

## New Generation Ferritic Stainless Steels Grades 445M2 & 404GP™ WELDING

New Generation Ferritic Stainless Steels 445M2 and 404GP™ are readily weldable by the usual methods used for sheet metal: TIG, MIG (including pulsed MIG), spot and seam welding.



Welding technique for ferritic stainless steels needs to be 'fine-tuned' by welders used to austenitic stainless grades.

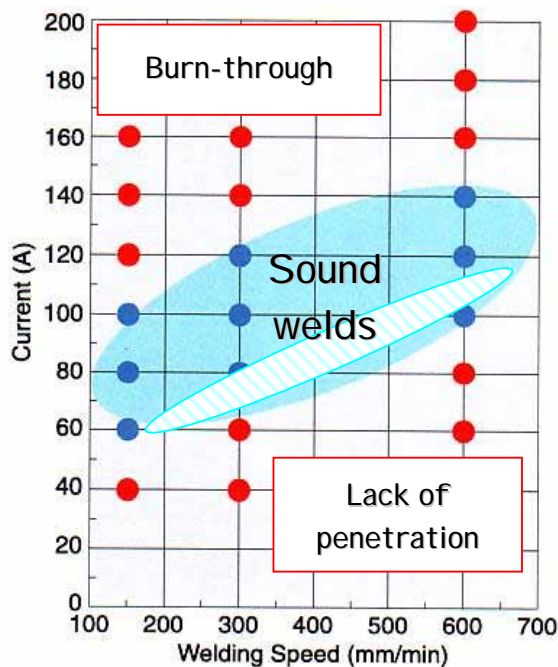
- ❖ Heat is conducted away from the weld pool faster than with austenitics, so compared to the setup for 316 or 304, 445M2 and 404GP™ need higher amps, or lower travel speed. 10-30% more is needed.
- ❖ Carbon and nitrogen contamination of the weld pool can cause sensitisation and loss of corrosion resistance, so you need clean sheet, clean rods and good shielding, with CO<sub>2</sub> no more than 3%.
- ❖ Cleanliness of the sheet and rod is even more important than it is for austenitics.
- ❖ Too much heat can cause poor impact properties, so make small welds with minimum reinforcement, and don't weave

Sheet metal welds made with the current too high or the travel speed too low will suffer from burn-through. Tight fitup without a gap helps to avoid burn-through.

If the current is too low, or the travel speed too high, there will be lack of penetration. For seal welds, this may not be a problem, but the crevice on the non-welded side is prone to crevice corrosion and should not be immersed or exposed to aggressive conditions.

Sound welds can be made with the balance of travel speed and current in the blue zone.

Best welds, with best impact and fatigue resistance, are made in the striped part of the blue zone. Avoid too much reinforcement – don't over-weld!



## Burn-through

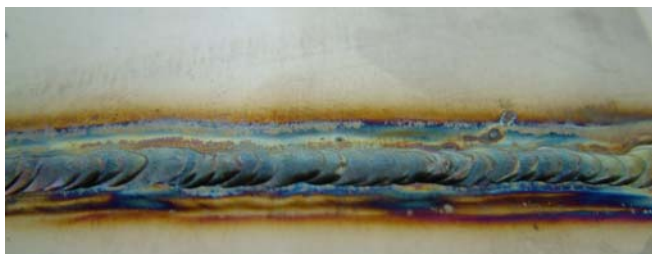
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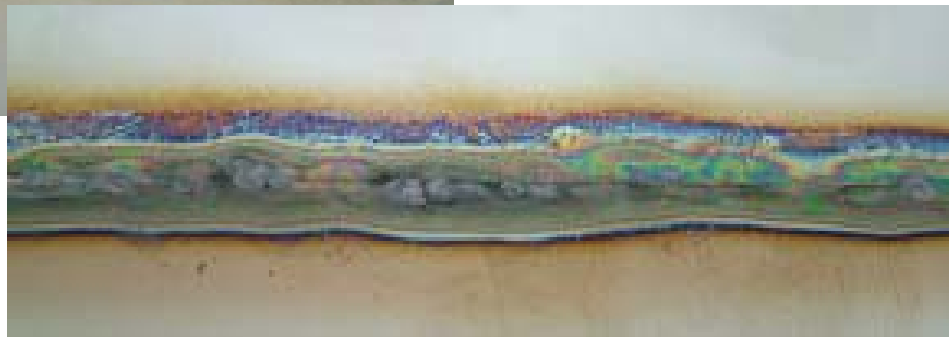


## Lack of Penetration

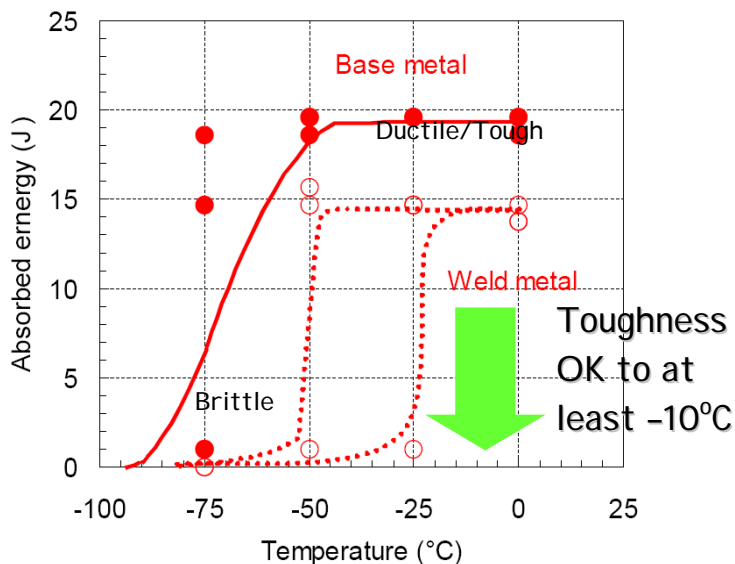
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## Impact Toughness - Charpy Impact Test (1.6mm sheet)



Don't over-weld – too much reinforcement on welds causes grain growth and hurts impact toughness



**445M2 and 404GP™** are new generation ferritic stainless steel grades made by premium Japanese mills. Like all ferritic stainless steels, these grades should be used only between 0°C and 400°C, and should not be used in pressure vessels or structures without full qualification.

## Filler Metals

- ❖ TIG welds are often made without adding filler metal, especially in the lighter gauges
- ❖ TIG welds in heavier gauges and MIG welds need filler metal
- ❖ Cut strips of sheet may be used for TIG – be sure they are clean.
- ❖ Filler wires for TIG and MIG are over-alloyed for best corrosion resistance.
- ❖ Choose a filler wire for the combination of corrosion resistance and economy you need.

Sheet	PRE	Filler	PRE
445M2 316	26 25	316L(Si)	27
404GP™ 304	21 18	308L(Si) 309L(Si) 316L(Si)	20 23 27

Corrosion resistance depends mainly on the levels of chromium and molybdenum in the steel.

PRE (Pitting Resistance Equivalent) gives the equivalent effect of these two alloys. The higher the PRE, the better the corrosion resistance.

## Shielding Gas

- ❖ TIG – argon
- ❖ MIG – argon. Argon + 1-2% oxygen improves arc stability and the weld pool is more fluid and controllable, with good bead contour.
- ❖ Do not use hydrogen or nitrogen in the shielding gas – ferritic grades do not tolerate these
- ❖ Consider a backing bar to protect the back of the weld for best corrosion resistance

## Preheat, Post Heat and Post Weld Heat Treatment

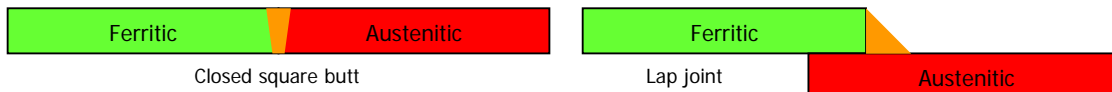
- ❖ These are not required with new generation ferritic grades 445M2 and 404GP™
- ❖ Beware of dampness on the metal – warm it to room temperature to dry it
  - Ferritics are less tolerant than austenitics to hydrogen pickup in the weld pool from moisture on the sheet.
  - Use an electric dryer – flames have a high moisture content

## Clean-up after welding

- ❖ Just like with austenitics, clean off the visible oxide to restore full corrosion resistance
- ❖ Grinding and/or polishing can remove the oxide – the smoother the surface finish, the better the corrosion resistance
- ❖ Pickling 445M2 may need more time because of the higher corrosion resistance
- ❖ If pickling is really slow, make sure the weld was properly shielded, including the back
- ❖ The best corrosion resistance is obtained by grinding off the surface affected by welding oxide, polishing it to at least as good a finish as the parent sheet, then pickling. Pickling is the most potent step, and for corrosion resistance grinding and polishing can be omitted.

## Can I weld a new generation ferritic grade to an austenitic ?

- ❖ Welding new generation ferritic grades to austenitics is OK
  - For best corrosion resistance, minimise melting of the austenitic
    - Closed square butt preparation can be used – keep the weld small
    - Lap joint is better as it requires less melting of the austenitic. Lap joints also make it easier to avoid burn-through.



- The risk is pickup of carbon in the weld pool from the austenitic grade. This is of concern in the most aggressive corrosion environments
- Beware of distortion caused by the difference of thermal expansion coefficient
- There will be no problems of galvanic/dissimilar metals corrosion when ferritic grades are welded or connected to austenitic grades

## Tips for Welding Stainless Steel

- **Clean** the weld joint and surrounding area to remove all foreign material: glue, paint, water stains, oil, grease, fingerprints, rust, and caulk
- Weld with as **short an arc** as possible (tungsten tip to base metal) to minimize distortion and heat input. Arc length should be about 1½ mm. Remember: as arc length increases, arc voltage (pressure) increases.
- **Avoid weaving** to keep heat input and weld metal dilution down. Maintain constant forward speed. Never reverse the arc travel direction. If you can't get adequate filler in the joint the first time, let it cool, clean the joint, and do it again.
- Use **only enough current** to obtain a smooth, soft arc and minimal base metal melting. With TIG, use about 40 — 45 amps on 0.7 — 1.2 mm metal.
- Use a pointed tungsten electrode – smaller electrodes make cooler welds and enable you to focus the heat where it's needed. Grind parallel to the length, and use a sharper angle for good penetration and a cool weld.
- Use a high frequency arc starter to avoid scratch starts to prolong tip life.
- **Filler metal** should be as **clean** as the base metal. Make sure your **gloves** are **clean**.
- If the **base metal** is burned **black** after welding, it got **too hot**. You have a lot of weld metal cleaning to do. Decrease the heat input, and maintain proper travel speed to prevent burned-black welds.
- Keep the **tungsten clean and pointed** at all times. A poor point can't direct the arc to such a fine line joint. Even the steadiest hands in an awkward position or joint will touch tungsten to base metal. If this happens, stop the arc and change the tungsten.
- It's **OK** to keep 3xx series and new generation ferritic stainless steels cool with a damp rag. Cool it down — it can be easy to push a weld through light gauge stainless steel if it's too hot. The weld will be gone before you realize what happened.
- Keep your shielding **gas flow** around **10 — 15 litres per minute**. If you need more volume, find out why and fix the problem. Don't waste gas.
- Use **1.6 mm filler metal on 1.6 — 3.0 mm** base metal.
- A properly executed TIG joint will have **no discolouration** after only light cleaning.

## Fixtures and Tack Welds

- ❖ Thin stainless steel sheet must be properly aligned and clamped to avoid buckling. Consider using a copper backing bar, usually nickel plated, water cooled in high productivity applications
- ❖ The backing bar can include a groove where argon can be provided to prevent backside oxidation. The two front side bars should be bevelled to make room for the torch.
- ❖ Ferritic grades need tack welds at about the same spacing as carbon steel, which is about double that used with austenitic grades.
- ❖ Tack welds must be shielded and cleaned (wire brushed or ground to clean metal) before making the main weld. Any crater cracks should be ground out.

**Grade 445M2** is made by Nisshin Steel Co Ltd, Japan. The corrosion resistance is as good as grade **316**.

**Grade 404GP™** is made by JFE Steel Corporation, Japan. The corrosion resistance is as good as grade **304**.

**Both grade 445M2 and 404GP™** are easier to fabricate – which gives better product quality and lower fabrication costs. They give much better economy than the austenitic grades they replace.