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Duplex and ASTM G48-A Test 🧪 6

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Guys,

I am really struggling on how to proceed with a weld procedure qualification that I am currently working on.

The material is 8" sch40 2205 Duplex. Our customer has a requirement for corrosion testing IAW ASTM G48 method A. **His criteria for the test is testing at 35°C for 72 hours.** The acceptance criteria is "No pitting or crevice corrosion in either the weld metal or HAZ is permitted"

I just received the test results and with my limited knowledge it does not look good. The test results are shown below.

FERRIC CHLORIDE PITTING TEST

Specification: ASTM G48, Method A

Temperature (°C): 35

Time (hour): 72

Length (cm)	Width (cm)	Thickness (cm)	Surface Area (cm ²)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Mass Loss (g/ m ²)	Corrosion Rate (mdd)
5.13	2.45	0.62	34.52	60.3497	60.2142	0.1355	39.2549	130.85

The test specimen was polished to a 120 grit finish and rinsed in an ultrasonic cleaner to remove any debris and then examined at a X20 magnification by stereomicroscope. It was passivated for 24 hours before being placed into the test solution. The test solution is prepared in accordance with ASTM G48 Method A. The solution and bath water temperature has to reach the identical temperature of 35°C, before the test specimen is placed in a one liter beaker and maintained at 35°C for a period of 72 hours. After the 72 hour test period, the specimen was then rinsed and cleaned in an ultrasonic cleaner to remove any debris, dried, weighed and evaluated. The specimen was then examined at X20 magnification by stereomicroscope. **Pitting was observed.**

If anyone know what is going wrong, I would really appreciate a push in the right direction!

Thanks

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You need to start with a micro, determine phase balance, and do a A923-C test. Use the ferric chloride test. This looks similar to G48 but it is different. Is this material as welded or has it been solution annealed? Follow the instruction in A923 exactly (temp and time). For 2205 (base metal or annealed welds) use 25C, for as welded 2205 use 22C. This test requires a sample with all surfaces freshly ground.

I would expect mill annealed and pickled product to pass 35C in G48A. Anything less than optimal (not pickled or not annealed) then there is no chance.

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P.E. Metallurgy, Plymouth Tube

[Great post!](#)[Report](#)

I hope you're not doing the test as per Aramco's standard, the text on the acceptance criteria tells me so.

The criteria for pitting corrosion test as per the specification- 35 Deg C/72 Hrs is quite stringent. Some of the suggested path forwards are as follows:

-What was the pitting corrosion test temp & time recorded on the MTR of welding consumables used on the failed PQR? Did it meet the required 35 Deg C/72 Hrs criteria? If not, do not try the same to take a chance with the same lot.

-Repeat the test with a new batch/lot of ER -2209 consumable. I would presume ER -2209 was used last time. Ensure that ER-2209 meets the G48A testing criteria at the consumable supplier's end as above at the time of procurement. If G-48A test goes well with this new ER-2209 lot you may have to use this for production welds as well as fresh PQR coupon welding. You need to clarify this from your client.

The other option is to weld the root + 1 layer with ER-2507, rest with ER-2209. Ensure that like ER-2209, ER-2507 is tested for pitting corrosion test (Temp & time as above). Usually ER-2507 consumable are guaranteed for pitting @ +40 Deg C or more.

Use of ER-2507 may cause marginal increase of hardness at weld root + marginal increase of ferrite volume fraction. PQR results only reveal those.

Failure in pitting corrosion test is most common at the weld root or at the HAZ. It's not clear from above where the failure was. If the failure is in the weld then one of the above would be the recommended way. For base metal it would be a different scenario.

It would be interesting to know the outcome.
Thx.

Pradip Goswami, P.Eng. IWE
Welding & Metallurgical Specialist
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All provided answer are personal opinions or personal judgements only. It's not connected with any employers by any means.

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Yes, that SAES-W-016 was always a bit poor when it came to the details of testing duplex stainless steel. One can see that immediately in the criterion of "no crevice corrosion" in a pitting test. I'm surprised that Aramco ever get much to pass with that combo of test regime and criteria, although a 24 hour "passivation?" does provide a bit of a counterbalance to the desire for failure. I only have the 2005 version, so I hope that they have moved on now. Most sensible companies adopt the standard developed aeons ago by TWI, and embedded in NORSOK M-630: 5 minute pickle; 24 hour test; 25 deg C for solution annealed, 22 deg C for as welded; no pitting at 20x magnification; weight loss less than 4 g per square metre.

If they are still persevering with that regime and criteria, I trust that it's not them blocking the progress of the draft ISO 17781.

Steve Jones
Corrosion Management Consultant

<http://www.linkedin.com/pub/8/83b/b04>

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Thanks Guys,

You are correct it is Aramco's SAES-W-016. I am not sure if they are open to waiving or changing these requirements but I will give it a try. So far these people have been very difficult to deal with so I am not holding out much hope.

Pradip, the consumables were ER2209 so I may give it a try with the ER2507.

Thanks for all your help guys.

[Great post!](#)

[Report](#)

Pretty harsh requirements, glad somebody else picked up on the crevice corrosion inclusion :S . Anyway, it has surpassed the

4g/m2 limit by a long way. We used to test DSS and SDSS @25degC and 50degC respectively for 24hrs as per NORSOK. Weight loss was usually negligible or in 1/100th of a gram. I did have one failed test and that was SDSS! The vendor was very coy with regards to what happened but 2.5%N was added to the backing gas and along with my witnessing the next weld it passed.

As mentioned above a micro would go a long way here to determine the ferrite/austenite balance and sigma content (if any). Consider backing gas changes if necessary and general diligence ie cleanliness, grinding etc

All of this assuming you base materials are sound?

Let us know how you get on

Jack

[Great post!](#)

[Report](#)

Hi Iam42,

The purpose of the discussion is not to open the floor for "criticism of some organizations specifications or design requirements". The requirements of Pitting Corrosion test definitely had been referenced in the P.O and appropriate questions should have been asked at the early stage to get it clarified. I would think it's still good to approach directly to Aramco with the test results and work out a technically feasible solution.

If the pitting failures at the is the root then using ER-2594 filler rest ER-2209 could be a valid solution according to many consumable manufacturers, over and above the basic welding requirements for welding duplex stainless steels. However it's always advisable to get the pitting corrosion results verified for the base metals and the welding consumables beforehand. Few years ago, I was approached by an organization on the exactly similar problem. The recommendations were pursued by the fabricator with Aramco and sensible resolutions were worked out. It would be nice to know the outcome. Thanks.

Pradip Goswami, P.Eng. IWE
Welding & Metallurgical Specialist
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But we can point out that one end user's specification differs wildly from relatively common practice published in industry standards, and that this wild difference tends to cause some difficulties.

Steve Jones
Corrosion Management Consultant

<http://www.linkedin.com/pub/8/83b/b04>

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[Great post!](#)

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Thanks Pradip,

I completely understand what you are saying. The fault lies within our own company. This job was quoted without my knowledge of the requirements. If I had seen the requirements I would have taken exception to them at the quote stage.

I am not a metallurgist or a corrosion engineer so any help you guys give is greatly appreciated. I have included a link to the MTR's for the base metal and the Welding wire. I have also included the welding data for the PQR. This may help you to help me. Hopefully!!

Can you see any glaring mistakes or is it just not possible to achieve the standard of "No pitting or crevice corrosion in either the weld metal or HAZ is permitted" with this base metal and consumable combination?

<https://onedrive.live.com/redir?resid=6ED80DB2682B...>

Thanks again.

[Great post!](#)[Report](#)

How was the sample passivated? If in air then 24 hr is way too short, 4 day min. If in nitric acid then they should say so. But that is just being picky.

If you understand the metallurgy and corrosion of duplex alloys you know that phase balance and secondary phases are the keys to corrosion resistance. This is why A923 was written and why it is the correct test for duplex grades, welded or not. Beyond that pickling the surface is about all that you can do to improve.

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P.E. Metallurgy, Plymouth Tube

[Great post!](#)[Report](#)

Thanks Ed,

As I stated I am not a metallurgist so it is very difficult for me to convey all the great advice given by you guys to my customer. I am going to try another test with the super duplex wire (ER2594) and take it from there.

Thanks

[Great post!](#)[Report](#)

Hi Iam42,

Please see some comments on the documents uploaded by you related to the Duplex S.S PQR. Hope it may be of help to you. Also I'm uploading another document from Sandvik to give you general welding guidelines for welding duplex.

Thanks

Pradip Goswami,P.Eng.IWE

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<http://files.engineering.com/getfile.aspx?folder=b8b4a3cc-8316-4a6c-a3a5-9b>

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Here's the other document,

Hope these info will help you to prepare for the re-qualification.Pitting @ 35Deg C/72 hrs for DSS-31803/SAF 2205 would be difficult. However 25-30 Deg C/72hrs may be feasible if base metal, fillers all are tested beforehand. What's the intended application, offshore O&G production or onshore(downstream) refining environment?

Thanks.

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<http://files.engineering.com/getfile.aspx?folder=b0d5817a-b8b9-473c-9a01-b7>

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Pradip,

Thank you so much for taking the time to help me with this. The information you have supplied is very helpful.

The purge gas I used was 100% Ar for the test piece.

I have another question.... Should I use 98/2 Ar/N2 for both the shielding and purging gas or is it ok to use this gas for the purging only?

The service is for an onshore installation and the process fluid is mono-ethylene glycol which I do not think is particularly corrosive (I may be wrong).

I have raised the question of the need for a G48 test with this process with the customer but as yet they have not responded.

Thanks Again.

[Great post!](#)

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The G48 test is deployed for quality control, it will not have a bearing on assessing the corrosion performance in MEG, either lean or rich. The end user is unlikely to waive the test completely, purely for the quality aspect. The hope will have to be that they recognise, and acknowledge, the difficulty associated with flying in the face of the bulk of the industry with an apparent excessively conservative test regime. Given the location of the end user, getting that acknowledgement may be very difficult, especially if they are operating with an intermediary "project management consultant."

Steve Jones
Corrosion Management Consultant

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Post Edited

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Steve,

You are correct in the fact that we are not dealing with the end user which makes it nearly impossible to get resolution on anything!

[Great post!](#)

[Report](#)

Weld gas question, We have done it using 5% N in the backing gas and pure Ar for weld gas, and we also have used 3% N for both gases. Both work fine.

= = = = =
P.E. Metallurgy, Plymouth Tube

[Great post!](#)

[Report](#)

Thanks Ed.

[Great post!](#)

[Report](#)

Hi Iam42,

I'm not a process engineering specialist. What I understand is MEG is one of common type of glycols used for gas dehydrating. Overhead vapor line piping in still columns are fabricated from duplex stainless steel or austenitic stainless steel. If the location of the plant is in the downstream environments then API TECHNICAL REPORT 938-C Use of Duplex Stainless Steels in the Oil Refining Industry may be looked at as the reference document.

As per this document: Ferric chloride corrosion tests shall be in accordance with ASTM A923 Test Method C. The test specimens shall include weld HAZ and base metal. This test Method is a 24-h test in 10 % ferric chloride. It detects a loss of corrosion resistance associated with local depletion of chromium and molybdenum as a result of the precipitation of chromium-rich and possibly molybdenum-rich phases.

Thanks.

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 <http://files.engineering.com/getfile.aspx?folder=aeea94a3-4036-4ca8-a70d-f9>

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Hi guys,

As promised I told you I would post the results of my 2nd test. This test was welded following Pradip's advise using the ER2594 wire with an Ar/N2 (98%/2%) purge gas.

The difference was better than I could have hoped for.

FERRIC CHLORIDE PITTING TEST

Specification: ASTM G48, Method A

Temperature (°C): 35

Time (hour): 72

Length (cm)	Width (cm)	Thickness (cm)	Surface Area (cm ²)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Mass Loss (g/ m ²)	Corrosion Rate (mdd)
5.11	2.53	0.63	35.48	63.4945	63.4942	0.0003	0.0846	0.28

Comments: No pitting observed

The test specimen was polished to a 120 grit finish and rinsed in an ultrasonic cleaner to remove any debris and then examined at a X20 magnification by stereomicroscope. It was passivated for 24 hours before being placed into the test solution. The test solution is prepared in accordance with ASTM G48 Method A. The solution and bath water temperature has to reach the identical temperature of 35°C, before the test specimen is placed in a one liter beaker and maintained at 35°C for a period of 72 hours. After the 72 hour test period, the specimen was then rinsed and cleaned in an ultrasonic cleaner to remove any debris, dried, weighed and evaluated. The specimen was then examined at X20 magnification by stereomicroscope and found it to be clean and free from defects, foreign particles, pits and or moisture.

Guys, Thanks for all you help with this one.

Pradip, thank you very much. I owe you a good dinner if we ever run into each other.

[Great post!](#)

[Report](#)

Hi Iam42,

Good to know that you had success at last and my suggestions had worked for you. Also thanks for your endorsements.You may keep in touch in my personal email: pgoswami@quickcltc.net.

It would be good to stay in touch on nice technical issues in future.

Thanks.

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Have you done mechanical testing of the welds?
And have you done any impact testing?

You should make sure that you meet A923 impact criteria.

=====

P.E. Metallurgy, Plymouth Tube

[Great post!](#)

[Report](#)

Hi Ed,

The tensiles were 112,000 psi and the Impact testing was average 47 ft-lbs for the weld and average of 95 ft-lbs. for the HAZ.

[Great post!](#)

[Report](#)

Here is the link to the TWI work from the 90s:

<http://www.twi-global.com/technical-knowledge/publ...>

Feel free to compare it to the Aramco and NORSOK requirements.

I would be interested to know the details of the assessment of the initial failed test piece in so much as where was the "pitting observed." In a 50 mm x 25mm test piece there will be a fair amount of parent material available to contribute to the mass loss and provide an area for pitting. If it did contribute, why didn't it do so again in the second test?

The draft ISO 17781 further complicates matters by providing yet another variant of testing

http://www.iso.org/iso/home/store/catalogue_tc/cat...

It has just been revised and reissued to go to a second round of voting on the DIS standard after the first version received a significant negative reaction. A copy for review should be available from your national standards organisation.

Steve Jones
Corrosion Management Consultant

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[Great post!](#)

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Hello guys,

I am new here, so please apologize if my question in relation to the topic of iam42 should be shifted to a new thread.

However, following question from my side to you specialists:

What are your experience with this requirement (SAES-W-016: corrosion test per ASTM G48A at 35 C for 72 h) for so-called "off-the-shelf" Equipment?

The mentioned specification does not clearly distinguish between the type of "parts having Duplex", respectively give space of interpretation.

It is like "...welding and testing of special corrosion-resistant piping materials", and later on "...Any service that uses duplex stainless steels".

I completely understand that you can not give me a binding or 100%-sure statement. Kindly note, my question refers more to your experience.

The fact is, at the moment our pump suppliers as well as the valves&instruments suppliers (also big brands as e.g. Yokogawa, Emerson, Wika) struggle with the requirements.

Thanks in advance!

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