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Deliverable D-43.54: Materials Testing of Thin Section Alloy 800H Weldments for Reactor Heat Exchanger Applications

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Advanced High-Temperature Reactors for Cogeneration of Heat and Electricity R&D

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Summary

A mock-up intermediate heat exchange for future (Very) High Temperature Reactors will be tested within the ARCHER EU Project that is running over the period 20011-2015. This document specifies the investigation programme on weldments of thin sheets (~3mm) of Alloy 800H within the workpackage WP43 "Intermediate Heat Exchanger". The specific object of the work is to measure any strength reduction that may occur in the weldment, and to develop an appropriate strength reduction factor for use in design.

The test programme is complementary to that on parent material being performed by MPA Stuttgart, and described in Deliverable D43.52: Specification of sample tests on thin sheets. The testing programme therefore includes tensile tests at different strain rates, and creep tests for temperatures up to 850°C.

Approval

Rev.	Date	First author	SP leader	Project Coordinator
0	month/year	Chris Bullough (ALSTOM)	D Buckthorpe; AMEC	S Groot; NRG
	8/2011			

Distribution list

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Materials Testing of Thin Section Alloy 800H Weldments for Reactor Heat Exchanger Applications

Test Specification September 2011

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Summary

A mock-up intermediate heat exchange for future (Very) High Temperature Reactors will be tested within the ARCHER EU Project that is running over the period 2011-2015. This document specifies the investigation programme on weldments of thin sheets (~3mm) of Alloy 800H within the workpackage WP43 "Intermediate Heat Exchanger". The specific object of the work is to measure any strength reduction that may occur in the weldment, and to develop an appropriate strength reduction factor for use in design.

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Revision History

Sept 2011 Initial - Test Programme Definition

Project Information

This document defines the testing programme within the ARCHER EU FP7 Project

The following project references apply:

1. ARCHER EU Programme: 269892 Description of Work 6th Submission [1].
2. ARCHER EU Programme: Work Package 4.3 Intermediate Heat Exchanger, Minutes of First Progress Meeting, 29th June 2011, AREVA, Lyon, France [2].
3. Alstom Power Rugby Internal Programme Reference: CPM00236-T04 (Project Leader C Bullough)
4. Within the Rugby Laboratory, P Jones has the technical responsibility for conducting the tests.
5. Background information on the ARCHER EU project can be found at the ARCHER website www.archer-project.eu.

Materials

Materials are being obtained by Alfa Laval from the producers Thyssen-Krupp in the form of 4mm thick hot-rolled sheet of Alloy 800H. Further details of the virgin material pedigree will be provided on their receipt in a revision of this report.

The materials are being laser-welded in preparatory trials of the manufacturing methods to produce the compact cross-flow intermediate heat exchanger:

- An approximately 20mm band around the edge of the sheet is machined to 3mm thickness, and the central region is machined to 1.5mm.
- A “sandwich” of 6 plates is then prepared to which are welded end pieces.
- The central “sandwich” contains the material that forms the gauge length of the test specimen, whilst the end pieces of 4mm thickness are used to prepare the shoulders and grips.
- Further details of the preparation route can be seen in Figure 1.

When available, material pedigrees will be reported in Table 1.

Testing Programmes

The following testing programmes are planned.

Tensile Testing

1. Tensile test specimens will be manufactured conforming to the drawing shown in Figure 2 (Note: final design may deviate slightly, incorporating a “waisting” to ensure failure in the gauge length).
2. Tensile tests at room and elevated temperature to Alstom Power Rugby Procedure WI 070, to meet the requirements of ISO6892-1:2009 and ISO6892-2:2011.
3. Tests will be performed on servoelectric or servohydraulic universal testing machines within the Alstom Power, Rugby Laboratory.
4. Test conditions are those shown in Table 2.
5. The test report will conform to the requirements of the standard, and contain at least:
 - a. Test conditions, Temperature (°C), Strain rate (%/s)
 - b. Rp0.2 (MPa), Rp1 (MPa), Rm (MPa),
 - c. Strain to rupture A (%), Reduction of Area Z (%)
 - d. Young Modulus E (MPa), Specimen cross sectional area (mm²)
6. The test report in .txt or .xls file format will also contain a separate table of at least the fields: time (s), strain (-), engineering stress (MPa)

Creep Testing

1. Creep test specimens will be manufactured conforming to the drawing shown in Figure 2 (Note: final design may deviate slightly, incorporating a “waisting” to ensure failure in the gauge length).
2. Creep tests at elevated temperature to Alstom Power Rugby Procedure WI 265, to meet the general requirements of ISO204:2009.
3. Tests will be performed on direct-load or lever-operated creep testing machines within the Alstom Power, Rugby Laboratory. Load-line displacement measurements will be taken.
4. Test conditions are those shown in Table 3.
5. The test report will conform to the requirements of the standard, and contain at least:
 - a. Test conditions, Temperature (°C), Initial Stress (MPa), Initial Plastic Strain (%)
 - b. Times (h) to specific plastic strains, 0.1, 0.2, 0.5, 1, 2, 5 (%)
 - c. Minimum Creep Rate (%/h)
 - d. Strain to rupture A (%), Reduction of Area Z (%)
 - e. Specimen cross sectional area (mm²)
6. The test report in .txt or .xls file format will also contain a separate table of at least the fields:
time (s), creep strain (-)

References

- [1] ARCHER - Advanced Reactor for Cogeneration of Heat & Electricity R&D. Co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Seventh Framework Programme. Grant Agreement Number: 269892. Description of Work, 6th Submission, Dec 2010.
- [2] ARCHER EU Programme: Sub Project 4, Work Package 3 Intermediate Heat Exchanger Minutes of First Progress Meeting, 29th June

Table 1. Material Details and Composition – Alloy 800H Sheet

(Further details will be provided on receipt of materials.)

Table 2. Tensile Testing Matrix – Alloy 800H Sheet Weldment – Cross Weld Samples
(Where indicated, test conditions and particularly strain rate, conform to the full requirements of ISO 6892)

a) Tests on samples with weldment flash machined away:

Temperature	650	650	750	750	850	850
Strain rate	1.00E-04	1.00E-05	1.00E-04	1.00E-05	1.00E-04	1.00E-05
	"ISO 6892"		"ISO 6892"		"ISO 6892"	

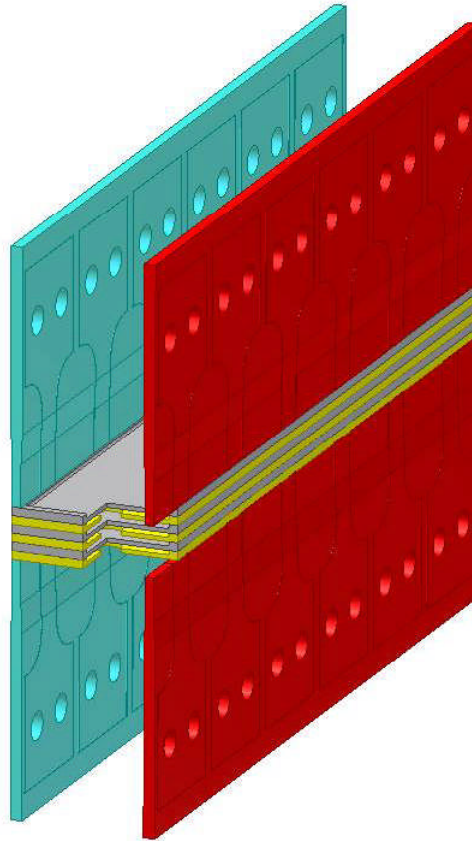
b) Tests on samples with weldment flash left in place:

Temperature	650	650	750	750	850	850
Strain rate	1.00E-04	1.00E-05	1.00E-04	1.00E-05	1.00E-04	1.00E-05
	"ISO 6892"		"ISO 6892"		"ISO 6892"	

Table 3. Creep Testing Matrix – Alloy 800H Sheet Weldment – Cross Weld Samples
(Samples with weldment flash machined away)

Temperature	650	650	750	750	750	850	850	850
Stress	93	106	44	50	75	21	24	40
Approx. Breaktime [h]	20,000	10,000	20,000	10,000	3,000	20,000	10,000	3,000
Test time [years]	2.3	1.1	2.3	1.1	0.3	2.3	1.1	0.3

Upper figure – general assembly of plates, weldments, and endpieces. (Test piece outlines shown for information only.)



Lower figure – general finished design of the test piece (schematic)

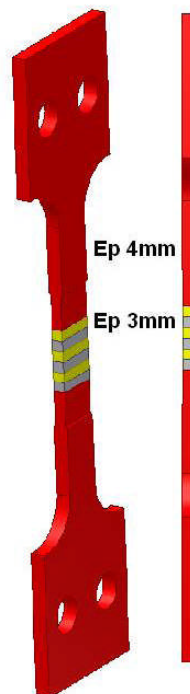


Figure 1. Details of the welding trials / specimen manufacture (Source: Alfa Laval)

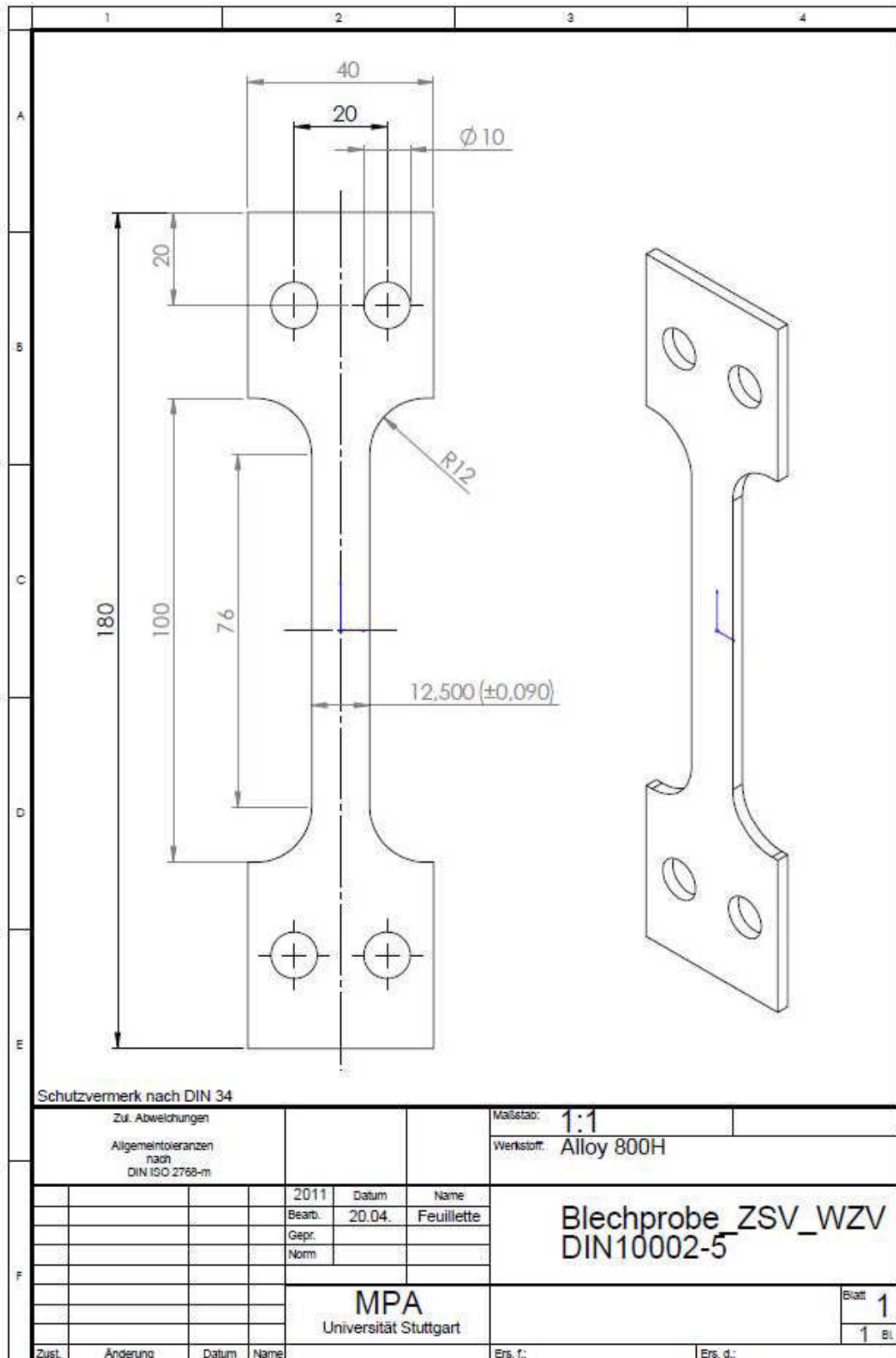


Figure 2. Details of the specimen geometry
(Source MPA Stuttgart – the same basic specimen geometry will be used by both labs.)