

Technical Newsletter from
ADOR WELDING LIMITED
Formerly Advani - Oerlikon Ltd.

WELDING OF DUPLEX AND SUPER DUPLEX STAINLESS STEELS

As you may be aware, there are many groups of stainless steels which are used for different applications. All stainless steels have specific properties and are meant for specific applications. In our earlier issues we had discussed the ferritic and martensitic stainless steels. In this article we will discuss another important group of stainless steels, duplex and the super duplex stainless steels.

WHAT ARE DUPLEX (DSS) AND SUPER DUPLEX (SDSS) STAINLESS STEELS?

Duplex stainless steels contain approximately 50:50 of ferrite and austenite at room temperature. This combination imparts special properties to this group of stainless steels. The austenite phase has general corrosion resistance, good toughness, ductility, high and low temperature properties and good weldability. The ferrite phase has good stress corrosion resistance and good strength. So the duplex stainless steels exhibit a combination of these properties which makes this steel an ideal candidate material for many applications.

Super duplex stainless steels are similar to duplex stainless steels but their pitting resistance is higher than the duplex stainless steels. If the pitting resistance equivalent (PRE) as calculated by

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the following formula is more than 40, then that steel is designated as SDSS.

$$PRE = \%Cr + 3.3(\%Mo) + 16(\%N)$$

WHAT ARE THE COMMON GRADES OF DSS AND SDSS?

GROUP	Alloy	UNS No	TYPICAL COMPOSITION	UTS MPa	YS MPa	%El
DSS	329	S32900	0.2C-25.5Cr-3.75Ni-1.5Mo	724	551	25
	2205	S31803	0.03C-22Cr-5.3Ni-2Mo-3Cu	760	520	27
	3RE60	S31500	0.03C-18.5Cr-4.75Ni-2.75Mo	617	482	48
SDSS	Ferralium 255	S32550	0.04C-25.5Cr-5.5Ni-3Mo-0.17N-2Cu	869	676	30
	SAF 2507	S32750	0.03C-25Cr-7Ni-4Mo-0.28N	800	550	25
	Zeron 100	S32760	0.03C-25Cr-7Ni-3.5Mo-0.25N-0.75Cu-0.75W	750	550	25

PROPERTIES OF DSS AND SDSS

Strength: These stainless steels are twice as strong as regular austenitic or ferritic stainless steels.

Toughness and ductility: DSS and SDSS have significantly better toughness and ductility than ferritic grades; however they do not reach the excellent values of austenitic grades.

Corrosion resistance: DSS and SDSS grades have a range of corrosion resistance similar to the range for austenitic stainless steels.

Stress Corrosion Cracking (SCC): These steels show very good SCC resistance, a property attributed to ferrite in the steels. While using austenitic stainless steels, SCC can be a problem under some circumstances (chlorides, humidity, elevated temperatures)

Due to increased yield strength compared to austenitic stainless steels, it may be possible to reduce section thickness while using DSS and SDSS.

APPLICATIONS OF DSS AND SDSS

- Higher Efficiency & Power Factor

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These steels are being increasingly used in:

- Oil and Gas industry equipment
- Heat exchangers and tubes
- Pressure vessels
- Desalination plants
- Sea water systems and pipes
- Chemical process industries
- Storage tanks and
- Many other industries

HOW IS THE WELDING BEHAVIOR OF THESE STEELS?

These steels don't pose much difficulty in welding, their behavior is similar to that of the austenitic grades and they are welded in the annealed condition. Their thermal expansion and contraction is less than the austenitic grades. These steels normally don't require pre-heating and post weld heat treatment. A solution annealing heat treatment can be employed in case of very high cold working. During heating and cooling there is no transformation to any hard phase but careless longer soaking at elevated temperatures, very slow cooling rates can help in transformation to sigma phase because of the higher ferrite contents. Both very high and low heat inputs are not preferred since very high heat input promotes excess grain growth, wider HAZ and very low heat input promotes faster cooling, inhibits reversion to gamma phase. A heat input range of 0.5-2.5KJ/mm is recommended.

As indicated earlier the presence of both austenite and ferrite in specific proportion is very essential for the mechanical and corrosion properties of the material, weld metal. The ferrite in these steels is measured using the terminology EFN (extended ferrite number) with WRC 1992 diagram.

SELECTION OF WELDING CONSUMABLES

These steels can be welded to other duplex stainless steels, to austenitic stainless steels and to carbon and low alloy steels.

Duplex stainless steel consumables with nickel content higher than base metal are most frequently used to weld duplex stainless

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steels to other duplex stainless steels. This ensures an adequate level of austenite is formed in the weld during cooling.

When welding duplex stainless steels to austenite grades, an austenitic filler metal with low carbon content and a moly content between the 2 types being joined is recommended; E309LMo and ER 309LMo types are frequently used for these joints. The same consumables can be used for joining duplex stainless steels to carbon and low alloy steels.

Both duplex and super duplex stainless steels can be welded with processes like SMAW, GTAW, GMAW, FCAW and appropriate consumables are available for the same.

AWS	Typical Chemistry	UTS MPa min	%EL min	For welding of
E2209 / ER-2209	0.03C-22.5Cr-9.5Ni-3Mo-0.15N	690	20	22%Cr DSS
E2553 / ER2553	0.03C-25.5Cr-7.5Ni-3.4Mo-0.17N-2Cu	760	15	25%Cr Dss
E2594 / ER2594	0.03C-25.5Cr-10Ni-4Mo-0.25N	760	15	32750 type SDSS; also for normal DSS and dissimilar joints in CS, LAS to DSS
E2595 / ER2595	0.03C-25.5.Cr-9Ni-3.8Mo-0.7Cu-0.7W-0.25N	760	15	32550,32750,32760 type SDSS; also for normal DSS and dissimilar joints in CS, LAS to DSS

In general the weld metal must have higher percentages of Ni which gives more austenite and also more toughness to the weld metal.

CORROSION PROPERTY TESTING

As these steels are meant for severe corrosive environments, a number of tests are to be conducted to ensure that they possess the desired corrosion resistance. Some of the common tests that are conducted are NACE MR 01 77 (for SSCC), ASTM G48 (for pitting and crevice corrosion), ASTM G36 (for chloride stress corrosion).

ADOR WELDING LTD. WELDING CONSUMABLES FOR DSS AND SDSS

The following table gives the consumables for various AWS

classifications. Please click on the brand name to know more about the consumables.

AWS CLASSIFICATION	PROCESS	AWL BRAND NAME
E2209-16	SMAW	BETANOX 4462
E2553-16	SMAW	BETANOX 2553
E2595-15	SMAW	BETANOX 2595-15 (UNDER DEVELOPMENT)
ER 2209	GTAW	TIGINOX 2209
ER2594	GTAW	TIGINOX 2594

CONCLUSION

DSS and SDSS are fast becoming the candidate materials for several critical applications especially in oil, gas and other industries. While welding of these steels rarely pose any problems, a good understanding of their welding behavior and the other factors, that can influence their properties like toughness, corrosion resistance, is essential, to produce a welded joint that will perform satisfactorily in service.

Please contact cmo@adorians.com for assistance in deciding type of stainless steel to be used for specific application, assistance in PQR and training of welders in welding various grades of stainless steels.



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