**Welding different materials**

Alloyed, unalloyed and non-ferrous metals all have varying structure and mechanical properties. EN8 is a type of unalloyed medium carbon steel. EN8 has a reasonable tensile strength, it is readily machinable and can be flame or induction hardened which will increase its wear resistance. EN8 can be welded however it needs to be heat treated if over 18mm to prevent cracking. It is also recommended to anneal after welding to prevent cracking.

Force on the weld can cause distortion of the weld. It occurs in six main forms; Longitudinal shrinkage, Transverse shrinkage, Angular distortion, bowing and dishing, Buckling and Twisting. The force could come from placing a clamp on the weld. Distortion occurs when a heavy load or pressure is place on the material that is being welded. The heavy load stops the metal from expanding equally as it is heated. After welding the metal cools and tries to return to its original strength but it is now fused to another piece of metal and cannot move. This will cause stresses on the weld joint which will, depending on the strength of the metal and weld, cause the weld to stretch and thin out weakening the weld. EN8 main failure is cracking.

To prevent distortion or cracking occurring in EN8 it is important to make sure to weld a certain way. Make sure to preheat to 180 degrees C. This could be done in a furnace, by induction heating, by resistance heating mats or by suitably disposed gas torches. It is important to maintain preheat during welding. For arc welding use basic coated electrodes like E7016 or E7018 to make sure that the metal hydrogen content is below 5ml/100g. Make sure that the metal being welded cools to 180 degrees C before tempering. Heat to 620 – 650 degrees C at a rate of 100 degrees C per hour or 6000/thickness (mm) degree C per hour. Do whichever is smaller. Temper for 2 hours. Cool to 200 degrees C at a controlled cooling rate of 100 degrees C per hour. Cool to room temperature in still air. If though, it is not possible to hold the metal at an intermediate temperature after welding, pending heating for tempering, other procedures can be used. You could boost the preheat to 250 degrees C and hold for 4 hours. Cool to room temperature at a maximum rate of 50 degrees C per hour. Temper when convenient. Inspect the weld by dye penetrant, magnetic particle or ultrasonic examination.

Dye penetrant, also called Liquid penetrant examination is one of the most popular non-destructive examinations in industry. The test surface is cleaned. Then the penetrant is applied to the item being tested. The penetrant is then given ‘dwell time’ to soak into any flaws. Generally 5 to 30 minutes. The excess penetrant is then removed from the surface. After the penetrant has been removed the developer is added. The developer draws the penetrant out onto the surface to form a visible indication. The inspector will use light to see were any defects have occurred. This particular type of testing is good because it is simple and easy to learn, it is not expensive and is quite a fast test to perform. However the test only will show surface flaws. The test needs to be performed on a smooth surface and can cause skin irritation if any of the chemicals are touched.

Magnetic particle testing is also a non – destructive type of testing. Magnetic particle testing works by sending line of magnetic flux though the weld. If there are no cracks then the flux will pass through the weld without interruption. When a crack or other discontinunity occurs then the magnetic flux will leak making the size and shape of the discontinuity easily visible.

Ultrasonic testing is again in the non-destructive family of weld testing. It works by sending a beam of ultra-sonic energy into the work piece. The ultra-sonic tester picks up any internal imperfections in the work piece. This type of testing is more expensive than the above to however the main expense will come from having to have a trained operator using the ultra-sonic tester.

http://me.aut.ac.ir/staff/solidmechanics/alizadeh/Magnetic%20Particle%20Inspection.htm

316 stainless steel is a type of alloyed steel. 316 has excellent elevated temperature tensile, creep and stress-rupture strengths. It is also very easy to weld with by all methods of fusion. Heavy welded sections of 316 require post-weld annealing for maximum corrosion resistance. Unlike EN8 316 stainless cannot be hardened by heat treatment.

It is important though while welding 316 to be aware of hot cracking. Hot cracking can appear in several locations on the metal. It is most common to find it as longitudinal centre line cracks or as flare cracks which are also longitudinal but at an angle to the through thickness direction. Cracking occurs when there is an insufficient supply of liquid weld metal to fill all the spaces in the cooling metal. One of the main causes of cracking is that there is a too higher strain on the weld pool. The other main causes of the cracking is that the narrow channels between the solidifying metal are blocked and the liquid metal cannot get through. It is important that while welding you maintain a wide, shallow weld pool. This will reduce the risk of cracking in the weld. Make sure to control the weld with a width to depth ratio of around 0.5. Also make sure to maintain a good travel speed while welding. Traveling too fast can result in a long weld pool that has a tail which makes it harder to get the liquid to the front of the weld pool.

Aluminium is a non-ferrous metal that can generally be welded by all three of the welding methods. Whilst welding it is important to make sure to avoid imperfections. Aluminium is affected by poor porosity, cracking and poor weld bead profile. The main cause of porosity is absorption of hydrogen in the weld pool which forms pores in the solidifying weld metal. Aluminium is one of the metals that is most susceptible to porosity. Hydrogen can come from many places including from contaminates on the metal or commonly from the filler wire surfaces or from water vapour in the in the shielding gas.

To minimise the risk of hydrogen getting into the weld, it is important that the material surface and filler wire is cleaned well before use. The best way to clean is either by Mechanical cleaning, solvent degreasing and chemical etching. Mechanical cleaning involves wire brushing with stainless steel bristles to remove surface oxide and contaminates. Solvent degreasing should be carried out by dipping, spraying or wiping with organic solvents that can be used to remove grease, oil, dirt and loose particles. For chemical etching a solution of 5% sodium hydroxide can be used for batch cleaning but this should be followed by rinsing in HN03 and water to remove products from the surface. Aluminium is also affected by cracking; solidification and liquation cracking. To reduce the risk of solidification cracking the weld bead must be thick enough to withstand contraction stresses. Also, the degree of the restraint on the weld be minimised by using correct edge preparation, accurate joint set up and correct weld sequence. The risk can be reduced by using a filler metal with a lower melting point than the parent metal. Another impurity that aluminium welding suffers from is a poor weld bead profile. Wrong welding parameter settings or poor welder technique can cause imperfections such as lack of fusion, lack of penetration and undercut. Aluminium has a high thermal conductivity and the rapidly solidifying weld pool can make these aluminium alloys particularly susceptible to profile imperfections. Aluminium 2124 is an example of a grade of aluminium. It is not recommended to weld by Arc or MIG welding with this grade. Spot welding is recommended, however this limits the applications of 2124. TIG welding though can be used instead of MIG and Arc welding. 2124 is difficult to weld as it is highly susceptible to cracking. It is important that 2124 is as strong as it can be as its main use is mainly in planes.