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|  **ADVANCE INSTITUTE OF WELDING TECHNOLOGY****BMQR_ISO_9001_Logo# 20, Bharathi Nagar, Gerugembakkam, Chennai 600 122, Tamilnadu, India.**  E-mail: aiwt\_welding@yahoo.co.in ; sridhar305@yahoo.com & vreajasaker@yahoo.com **web site: www: advance welding institute.com**; **🕾 91-44 658 55176 & 23821812****Annexure:****Welding of Carbon Steel To Austenitic Steel** |

When a weld is made using a filler wire or consumable, there is a mixture in the weld consisting of approximately 20% parent metal and  80% filler metal alloy ( percentage depends on welding process, type of joint and welding parameters). Any reduction in alloy content of 304 / 316 type austenitic is likely to cause the formation of matensite on cooling.  This could lead to cracking problems and poor ductility.  To avoid this problem an over alloyed filler metal is used, such as a 309, which should still form austenite on cooling providing dilution is not excessive. The Schaeffler diagram can be used to determine the type of microstructure that can be expected when a filler metal and parent metal of differing compositions are mixed together in a weld. **The Schaeffler Diagram**

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The Nickel and other elements that form Austenite, are plotted against Chrome and other elements that form ferrite,  using the following formula:-Nickel Equivalent =  %Ni + 30%C + 0.5%Mn Chrome Equivalent = %Cr + %Mo + 1.5%Si + 0.5%Nb Example, a typical 304L = 18.2%Cr, 10.1%Ni, 1.2%Mn, 0.4%Si, 0.02%C Ni Equiv = 10.1 + 30 x 0.02 + 0.5 x 1.2 =  11.3 Cr Equiv = 18.2 + 0 + 1.5 x 0.4 + 0 = 18.8 A typical 309L welding consumable Ni Equiv = 14.35, Cr Equiv = 24.9 The main disadvantage with this diagram is that it does not represent Nitrogen, which is a very strong Austenite former. **AIWT-Chennai continuation sheet,****Ferrite Number:**The ferrite number uses magnetic attraction as a means of measuring the proportion of delta ferrite present.  The ferrite number is plotted on a modified Schaeffler diagram, the Delong Diagram. The Chrome and Nickel equivalent is the same as that used for the Schaeflfer diagram, except that the Nickel equivalent includes the addition of 30 times the Nitrogen content.

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| Delong diagram |

**Examples**

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The Schaeffler diagram above illustrates a carbon steel **C.S** , welded with **304L** filler. Point **A** represents the anticipated composition of the weld metal, if it consists of a mixture of filler metal and 25% parent metal. This diluted weld, according to the diagram, will contain martensite.  This problem can be overcome if a higher alloyed filler is used, such as a 309L, which has a higher nickel and chrome equivalent that will tend to pull point **A** into the austenite region.  If the welds molten pool spans two different metals the process becomes more complicated.  First plot both parent metals on the Schaeffler diagram and connect them with a line.  If both parent metals are diluted by the same amount, plot a false point **B** on the diagram midway between them.  (Point B represents the microstructure of the weld if no filler metal was applied.)  **AIWT-Chennai continuation sheet,**

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Next, plot the consumable on the diagram, which for this example is a **309L**. Draw a line from this point to false point **B** and mark a point **A** along its length equivalent to the total weld dilution.  This point will give the approximate microstructure of the weld metal. The diagram below illustrates 25% total weld dilution at point **A,** which predicts a good microstructure of Austenite with a little ferrite.

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The presence of martensite can be detected by subjecting a macro section to a hardness survey, high hardness levels indicate martensite. Alternatively the weld can be subjected to a bend test ( a side bend is required by the ASME code for corrosion resistant overlays), any martensite present will tend to cause the test piece to break rather than bend. However the presence of martensite is unlikely to cause hydrogen cracking, as any hydrogen evolved during the welding process will be absorbed by the austenitic filler metal.  **AIWT-Chennai continuation sheet,****Evaluating Dilution**

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**Causes Of High Dilution** * **High Travel Speed**. Too much heat applied to parent metal instead of on filler metal.
* **High welding Current**.  High current welding processes, such as Submerged Arc Welding can cause high dilution.
* **Thin Material.**  Thin sheet TIG welded can give rise to high dilution levels.
* **Joint Preparation.**  Square preps generate very high dilution. This can be reduced by carefully buttering the joint face with high alloy filler metal.

 Sridhar  |

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 **(a collection from various references)**