple arcs.

(10) A change of more than 10%, or 1/16 in. [2 mm], whichever is greater, in the lateral spacing of multiple arcs.

(11) A change of more than $\pm 10^\circ$ in the angular position of any parallel electrode.

(12) A change in the angle of electrodes in machine or automatic welding of more than:

(a) $\pm 3^\circ$ in the direction of travel.

(b) $\pm 5^\circ$ normal to the direction of travel.

(13) For a specified groove, a change of more than $\pm 25\%$ in the specified number of passes. If the area of the groove is changed, it is permissible to change the number of passes in proportion to change in the area.

(14) A change in position in which welding is done as defined in 9.8.

(15) For a change in groove type:

(a) A change in the type of groove (a change from a V-groove to U-groove for example), except qualification of a complete joint penetration groove weld qualifies for any groove detail which complies with the requirements of 6.10.1.

(b) A change in the type of groove to a square-groove or vice versa.

(16) A change exceeding the tolerance of Section 6, Weld Joint Design, in the shape of any one type of groove involving.

13. Active and alloy fluxes are voltage dependent. AWS A5.17/A5.17M-97, Annex A6 contains more complete descriptions of these fluxes and their applications.

(a) A decrease in the included angle of the groove.

(b) A decrease in the root opening of the groove.

(c) An increase in the root face of the groove.

(d) The omission, but not inclusion, of backing material.

(17) A decrease of more than 25°F [15°C] in the minimum specified preheat or interpass temperature.

(18) An increase in the diameter of the electrode used over that called for in the welding procedure specification.

(19) The addition or deletion of supplemental powdered, granular, or cut wire filler metal.

(20) An increase in the amount of supplemental powdered, granular, or cut wire filler metal.

(21) If the alloy content of the weld metal is largely dependent on the composition of supplemental powdered filler metal, any change in the joint welding procedure that would result in the content of important alloying elements in the weld metal not meeting the chemical requirements given in the welding procedure specification.

(22) The omission, but not the inclusion, of backgouging.

(23) The addition or deletion of postweld heat treatment.

9.5.2.3 Gas Metal Arc Welding (GMAW). A change in any of the following variables requires requalification of the WPS:

(1) A change in the electrode and method of shielding not covered by AWS A5.18 or AWS A5.28.

(2) A change in filler metal to one of higher strength level, but not vice versa (for example, ER70S-X to ER80S-X).

(3) A change in electrode diameter.

(4) A change in the number of electrodes used.

(5) A change from a single shielding gas to any other single gas or to a mixture of gases, or a change in specified composition of a gas mixture not covered by AWS A5.18 or AWS A5.28.

(6) A change of more than 10% above or below the specified mean amperage or wire feed speed for each diameter electrode used.¹²

(7) A change of more than 7% above or below the specified mean arc voltage for each diameter electrode used.¹²

(8) A change of more than 10% above or below the specified mean travel speed.¹²

(9) An increase of 25% or more or a decrease of 10% or more in the flow rate of the shielding gas.

(10) For a specified groove, a change of more than ±25% in the specified number of passes. If the area of the groove is changed, it is permissible to change the number of passes in proportion to the change in area.

(11) A change in the position in which welding is done as defined in 9.8.

(12) For a change in groove type:

(a) A change in the type of groove (a change from a V-groove to U-groove for example), except qualification of a complete joint penetration groove qualifies for any groove detail which complies with the requirements of 6.10.1.

(b) A change in the type of groove to a square-groove or vice versa.

(13) A change exceeding the tolerance of Section 6, Weld Joint Design in the shape of any type of groove involving:

(a) A decrease in the included angle.

(b) A decrease in the root opening.

(c) An increase in the root face.

(d) The omission, but not inclusion, of backing material.

(14) A decrease of more than 25°F [15°C] in the minimum specified preheat or interpass temperature.

(15) In vertical welding, a change in the progression specified for any pass from upward to downward, or vice versa.

(16) A change in type of welding current (ac or dc), polarity, or mode of metal transfer across the arc.

(17) The omission, but not the inclusion, of backgouging.

(18) The addition or deletion of postweld heat treatment.

(19) When required, an increase of more than 10% in the heat input (combination of travel speed, current and voltage).

9.5.2.4 Flux Cored Arc Welding (FCAW). A change in any of the following variables requires requalification of the WPS:

(1) A change in the electrode and method of shielding not covered by AWS A5.20 or AWS A5.29.

(2) A change increasing the filler metal strength level (for example, from E70T-X to E80TX-X, but not vice versa).

(3) An increase in the diameter of electrode used over that called for in the welding procedure specification.

(4) A change in the number of electrodes used.

(5) A change from a single shielding gas to any other single gas or to a mixture of gases, or a change in the specified composition of a gas mixture not covered by AWS A5.20 or AWS A5.29.

(6) A change of more than 10% above or below the specified mean amperage or wire feed speed for each size of electrode used.¹²

(7) A change of more than 7% above or below the specified mean arc voltage for each size of electrode used.¹²

(8) A change of more than 10% above or below the specified mean travel speed.¹²

(9) An increase of 25% or more or a decrease of 10% or more, in the rate of flow of shielding gas.

(10) For a specified groove, a change of more than $\pm 25\%$ in the specified number of passes. If the area of the groove is changed, it is permissible to change the number of passes in proportion to the change in area.

(11) A change in the position in which welding is done, as defined in 9.8.

(12) For a change in groove type:

(a) A change in the type of groove (a change from a V-groove to U-groove for example), except qualification of a complete joint penetration groove weld qualifies for any groove detail which complies with the requirements of 6.10.1.

(b) A change in the type of groove to a square-groove or vice versa.

(13) A change exceeding the tolerance of Section 6, Weld Joint Design, in the shape of any type of groove involving:

(a) A decrease in the included angle.

(b) A decrease in the root opening.

(c) An increase in the root face.

(d) The omission, but not inclusion, of backing material.

(14) A decrease of more than 25°F [15°C] in the minimum specified preheat or interpass temperature.

(15) In vertical welding, a change in the progression specified for any pass from upward to downward, or vice versa.

(16) A change in type of welding current (ac or dc), polarity, or mode of metal transfer across the arc.

(17) The omission, but not the inclusion, of backgouging.

(18) The addition or deletion of postweld heat treatment.

(19) When required, an increase of more than 10% in the heat input (combination of travel speed, current and voltage).

9.5.2.5 Electroslag Welding (ESW) and Electro-gas Welding (EGW). A change in any of the following variables requires requalification of the WPS:

(1) A change in filler metal or consumable guide tube metal composition.

(2) A change in the metal core cross-sectional area of the consumable guide tube exceeding 30%.

(3) A change in flux system (cored, magnetic electrode, external flux, etc.).

(4) A change in flux composition, including consumable guide tube covering.

(5) A change in shielding gas composition by a change in flow of any one constituent of a mixture by more than 5% of the total gas flow.

(6) A change either in welding current exceeding 20% or a change in wire feed speed exceeding 40%.

(7) A change in groove design, other than a square-groove, that increases the groove cross-sectional area.

(8) A change in joint thickness (T) outside the limits of 0.5T to 1.1T where T is the thickness used for the procedure qualification.

(9) A change in number of electrodes.

(10) A change from single-to multiple-pass, or vice versa.

(11) A change to a combination with any other welding process or method.

(12) A change in postweld heat treatment.

(13) A change in design of molding shoes, either fixed or movable, from nonfusing solid to water-cooled, or vice versa.

(14) A change exceeding $1/32$ in. [1 mm] in filler metal diameter.

(15) A change exceeding 10 in./min [4 mm/s] in filler metal oscillation traverse speed.

(16) A change in filler metal oscillation traverse dwell time exceeding 2 seconds, except as necessary to compensate for variation in the joint opening.

(17) A change in filler metal oscillation traverse length that affects, by more than $1/8$ in. [3 mm], the proximity of filler metal to the molding shoes.

(18) A change in flux burden exceeding 30%.

(19) A change in shielding gas flow rate exceeding 25%.

(20) A change in design of molding shoes, either fixed or movable, as follows:

(a) Metallic to nonmetallic, or vice versa.

(b) Nonfusing to fusing, or vice versa.

(c) A reduction in any cross-sectional dimension or area of solid nonfusing shoe exceeding 25%.

(21) A change in welding position from the qualified verticality by more than 10° .

(22) A change of welding current from ac to dc, or vice versa, or a change in electrode polarity for direct current.

(23) A change in welding power volt-ampere characteristics from constant voltage to constant current, or vice versa.

(24) A change in welding voltage exceeding 10%.

(25) A change exceeding $1/4$ in. [6 mm] in the root opening of a square-groove weld.

(26) A change in groove design that reduces the cross-sectional area.

(27) A change in speed of vertical travel, if not an automatic function of arc length or deposition rate, exceeding 20% except as necessary to compensate for variation in joint opening.

9.5.3 Prototype Testing

9.5.3.1 With prior agreement between the Owner and the Manufacturer, welding procedures may be qualified by utilizing prototype structures or components that comply with the minimum performance criteria as follows:

(1) Simulated service tests of a welded assembly or a mockup of the welded joint. The simulated service test shall include impact loading, loading in bending, static loading, or fatigue testing to duplicate the type of loading the joint will be subjected to in service.

(2) A field test of the welded assembly on a machine loaded and performing the work for which it was designed.

9.5.3.2 For simulated service or field tests, the following shall be documented and recorded:

(1) The weldment drawing to which the test part or assembly was made.

(2) The material specifications of all items included in the assembly.

(3) The detailed welding procedure employed including welding process, filler metal, joint preparation, pre-heat, welding conditions, and sequence of weld passes (see Annex A).

(4) The type of loading applied, direction, and magnitude of forces (by calculation or instrumentation), frequency and total number of applications, or specific duration of the test.

(5) The results of visual examination and nondestructive testing of all welded joints subjected to loading in the test.

(6) The results of destructive tests of weldments.

9.5.3.3 The welding procedure employed for the test assembly shall be considered qualified provided the following are met:

(1) Visual and any required nondestructive examinations, prior to test, meet the requirements of Section 10, Weld Quality and Inspection.

(2) Specified examinations conducted after test assure performance criteria are met.

9.5.3.4 A test assembly welding procedure shall be requalified when a change in an essential variable exceeds the limits for the welding process (see 9.5.2.1 through 9.5.2.5).

9.6 Types of Tests and Purposes. The tests that are used to determine the mechanical properties and soundness of welded joints made to qualify a welding procedure are as follows:

9.6.1 Groove Welds. The tests for groove welds are as follows:

- (1) Reduced-section tension test for tensile strength,
- (2) Root-, face-, and side-bend tests for soundness,
- (3) Radiographic test for soundness,
- (4) Ultrasonic test for soundness,
- (5) All-weld-metal tension test for mechanical properties,
- (6) Impact test for toughness, and

(7) Macroetch test for soundness and weld size in partial joint penetration groove welds.

9.6.2 Fillet Welds. Fillet welds should be macroetch tested for soundness and fusion.

9.7 Base Metal. The base metal and the preparation for welding shall be that specified in the procedure specification being qualified. For all types of welded joints, the length of the welded joint and dimensions of the base metal shall provide sufficient material for the required test specimens.

9.8 Position of Test Welds

9.8.1 All welds that will be encountered in actual construction shall be classified as flat, horizontal, vertical, or overhead. Welding position limitations for procedure qualification are shown in Table 13.

9.8.2 Plate Groove Weld Tests. When making tests to qualify welding procedures for groove welds in plate, test plates shall be welded in each of the positions to be qualified as follows:

(1) Position 1G (flat)—The test plates shall be placed in an approximately horizontal plane and the weld metal deposited on the upper side. See Figure 11(A).

(2) Position 2G (horizontal)—The test plates shall be placed in an approximately vertical plane with the groove approximately horizontal. See Figure 11(B).

(3) Position 3G (vertical)—The test plates shall be placed in an approximately vertical plane with the groove approximately vertical. See Figure 11(C).

(4) Position 4G (overhead)—The test plates shall be placed in an approximately horizontal plane, and the weld metal deposited on the under side. See Figure 11(D).

9.8.3 Pipe Groove Weld Tests. When making tests to qualify welding procedures for groove welds in pipe, test pipes shall be welded in each of the positions to be qualified as follows:

(1) Position 1G (pipe horizontal, rolled)—The test pipe shall be placed with its axis horizontal and the groove approximately vertical. The pipe shall be rotated during welding so the weld metal is deposited on the upper side. See Figure 12(A).

(2) Position 2G (pipe vertical)—The test pipe shall be placed with its axis vertical to the welding groove approximately horizontal. The pipe shall not be rotated during welding. See Figure 12(B).

(3) Position 5G (pipe horizontal, fixed)—The test pipe shall be placed with its axis horizontal and the groove approximately vertical. The pipe is not rotated during welding. See Figure 12(C).

Table 13
Procedure Qualification—Type and Position Limitations (see 9.10.5)

Qualification Test		Type of Weld and Position of Welding Qualified ⁽¹⁾			
		Plate ⁽²⁾		Pipe ⁽²⁾	
Weld Type	Plate or Pipe Positions ⁽³⁾	Groove	Fillet	Groove	Fillet
Plate-groove	1G	F	F	F	F
	2G	H	F, H	F, H	F, H
	3G	V	V		
	4G	OH	OH		
Plate-fillet	1F		F		F,
	2F		F, H		F, H
	3F		V		V
	4F		OH		OH
Pipe-groove	1G Rotated	F	F	F	F
	2G	F, H	F, H	F, H	F, H
	5G	F, V, OH	F, V, OH	F, V, OH	F, V, OH
	6G ⁽⁴⁾	F, H, V, OH	F, H, V, OH	F, H, V, OH	F, H, V, OH

Notes:

- (1) Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead.
 (2) Qualifies for a welding axis with an essentially straight line and specifically includes plates, wrought shapes, fabricated sections, and rectangular fabricated sections and pipe or tubing over 24 in. [600 mm] minimum in diameter, except for complete joint penetration welds in tubular T-, Y-, and K-connections. This includes welding along a line parallel to the axis of round pipe.
 (3) See Figures 11, 12, and 13.
 (4) Qualifies for fillet and groove welds in all positions except for complete joint penetration groove welding of T-, Y-, and K-connections.

(4) Position 6G (pipe inclined, fixed)—The test pipe shall be inclined at 45° with the horizontal. The pipe is not rotated during welding. See Figure 12(D).

9.8.4 Fillet Weld Tests. When making tests to qualify welding procedures for fillet welds, test plates shall be welded in each of the positions to be qualified as follows:

(1) Position 1F (flat)—The test plates shall be so placed that each fillet weld is deposited with its axis and face approximately horizontal, and its throat approximately vertical. See Figure 13(A).

(2) Position 2F (horizontal)—The test plates shall be so placed that each fillet weld is deposited on the upper side of a horizontal surface and against a vertical surface. See Figure 13(B).

(3) Position 3F (vertical)—The test plates shall be placed in an approximately vertical plane, and each fillet weld deposited on vertical surfaces with the axis of the weld vertical. See Figure 13(C).

(4) Position 4F (overhead)—The test plates shall be so placed that each fillet weld is deposited on the underside of a horizontal surface and against a vertical surface. See Figure 13(D).

Note: There are no provisions for separate tests to qualify welding procedures for pipe fillet welds. Pipe groove weld tests will qualify welding procedures for pipe fillet welds.

9.9 Joint Welding Procedure

9.9.1 The procedure for welding a joint shall comply in all respects with the welding procedure specification.

9.9.2 Cleaning during the welding of test weld shall be done in the welding position being qualified.

9.10 Test Specimens

9.10.1 Complete Joint Penetration Groove Welds

9.10.1.1 The type and number of test specimens that shall be tested to qualify a welding procedure are shown in Table 14, together with the range of thickness that is qualified for use in construction. The range is based on the thickness of the test plate, pipe, or tubing used in making the qualification test.

9.10.1.2 Test specimens to qualify groove welds in T-joints or corner joints shall be butt joints having the

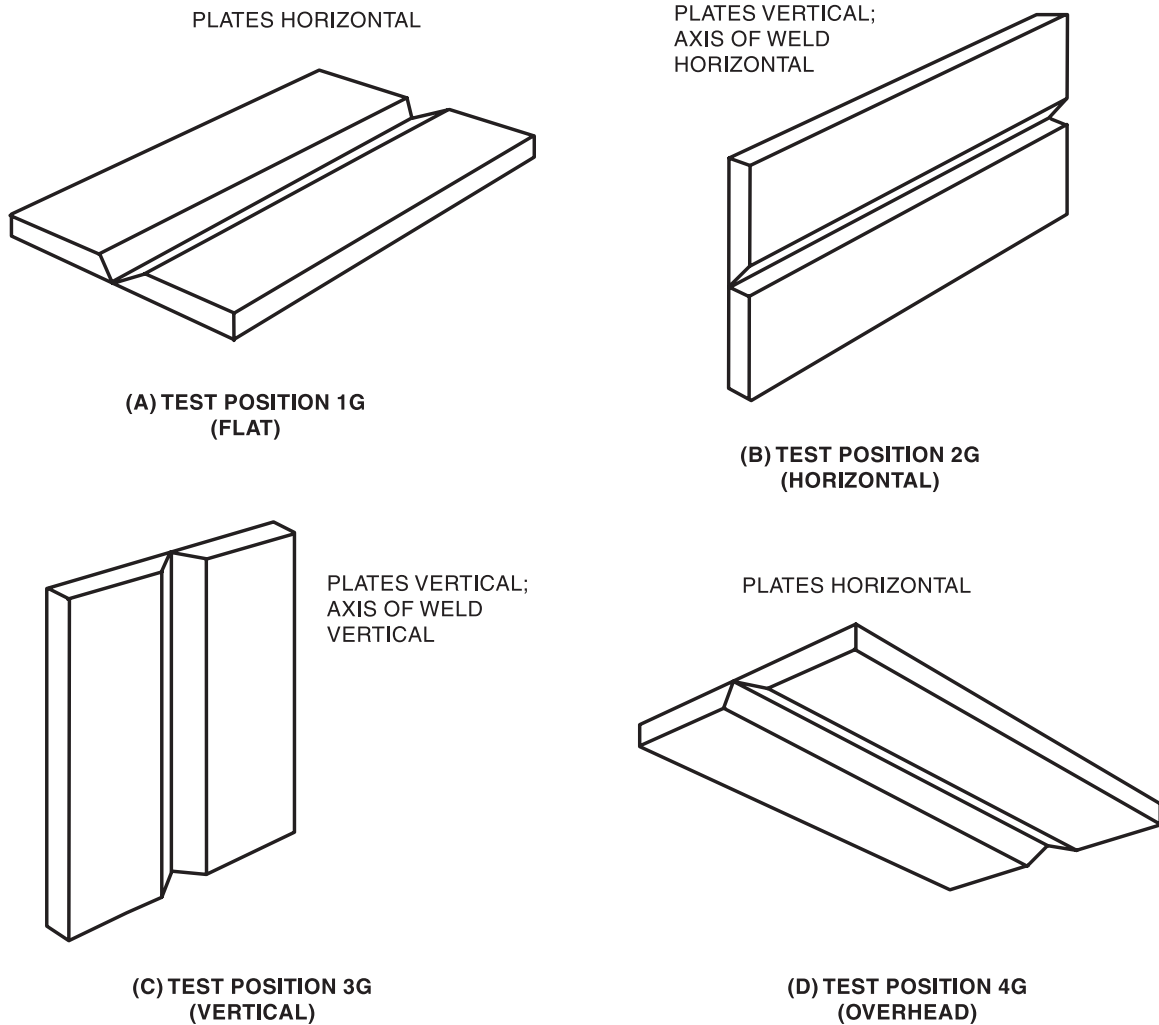


Figure 11—Positions of Test Plates for Groove Welds

same groove configurations as the T-joints or corner joints to be used in construction.

9.10.1.3 Nondestructive Testing. Procedure qualification test plates, pipe or tubing (Figures 14A through 14E) shall be radiographically or ultrasonically examined for soundness before preparing the required mechanical test specimens. Radiographic or ultrasonic testing shall apply only to that portion of the weld in test plates between the discard strips, except that a minimum of 6 in. [150 mm] of effective weld length shall be examined. The full circumference of a completed weld in pipe or tubing shall be examined. The welding procedure is unacceptable if the test results do not conform to the requirements of 9.12.

9.10.1.4 Mechanical Testing. Test specimens shall be prepared by cutting the welded test plate, pipe, or tubing as shown in Figures 14A through 14E, whichever is applicable. The specimens shall be prepared for testing in accordance with Figures 15A through 15D, as applicable.

9.10.1.5 When material combinations differ markedly in mechanical bending properties, as between two base materials or between the weld metal and the base metal, longitudinal bend tests (face and root) may be used in lieu of the transverse face- and root-bend tests. The welded test assemblies conforming to 9.10.1.3 shall have test specimens prepared by cutting the test plate as shown in Figures 14D or 14E, whichever is applicable. The test specimens for the longitudinal bend test shall be prepared for testing as shown in Figure 15C.

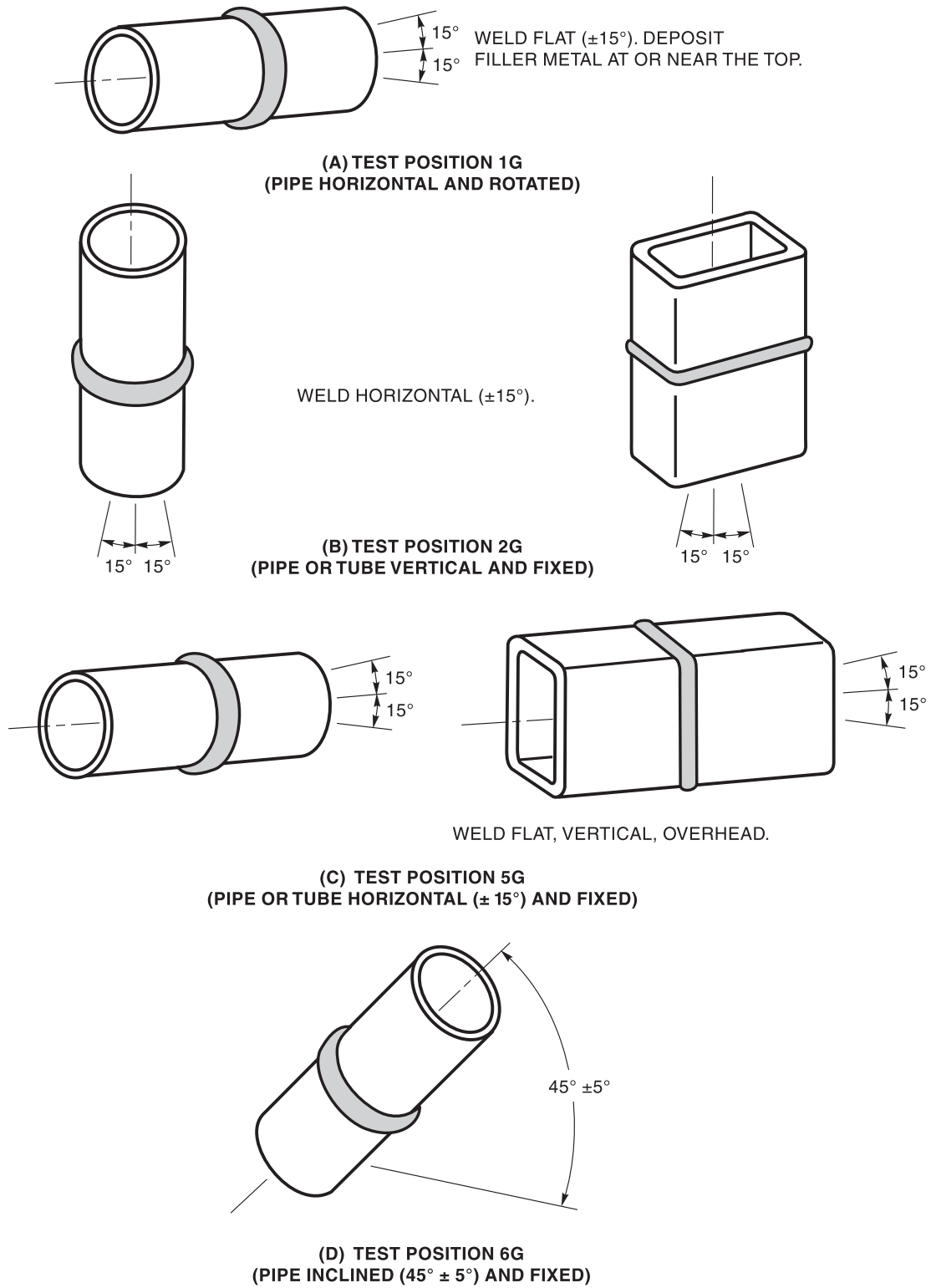


Figure 12—Positions of Test Pipe or Tubing for Groove Welds

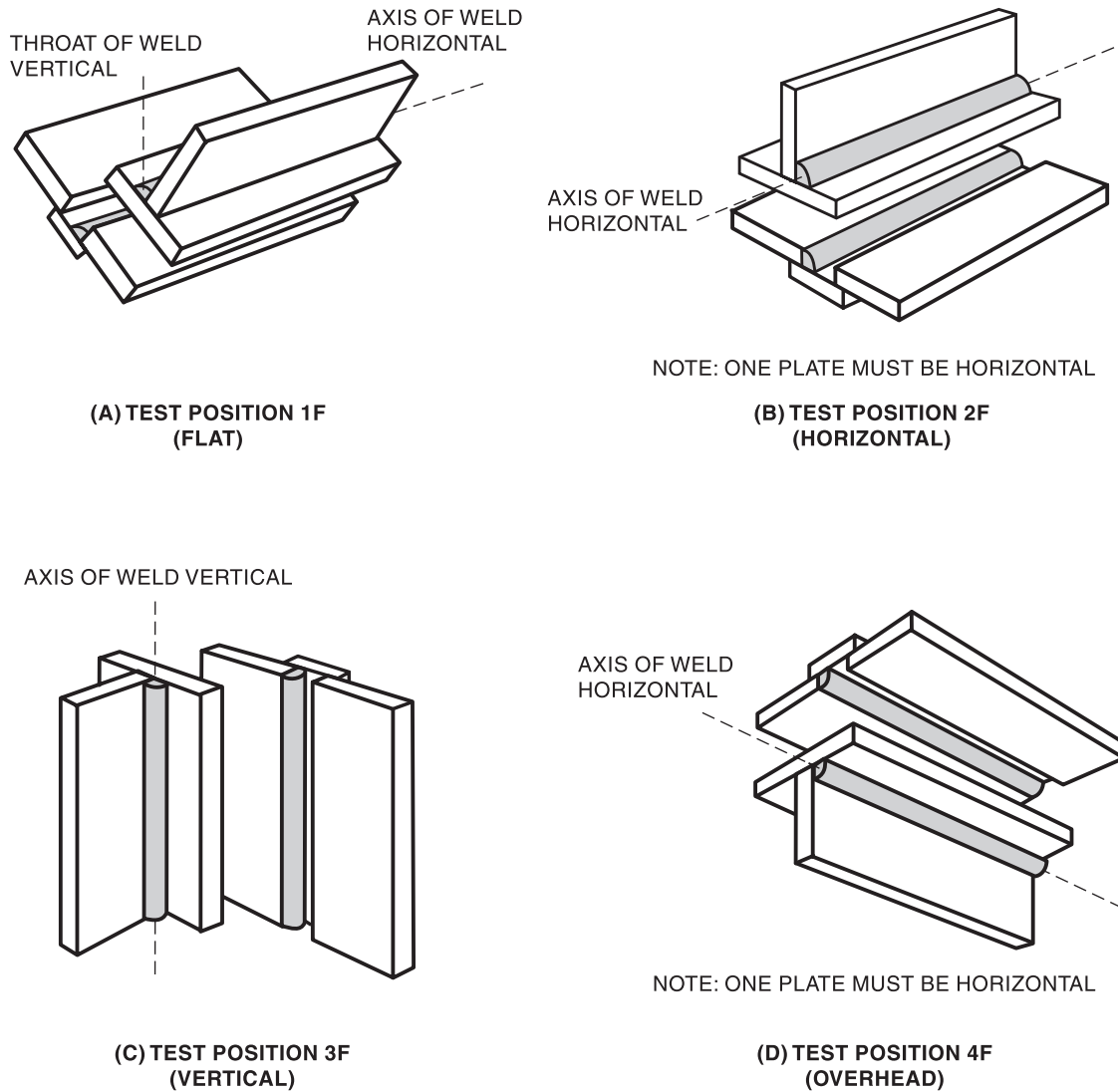


Figure 13—Positions of Test Plates for Fillet Welds

9.10.2 Partial Joint Penetration Groove Welds

9.10.2.1 A sample weld shall be made using the type of groove design and joint welding procedure to be used in construction, except that the depth of groove need not exceed 1 in. [25 mm]. If the partial joint penetration groove weld is to be used for corner or T-joints, the butt joint shall have a temporary restrictive plate in the plane of the square face to simulate a T-joint configuration. The sample weld shall first be visually examined to 9.12.7 and, if applicable, further examined as follows:

9.10.2.2 For joint welding procedures which conform in all respects to Sections 7 (Workmanship) and 8

(Processes and Filler Metals), three macroetch cross section specimens shall be prepared to demonstrate that the designated effective throat (obtained from the requirements of the procedure specification) is met.

9.10.2.3 When a joint welding procedure has been qualified for a complete joint penetration groove weld and is applied to the welding conditions of a partial joint penetration groove weld, three macroetch cross section test specimens are required.

9.10.2.4 If a joint welding procedure is not covered by either 9.10.2.2 or 9.10.2.3, or if the welding variables do not meet a prequalified status or have not been used

Table 14
Number and Type of Test Specimens and Range of Thickness Qualified—
Procedure Qualification; Complete Joint Penetration Groove Welds

1. Tests on Plate

Plate Thickness (T) Tested, in. [mm]	Number of Sample Welds per Position	NDT ⁽¹⁾	Test Specimens Required				Plate Thickness (T) Qualified, in. [mm] Maximum ⁽²⁾
			Reduced- Section Tension (see Fig. 17A)	Root Bend (see Fig. 17C)	Face Bend (see Fig. 17C)	Side Bend (see Fig. 17D)	
1/8 [2] ≤ T < 3/8 [10]	1	Yes	2	2	2	—	1/8 [3] to 2T
3/8 [10]	1	Yes	2	2	2	—	3/4 [20]
3/8 [10] < T < 1 [25]	1	Yes	2	—	—	4	2T
≥ 1 [25]	1	Yes	2	—	—	4	Unlimited

Notes:

- (1) A minimum of 6 in. [150 mm] of effective weld length shall be examined by radiographic or ultrasonic testing prior to mechanical testing.
- (2) For square groove welds, qualification shall be limited to thickness tested.

General Note: All welded test plates shall be visually inspected (see 9.12.7).

2. Tests on Pipe or Tubing

Pipe Size of Sample Weld		Number of Sample Welds per Position	NDT ⁽³⁾	Test Specimens Required				Pipe or Tube Size Qualified		
Diameter in. [mm]	Wall Thickness			Number of Specimens				Diameter, in. [mm]	Wall Thickness, in. [mm]	
		Reduced- Section Tension (see Fig. 17A)	Root Bend (see Fig. 17C)	Face Bend (see Fig. 17C)	Side Bend (see Fig. 17D)	Min	Max			
2 [50] or 3 [75]	Sch. 80 or Sch. 40	2	Yes	2	2	2	—	3/4 [20] through 4 [100]	0.125 [3]	0.674 [17]
6 [150] or 8 [200]	Sch. 120 or Sch. 80	1	Yes	2	—	—	4	4 [100] and over	0.187 [5]	Any

Job Size Pipe or Tubing

Diameter in. [mm]	Wall Thickness, T, in. [mm]									
< 24 [600]	1/8 ≤ T ≤ 3/8 [3 ≤ T ≤ 10]	1	Yes	2	2	2	—	Test diameter and over	1/8 [3]	2T
	3/8 < T < 3/4 [10 < T < 20]	1	Yes	2	—	—	4	Test diameter and over	T/2	2T
	T ≥ 3/4 [20]	1	Yes	2	—	—	4	Test diameter and over	0.375 [10]	Unlimited
≥ 24 [600]	1/8 ≤ T ≤ 3/8 [3 ≤ T ≤ 10]	1	Yes	2	2	2	—	Test diameter and over	1/8 [3]	2T
	3/8 < T < 3/4 [10 < T < 20]	1	Yes	2	—	—	4	24 [600] and over	T/2	2T
	T ≥ 3/4 [20]	1	Yes	2	—	—	4	24 [600] and over	0.375 [10]	Unlimited

Notes:

- (3) For pipe or tubing, the full circumference of the completed weld shall be examined by radiographic or ultrasonic testing prior to mechanical testing.

General Note: All welded test pipes or tubing shall be visually inspected (see 9.12.6).

(continued)

Table 14 (Continued)
Number and Type of Test Specimens and Range of Thickness Qualified—
Procedure Qualification; Complete Joint Penetration Groove Welds

3. Tests on Electroslag and Electrogas Welding

Plate Thickness (T) Tested, in. [mm]	Number of Sample Welds	NDT ⁽⁴⁾	Test Specimens Required				Plate Thickness (T) Qualified
			Reduced- Section Tension (see Fig. 17A)	All-Weld Metal Tension (see Fig. 17B)	Side Bend (see Fig. 17D)	Impact Tests ⁽⁵⁾ (see 8.5.2)	
T ⁽⁶⁾	1	Yes	2	1	4	5	0.5T–1.1T

Notes:

(4) 6 in. [150 mm] minimum length of weld shall be examined by radiographic or ultrasonic testing prior to mechanical testing (see 9.10.1.3).

(5) If required.

(6) T is the test plate thickness.

General Note: All welded test plates shall be visually inspected (see 9.12.7).

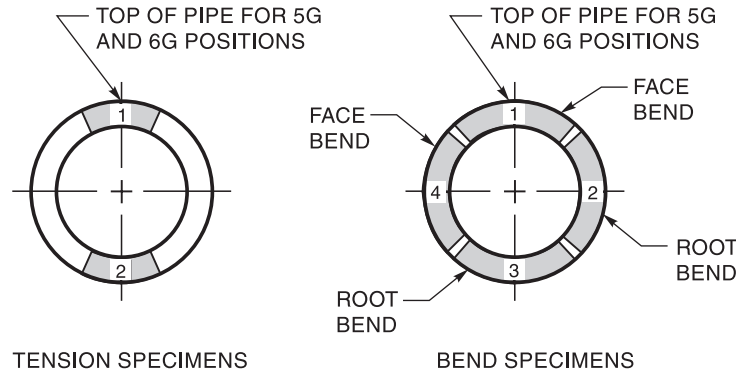


Figure 14A—Location of Test Specimens on Welded Test Pipe
2 in. [50 mm] or 3 in. [75 mm] in Diameter

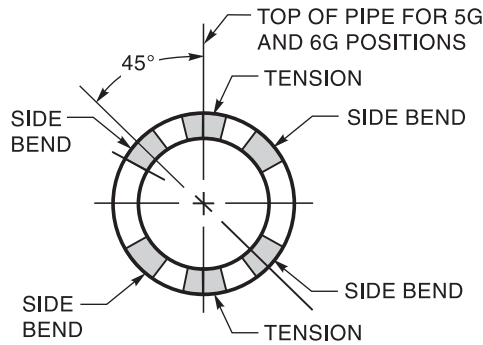
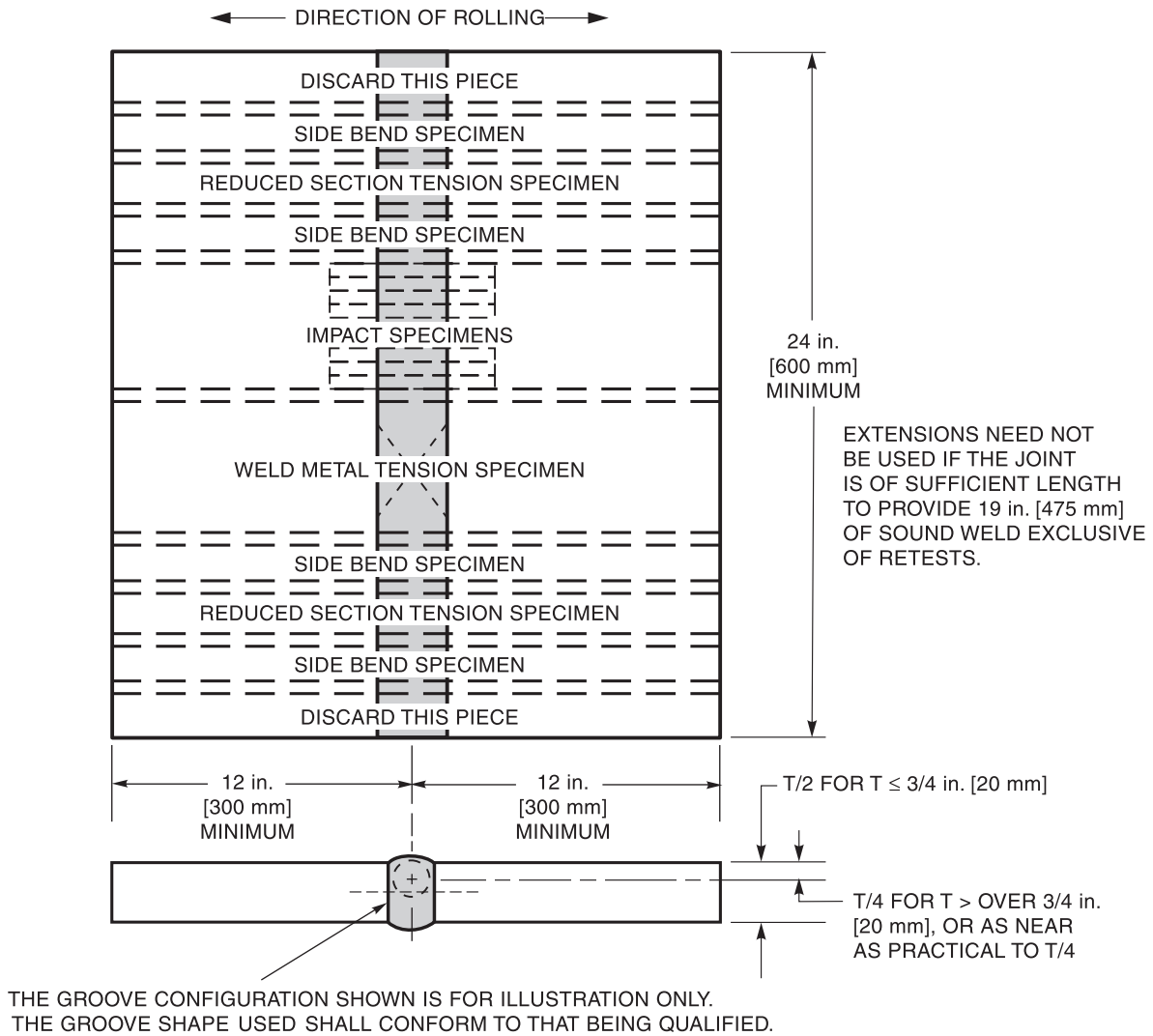


Figure 14B—Location of Test Specimens on Welded Test Pipe
6 in. [150 mm] or 8 in. [200 mm] in Diameter



**Figure 14C—Location of Test Specimens on Welded Test Plate—
Electroslag and Electro-gas Welding—Procedure Qualification**

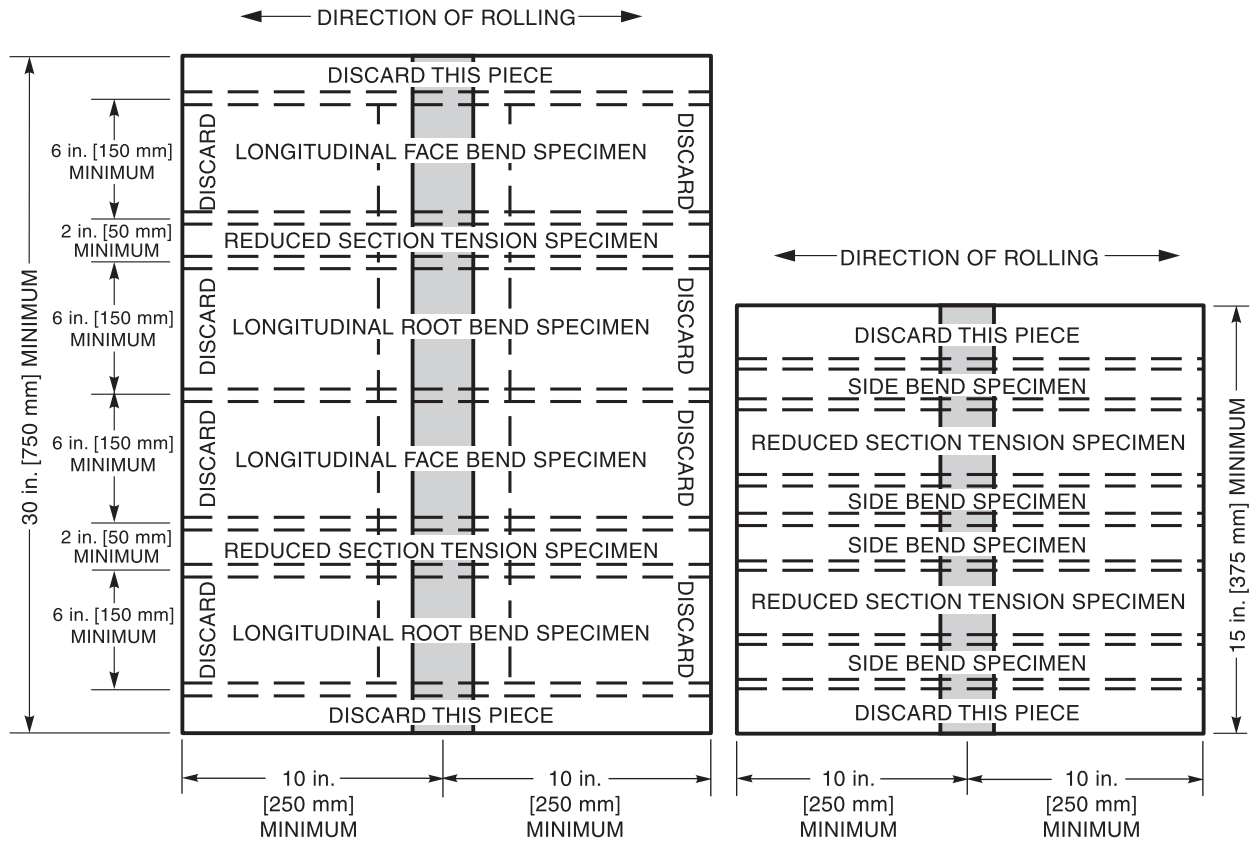
and tested for a complete joint penetration groove weld, then a test sample joint shall be prepared. The first test on the joint is a macroetch test to determine the effective throat of the weld. Next, material is machined from the bottom side of the joint until its thickness is equal to the effective throat of the weld. Tension and bend test specimens shall then be prepared from the test joint, and tests performed as required for complete joint penetration groove welds (see 9.10.1).

9.10.3 Fillet Welds. A T-shaped specimen with a double fillet weld, as shown in Figure 16, shall be made for each welding procedure and welding position to be used in construction. One of the test welds shall be the

maximum size single-pass fillet weld, and the other test weld shall be the minimum size multiple-pass fillet weld to be used in construction. The weldments shall be cut perpendicular to the direction of welding at three locations, as shown in Figure 16. One face of each of the three cuts shall be prepared for macroetch examination in accordance with 9.11.2.

9.10.4 Test specimens may be aged between 200°F and 225°F [95°C and 105°C] for 46 to 50 hours when required or permitted by the filler metal specification applicable to the weld metal being tested.

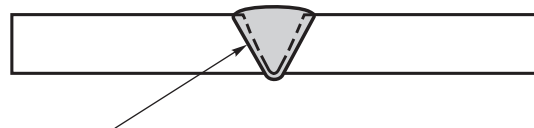
9.10.5 Qualification on pipe shall also qualify for plate, but not vice versa. One exception is that qualifica-



WHEN IMPACT TESTS ARE REQUIRED, THE SPECIMENS SHALL BE REMOVED FROM THEIR LOCATIONS, AS SHOWN IN FIGURE 17C.

(1) LONGITUDINAL BEND SPECIMENS

(2) TRANSVERSE BEND SPECIMENS



THE GROOVE CONFIGURATION SHOWN IS FOR ILLUSTRATION ONLY.
THE GROOVE SHAPE USED SHALL CONFORM TO THAT BEING QUALIFIED.

Figure 14D—Location of Test Specimens on Welded Test Plate Over 3/8 in. [10 mm] Thick—Procedure Qualification

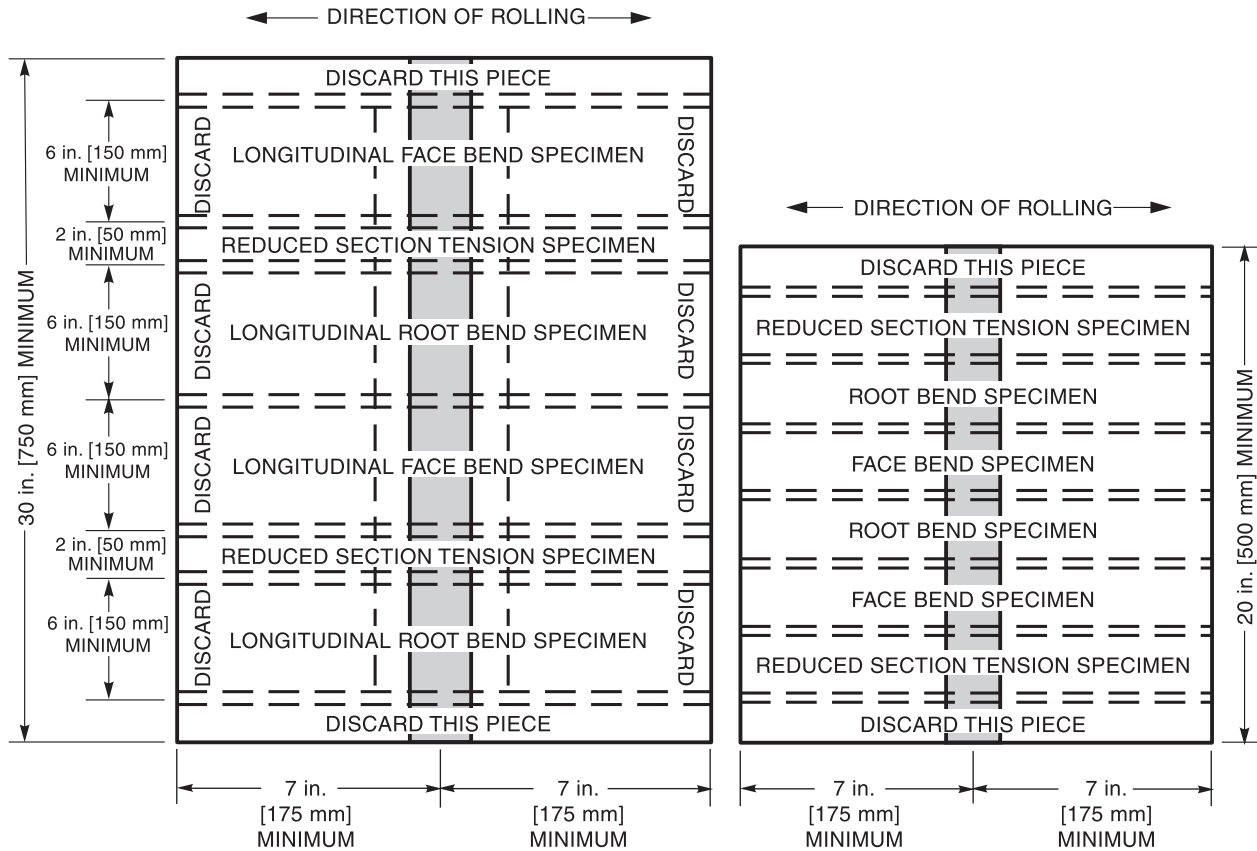
tion on plate in the 1G (flat) or 2G (horizontal) positions shall qualify for welding groove welds and fillet welds in pipe or tubing that is over 24 in. [600 mm] in diameter. Welding position limitations for procedure qualification are shown in Table 13.

9.11 Method of Testing Specimens

9.11.1 Reduced-Section Tension Specimens. Before testing, the least width and corresponding thickness of the reduced section shall be measured. The initial cross-

sectional area shall be obtained by multiplying this width by the thickness. The specimen shall be ruptured under tensile load, and the maximum load shall be determined. The tensile strength shall be obtained by dividing the maximum load by the initial cross-sectional area.

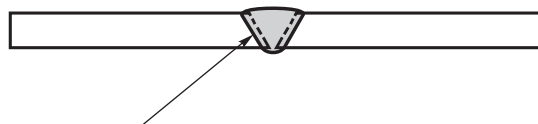
9.11.2 Macroetch Test. The weld test specimens shall be prepared with a finish suitable for macroetch examination. A suitable macroetch solution (such as hot ammonium persulfate) shall be used for etching to



WHEN IMPACT TESTS ARE REQUIRED, THE SPECIMENS SHALL BE REMOVED FROM THEIR LOCATIONS, AS SHOWN IN FIGURE 17C.

(1) LONGITUDINAL BEND SPECIMENS

(2) TRANSVERSE BEND SPECIMENS



THE GROOVE CONFIGURATION SHOWN IS FOR ILLUSTRATION ONLY.
THE GROOVE SHAPE USED SHALL CONFORM TO THAT BEING QUALIFIED.

**Figure 14E—Location of Test Specimens on Welded Test Plate
3/8 in. [10 mm] Thick and Under—Procedure Qualification**

accentuate the gross structure of the weld and any exposed internal discontinuities.

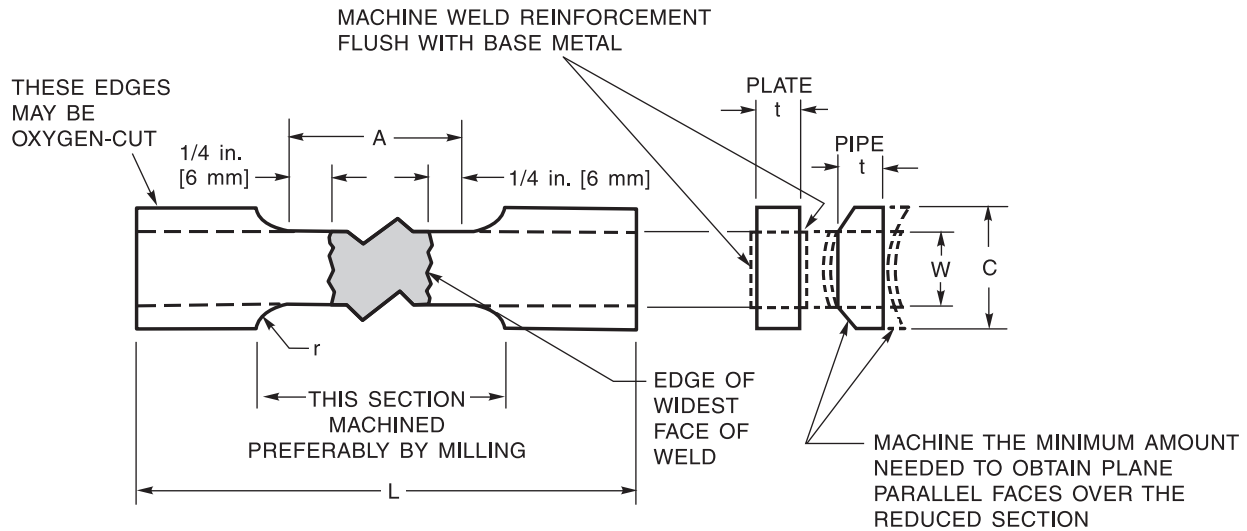
9.11.3 Root-, Face-, and Side-Bend Specimens

9.11.3.1 Each specimen shall be bent in a guided bend test jig. Any convenient means may be used to complete the bend test (see 9.27.1).

9.11.3.2 Face-bend specimens shall be oriented so that the face of the weld will be in tension. Root-bend

and fillet-weld-soundness specimens shall be oriented so that the root of the weld will be in tension. Side-bend specimens shall be oriented so that the side showing the larger discontinuity, if any, will be in tension.

9.11.3.3 The specimen shall be formed into a U-shape. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after bending.

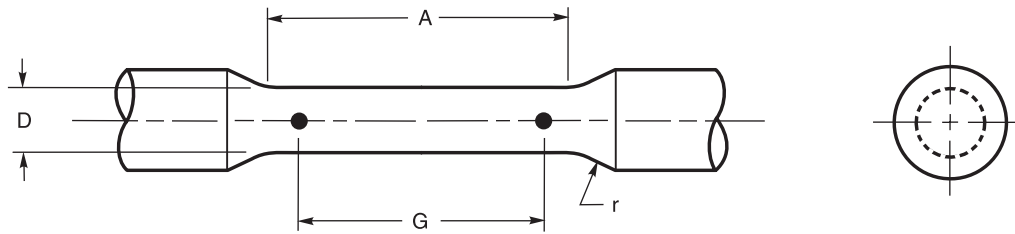


	Dimensions, in. [mm]				
	Test Plate ⁽¹⁾			Test Pipe	
	$T_p \leq 1$ [25]	$1 < T_p < 1\text{-}1/2$ [25 < T_p < 40]	$T_p \geq 1\text{-}1/2$ [40]	2 [50] & 3 [75] Diameter	6 [150] & 8 [200] Diameter or Larger
A—Length of Reduced Section	Widest Face of Weld + 1/2 [13], 2-1/4 [55] minimum			Widest Face of Weld + 1/2 [3], 2-1/4 [55] minimum	
L—Overall Length, minimum ⁽²⁾	As required by Testing Equipment			As required by Testing Equipment	
W—Width of Reduced Section ^{(3), (4)}	$1\text{-}1/2 \pm 0.01$ [40 ± 0.3]	1 ± 0.01 [25 ± 0.3]	1 ± 0.01 [25 ± 0.3]	$1/2 \pm 0.01$ [13 ± 0.3]	$3/4 \pm 0.01$ [20 ± 0.3]
C—Width of Grip Section ^{(4), (5)}	2 [50]	1-1/2 [40]	1-1/2 [40]	1 [25] approx.	1-1/4 [30] approx.
t—Specimen Thickness ^{(6), (7)}	T_p	T_p	T_p/n (Note 7)	Maximum possible with plane parallel faces within Length A	
r—Radius of Fillet, minimum	1/2 [13]	1/2 [13]	1/2 [13]	1 [25]	1 [25]

Notes:

- (1) T_p = thickness of the plate.
- (2) It is desirable, if possible, to make the length of the grip section large enough to allow the specimen to extend into the grips a distance equal to two-thirds or more of the length of the grips.
- (3) The ends of the reduced section shall not differ in width by more than 0.004 in. [0.10 mm]. Also, there may be a gradual decrease in width from the ends to the center, but the width of either end shall not be more than 0.015 in. [0.40 mm] larger than the width at the center.
- (4) Narrower widths (W and C) may be used when necessary. In such cases, the width of the reduced section should be as large as the width of the material being tested permits. If the width of the material is less than W, the sides may be parallel throughout the length of the specimen.
- (5) For standard plate-type specimens, the ends of the specimen shall be symmetrical with the centerline of the reduced section within 0.25 in. [6 mm], except for referee testing, in which case the ends of the specimen shall be symmetrical with the centerline of the reduced section within 0.10 in. [2.5 mm].
- (6) The dimension t is the thickness of the specimen as provided for in the applicable material specifications. The minimum nominal thickness of 1-1/2 in. [40 mm] wide specimens shall be 3/16 in. [5 mm], except as permitted by the product specification.
- (7) For plates over 1-1/2 in. [40 mm] thick, specimens may be cut into the minimum number of approximately equal strips not exceeding 1-1/2 in. [40 mm] in thickness. Test each strip and average the results.

Figure 15A—Reduced-Section Tension Specimens



Nominal Diameter	Dimensions, in. [mm]		
	Standard Specimen	Small-Size Specimens Proportional to Standard	
	0.500 [12.7] Round	0.350 [8.9] Round	0.250 [6.35] Round
G—Gage Length ⁽¹⁾	2.000 ± 0.005 [51.4 ± 0.13]	1.400 ± 0.005 [35.6 ± 0.13]	1.000 ± 0.005 [25.4 ± 0.13]
D—Diameter ⁽²⁾	0.500 ± 0.010 [12.7 ± 0.25]	0.350 ± 0.007 [8.9 ± 0.18]	0.250 ± 0.005 [6.35 ± 0.13]
r—Radius of Fillet, minimum	3/8 [10]	1/4 [6]	3/16 [5]
A—Length of Reduced Section ⁽³⁾	2-1/4 [55]	1-3/4 [45]	1-1/4 [30]

Notes:

- (1) The gage length and fillets shall be as shown, but the ends may be of any form to fit the holders of the testing machine in such a way that the load shall be axial. If the ends are to be held in wedge grips, it is desirable, if possible, to make the length of the grip section great enough to allow the specimen to extend into the grips a distance equal to two-thirds or more of the length of the grips.
- (2) The reduced section may have a gradual taper from the ends toward the center, with the ends not more than 1% larger in diameter than the center (controlling dimension).
- (3) If desired, the length of the reduced section may be increased to accommodate an extensometer of any convenient gage length. Reference marks for the measurement of elongation should be spaced at the indicated gage length.

Figure 15B—All-Weld-Metal Tension Specimens

9.11.3.4 When using a wraparound jig, the specimen shall be firmly clamped on one end so that it does not slide during the bending operation. The weld and heat-affected zones shall be completely in the bent portion of the specimen after testing. Test specimens are to be removed from the jig after the bending roller has been moved 180° from the starting point.

9.11.4 All-Weld-Metal Tension Test. The test specimen shall be tested in accordance with the latest edition of AWS B4.0 or B4.0M, *Standard Methods for Mechanical Testing of Welds*.

9.11.5 Radiography. The radiographic procedure and technique shall be in conformance to the requirements of Section 10, Weld Quality and Inspection.

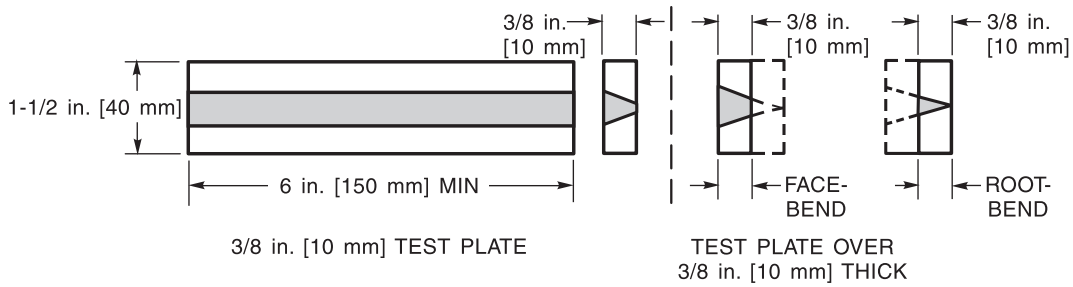
9.11.6 Ultrasonic Testing. The ultrasonic procedure and technique shall be in conformance to the requirements of Section 10.

9.12 Test Results Required

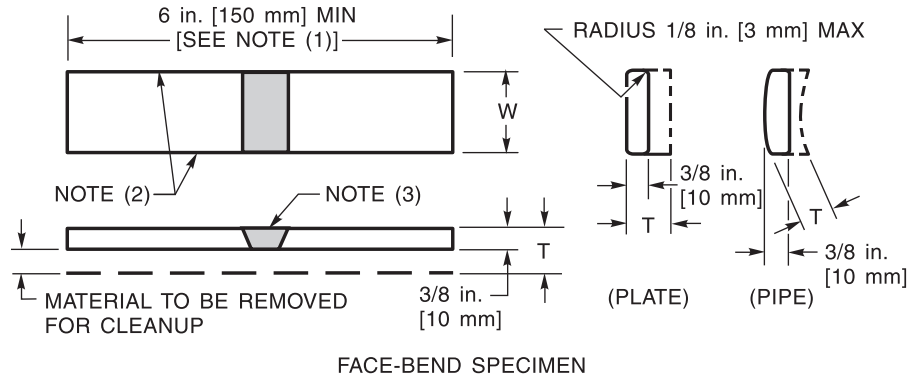
9.12.1 Reduced-Section Tension Test. The tensile strength shall not be less than the minimum of the specified tensile range of the base metal.

9.12.2 Root-, Face-, and Side-Bend Tests. The convex surface of the specimen shall be examined for the appearance of cracks or other open discontinuities. A specimen shall be considered as failed when a crack or other open discontinuity exceeding 1/8 in. [3 mm], measured in any direction, is present after the bending. Cracks occurring on the corners of the specimen may be 1/4 in. [6 mm] maximum length, provided there is no evidence of slag inclusions or other fusion-type discontinuities.

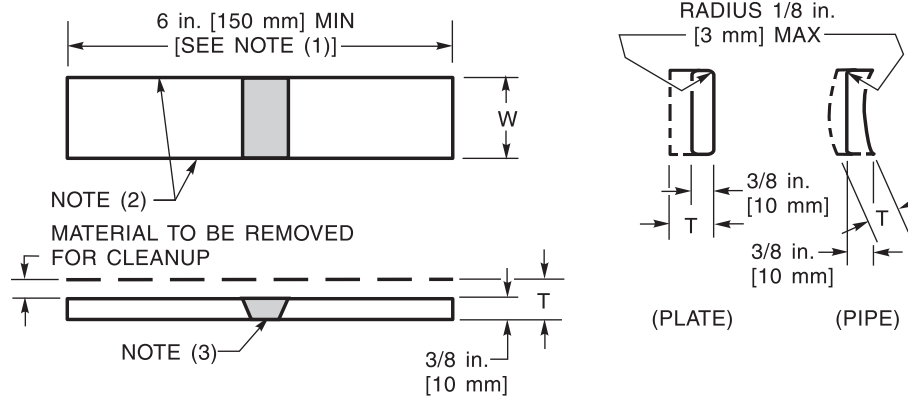
9.12.3 Macroetch Tests. The macroetched surfaces of the specimens shall be examined for discontinuities, and the welds shall be considered as failed when discontinuities prohibited by 10.6 are observed on the macroetched surfaces. Partial joint penetration groove welds shall have the designated effective throat. Fillet welds shall show fusion to the root of the joint, but not necessarily beyond, and both legs shall be equal to within 1/8 in. [3 mm]. Convexity shall not exceed the limits specified in 10.7.



(1) LONGITUDINAL BEND SPECIMEN



FACE-BEND SPECIMEN



ROOT-BEND SPECIMEN

(2) TRANSVERSE BEND SPECIMENS

Dimensions, in. [mm]	
Test Weldment	Test Specimen Width (W)
Plate	1-1/2 [40]
Test Pipe 2 [50] and 3 [75] in Diameter	1 [25]
Test Pipe 6 [150] and 8 [200] in Diameter	1-1/2 [40]

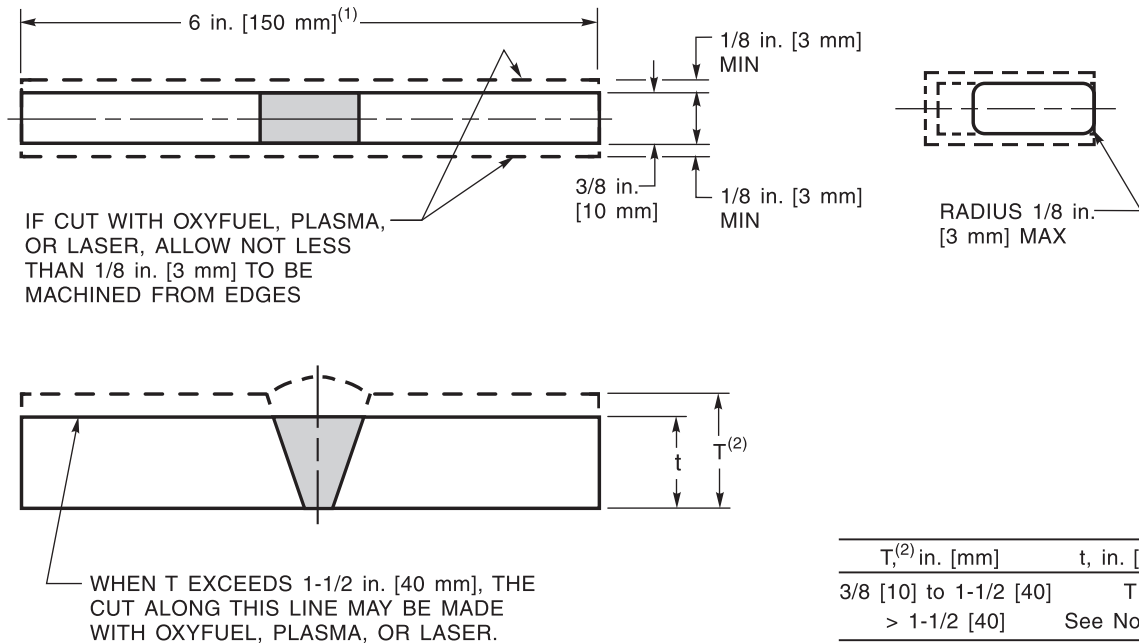
Notes:

- (1) A longer specimen length may be necessary when using a wraparound-type bending fixture or when testing steel with a yield strength of 90 ksi [620 MPa] or more.
- (2) These edges may be oxyfuel, plasma, or laser cut.
- (3) The weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. If a recessed backing is used, this surface may be machined to a depth not exceeding the depth of the recess to remove the backing. In such cases, the thickness of the finished specimen shall be that specified above. Cut surfaces shall be smooth and parallel.

General Notes:

- 1. T = plate or pipe thickness.
- 2. When the thickness of the test plate is less than 3/8 in. [10 mm], the nominal thickness shall be used for face-bend and root-bend specimens.

Figure 15C—Face- and Root-Bend Specimens



Notes:

- (1) A longer specimen length may be necessary when using a wraparound-type bending fixture or when testing steel with a yield strength of 90 ksi [620 MPa] or more.
- (2) T = plate or pipe thickness.
- (3) For plates over 1-1/2 in. [40 mm] thick, the specimen shall be cut into approximately equal strips with the t dimension between 3/4 in. [20 mm] and 1-1/2 in. [40 mm], and each strip shall be tested.

Figure 15D—Side-Bend Specimens

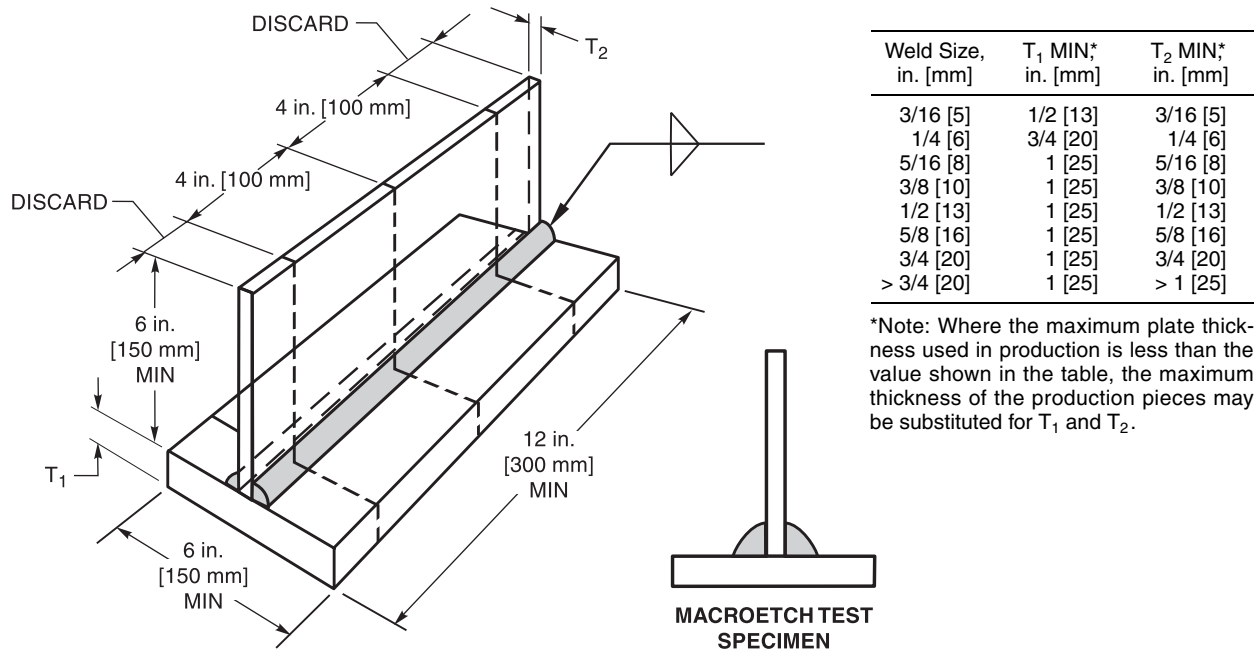


Figure 16—Fillet Weld Soundness Test for Procedure Qualification

9.12.4 All-Weld-Metal Tension Test (Electroslag and Electrode). The mechanical properties shall equal or exceed those specified in Table 12.

9.12.5 Nondestructive Testing. The weld soundness, as revealed by either radiographic or ultrasonic testing, shall conform to the requirements of Section 10, Weld Quality and Inspection.

9.12.6 Visual Inspection—Pipe and Tubing. For acceptable qualification, a pipe weld shall conform to the following requirements.

9.12.6.1 The weld shall be free of cracks.

9.12.6.2 All craters shall be filled to the full cross section of the weld.

9.12.6.3 The face of the weld shall be at least flush with the outside surface of the pipe, and the weld shall merge smoothly with the base metal. Undercut shall not exceed 1/64 in. [0.5 mm]. Weld reinforcement shall not exceed values given in Table 15.

9.12.6.4 The root of the weld shall be inspected. There shall be no evidence of cracks, incomplete fusion, or inadequate joint penetration. A concave root surface is permitted within the limits shown in 9.12.6.5, provided the total weld thickness is equal to or greater than that of the base metal.

9.12.6.5 The root surface concavity shall be 1/16 in. [2 mm] or less, and the melt-through shall be 1/8 in. [3 mm] or less.

9.12.7 Visual Inspection—Plate. For acceptable qualification, the welded test plate shall conform to the requirements for visual inspection in Section 10, Weld Quality and Inspection.

9.13 Records. Records of the test results shall be kept by the Manufacturer or contractor, and shall be available to those authorized to examine them.

9.14 Retests. If any one tested specimen fails to meet the test requirements, two retests of that particular type of test specimen may be performed with specimens cut from the same procedure qualification test material. The results of both retest specimens shall meet the test requirements. For material over 1-1/2 in. [40 mm] thick, failure of a specimen shall require testing of all specimens of the same type from two additional locations in the test material.

Part C

Welder Qualification

9.15 General. The qualification tests described are specially devised to determine a welder's ability to produce sound welds. These tests are not intended to be used as a guide for welding during actual construction. Welding during manufacturing shall be performed in accordance with the requirements of the welding procedure specification.

9.16 Limitations. For the qualification of welders, the following rules shall apply:

9.16.1 Qualification established with any one of the steels permitted by this specification shall be considered as qualification to weld or tack weld any of the other steels.

9.16.2 A welder shall be qualified for each process used.

9.16.3 A welder qualified for SMAW with an electrode identified in Table 16 shall be considered qualified to weld, or tack weld, with any other electrode in the same group designation, and with any electrode listed in a numerically lower group designation.

9.16.4 A welder qualified with an approved electrode-shielding medium combination shall be considered qualified to weld or tack weld with any other approved electrode-shielding medium combination for the process used in the qualification test.

9.16.5 A change in the position of welding to one for which the welder is not qualified to weld shall require qualification in that position.

9.16.6 A change from one diameter/thickness grouping of pipe shown in Table 17, Part 2, to another grouping shall require requalification.

9.16.7 A change in the direction of welding shall require requalification when the plate is in the vertical position, or the pipe or tubing is in the 5G or 6G position.

Table 15
Acceptable Reinforcement on Groove Welds in Pipe and Tubing

Wall Thickness		Maximum Reinforcement	
in.	mm	in.	mm
≤ 3/8	≤ 10	3/32	2
> 3/8 to ≤ 3/4	> 10 to ≤ 20	1/8	3
> 3/4	> 20	3/16	5

Table 16
SMAW Electrode Groups

Group Designation	AWS Electrode Classification ⁽¹⁾
F4	EXX15, EXX16, EXX18, EXX15-X, EXX16-X, EXX18-X, EXX18M
F3	EXX10, EXX11, EXX10-X, EXX11-X
F2	EXX12, EXX13, EXX14, EXX13-X, EXX19
F1	EXX20, EXX24, EXX27, EXX28, EXX20-X, EXX27-X

Note:

(1) The letters "XX" used in the classification designations in this table represent the various strength levels 60 ksi [415 MPa], 70 ksi [480 MPa], 80 ksi [550 MPa], 90 ksi [620 MPa], 100 ksi [690 MPa], 110 ksi [760 MPa], and 120 ksi [830 MPa] of deposited weld metal.

9.16.8 The omission of backing material in complete joint penetration welds that are welded from one side shall require requalification.

9.17 Qualification Tests Required

9.17.1 The welder qualification tests for manual and semiautomatic welding of plate shall be as follows:

- (1) Groove weld qualification test for plate of unlimited thickness.
- (2) Groove weld qualification test for plate of limited thickness.
- (3) Fillet weld qualification test for fillet welds only, Option 1 or 2 (see 9.22).

9.17.2 The pipe or tubing qualification tests for manual and semiautomatic welding shall be as follows:

- (1) Groove weld qualification test for butt joints in pipe or tubing.
- (2) Groove weld qualification test for T-, Y-, or K-connections in pipe or tubing.

9.17.3 A welder who makes a successful procedure qualification test of a complete joint penetration groove weld in flat plate is qualified to weld production plate with the welding process and in the position used in the test. The thickness range qualified for and the number of test specimens required shall be as specified in Table 17, Part 1. The welder is also qualified to make fillet welds in plate and pipe, as shown in Table 18.

9.17.4 The welder who makes a successful procedure qualification test of a complete joint penetration groove weld in pipe without a backing strip is qualified to weld pipe and tubing with the process and in the position used in the test. The diameter and wall thickness ranges qualified for and the number of test specimens required shall be as specified in Table 17, Part 2.

9.18 Groove Weld Plate Qualification Test for Plate of Unlimited Thickness. The joint detail shall be as follows: 1 in. [25 mm] plate, single-V-groove, 45° included angle, 1/4 in. [6.4 mm] root opening with backing (see Figure 17A). For horizontal position qualification, the joint detail may, at the contractor's option, be a single-bevel-groove, 45° groove angle, 1/4 in. [6.4 mm] root opening with backing (see Figure 17B). Backing shall be at least 3/8 in. [10 mm] × 3 in. [75 mm] if radiographic testing is used without prior removal of backing. Backing shall be at least 3/8 in. [10 mm] × 2 in. [50 mm] for mechanical testing or for radiographic testing after the backing is removed. The minimum length of the weld groove shall be 5 in. [125 mm].

9.19 Groove Weld Plate Qualification Test for Plate of Limited Thickness. The joint detail shall be as follows: 3/8 in. [10 mm] plate, single-V-groove, 45° included angle, 1/4 in. [6.4 mm] root opening with backing (see Figure 18A). For horizontal position qualification, the joint detail may, at the contractor's option, be single bevel groove, 45° groove angle, 1/4 in. [6.4 mm] root opening with backing (see Figure 18B). Backing shall be at least 3/8 in. [10 mm] × 3 in. [75 mm] if radiographic testing is used without prior removal of the backing. Backing shall be at least 3/8 in. [10 mm] × 2 in. [50 mm] for mechanical testing or for radiographic testing after the backing is removed. The minimum length of the weld groove shall be 5 in. [125 mm].

9.20 Groove Weld Qualification Test for Butt Joints in Pipe or Tubing. The joint detail shall be that shown in a qualified welding procedure specification for a single-welded pipe butt joint. Alternatively, the joint may be prepared in job-sized pipe with a single V-groove, 60° included angle, 1/8 in. [3 mm] maximum root face and root opening without backing (see Figure 19A), or a single-V-groove, 60° included angle, and suitable root opening with backing (see Figure 19B).

9.21 Groove Weld Qualification Test for T-, Y-, and K-Connections on Pipe or Tubing. The test joint design is shown in Figure 20. The joint detail shall be as follows: single bevel groove, 37.5° included angle, 1/16 in. [2 mm] maximum root face, 1/8 in. [3 mm] root opening with the bevel on a pipe or tube that is at least 1/2 in. [13 mm] thick. The square edge pipe or tube shall be at least 1/16 in. [2 mm] thicker than the beveled pipe. A restriction ring shall be placed on the thicker pipe within 1/2 in. [13 mm] of the joint, and shall extend at least 6 in. [150 mm] beyond the surface of the pipe or tube (see Figure 20). Test specimens for side bends shall be taken as indicated in Figure 21 and machined as standard specimens with parallel sides.

Table 17
Number and Type of Test Specimens and Range of Thickness Qualified—
Welder and Welding Operator Qualification

1. Tests on Plate

Type of Weld	Thickness of Test Plate (T) As Welded, in. [mm]	Visual Inspection	Number of Specimens					Plate Thickness Qualified, in. [mm]
			Bend Tests ⁽¹⁾			T-Joint Break	Macroetch Test	
			Face	Root	Side			
Groove ⁽²⁾	3/8 [10]	Yes	1	1	—	—	—	3/4 [20] max ⁽³⁾
Groove	3/8 [10] < T < 1 [25]	Yes	—	—	2	—	—	T/2–2T ^{(3),(4)}
Groove	≥ 1 [25] or over	Yes	—	—	2	—	—	Unlimited ⁽³⁾
Fillet option No. 1 ⁽⁵⁾	1/2 [13]	Yes	—	—	—	1	1	Unlimited
Fillet option No. 2 ⁽⁶⁾	3/8 [10]	Yes	—	2	—	—	—	Unlimited

Notes:

- (1) Radiographic examination of the welder or welding operator test plate may be made in lieu of the bend test (see 9.3.2).
(2) Not applicable for welding operator qualification.
(3) Also qualifies for welding fillet welds on material of unlimited thickness.
(4) T is the maximum for welding operator qualification.
(5) See Figure 21.
(6) See Figure 22.

2. Tests on Pipe or Tubing

Type of Weld	Pipe or Tubing Size, As Welded		Visual Inspection	Number of Specimens						Pipe or Tube Size Qualified, in. [mm]	Pipe or Tube Wall Thickness Qualified, in. [mm]	
				All Positions Except 5G & 6G			5G & 6G Positions Only				Min	Max ⁽⁸⁾
	Diam., in. [mm]	Thickness		Face Bend	Root Bend	Side Bend	Face Bend	Root Bend	Side Bend			
Groove	2 [50] or 3 [75]	Sch. 80 or Sch. 40	Yes	1	1	—	2	2	—	≤ 4 [100]	0.125 [3]	0.674 [17]
	6 [150] or 8 [200]	Sch. 120 or Sch. 80	Yes	—	—	2	—	—	4	> 4 [100]	0.187 [5]	Unlimited
	See Figure 20		Yes	—	—	—	—	—	4	T-, Y-, and K-connections	—	Unlimited

Job Size Pipe
or Tubing

Type of Weld	Diam., in. [mm]	Wall Thickness										
Groove	≤ 4 [100]	Any	Yes	1	1	—	2	2	—	≥ 3/4 [20] to ≤ 4 [100]	0.125 [3]	0.674 [17]
	> 4 [100]	< 3/8 [10]	Yes	1	1	—	2	2	—	1/2 test diameter or 4 [100] min. ⁽⁹⁾	0.125 [3] 0.187 [5]	0.674 [17] Unlimited
	> 4 [100]	≥ 3/8 [10]	Yes	—	—	2	—	—	4			

Notes:

- (7) Radiographic examination of the welder or welding operator test plate may be made in lieu of the bend test (see 9.3.2).
(8) Also qualifies for welding fillet welds of material of unlimited thickness.
(9) Minimum pipe size qualified shall not be less than 4 in. [100 mm] or 1/2d, whichever is greater, where d is diameter of test pipe.

(continued)

Table 17 (Continued)
Number and Type of Test Specimens and Range of Thickness Qualified—
Welder and Welding Operator Qualification

3. Tests on Electroslag and Electrogas Welds

Plate Thickness Tested, in. [mm]	Number of Sample Welds	Test Specimens Required		Plate Thickness Qualified, in. [mm]
		Visual Inspection	Side Bend ⁽¹⁰⁾	
1-1/2 [40] max	1	Yes	2	Unlimited for 1-1/2 [40] Max tested for <1-1/2 [40]

Note:

(10) Radiographic examination of the welder or welding operator test plate may be made in lieu of the bend test (see 9.3.2).

Table 18
Welder Qualification—Type and Position Limitations

Qualification Test	Type of Weld and Position of Welding Qualified ⁽¹⁾					
	Weld	Plate or Pipe Positions	Plate		Pipe	
			Groove	Fillet	Groove	Fillet
Plate-Groove ⁽²⁾	1G	F	F, H	F ⁽³⁾	F, H ⁽³⁾	
	2G	F, H	F, H	F, H ⁽³⁾	F, H ⁽³⁾	
	3G	F, H, V	F, H, V		F, H	
	4G	F, OH	F, H, OH		F	
	3G and 4G	All	All		F, H	
Plate-Fillet ^{(2),(4)}	1F		F		F	
	2F		F, H		F, H	
	3F		F, H, V			
	4F		F, H, OH			
	3F and 4F		All			
Pipe-Groove	1G Rotated	F	F, H	F	F, H	
	2G	F, H	F, H	F, H	F, H	
	5G	F, V, OH	F, V, OH	F, V, OH	F, V, OH	
	6G	Note (5)	Note (5)	Note (5)	Note (5)	
	2G and 5G	Note (5)	Note (5)	Note (5)	Note (5)	
	6GR	All	All	All	All	

Notes:

- (1) Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead.
- (2) Not applicable for welding operator qualification [see 9.34(5)].
- (3) Welding operators qualified to weld pipe or tubing over 24 in. [600 mm] in diameter for the test positions indicated.
- (4) Not applicable for fillet welds between parts having a dihedral angle of 75° or less.
- (5) Qualifies for all but groove welds for T-, Y-, and K-connections.

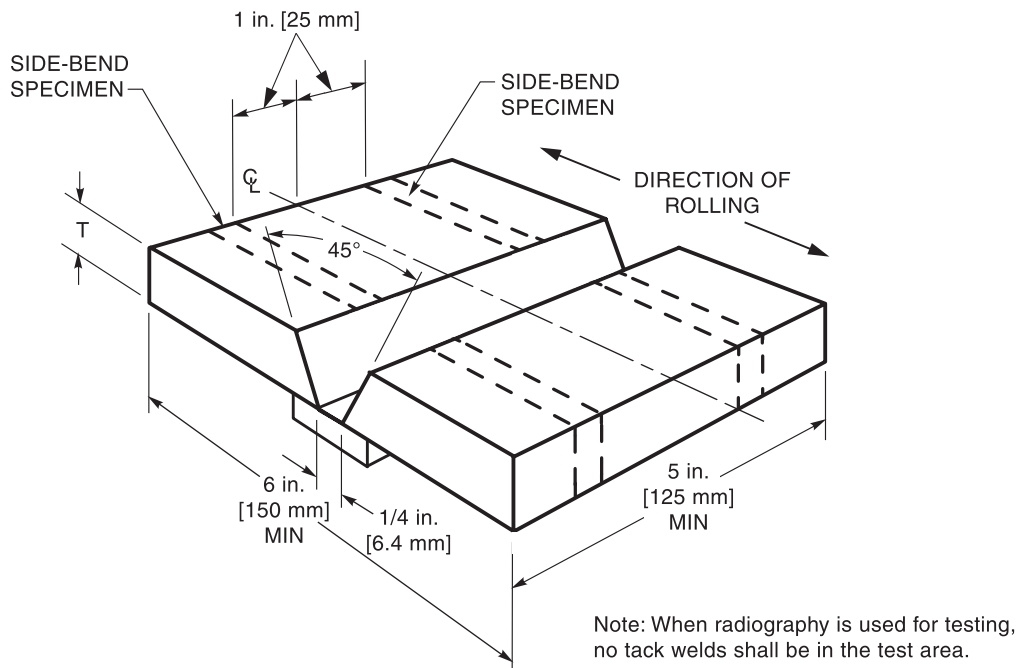


Figure 17A—Test Plate for Unlimited Thickness—Welder Qualification

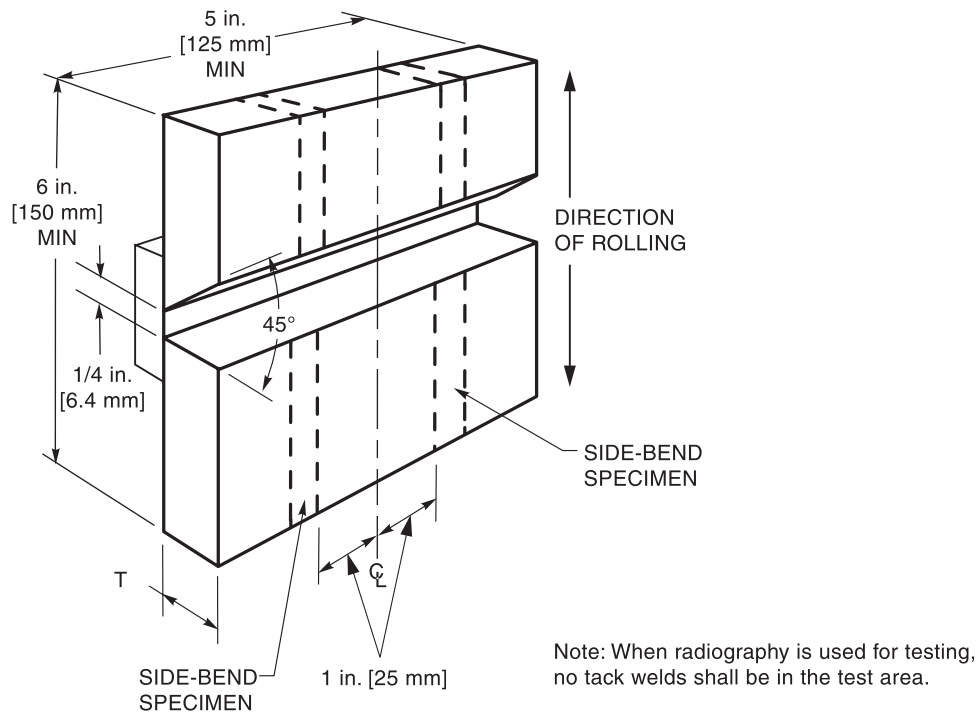


Figure 17B—Optional Test Plate for Unlimited Thickness, Horizontal Position—Welder Qualification

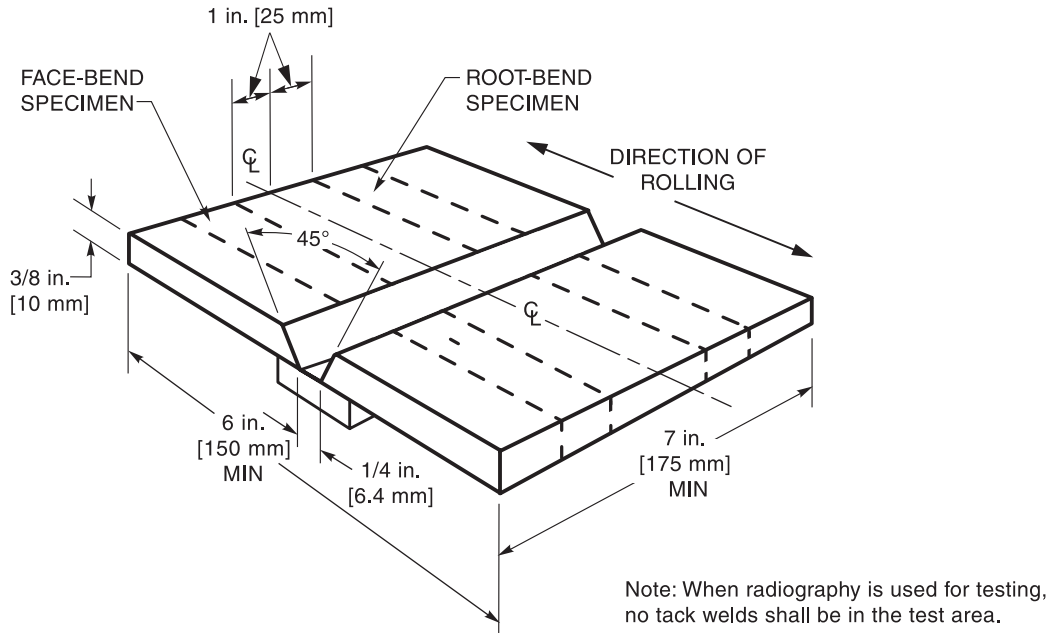


Figure 18A—Test Plate for Limited Thickness, All Positions—Welder Qualification

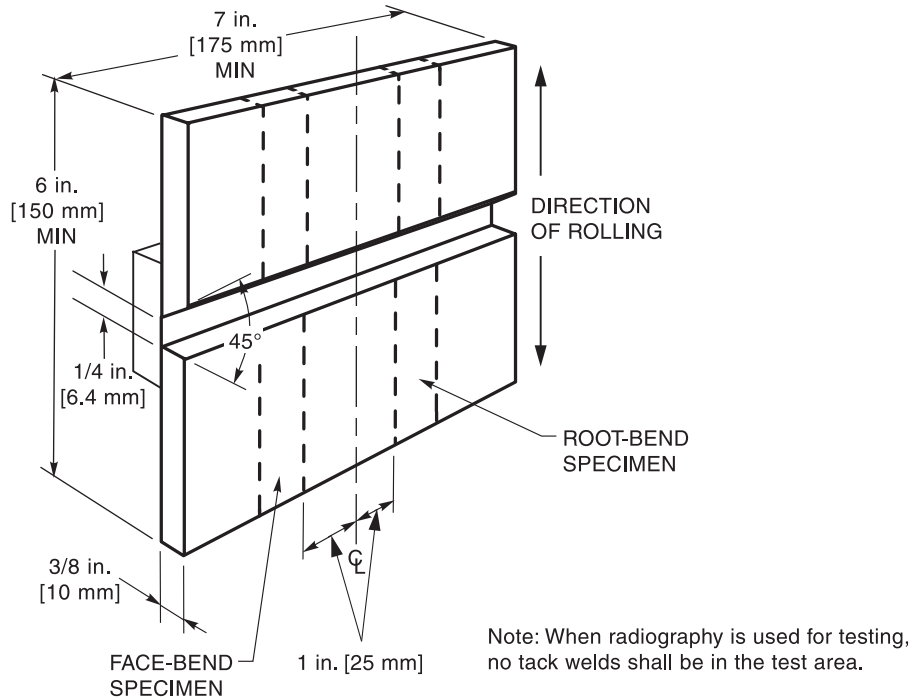


Figure 18B—Optional Test Plate for Limited Thickness, Horizontal Position—Welder Qualification

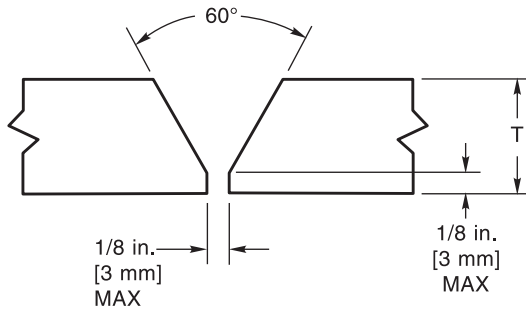


Figure 19A—Pipe Test Butt Joint without Backing—Welder Qualification

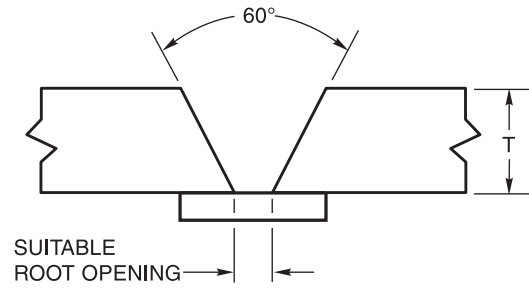


Figure 19B—Pipe Test Butt Joint with Backing—Welder Qualification

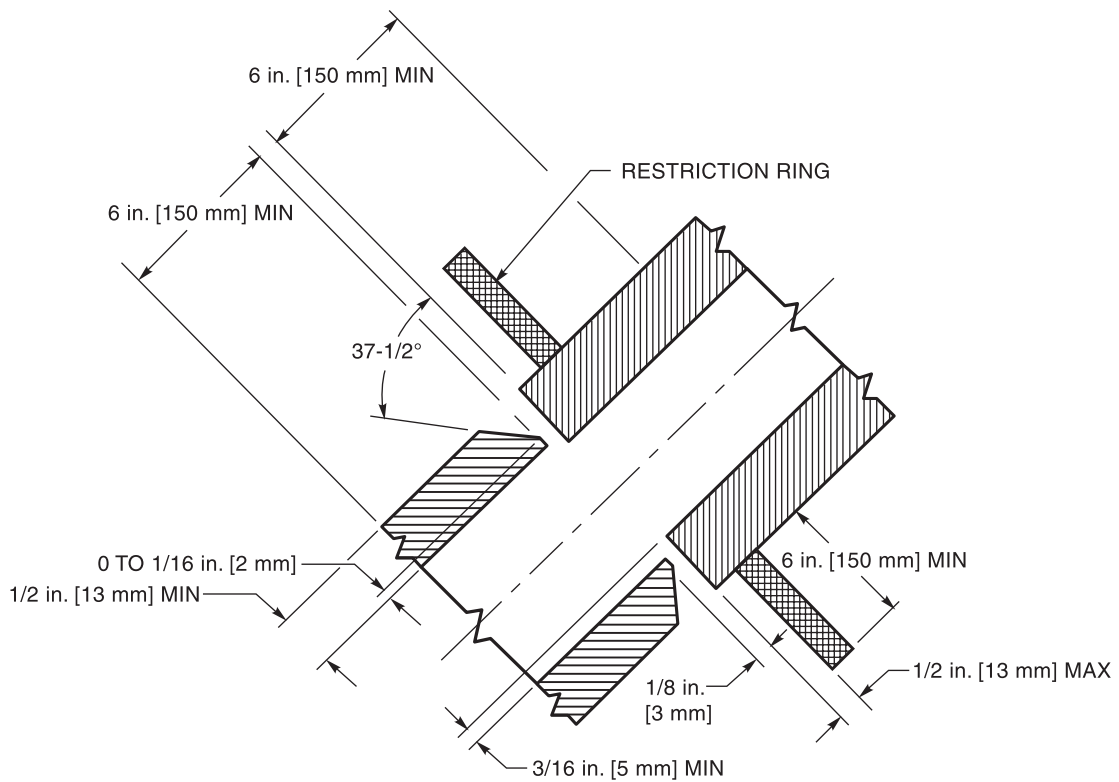
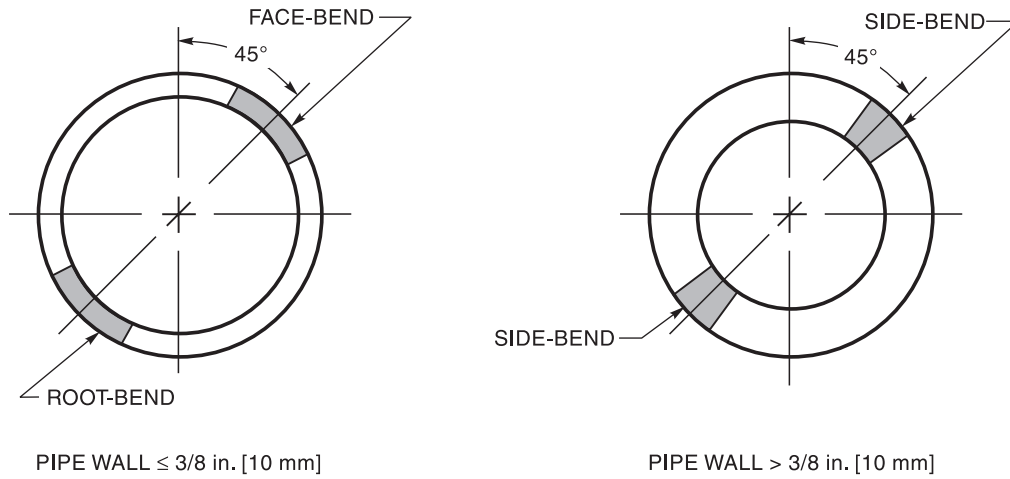
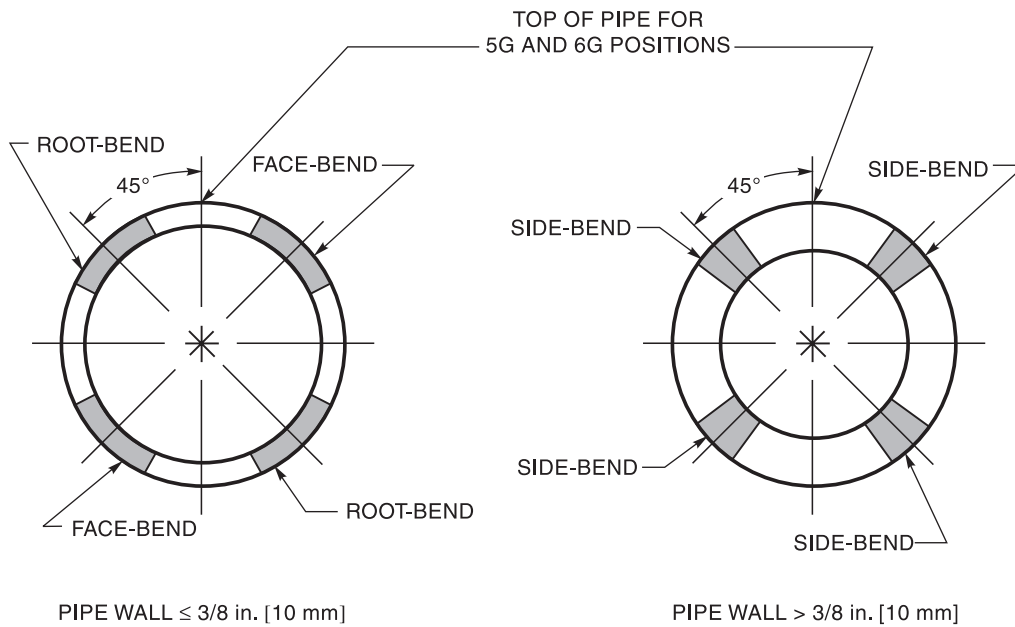


Figure 20—Test Joint for T-, Y-, and K- Connections on Pipe or Tubing—Welder Qualification



SPECIMENS FOR 1G AND 2G POSITIONS



SPECIMENS FOR 5G AND 6G POSITIONS

Figure 21—Location of Test Specimens on Welded Test Pipe—Welder Qualification

9.22 Fillet Weld Qualification Test. For fillet weld qualification only, the welder shall weld a test plate according to Option 1 or Option 2, depending on the contractor's choice, as follows:

(1) Option 1—Weld a T-test plate in accordance with Figure 22.

(2) Option 2—Weld a soundness test plate in accordance with Figure 23.

9.23 Position of Test Welds. The positions shall be as listed in Table 17.

9.23.1 Groove Plate Test Welds

9.23.1.1 Qualification in the 1G (flat) position qualifies the welder for flat-position groove welding of plate, pipe, and tubing, and flat- and horizontal-position fillet welding of plate, pipe, and tubing.

9.23.1.2 Qualification in the 2G (horizontal) position qualifies the welder for flat- and horizontal-position groove welding, and flat- and horizontal-position fillet welding of plate, pipe, and tubing.

9.23.1.3 Qualification in the 3G (vertical) position qualifies the welder for flat-, horizontal-, and vertical-position groove welding, and flat-, horizontal-, and

vertical-position fillet welding of plate; and flat- and horizontal-position fillet welding of pipe and tubing.

9.23.1.4 Qualification in the 4G (overhead) position qualifies the welder for flat- and overhead-position groove welding, and flat-, horizontal-, and overhead-position fillet welding of plate; and flat-position fillet welding of pipe and tubing.

9.23.2 Groove Pipe Test Welds

9.23.2.1 Qualification in the 1G (pipe horizontal, rotated) position qualifies the welder for flat-position groove welding of pipe, tubing, and plate; and flat- and horizontal-position fillet welding of pipe, tubing, and plate.

9.23.2.2 Qualification in the 2G (pipe vertical) position qualifies the welder for flat- and horizontal-position groove welding and flat- and horizontal-position fillet welding of pipe, tubing, and plate.

9.23.2.3 Qualification in the 5G (pipe horizontal, fixed) position qualifies the welder for flat-, vertical-, and overhead-position groove welding and flat-, vertical-, and overhead-position fillet welding of pipe, tubing, and plate.

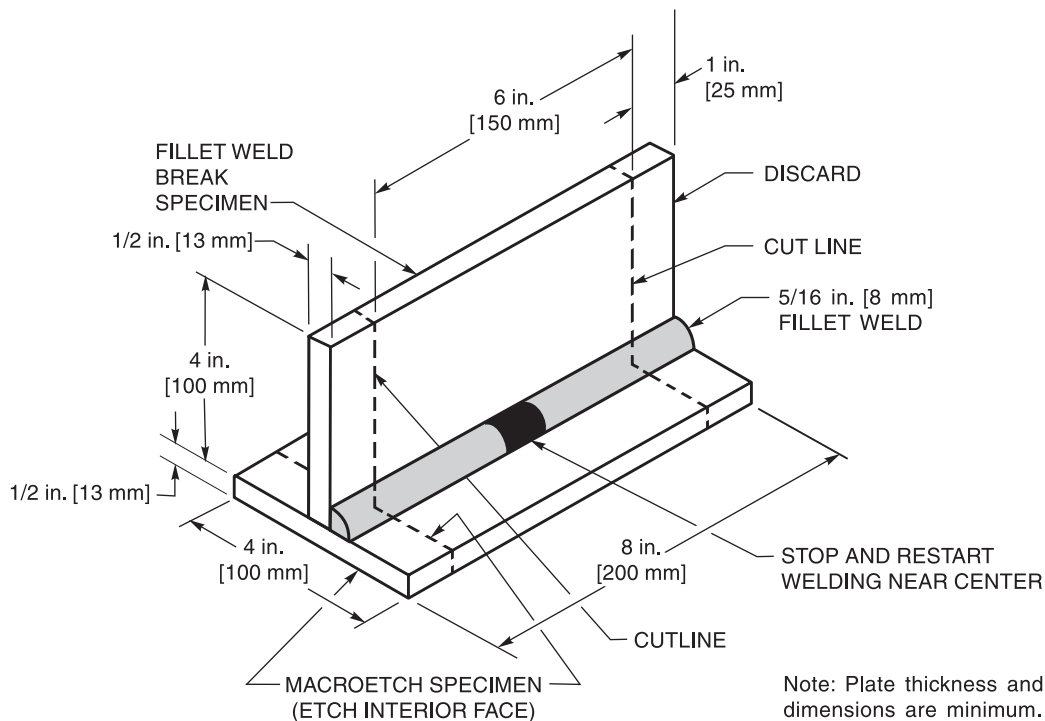


Figure 22—Fillet Weld Break and Macroetch Test Plate—Welder Qualification, Option 1

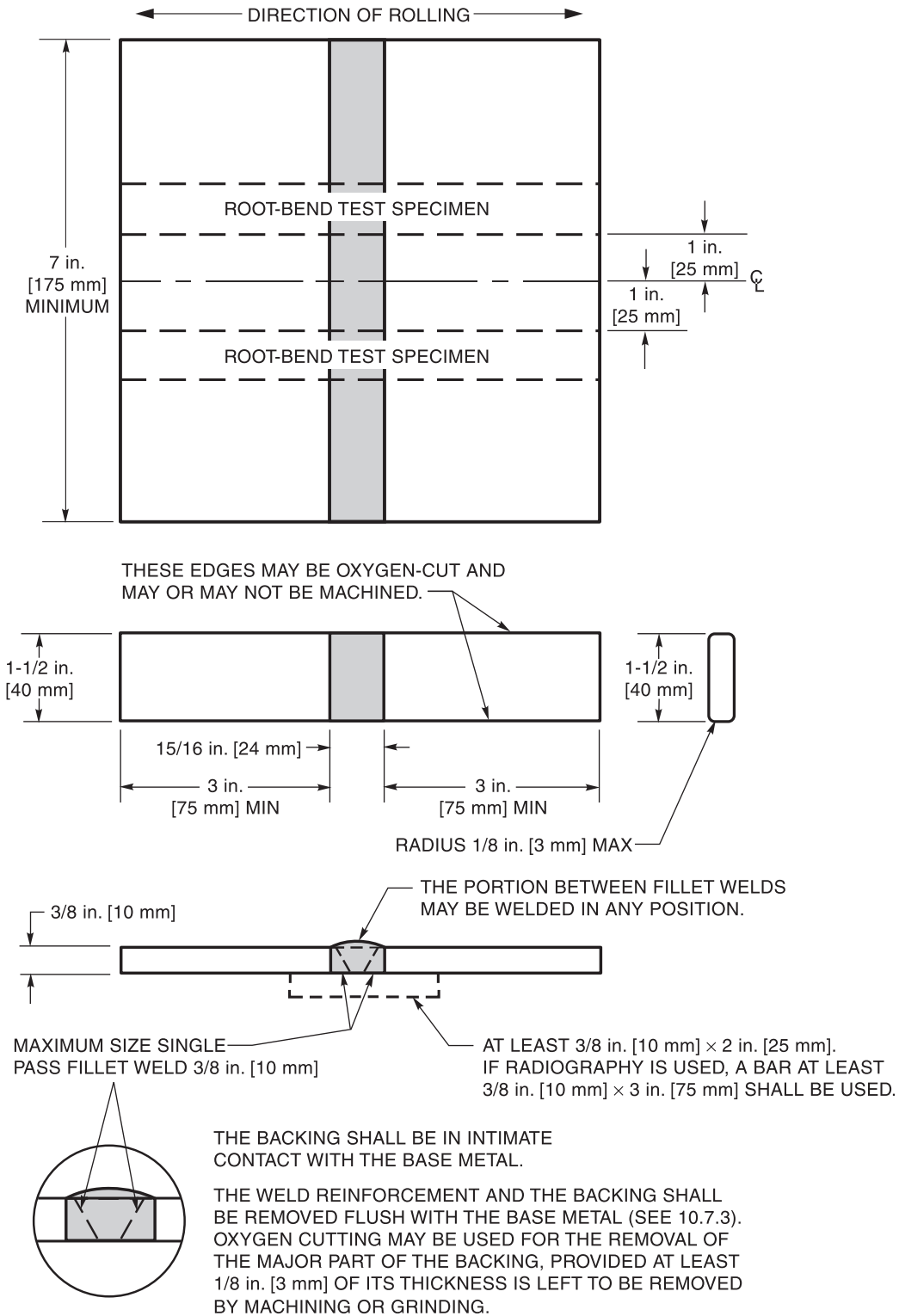


Figure 23—Fillet Weld Root-Bend Test Plate—Welder Qualification, Option 2

9.23.2.4 Qualification in the 6G (inclined, fixed) position qualifies the welder for all-position groove and all-position fillet welding of pipe, tubing, and plate.

9.23.2.5 Qualification for T-, Y-, or K-connections in the 6GR (inclined, fixed) position qualifies the welder for groove welding of T-, Y-, or K-connections, and for groove and fillet welding of pipe, tubing, and plate in all positions.

9.23.3 Fillet Weld Test

9.23.3.1 Qualification in the 1F (flat) position qualifies the welder for flat-position welding of plate, pipe, and tubing.

9.23.3.2 Qualification in the 2F (horizontal) position qualifies the welder for flat- and horizontal-position fillet welding of plate, pipe, and tubing.

9.23.3.3 Qualification in the 3F (vertical) position qualifies the welder for flat-, horizontal-, and vertical-position fillet welding of plate.

9.23.3.4 Qualification in the 4F (overhead) position qualifies the welder for flat-, horizontal-, and overhead-position fillet welding of plate.

9.24 Base Metal. The base metal used shall comply with the welding procedure specification.

9.25 Joint Welding Procedure

9.25.1 The welder shall follow a joint welding procedure specification applicable to the joint details given in 9.18, 9.19, 9.20, 9.21, or 9.22, whichever is applicable. For complete joint penetration groove welds that are welded from one side without backing, the welder shall follow a welding procedure specification applicable to the joint detail shown in Figure 19A.

9.25.2 Weld cleaning shall be done with the test weld in the same position as the welding position being qualified.

9.26 Test Specimens

9.26.1 The type and number of test specimens that shall be tested to qualify a welder by mechanical testing are given in Table 18. The range of thickness that can be welded in construction, which depends on the thickness of the test plate, is also given in the table. Radiographic examination of the test weld may be used in lieu of mechanical testing at the contractor's option.

9.26.2 Guided bend test specimens shall be prepared by cutting the test plate, pipe, or tubing as shown in Figures 17A and 17B, 18A and 18B, 21 or 23, whichever is applicable, to form specimens approximately rectangular in cross section. The specimens shall be prepared for

testing in accordance with Figures 15A through 15D, whichever is applicable.

9.26.3 The fillet weld break and macroetch test specimens shall be cut from the test joint as shown in Figure 22. The exposed section of the macroetch test specimen shall be smoothed for etching.

9.26.4 The weld reinforcement need not be ground or otherwise smoothed for inspection when radiographic testing is used in lieu of the prescribed bend tests, unless surface irregularities or juncture with the base metal would cause objectionable weld discontinuities to be obscured in the radiograph. If the backing is removed for radiographic testing, the root shall be ground flush with the base metal (see 10.7.3).

9.27 Method of Testing Specimens

9.27.1 Root-, Face-, and Side-Bend Specimens. Each specimen shall be bent in a guided bend test jig that meets the requirements shown in Figure 24A, 24B, or 24C, or is substantially in accordance with those figures, provided the maximum bend radius is not exceeded. The plunger member (if used) may be moved with relation to the die member by any convenient means.

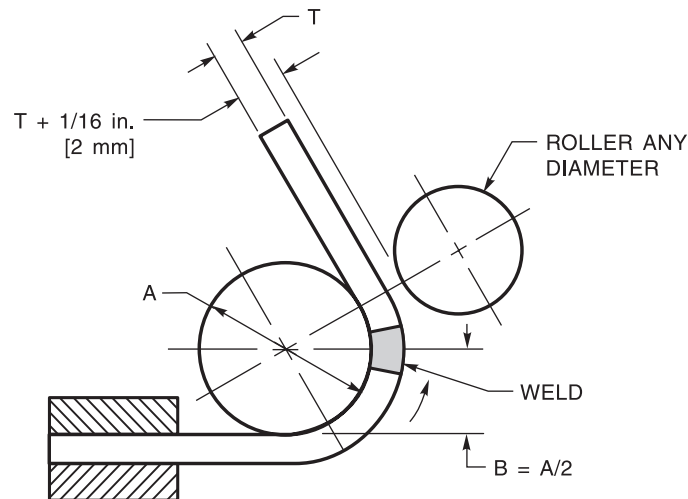
9.27.1.1 Face-bend specimens shall be oriented so that the face of the weld will be in tension. Root-bend and fillet weld Option No. 2 soundness specimens shall be oriented so that the root of the weld will be in tension. Side-bend specimens shall be oriented so that the side showing the larger discontinuity, if any, will be in tension.

9.27.1.2 The specimen shall be forced into the die or wrapped around member "A" of the wraparound jig until it assumes a U-shape. The weld and heat-affected zones shall be completely within the bent portion of the specimen after bending.

9.27.1.3 When using a wraparound jig (see Figure 24B), the specimen shall be firmly clamped on one end so that the specimen does not slide during the bending operation. The weld and heat-affected zones shall be completely within the bent portion of the specimen after testing. The test specimen shall be removed from the jig after the outer roll has been moved 180° from the starting point.

9.27.2 Fillet Weld Break Test (Option No. 1). The entire length of the fillet weld shall be examined visually, and then a 6 in. [150 mm] long specimen shall be cut from the sample and loaded in such a way that the root of the weld is in tension. The load shall be steadily increased or repeated until the specimen fractures or bends flat upon itself.

9.27.3 Macroetch Test (Fillet Option No. 1). The test specimens shall be suitably smoothed for macroetch



Specified or Actual Base Metal Yield Strength, ksi [MPa]	A in. [mm]	B in. [mm]
50 [345] & Under	1-1/2 [38.1]	3/4 [19.0]
Over 50 [345] to 90 [620]	2 [50.8]	1 [25.4]
90 [620] & Over	2-1/2 [63.5]	1-1/4 [31.8]

General Note: Plunger and interior die surfaces shall be machine-finished.

Source: AWS D1.1/D1.1M:2004, Figure 4.16, as adapted from AWS B4.0-98, Figure A1.

Figure 24B—Alternative Guided-Bend Test Jig—Wraparound Design

vided there is no evidence of slag inclusions or other fusion-type discontinuities.

9.28.2 Fillet Weld Break Test

9.28.2.1 To pass visual examination, the fillet weld shall present a reasonably uniform appearance and shall be free of overlap, cracks, and excessive undercut. There shall be no porosity visible on the surface of the weld.

9.28.2.2 The fillet weld specimen passes the test if it bends flat upon itself. If the fillet weld fractures, the fractured surface shall show complete fusion to the root of the joint, and exhibit no inclusion or porosity larger than 3/32 in. [2.5 mm] in the greatest dimension to pass the test. The sum of the greatest dimensions of all inclusions and porosity at the fractured surface shall not exceed 3/8 in. [10 mm] in the 6 in. [150 mm] long specimen.

9.28.3 Macroetch Test. The specimen shall be examined for discontinuities. If discontinuities prohibited by Section 10, Weld Quality and Inspection, are found, the test shall be considered as failed. The weld shall show

fusion to the root, but not necessarily beyond, and both legs shall be equal to within 1/8 in. [3 mm]. Convexity shall not exceed the limits specified in 10.7, e.g., 1/16 in. [2 mm] for a 5/16 in. [8 mm] test weld.

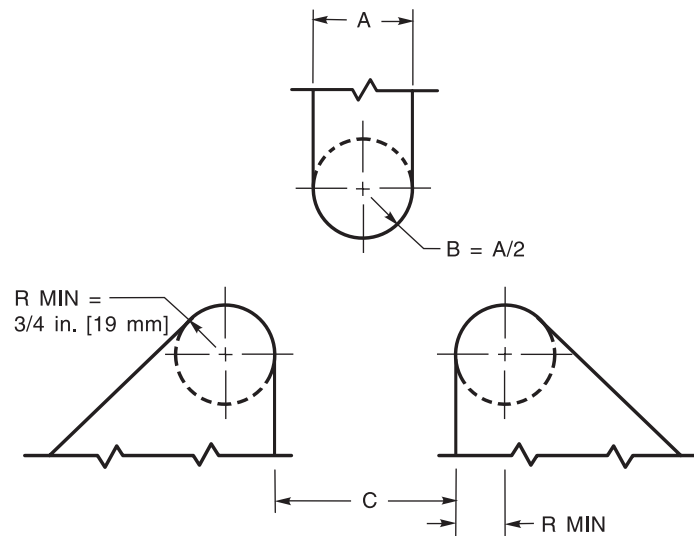
9.28.4 Radiographic Test. To qualify, the weld, as revealed by the radiograph, shall conform to the requirements of Section 10.

9.28.5 Visual Inspection of Pipe and Tubing (see 9.12.6)

9.28.6 Visual Inspection of Plate. For acceptable qualification, the welded test plates shall conform to the requirements for visual inspection in Section 10.

9.29 Retests. If one or more test welds made by a welder fails to meet the requirements, a retest may be allowed under the following conditions:

(1) An immediate retest may be made consisting of two welds of each type on which the welder failed. The retest specimens shall meet all the specified requirements.



Specified or Actual Base Metal Yield Strength, ksi [MPa]	A in. [mm]	B in. [mm]	C in. [mm]
50 [345] & Under	1-1/2 [38.1]	3/4 [19.0]	2-3/8 [60.3]
Over 50 [345] to 90 [620]	2 [50.8]	1 [25.4]	2-7/8 [73.0]
90 [620] & Over	2-1/2 [63.5]	1-1/4 [31.8]	3-3/8 [85.7]

General Note: Plunger and interior die surfaces shall be machine-finished.

Source: AWS D1.1/D1.1M:2004, Figure 4.17, as adapted from AWS B4.0-98, Figure A3.

Figure 24C—Alternative Guided-Bend Test Jig—Roller-Equipped Design for Bottom Ejection of Test Specimens

(2) A retest may be made, provided there is evidence that the welder has had further training or practice. In this case, one complete retest shall be made.

9.30 Period of Effectiveness. The welder's qualification, as specified, shall remain in effect indefinitely unless:

(1) The welder is not engaged in a given process of welding for which the welder is qualified for a period exceeding 6 months; or

(2) There is some specific reason to question the welder's ability.

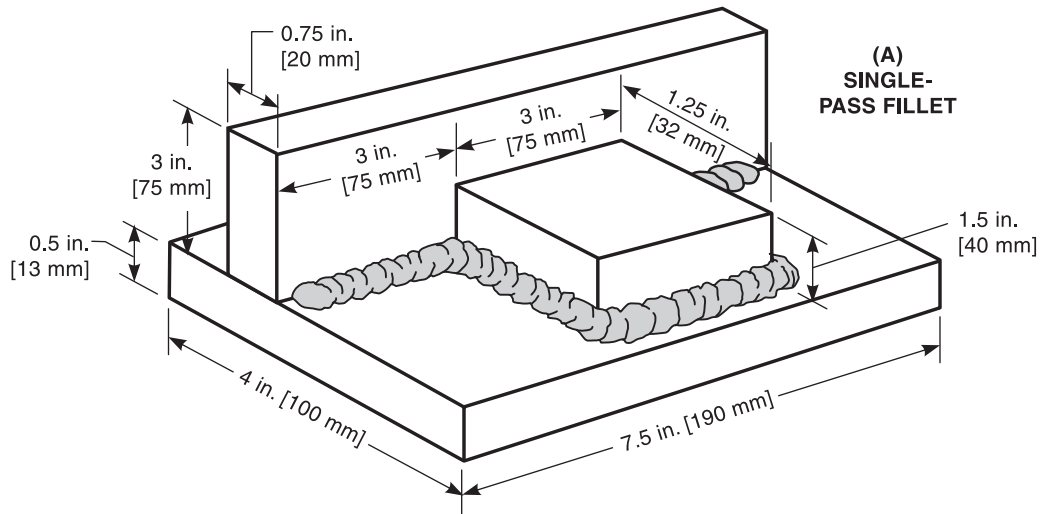
In case (1), the requalification test need be made only in the 3/8 in. [10 mm] thickness.

9.31 Records. Records of the test results shall be kept by the Manufacturer or contractor and shall be available to those authorized to examine them.

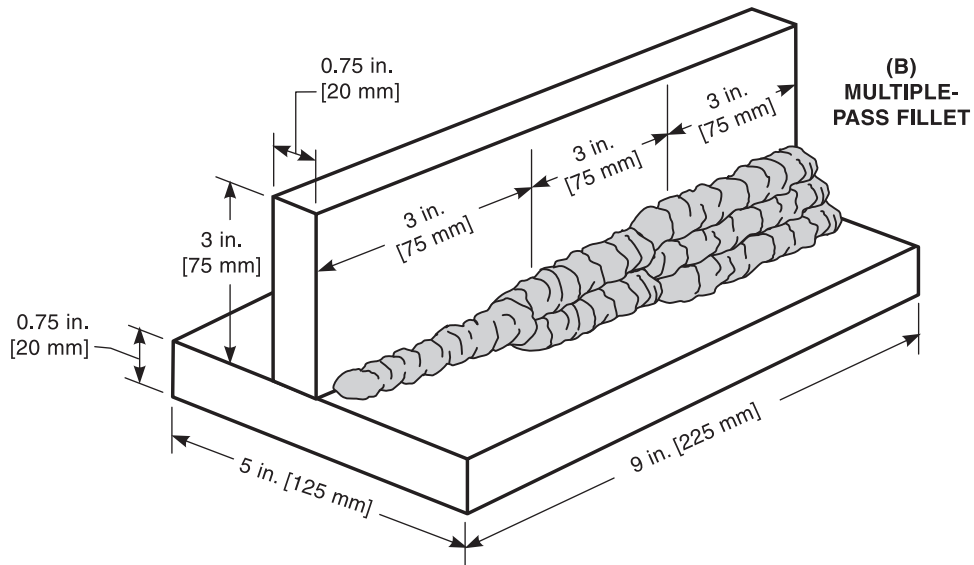
9.32 Workmanship Qualification

9.32.1 Scope. The tests described herein are a second method of welder qualification for welders performing operations on secondary stressed components and non-critical weldments. Workmanship samples, as shown in Figures 25(A) and 25(B), or a sample similar to the production welds shall be made.

9.32.2 Welder Qualification. Qualification tests are used to determine a welder's ability to produce sound, acceptable welds when welding to the requirements of a qualified procedure specification using a manually-directed welding process. The type and number of samples to be made shall be determined by the Manufacturer to represent the type of work the welder will be doing. The test shall be witnessed, evaluated, and recorded by personnel authorized by the Manufacturer to do so, using visual inspection and appropriate sectioning and etching of each sample. The welds shall meet the requirements of



(A) FILLET WELD SIZE IS LIMITED BY THE WELDING PROCESS AND POSITION OF THE TEST



(B) FILLET WELD SIZE SHOULD BE A MINIMUM OF 0.75 in. [20 mm]. NUMBER OF PASSES REQUIRED IS DETERMINED BY THE WELDING PROCESS, POSITION OF TEST, AND PROCEDURE.

Figure 25—Examples of Workmanship Samples

Sections 7 (Workmanship) and 10 (Weld Quality and Inspection).

9.32.3 Production Qualification. After successful completion of one or more workmanship samples, the capability of the welder to satisfactorily perform production welding will be determined after a tryout at the job station. Qualification shall be achieved when the welder produces a typical production part that meets the quality requirements of this specification, as witnessed and recorded by personnel authorized by the Manufacturer to do so.

9.32.4 Sample Examination. Methods of examining samples shall be visual, sectioning and etching, and physical measurement.

9.32.4.1 Visual Examination. To pass the visual examination, the weld shall meet the requirements of Section 7 (Workmanship) and Section 10 (Weld Quality and Inspection).

9.32.4.2 Macroetch Examination. The specimen cross section shall be smoothed, etched, and examined for discontinuities. The sample shall meet the applicable requirements in other sections of this specification. The weld shall show complete fusion to the root, but not necessarily beyond. Convexity and concavity of the weld shall not exceed the limits specified in Sections 7 and 10.

9.32.4.3 Physical Measurement Examination. Welds shall be measured to ascertain that they meet the size tolerances specified in Sections 7 and 10.

9.32.5 Retests. In case one or more test welds fail to meet the requirements of 9.32.4, the welder may be retested under the following conditions:

(1) An immediate retest may be made that shall consist of two test welds of each type that failed. Both test specimens shall meet all the requirements specified for such welds.

(2) A retest may be made, provided there is evidence that the welder has had further training or practice. In this case, one complete retest shall be made.

9.32.6 Period of Effectiveness. Welder qualification verified by workmanship samples shall remain in effect indefinitely unless:

(1) The welder does not use a welding process for which the welder is qualified for a period exceeding six months; or

(2) There is some specific reason to question the welder's ability.

In case (1), the requalification test need be made only with 3/8 in. [10 mm] thick material.

9.32.7 Records. Records of the test results shall be kept by the Manufacturer and shall be available to those

authorized to examine them (see suggested sample form in Annex A).

Part D

Welding Operator Qualification

9.33 General. The qualification tests described in this section are specially devised to determine a welding operator's ability to produce sound welds. The tests are not intended to be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the procedure specification. For an alternate method of qualification, see 9.32.

9.34 Limitations. For the qualification of a welding operator, the following rules shall apply:

(1) Qualification established with any one of the steels permitted by this specification shall be considered as qualification to weld any of the other steels.

(2) A welding operator qualified with an approved electrode-shielding medium combination shall be considered qualified to weld with any other approved electrode-shielding medium combination for the process used in the qualification test.

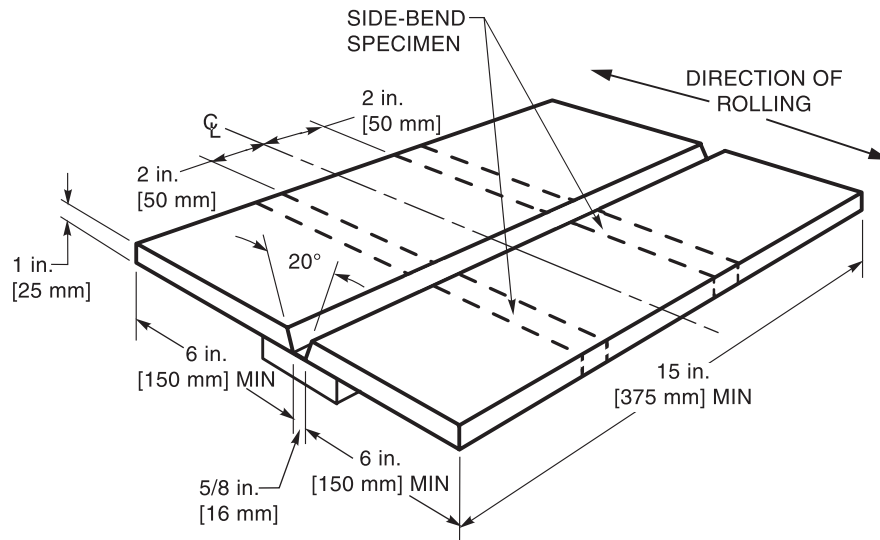
(3) A welding operator qualified to weld with multiple electrodes or welding heads shall be qualified to weld with a single electrode, but not vice versa. This does not apply to electrogas and electroslog welding.

(4) An electroslog or electrogas welding operator qualified with an approved electrode-shielding medium combination shall be considered qualified to weld with any other approved electrode-shielding medium combination for the process used in the qualification test.

(5) A change in the position in which welding is done shall require qualification in the new position (see 9.35.3).

9.35 Qualification Tests Required

9.35.1 The welding operator qualification test, for other than electroslog or electrogas welding, shall have the following joint detail: 1 in. [25 mm] plate, single-V-groove, 20° groove angle, and 5/8 in. [16 mm] root opening with backing (see Figure 26). Backing shall be at least 3/8 in. [10 mm] × 3 in. [75 mm] if radiographic testing is used without prior removal of backing. It shall be at least 3/8 in. [10 mm] × 2 in. [50 mm] for mechanical and ultrasonic testing and for radiographic testing after the backing is removed. Minimum length of the welding groove shall be 15 in. [375 mm]. This test will qualify the welding operator for groove and fillet welding in



General Notes:

1. When radiography is used for testing, no tack welds shall be in test area.
2. The joint configuration of a qualified groove weld procedure may be used in lieu of the groove configuration shown here.

Figure 26—Test Plate for Unlimited Thickness—Welding Operator Qualification

materials of unlimited thickness if the test results are satisfactory.

9.35.2 An electroslag or electrogas welding operator shall be tested by welding a joint in material of the maximum thickness to be used in construction, except that the material thickness for the test weld need not exceed 1-1/2 in. [40 mm] (see Figure 27). If a 1-1/2 in. [40 mm] thick test weld is made, tests need not be made for thinner sections. This test shall qualify the welding operator for groove welds in material of unlimited thickness if the test results are satisfactory.

9.35.3 The welding operator who makes a complete joint penetration groove weld procedure qualification test that meets the test requirements is qualified for that process and test position for plate of the same thickness as the welded test plate. If the test plate is 1-1/2 in. [40 mm] or over in thickness and welded by electroslag or electrogas welding, or 1 in. [25 mm] or over and welded by any other processes, the welding operator will be qualified for all thicknesses with the welding process used if the test results are satisfactory.

A welding operator qualified to weld pipe shall also be qualified to weld plate, but not vice versa, except that qualification on plate in the 1G (flat) or 2G (horizontal) position shall qualify the operator for welding pipe or

tubing over 24 in. [600 mm] diameter in the position qualified. See Table 17 (Note 2) for additional pipe position qualifications.

9.35.4 For fillet weld qualification only, the welding operator shall weld a test plate according to Option 1 or Option 2, depending on the contractor's choice, as follows:

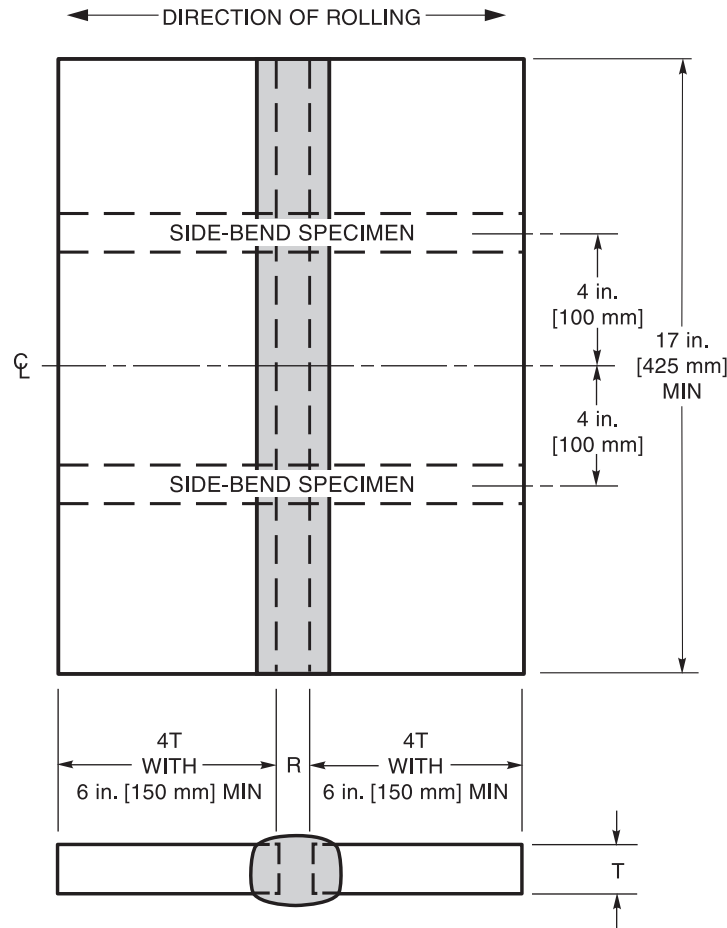
- (1) Option 1—Weld a T-shaped test plate in accordance with Figure 28.
- (2) Option 2—Weld a soundness test plate in accordance with Figure 29.

9.36 Base Metal. The base metal used shall comply with Section 4, Base Metals, or the welding procedure specification used for qualification.

9.37 Joint Welding Procedure

9.37.1 The welding operator shall follow the joint welding procedure specified by the welding procedure specification.

9.37.2 Weld cleaning shall be done with the test weld in the same position as the welding position being qualified.



General Notes:

1. Root opening "R" established by procedure qualification.
2. T = maximum to be welded in construction but not to exceed 1-1/2 in. [40 mm].
3. Extensions need not be used if joint is of sufficient length to provide 17 in. [425 mm] of sound weld.

Figure 27—Butt Joint for Electroslag and Electrogas—Welding Operator Qualification

9.38 Test Specimens

9.38.1 Guided bend test specimens for mechanical testing shall be prepared by cutting the test plate as shown in Figure 26, 27, or 29, whichever is applicable, to form specimens approximately rectangular in cross section. The specimens shall be prepared for testing in conformance to Figures 15A through 15D, as applicable.

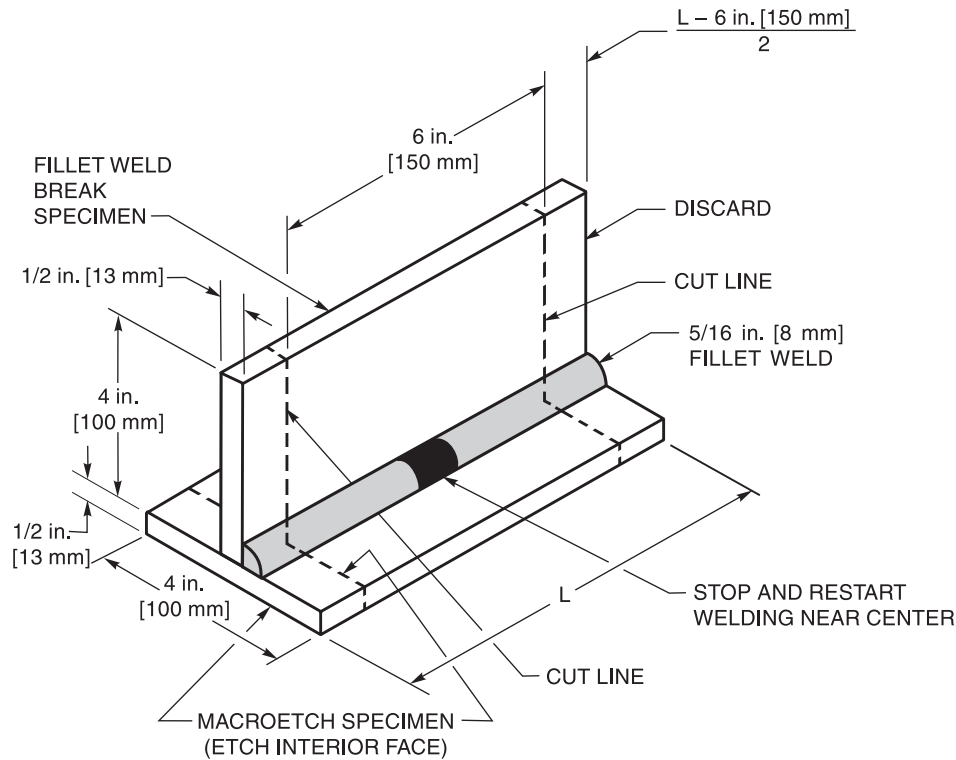
9.38.2 At the Manufacturer's option, radiographic testing of the weld may be performed in lieu of the guided bend test. In that event, the weld reinforcement need not be ground or otherwise smoothed for inspection, unless surface irregularities or juncture with the

base metal would cause objectionable weld discontinuities to be obscured during the radiographic inspection. If the backing is removed for radiographic testing, the root shall be ground flush with the base metal (see 10.7.3).

9.38.3 The fillet weld break and macroetch test specimens shall be cut from the test joint as shown in Figure 28. The exposed section of the macroetch test specimen shall be finished smooth for etching.

9.39 Method of Testing Specimens

9.39.1 Root- or Side-Bend Specimens. Each specimen shall be bent in a guided bend test jig that meets the



General Notes:

1. L = 15 in. [375 mm] minimum.
2. Plate thickness and dimensions are minimum.

**Figure 28—Fillet Weld Break and Macroetch Test Plate—
Welding Operator Qualification, Option 1**

requirements shown in Figure 24A, 24B, or 24C, or is substantially in accordance with those figures, provided the maximum bend radius is not exceeded. Any convenient means may be used to move the plunger member (if used) with relation to the die member.

9.39.1.1 Root-bend specimens shall be oriented so that the root of the weld will be in tension. Side-bend specimens shall be oriented so that the side showing the larger discontinuity, if any, will be in tension.

9.39.1.2 The specimen shall be forced into the die or wrapped around member “A” of the wraparound jig until it assumes a U-shape. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after testing.

9.39.1.3 When using a wraparound jig, the specimen shall be firmly clamped on one end so that it does not slide during the bending operation. The weld and heat-affected zones shall be completely in the bent por-

tion of the specimen after testing. Test specimens are to be removed from the jig after the bending roller has been moved 180° from the starting point.

9.39.2 Radiographic procedure and technique shall be in accordance with the requirements of Section 10, Weld Quality and Inspection. Only the center 50% of the test weld shall be subject to testing.

9.39.3 Fillet Weld Break Test. The entire length of the fillet weld shall be examined visually, and then a 6 in. [150 mm] long specimen shall be cut from the test sample and loaded in such a way that the root of the weld is in tension. The load shall be steadily increased or repeated until the specimen fractures or bends flat upon itself.

9.39.4 Macroetch Test. The test specimens shall be prepared with a finish suitable for macroetch examination. A suitable solution (such as hot ammonium persulfate) shall be used to give a clear definition of the weld area.

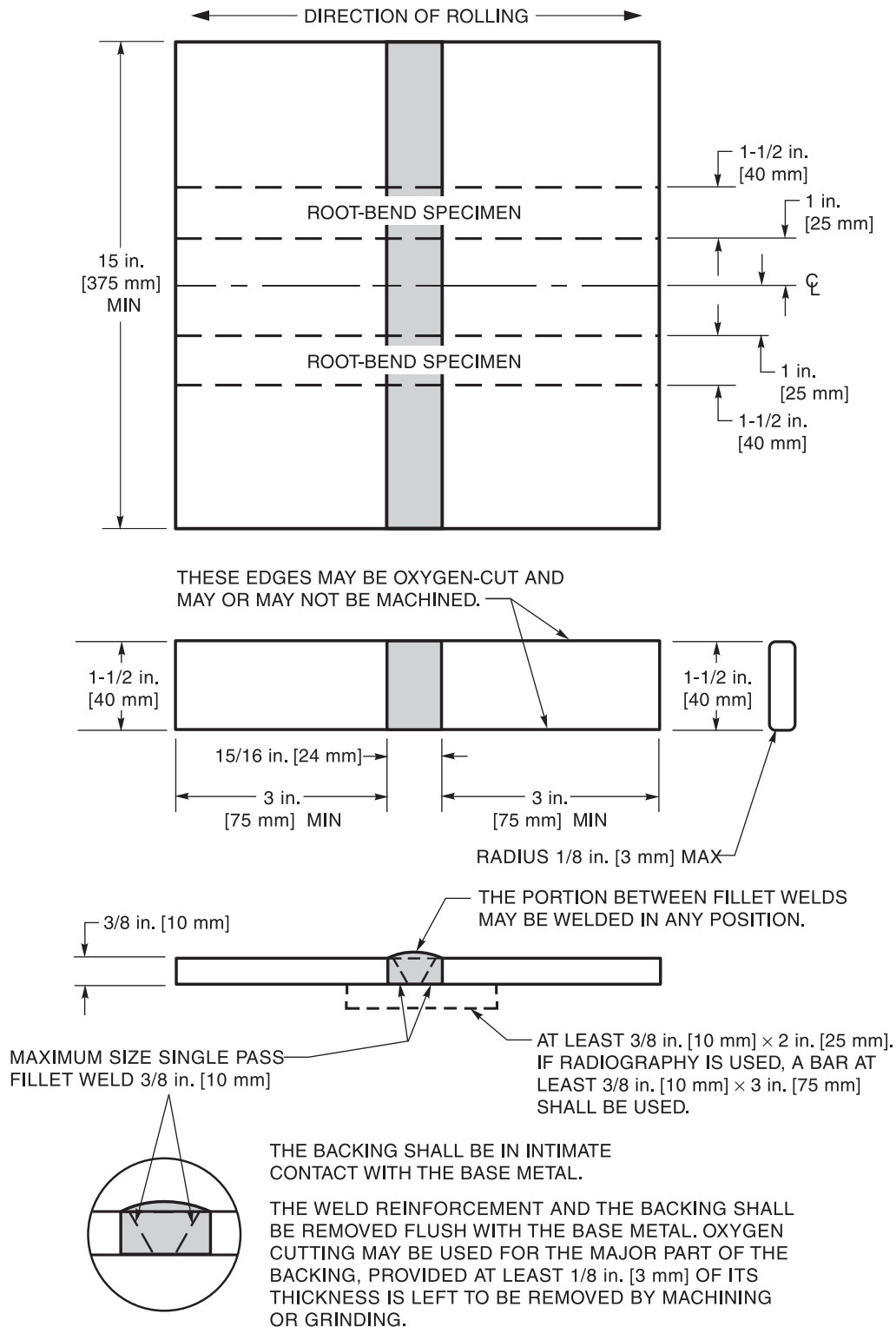


Figure 29—Fillet Weld Root-Bend Test Plate—Welding Operator Qualification, Option 2

9.40 Test Results Required

9.40.1 Root- and Side-Bend Test. The convex surface of the specimen shall be examined for the appearance of cracks or other open discontinuities. Any bent specimen containing a crack or other open discontinuity exceeding 1/8 in. [3 mm], measured in any direction, shall be considered as failed. Cracks occurring on the corners of the specimen may be 1/4 in. [6 mm] maximum length, provided there is no evidence of slag inclusions or other fusion-type discontinuities.

9.40.2 Welds examined by radiographic examination shall conform to the requirements of Section 10, Weld Quality and Inspection.

9.40.3 Fillet Weld Break Test

9.40.3.1 To pass the visual examination, the fillet weld shall present a reasonably uniform appearance and shall be free of overlap, cracks, and excessive undercut. There shall be no porosity visible on the face of the weld.

9.40.3.2 The specimen passes the test if it bends flat upon itself. If the fillet weld fractures, the fractured surface shall show complete fusion to the root of the joint, and shall exhibit no inclusion or porosity larger than 3/32 in. [2.5 mm] in the greatest dimension. The sum of the greatest dimensions of all inclusions and porosity shall not exceed 3/8 in. [10 mm] in the 6 in. [150 mm] long specimen.

9.40.4 Macroetch Test. The test specimen shall be examined for discontinuities. If any discontinuities prohibited by 10.6 are found on the surface, the specimen shall be considered to have failed. The weld shall show complete fusion to the root, but not necessarily beyond, and both legs shall be equal within 1/8 in. [3 mm]. Convexity shall not exceed the limits specified in 10.7.

9.40.5 Visual Inspection. For acceptable qualification, the welded test plate, when inspected visually, shall conform to the requirements for visual inspection in Section 10, Weld Quality and Inspection.

9.41 Retests. If one or more test welds made by a welding operator fail to meet the requirements, a retest may be allowed under the following conditions:

(1) An immediate retest may be made consisting of two test welds of each type on which the welding operator failed. The retest specimens shall meet all the requirements specified for such welds.

(2) A retest may be made, provided there is evidence that the welding operator has had further training or practice. In this case, one complete retest shall be made.

9.42 Period of Effectiveness. The welding operator's qualification specified in this section shall remain in effect indefinitely unless:

(1) The welding operator is not engaged in a given process of welding for which the operator is qualified for a period exceeding 6 months; or

(2) There is some specific reason to question the welding operator's ability.

9.43 Records. Records of the test results shall be kept by the Manufacturer and shall be available to those authorized to examine them (see suggested sample form in Annex A).

Part E

Qualification of Tack Welders

9.44 General. The qualification tests described in this section are specifically devised to determine a tack welder's ability to produce sound tack welds. The qualification tests are not intended to be used as a guide for tack welding during actual construction. The latter shall be performed in accordance with the requirements of the welding procedure specification. For an alternate method of qualification, see 9.32.

9.45 Limitations. For the qualification of a tack welder, the following rules apply:

9.45.1 Qualification established with any one of the steels permitted by this specification shall qualify the tack welder to tack weld any of the other steels.

9.45.2 Qualification of a tack welder for SMAW with an electrode identified in Table 16 shall qualify the tack welder to tack weld with any other electrode in the same group designation and with any electrode listed in a numerically lower group designation.

9.45.3 Qualification of a tack welder with an approved electrode-shielding medium combination shall qualify the tack welder to tack weld with any other approved electrode-shielding medium combination for the process used in the qualification test.

9.45.4 A tack welder shall be qualified for each process used.

9.45.5 A change in the position in which tack welding is done, as defined in 9.8, shall require qualification in the new position.

9.46 Qualification Tests Required. A tack welder shall be qualified by making one test specimen in each position in which he or she will tack weld on the job.

9.47 Base Metal. The base metal used shall comply with the welding procedure specification.

9.48 Test Specimen. The tack welder shall make a tack weld of 1/4 in. [6 mm] maximum size and approximately 2 in. [50 mm] long on a fillet weld break specimen, shown in Figure 30.

9.49 Method of Testing. A force shall be applied to the specimen, as shown in Figure 31, until rupture occurs. The force may be applied by any convenient means. The surface of the weld prior to testing and the fracture surface shall be examined visually for discontinuities.

9.50 Test Results Required

9.50.1 A qualification tack weld shall have a reasonably uniform appearance and be free of overlap, cracks, and excessive undercut. There shall be no visible porosity on the surface of the tack weld.

9.50.2 The fractured surface of the tack weld shall show complete fusion to the root, but not necessarily beyond, and complete fusion to the base metal. Any inclusion or porosity larger than 3/32 in. [2.5 mm] in greatest dimension is unacceptable.

9.50.3 A tack welder who passes the fillet weld break test shall be eligible to tack weld all types of joints in the position and with the welding process used for qualification.

9.51 Retests. In case of failure to pass the qualification test, the tack welder may make one retest without additional training.

9.52 Period of Effectiveness. A tack welder who passes the qualification test shall be eligible to perform tack welding indefinitely in the positions and with the pro-

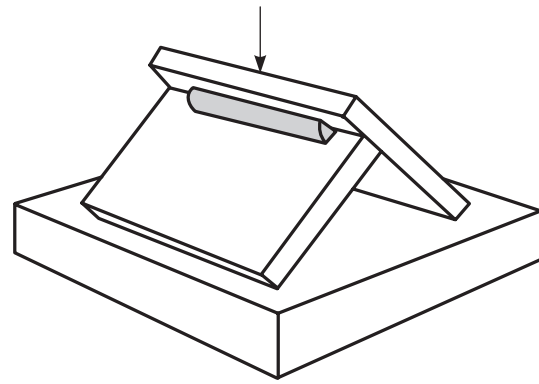


Figure 31—Method of Fracturing Fillet Weld Break Specimen—Tack Welder Qualification

cesses used for qualification unless there is some specific reason to question the tack welder’s ability. In such cases, the tack welder shall be required to demonstrate the ability to make sound tack welds by again passing the prescribed welding test.

9.53 Records. Records of the test results shall be kept by the Manufacturer or contractor and shall be available to those authorized to examine them (see suggested sample form in Annex A).

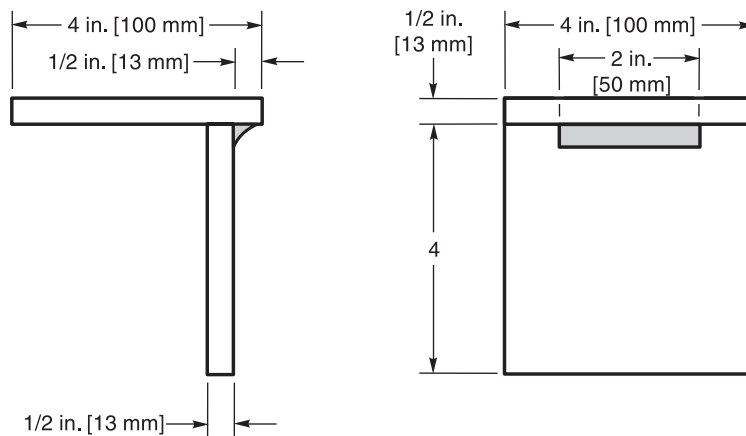


Figure 30—Fillet Weld Break Specimen—Tack Welder Qualification

10. Weld Quality and Inspection

10.1 General

10.1.1 Inspection personnel shall perform tests as necessary prior to, during, and after assembly and welding to ensure that materials and workmanship meet the requirements of this specification.

10.1.2 Personnel performing nondestructive examination other than visual shall be qualified in accordance with the American Society for Nondestructive Testing *Recommended Practice No. SNT-TC-1A*. Only individuals qualified for NDT Level I, and working under the NDT Level II, or individuals qualified for NDT Level II, may perform nondestructive examination. Certification of Level I and Level II individuals shall be performed by a Level III individual who has been certified by (1) The American Society for Nondestructive Testing, or (2) has the education, training, experience, and has successfully passed the written examination prescribed in SNT-TC-1A.

10.1.3 Inspectors responsible for acceptance or rejection of material and workmanship shall be qualified. The basis of inspector qualification shall be documented. If the Engineer elects to specify the basis of inspector qualification, it shall be so stated in contract documents. The following are acceptable qualification bases:

(1) Current certification as an AWS Senior Certified Welding Inspector (SCWI) or AWS Certified Welding Inspector (CWI) in conformance to the provisions of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, or

(2) Current certification by the Canadian Welding Bureau (CWB) to the requirements of the Canadian Standard Association (CSA) Standard W178.2, *Certification of Welding Inspectors*, or

(3) An Engineer or technician who, by training or experience, or both, in metals fabrication, inspection, and testing, is competent to perform inspection of the work.

10.2 Owner's Representative

10.2.1 A representative designated by the Owner, when required by the contract, shall verify that all fabrication by welding is performed in conformance to the requirements of this specification. At their discretion, Owners, or their representatives, may waive verification of welding and fabrication inspection.

10.2.2 The representative shall be furnished with or have access to a complete set of detailed drawings showing the size, length, type, and location of all welds that are to be made.

10.2.3 The representative shall be notified in advance of the start of any welding operations, when required by the contract.

10.2.4 The representative shall not delay the normal operating schedule of the Manufacturer if the representative cannot be on site after proper notification, unless otherwise agreed to in the contract.

10.2.5 The representative shall have the option of performing all, or any part of, the functions set forth in 10.3, 10.4, and 10.5.

10.2.6 If agreed to in the contract, the representative may keep records of all welder and welding operator qualifications, all procedure qualifications, other tests that are made, and other information that may be required for the execution of duties. Otherwise, this information shall be made available for review at the Manufacturer's facility.

10.3 Inspection of Welding Procedure Qualifications. The Owner's representative may witness or review the records of welding and testing of any procedure qualifications that are required in this specification.

10.4 Inspection of Welder, Tack Welder, and Welding Operator Qualifications. The Owner's representative shall only permit welding to be performed by welders, tack welders, and welding operators who are qualified in advance in accordance with the requirements of this specification. If retesting or qualification is required, the purchasing representative may witness the welding and testing of the qualification test for each welder, tack welder, or welding operator. Otherwise, the purchasing representative may review the records of past qualification and testing.

10.5 Inspection of Work and Records

10.5.1 The Owner's representative shall make certain that the size, length, and location of welds conform to the requirements of this specification and to the detailed drawings, and that no specified welds are omitted.

10.5.2 The Owner's representative shall make certain that only those welding procedures that meet the provisions of this specification are employed.

10.5.3 The Owner's representative may, at suitable intervals, observe the technique and performance of any welder, welding operator, or tack welder to make certain that the applicable workmanship requirements of Section 7, Workmanship, are being met.

10.5.4 The Owner's representative may examine the work to make certain that it meets the requirements of the workmanship standards of this specification. Size and contour of the welds shall be measured with suitable gauges. Visual inspection for cracks in welds and base metal and for other defects should be aided by strong light or other devices, such as magnifiers, where they may be helpful.

10.5.5 The Owner's representative should identify all parts or joints that have been inspected and accepted with a distinguishing mark.

10.6 Visual Examination. All welds shall be visually examined. Examination shall be performed after removal of foreign debris, including slag. A weld shall be acceptable by visual examination if it meets the specified size on the drawings (see Section 7, Workmanship), and the following conditions are met:

- (1) The weld has no cracks.
- (2) Complete fusion exists between adjacent layers of weld metal and between weld metal and base metal.
- (3) All craters are filled to the full cross section of the weld.
- (4) Weld profiles are in accordance with 10.7.
- (5) Permissible frequency and size of piping porosity in fillet welds shall be limited as follows:
 - (a) For primary welds, no more than 1 pore in each 4 in. [100 mm] of length, and no larger in diameter than 3/32 in. [2.5 mm].
 - (b) For secondary welds, the sum of the diameters of piping porosity shall not exceed 3/8 in. [10 mm] in any linear inch of weld, and shall not exceed 3/4 in. [20 mm] in any 12 in. [300 mm] length of weld.
- (6) The actual size of a portion of continuous fillet weld, 3/8 in. [10 mm] or larger, can be under the nominal required fillet weld size by 1/16 in. [2 mm] without correction, provided that the undersize portion does not exceed 10% of the weld length. On web-to-flange fillet welds on girders, no undersize weld is permitted at the end of the joint in a length equal to twice the width of the flange.
- (7) Primary groove welds shall have no piping porosity. Secondary groove welds shall meet the porosity requirements for fillet welds in 10.6(5)(a).
- (8) Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Acceptance criteria for ASTM A 514, A 517, and A 709 grades 100 and 100W steels shall be based on visual inspection performed not less than 48 hours after completion of the weld.

10.7 Welding Profiles

10.7.1 The faces of fillet welds may be slightly convex, flat, or slightly concave, as shown in Figures 32(A), 32(B), and 32(C), but with none of the unacceptable profiles shown in 32(D). Except at outside corner joints, the convexity C shall not exceed the sum of $0.1S + 0.03$ in. [0.8 mm], where S is the actual size of the fillet weld in inches [millimeters]. See Figures 32(B) and 32(C).

10.7.2 Groove welds shall be made with slight or minimum reinforcement, except as may be otherwise provided. For butt and corner joints, the reinforcement

height, R , shall not exceed 1/8 in. [3 mm] for metal thickness of 2 in. [50 mm] and under, and 3/16 in. [5 mm] for metal thicknesses over 2 in. [50 mm]. It shall have gradual transition to the plane of the base metal's surface, as shown in Figure 32(E). Groove welds shall be free of the discontinuities shown for butt joints in Figure 32(F).

10.7.3 Where the surface of butt joints are required to be flush, the thickness of the thinner base metal or weld metal shall not be reduced by more than 1/32 in. [1 mm], or 7% of the thickness, whichever is smaller, and weld reinforcement shall not exceed 1/32 in. [1 mm]. However, all reinforcement shall be removed where the weld forms part of a faying or contact surface. Any reinforcement shall blend smoothly into the plate surfaces with transition areas free from undercut. Chipping may be used, provided it is followed by grinding. Where surface finishing is required, the roughness value shall not exceed 250×10^{-6} in. [6×10^{-6} m]. Surfaces finished to values of over 125×10^{-6} in. [3×10^{-6} m] through 250×10^{-6} in. [6×10^{-6} m] shall be finished parallel to the direction of primary stress. Surfaces finished to 125×10^{-6} in. [3×10^{-6} m] or less may be finished in any direction. (See ASME B46.1, *Surface Texture*, for measurement method.)

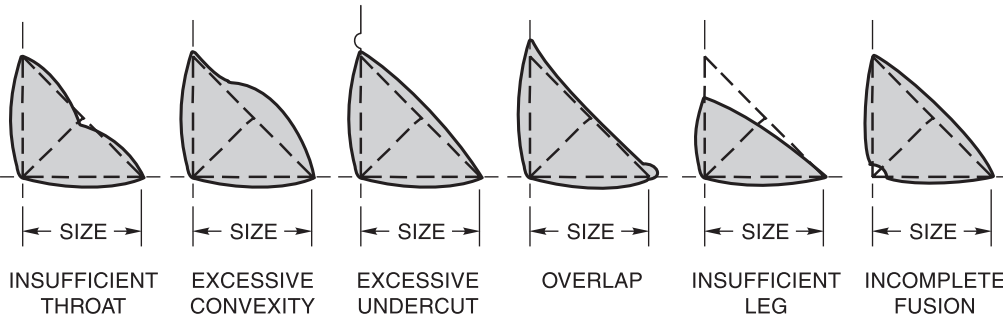
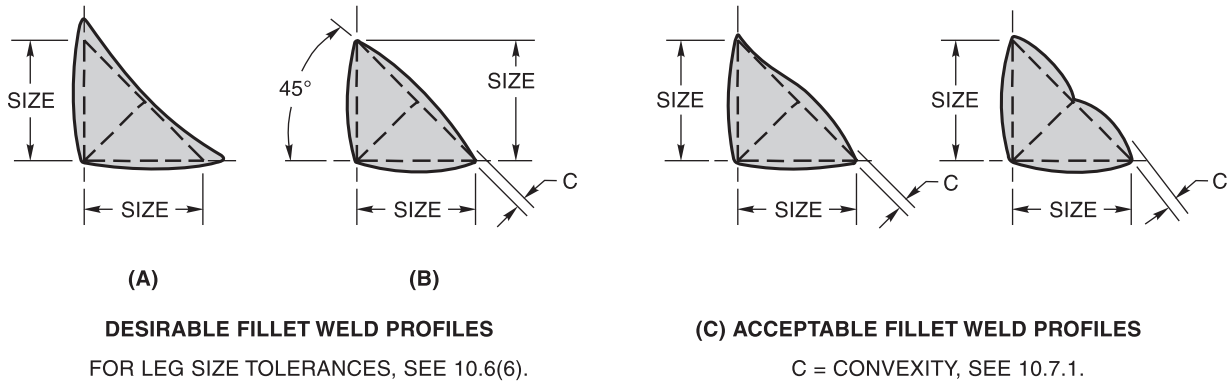
10.7.4 Undercut depth shall not exceed 1/32 in. [1 mm] or 7% of the base metal thickness, except that Joint Class IV, V, and VI welds with a total undercut of less than 1/2 in. [13 mm] in length in any linear 12 in. [300 mm] of weld are acceptable without measurement of the undercut depth.

10.7.5 Welds shall be free from overlap.

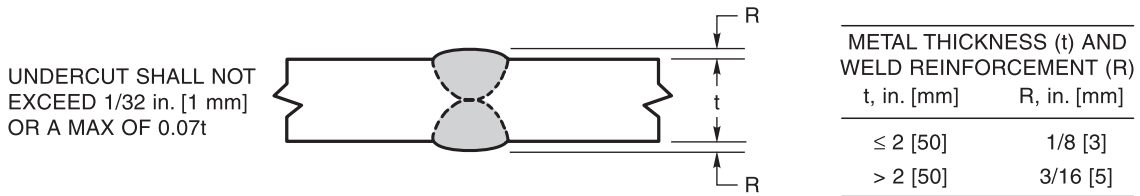
10.7.6 Fillet welds may not deviate from designated size by more than the tolerances given in 10.6(6). The convexity shall meet the tolerances given in 10.7.1. If the deviation exceeds these tolerances, the weld shall be corrected as noted in Section 12, Repair and Correction of Defects.

10.8 Nondestructive Examination

10.8.1 Joint Class I and II weld joints shall require either radiographic or ultrasonic examination in addition to magnetic particle or dye penetrant examination. Non-destructive examination (other than visual inspection) of weld joints other than Joint Class I or II, when it is to be required as a part of the contract, shall be announced in the information furnished to bidders. The information provided shall designate the inspection process to be employed, the welds to be examined, and the extent of examination of each weld. Such nondestructive examination shall be conducted in conformance to the require-



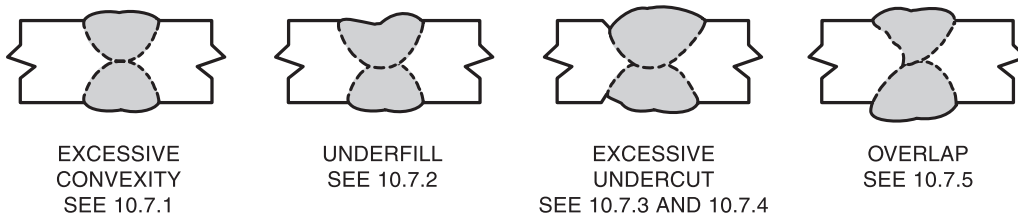
(D) UNACCEPTABLE FILLET WELD PROFILES



METAL THICKNESS (t) AND WELD REINFORCEMENT (R)	
t, in. [mm]	R, in. [mm]
≤ 2 [50]	1/8 [3]
> 2 [50]	3/16 [5]

SEE 10.7

(E) ACCEPTABLE BUTT JOINT WELD PROFILE



(F) UNACCEPTABLE GROOVE WELD PROFILES IN BUTT JOINTS

Figure 32—Acceptable and Unacceptable Weld Profiles

ments of this specification, or as modified by mutual agreement between the Manufacturer and Owner.

For welds subject to nondestructive testing in accordance with 10.8, 10.11, 10.15, 10.16, or 10.17, the testing may begin immediately after the completed welds have cooled to ambient temperature. However, nondestructive testing of ASTM A 514, A 517, and A 709 Grade 100 and 100W steels shall begin not less than 48 hours after the completed welds have cooled to ambient temperature.

Refer to ASTM E 1316, *Standard Terminology for Nondestructive Examinations*, for standard definitions of terms.

10.8.2 Welds that do not meet the nondestructive examination requirements of this specification shall be repaired by the methods permitted by Section 12, Repair and Correction of Defects.

10.8.3 Nondestructive examination in this specification is only intended to apply to primary welds, unless otherwise specifically agreed to in the contract between the Manufacturer and the Owner.

10.8.4 A weld that is to be subjected to nondestructive examination need not be ground or otherwise smoothed, provided surface irregularities or juncture with the base metal do not obscure objectionable weld discontinuities during examination.

10.9 Radiographic Examination of Welds

10.9.1 The procedures and standards set forth in this section are to govern radiographic examination of welds when such testing is required by stipulation of 10.8. These procedures are restricted to inspection of groove welds with complete joint penetration.

10.9.2 Variations in testing procedure, equipment, and acceptance standards from those given in this section may be used upon agreement with the Owner. Such variations include the radiographic examination of fillet welds, T-welds, or corner welds; changes in source-to-film distance; unusual geometries; unusual penetrometer application, film type, or densities; and film exposure or development variations.

10.9.3 Information furnished to the bidders shall clearly identify the extent of radiographic testing required.

10.9.4 Complete testing, when specified, requires that the entire length of weld in each designated joint shall be tested.

10.9.5 Spot testing, when specified, requires that the number of spots to be radiographed in a stated length of weld in each designated category of weld joint shall be included in information furnished to bidders. Each spot

radiograph shall show at least 4 in. [100 mm] of weld length. If a spot radiograph shows discontinuities that require repair, as defined in 10.11, two adjacent spots shall be tested. If discontinuities requiring repair are detected in either of these, the entire length of weld in that joint shall be tested radiographically.

10.10 Radiographic Procedure

10.10.1 Radiographs shall be made by either X-ray or isotope radiation methods. Radiography shall be conducted in accordance with ASTM E 94, *Standard Guide for Radiographic Examination*.

10.10.2 The radiographic sensitivity shall be judged based on penetrameters. Radiographic technique and equipment shall provide sufficient sensitivity to clearly delineate the required penetrameters and the essential holes as described in 10.10.4 and Table 19. Identifying letters and numbers shall show clearly in the radiograph. *Note: Alternative image quality indicators may be used when approved by the Engineer.*

10.10.3 Radiographs shall have an H & D density¹⁴ of 2.0 minimum and 4.0 maximum. In addition, the density in the area of interest shall not vary more than minus 15% and plus 30% from the density through the penetrometer.

10.10.4 One penetrometer, centered on the film, shall be used for film 10 in. [250 mm] or less in length. Two penetrameters, one centered and one at the end of the film, shall be used for radiographs with a film length greater than 10 in. [250 mm] in length. For panoramic exposures, three penetrameters shall be placed 120° apart around the object being radiographed. Penetrameters shall be placed on the source side whenever possible. Failure to prove adequate sensitivity on all three penetrameters shall disqualify the exposure, and the entire technique shall be repeated.

10.10.5 Radiographs shall be made using a single source of radiation approximately centered with respect to the length and width of the area being examined. The minimum source-to-object distance shall be the greater of the film length or 7 times the maximum thickness of the weld being examined. For panoramic exposures, the minimum source-to-object distance shall be 7 times the maximum weld thickness. During exposure, the film shall be as close as possible to the opposite side of the weld being examined. Edge blocks shall be used when radiographing butt joints greater than 1/2 in. [13 mm]

14. H & D density, D, is a measure of film blackening expressed as $D = \log (I_0/I)$, where:

I_0 = light intensity on the film

I = light transmitted through the film

Table 19
Penetrameter Requirements (see 10.10.2)

Nominal Material Thickness Range ⁽¹⁾		Source Side		Film Side ⁽²⁾	
in.	mm	Designation	Essential Hole	Designation	Essential Hole
Up to 0.25 incl.	Up to 6 incl.	10	4T	7	4T
Over 0.25 through 0.375	Over 6 to 10	12	4T	10	4T
Over 0.375 through 0.625	Over 10 to 16	15	4T	12	4T
Over 0.625 through 0.75	Over 16 to 19	17	4T	15	4T
Over 0.75 through 1.00	Over 19 to 25	20	4T	17	4T
Over 1.00 through 1.25	Over 25 to 32	25	4T	20	4T
Over 1.25 through 1.50	Over 32 to 40	30	2T	25	2T
Over 1.50 through 2.00	Over 40 to 50	35	2T	30	2T
Over 2.00 through 2.50	Over 50 to 65	40	2T	35	2T
Over 2.50 through 3.00	Over 65 to 75	45	2T	40	2T
Over 3.00 through 4.00	Over 75 to 100	50	2T	45	2T
Over 4.00 through 6.00	Over 100 to 150	60	2T	50	2T
Over 6.00 through 8.00	Over 150 to 200	80	2T	60	2T

Notes:

(1) Single wall radiographic thickness (for tubulars).

(2) Applicable to tubular structures only.

thick. The minimum width of the edge blocks shall be 1 in. [25 mm] or half the weld thickness, whichever is greater. The edge blocks shall have a thickness equal to or greater than the thickness of the weld being radiographed.

10.10.6 All radiographs shall be free from chemical and mechanical blemishes that could mask discontinuities in the area of interest. Such blemishes include, but are not limited to, finger prints, crimps, screen marks, water marks, streaks, chemical stains, and fogging. Film identification shall be made permanent on the film by radiographic image, lead tape, flash type ID, or other approved means.

10.11 Acceptability of Radiographed Welds

10.11.1 Welds subject to radiographic examination shall first be visually examined in conformance to the requirements of 10.6 and 10.7.

10.11.2 The greatest dimension of any porosity or fusion-type discontinuity indications that are 1/16 in. [2 mm] or larger shall not exceed the size, B, indicated in Figure 33 for the effective throat of a groove weld or weld size of a fillet weld. The distance from any indication of porosity or fusion-type discontinuity to another such indication, to an edge, or to any intersecting weld shall not be less than the minimum clearance allowed, C, indicated in Figure 33 for the size of discontinuity under examination. Annex B illustrates the application of the requirements given in 10.11.2.

10.11.3 Discontinuities meeting requirements of 10.11.1 and having a greatest dimension of less than 1/16 in. [2 mm] are nevertheless not acceptable if the sum of their greatest dimensions exceeds 3/8 in. [10 mm] in any linear inch [25 mm] of weld.

10.11.4 The limitations for 1-1/2 in. [40 mm] groove weld effective throat given in Figure 33 shall apply to all welds with larger effective throats.

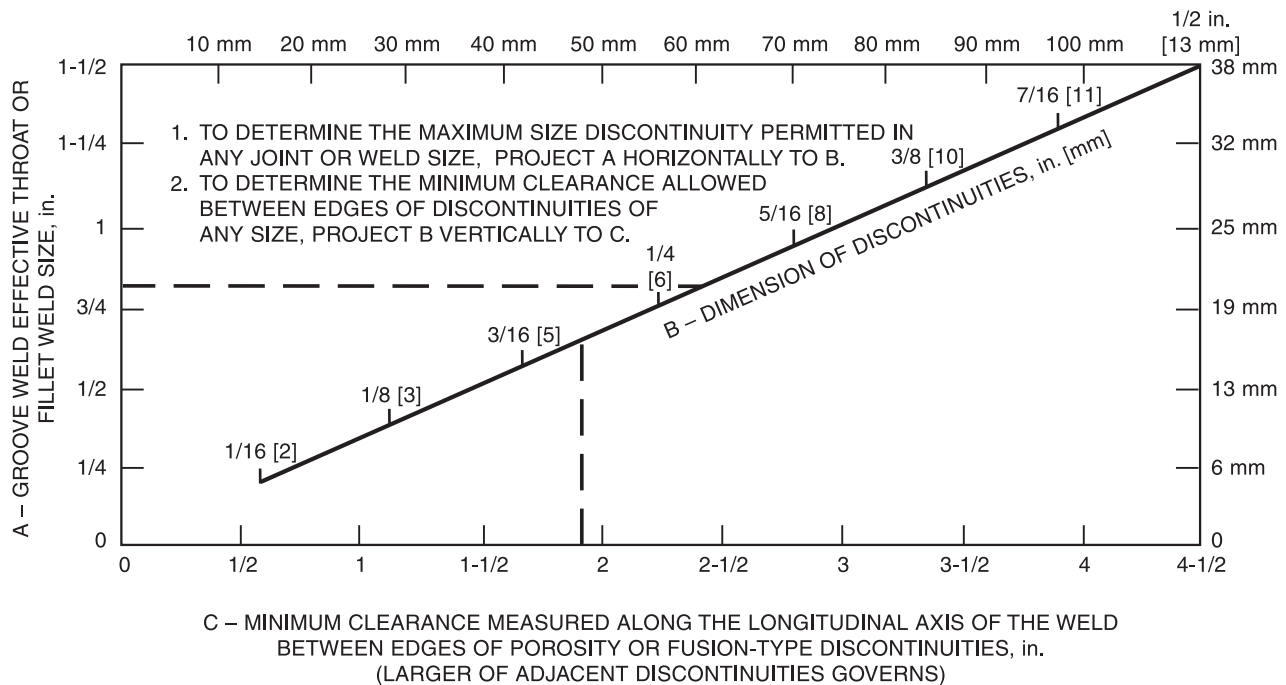
10.11.5 A recommended form for reporting the results of radiographic examination is shown in Annex A.

10.12 Examination, Report, and Disposition of Radiographs

10.12.1 The contractor shall provide a suitable high-intensity viewer with sufficient capacity to illuminate radiographs with a density of 4.0 without difficulty. It is recommended that at least a two-level or variable-intensity illuminator be used.

10.12.2 All radiographs of welds that are subject to contractual radiographic examination by the Manufacturer, including those that show unacceptable quality prior to repair, and a report interpreting them, shall be available for review by the Owner's representative before the weld is accepted.

10.12.3 A full set of radiographs for welds subject to radiographic examination by the Manufacturer for the Owner, including those that show unacceptable quality prior to repair, shall be delivered to the Owner upon



General Note: Adjacent discontinuities, spaced less than the minimum required clearance shall be measured as one length equal to the sum of the total length of the discontinuities plus the length of the space between them and evaluated as a single discontinuity.

Figure 33—Weld Quality Requirements for Discontinuities Occurring in Welds (Limitation of Porosity and Fusion—Type Discontinuities)

completion of the work. The Manufacturer’s obligation to retain radiographs shall cease (1) upon delivery of this full set to the Owner, (2) one full year after completion of the Manufacturer’s work, in the event that delivery is not required, or (3) as otherwise stated in the contract.

10.13 Ultrasonic Examination of Welds

10.13.1 The procedures and standards set forth in this section govern the ultrasonic examination of groove welds between the thicknesses of 5/16 in. [8 mm] and 8 in. [200 mm] inclusive, when such testing is required by 10.8 of this specification. These procedures and standards are not to be used as a basis for rejection of the base metal.

10.13.2 Variations in testing procedure, equipment, and acceptance standards not included in this section may be used by agreement between the Manufacturer and Owner. Such variations include other thicknesses, weld geometries, transducer sizes, frequencies, and couplants.

10.13.3 Spot radiography is suggested to supplement ultrasonic testing of electroslag and electrogas groove welds in material 2 in. [50 mm] and over in thickness to detect possible piping porosity.

10.13.4 Information furnished to bidders shall clearly identify the extent of ultrasonic testing required.

10.13.5 Complete testing, when specified, requires testing of the entire length of the weld in each designated joint.

10.13.6 Spot testing, when specified, requires that the number of spots in each designated category of weld, or the number required to be made in a stated length of weld, be included in the information furnished to bidders. When spot testing reveals discontinuities that require repair, two adjacent spots shall be tested. If discontinuities requiring repair are revealed in either of these, the entire length of the weld in that joint shall be tested ultrasonically.

10.14 Ultrasonic Testing Equipment and Calibration

10.14.1 The apparatus for ultrasonic examination shall meet the requirements of ASTM E 164, *Recommended Practice for Ultrasonic Contact Examination of Weldments*, and ASTM E 317, *Recommended Practices for Evaluating Performance Characteristics of Pulse-Echo Ultrasonic Testing Systems*. Refer to ASTM E 1316, *Standard Terminology for Nondestructive Examinations*, for standard definitions of terms.

10.14.2 Test instruments shall include internal stabilization so that, after warm up, no variation in response greater than ± 1 dB occurs with supply voltage changes of 15% nominal or, in the case of battery powered instruments, over the battery charge operating life. There shall be an alarm or meter to signal a drop in battery voltage prior to instrument shutoff due to battery exhaustion.

10.14.3 The test instrument shall have a calibrated gain control (attenuator) adjustable in discrete 1 or 2 dB steps over a range of at least 60 dB.

10.14.4 The dynamic range of the instrument's display shall be such that a difference of 1 dB of amplitude can be easily detected.

10.14.5 Each search unit shall be marked to clearly indicate the frequency of the transducer, nominal angle of refraction, and index point.

10.14.6 Preferred couplants are a cellulose gum-water mixture and glycerine with a wetting agent. Where possible, avoid the use of oil or grease as the couplant for examination of welds. If oil or grease is used as the couplant, the requirements of 7.2.1 shall be met before any repairs are made.

10.14.7 The horizontal linearity of the test instrument shall be within $\pm 5\%$ over the linear range that includes 90% of the sweep length presented on the display for the longest sound path to be used. The horizontal linearity shall be measured by the techniques prescribed in Section 7.9 of ASTM E 317, except that the results may be tabulated rather than graphically represented. Horizontal linearity shall be checked after each 40 hours of instrument use.

10.14.8 Internal reflections from the search unit, with a screen presentation higher than the horizontal reference line, appearing on the screen to the right of the sound entry point shall not occur beyond 1/2 in. [13 mm] equivalent distance in steel when the sensitivity is as follows: 20 dB more than that required to produce a maximized horizontal reference-line height indication from the 1/16 in. [1.59 mm] diameter hole in the International Institute of Welding (IIW) reference block (see ASTM E 164).

10.14.9 The dimensions of the search unit shall be such that the minimal allowable distance, X, between the toe of the search unit and the edge of the IIW block, shall be as follows:

- (1) 70° transducer, X = 2 in. [50 mm]
- (2) 60° transducer, X = 1-7/16 in. [37 mm]
- (3) 45° transducer, X = 1 in. [25 mm]

The search unit shall be positioned for maximum indication from the 1/16 in. [1.59 mm] diameter hole in the IIW calibration block.

10.14.10 Resolution

10.14.10.1 For shear waves, the combination of search unit and instrument shall resolve the appropriate three holes in the resolution test block shown in Figures 34A and 34B. For a 70° angle, the transducer should be set in position Q on the resolution block as shown in Figure 34C. The resolution shall be evaluated with the instrument controls set at normal test settings, and with indications from the holes brought to midscreen height. Resolution shall be sufficient to distinguish at least the peaks of indications from the three holes.

10.14.10.2 To determine longitudinal wave resolution, the instrument controls shall be at normal settings with indications from the holes brought to midscreen height (see Figure 34C).

- (1) Set the transducer in position F on the IIW block.
- (2) Transducer and instrument should resolve all three distances.

10.14.11 The IIW ultrasonic reference block, shown in ASTM E 164, shall be the standard used for both distance and sensitivity calibration. More portable reference blocks of other designs may be used, provided they meet the requirements of this specification and are referenced back to the IIW block. Approved designs are shown in ASTM E 164. See Figure 34C for application.

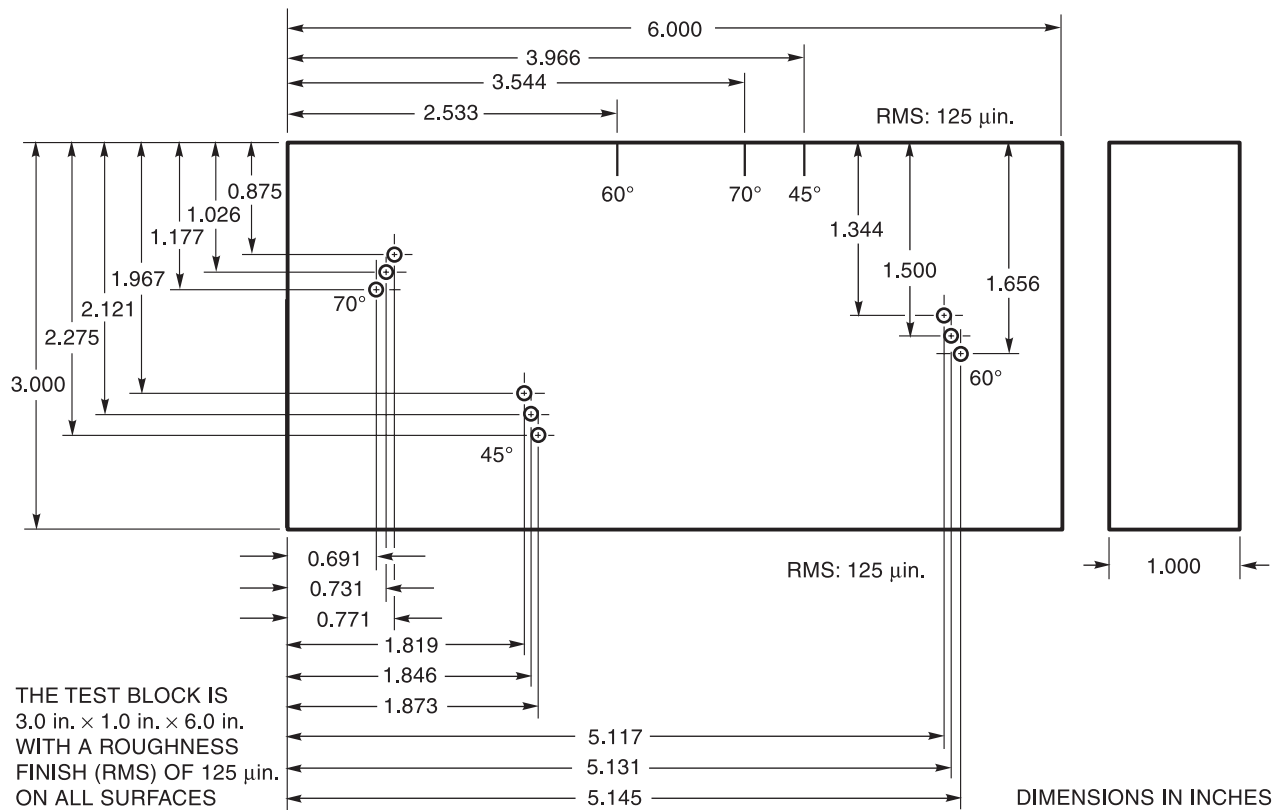
10.14.12 Using a corner reflector for calibration purposes is prohibited.

10.14.13 The gain control (attenuator) of the instrument shall meet the requirements of 10.14.3 and shall be checked for correct calibration at two-month intervals in accordance with a procedure approved by the manufacturer of the instrument.

10.14.14 With the use of an approved calibration block, each angle-beam search unit shall be checked after each eight hours of use to determine that:

- (1) The contact face is flat,
- (2) The sound entry point is correct, and
- (3) The beam angle is within the permitted $\pm 2^\circ$ tolerance.

Search units that do not meet these requirements shall be corrected or replaced.



General Note: All holes are 1/16 in. in diameter.

Source: Adapted from AWS D1.1/D1.1M:2004, Figure 6.23, p. 248.

Figure 34A—RC Resolution Reference Block (U.S. Units)

10.14.15 Calibration for sensitivity and horizontal sweep (distance) shall be made at the location of testing by the ultrasonic operator just prior to examination of each weld and at intervals of 30 minutes during examination. Recalibration shall be made when:

- (1) There is a change of operators,
- (2) Transducers are changed,
- (3) New batteries are installed, and
- (4) Equipment operating from a 110 volt source is connected to a different power outlet.

10.14.16 Calibration for straight beam testing shall be performed as follows:

(1) The horizontal sweep shall be adjusted for distance calibration to present the equivalent of a least two plate thicknesses on the display.

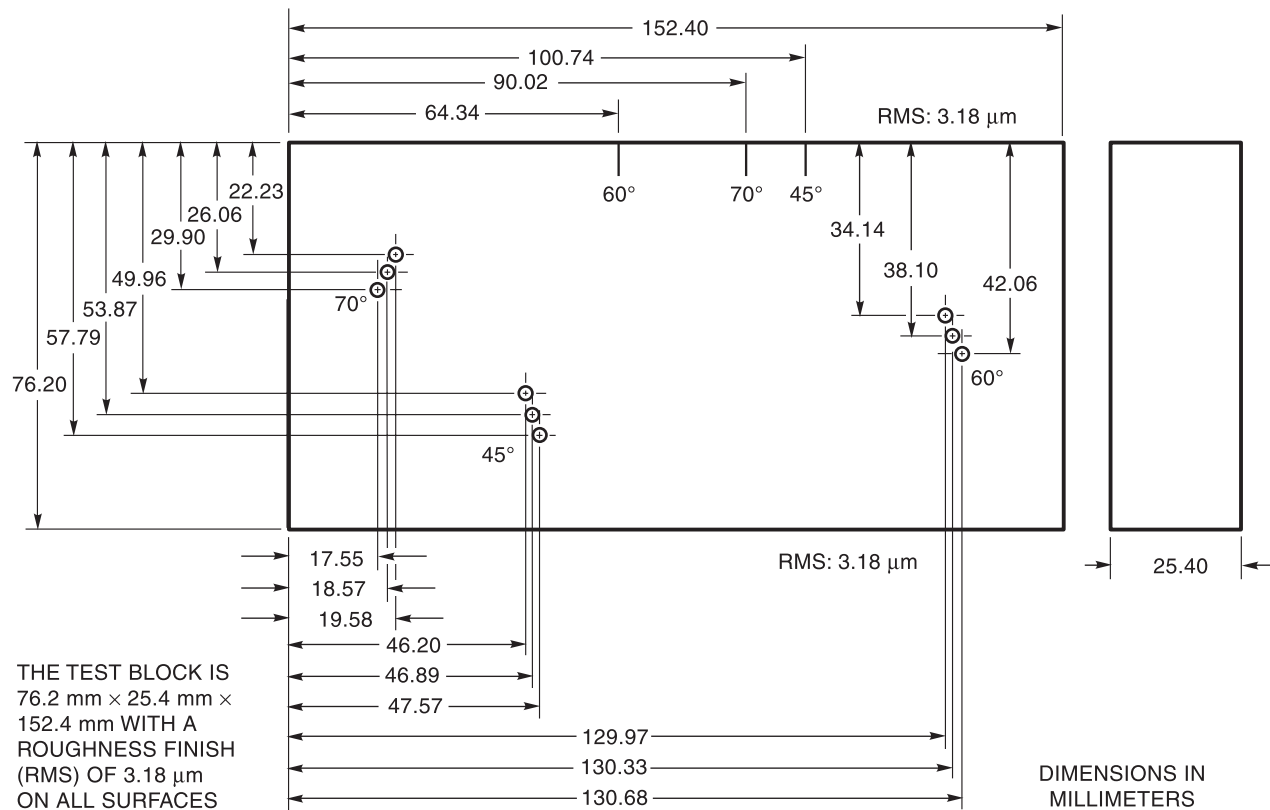
(a) Set the transducer in position G on the IIW block, position H on the DC block, or position M on the DSC block (see Figure 34C).

(b) Adjust instrument to produce indications at 1 in. [25 mm], 2 in. [50 mm], 3 in. [75 mm], 4 in. [100 mm], etc. on the display.

(2) The sensitivity (gain) shall be adjusted at a location free of indications so that the first back reflection from the far side of the plate will be 50% to 70% of full screen height. For this purpose, the reject (clipping) control shall be turned off.

10.14.17 Calibration for angle beam testing shall be performed as follows:

(1) The horizontal sweep shall be adjusted to represent the actual sound-path distance by using acceptable distance calibration blocks shown in Figure 34C and ASTM E 164. This distance calibration shall be made using either the 5 in. [125 mm] scale or the 10 in. [250 mm] scale on the display, whichever is appropriate, unless joint configuration or thickness prevents full examination of the weld at either of these settings.



Source: Adapted from AWS D1.1/D1.1M:2004, Figure 6.23 (Continued), p. 249.

Figure 34B—RC Resolution Reference Block (SI Units)

(a) Set the transducer in position D on the IIW block (any angle).

(b) Adjust the instrument to obtain indications on the display at 4 in. [100 mm] and 9 in. [225 mm] from a Type 1 block, or at 4 in. [100 mm] and 8 in. [200 mm] from a Type 2 block.

(c) Set the transducer in position J or L on the DSC block (any angle).

(d) Adjust the instrument to obtain indications on the display at 1 in. [25 mm], 5 in. [125 mm], 9 in. [225 mm] in the J position, or at 3 in. [75 mm], and 7 in. [175 mm] in the L position.

(e) Set the transducer in position I on the DC block (any angle).

(f) Adjust the instrument to obtain indications on the display at 1 in. [25 mm], 2 in. [50 mm], 3 in. [75 mm], 4 in. [100 mm], and so forth.

(2) With the unit adjusted to conform with the requirements of 10.14.1 through 10.14.10, the sensitivity shall be adjusted by the use of the gain control (attenuator) so that a horizontal reference-level trace deflection results on the display with the maximum indication from the 0.060 in. [1.59 mm] diameter hole in the IIW block or from the equivalent reference reflector in other acceptable calibration blocks. This basic sensitivity then becomes the zero reference level for discontinuity evaluation and shall be recorded on the ultrasonic test reports under reference level. See Annex A for a sample ultrasonic test report form.

(a) Set the transducer in position A on the IIW block (any angle).

(b) Adjust the maximized signal from the 0.060 in. [1.59 mm] hole to attain a horizontal reference-line height indication.

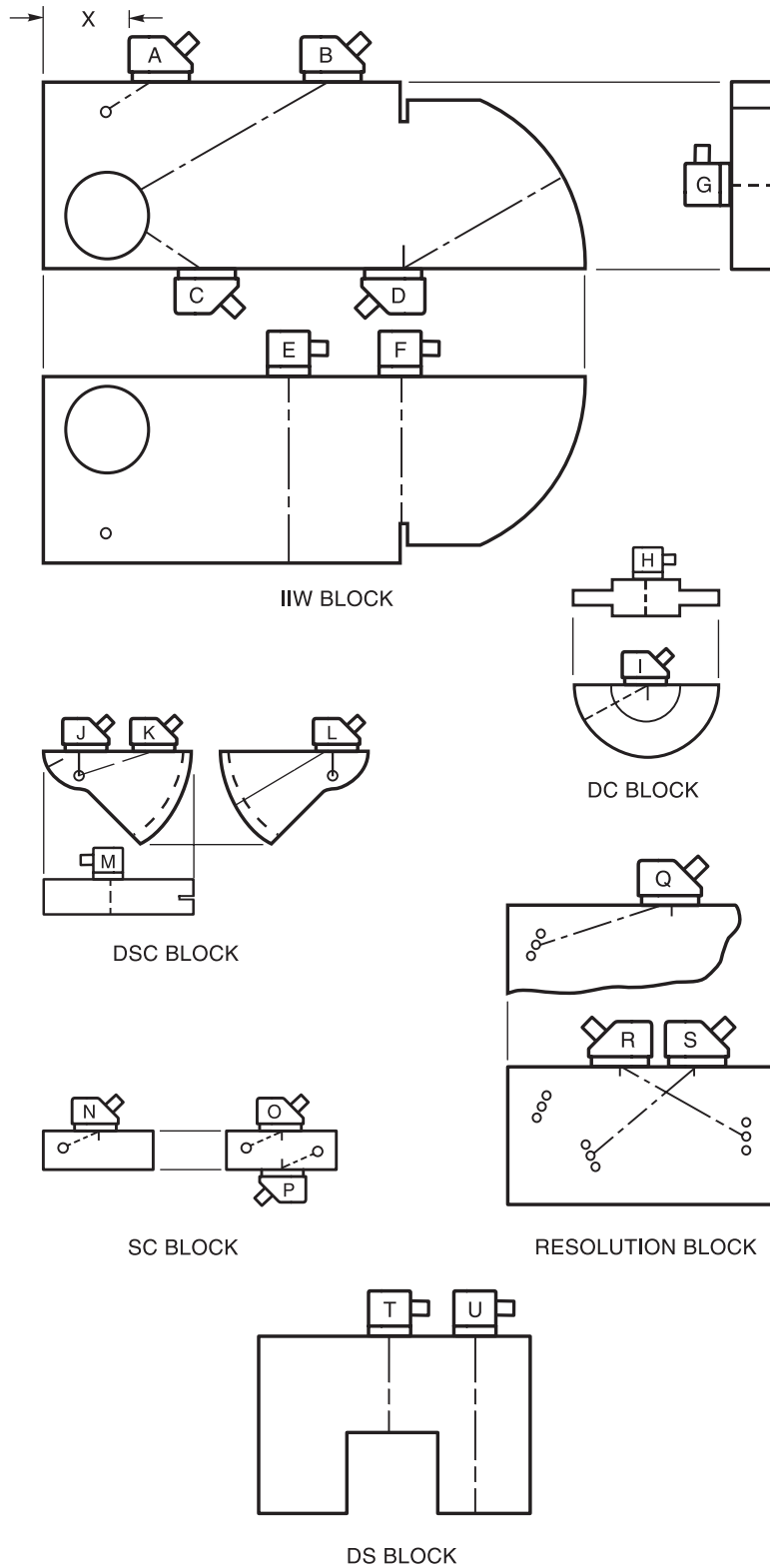


Figure 34C—Typical Transducer Positions

(c) Set the transducer in position L on the DSC block (any angle).

(d) Adjust the maximized signal from the 1/32 in. [0.8 mm] slot to attain a horizontal reference-line height indication.

(e) Set the transducer on the SC block in position N for 70° angle, position O for 45° angle, or position P for 60° angle.

(f) Adjust the maximized signal from the 0.060 in. [1.59 mm] hole to attain a horizontal reference-line height indication.

(g) The decibel reading obtained in (f) shall be used as the reference level, b, reading on the test report sheet (see Annex A).

10.15 Ultrasonic Testing Procedure, Acceptance Criteria, and Reports

10.15.1 The letter Y accompanied by a weld identification number shall be clearly marked on the base metal adjacent to the weld at the left end of each weld that is ultrasonically examined. This identification number serves as an orientation direction for weld discontinuity location and as the report number on the report form (see Annex A for suggested report form).

10.15.2 All surfaces to which a search unit is applied shall be free of weld spatter, dirt, grease, oil, (other than that used as a couplant) and loose scale and shall have a contour permitting intimate coupling. Tight layers of paint need not be removed unless their combined thickness exceeds 0.010 in. [0.25 mm].

10.15.3 A couplant shall be used between the search unit and the metal. The couplant should be either glycerine with a wetting agent, if needed, or a cellulose gum and water mixture of a suitable consistency. Light machine oil, or equivalent, may be used for couplant on calibration blocks.

10.15.4 The entire base metal through which ultrasonic vibrations must travel to test the weld shall be examined for laminar reflectors, using a straight-beam search unit conforming to the requirements of 10.14. If any area of base metal exhibits total loss of back reflection and is located in a position that would interfere with the normal weld scanning procedure, the following alternate weld scanning procedure shall be used. Alternate weld scanning procedure inspection may also be conducted in accordance with ASTM E 164.

(1) The area of the laminar reflector and its depth from the surface shall be determined and reported on the ultrasonic test report.

(2) If part of a weld is inaccessible to testing in accordance with the requirements of Table 20 because of laminar content recorded in accordance with 10.15.4(1), the testing shall be conducted by using an alternate scanning

pattern described in 10.15.5, by first grinding the weld surfaces flush to make total weld areas accessible to ultrasonic testing, or both.

10.15.5 Alternate Scanning Patterns (See Figure 35)

(1) *Longitudinal Discontinuities.* Scanning patterns shall consist of the following combined movements:

(a) Scanning movement A—Rotation angle, a, equals 10°.

(b) Scanning movement B—Scanning distance, b, shall be sufficient to ensure that the section of weld being examined is covered.

(c) Scanning movement C—Progression distance, c, shall be approximately one-half of the transducer width.

(2) *Transverse Discontinuities*

(a) Scanning pattern D—when welds are ground flush.

(b) Scanning pattern E—when weld is not ground flush.

(c) Scanning angle $e = 15^\circ$ maximum.

(d) Scanning pattern shall ensure the full weld section is covered.

(3) *Electroslag or Electrodeposited Welds.* (Additional scanning pattern)—scanning pattern E

(a) Search unit rotation angle, e, between 45° and 60°.

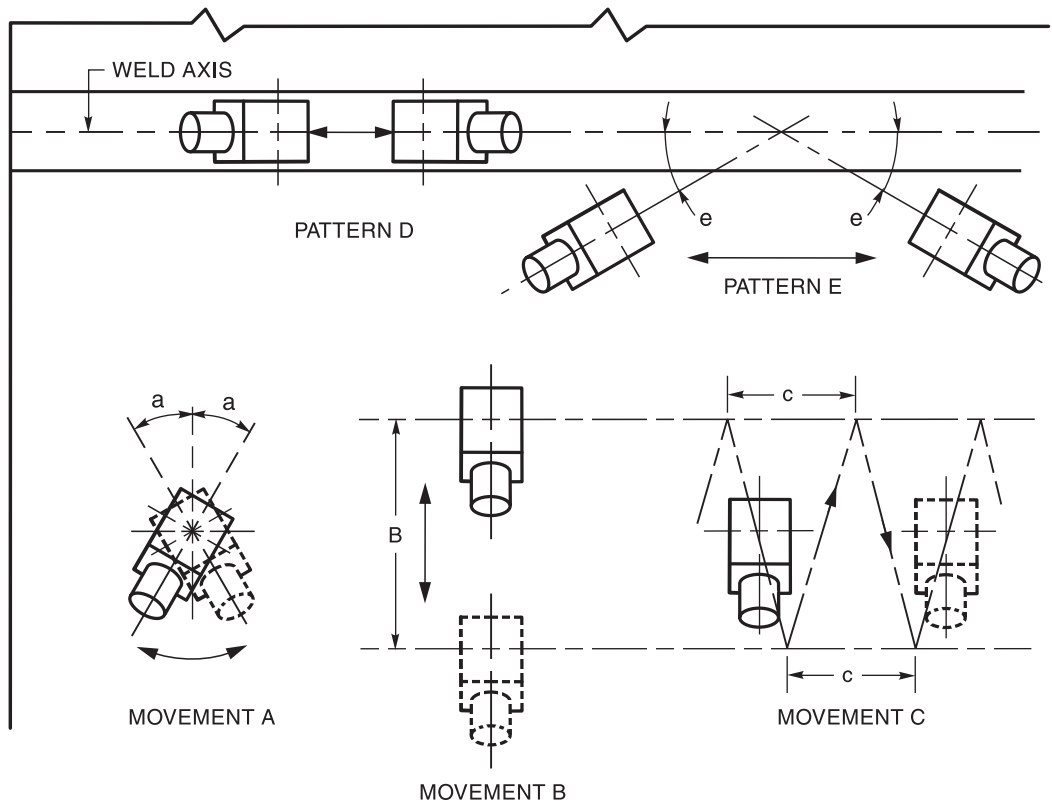
(b) Scanning pattern shall ensure that the full weld section is covered.

10.15.6 Welds shall be examined using an angle-beam search unit conforming to the requirements of 10.14 and ASTM E 164. Following calibration and during testing, the only instrument adjustment permitted is in the sensitivity-level adjustment with the calibrated gain control or attenuator. Sensitivity shall be increased from the reference level for weld scanning in accordance with Table 21.

10.15.6.1 If mechanically possible, all welds shall be scanned from both sides on the same face for longitudinal and transverse discontinuities. The applicable scanning pattern, or patterns, shown in Figure 35 shall be used.

10.15.6.2 The testing angle shall be as shown in Table 20.

10.15.6.3 When a discontinuity indication appears on the screen, the maximum attainable indication from the discontinuity shall be adjusted to produce a horizontal reference level trace deflection on the display. This adjustment shall be made with the calibrated gain control or attenuator, and the instrument reading in decibels shall be recorded on the ultrasonic test report under the heading Indication Level, a.



General Notes:

1. Testing patterns are all symmetrical around the weld axis with the exception of pattern D, which is conducted directly over the weld axis.
2. Testing from both sides of the weld axis is to be made wherever mechanically possible.

Figure 35—Plan View of UT Scanning Patterns

10.15.6.4 The attenuation factor, c , on the test report is obtained by subtracting 1 in. [25.4 mm] from the sound-path distance and multiplying the remainder by 2 [0.0787].

10.15.6.5 The indication rating, d , on the test report is the difference between the reference level and the indication level after the indication level has been corrected by the attenuation factor.

Instruments with gain in dB: $a - b - c = d$

Instruments with attenuation in dB: $b - a - c = d$

10.15.6.6 The length of a discontinuity, as entered under indication length on the test report, shall be determined by locating the points at each end at which the indication amplitude drops 6 dB (50%) and measuring between the centerlines of those transducer locations.

10.15.6.7 Each weld discontinuity shall be accepted or rejected on the basis of its indication rating and its length in accordance with Table 21. Only those discontinuities which are rejectable need be recorded on the test report.

10.15.7 Each rejectable discontinuity shall be indicated on the weld by a mark directly over the discontinuity for its entire length. The depth from the surface and type of discontinuity shall be noted on nearby base metal.

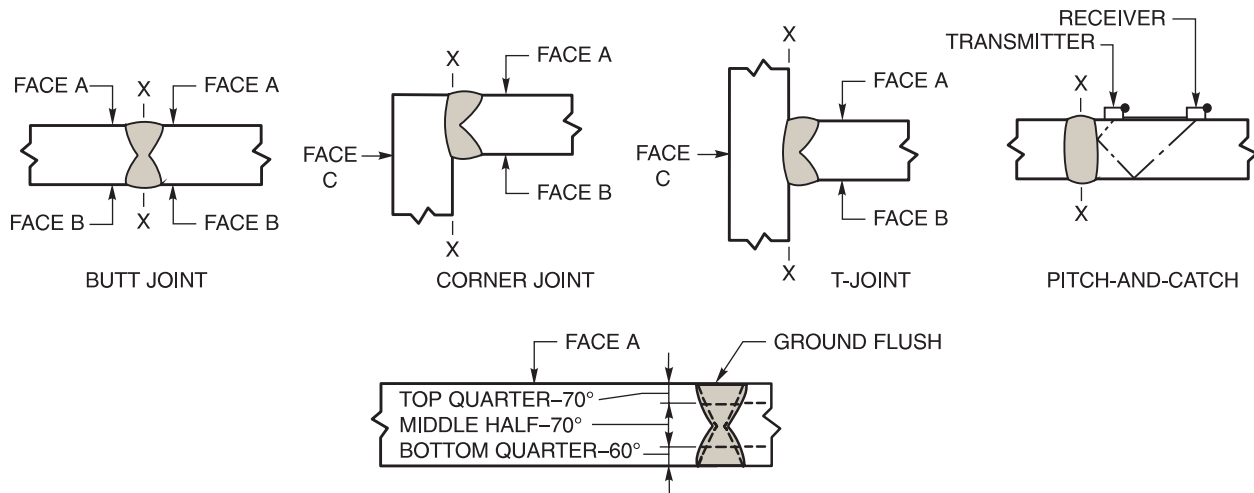
10.15.8 Welds found unacceptable by ultrasonic testing shall be repaired by methods permitted by Section 12, Weld Repairs, of this specification. Repaired welds shall be reexamined ultrasonically, and an additional report form completed.

Table 20
Ultrasonic Testing Angle

Procedure Chart

Material Thickness, in. [mm]

Weld Type	5/16 [8]	>1-1/2 [40]	>1-3/4 [45]	>2-1/2 [65]	>3-1/2 [90]	>4-1/2 [115]	>5 [125]	>6-1/2 [165]	>7 [180]
	to ≤1-1/2 [40]	to ≤1-3/4 [45]	to ≤2-1/2 [65]	to ≤3-1/2 [90]	to ≤4-1/2 [115]	to ≤5 [125]	to ≤6-1/2 [165]	to ≤7 [180]	to ≤8 [200]
	*	*	*	*	*	*	*	*	*
Butt	1 O	1 F	1G or 4 F	1G or 5 F	6 or 7 F	8 or 10 F	9 or 11 F	12 or 13 F	12 F
T-	1 O	1 F or XF	4 F or XF	5 F or XF	7 F or XF	10 F or XF	11 F or XF	13 F or XF	— —
Corner	1 O	1 F or XF	1G or 4 F or XF	1G or 5 F or XF	6 or 7 F or XF	8 or 10 F or XF	9 or 11 F or XF	13 or 14 F or XF	— —
Electrogas & Electroslag	1 O	1 O	1G or 4 1**	1G or 3 P1 or P3	6 or 7 P3	11 or 15 P3	11 or 15 P3	11 or 15 P3	11 or 15** P3



General Notes:

- Where possible, all examinations shall be made from Face A and in Leg 1, unless otherwise noted in this table.
- Root areas of single groove weld joints which have backing not requiring removal by contract, shall be tested in Leg 1, where possible, with Face A being that opposite the backing. (Grinding of the weld face or testing from additional weld faces may be necessary to permit complete scanning of the weld root.)
- Examination in Leg II or III shall be made only to satisfy provisions of this table or when necessary to test weld areas made inaccessible by an unground weld surface, or interference with other portions of the weldment.
- A maximum of Leg III shall be used only where thickness or geometry prevents scanning of complete weld areas and heat-affected zones in Leg I or Leg II.
- On tension welds in cyclically loaded structures, the top quarter of thickness shall be tested with the final leg of sound progressing from Face B toward Face A, and the bottom quarter of thickness shall be tested with the final leg of sound progressing from Face A toward Face B; i.e., the top quarter of thickness shall be tested either from A in Leg II or from B in Leg I at the contractor's option, unless otherwise specified in the contract documents.
- The weld face indicated shall be ground flush before using procedure 1G, 6, 8, 9, 12, 14, or 15. Face A for both connected members shall be in the same plane.

(See Legend on next page)

Table 20 (Continued)
Ultrasonic Testing Angle

Legend:

X — Check from Face “C.”

G — Grind weld face flush.

O — Not required.

A Face — The face of the material from which the initial scanning is done (on T- and corner joints, follow above sketches).

B Face — Opposite the “A” face (same plate).

C Face — The face opposite the weld on the connecting member or a T- or corner joint.

* — Required only where reference level indication of discontinuity is noted in fusion zone (weld metal to base metal interface) while searching at scanning level with primary procedures selected from first column.

** — Use 15 in. [375 mm] or 20 in. [500 mm] screen distance calibration.

P — Pitch and catch shall be conducted for further discontinuity evaluation in only the middle half of the material thickness with only 45° or 70° transducers of equal specification, both facing the weld. (Transducers shall be held in a fixture to control positioning—see sketch.) Amplitude calibration for pitch and catch is normally made by calibrating a single search unit. When switching to dual search units for pitch and catch inspection, there should be assurance that this calibration does not change as a result of instrument variables.

F — Weld metal to base metal interface indications shall be further evaluated with either 70°, 60°, or 45° transducer—whichever sound path is nearest to being perpendicular to the suspected fusion surface.

Procedure Legend

Area of Weld Thickness

No.	Area of Weld Thickness		
	Top Quarter	Middle Half	Bottom Quarter
1	70°	70°	70°
2	60°	60°	60°
3	45°	45°	45°
4	60°	70°	70°
5	45°	70°	70°
6	70°G A	70°	60°
7	60° B	70°	60°
8	70°G A	60°	60°
9	70°G A	60°	45°
10	60° B	60°	60°
11	45° B	70°**	45°
12	70°G A	45°	70°G B
13	45° B	45°	45°
14	70°G A	45°	45°
15	70°G A	70°A B	70°G B

Table 21
Ultrasonic Acceptance and Rejection Criteria

Weld Thickness, ⁽¹⁾ in. [mm] and Search Unit Angle											
Flaw Class	≥ 5/16 [8] to ≤ 3/4 [20]	> 3/4 [20] to ≤ 1-1/2 [40]	> 1-1/2 [40] to ≤ 2-1/2 [65]			> 2-1/2 [65] to ≤ 4 [100]			> 4 [100] to ≤ 8 [200]		
	70°	70°	70°	60°	45°	70°	60°	45°	70°	60°	45°
Class A	+10 & lower	+8 & lower	+4 & lower	+7 & lower	+9 & lower	+1 & lower	+4 & lower	+6 & lower	-2 & lower	+1 & lower	+3 & lower
Class B	+11	+9	+5 +6	+8 +9	+10 +11	+2 +3	+5 +6	+7 +8	-1 +0	+2 +3	+4 +5
Class C	+12	+10	+7 +8	+10 +11	+12 +13	+4 +5	+7 +8	+9 +10	+1 +2	+4 +5	+6 +7
Class D	+13 & up	+11 & up	+9 & up	+12 & up	+14 & up	+6 & up	+9 & up	+11 & up	+3 & up	+6 & up	+8 & up

Note:

(1) Weld thickness shall be defined as the nominal thickness of the thinner of the two parts being joined.

General Notes:

- Class B and C flaws shall be separated by at least 2L, L being the length of the longer flaw, except that when two or more such flaws are not separated by at least 2L, but the combined length of flaws and their separation distance is equal to or less than the maximum allowable length under the provisions of Class B or C, the flaw shall be considered a single acceptable flaw.
- Class B and C flaws shall not begin at a distance less than 2L from the end of the weld, L being the flaw length.
- Discontinuities detected at "scanning level" in the root face area of complete penetration double groove weld joints shall be evaluated using an indicating rating 4 dB more sensitive than described in 10.15.6.5 when such welds are designated as "tension welds" on the drawing (subtract 4 dB from the indication rating "d"). This shall not apply if the weld joint is backgouged to sound metal to remove the root face, and magnetic particle examination is used to verify that the root face has been removed.

Class A (Large Flaws)

Any indication in this category shall be rejected (regardless of length).

Class B (Medium Flaws)

Any indication in this category having a length greater than 3/4 in. [20 mm] shall be rejected.

Class C (Small Flaws)

Any indication in this category having a length greater than 2 in. [50 mm] length in the middle half or 3/4 in. [20 mm] length in the top of bottom quarter of weld thickness shall be rejected.

Class D (Minor Flaws)

Any indication in this category shall be accepted regardless of length or location in the weld.

Scanning Levels

Sound path, ⁽²⁾ in. [mm]	Above Zero Reference, dB
≤ 2-1/2 [65]	20
> 2-1/2 [65] to ≤ 5 [125]	25
> 5 [125] to ≤ 10 [250]	35
> 10 [250] to ≤ 15 [375]	45

Note: (2) refers to sound path distance; NOT material thickness.

10.15.9 A report form which clearly identifies the work and the area of inspection shall be completed by the ultrasonic inspector at the time of the inspection. The report form for welds that are unacceptable need only contain sufficient information to identify the weld, the inspector (signature), and the acceptability of the weld. An example of such a form is shown in Annex A.

10.15.10 All report forms pertaining to a weld subject to contractual ultrasonic testing by the Manufacturer for

the Owner, including those that show unacceptable quality prior to repair, shall be available for review by the Owner's representative before the weld is accepted.

10.15.11 A full set of completed report forms of welds subject to contractual ultrasonic testing by the Manufacturer for the Owner, including any that show unacceptable quality prior to repair, shall be delivered to the Owner upon completion of the work. The Manufacturer's obligation to retain ultrasonic reports shall cease

(1) upon delivery of this full set to the Owner or (2) at the end of one full year after completion of the Manufacturer's work, in the event that delivery is not required, or as otherwise provided in the contract.

10.16 Magnetic Particle Examination of Welds

10.16.1 The procedure and technique for magnetic particle examination, when required, shall be in accordance with ASTM E 709, *Practice for Magnetic Particle Inspection* (latest edition), and the standards of acceptance shall be in accordance with 10.16.4.

10.16.2 Variations in testing procedure, equipment, and acceptance standards not included in this specification may be used upon agreement between the Manufacturer and the Owner.

10.16.3 Welds subject to magnetic particle examination shall first be subject to visual examination in accordance with the requirements of 10.6 and 10.7.

10.16.4 Welds that are subject to magnetic particle examination shall be unacceptable if any discontinuities exceed the following limits:

(1) A magnetic particle indication of any porosity or fusion-type discontinuity, that is 1/16 in. [1.5 mm] or larger in greatest dimension, shall not exceed the size, B, indicated in Figure 33 for the effective throat or weld size involved. The distance from any indication of an acceptable porosity or fusion-type discontinuity to another discontinuity, to an edge, or to any intersecting weld shall not be less than the minimum clearance, C, indicated by Figure 33 for the size of discontinuity under examination. (Annex B illustrates the application of the requirements given. A sample report form is shown in Annex A.)

(2) Discontinuities meeting the requirements of 10.16.4(1) and having a greatest dimension of less than 1/16 in. [1.5 mm] are nevertheless not acceptable if the sum of their greatest dimensions exceeds 3/8 in. [10 mm] in any linear inch [25 mm] of weld.

(3) The limitations given by Figure 33 for a groove weld effective throat of 1-1/2 in. [40 mm] shall apply to groove welds of greater thickness.

10.17 Liquid Penetrant Examination of Welds

10.17.1 When liquid penetrant examination is required, the procedure and technique shall be in accordance with ASTM E 165, *Recommended Practice for Liquid Penetrant Inspection*. The standard of acceptance shall be in accordance with 10.17.3.

10.17.2 Variations in testing procedure, equipment, and acceptance standards not included in this specification may be used upon agreement between the Manufacturer and Owner.

10.17.3 Welds that are subject to liquid penetrant examination shall be evaluated on the basis of the requirements for visual inspection as defined in 10.6 and 10.7.

11. Field Weld Repair and Modification

11.1 General. Repairs and modifications shall require the approval of the Engineer (see 11.3.1). The material composition of the components shall be identified and the welding procedures approved by the Engineer before starting repair or modification. The repair and modification work shall conform to all applicable sections of this specification. When a modification includes removal, addition, or alteration of structural members, the Engineer shall verify that the original design requirements are satisfied. This section is a guide to aid the Manufacturer and the Owner by suggesting pertinent items that shall be considered at the time of initial contract negotiations. The eventual need for field weld repairs as a result of normal wear and tear, modification, or accident is often forgotten. Every repair, no matter how small, becomes the total responsibility of the Owner and the organization performing the repair work, who must consider its effect on the equipment involved. The original Manufacturer should be contacted to ensure that the projected repair is advisable and sound from an engineering standpoint. Safe recommended repairs and modifications can only be accomplished with knowledge of the design loading on the equipment and the resulting stresses at the repair locations.

Caution: *Leaking of flammable liquids from pressurized lines may exist and shall be addressed to prevent fires when welding and cutting is performed. Confined space circumstances can also exist on some repair operations.*

11.2 Field Repair—Manufacturer's Responsibility.

The Manufacturer shall furnish, as a part of instruction manuals or as a separate publication, instructions for field repair when required by the contract. The completeness and extent of material identification and welding repair procedures shall be covered in the contract.

11.2.1 Instructions by the Manufacturer shall include the following:

(1) Qualification requirements of the welder performing the repair (see Section 9, Qualification, for minimum requirement).

(2) A list of materials used in the manufacture of the equipment and the location of materials by some appropriate means such as an outline drawing. This shall include lists and locations of those materials that:

(a) Are easily weldable without preheat or postheat treatment, provided ambient temperatures are considered normal, and

(b) Require special welding procedures. For special welding procedures, the Manufacturer shall include information concerning the base metals, filler metals, and preheat or postheat treatment so that properly qualified welders can make an acceptable weld repair.

11.2.2 All field weld repair procedures shall include recommended means for inspection or testing of the repair by the Engineer or the equipment manufacturer and necessary nondestructive testing procedures.

11.2.3 The manufacturers should list special precautions for field welding of their products and other necessary precautions. The following items should be addressed.

11.2.3.1 Field repair should not proceed:

(1) Without adequate preparation (thorough cleaning and joint preparation) and a full review of any previous repairs in the area involved;

(2) Until the welder and weld repair area are adequately protected from the elements, and a proper equipment environment is provided; or

(3) Without considering the stresses on the members.

11.2.3.2 A method by which stresses can be relieved before welding, as well as the sequence of repair, should be considered.

11.2.3.3 The Manufacturer shall indicate weldments and components on which field repairs are not recommended.

11.2.4 Safety precautions and good workmanship instructions listed in the various ANSI and AWS specifications shall be followed, including, but not limited to ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

11.3 Field Repair—Owner's Responsibility

11.3.1 The Owner shall appoint the Engineer who shall be responsible for the actual field execution of the repair work, and the complete detailed adherence to the repair procedures furnished by the Manufacturer.

11.3.2 Owners or their agents shall permit only qualified and properly trained personnel to perform field weld repairs, such as welders qualified in accordance with this specification.

11.3.3 Full and complete records of all repaired welds shall be maintained by means of marked outline drawings or other appropriate documents.

12. Repair and Correction of Defects

12.1 Weld Repairs

12.1.1 Overlap or Excessive Convexity. Excess weld metal shall be removed.

12.1.2 Excessive Concavity of Weld or Crater and Undersize Welds. Prepare surfaces and deposit additional weld metal. All slag shall be removed and the adjacent base metal shall be clean before additional welding.

12.1.3 Cracks in Weld or Base Metal. Determine the extent of the crack by liquid penetrant, magnetic particle examination, or other suitable means. Remove the crack and adjacent sound metal for a 2 in. [50 mm] length beyond each end of the crack.

Prior to rewelding, these areas shall be checked by an appropriate inspection method, such as magnetic particle or liquid penetrant, to ensure complete removal of cracked material. After rewelding in conformance to an approved repair welding procedure, the repaired area(s) shall be reinspected per Section 10.

12.1.4 Undercutting. Undercutting may be repaired by grinding and blending or by welding. It is preferably done by careful grinding and blending. Grinding should be performed with a pencil-type grinder. The grinding marks should be transverse to the length of the weld, and have a 250×10^{-6} in. [6×10^{-6} m] finish or better. Blending shall be done with a slope not to exceed 1 in 3. On plates of 1/2 in. [13 mm] thickness and above, up to 7% reduction of base-material thickness is permitted. Repair of undercut areas by grinding and blending in excess of this amount may be permitted with the approval of the Design Engineer. When undercut is to be repaired by welding, the surfaces should be prepared and then additional weld metal deposited.

12.1.5 Weld areas containing unacceptable incomplete fusion, porosity or slag inclusions shall be removed (see 12.3) and rewelded.

12.2 Base Metal Repairs

12.2.1 Defects in Edges of Plate. If a defect is found in a plate edge that exceeds the limits imposed in Table 7, it shall be removed and repaired in accordance with 7.3.

12.2.2 Arc Strikes and Temporary Attachment Areas. Arc strikes or severed temporary welds shall be ground smooth to ensure that no abrupt change in section exists. The smoothed area shall be inspected by an appropriate nondestructive testing method to ensure that there are no existing cracks or similar discontinuities. The Engineer may require hardness testing of the area to

verify material properties. Any cracks or similar discontinuities shall be repaired in accordance with 12.1.3.

12.3 Removal of Defective Areas. The removal of weld metal or portions of the base metal may be done by machining, grinding, chipping, oxygen gouging, or air carbon arc gouging. It shall be done in such a manner that the remaining weld metal is not nicked or undercut. Oxygen gouging shall not be used on quenched and tempered steel. Unacceptable portions of the weld shall be removed without substantial removal of the base metal. Additional weld metal, to compensate for any deficiency in size, shall be deposited using low-hydrogen electrodes, preferably smaller in diameter than those used for making the original weld, and preferably not more than 5/32 in. [4 mm] in diameter. The surfaces shall be cleaned thoroughly before welding. Defects that occur in material handling that do not affect the structural integrity of the design can be repaired by grinding.

12.4 Distortion and Camber. Members distorted by welding may be straightened by mechanical means or by carefully supervised application of a limited amount of localized heat. The temperature of heated areas, as mea-

sured by approved methods, shall be limited to that imposed by the materials exposed to the heat, but it shall not exceed 1100°F [590°C] for quenched and tempered or normalized and tempered steels, nor 1200°F [650°C] for other steels. The part to be heated for straightening shall be substantially free of stress and external forces, except those stresses resulting from the mechanical straightening method used in conjunction with the application of heat. All heat-straightening operations shall be covered by an approved written procedure (see 7.2.4).

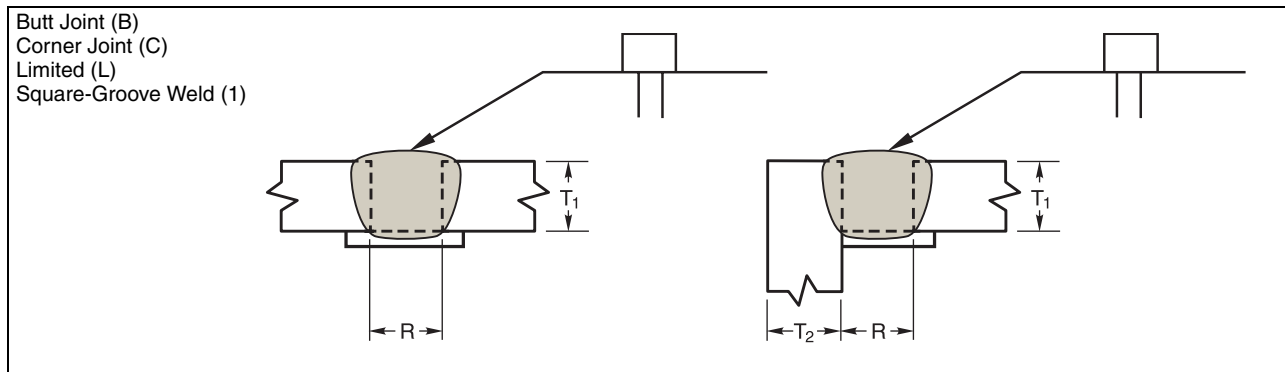
12.5 Correction of Improperly Fitted and Welded Members. If a weld is found to be unacceptable after additional work has rendered it inaccessible, or new conditions make correction of the unacceptable weld dangerous or ineffectual, the original conditions shall be restored by removing welds or members, or both, before the corrections are made. If this is not done, the deficiency shall be compensated for by additional work performed according to an approved revised design. Improperly fitted and welded members require Design Engineer approval prior to cutting apart. Cutting is to be handled by methods similar to those in 12.3.

Mandatory Annex

Annex I

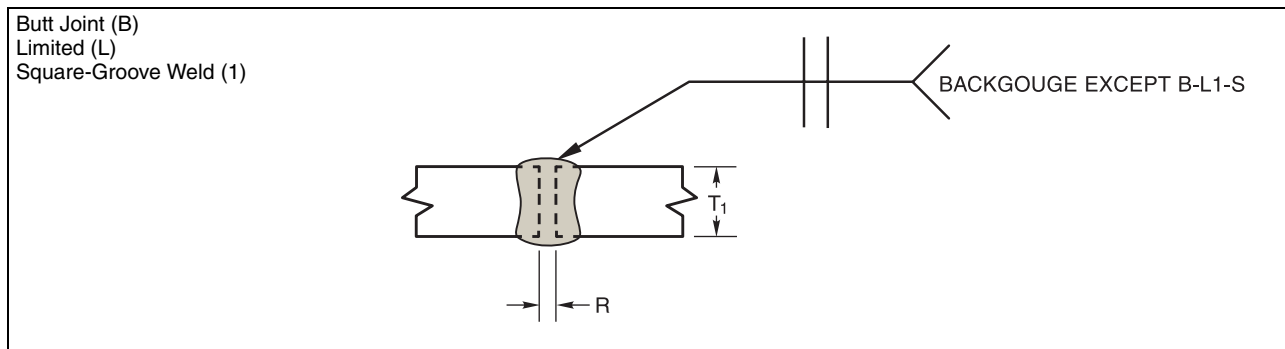
Prequalified Weld Joints

(This Annex is a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, and includes mandatory elements for use with this standard.)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening	Tolerances, in. [mm]				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-L1a	1/4 [6] max	—	R = T ₁	+1/16 [2], -0	+1/4 [6], -1/16 [2]	All	—	—
	C-L1a	1/4 [6] max	U	R = T ₁	+1/16 [2], -0	+1/4 [6], -1/16 [2]	All	—	—
GMAW FCAW	B-L1a-GF	3/8 [10] max	—	R = T ₁	+1/16 [2], -0	+1/4 [6], -1/16 [2]	All	Not Required	A

(A)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Tolerances, in. [mm]				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-L1b	1/4 [6] max	—	$R = \frac{T_1}{2}$	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	—	C
GMAW FCAW	B-L1b-GF	3/8 [10] max	—	R = 0 to 1/8 [3]	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	Not Required	A, C
SAW	B-L1-S	3/8 [10] max	—	R = 0	±0	+1/16 [2], -0	Flat	—	D

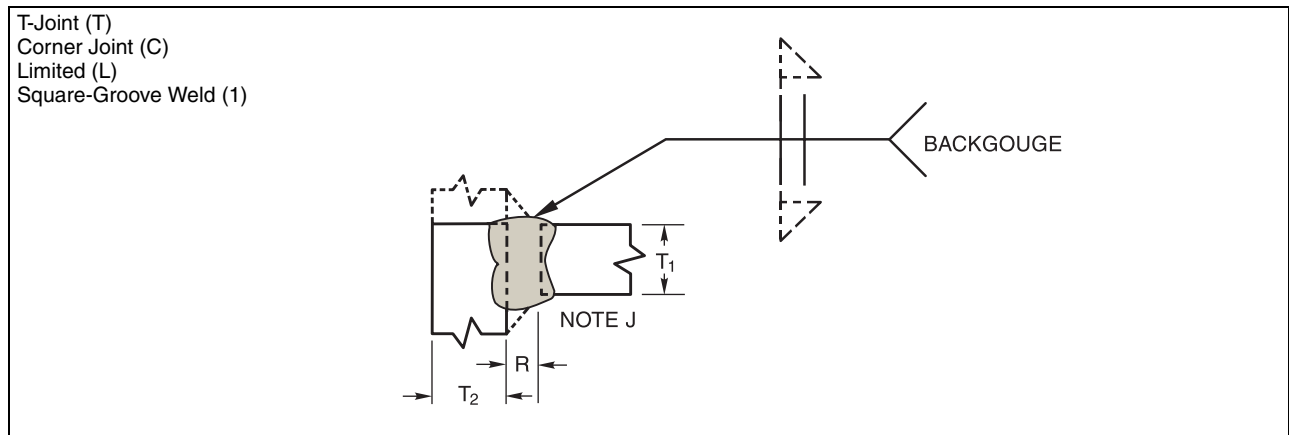
(B)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note C: Gouge root before welding second side.

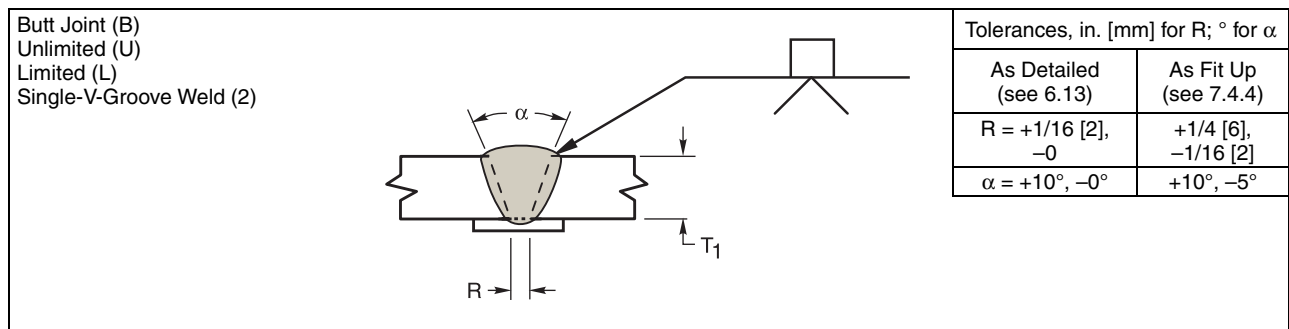
Note D: Welds shall be centered on joint.

Figure I.1—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Tolerances, in. [mm]				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	TC-L1b	1/4 [6] max	U	$R = \frac{T_1}{2}$	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	—	C, J
GMAW FCAW	TC-L1-GF	3/8 [10] max	U	R = 0 to 1/8 [3]	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	Not Required	A, C, J
SAW	TC-L1-S	3/8 [10] max	U	R = 0	±0	+1/16 [2], -0	Flat	—	C, J

(C)



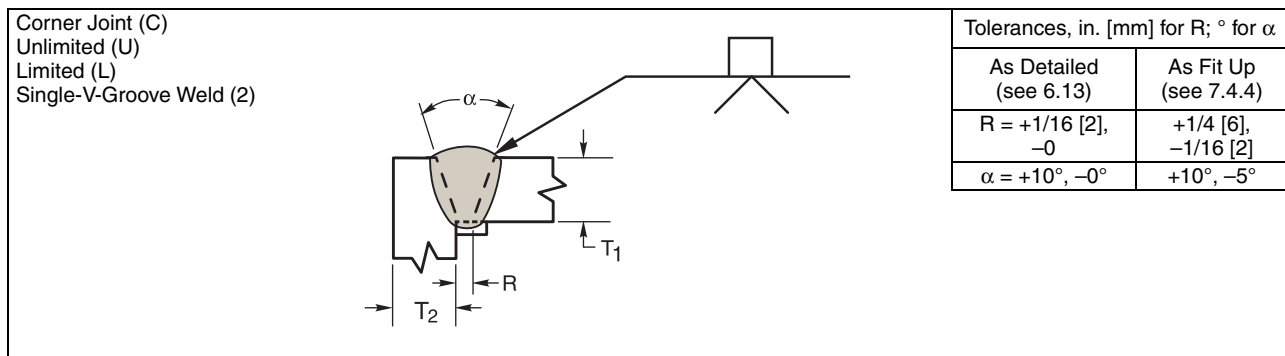
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions ⁽¹⁾	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Groove Angle			
SMAW	B-U2a	U	—	R = 1/4 [6]	alpha = 45°	All	—	—
				R = 3/8 [10]	alpha = 30°	F, V, OH	—	—
				R = 1/2 [13]	alpha = 20°	F, V, OH	—	—
GMAW FCAW	B-U2a-GF	U	—	R = 3/16 [5]	alpha = 30°	F, V, OH	Required	A
				R = 1/4 [6]	alpha = 30°	F, V, OH	Not Req.	A
				R = 3/8 [10]	alpha = 45°	F, V, OH	Not Req.	A
SAW	B-L2a-S	2 [50] max	—	R = 1/4 [6]	alpha = 30°	F	—	—
SAW	B-U2-S	U	—	R = 5/8 [16]	alpha = 20°	F	—	—

(D)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
 Note C: Gouge root before welding other side.
 Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

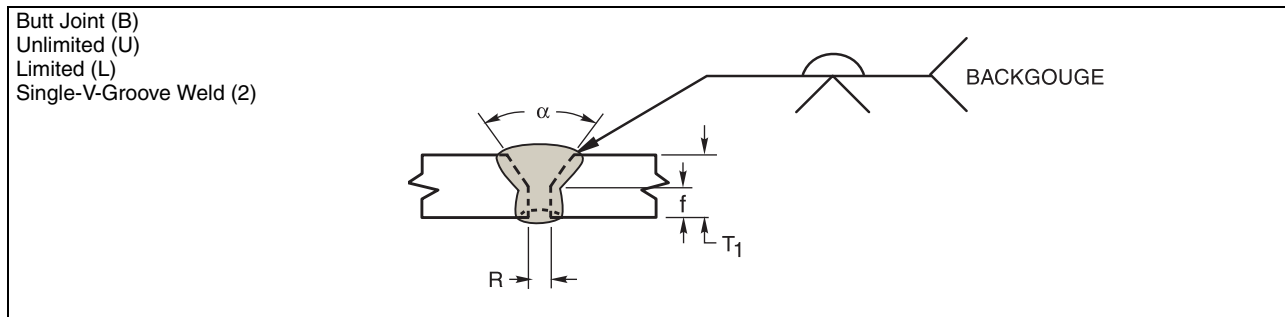
(1) F = Flat, OH = Overhead, V = Vertical

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions ⁽¹⁾	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Groove Angle			
SMAW	C-U2a	U	—	R = 1/4 [6]	α = 45°	All	—	—
				R = 3/8 [10]	α = 30°	F, V, OH	—	—
				R = 1/2 [13]	α = 20°	F, V, OH	—	—
GMAW FCAW	C-U2a-GF	U	—	R = 3/16 [5]	α = 30°	F, V, OH	Required	A
				R = 3/8 [10]	α = 30°	F, V, OH	Not Req.	A
				R = 1/4 [6]	α = 45°	F, V, OH	Not Req.	A
SAW	C-L2a-S	2 [50] max	—	R = 1/4 [6]	α = 30°	F	—	—
SAW	C-U2-S	U	—	R = 5/8 [16]	α = 20°	F	—	—

(E)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-U2	U	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 60°	+1/16 [2], -0 +1/16 [2], -0 + 10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	—	C
GMAW FCAW	B-U2-GF	U	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 60°	+1/16 [2], -0 +1/16 [2], -0 + 10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	Not Required	A, C
SAW	B-L2c-S	Over 1/2 [13] to 1 [25]	—	R = 0 f = 1/4 [6] max α = 60°	R = ±0 f = +0, -f α = +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	F	—	C
		Over 1 [25] to 1-1/2 [40]	—	R = 0 f = 1/2 [13] max α = 60°					
		Over 1-1/2 [40] to 2 [50]	—	R = 0 f = 5/8 [16] max α = 60°					

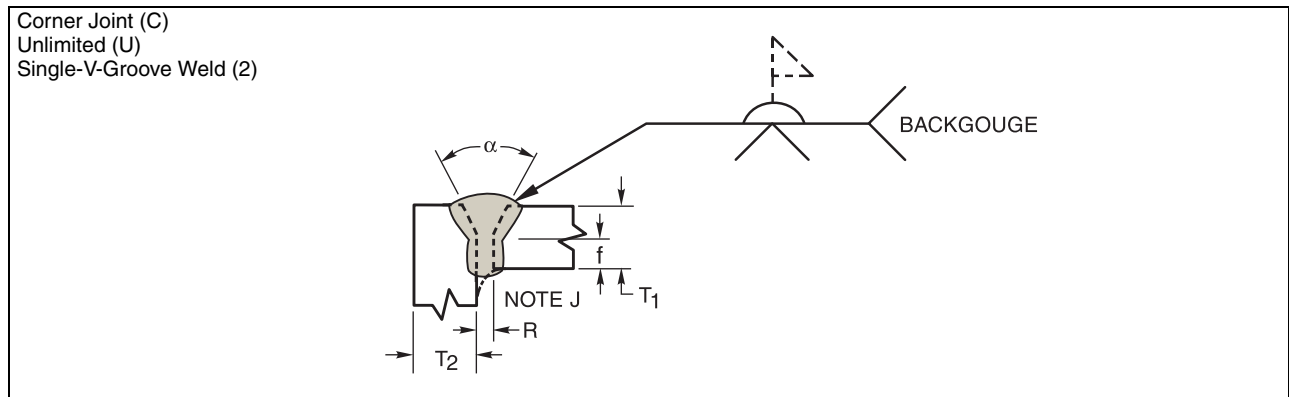
(F)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note C: Gouge root before welding other side.

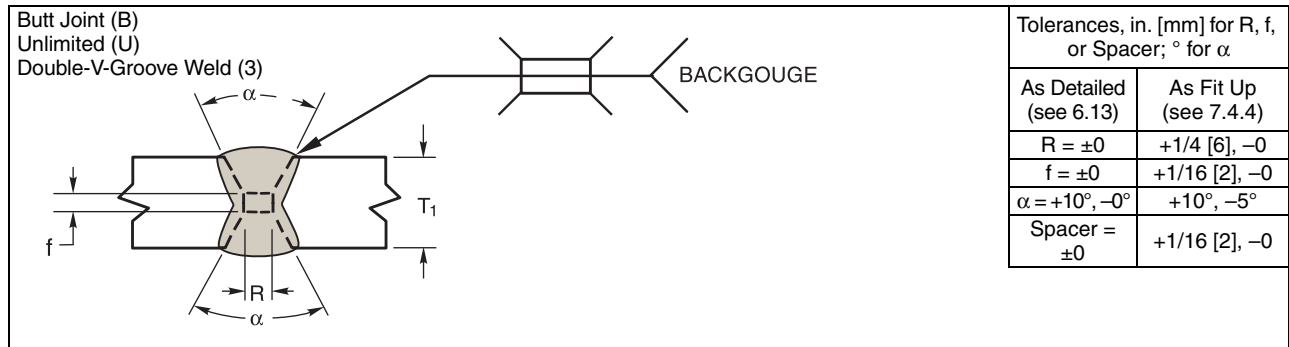
(1) F = Flat, OH = Overhead, V = Vertical

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	C-U2	U	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 60°	+1/16 [2], -0 +1/16 [2], -0 + 10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	—	C, J
GMAW FCAW	C-U2-GF	U	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 60°	+1/16 [2], -0 +1/16 [2], -0 + 10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	Not Required	A, C, J
SAW	C-U2b-S	U	U	R = 0 f = 1/4 [6] max α = 60°	R = ±0 f = +0, -1/4 [6] α = +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	Flat	—	C, J, K

(G)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions ⁽¹⁾	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SAW	B-U3a-S	U Spacer = 1/4R	—	R = 5/8 [16]	f = 0 to 1/4 [6]	α = 20°	F	—	C, M

(H)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note C: Gouge root before welding other side.
- Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
- Note K: Weld root after welding at least one pass on narrow side.
- Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

(1) F = Flat, OH = Overhead, V = Vertical

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

Butt Joint (B) Unlimited (U) Double-V-Groove Weld (3)						For B-U3c-S only, in. [mm]			
						T ₁	S ₁		
				>2 [51] to ≤2-1/2 [63]	1-3/8 [35]				
				>2-1/2 [63] to ≤3 [75]	1-3/4 [44]				
				>3 [75] to ≤3-5/8 [92]	2-1/8 [54]				
				>3-5/8 [92] to ≤4 [102]	2-3/8 [60]				
				>4 [102] to ≤4-3/4 [121]	2-3/4 [70]				
				>4-3/4 [121] to ≤5-1/2 [140]	3-1/4 [83]				
				>5-1/2 [140] to ≤6-1/4 [159]	3-3/4 [95]				
				For T ₁ > 6-1/4 [159], or T ₁ ≤ 2 [50] S ₁ = 2/3 (T ₁ - 1/4 [6])					
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm] Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
SMAW	B-U3b	U	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = β = 60°	+1/16 [2], -0 +1/16 [2], -0 +10°, -0°	+1/16 [2], -1/8 [3]	All	—	C, M
GMAW FCAW	B-U3-GF	preferably 5/8 [16] or thicker	—	R = 0 f = 1/4 [6] max α = 60°	±0 +0, -f +10°, -0°	Not Limited +10°, -5°	All	Not Required	A, C, M
SAW	B-U3c-S	U	—	R = 0 f = 1/4 [6] max α = 60°	±0 +0, -f +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	Flat	—	C, M
To find S ₁ see table above; S ₂ = T ₁ - (S ₁ + f)									

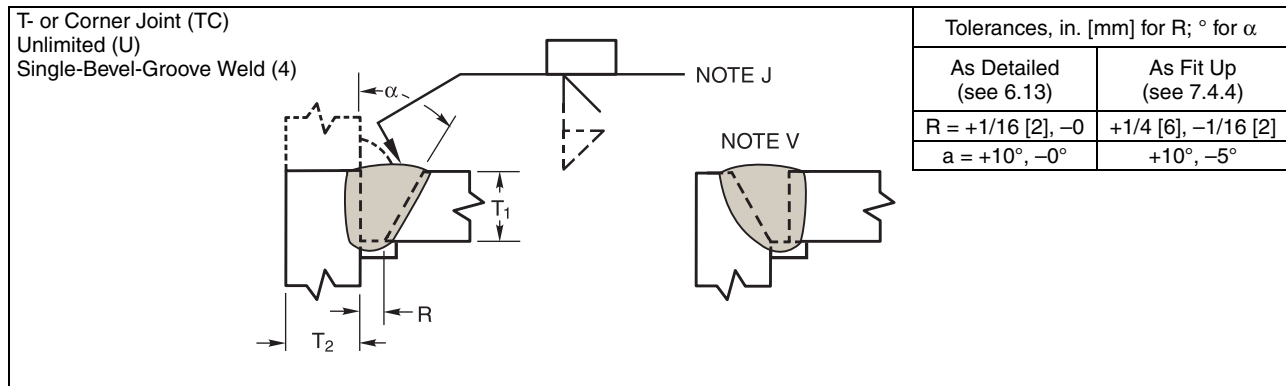
(I)

Butt Joint (B) Unlimited (U) Single-Bevel-Groove Weld (4)						Tolerances, in. [mm] for R; ° for α		
						As Detailed (see 6.13)	As Fit Up (see 7.4.4)	
				R = +1/16 [2], -0	+1/4 [6], -1/16 [2]			
				α = +10°, -0°	+10°, -5°			
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Groove Angle			
SMAW	B-U4a	U	—	R = 1/4 [6]	α = 45°	All	—	Br
				R = 3/8 [10]	α = 30°			
GMAW FCAW	B-U4a-GF	U	—	R = 3/16 [5]	α = 30°	All	Required	A
				R = 1/4 [6]	α = 45°			
				R = 3/8 [10]	α = 30°	Flat	Not Req.	A

(J)

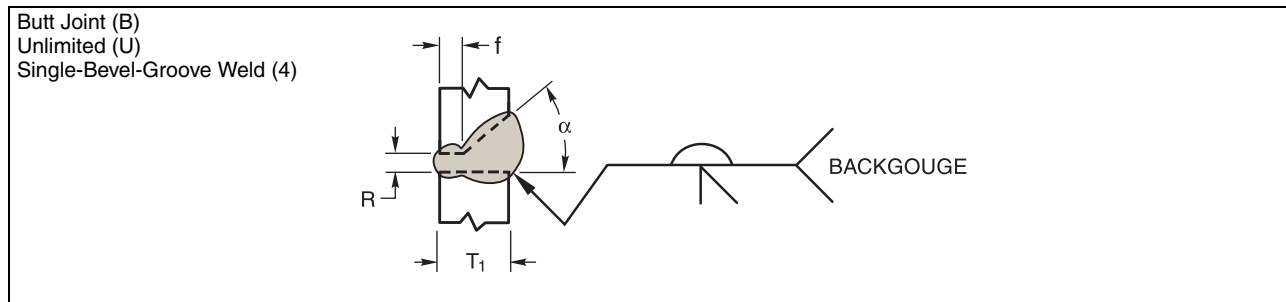
- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note Br: Dynamic load application limits these joints to the horizontal welding position.
- Note C: Gouge root before welding second side.
- Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions ⁽¹⁾	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Groove Angle			
SMAW	TC-U4a	U	U	R = 1/4 [6]	$\alpha = 45^\circ$	All	—	J, V
				R = 3/8 [10]	$\alpha = 30^\circ$	F, V, OH	—	J, V
GMAW FCAW	TC-U4a-GF	U	U	R = 3/16 [5]	$\alpha = 30^\circ$	All	Required	A, J, V
				R = 3/8 [10]	$\alpha = 30^\circ$	F	Not Req.	A, J, V
				R = 1/4 [6]	$\alpha = 45^\circ$	All	Not Req.	A, J, V
SAW	TC-U4a-S	U	U	R = 3/8 [10]	$\alpha = 30^\circ$	F	—	J, V
				R = 1/4 [6]	$\alpha = 45^\circ$	F	—	J, V

(K)



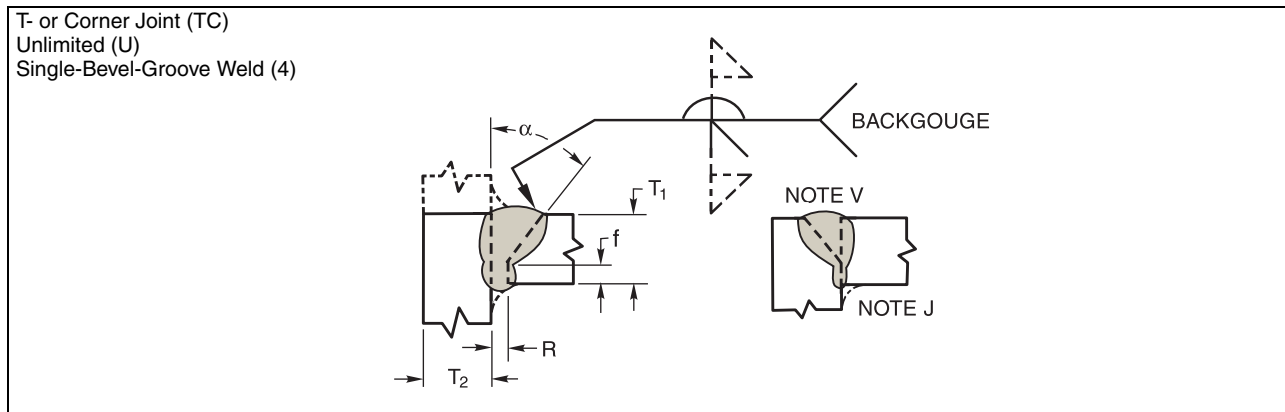
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-U4b	U	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] $\alpha = 45^\circ$	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	—	C
GMAW FCAW	B-U4b-GF	U	—		+1/16 [2], -0 +10°, -0°	Not Limited 10°, -5°	All	Not Required	A, C

(L)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note C: Gouge root before welding second side.
- Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
- Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

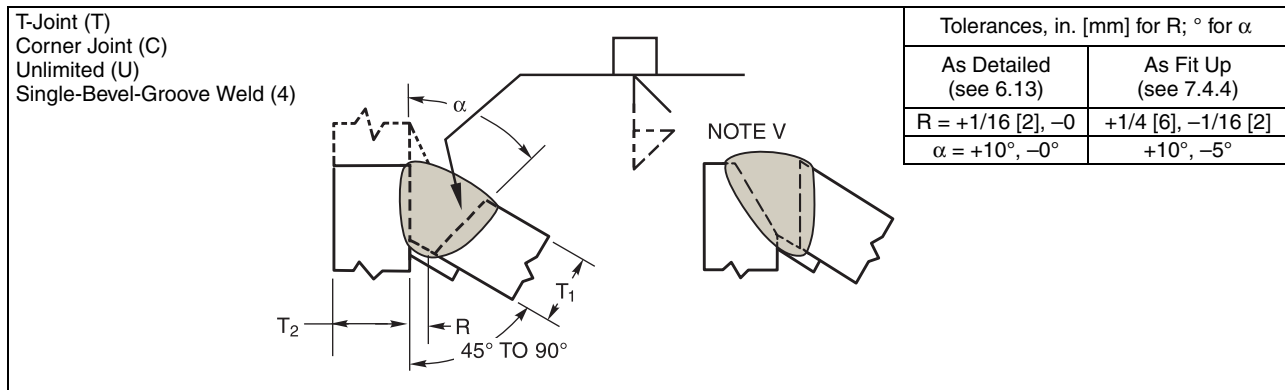
(1) F = Flat, OH = Overhead, V = Vertical

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes	
		T ₁	T ₂	Root Opening, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)				As Fit Up (see 7.4.4)
SMAW	TC-U4b	U	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45°	+1/16 [2], -0 +1/16 [2], -0 +10°, -0°	+1/16 [2], -1/8 [3]	All	—	C, J, V
GMAW FCAW	TC-U4b-GF	U	U	R = 0 f = 0 to 1/8 [3] α = 45°	±0 +0, -1/8 [3] +10°, -0°	Not Limited +10°, -5°	All	Not Required	A, C
SAW	TC-U4b-S	U	U	R = 0 f = 1/4 [6] max α = 60°	±0 +0, -1/8 [3] +10°, -0°	+1/4 [6], -0 ±1/16 [2] +10°, -5°	Flat	—	C, J, V, Y

(M)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Groove Angle			
GMAW FCAW	TC-U4d-GF	U	U	R = 3/16 [5] R = 3/8 [10] R = 1/4 [6]	α = 30° α = 30° α = 45°	All Flat All	Required Not Req. Not Req.	A, J, V
SAW	TC-U4d-S	U	U	R = 3/8 [10] R = 1/4 [6]	α = 30° α = 45°	Flat	—	J, V

(N)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
 Note C: Gouge root before welding second side.
 Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
 Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.
 Note Y: Shielded metal arc or submerged arc backing fillet weld required.

(1) F = Flat, OH = Overhead, V = Vertical

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

T-Joint (T)
 Corner Joint (C)
 Unlimited (U)
 Single-Bevel-Groove Weld (4)

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	TC-U4c	U	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45°	+1/16 [2], -0	+1/16 [2], -1/8 [3]	All	—	C, J, V
GMAW FCAW	TC-U4c-GF	U	U	R = 0 f = 1/4 [6] max α = 60°	+1/16 [2], -0 +10°, -0°	Not Limited +10°, -5°	All	Not Required	A, C, J, V
SAW	TC-L4c-S	U	U	R = 0 f = 1/4 [6] max α = 60°	±0 +0, -1/8 [3] +10°, -0°	+1/4 [6], -0 ±1/16 [2] +10°, -5°	Flat	—	C, J, V, Y

(O)

Butt Joint (B)
 T-Joint (T)
 Corner Joint (C)
 Unlimited (U)
 Single-Bevel-Groove Weld (4)

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	B-U5b	U	—	R = 1/4 [6]	f = 0 to 1/8 [3]	α = 45°	All	—	C, M
	TC-U5a	U, preferably 5/8 [16] or thicker Spacer = 1/8R	U	R = 1/4 [6]	f = 0 to 1/8 [3]	α = 45°	All	—	C, J, M, V
				R = 3/8 [10]	f = 0 to 1/8 [3]	α = 30°	Flat & Overhead	—	C, J, M, V

Tolerances, in. [mm] for R, f, & Spacer; ° for α	
As Detailed (see 6.13)	As Fit Up (see 7.4.4)
R = ±0	+1/4 [6], -0
f = +1/16 [2], -0	±1/16 [2]
α = +10°, -0°	+10°, -5°
Spacer = +1/16 [2], -0	+1/8 [3], -0

Spacer same steel as base metal.

(P)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note C: Gouge root before welding second side.
- Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
- Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.
- Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.
- Note Y: Shielded metal arc or submerged arc backing weld required.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

Butt Joint (B)
Unlimited (U)
Double-Bevel-Groove Weld (5)

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes	
		T ₁	T ₂	Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α & β				
					As Detailed (see 6.13)				As Fit Up (see 7.4.4)
SMAW	B-U5a	U, preferably 5/8 [16] or thicker	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45° β = 0° to 15°	+1/16 [2], -0 +1/16 [2], -0 α + β +10° -0°	+1/16 [2], -1/8 [3] Not Limited α + β +10° -5°	All	—	C, M, Z
GMAW FCAW	B-U5-GF	U, preferably 5/8 [16] or thicker	—	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45° β = 0° to 15°	+1/16 [2], -0 +1/16 [2], -0 α + β +10° -0°	+1/16 [2], -0 +1/16 [2], -0 α + β +10° -0°	All	Not Required	A, C, M

(Q)

T- or Corner Joint (TC)
Unlimited (U)
Double-Bevel-Groove Weld (5)

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes	
		T ₁	T ₂	Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)				As Fit Up (see 7.4.4)
SMAW	TC-U5b	U	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45°	+1/16 [2], -0 +1/16 [2], -0 + 10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	—	C, J, M, V
GMAW FCAW	TC-U5-GF	U	U	R = 0 f = 3/16 [5] max α = 60°	±0 +0, -3/16 [5] +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	All	Not Required	A, C, J, M, V
SAW	TC-U5-S	U	U	R = 0 f = 3/16 [5] max α = 60°	±0 +0, -3/16 [5] +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	Flat	—	C, J, M, V

(R)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note C: Gouge root before welding other side.
- Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
- Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.
- Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.
- Note Z: When lower plate is beveled, make the first root pass on this side.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

T-Joint (T) Corner Joint (C) Unlimited (U) Double-Bevel-Groove Weld (5)							Tolerances, in. [mm] for R, f, & Spacer; ° for α			
				As Detailed (see 6.13)		As Fit Up (see 7.4.4)				
				R = ±0		+1/4 [6], -0				
				f = +1/16 [2], -0		±1/16 [2]				
				α = +10°, -0°		+10°, -5°				
				Spacer = +1/16 [2], -0		+1/8 [3], -0				
				Spacer same steel as base metal.						
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes	
		T ₁	T ₂	Root Opening in. [mm]	Root Face, in. [mm]	Groove Angle				
SMAW	TC-U5c	U ⁽¹⁾ Spacer = 1/8R		U	R = 1/4 [6]	f = 0 to 1/8 [3]	α = 45°	All	—	C, J, M, V
					R = 3/8 [10]	f = 0 to 1/8 [3]	α = 30°			

(S)

T-Joint (T) Corner Joint (C) Unlimited (U) Double-Bevel-Groove Weld (5)									
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α		Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂		As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	TC-U5d	U ⁽¹⁾	U	R = 0 to 1/8 [3] f = 0 to 1/8 [3] α = 45°	+1/16 [2], -0 +1/16 [2], -0 +10°, -0°	+1/16 [2], -1/8 [3] Not Limited +10°, -5°	All	—	C, J, M, V

(T)

Note C: Gouge root before welding other side.

Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

(1) It is recommended that T₁ is 5/8 in. [16 mm] or thicker.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

Butt Joint (B) Corner Joint (C) Unlimited (U) Single-U-Groove Weld (6)						Tolerances, in. [mm] for R, f, & r; ° for α					
						As Detailed (see 6.13)		As Fit Up (see 7.4.4)			
						R = +1/16 [2], -0		+1/16 [2], -1/8 [3]			
						f = ±1/16 [2]		Not Limited			
						$\alpha = +10^\circ, -0^\circ$		+10°, -5°			
						r = +1/8 [3], -0		+1/8 [3], -0			
Groove Radius (r) = 1/4 in. [6 mm] for all											
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes		
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle					
SMAW	B-U6	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 45^\circ$	All	—	C		
				R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	F, OH ⁽¹⁾	—	C		
	C-U6	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 45^\circ$	All	—	C, J		
				R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	F, OH ⁽¹⁾	—	C, J		
GMAW FCAW	B-U6-GF	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	All	Not Req.	C, M		
	C-U6-GF	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	All	Not Req.	A, C, J		

(U)

Butt-Joint (B) Unlimited (U) Double-U-Groove Weld (7)						Tolerances, in. [mm] for R, f, & r; ° for α					
						As Detailed (see 6.13)		As Fit Up (see 7.4.4)			
						For B-U7 and B-U7-GF					
						R = +1/16 [2], -0		+1/16 [2], -1/8 [3]			
						f = ±1/16 [2], -0		Not Limited			
						$\alpha = +10^\circ, -0^\circ$		+10°, -5°			
r = +1/4 [6], -0		±1/16 [2]									
Groove Radius (r) = 1/4 in. [6 mm] for all											
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes		
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle					
SMAW	B-U7	U	—	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 45^\circ$	All	—	C, M,		
				R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	F, OH ⁽¹⁾	—	C, M		
GMAW FCAW	B-U7-GF	U	—	R = 0 to 1/8 [3]	f = 1/8 [3]	$\alpha = 20^\circ$	All	Not Required	A, C, M		
SAW	B-U7-S	U	—	R = 0	f = 1/4 [6] max	$\alpha = 20^\circ$	Flat	—	C, M		

(V)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note C: Gouge root before welding other side.

Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

(1) F = Flat, OH = Overhead

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

Butt Joint (B) Unlimited (U) Single-J-Groove Weld (8)		Tolerances, in. [mm] for R, f, & r; ° for α	
		As Detailed (see 6.13)	As Fit Up (see 7.4.4)
		R = +1/16 [2], -0	+1/16 [2], -1/8 [3]
		f = +1/16 [2], -0	Not Limited
		α = +10°, -0°	+10°, -5°
r = +1/4 [6], -0	±1/16 [2]		

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	B-U8	U	—	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All	—	C
GMAW FCAW	B-U8-GF	U	—	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All	Not Req.	A, C

(W)

T-Joint (T) Corner Joint (C) Unlimited (U) Single-J-Groove Weld (8)		Tolerances, in. [mm] for R, f, & r; ° for α	
		As Detailed (see 6.13)	As Fit Up (see 7.4.4)
		R = +1/16 [2], -0	+1/16 [2], -1/8 [3]
		f = +1/16 [2], -0	Not Limited
		α = +10°, -0°	+10°, -5°
r = +1/4 [6], -0	±1/16 [2]		

Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	TC-U8a	U	U	R = 0 to 1/8 [3]	α = 45°	f = 1/8 [3]	All	—	C, J, V
				R = 0 to 1/8 [3]	α = 30°	f = 1/8 [3]	F, OH ⁽¹⁾	—	C, J, V
GMAW FCAW	TC-U8a-GF	U	U	R = 0 to 1/8 [3]	α = 30°	f = 1/8 [3]	All	Not Required	A, C, J, V

(X)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

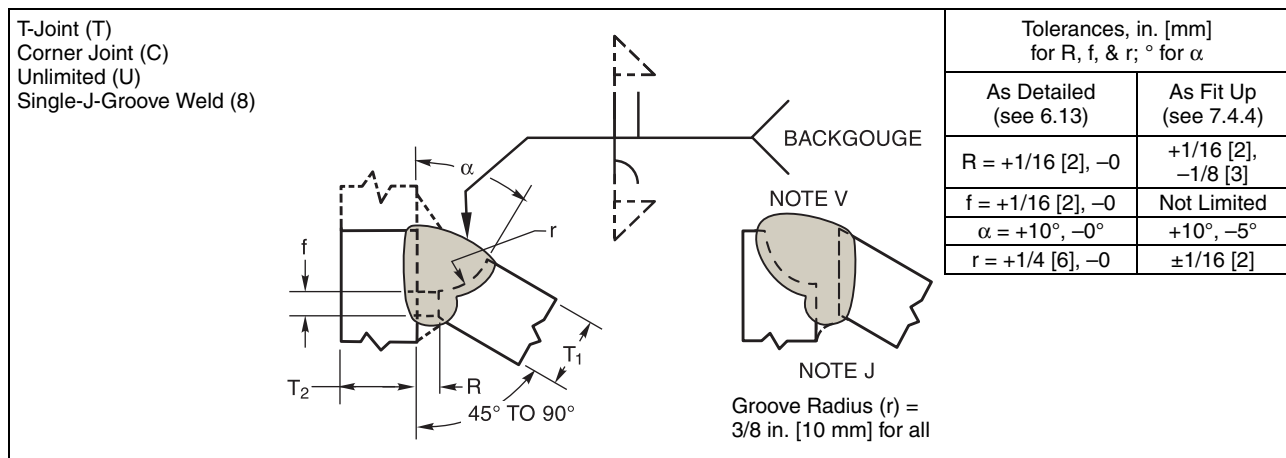
Note C: Gouge root before welding other side.

Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

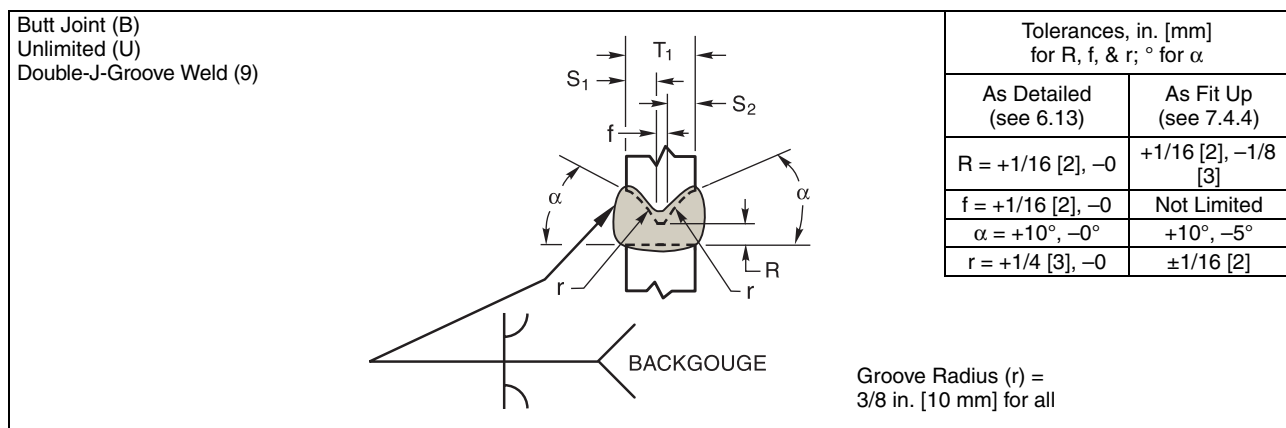
*F = Flat, OH = Overhead

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	TC-U8b	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All F, OH ⁽¹⁾	—	C, J, V
				R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°			
GMAW FCAW	TC-U8-GF	U	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	All	Not Required	A, C, J, V

(Y)
(1) F = Flat, OH = Overhead



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	B-U9	U ⁽¹⁾	—	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All	—	C, M
GMAW FCAW	B-U9-GF	U ⁽¹⁾	—	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	All	Not Required	A, C, M

(Z1)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note C: Gouge root before welding second side.

Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

(1) It is recommended that T₁ is 5/8 in. [16 mm] or thicker.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints

T-Joint (T) Corner Joint (C) Unlimited (U) Double-J-Groove Weld (9)		<p style="text-align: center;">Groove Radius (r) = 3/8 in. [10 mm] for all</p>					Tolerances, in. [mm] for R, f, & r; ° for α		
							As Detailed (see 6.13)	As Fit Up (see 7.4.4)	
							R = +1/16 [2], -0	+1/16 [2], -1/8 [3]	
							f = +1/16 [2], -0	Not Limited	
							α = +10°, -0°	+10°, -5°	
							r = +1/8 [3], -0	±1/16 [2]	
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	TC-U9a	U ⁽¹⁾	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All	—	C, J, M, V
				R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	Flat & Overhead	—	C, J, M, V
GMAW FCAW	TC-U9a-GF	U ⁽¹⁾	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	All	Not Required	A, C, J, M, V

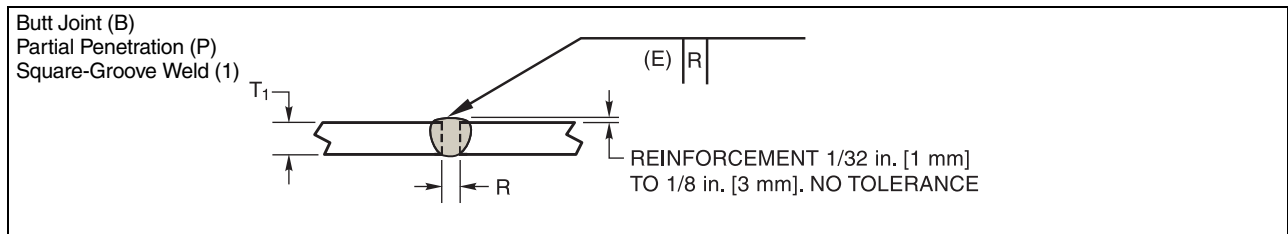
(Z2)

T-Joint (T) Corner Joint (C) Unlimited (U) Double-J-Groove Weld (9)		<p style="text-align: center;">Groove Radius (r) = 3/8 in. [10 mm] for all</p>					Tolerances, in. [mm] for R, f, & r; ° for α		
							As Detailed (see 6.13)	As Fit Up (see 7.4.4)	
							R = +1/16 [2], -0	+1/16 [2], -1/8 [3]	
							f = +1/16 [2], -0	Not Limited	
							α = +10°, -0°	+10°, -5°	
							r = +1/8 [6], -0	±1/16 [2]	
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T ₁	T ₂	Root Opening in. [mm]	Root Face, in. [mm]	Groove Angle			
SMAW	TC-U9b	U ⁽¹⁾	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 45°	All	—	C, J, M, V
				R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	Flat & Overhead	—	C, J, M, V
GMAW FCAW	TC-U9b-GF	U ⁽¹⁾	U	R = 0 to 1/8 [3]	f = 1/8 [3]	α = 30°	All	Not Required	A, C, J, M, V

(Z3)

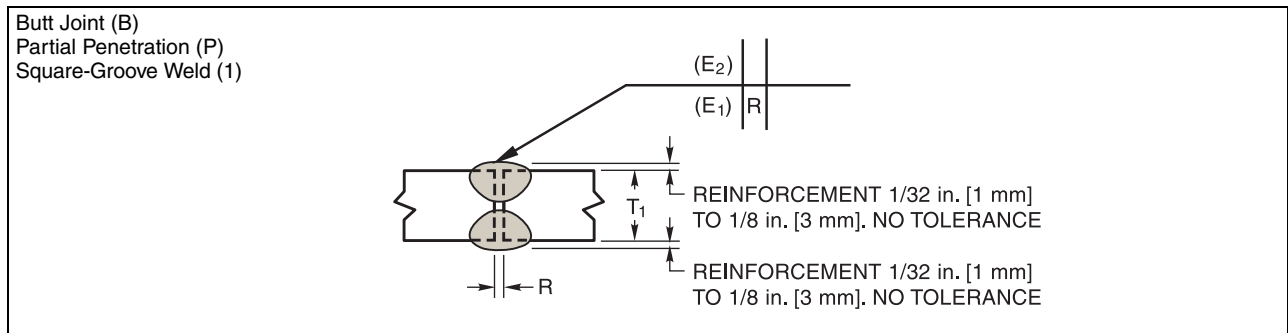
- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
 - Note C: Gouge root before welding other side.
 - Note J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].
 - Note M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.
 - Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.
- (1) It is recommended that T₁ is 5/8 in. [16 mm] or thicker.

Figure I.1 (Continued)—Prequalified Complete Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Tolerances, in. [mm]				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-P1a	1/8 [3]	—	R = 0 to 1/16 [2]	+1/16 [2], -0	±1/16 [2]	All	T ₁ - 1/32 [1]	B
	B-P1c	1/4 [6] max	—	R = $\frac{T_1}{2}$ minimum	+1/16 [2], -0	±1/16 [2]	All	$\frac{T_1}{2}$	B, E

(A)

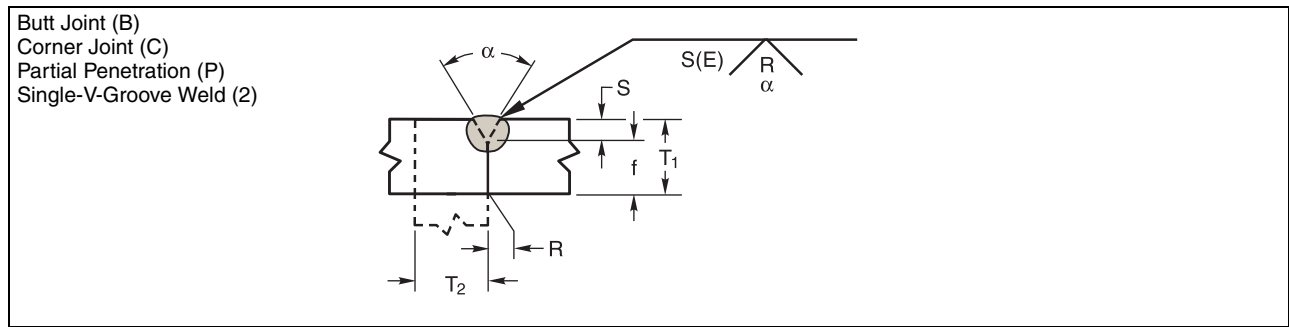


Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening, in. [mm]	Tolerances, in. [mm]				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-P1b	1/4 [6] max	—	R = $\frac{T_1}{2}$ minimum	+1/16 [2], -0	±1/16 [2]	All	$\frac{3T_1}{4}$	C2, E

(B)

- Note B: Joints welded from one side.
- Note C2: Root need not be gouged before welding other side.
- Note E: Minimum effective throat as stated in Table 5.

Figure I.2—Prequalified Partial Joint Penetration Groove Welded Joints



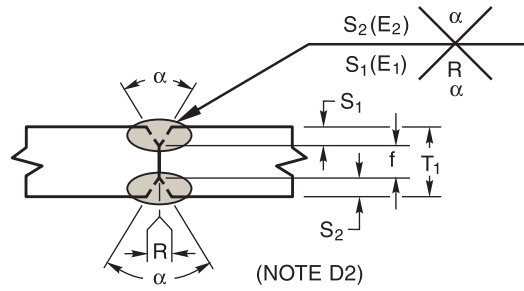
Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes	
		T ₁	T ₂	Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)				As Fit Up (see 7.4.4)
SMAW	BC-P2	1/4 [6] min	U	R = 0 f = 1/32 [1] min α = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	All	S	B, E
GMAW FCAW	BC-P2-GF	1/4 [6] min	U	R = 0 f = 1/8 [3] min α = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	All	S	A, B, E
SAW	BC-P2-S	7/16 [11] min	U	R = 0 f = 1/4 [6] min α = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	Flat	S	B, E

(C)

- Note A: Not prequalified for gas metal arc welding using short circuiting transfer.
- Note B: Joint is welded from one side only.
- Note E: Minimum effective throat as shown in Table 5.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints

Butt Joint (B)
 Partial Penetration (P)
 Double-V-Groove Weld (3)



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
				Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for alpha				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-P3	1/2 [13] min	—	R = 0 f = 1/8 [3] min alpha = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	All	S	E, Mp, D2
GMAW FCAW	B-P3-GF	1/2 [13] min	—	R = 0 f = 1/8 [3] min alpha = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	All	S	A, E, Mp, D2
SAW	B-P3-S	3/4 [20] min	—	R = 0 f = 1/4 [6] min alpha = 60°	+1/16 [2], -0 +U, -0 +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	Flat	S	E, Mp, D2

(D)

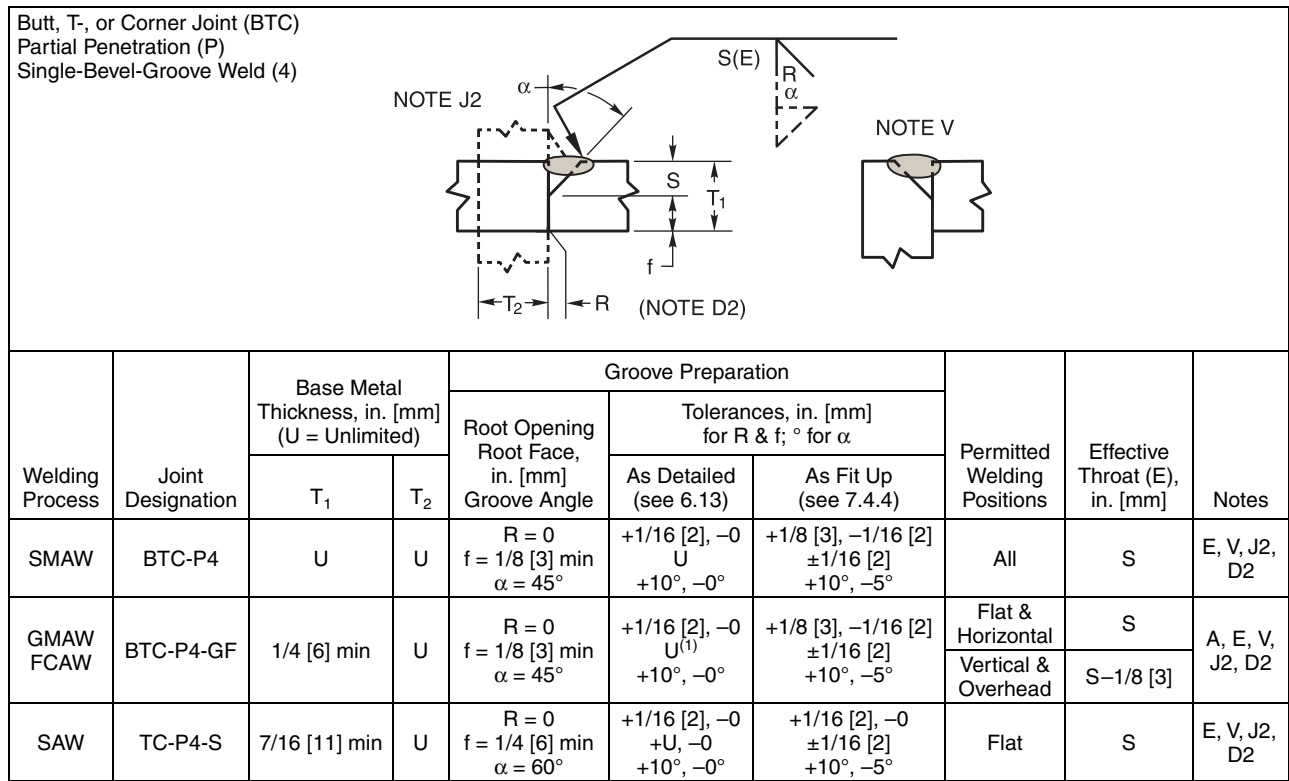
Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm]) except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

Note Mp: Double-groove welds may have grooves of unequal depth, provided these conform to Note E. Also, the effective throat (E₁ or E₂), less any reduction, applies individually to each groove.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



(E)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm]) except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

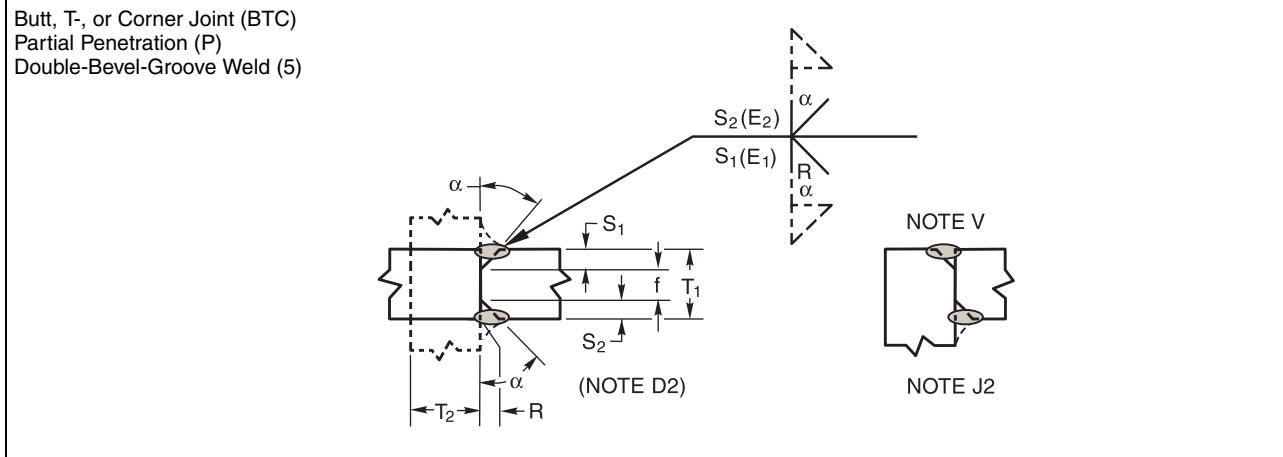
Note J2: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note Mp: Double-groove welds may have grooves of unequal depth, provided these conform to Note E. Also, the effective throat (E), less any reduction, applies individually to each groove.

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

(1) For flat and horizontal positions, the tolerance for f = +U, -0.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening Root Face, in. [mm] Groove Angle	Tolerances, in. [mm] for R & f; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	BTC-P5	5/16 [8] min	U	R = 0 f = 1/8 [3] min α = 45°	+1/16 [2], -0 U +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	All	(S ₁ + S ₂) -1/4 [6]	D2, E, J2, Mp
GMAW FCAW	BTC-P5-GF	1/2 [13] min	U	R = 0 f = 1/8 [3] min α = 45°	+1/16 [2], -0 U ⁽¹⁾ +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] +10°, -5°	Flat & Horizontal Vertical & Overhead	S ₁ + S ₂ (S ₁ + S ₂) -1/4 [6]	A, D2, E, J2, Mp
SAW	TC-P5-S	3/4 [20] min	U	R = 0 f = 1/4 [6] min α = 60°	±0 +U, -0 +10°, -0°	+1/16 [2], -0 ±1/16 [2] +10°, -5°	Flat	S ₁ + S ₂	D2, E, J2, Mp

(F)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm] except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

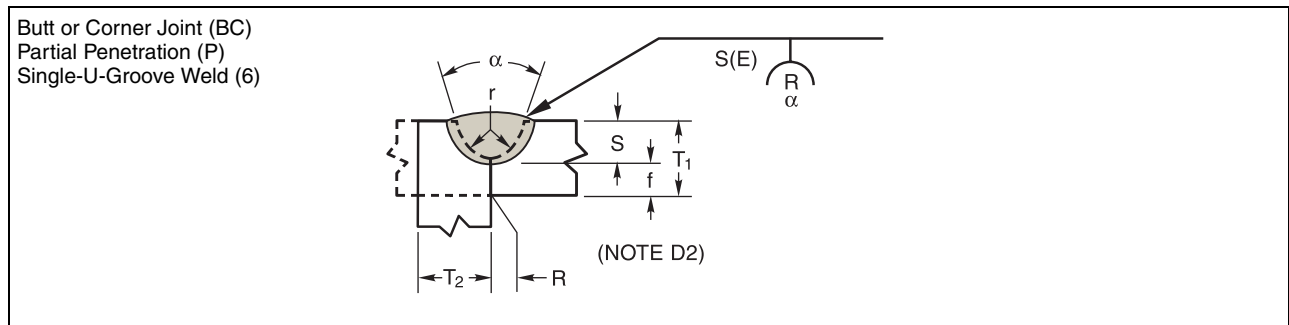
Note J2: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note Mp: Double-groove welds may have grooves of unequal depth, provided these conform to Note E. Also, the effective throat (E₁ or E₂), less any reduction, applies individually to each groove.

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

(1) For flat and horizontal positions, the tolerance for f = +U, -0.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes	
		T ₁	T ₂	Root Opening Root Face Groove Radius, in. [mm] Groove Angle	Tolerances, in. [mm] for R, f, & r; ° for α				
					As Detailed (see 6.13)				As Fit Up (see 7.4.4)
SMAW	BC-P6	1/4 [6] min	U	R = 0 f = 1/32 [1] min r = 1/4 [6] α = 45°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	D2, E
GMAW FCAW	BC-P6-GF	1/4 [6] min	U	R = 0 f = 1/8 [3] min r = 1/4 [6] α = 20°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	A, D2, E
SAW	BC-P6-S	7/16 [11] min	U	R = 0 f = 1/4 [6] min r = 1/4 [6] α = 20°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/16 [2], -0 ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S	D2, E

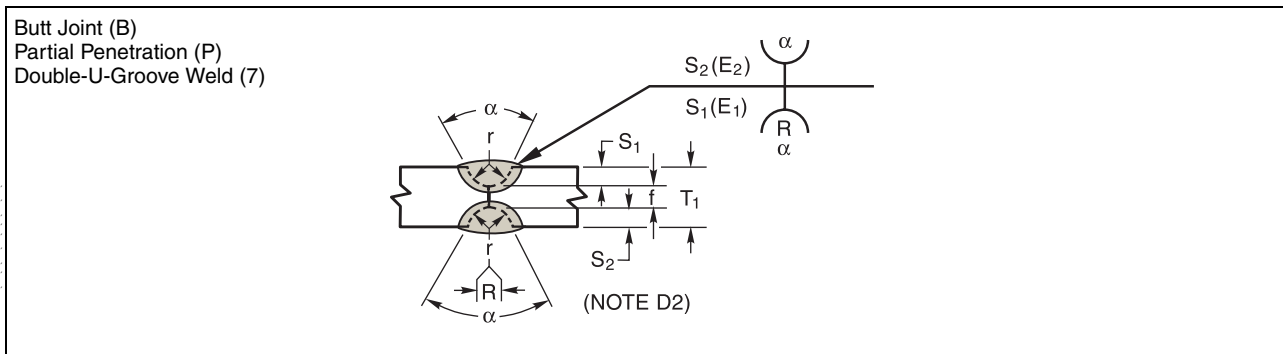
(G)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm]) except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening Root Face Groove Radius, in. [mm] Groove Angle	Tolerances, in. [mm] for R, f, & r; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	B-P7	1/2 [13] min	—	R = 0 f = 1/8 [3] min r = 1/4 [6] α = 45°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S ₁ + S ₂	D2, E, Mp
GMAW FCAW	B-P7-GF	1/2 [13] min	—	R = 0 f = 1/8 [3] min r = 1/4 [6] α = 20°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S ₁ + S ₂	A, D2, E, Mp
SAW	B-P7-S	3/4 [20] min	—	R = 0 f = 1/4 [6] min r = 1/4 [6] α = 20°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 + 10°, -0°	+1/16 [2], -0 ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S ₁ + S ₂	D2, E, Mp

(H)

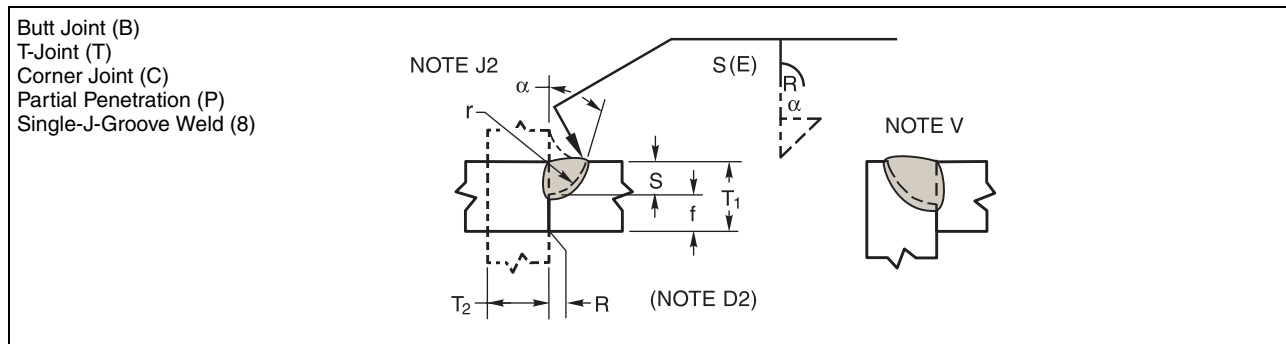
Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm]) except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

Note Mp: Double-groove welds may have grooves of unequal depth, provided these conform to Note E. Also, the effective throat (E₁ or E₂), less any reduction, applies individually to each groove.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening Root Face Groove Radius, in. [mm] Groove Angle	Tolerances, in. [mm] for R, f, & r; ° for α				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	TC-P8 (T & Inside Corner Joints)	1/4 [6] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] α = 45°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	D2, E, J2
	BC-P8 (Butt & Outside Corner Joints)	1/4 [6] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] α = 30°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	D2, E, V
GMAW FCAW	TC-P8-GF (T & Inside Corner Joints)	1/4 [6] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] α = 45°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	A, D2, E, J2
	BC-P8-GF (Butt & Outside Corner Joints)	1/4 [6] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] α = 30°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/8 [3], -1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S	A, D2, E, V
SAW	C-P8-S (Outside Corner)	7/16 [11] min	U	R = 0 f = 1/4 [6] min r = 1/2 [13] α = 20°	±0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/16 [2], -0 ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S	D2, E, V
	T-P8-S (T- & Inside Corner)	7/16 [11] min	U	R = 0 f = 1/4 [6] min r = 1/2 [13] α = 45°	±0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/16 [2], -0 ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S	D2, E, J2

(I)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

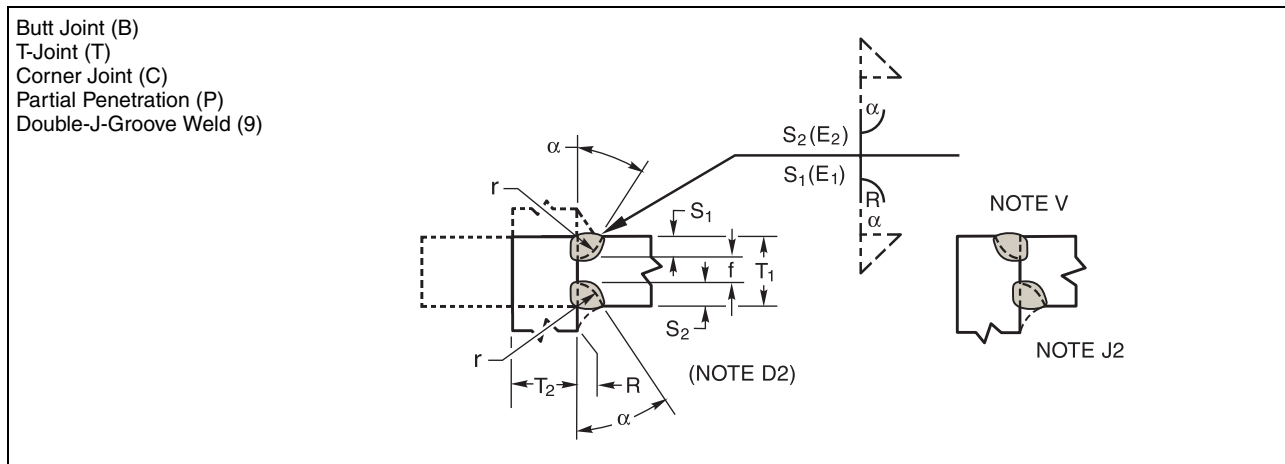
Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm]) except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

Note J2: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but need not exceed 3/8 in. [10 mm].

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints



Welding Process	Joint Designation	Base Metal Thickness, in. [mm] (U = Unlimited)		Groove Preparation			Permitted Welding Positions	Effective Throat (E), in. [mm]	Notes
		T ₁	T ₂	Root Opening Root Face Groove Radius, in. [mm] Groove Angle	Tolerances, in. [mm] for R, f, & r; ° for alpha				
					As Detailed (see 6.13)	As Fit Up (see 7.4.4)			
SMAW	BTC-P9	1/2 [13] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] alpha = 45°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	±1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S ₁ + S ₂	D2, E, J2, V
GMAW FCAW	BTC-P9-GF	1/2 [13] min	U	R = 0 f = 1/8 [3] min r = 3/8 [10] alpha = 30°	+1/16 [2], -0 +U, -0 +1/4 [6], -0 +10°, -0°	±1/16 [2] ±1/16 [2] ±1/16 [2] +10°, -5°	All	S ₁ + S ₂	A, D2, E, J2, V
SAW	C-P9-S	3/4 [20] min	U	R = 0 f = 1/4 [6] min r = 1/2 [13] alpha = 20°	±0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/16 [2], -0 ⁽¹⁾ ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S ₁ + S ₂	D2, E, J2, V
	T-P9-S	3/4 [20] min	U	R = 0 f = 1/4 [6] min r = 1/2 [13] alpha = 45°	±0 +U, -0 +1/4 [6], -0 +10°, -0°	+1/16 [2], -0 ⁽¹⁾ ±1/16 [2] ±1/16 [2] +10°, -5°	Flat	S ₁ + S ₂	D2, E, J2

(J)

Note A: Not prequalified for gas metal arc welding using short circuiting transfer.

Note D2: The parts to be joined by partial joint penetration groove welds parallel to the length of the member, bearing joints excepted, shall be brought into as close contact as practicable. The gap between parts shall not exceed 3/16 in. [5 mm] except in cases involving rolled shapes or plates 3 in. [75 mm] or greater in thickness if, after straightening and in assembly, the gap cannot be closed sufficiently to meet this tolerance. In such cases, a maximum gap of 5/16 in. [8 mm] is applicable provided a sealing weld or suitable backing material is used to prevent melt-through and the final weld meets the requirements for effective throat. Tolerances for bearing joints shall be in accordance with the applicable contract specifications.

Note E: Minimum effective throat as shown in Table 5.

Note J2: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, they shall be equal to 1/4 T₁, but not exceed 3/8 in. [10 mm].

Note V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

(1) Fit-up tolerance. SAW: see Note D2; for rolled shapes R may be 5/16 in. [8 mm] in thick plates if backing is provided.

Figure I.2 (Continued)—Prequalified Partial Joint Penetration Groove Welded Joints

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Nonmandatory Annexes

Annex A

Suggested Forms

(This Annex is not a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, but is included for informational purposes only.)

A1. Commentary on the Use of Welding Procedure Forms (Front) and (Back)

The form may be used to record information for either a WPS or a PQR. The user should indicate their selected application in the appropriate boxes or the user may choose to blank out the inappropriate headings.

The WPSs and PQRs are to be signed by the authorized representative of the Manufacturer or Contractor.

For joint details on the WPS, a sketch or a reference to the applicable prequalified joint detail may be used (e.g., B-U4a).

A2. Prequalified

The WPS may be Prequalified in accordance with all of the provisions of 9.1, in which case only the one-page document, Form E1, is required.

A3. Qualified by Testing

The WPS may be qualified by testing in accordance with the provisions of Part B of Section 9. In this case, a supporting PQR is required in addition to the WPS. For the PQR, Form E1 (Front) can again be used with an appropriate heading change. Also, the Form E1 (Back) may be used to record the test results and the certifying statement.

For the WPS, state the permitted ranges qualified by testing or state the appropriate tolerances on essential variables (e.g., 250 A \pm 10%).

For the PQR, record the actual joint details and the values of essential variables used in the testing. Attach a copy of the Mill Test Report for the material tested. Testing laboratory data reports may also be included as backup information.

The inclusion of items not required by this Specification is optional; however, they may be of use in setting up equipment or understanding test results.

WELDING PROCEDURE SPECIFICATION (WPS) Yes
PREQUALIFIED _____ QUALIFIED BY TESTING _____
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes

Company Name _____
 Welding Process(es) _____
 Supporting PQR No.(s) _____

Identification # _____
 Revision _____ Date _____ By _____
 Authorized by _____ Date _____
 Type—Manual Semi-Automatic
 Machine Automatic

JOINT DESIGN USED

Type:
 Single Double Weld
 Backing: Yes No
 Backing Material: _____
 Root Opening _____ Root Face Dimension _____
 Groove Angle: _____ Radius (J-U) _____
 Back Gouging: Yes No Method _____

BASE METALS

Material Spec. _____
 Type or Grade _____
 Thickness: Groove _____ Fillet _____
 Diameter (Pipe) _____

FILLER METALS

AWS Specification _____
 AWS Classification _____

SHIELDING

Flux _____ Gas _____
 Composition _____
 Electrode-Flux (Class) _____ Flow Rate _____
 Gas Cup Size _____

PREHEAT

Preheat Temp., Min _____
 Interpass Temp., Min _____ Max _____

POSITION

Position of Groove: _____ Fillet: _____
 Vertical Progression: Up Down

ELECTRICAL CHARACTERISTICS

Transfer Mode (GMAW) Short-Circuiting
 Globular Spray
 Current: AC DCEP DCEN Pulsed
 Other _____
 Tungsten Electrode (GTAW)
 Size: _____
 Type: _____

TECHNIQUE

Stringer or Weave Bead: _____
 Multi-pass or Single Pass (per side) _____
 Number of Electrodes _____
 Electrode Spacing Longitudinal _____
 Lateral _____
 Angle _____
 Contact Tube to Work Distance _____
 Peening _____
 Interpass Cleaning: _____

POSTWELD HEAT TREATMENT

Temp. _____
 Time _____

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals		Current		Volts	Travel Speed	Joint Details
		Class	Diam.	Type & Polarity	Amps or Wire Feed Speed			

Figure A.1—Sample Form E1, Front

**Procedure Qualification Record (PQR) # _____
Test Results**

TENSILE TEST

Specimen No.	Width	Thickness	Area	Ultimate Tensile Load, lb	Ultimate Unit Stress, psi	Character of Failure and Location

GUIDED BEND TEST

Specimen No.	Type of Bend	Result	Remarks

VISUAL INSPECTION

Appearance _____
 Undercut _____
 Piping porosity _____
 Convexity _____
 Test date _____
 Witnessed by _____

RADIOGRAPHIC-ULTRASONIC EXAMINATION

RT Report No.: _____ Result _____
 UT Report No.: _____ Result _____

FILLET WELD TEST RESULTS

Minimum size multiple pass Maximum size single pass
 Macroetch Macroetch
 1. _____ 3. _____ 1. _____ 3. _____
 2. _____ 2. _____

OTHER TESTS

ALL-WELD-METAL TENSION TEST

Tensile strength, psi [MPa] _____
 Yield point/strength, psi [MPa] _____
 Elongation in 2 in. [50 mm], % _____
 Laboratory Test No. _____

Welder's name _____
 Who by virtue of these tests is also qualified as an individual.

Clock No. _____ Stamp No. _____

Tests conducted by _____ Laboratory

Laboratory Test No. _____

Per _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D14.1, (_____) (year)

Signed _____
 Manufacturer or Contractor

By _____

Title _____

Date _____

Figure A.2—Sample Form, E1, Back

WELDER, WELDING OPERATOR OR TACK WELDER QUALIFICATION TEST RECORD

Type of Welder _____
 Name _____ Identification No. _____
 Welding Procedure Specification No. _____ Rev _____ Date _____

Variables	Record Actual Values Used in Qualification	Qualification Range
Process/Type (9.16.2)	_____	_____
Electrode (single or multiple)	_____	_____
Current/Polarity	_____	_____
Position (9.16.5)	_____	_____
Weld Progression (9.16.7)	_____	_____
Backing (YES or NO) (9.16.8)	_____	_____
Material/Spec. (9.16.1)	_____ to _____	_____
Base Metal	_____	_____
Thickness: (Plate)	_____	_____
Groove	_____	_____
Fillet	_____	_____
Thickness: (Pipe/tube)	_____	_____
Groove	_____	_____
Fillet	_____	_____
Diameter: (Pipe)	_____	_____
Groove	_____	_____
Fillet	_____	_____
Filler Metal (9.16.3)	_____	_____
Spec. No.	_____	_____
Class	_____	_____
F-No.	_____	_____
Gas/Flux Type (9.16.4)	_____	_____
Other	_____	_____

VISUAL INSPECTION (9.12.6 or 9.12.7)			
Acceptable YES or NO _____			
Guided Bend Test Results (9.28.1/9.29)			
Type	Result	Type	Result
_____	_____	_____	_____
_____	_____	_____	_____
Fillet Test Results (9.28.2/9.28.3; 9.39.4/9.39.5)			
Appearance _____	Fillet Size _____		
Fracture Test Root Penetration _____	Macroetch _____		
(Describe the location, nature, and size of any crack or tearing of the specimen.)			

Inspected by _____ Test Number _____
 Organization _____ Date _____

RADIOGRAPHIC TEST RESULTS (9.28.4/9.39.2)					
Film Identification Number	Results	Remarks	Film Identification Number	Results	Remarks
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Interpreted by _____ Test Number _____
 Organization _____ Date _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D14.1, (_____).

Manufacturer or Contractor _____ (year)
 Authorized By _____
 Date _____

Figure A.3—Sample Form E2

WPS QUALIFICATION TEST RECORD FOR ELECTROSLAG AND ELECTROGAS WELDING

PROCEDURE SPECIFICATION

Material specification _____
 Welding process _____
 Position of welding _____
 Filler metal specification _____
 Filler metal classification _____
 Filler metal _____
 Flux _____
 Shielding gas _____ Flow rate _____
 Gas dew point _____
 Thickness range this test qualifies _____
 Single or multiple pass _____
 Single or multiple arc _____
 Welding current _____
 Preheat temperature _____
 Postheat temperature _____
 Welder's name _____

VISUAL INSPECTION

Appearance _____
 Undercut _____
 Piping porosity _____

 Test date _____
 Witnessed by _____

TEST RESULTS

Reduced-section tensile test

Tensile strength, psi [MPa]
 1. _____
 2. _____

All-weld-metal tension test

Tensile strength, psi [MPa] _____
 Yield point/strength, psi [MPa] _____
 Elongation in 2 in. [50 mm], % _____

Side-bend tests

1. _____ 3. _____
 2. _____ 4. _____

Radiographic-ultrasonic examination _____

RT Report No. _____
 UT Report No. _____

Impact tests, ft-lb [N]

Size of specimen _____ Test temp. _____
 1. _____ 2. _____ 3. _____ 4. _____
 5. _____ 6. _____ Avg. _____
 High _____ Low _____
 Laboratory Test No. _____

WELDING PROCEDURE

Pass No.	Electrode Size	Welding Current		Joint Detail
		Amperes	Volts	
Guide tube flux _____ Guide tube composition _____ Guide tube diameter _____ Vertical rise speed _____ Traverse length _____ Traverse speed _____ Dwell _____ Type of molding shoe _____				

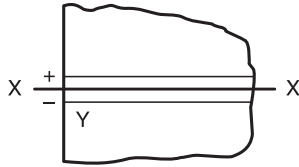
We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D14.1, (_____).
 (year)

Procedure No. _____ Manufacturer or Contractor _____
 Revision No. _____ Authorized by _____
 Date _____

Figure A.4—Sample Form E3

REPORT OF ULTRASONIC TESTING OF WELDS

Project _____ Report No. _____



Weld identification _____
 Material thickness _____
 Weld joint AWS _____
 Welding process _____
 Quality requirements—Section No. _____
 Remarks _____

Line Number	Indication Number	Transducer Angle	From Face (A, B, C)	Leg (I, II, III)	Decibels				Discontinuity				Discontinuity Evaluation	Remarks	
					Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance (sound path)	Depth from "A" Surface	Distance			
												a			b
1															
2															
3															
4															
5															
6															
7															
8															
9															
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21															
22															
23															
24															
25															
26															

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AWS D14.1, (____).
 (year)

Test date _____ Manufacturer or Contractor _____
 Inspected by _____ Authorized by _____
 Date _____

Figure A.7—Sample Form E6

Notes:

1. In order to attain Rating “d”
 - (A) With instruments with gain control, use the formula $a - b - c = d$.
 - (B) With instruments with attenuation control, use the formula $b - a - c = d$.
 - (C) A plus or minus sign shall accompany the “d” figure unless “d” is equal to zero.
2. Distance from X is used in describing the location of a weld discontinuity in a direction perpendicular to the weld reference line. Unless this figure is zero, a plus or minus sign shall accompany it.
3. Distance from Y is used in describing the location of a weld discontinuity in a direction parallel to the weld reference line. This figure is attained by measuring the distance from the “Y” end of the weld to the beginning of said discontinuity.
4. Evaluation of Retested Repaired Weld Areas shall be tabulated on a new line on the report form. If the original report form is used, R_n shall prefix the indication number. If additional forms are used, the R number shall prefix the report number.

Figure A.7 (Continued)—Sample Form E6

.....

LIQUID PENETRANT INSPECTION REPORT

Customer _____ Date _____
 Order No. _____ Material _____
 Dwg. No. _____ Specification _____
 For _____

Pieces	Description	Comments

Soak Time _____

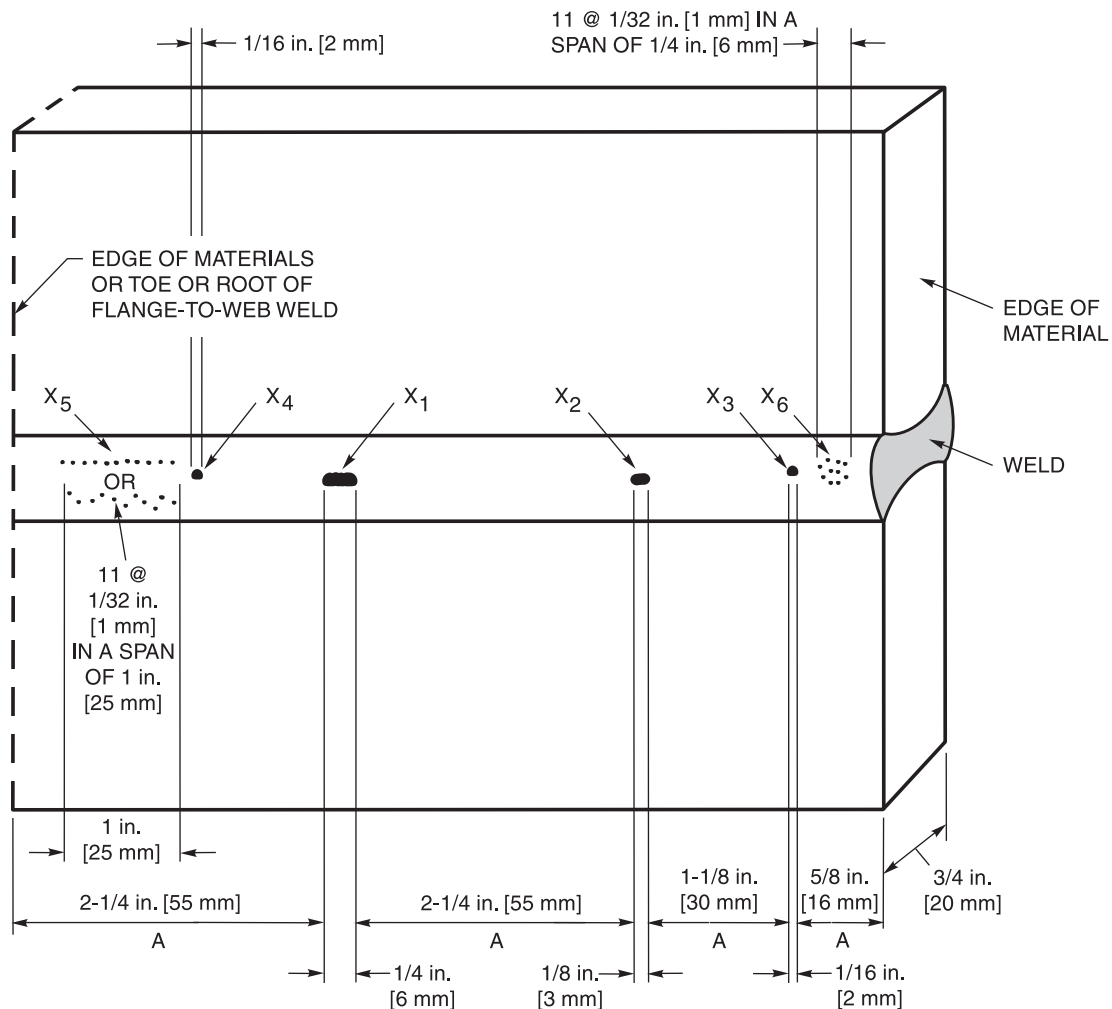
The above parts have been carefully tested with liquid penetrant. This inspection is limited to defects of the type which can normally be located with the liquid penetrant inspection method.

Figure A.8—Sample Form E7

Annex B

Examples of Weld Quality Requirements

(This Annex is not a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and other Material Handling Equipment*, but is included for informational purposes only.)



Notes:

1. A—the minimum clearance allowed between edges of porosity or fusion-type discontinuities 1/16 in. [2 mm] or larger. The larger of adjacent discontinuities governs.
2. X₁—the largest permissible porosity or fusion-type discontinuity for 3/4 in. [20 mm] joint thickness (see Figure 35).
3. X₂, X₃, X₄—porosity or fusion-type discontinuity 1/16 in. [2 mm] or larger, but less than maximum permissible for 3/4 in. [20 mm] joint thickness.
4. X₅, X₆—porosity or fusion-type discontinuity less than 1/16 in. [2 mm].

Interpretation:

1. Discontinuity size indicated is assumed to be its greatest dimension.
2. Porosity or fusion-type discontinuity X₄ is not acceptable because it is within the minimum clearance allowed between edges of such discontinuities (see 10.11.2 and Figure 35).
3. Remainder of weld is acceptable.

Figure B.1—Examples of Weld Quality Requirements

.....

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Annex C

Guidelines for Preparation of Technical Inquiries for AWS Technical Committees

(This Annex is not a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, but is included for informational purposes only.)

C1. Introduction

The AWS Board of Directors has adopted a policy whereby all official interpretations of AWS standards will be handled in a formal manner. Under that policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

C2. Procedure

All inquiries shall be directed to:

Managing Director, Technical Services
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to fully understand the point of concern in the inquiry. If that point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and should also be in the format used here.

C2.1 Scope. Each inquiry shall address one single provision of the standard, unless the point of the inquiry involves two or more interrelated provisions. That provision shall be identified in the scope of the inquiry, along

with the edition of the standard that contains the provisions or that the inquirer is addressing.

C2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be either to obtain an interpretation of a standard's requirement, or to request the revision of a particular provision in the standard.

C2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to quickly and fully understand the point of the inquiry. Sketches should be used when appropriate and all paragraphs, figures, tables, or Annexes, which bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

C2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry, or the wording for a proposed revision, if that is what inquirer seeks.

C3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS Technical Committee. The secretary of the committee refers all inquiries to the Chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon

approval by the committee, the interpretation will be an official interpretation of the Society, and the secretary will transmit the response to the inquirer and to the *Welding Journal* for publication.

C4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal*.

C5. Telephone Inquiries

Telephone inquiries to AWS headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The Board of Directors' policy requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained

only through a written request. The AWS headquarters staff cannot provide consulting services. The staff can, however, refer a caller to any of those consultants whose names are on file at AWS headquarters.

C6. The AWS Technical Committee

The activities of AWS Technical Committees in regard to interpretations are limited strictly to the interpretation of provisions of standards prepared by the Committee or to consideration of revisions to existing provisions on the basis of new data or technology. Neither the Committee nor the staff is in a position to offer interpretive or consulting services on: (1) specific engineering problems; or (2) requirements of standards applied to fabrications outside the scope of the document or points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

Annex D

Bibliography

(This Annex is not a part of AWS D14.1/D14.1M:2005, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*, but is included for informational purposes only.)

D1. American Welding Society (AWS) References

- (1) AWS A1.1, *Metric Practice Guide for the Welding Industry*
- (2) AWS A5.17/5.17M-97, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
- (3) AWS C3.2, *Standard Method for Evaluating the Strength of Brazed Joints in Shear*
- (4) AWS D1.1, *Structural Welding Code—Steel*
- (5) AWS D15.2, *Recommended Practice for the Welding of Rails and Related Rail Components for Use by Rail Vehicles*
- (6) AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances*

D2. American Association of State Highway & Transportation Officials (AASHTO)

- (1) *Standard Specifications for Highway Bridges*

D3. American National Standards Institute (ANSI)

- (1) ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*
- (2) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* (Published by AWS)

D4. American Society of Mechanical Engineers (ASME) Standards

- (1) ASME Boiler and Pressure Vessel Code, Section IX, *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*

D5. Canadian Standards Association (CSA)

- (1) W178.2, *Certification of Welding Inspectors*

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List of AWS Documents on Machinery and Equipment

Designation	Title
D14.1/D14.1M	<i>Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment</i>
D14.3/D14.3M	<i>Specification for Welding Earthmoving and Construction Equipment</i>
D14.4/D14.4M	<i>Specification for Welded Joints in Machinery and Equipment</i>
D14.5	<i>Specification for Welding of Presses and Press Components</i>
D14.6/D14.6M	<i>Specification for Welding of Rotating Elements of Equipment</i>

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**FEDERATION EUROPEENNE DE LA MANUTENTION
SECTION I
HEAVY LIFTING APPLIANCES**

**F. E. M.
1.001
3RD EDITION 1987.10.01**

RULES FOR THE DESIGN OF HOISTING APPLIANCES

BOOKLET 8

TEST LOADS AND TOLERANCES

**The total 3rd Edition comprises booklets 1 to 8
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Also available in French and German**

BOOKLET 8

TEST LOADS AND TOLERANCES

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Static test	8.1.2.	8-3
Notes	8.1.3	8-3
TOLERANCES OF CRANES AND TRAKS	8.2	8-4
Measuring procedure	8.2.1.	8-4
Manufacturing tolerance for cranes	8.2.2.	8-4
Tolerance for crane tracks	8.2.3.	8-8

APPENDIX

TEST LOADS FOR CRANSE IN SOME EUROPEAN COUNTRIES	A-8.1.3	8-11
LIST OF SYMBOLS AND NOTAITIOMS	SEE BOOKLET	

8.1.

TESTS

Prior to being placed in service, appliances must be tested under overload conditions, as follows

8.1.1.

DYNAMIC TEST

The dynamic test shall be carried out with an, overload coefficient $p_1 = 1,2$, i.e. with a load equal to 120 % of the safe working load. All motions shall be carefully operated in turn, without checking speeds- of temperature rises in the motors (see clause 2.3.3.0).

8.1.2.

STATIC TEST

The static test shall be carried out with an overload coefficient $p_2 = 1,4$, i.e. with a load equal to 140 % of the safe working load. This test must be carried out under still conditions and consists in hoisting the safe working load to a small distance above the ground and then adding the required surplus without shock (see clause 2.3.3.c.).

8.1.3.

NOTE 1

The figures given for these test loads represent minim requirements. Where national legislation or rules call for higher values, these must be complied with insofar as appliances destined for such countries are concerned.

The test to be used in certain countries are given in appendix A-8.1.3. for information.

NOTE 2

When making these tests, it is customary to measure the deflection of the structure of an appliance.

The present rules impose no obligation as to the allowable deflections.

Should the user wish to impose a deflection limit, he must specify this in his call for tenders (1).

(1) The custom of regarding small deflection under load as a measure of the strength of an appliance should be discontinued.

Although an unduly large deflection can adversely affect lattice girders because of the danger of movement at the joints, no untoward effects are to be feared in the case of solid-web or box girders.

In practice, the magnitude of the deflection should be limited only from the standpoint of convenience of operation, since vertical oscillations of the load can be troublesome in some cases.

8. 2.

TOLERANCES OF CRANES AND TRACKS

GENERAL

The use of the Design Rules presupposes that the tolerances specified hereafter for cranes and tracks shall be maintained. These tolerances apply unless other conditions have been agreed with the user, and take no account of elastic deformations during the operation. The elastic deformations have to be taken into consideration if required.

The specified tolerances are valid for overhead traveling cranes, gantry cranes and jib cranes, but not for railway cranes. For cranes which have been erected for temporary use only, e.g. building cranes, these rules are only partially valid, in other cases they are to be used judiciously.

8.2.1.

MEASURING PROCEDURE

when using measuring tapes, calibrated steel measuring tapes are to be used. The rules for the use of these measuring tapes are to be observed. The readings obtained are to be corrected for the sag of the tape measure as well as for the divergence of the ambient temperature from the standard temperature. All measurements on one and the same crane have to be made with the same tape and the same tension force.

8.2.2.

MANUFACTURING TOLERANCES FOR CRANES

8.2.2.1. The greatest divergence Δs of the crane span s from the drawing dimension must not exceed the following values:

$$s \leq 15 \text{ m} : \Delta s = \begin{matrix} + \\ - \end{matrix} 2 \text{ mm}$$

for

$$s > 15 \text{ m} : \Delta s = \begin{matrix} + \\ - \end{matrix} [2 + 0.15 \cdot (s - 15)] \text{ mm} (\text{max. } \begin{matrix} + \\ - \end{matrix} 15 \text{ mm})$$

for $s > 15 \text{ m}$ - $\Delta s = +[2 + 0.15 \cdot (s - 15)] \text{ mm}$ (max. +15 mm)

(s is to be expressed in m)

(see figure 8.2.2.1.)

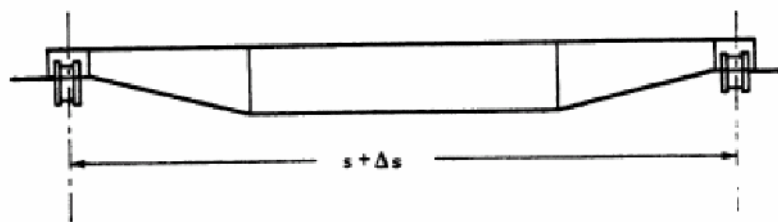


Figure 8.2.2.1.

8.2.2.2. Cram girders, freely supported at their ends, must have no sag, even if the drawing does not prescribe a camber. This means that the track of the trolley with unloaded crane (without trolley) must have no deviation downward from the horizontal. This requirement only applies to cranes with a span longer than 20 m.

8.2.2.3. In cases where the top of the rail is flat, the inclination of the wheel axis from the horizontal, for the unladen crane, must be between $+0,2\%$ and $-0,05\%$ (see figure 8.2.2.3.)

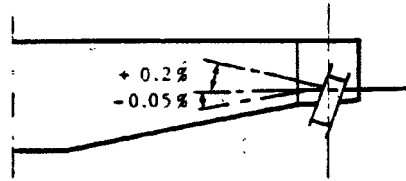


Figure 8.2.2.3.

By unladen crane is meant the crane bridge without trolley, freely supported on the end carriages.

8.2.2.4. The trolley rail center distance must not differ from the nominal dimension s by more than $+3$ mm (see figure 8.2.2.4.).

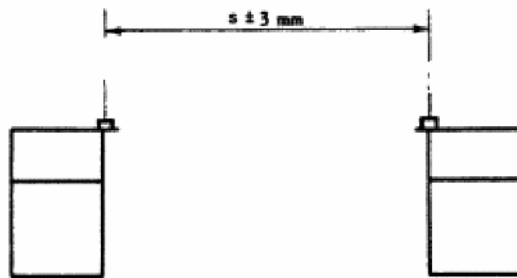


Figure 8.2.2.4.

8.2.2.5. In a plane perpendicular to the travel direction of the trolley, the difference in height of two opposite points of the trolley track shall not exceed $0,15\%$ of the trolley rail center distance, with a maximum of 10 mm (see figure 8.2.2.5.).

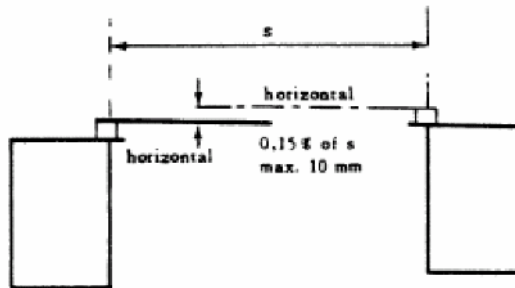


Figure 8.2.2.5.

8.2.2.6 Trolley rails shall be laid in such a way that the running surface is horizontal and that the greatest unevenness of the bearing surface is no more than ± 3 mm for rail centers up to 3 m and no more than $\pm 0,1\%$ of the trolley wheel center distance if it exceeds 3 m (see figure 8.2.2.6.).

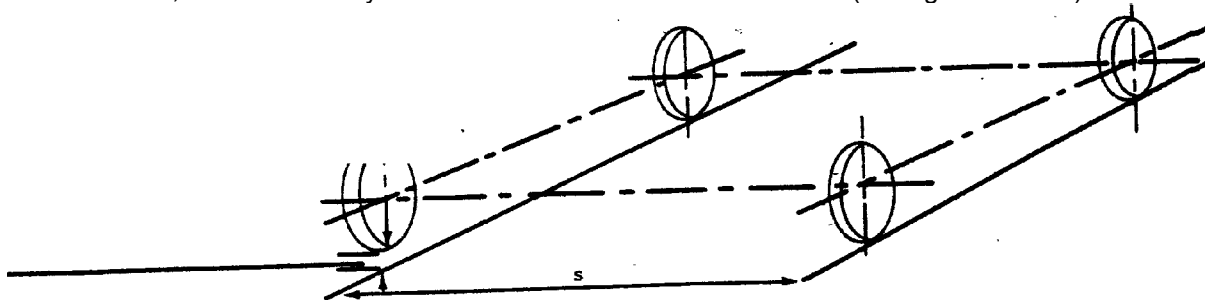


Figure 8.2.2.6

8.2.2.7. The vertical axis of the trolley rail must not diverge from the vertical axis of the rail girder web by more than half the thickness of the rail girder web (see figure 8.2.2.7.).

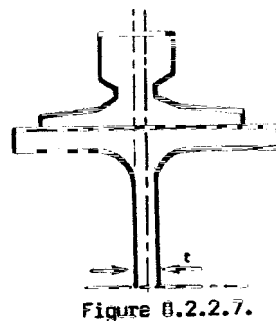


Figure 8.2.2.7.

8.2.2.8 The axes of the trolley rails must not diverge from their theoretical axis by more than $\pm 1,0$ mm in a rail length of 2 m. There should be no misalignments at rail joints (see figure 8.2.2.8.).

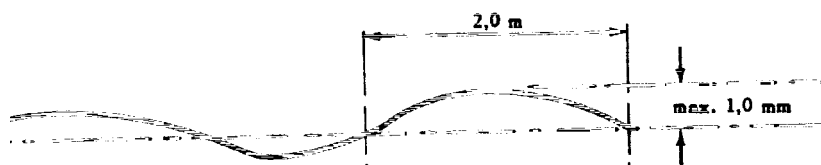


Figure 8.2.2.8.

8.2.2.9. The axes of the wheel bores must not have an angular deviation greater than $\pm 0,04 \%$ from its theoretical axis, in the horizontal plane (see figure 8.2.2.9.).

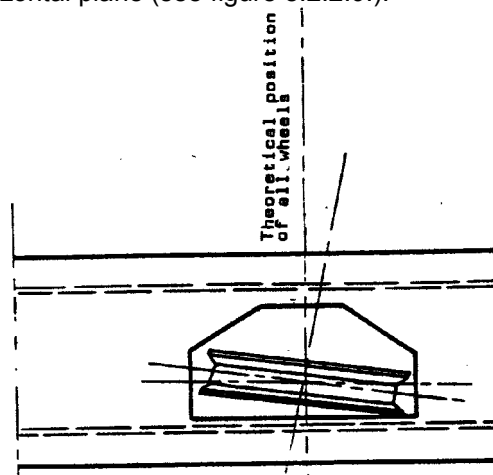


Figure 8.2.2.9.

8.2.2.10. The axle bores of wheels opposite to each other at each side of the track, and if wheels are mounted in bogies the axes of the bogie pins of the unwrapped trolley and crane bridge shell have an alignment divergence in the vertical plane, less than $0,15 \%$, maximum 2 mm of the wheel center distance (see figure 8.2.2.10.).

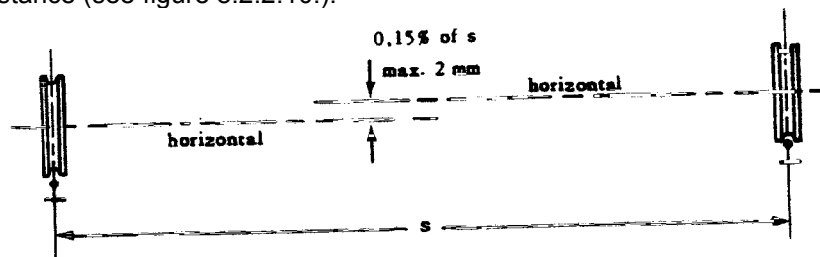


Figure 8.2.2.10.

8.2.2.11. The centre planes of wheels rolling on a common rail must not diverge more than $\pm 1 \text{ mm}$ from the rail axis (see figure 8.2.2.11.).

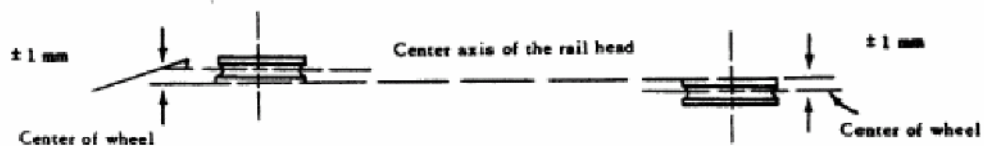


Figure 8.2.2.11.

For bushed wheels the above tolerances apply with the wheel in a central position between the contact surfaces at either side of the wheel.

8.2.2.12. If horizontal guide rollers are used, the center of the distance between guide rollers at one corner must not deviate more than ± 1 mm from the axis of the rail (see figure 8.2.2.12.)

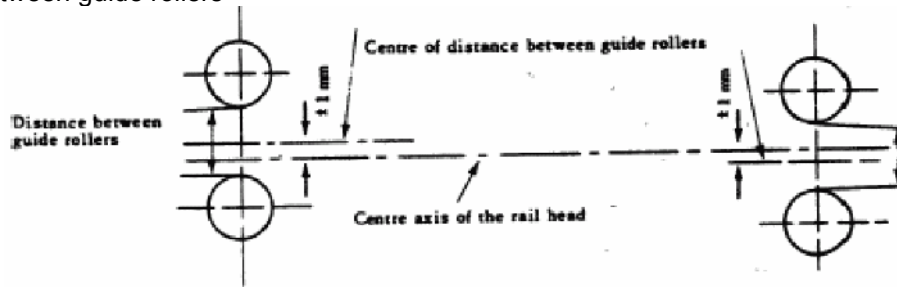


Figure 8.2.2.12.

8.2.2.13. The diameter tolerance of the wheels should correspond to the ISO tolerance classification h9. If runner wheel speeds are synchronized by an "electrical shaft", tighter tolerances may be required. These will have to be determined from case to case. These tolerances will apply also to non driven wheels, as the wheels must be interchangeable.

8.2.3, TOLERANCES FOR CRANE TRACKS

The tolerances specified below apply to new crane tracks. If in the course of use, these tolerances are exceeded by 20 %, the track must be realigned. If the traveling behavior is noticeably deteriorating, it may be necessary to realign the track, even if the tolerance excess has not reached 20 %.

1 - The greatest divergence Δs from the span s is:

for $s \leq 15\text{m}$: $\Delta s = \pm 3$ mm

for $s > 15\text{m}$: $\Delta s = \pm [3 + 0,25 \cdot (s-15)]$ mm (max. ± 25 mm)

(s is to be expressed in m)

(see figure 8.2.2.1.)

If horizontal guide rollers are provided on one rail only, the tolerances for other rail only may be increased to three times the above values, but must exceed 25 mm.
the not

2 - It is assumed that with the trolley positioned in the center of the span the deflection of both rail tracks is approximately equal

3 - The greatest permissible tolerance of the upper edge of the rail is ± 10 mm from the theoretical height position. The theoretical height is either the horizontal position, or if applicable, the theoretical camber curve. The height position of the two rails may show a divergence of 10 mm. The curvature in a longitudinal direction may, at each point of a measured length, of 2 m, not exceed a rise of +2 mm.

4 - The inclination of the rail rolling surface must not exceed the following values as compared with the theoretical position :

Longitudinally : 0,3 %
Laterally : 0,3 %
(see figure 8.2.3.a.)

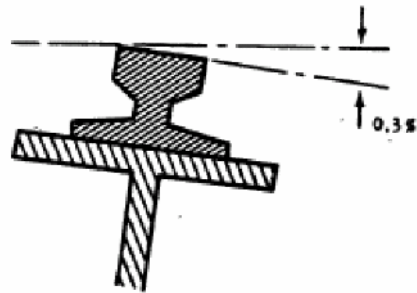


Figure 8.2.3.a.

5 - The maximum permissible lateral deviation of each rail in a horizontal plane is ± 10 mm. The curvature in the longitudinal axis at any point shall not exceed ± 1 mm in a length of 2 m (see figure 8.2.3.b.).

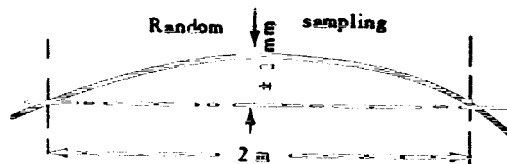


Figure 8.2.3.b.

For cranes guided on both sides by horizontal rollers, the above values are valid also for the rail surfaces of the horizontal rollers.

For cranes guided on one rail only, the requirement for the straightness of the non guiding rail can be lowered, in agreement with manufacturer.

6 - No account has to be taken of misalignment at the rail joints. It is recommended that welded rail joints are used.

APPENDIX A - 8.1.3.

**TEST LOADS FOR CRANES IN
SOME EUROPEAN COUNTRIES**

Country	Dynamic tests	Static tests	Comments
AUSTRIA	125 % up to 25 t 110 % over 25 t		
BELGIUM	Up to 20 t 125 % From 20 to 50 t .. + 5 t over 50 t 110 %	25 t 140 % 25 to 50 t 10 t 50 t 120 %	
SUITZERLAND			According to DIN 15030
GERMANY	$p_k = 1,29 P$ $P_g = 1,33 P$ (H1 and H2) $p_k = 1,25 P$ $p_k = 1,25 P_1 + 0,25 P_0$	$P_g = 1,50 P$ (H3 and H4) $P_g = 1,33 P - 1,4 P$	DIN 15018 pert 1 DIN 15019 Part 1 DIN 15030
FRANCE	120 % (excluding builder's tower cranes and some dismount- table appliances : 110 %)	150 % (excluding builder's tower cranes and some dismount- table appliances : 133 %)	
GREAT BRITAIN	125 % of the SWL		
ITALY	128 % self propelled cranes 120 % tower cranes 110 % other lifting appliances		During 15 min.
NETHERLANDS	Up to 20 t 125 % From 20 to 50 t .. + 5 t	Not Compulsory	
NORWAY	Up to 20 t 125 % From 20 to 50 t .. + 5 t Over 50 t 110 % or FEM	FEM	
SWEDEN	Up to 5 t 125 % From 5 to 20 t ... 120 % From 20 to 50 t .. 115 % Over 50 t 110 %		

**Cranes — Tolerances for wheels and
travel and traversing tracks —**

**Part 1:
General**

*Appareils de levage à charge suspendue — Tolérances des galets et
des voies de translation et de direction —*

Partie 1: Généralités

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 12488-1 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 8, *Jib cranes*.

This second edition cancels and replaces the first edition (ISO 12488-1:2005), which has been technically revised. It also incorporates the Technical Corrigendum ISO 12488-1:2005/Cor 1:2008.

ISO 12488 consists of the following parts, under the general title *Cranes — Tolerances for wheels and travel and traversing tracks*:

- *Part 1: General*
- *Part 4: Jib cranes*

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Introduction

This part of ISO 12488 establishes requirements and gives guidance and design rules that reflect the present state of the art in the field of crane machine design. The rules given represent good design practice that ensures fulfilment of essential safety requirements and adequate service life of components. Deviation from these rules normally leads to increased risks or reduction of service life, but it is acknowledged that new technical innovations, materials etc. may provide new solutions that result in equal or improved safety and durability.

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Cranes — Tolerances for wheels and travel and traversing tracks —

Part 1: General

1 Scope

This part of ISO 12488 specifies tolerances for construction assemblies and operational conditions of cranes and associated crane tracks as defined in ISO 4306-1. The purpose of the requirements in this part of ISO 12488 is to promote safe operation and achievement of the expected life of components by the elimination of excessive load effects due to deviations or misalignments from the normal dimensions of the structure.

Tolerances given are extreme values. The elastic deformations due to load effects are outside the scope of this part of ISO 12488. These will need to be taken into account at the design stage using other criteria to achieve the intended operation and performance.

Specific values for particular crane types are given in other parts of ISO 12488.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

construction tolerance

amount by which a specific dimension is permitted to vary, resulting from the assembly of the complete crane and its tracks, in new, modified, rebuilt or repaired buildings, before operational use

NOTE 1 This applies to new build or repaired or modified cranes and tracks.

NOTE 2 The amount is given either by the absolute value of the difference between the limits of size, or by the allowable geometric variation.

3.2

operational tolerance

amount by which a specific dimension is permitted to vary, resulting from the use of the crane and its tracks

NOTE The amount is given either by the absolute value of the difference between the limits of size, or by the allowable geometric variation.

4 Symbols

A	Tolerance of the span, related to the rail centre of travelling or traversing tracks, at each point of the track or to the wheel centre of crabs or cranes
B	Tolerance of the horizontal straightness, in ground plan, at each point of the travelling track
b	Tolerance of horizontal straightness related to a test length of 2 m in ground plan, (sample value) at each point of the rail head
C	Tolerance of straightness related to the height of the crane rail centre at each point of the travelling track
c	Tolerance of straightness related to a test length of 2 m (sample value) at each point of height of the crane rail
a	Centre-to-centre distance between the horizontal guide rollers, in longitudinal direction of rail
e	Centre-to-centre distance between two wheels or bogeys, in longitudinal direction of rail
h_F	Distance between the top edge of a rail and the bottom edge of horizontal guide rollers
S	Span from centre to centre of the rail
0/00	Angle of inclination expressed as vertical points per horizontal thousand
D	Wheel diameter
E	Height tolerance related to opposite measuring points at right angles to each point of the track
F	Parallelism tolerance of end stops or buffers
G	Angularity tolerance related to rail cross-section with plane surface
H_F	Vertical offset of a welded connection
H_S	Horizontal offset of a rail head
K	Parallelism tolerance of a rail with reference to the web
ΔD	Diameter tolerance for coupled and independently driven crane/cab wheels
Δe	Tolerance of the wheel base in ground plan
ΔF	Alignment tolerance of guide rollers in ground plan
Δhr	Height tolerance of the points of wheel contact
ΔN	Tolerance of parallel offset of the wheels in ground plan
α_F	Axle tolerance of parallelism of guide rollers across the track
β_F	Axle tolerance of parallelism of guide rollers across the track
ϕk	Axle tolerance of parallelism in a ground plan of the hole (inclination of axis)
ϕr	Axle tolerance of parallelism in a ground plan of the wheel (inclination of wheel)
τk	Axle tolerance parallelism in elevation of the hole (axle camber)
τr	Axle tolerance of parallelism in elevation of the wheel (wheel camber)
b_s	Tolerance of straightness related to a test length of 1 m adjacent to a welded rail joint
c_h	Tolerance of straightness related to a test length of 2 m adjacent to a welded rail joint

These symbols and their meanings are applicable to all parts of ISO 12488.

Where symbols for construction tolerances are also applicable to operational tolerances (e.g. in operator instructions), the suffix *w* is used (e.g. A_w , B_w , C_w , E_w).

Where necessary, an additional suffix may be added, for example,

A_{w1}	operational tolerance for travelling tracks,
A_{w2}	operational tolerances for traversing tracks,
A_{w3}	operational tolerances for cranes,
A_{w4}	operational tolerances for crabs.

5 Classification of tolerances

The main criterion for determining the class of tolerance is the total amount of travel throughout the life of the crane; however, system sensitivity shall be considered along with the class of tolerance as given in other parts of ISO 12488.

NOTE In the context of this part of ISO 12488, system sensitivity is considered to be the amount of reaction of the system in terms of load effect resulting from the tolerance considered as unintentional displacement (see ISO 8686-1:1989, 6.1.5). In the case of highly sensitive systems, it could be appropriate to select a higher tolerance class than that shown in Table 1.

Table 1 — Tolerance classes

Tolerance class	Limits of travelling and traversing distance
	km
1	$50\,000 \leq L$
2	$10\,000 \leq L < 50\,000$
3	$L < 10\,000$, for stationary erected tracks
4	Temporarily erected tracks for building and erection purposes

NOTE L is calculated as the product of the normal travel speed and the specified working time of the relevant travel/traverse mechanism, either by application of customer specified values or through reference to the classification of the mechanism (see ISO 4301-1).

6 Tolerances

6.1 General

The tolerances for the various classes and parameters shall be as given in Tables 2, 3, 4, 5, 6 and 7.

6.2 Thermal effects

The tolerances given in Tables 2, 3, 4, 5, 6 and 7 shall be used for an ambient temperature of 20°C. Where the average ambient temperature for the operational position of the crane differs from 20°C, the tolerances shall be adjusted accordingly.

6.3 Application of vertical out-of-plane tolerance

The tolerance Δhr given in Tables 4 and 5 for the vertical out-of-plane displacement of a corner of rail wheel of a crane or crane crab, and the corresponding tolerances for tracks given in Tables 2 and 3 are valid for rigid structures travelling or traversing on the rails, i.e. for box beam structures of main girders, crabs or portals. For frames built from open sections, the tolerances used may be one or two classes lower.

6.4 Construction tolerances

6.4.1 General

The measurements shall be taken in the unloaded condition with the crane and its associated tracks supported in the manner in which they will be operated. Tables 2 to 6 show the appropriate tolerances.

If technical documentation requires a means for differentiation of the tolerances, a suffix shall be added to the tolerance symbol, corresponding to the relevant table in this part of ISO 12488.

EXAMPLE A_2 is the construction tolerances for travelling tracks as per Table 2.

6.4.2 Rail joints

Construction tolerances shall be in accordance with Table 6.

6.5 Operational tolerances

The operational tolerances given in Table 7 shall be measured with the crane in the unloaded condition.

NOTE Tolerances in excess of those shown in Table 7 can result in unacceptable ride characteristics and additional stresses, leading to increased wear on rails, wheels, guide rollers etc., and possible damage to the supporting structure. If any measurements are beyond the tolerances in Table 7, then investigations should be undertaken by a competent engineer and the appropriate action taken.

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Table 2 — Construction tolerances for travelling tracks of tolerance classes 1 to 4

Symbol	Description with respect of this table	Tolerance parameter Graphical representation	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
A	Tolerance of span S of the crane rails related to rail centre at each point of travelling track	<p>$+A = S_{\max} - S$ $-A = S_{\min} - S$</p>	± 3 Valid for all spans $S \leq 16$ m $\pm[3 + 0,25(S-16)]$ ± 10 max. Valid for spans $S > 16$ m, S in metres	± 5 Valid for all spans $S \leq 16$ m $\pm[5 + 0,25(S-16)]$ ± 15 max. Valid for spans $S > 16$ m, S in metres	± 8 Valid for all spans $S \leq 16$ m $\pm[8 + 0,25(S-16)]$ ± 20 max. Valid for spans $S > 16$ m, S in metres	$\pm 12,5$ Valid for all spans $S \leq 16$ m $\pm[12,5 + 0,25(S-16)]$ ± 25 max. Valid for spans $S > 16$ m, S in metres	mm
B	Tolerance of horizontal straightness of rail head at each point of travelling track	<p>Position of crane rail in ground plan</p>	± 5	± 10	± 20	± 40	mm
b	Tolerance of horizontal straightness related to test length of 2 000 mm (sample value) at each point of rail head		1	1	2	4	mm
C	Tolerance of straightness related to height of crane rail centre at each point of travelling track	<p>Height of crane rail (axial slope)</p>	± 5	± 10	± 20	± 40	mm
c	Tolerance of straightness related to test length of 2 000 mm (sample value) at each point of height of crane rail		1	2	4	8	mm
E	Tolerance of height related to opposite measuring points at right angles at each point of travelling track	<p>Height of travelling track (lateral slope)</p>	$\pm 0,5S$ S in metres $E \leq E_{\max}$ ± 5 max.	$\pm S$ S in metres $E \leq E_{\max}$ ± 10 max.	$\pm 2S$ S in metres $E \leq E_{\max}$ ± 20 max.	$\pm 4S$ S in metres $E \leq E_{\max}$ ± 40 max.	mm

Table 2 (continued)

Symbol	Description with respect of this table	Tolerance parameter	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
<i>F</i>	Tolerance of parallelism of end stops or buffers on travelling track at right angles to longitudinal axis with parallelism symbol //	Position in a ground plan (datum symbol in accordance with ISO 1101) 	$\pm 0,8S$ ± 8 max. <i>S</i> in metres	$\pm S$ ± 10 max. <i>S</i> in metres	$\pm 1,25 S$ $\pm 12,5$ max. <i>S</i> in metres	$\pm 1,6 S$ ± 16 max. <i>S</i> in metres	mm
<i>G</i> (see Table 3)	Tolerance of angularity related to crane rail cross-section at each point of travelling track with angularity symbol \angle		4	6	9	12	0/00
Δhr	Height tolerance of points of wheel contact of each point of travelling track		$0,5S$ or $0,5e$ 5 max. <i>e</i> and <i>S</i> in metres, insert <i>e</i> or <i>S</i> , whichever is the least	$1,0S$ or $1,0e$ 10 max. <i>e</i> and <i>S</i> in metres, insert <i>e</i> or <i>S</i> , whichever is the least	$1,6S$ or $1,6e$ 16 max. <i>e</i> and <i>S</i> in metres, insert <i>e</i> or <i>S</i> , whichever is the least	$2,0S$ or $2,0e$ 20 max. <i>e</i> and <i>S</i> in metres, insert <i>e</i> or <i>S</i> , whichever is the least	mm
<i>K</i>	Tolerance of parallelism of crane rail to web at each point of travelling track	r_{min} = smallest thickness of web 	$\pm 0,5r_{min}$				mm

Table 3 — Construction tolerances for traversing tracks of tolerance classes 1 to 4

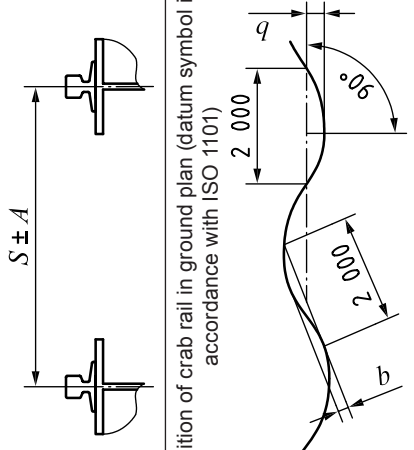
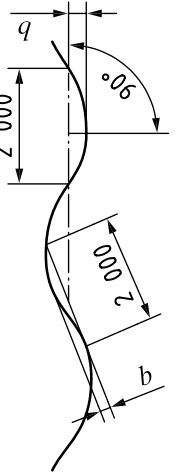
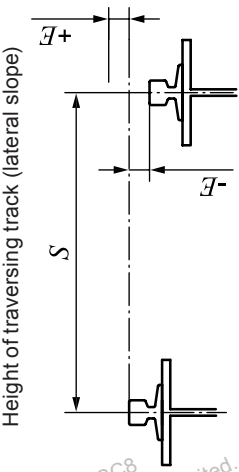
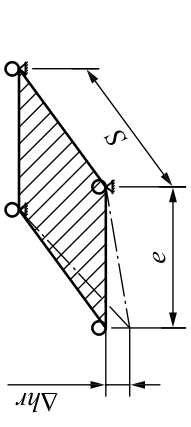
Symbol	Description with respect to this table	Graphical representation	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
<i>A</i>	Tolerance of span <i>S</i> of crab rails related to rail centre at each point of traversing track		±3 Valid for all spans $S \leq 16$ m	±5 Valid for all spans $S \leq 16$ m	±8 Valid for all spans $S \leq 16$ m	±12,5 Valid for all spans $S \leq 16$ m	mm
<i>b</i>	Tolerance of horizontal straightness related to test length of 2 000 mm (sample value) at each point of rail head		1	1	2	4	mm
<i>E</i>	Tolerance of height related to opposite measuring points at right angles at each point of traversing track		±3,2 Valid for all spans $S \leq 2$ m ±1,6 <i>S</i> $E \leq E_{max}$ <i>S</i> in metres, valid for $S > 2$ m ±6,3 max.	±4,2 Valid for all spans $S \leq 2$ m ±2 <i>S</i> $E \leq E_{max}$ <i>S</i> in metres, valid for $S > 2$ m ±8 max.	±5 Valid for all spans $S \leq 2$ m ±2,5 <i>S</i> $E \leq E_{max}$ <i>S</i> in metres, valid for $S > 2$ m ±10 max.	±6,3 Valid for all spans $S \leq 2$ m ±3,2 <i>S</i> $E \leq E_{max}$ <i>S</i> in metres, valid for $S > 2$ m ±12,5 max.	mm
Δhr	Height tolerance of points of wheel contact at each point of traversing track		1,6 Valid for all spans $S \leq 2$ m 0,8 <i>S</i> $\Delta hr \leq \Delta hr_{max}$ <i>S</i> in metres, valid for $S > 2$ m 3,2 max.	2 Valid for all spans $S \leq 2$ m 1 <i>S</i> $\Delta hr \leq \Delta hr_{max}$ <i>S</i> in metres, valid for $S > 2$ m 4 max.	2,5 Valid for all spans $S \leq 2$ m 1,25 <i>S</i> $\Delta hr \leq \Delta hr_{max}$ <i>S</i> in metres, valid for $S > 2$ m 5 max.	3,2 Valid for all spans $S \leq 2$ m 1,6 <i>S</i> $\Delta hr \leq \Delta hr_{max}$ <i>S</i> in metres, valid for $S > 2$ m 6,3 max.	mm

Table 3 (continued)

Symbol	Description with respect to this table	Tolerance parameter				Unit			
		Class 1	Class 2	Class 3	Class 4				
<i>F</i>	Tolerance of parallelism of end stops or buffers on traversing track to right angles to longitudinal axis with parallelism symbol //			<p>Class 1</p> <p>0,8<i>S</i> ±8 max. <i>S</i> in metres</p>	<p>Class 2</p> <p><i>S</i> ±10 max. <i>S</i> in metres</p>	<p>Class 3</p> <p>1,25<i>S</i> ±12,5 max. <i>S</i> in metres</p>	<p>Class 4</p> <p>1,6<i>S</i> ±16 max. <i>S</i> in metres</p>	mm	
<i>G</i> (see Note)	Tolerance of angularity related to crab rail cross-section at each point of traversing track with angularity symbol ∠			4	6	9	12	0/00	
<i>K</i>	Tolerance of parallelism of crab rail related to web at each point of traversing track with parallelism symbol //			±0,5/ <i>t</i> _{min}				—	mm
NOTE		Parameter <i>G</i> with the characteristic of datum applies to crab rails with flat upper rail surfaces only. For crab rails with convex surfaces, tolerances for <i>G</i> are not required.							

Table 4 — Construction tolerances for crane wheels of tolerance classes 1 to 4

Symbol	Description with respect to this table	Graphical representation	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
A	Tolerance of span S of a crane related to wheel centre, wheel with flanges		± 2 Valid for all spans $S \leq 10$ m $\pm [2 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	$\pm 2,5$ Valid for all spans $S \leq 10$ m $\pm [2,5 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	$\pm 3,2$ Valid for all spans $S \leq 10$ m $\pm [3,2 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	± 4 Valid for all spans $S \leq 10$ m $\pm [4 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	mm
A	Tolerance of span S of a crane related to wheel centre, flangeless wheels, guide rollers on one side		$\pm 3,2$ Valid for all spans $S \leq 10$ m $\pm [3,2 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	± 4 Valid for all spans $S \leq 10$ m $\pm [4 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	± 5 Valid for all spans $S \leq 10$ m $\pm [5 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	$\pm 6,3$ Valid for all spans $S \leq 10$ m $\pm [6,3 + 0,1(S-10)]$ S in metres, valid for all spans $S > 10$ m	mm
Δe	Tolerance of wheel base e or bogey distance e , 8 wheels		$\pm 3,2$ Valid for $e \leq 3$ m $\pm e$ e in metres, valid for $e > 3$ m	± 4 Valid for $e \leq 3$ m $\pm 1,25e$ e in metres, valid for $e > 3$ m	± 5 Valid for $e \leq 3$ m $\pm 1,6e$ e in metres, valid for $e > 3$ m	$\pm 6,3$ Valid for $e \leq 3$ m $\pm 2e$ e in metres, valid for $e > 3$ m	mm
ΔN	Parallel offset of crane wheels or bogeys, 8 wheels		± 5 Valid for independent drive only ± 2 Valid for coupled drive only, $S \leq 20$ m $\pm [2 + 0,2(S-20)]$ S in metres, valid for coupled drive only, $S > 20$ m	$\pm 6,3$ Valid for independent drive only $\pm 2,5$ Valid for coupled drive only, $S \leq 20$ m $\pm [2,5 + 0,2(S-20)]$ S in metres, valid for coupled drive only, $S > 20$ m	± 8 Valid for independent drive only $\pm 3,2$ Valid for coupled drive only, $S \leq 20$ m $\pm [3,2 + 0,2(S-20)]$ S in metres, valid for coupled drive only, $S > 20$ m	± 10 Valid for independent drive only ± 4 Valid for coupled drive only, $S \leq 20$ m $\pm [4 + 0,2(S-20)]$ S in metres, valid for coupled drive only, $S > 20$ m	mm

Table 4 (continued)

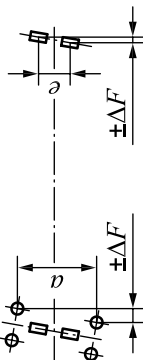
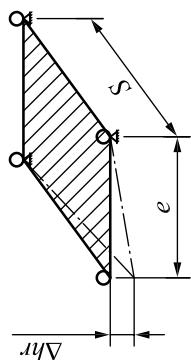
Symbol	Description with respect to this table	Tolerance parameter				Unit
		Graphical representation	Class 1	Class 2	Class 3	
ΔF	Alignment tolerance of guide rollers or wheel flanges		$\pm 0,32a$ a in metres $\pm 0,4e$ e in metres	$\pm 0,4a$ a in metres $\pm 0,5e$ e in metres	$\pm 0,5a$ a in metres $\pm 0,63e$ e in metres	$\pm 0,63a$ a in metres $\pm 0,8e$ e in metres mm
Δhr	Height tolerance of points of wheel contact For a given stiffness of structures related to wheel loads, the difference in height between the points of wheel contact shall be limited in such a way that the mean wheel load (crab with load in centre of bridge) of the driven wheels can change by no more than $\pm 5\%$. Where this calculation is not made, Δhr is valid for the height tolerance according to this table. The height tolerance of the points of wheel contact of a crane is the maximum vertical distance of a point of wheel contact from a plane S ; e set by three points of wheel contact. For statically determinate supported cranes, $\Delta hr = 0,4 S$ may be used.		2 max. Valid for all spans $S \leq 10$ m [2 + 0,1(S-10)] max. S in metres, valid for all spans $S > 10$ m	2,5 max. Valid for all spans $S \leq 10$ m [2,5 + 0,1(S-10)] max. S in metres, valid for all spans $S > 10$ m	3,2 max. Valid for all spans $S \leq 10$ m [3,2 + 0,1(S-10)] max. S in metres, valid for all spans $S > 10$ m	4 max. Valid for all spans $S \leq 10$ m [4 + 0,1(S-10)] max. S in metres, valid for all spans $S > 10$ m mm

Table 4 (continued)

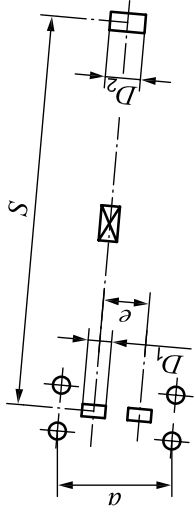
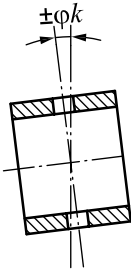
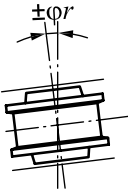
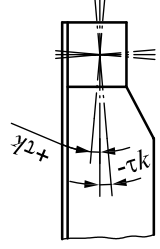
Symbol	Description with respect to this table	Tolerance parameter	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
ΔD	Diameter tolerance for coupled and independently driven crane wheels. a/S without wheel flanges e/S with wheel flanges	 <p style="text-align: center;">$\Delta D = D_1 - D_2$; $D = \frac{D_1 + D_2}{2}$; $D_1 > D_2$</p> <p>Where wheels are mechanically or electrically coupled, it is necessary to check whether the maximum allowable diameter difference requires higher values for e and a, or lower tolerances. For cranes with two coupled drives, ΔD shall be divided by 1,4.</p>	h9 For D_1 and D_2 . Diameter tolerance according to ISO 286-2 $\frac{1,6 a D}{S}$ D in metres $\frac{1,6 e D}{S}$ D in metres	h9 For D_1 and D_2 . Diameter tolerance according to ISO 286-2 $\frac{2 a D}{S}$ D in metres $\frac{2 e D}{S}$ D in metres	h9 For D_1 and D_2 . Diameter tolerance according to ISO 286-2 $\frac{2,5 a D}{S}$ D in metres $\frac{2,5 e D}{S}$ D in metres	h9 For D_1 and D_2 . Diameter tolerance according to ISO 286-2 $\frac{3,2 a D}{S}$ D in metres $\frac{3,2 e D}{S}$ D in metres	mm
φk	Axle parallelism tolerance in a ground plan (inclination of axis)		$\pm 0,3$	$\pm 0,4$	$\pm 0,5$	$\pm 0,63$	0/00
φr	Axle parallelism tolerance in a ground plan (inclination of wheel)		$\pm 0,4$	$\pm 0,5$	$\pm 0,63$	$\pm 0,8$	0/00
τk	Axle parallelism tolerance in elevation (axle camber) The tolerances are for an unloaded crane (without crab) with unrestricted support on or near the end carriages. The mean values of tolerances are chosen approximately so that under load (crab with total load in centre of bridge), a horizontal position of the wheel axle will result from elastic deformation.		+ 1,9 - 0,4			+ 2,4 - 0,5	0/00

Table 4 (continued)

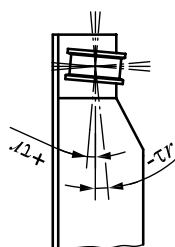
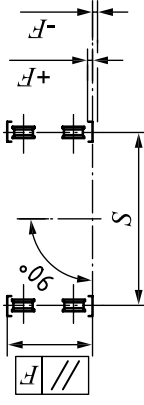
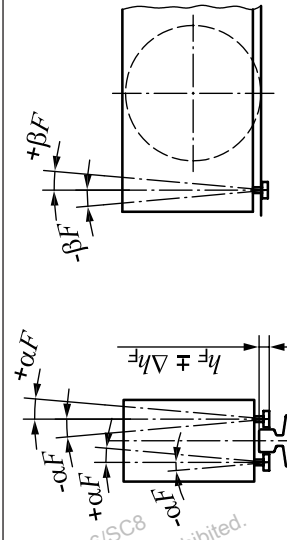
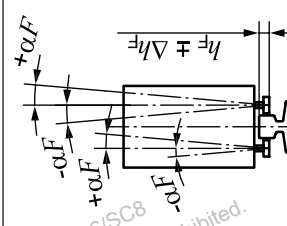
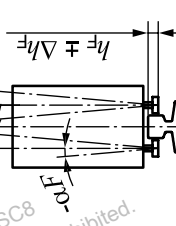
Symbol	Description with respect to this table	Tolerance parameter				Unit			
		Class 1	Class 2	Class 3	Class 4				
π'	<p>Axle parallelism tolerance in elevation (wheel camber)</p> <p>The tolerances are for an unloaded crane (without crab) with unrestricted support on or near the end carriages. The mean values of tolerances are chosen approximately so that under load (crab with total load in centre of bridge), a horizontal position of the wheel axle will result from elastic deformation.</p>					<p>+2,6 -0,6</p>	0/00		
F	<p>Tolerance of parallelism of end stops or buffers on crane at right angles to longitudinal axis with parallelism symbol //</p>					<p>±(1,0S) S in metres ±10 max.</p>	<p>±(1,25S) S in metres ±12,5 max.</p>	<p>±(1,6S) S in metres ±16 max.</p>	mm
αF	<p>Axle parallelism tolerance of guide rollers across travelling track</p>					<p>±0,63</p>	<p>±0,8</p>	<p>±1</p>	0/00
βF	<p>Axle parallelism tolerance of guide rollers along travelling track</p>					<p>±0,4</p>	<p>±0,5</p>	<p>±0,63</p>	0/00
Δh_F	<p>Height tolerance of h_F</p>					<p>+0 -1,6</p>	<p>+0 -2,5</p>	<p>+0 -4</p>	mm

Table 5 — Construction tolerances for crab wheels of tolerance classes 1 to 4 and tolerance for the guide rollers in Table 4

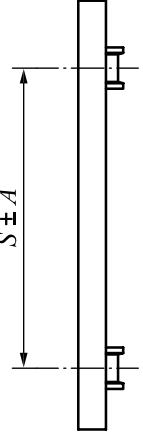
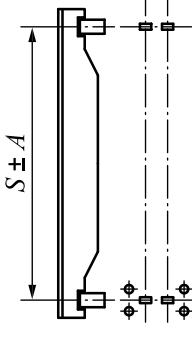
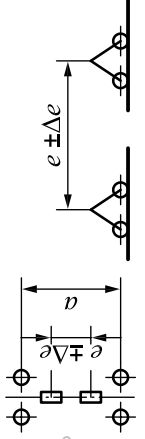
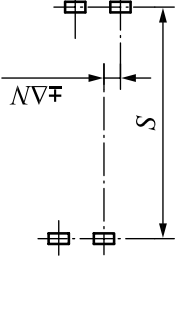
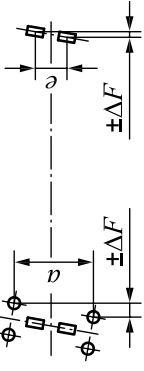
Symbol	Description with respect to this table	Graphical representation	Tolerance parameter				Unit
			Class 1	Class 2	Class 3	Class 4	
A	Tolerance of span S of a crab related to wheel centre, wheel with flanges		± 1 Valid for all spans $S \leq 2$ m $\pm[1 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	± 2 Valid for all spans $S \leq 2$ m $\pm[2 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	$\pm 2,5$ Valid for all spans $S \leq 2$ m $\pm[2,5 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	$\pm 3,2$ Valid for all spans $S \leq 2$ m $\pm[3,2 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	mm
A	Tolerance of span S of a crab related to wheel centre, flangeless wheel, with guide rollers on one side		$\pm 1,6$ Valid for all spans $S \leq 2$ m $\pm[1,6 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	$\pm 3,2$ Valid for all spans $S \leq 2$ m $\pm[3,2 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	± 4 Valid for all spans $S \leq 2$ m $\pm[4 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	± 5 Valid for all spans $S \leq 2$ m $\pm[5 + 0,1(S-2)]$ S in metres, valid for all spans $S > 2$ m	mm
Δe	Tolerance of wheel base e of crab wheels or bogey distance e , 8 wheels		$\pm 3,2$ e in metres, valid for $e \leq 3$ m $\pm e$ e in metres, valid for $e > 3$ m	± 4 e in metres, valid for $e \leq 3$ m $\pm 1,25e$ e in metres, valid for $e > 3$ m	± 5 e in metres, valid for $e \leq 3$ m $\pm 1,6e$ e in metres, valid for $e > 3$ m	$\pm 6,3$ e in metres, valid for $e \leq 3$ m $\pm 2e$ e in metres, valid for $e > 3$ m	mm
ΔN	Parallel offset of crab wheels or bogeys, 8 wheels		± 5 Valid for independent drive only ± 2 Valid for coupled drive only	$\pm 6,3$ Valid for independent drive only $\pm 2,5$ Valid for coupled drive only	± 8 Valid for independent drive only $\pm 3,2$ Valid for coupled drive only	± 10 Valid for independent drive only ± 4 Valid for coupled drive only	mm
ΔF	Alignment tolerance of guide rollers or wheel flanges		$\pm 0,32a$ a in metres $\pm 0,4e$ e in metres	$\pm 0,4a$ a in metres $\pm 0,5e$ e in metres	$\pm 0,5a$ a in metres $\pm 0,63e$ e in metres	$\pm 0,63a$ a in metres $\pm 0,8e$ e in metres	mm

Table 5 (continued)

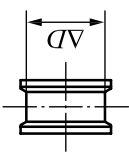
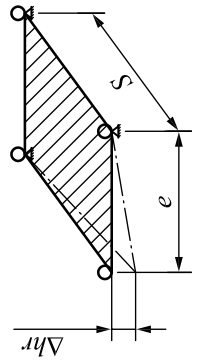
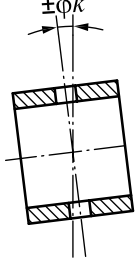
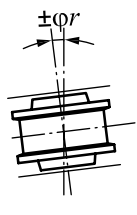
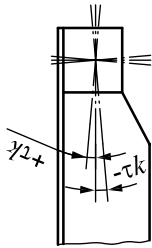
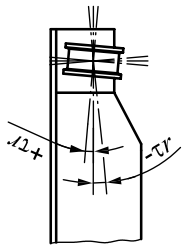
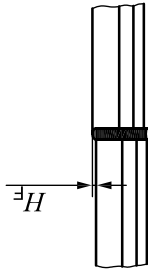
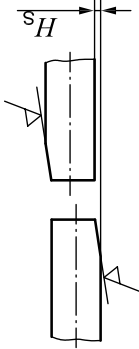
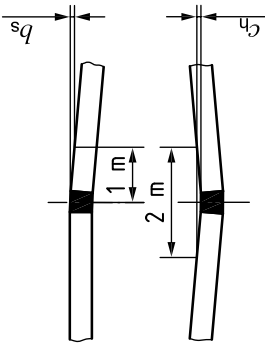
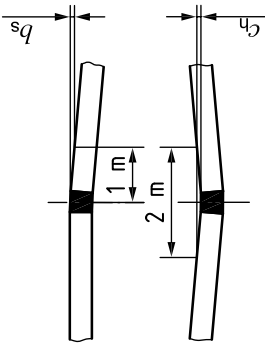
Symbol	Description with respect to this table	Tolerance parameter	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
ΔD	Diameter tolerance for coupled and independently driven crab wheels		h9 Diameter tolerance according to ISO 286-2	h9 Diameter tolerance according to ISO 286-2	h9 Diameter tolerance according to ISO 286-2	h9 Diameter tolerance according to ISO 286-2	mm
Δhr	Height of tolerance of points of wheel contact		1,6 max. Valid for all spans $S \leq 2$ m [1,6 + 0,1(S-2)] max. S in metres, valid for all spans $S > 2$ m	2 max. Valid for all spans $S \leq 2$ m [2 + 0,1(S-2)] max. S in metres, valid for all spans $S > 2$ m	2,5 max. Valid for all spans $S \leq 2$ m [2,5 + 0,1(S-2)] max. S in metres, valid for all spans $S > 2$ m	3,2 max. Valid for all spans $S \leq 2$ m [3,2 + 0,1(S-2)] max. S in metres, valid for all spans $S > 2$ m	mm
ϕk	Axle parallelism tolerance in a ground plan of crab frame (inclination of axis)		±0,3	±0,4	±0,5	±0,63	0/00
ϕr	Axle parallelism tolerance in a ground plan of crab wheel (inclination of wheel)		±0,4	±0,5	±0,63	±0,8	0/00
τk	Axle parallelism tolerance in elevation of crab frame (axle camber)		+19 -0,4	+2,4 -0,5	—	—	0/00
τr	Axle parallelism tolerance in elevation of crab wheel (wheel camber)		+2 -0,5	+2,4 -0,5	—	+2,6 -0,6	0/00

Table 5 (continued)

Symbol	Description with respect to this table	Tolerance parameter	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
<i>F</i>	Tolerance of parallelism of end stops of buffers on crab at right angles to longitudinal axis with parallelism symbol //		$\pm 0,8S$ <i>S</i> in metres ± 8 max.	$\pm S$ <i>S</i> in metres ± 10 max.	$\pm 1,25S$ <i>S</i> in metres $\pm 12,6$ max.	$\pm 1,6S$ <i>S</i> in metres ± 16 max.	mm
NOTE For tolerances of guide rollers, see Table 4.							

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Table 6 — Construction tolerances for rail joints

Tolerance parameter		Tolerance	
Symbol	Description	Graphical representation	All classes
H_F	Vertical offset of the welded joint at the rail flange		0 (for welding in production) 1 max. (for welding on site)
H_S	Horizontal offset of the rail head		1 max., with a taper of 1:50 to blend the offset
b_s	Inclination of rail in ground plan b_s and height c_h (lateral slope) with angularity symbol		2
c_h	Tolerances b_s and c_h related to a test length of 1 m		2
H_X	Flatness after grinding the trued-up area of H_S No finishing required at the rail end joint near the rail fastening for a staggered rail end joint	—	0,5 max.

Detachable rail joints shall be in accordance with this table.

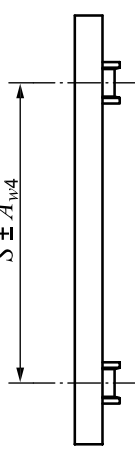
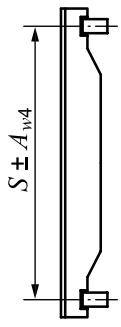
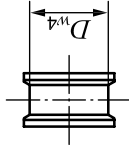
Table 7 — Operational tolerances for travel and traverse tracks and crane and crab wheels of tolerances classes 1 to 4

Symbol	Description with respect to this table	Tolerance parameter Graphical representation	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
A_{w1}	Tolerance of span S of crane rails related to rail centre at each point of travelling track	<p>$+A = S_{\max} - S$ $-A = S_{\min} - S$</p>	± 10 Valid for all spans $S \leq 16$ m $\pm[10 + 0,25(S-16)]$ S in metres, valid for all spans $S > 16$ m	± 16 Valid for all spans $S \leq 16$ m $\pm[16 + 0,25(S-16)]$ S in metres, valid for all spans $S > 16$ m	± 25 Valid for all spans $S \leq 16$ m $\pm[25 + 0,25(S-16)]$ S in metres, valid for all spans $S > 16$ m	± 40 Valid for all spans $S \leq 16$ m $\pm[40 + 0,25(S-16)]$ S in metres, valid for all spans $S > 16$ m	mm
B_{w1}	Tolerance of horizontal straightness of rail head at each point of travelling track	<p>Position of crane rail in ground plan</p>	± 10	± 20	± 40	± 80	mm
E_{w1}	Tolerance of height related to opposite measuring points at right angles at each point of travelling track	<p>Height of traversing track (lateral slope)</p>	± 10	± 20	± 40	± 80	mm
A_{w2}	Tolerance of span S of crab rails related to rail centre at each point of traversing track	<p>$S \pm A_{w2}$</p>	± 6 Valid for all spans $S \leq 16$ m	± 10 Valid for all spans $S \leq 16$ m	± 16 Valid for all spans $S \leq 16$ m	± 25 Valid for all spans $S \leq 16$ m	mm

Table 7 (continued)

Symbol	Description with respect to this table	Tolerance parameter Graphical representation	Tolerance				Unit
			Class 1	Class 2	Class 3	Class 4	
E_{w2}	Tolerance of height related to opposite measuring points at right angles at each point of traversing track	<p>Height of traversing track (lateral slope)</p>	$\pm 12,5$	± 16	± 20	± 25	mm
A_{w3}	Tolerance of span S of a crane related to wheel centre, with flanges		± 5 Valid for $S \leq 10$ m $\pm[5+0,2(S-10)]$ S in metres, valid for $S > 10$ m	± 8 Valid for $S \leq 10$ m $\pm[8+0,2(S-10)]$ S in metres, valid for $S > 10$ m	$\pm 12,5$ Valid for $S \leq 10$ m $\pm[12,5+0,2(S-10)]$ S in metres, valid for $S > 10$ m	± 20 Valid for $S \leq 10$ m $\pm[20+0,2(S-10)]$ S in metres, valid for $S > 10$ m	mm
A_{w3}	Tolerance of span S of a crane related to wheel centre, with flangeless wheels and guide rollers on one side		$\pm 12,5$ Valid for $S \leq 10$ m $\pm[12,5+0,2(S-10)]$ S in metres, valid for $S > 10$ m	± 14 Valid for $S \leq 10$ m $\pm[14+0,2(S-10)]$ S in metres, valid for $S > 10$ m	± 16 Valid for $S \leq 10$ m $\pm[16+0,2(S-10)]$ S in metres, valid for $S > 10$ m	± 20 Valid for $S \leq 10$ m $\pm[20+0,2(S-10)]$ S in metres, valid for $S > 10$ m	mm
ΔD_{w3}	Tolerance on crane wheel diameter for independent drive		h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	mm
ΔD_{w3}	Tolerance on crane wheel diameter for coupled drive		IT12 Tolerances according to ISO 286-2	IT13 Tolerances according to ISO 286-2	IT14 Tolerances according to ISO 286-2	IT14 Tolerances according to ISO 286-2	mm

Table 7 (continued)

Tolerance parameter		Tolerance					Unit
Symbol	Description with respect to this table	Graphical representation	Class 1	Class 2	Class 3	Class 4	
A_{w4}	Tolerance of span S of a crab related to wheel centre, wheel with flanges		±3 Valid for all spans $S \leq 2$ m $\pm[3 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±6 Valid for all spans $S \leq 2$ m $\pm[6 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±8 Valid for all spans $S \leq 2$ m $\pm[8 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±12 Valid for all spans $S \leq 2$ m $\pm[12 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	mm
	Tolerance of span S of a crab related to wheel centre, with flangeless wheels and guide rollers on one side		±5 Valid for all spans $S \leq 2$ m $\pm[5 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±10 Valid for all spans $S \leq 2$ m $\pm[10 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±12 Valid for all spans $S \leq 2$ m $\pm[12 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	±16 Valid for all spans $S \leq 2$ m $\pm[16 + 0,2(S-2)]$ S in metres, valid for $S > 2$ m	mm
ΔD_{w4}	Tolerance of crab wheel diameter for independent drive		h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	h18 Tolerances according to ISO 286-2	mm
ΔD_{w4}	Tolerance of crab wheel diameter for coupled drive		IT12 Tolerances according to ISO 286-2	IT13 Tolerances according to ISO 286-2	IT14 Tolerances according to ISO 286-2	IT14 Tolerances according to ISO 286-2	mm

Bibliography

- [1] ISO 8686-1:1989, *Cranes — Design principles for loads and load combinations — Part 1: General*

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ICS 53.020.20

Price based on 20 pages

Section 7) Surfaces Protection

All metallic surfaces of equipment shall be protected against atmospheric and / or service corrosion as specified below.

- **PAINTING SYSTEMS**

DESCRIPTION	RAL NO.	TABLE
Outside Surfaces of Steel Framed buildings, sheds, pipe racks, conveyor, towers, inside buildings, pults, platforms and ancillary Structural steel works in general, Stairs and gangways, supporting structure	(Green) 6011	1
Floor plates:		
- Floor Side	(Grey) 7038	1
- Ceiling side	(Green) 6011	
Stairs and gangways: supporting structure	(Green) 6011	1
Steps and footpaths	(Black) 9005	
Railing: Handrails and treads	(Black) 9005	1
Uprights and Legboards	(Yellow) 1021	
Gratings (Deck, Stairs, etc.), Bolts, Nuts, washers	(Green) 6011	1
Machined Surfaces ⁽¹⁾	Rust Preventive Oil	----

NOTES:

(1) Items listed below need no paint;

Weight Elements (in take-up assembly), High strength fasteners (10.9 and above), parts in contact with concrete (e.g. base-plates), Rubber and parts made of stainless steel, copper and aluminum alloys, **tanks rubber lined surfaces.**

Table 1

- The painting shall be applied according to following table.

Process		Paint Name or Treatment *	No. of Coats	Painting Method	Dry Film Thickness of each Coat (microns)	Interval Min. Max. (hrs.)**	
At Shop	Surface Preparation	SIS SA 2 $\frac{1}{2}$					
At Shop	Primer Coat	2-Component Epoxy(P9)	1	Airless	70	48	---
At Shop	Intermediate Coat	Epoxy(P14)	1	Airless	70	16	---
At Shop	Final coat	Epoxy(P20)	1	Airless	80	16	---

* : For detail specification of painting cycles refer to pages 11~16 of "packing instruction & painting cycles & welding inspection" attached.

** : Up to paint manufacturer instruction.

Painting cycles

P.9 Epoxy consisting of two-elements Primer

Painting Product characteristics

-TYPE:	Two-components	
-COLOUR:	Brown-red	
- PIGMENT: percentage :	40÷45	
Chemical composition:	Zinc-chromate,Zinc-phosphates,synthetic red-iron-oxide,alluminium and magnesium silicates.	
	Pigments and extenders shall not be water-soluble.Carbonates must be avoided .	
-VEHICLE: percentage:	50÷55	
Chemical composition:	Epoxy resin solid solution.	
-HARDENER:	Amino or polyamides to be mixed at the time of use.	
-SPECIFIC WEIGHT:	1,30 ÷ 1,40	(regarding the
-VISCOSITY AT 25° C.:	130" ÷ 150" FORD Cup 4(product mixed and ready for use.)	

Application Field and characteristics

- SURFACE ON WHICH THE PRIMER IS TO BE APPLIED :

Rust grade A-B-C-D Steel

Surface : Sa 2.1/2 Minimum grade blast cleaning

-PAINTING PRODUCTS WHICH CAN BE RECOATED:

(P.14) Epoxy intermediate coat or any others according to the "Compatibility Table"(Parag.6.6.)

- APPLICATION: Brush, Spray, Airless, Roller
- DRYING TIME: 6 hours to the touch

-MINIMUM INTERVAL FOR RECOATING: 24 Hours

RECOATING:

- DRIED COAT LOOKS: Semi-Gloss

-MINIMUM THICKNESS OF

DRIED FILM: 40÷50 microns

- AVERAGE YELD sq.m/kg: 5 ÷ 7

Resistance Characteristics:

- SALT-SPRAY CHAMBER TEST (According to ASTM B-117)

350 Hours exposure

- HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)

350 Hours exposure.

P.14 Epoxy Intermediate Coat

Painting Products characteristics

- TYPE: Two-components
- COLOUR: Grey, Yellow, Green (Upon request)
- PIGMENT: percentage: 45 ÷ 50
 - Chemical composition: Grey:
Titanium dioxide, Black Ferric oxide, Alluminium and Magnesium silicates.
 - Yellow:
Lead-Chromate, Yellow Ferric oxide, Alluminium and Magnesium silicates.
 - Green:
Green Chromium oxide, Titanium dioxide, Alluminium and Magnesium silicates.
- Pigments and extenders shall not be water-soluble. Carbonates must be avoided.
- VEHICLE: percentage: 55 ÷ 50
 - Chemical composition: Epoxy resin solid solution.
Among solvents, chlorinated and benzene must be avoided.
- HARDENER: Amino and polyamides or any others to be mixed at the time of use.
- SPECIFIC WEIGHT: 1,20 ÷ 1,40 (regarding the
- VISCOSITY at 25 °C.: 50" ÷ 70" FORD Cup 4 (product mixed and ready for use.)

Application Field and characteristics

- SURFACE ON WHICH THE PRODUCT IS TO BE APPLIED :
- (P.9.) Epoxy consisting of two-elements primer or any others according to the "Compatibility Table" (Parag. 6.6.)

- PAINTING PRODUCTS WHICH CAN BE RECOATED:

(P.20) Epoxy Finish Coat or any others according to the "Compatibility Table" (Parag.6.6.)

- APPLICATION: Brush, Spray, Airless, Roller.

- DRYING TIME: 4 ÷ 6 hours to the touch

- MINIMUM INTERVAL FOR RECOATING: 24 hours

-DRIED COAT LOOKS: Semi-Gloss

-MINIMUM THICKNESS OF DRIED FILM: 40 ÷ 45 microns

AVERAGE YIELD sq.m/kg: 5 - 6

Resistance Characteristics :

-SALT-SPRAY CHAMBER TEST (According to ASTM B-117)
350 Hours exposure

-HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)
350 Hours exposure

P.20 Epoxy Finish Coat

Painting Product characteristics

- TYPE: Two components
- COLOUR: (Upon request)
- PIGMENT: percentage: Black Colour: 12 ÷ 15
Other Colours: 25 ÷ 35
- Chemical composition: According to the colour .
Pigments and extenders shall have strong corrosion-proof characteristics.
Furthermore they shall not undergo any colour's degradation and/or alteration.
Pigments and extenders shall not be water-soluble. Carbonates must be avoided.
- VEHICLE: percentage: Black Colour: 88 ÷ 85
Other Colours: 75 ÷ 65
- Chemical composition: Epoxy resin solid solution.
Among solvents, chlorinated and benzene must be avoided .
- HARDENER: Amino and polyamides or any others to be mixed at the time of use.
- SPECIFIC WEIGHT: 1,10 ÷ 1,40 (regarding the
- VISCOSITY at 25 °C.: 50" ÷ 70" FORD Cup 4 (product mixed and ready for use.)

Application Field and characteristics

- SURFACE ON WHICH THE PRODUCT IS TO BE APPLIED :
(P.14) Epoxy Intermediate Coat or any others according to the "Compatibility Table" (Parag. 6.6.)
- APPLICATION: Brush, Spray, Airless, Roller.
- DRYING TIME: 2 hours to the touch
- DRIED COAT LOOKS: Gloss

-MINIMUM THICKNESS OF 30 ÷ 40 microns

DRIED FILM:

AVERAGE YELD sq.m/kg: Black Colour: 7÷8

Other Colours: 6÷7

Resistance Characteristics :

-SALT-SPRAY CHAMBER TEST (According to ASTM B-117)

350 Hours exposure.

-HUMIDISTATIC CHAMBER TEST (According to ASTM D-2247)

350 Hours exposure.

For the performance of both tests, the steel samples shall be given two coats of the painting product_