



SAFETY ASSESSMENT
FEDERATION

Guidance

Weld Repairs to Safety Critical Components on Lifting & Work Equipment

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1. BACKGROUND

Lifting and work equipment is subject to stresses and wear in normal use and on occasion may also be subject to misuse. These factors may result in deformation or fracture of components. Consequently, when the equipment is presented for thorough examination or inspection, the competent person may be confronted with a weld repair of a safety critical component. The repair may be to an originally welded area or it may be introducing a weld into a previously un-welded area.

The owner or duty holder of the lifting/work equipment is responsible for ensuring that any repairs are undertaken correctly and that these repairs do not compromise the safety of the equipment. The competent person should take any repairs of safety critical components into consideration during thorough examination or inspection and should satisfy themselves that due process has been undertaken to produce a satisfactory repair.

2. GUIDANCE

Aim:

The purpose of this guidance is to offer support to the competent person regarding a common approach to ensure that safety critical components on lifting or work equipment, which have been subject to weld repair, have been repaired to an acceptable standard and the safety of the equipment is maintained.

Definitions:

For the purposes of this guidance, the following definitions apply:

Competent Person (CP) - A person who has the appropriate practical and theoretical knowledge and experience of the equipment to be thoroughly examined/inspected as will enable them to detect defects or weaknesses and to assess their importance in relation to the safety and continued use of the equipment.

Safety Critical Component (SCC) - Any component of an item of equipment which, should it or any part of it fail singularly, could cause a serious hazard. A SCC may include back up safety device(s), which would come into operation, in the event of single component failure.

[**Note:** See SAFed document MLCC07 for further information regarding SCC's]

Serious Hazard - A potential to cause serious injury or death to a person or persons

3. INTRODUCTION

During the thorough examination of lifting equipment in accordance with Regulation 9 of the "Lifting Operations and Lifting Equipment Regulations 1998" (LOLER) or inspection of non-lifting work equipment in accordance with Regulation 6 of the "Provision and Use of Work Equipment 1998" (PUWER), the CP must make an assessment of the condition and function of all SCC's.

One or more of the SCC's may have been subject to a weld repair, which if undertaken without due attention to proper process, could lead to a failure of the repair or the component which may result in a risk to persons. The repairs may be to previously welded areas, such as the seam weld of a telehandler boom; or in previously un-welded areas, such as the material web of a mobile crane boom.

Improper repair of either scenario could introduce unseen stress raisers through poor weld preparation, geometry, technique, post weld treatment etc. which may lead to sudden catastrophic failure of the component or areas surrounding the repair.

The CP does not have responsibility to determine the method or suitability of any repair, but during any thorough examination or inspection the CP must satisfy themselves that the repair has been completed to a satisfactory standard and thus its undertaking has not compromised the integrity of the component or machine.

At any time, further testing may be requested by the CP (LOLER ACOP Guidance Regulation 9 paragraph 312).

This guidance should be read in conjunction with SAFed document WMC08 Guidance – Repairs to Welded Structures (Non- Pressure). Repair to a component may compound or conceal an underlying issue e.g. material fatigue, which should be investigated and resolved before weld repair.

Weld repairs may also take place on components where failure of the repair or component would not normally affect safety. This document is not intended to include those within this scope and it is presumed that manufacturer's guidance or general engineering assessment and criteria would be applied to determine the appropriate method for these types of repairs.

4. REPAIR PROCESS

The owner of the equipment should in the first instance contact the manufacturer to ascertain if a welding technique and process is available for the repair required. If so, this should be followed.

If the manufacturer's advice is not available, the owner should firstly produce a method statement regarding the repair. This document should detail the step by step procedure for the repair being carried out.

The method statement would typically contain the following information:

- Plant identification including manufacturer, design standard, original materials of construction, serial/plant number, safe operating limits, etc.
- Details of the repair being undertaken including photographs or a sketch of the location.
- Repair procedure including preparation, inspection requirements, proposals for NDT and load testing on completion (if applicable).
- Any special procedures required – for example specific bending requirements, pre or post weld heat treatment.
- Confirmation that repair materials are compatible with the component.

Note: Where a weld is to be introduced into a previously un-welded area; suitable investigatory techniques e.g. Finite Element Analysis; or confirmation from the manufacturer as to the suitability of any repair should be undertaken by the repairer. The absence of confirmation of this may not preclude a thorough examination or inspection, but a statement from the repairer that the machine is fit to enter service should be documented or sought.

5. WELDING DOCUMENTATION

Once the repair process has been outlined, the appropriate welding procedure(s) and certification should be prepared. Documentary evidence of these should be as below.

Welding Procedure Specification (WPS)

The WPS gives details of how the welding is to be performed giving information on the specific welding task to be completed and is job specific.

Its purpose is to aid the planning and quality control of the welding operation. This documentation will be supported by the welding certification forms. (SAFed forms are numbered E1 to E4).

Note. Sometimes a repairer will send copies of all their weld procedures. This is not satisfactory as it is necessary to specify the actual procedures to be used and not for the competent person to attempt to interpret which procedure is to be used by the welder.

Welding Certification (Reference SAFed Guidelines on Approval Testing)

A WPS is supported by a Procedure Qualification Record (PQR or WPQR). A PQR is a record of a test weld performed and tested (more rigorously) to ensure that the procedure will produce a satisfactory weld. Individual welders are certified with a qualification test documented in a Welder Qualification Test Record (WQTR) that shows they have the understanding and demonstrated ability to work within the specified WPS.

Welding certification comprises of:

Certificate E1 —Welding Procedure Qualification Record (WPQR)

This gives details of the specific type of weld and procedure it has been certified to, in accordance with applicable standards e.g. BS EN ISO 15614 series

Certificate E2 — Details of Weld Test.

This gives details of what actually took place during the test weld being manufactured.

Certificate E3 —Test Results, gives details of NDT and Mechanical testing results.

The above three certificates are all required to complete a weld procedure qualification record.

Certificate E4 —Welder Qualification Test Certificate or Welder Performance Qualification- This is the individual welder approval part of the qualification. There must be an E4 certificate for each welder that uses the weld procedure. The E4 contains the information relating to the welder's competence and is detailed below. See Appendix for designated variables.

[Note: Forms are no longer identified as E1 through E4 although it is still common practice to refer to them as such.]

6. THOROUGH EXAMINATION & INSPECTION

At the thorough examination or inspection, the CP should request the repair documentation from the owner and this should be reviewed, as follows.

It should be determined that:

- The method statement pertains to the correct machine and area of repair
- The WPS is approved by either the manufacturer/authorised representative or an authoritative competent organisation and that it reflects the actual repair made
- The welder was qualified to undertake the weld specified
- Appropriate NDT has been undertaken by an appropriately qualified practitioner
- Any other appropriate testing has been undertaken e.g. load test (if applicable)

Examples are given in the following Appendices to guide the CP in determining if the welding process has been followed correctly. The examples identify key areas that should be verified to determine that a correct procedure has been adhered to.

If the owner is unable to produce all or any supporting documentation, then the CP will need to consider if it is possible to determine if the machine is safe for continued service.

On occasion, weld repairs undertaken may be simplistic and have established procedures that have previously been approved and documentation may not be available regarding the individual procedure. However, the procedure used should still be documented and the welder approval should reference that procedure. Furthermore, some procedures may not need approval, see the applicable British Standards referenced in Appendix 3.

7. APPENDIX 1 -EXAMPLE REPAIR DOCUMENTATION – 1 (EXAMPLE TAKEN FROM WG01)



WELDING PROCEDURE APPROVAL TEST CERTIFICATE

Page 1 of 3

1
 2
 3 *Manufacturer's Welding Procedure*
 4 *Reference No.* PQR 001
 5 *Manufacturer:* A FABRICATOR
 6 *Address:* 1 WELDING STREET
 JOINHAM
Inspecting Authority: ZC/NP/120580
Reference No.: SS42528876/300

7 *Code / Testing Standard:* BSEN ISO 15614-1 A2 2012
 8 *Date of Welding:* 31/05/2012
 9 **RANGE OF QUALIFICATION**
 10 *Welding Process:* MANUAL TIG (141)wm & MMA (111)
 11 *Joint Type:* BUTT WELDS(1) & FILLET WELDS(2)
 12 *Parent Metal Groups- Sub Groups:* 5.1, 5.1.5.1, 1, 5.1, 2
 13 *Parent Metal Thickness (mm):* 3 - 22.14mm
Weld Metal Thickness (mm): 141: 3 - 6mm, 111: 3 - 16.14mm
Throat Thickness (mm): NOT RESTRICTED
Single run / Multi run: MULTI RUN ONLY
 14 *Pipe Outside Diameter (mm):* 7-30; 15mm
 15 *Filler Metal Type / Designation:* 141: ISO 21952-A W CrMo1Si, 111: ISO 3580-A ECrMo1 B
Filler Material Make: 141: NOT RESTRICTED, 111: METRODE CHROMET 1 (3)
Filler Material Size: WITHIN HEAT INPUT RESTRICTIONS
 16 *Designation of Gas / Flux:* ISO 14175 II / BASIC COATED
Designation of Backing Gas: N/A
 17 *Type of Welding Current / Polarity:* DC-VE / DC+VE
Mode of Metal Transfer: N/A
Heat Input: ±25% OF RECORDED VALUES (4)
 18 *Welding Position(s):* ALL EXCEPT VERTICAL DOWN
 19 *Preheat Temperature:* 120°C MINIMUM, INTERPASS: 250°C MAXIMUM
Post-Heating: NONE
 20 *Post Weld Heat Treatment:* 650°C SOAK TEMPERATURE
 21 **OTHER INFORMATION** SEE BSEN ISO 15614-1 A2 2012
 (1) 141: ss,nb,mb,bs,ng,gg, 111: ss,mb,bs,gg
 (2) SEE CLAUSE 8.4.3a
 (3) RESTRICTED FOR IMPACT TESTED APPLICATIONS
 (4) FOR NON IMPACT TESTED APPLICATIONS -25% RECORDED VALUES MAX

Do these values reflect the repair?

22 *Certified that test welds were prepared, welded and tested satisfactorily in accordance with the requirements of the code / testing standard indicated above.*

23 <i>Location:</i>	<i>Date of Issue:</i>	<i>Name and Signature</i>
BIRMINGHAM	14/06/2012	A ENGINEER
24		<i>Inspecting Authority</i>
25		(CEOC Member Organization Notified Body/ SaFed
Übersetzung des vorgedruckten Formblatt-Textes auf der Rückseite	Translation of printed test on the reverse side	Traduction des rubriques imprimées au verso

Note: This is a Welding Procedure Qualification Record and is applicable to the named manufacturer alone. This qualification is not a Standard Welding Procedure and may not be reproduced in whole or part and used as such.



E4

1 **WELDER APPROVAL TEST CERTIFICATE**

2 **DESIGNATION** BS EN 287-1,MAN141,T,BW,5.1,t3,D60.3,H-L045,ss,nb
BS EN 287-1,111,T,BW,5.1,B,t8.07,D60.3,H-L045,ss,mb

3 Page 1 of 2
4 **Manufacturer's Welding Procedure** Inspecting Authority ZC/WA/123446
5 **Reference No.** WPS 001 Reference No. SS42520000/99
6 **Welder's Name:** A WELDER
7 **Identification:** W007
8 **Method of Identification:** WELDER I/D
9 **Date and Place of Birth:** 06/06/66 - BIG CITY
10 **Employer:** A FABRICATOR
11 **Code / Testing Standard:** BS EN 287-1 2011
12 **Job Knowledge:** Not Tested

Is this the welder approved for the type of weld?



13	Weld Test Details		Range of Approval	
14 Welding Process(es)	MANUAL TIG (141)	& MMA (111)	MAN 141,142,143,145	& MMA (111)
15 Plate or Pipe	PIPE (T)		P,T	
16 Type of Joint / Weld	BUTT WELD (BW)		BW ONLY	
17 Material Group / Sub-Group	5.1		1 THRU 7, 9.1 and 11	
18 Welding Consumable(s)	ISO21952-A WCrMo1Si	ISO 3580-A ECrMo1B	COMPATIBLE FILLERS	
19 Shielding Gas / Flux	ARGON 99.99%	BASIC FLUX	COMPATIBLE GAS	B,A,RA,RB,RC,RR,R
20 Auxiliaries	-		-	
21 Material Thickness	11.07mm		3mm to 22.14mm	
22 Weld Metal Thickness	3mm	8.07mm	3mm to 6mm	3mm-16.14mm
23 Pipe Outside Diameter	60.3mm		>=30.15mm	
24 Welding Position	H-L045		ALL EXCEPT PG & J-L045	
24 Weld Details (Backing / Gauging)	NONE	BACKED		
	ss,nb	ss,mb	ss,nb,mb,bs	ss,mb, bs
	Single layer / Multi layer	ML	-	
25 Additional information is available on attached sheet / or welding procedure Specification No:	WPS 001			

26	Performed and		Name and Signature	
27	Type of Test	Acceptable	Not Required	THE ENGINEER
28				Inspecting Authority NOTIFIED BODY / SaFed MEMBER
29				(CEOC Member Organization)
30	Visual	ACCEPTABLE	-	Date of Issue: 31/05/2012
31	Radiography	ACCEPTABLE	-	Location: BIRMINGHAM
32	Magnetic Particle	-	NOT REQUIRED	Approval Valid Until: 30/05/2014
33	Penetrant	-	NOT REQUIRED	
34	Macro	-	NOT REQUIRED	
35	Fracture	-	NOT REQUIRED	
36	Bend	-	NOT REQUIRED	
36	Additional Tests *	-	NOT REQUIRED	

Location: BIRMINGHAM
Approval Valid Until: 30/05/2014



Is this document still date valid?

37	PROLONGATION FOR APPROVAL BY INSPECTING AUTHORITY		
38	Date	Signature	Position or Title
39			

*) Append separate sheet if required

Übersetzung des vorgedruckten Formblatt-Textes auf der Rückseite

Translation of printed text on the reverse side

Traduction des rubriques imprimées au verso

EXAMPLE REPAIR DOCUMENTATION – 2

Sample repair method statement

1. Description of defect				
Drawing	Identification	Affected Components		
0001 00	0001 0001	1,10		
Weld seam fractured between the above mentioned items.				
2. Repair Proposal				
Gouge out, grind and re-weld the fractured area.				
Is this an accurate description of the repair?				
3. Material				
Plate:	S 500 Q, EN 10025-6;			
Pipe:	N/A			
Cast Piece:	N/A			
Check this on WPS and WPQR				
4. Required Welder Qualification according to BS EN ISO 9606-1:2017				
141 P FW FM2 S s10 PE ss nb				
5. Required scope of weld examination				
Check this against welder qualification record				
NDT – examination		Standards		
Visual examination	100	ISO 5817-B	ISO 17637	
ASME-Code Div 1, Sec. VIII				
MP - examination	100		ISO 17638	ASME-Code Div 1, Sec. VIII
* or PT	100		ISO 3452-1	ASME-Code Div 1, Sec. VIII
US - examination	N/A		ISO 17640	ASME-Code Div 1, Sec. VIII
X-Ray - examination	N/A	ISO 17636	ASME-Code Div 1, Sec. VIII	
<small>* Liquid penetrant-examination (PT) can be used as well instead of MP-examination. The above specified scope of examination shall be carried out by the customer or a third party provided by the customer. The examiner must be certified acc. to ISO 9712 Qualification level 2 or equivalent.</small>				
Waiting time [h] between welding and NDT in relation to wall thickness [mm]				
Materials (Yield Strength)	3 ≤ t ≤ 24	25 ≤ t ≤ 49	50 ≤ t	
Re 770 N/mm ²	12	24	48	
770 N/mm ² < Re ≤ 960 N/mm ²	24	48	72	
6. Enclosures				
List of filler metal.				
pWPS A – 001-01/01	or	pWPS B – 001-01/01		
pWPS A – 002-02/02	or	pWPS B – 002-02/02		

EXAMPLE REPAIR DOCUMENTATION – 3

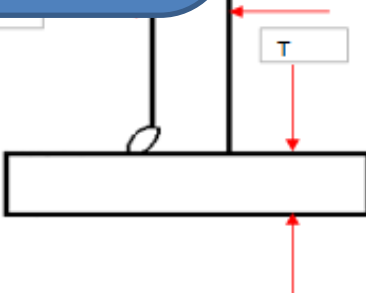
Sample welding procedure specification

WELDING PROCEDURE SPECIFICATION					
Company	ABC Welding	Approved by	A N Other		
WPS No.	1A	Date	08/04/2020		
WPS Revision No.		Rev, Date			
Supporting PQR No.	1A-1A	Type(s)	Manual		
Welding Process(es)	TIG	Manual, Semi-automatic, Automatic, Robotic, Mechanised			
Joint Type	T Joint				
Backing	None				
Backing Material (Type)	None				
Groove Angle	n/a				
Root Opening Radius (U/J)					
Root Face					
Backgouging (Yes/No)					
Backgouging Method					
<p>Check all these against the WPQR- does the information correlate?</p>					
M No.	Unlisted			Group No.	Unlisted
Specification Type and Grade	S 500 Q	to M No.	1		
Thickness range of Base Metal	Groove	n/a	Group No.	1	
Deposited Weld Metal	Groove	n/a	to Specification Type and Grade	S 500 Q	
Pipe Diameter Range	Groove	n/a	Fillet	8 mm - unlimited	
Other			Fillet	8 mm max (1 pass)	
			Fillet		
FILLER METALS					
Filler Metal F No.	6	Other			
ISO 2560 Classification	E46 4 B 32 H5				
Weld Metal A No.	1	Other			
Filler Metal Size	8 mm	Electrode Flux (Class)	Basic		
Filler Metal Manf.	Various	Flux Trade Name	n/a		
Consumable Insert	None	Other			
POSITIONS		PREHEAT			
Groove Position(s)	n/a	Preheat Temp. (min)	320°C		
Fillet Position(s)	1F, 2F	Preheat Maintenance	320°C min		
Weld Progression		Interpass Temp (Max)	none (single pass)		
PWHT		Continuous of Special Heating or Maintenance:			
Temp.		Part is to be slow cooled by the use of approved			
Time		heating blankets.			

EXAMPLE REPAIR DOCUMENTATION – 4

Sample welding procedure qualification record

WELDING PROCEDURE QUALIFICATION RECORD			
Company Name		ABC Welding	
Procedure Qualification Record		1A-1A	
WPS No.		1A	
Welding Process(es)		TIG	
Types (Manual, Automatic, Semi-Auto.)		Manual	
Date		01/01/2019	
JOINTS			
Joint Design	T Joint		
Backing	No		
Backing Mtrl	None		
Included Angle = A	Side 1	Side 2	
Root Face = F	N/A		
Root spacing = G	N/A		
Radius = R			
Thickness = T	10mm		
Fill et Size = Leg Size	8 mm		
BASE METALS		POSTWELD HEAT TREATMENT	
Material Spec.	S500Q		
Grade			
Thickness of Test Piece	10mm		
Length of Test Piece	150mm		
Other			
		Temperature	
		None	
		Time	
		Other	
		Part is to be slow cooled using heating blankets	
		Gas	
		Percent Composition	
		Gas(es)	(Mixture)
			Flow rate
FILLER METALS		ELECTRICAL CHARACTERISTICS	
	1 st Process	2 nd Process	
Specification	A5.1	A5.1	
Classification	E6010	E7018M	
Filler Metal F	3	4	
Weld Metal Analysis	1	1	
Size of Filler (mm)	1.6, 2.4, 3.2	1.6, 2.4, 3.2	
Weld Metal Thickness	1.6 - 3.2	1.6 - 9.4	
Other			
POSITION		TECHNIQUE	
Position of Groove	6G		
Weld Progression (up/Down)	UP		
Other			
PREHEAT		Current	
Preheat Temp	Yes	None	
Interpass Temp	320 deg		
Other	None		
	PREHEAT WITH TORCH		
		DCEP	
		REVERSED	
		Amps	(1)75-150 Volts
			(1)20-26
		Tungsten Electrode Size	
		5mm	
		Other	
		Travel Speed	
		Var./Manual	
		Stringer or Weave Beac S or W	
		Oscillation	
		Multiple or Single Pass S or M	
		Single or Multi Electrodes	Single
		Other	



Do these correlate to WPS?

EXAMPLE REPAIR DOCUMENTATION – 5

Sample welder approval test certificate

WELDER APPROVAL TEST CERTIFICATE

Designation **ISO 9606-1, Manual 141, P,FW, FM1/FM2, S, s10,D10,H-L045, ss,nb**

Manufacturers Welding Procedure: 1A Inspecting Authority: A MET

Reference No. 1A-1A Reference No. 1A

Welders Name: A N Oth

Identification: A O

Method of Identification: Initials

Date and Place of Birth: 01/01/1980 / Not Stated

Employer: ABC Welding

Code / Testing Standard: BS EN ISO 9606-1:2017

Job Knowledge: Not Tested

Does this correlate to the specification shown in method statement, see Appendix 2 for variables

	Weld Test Details	Range of Approval
Welding Process(es)	Manual TIG (141)	Manual TIG 141, 142
Transfer mode	Spray	Spray Globular
Plate or Pipe	Plate (P)	P, T
Type of Joint / Weld	Fillet Weld (FW)	FW
Material Group / Sub-Group	3, 2	1 Through 11
Filler Material Group(s)	FM1 / FM2	FM1, FM2
Welding Consumables	EN ISO 14341-A G4Si1 EN ISO 16834-A G 7 95 M21	-
Shielding Gas / Flux	EN ISO 14175-M21-ArC 20	Compatible Gases
Auxiliaries	Solid Wire (S)	S, M
Type of Current and Polarity	DC+ve	-
Material Thickness	10 mm	-
Weld Material Thickness	8 mm	≥3 mm
Welding Position	Fixed 45° Vertical-Up (H-L045)	All Except vertical Down
Gouging / Backing	None (SS,nb)	ss, nb, mb, gb, fb/lbs
Single layer / Multilayer	Single Layer (sl)	0

Type of Test	Performed and Acceptable	Not Required
Visual	Acceptable	
Radiography	Acceptable	
Magnetic Particle	-	Not Required
Macro	-	Not Required
Fracture	-	Not Required
Bend	(X2) Acceptable	
Additional Tests	-	Not Required

Date Of Issue: 01/01/2019 Qualification Valid Until: 31/12/2022

Verified By: A Qualifier Lab No.: 1

Is the welder's qualification in date?

8. APPENDIX 2 – DESIGNATED VARIABLES SHOWN ON WELDER QUALIFICATION TEST CERTIFICATION

The following are variables used when specifying the type of weld an individual needs to be able to satisfactorily produce.

Welding Process (Common examples):

- 111 - Manual metal arc (MMA)
- 131 - Manual Metal Inert Gas (MIG)
- 135 - Manual Metal Active Gas with solid wire electrode (MAG)
- 136 - Manual Metal Active Gas with flux cored electrode (FCAW)
- 138 - Manual Metal Active Gas with metal cored electrode (MCAW)
- 141 – Tungsten Inert Gas Welding with solid wire electrode (TIG)
- 142 – Autogenous (No filler) Tungsten Inert Gas (TIG)

Product type:

- P – Plate,
- T – Tube

Type of weld:

- BW butt weld
- FW - fillet weld
- TEW - tube end weld

9. APPENDIX 3 – APPLICABLE BRITISH STANDARDS

BS 4872-1: 1982 Specification for Approval testing of welders when welding procedure is not required. Part 1: Fusion welding of steel.

BS 4872-2: 1976 Specification for Approval testing of welders when welding procedure is not required. Part 2: TIG or MIG welding of aluminium and its alloys.

BS EN 287-6: 2018 Qualification test of welders. Fusion welding. Cast irons.

BS EN ISO 9606-1: 2017 Qualification testing of welders. Fusion welding. Steels.

BS EN ISO 9606-2: 2004 Qualification test of welders. Fusion welding. Aluminium and aluminium alloys.

BS EN ISO 15607: 2019 Specification and qualification of welding procedures for metallic materials. General rules.

BS EN ISO 15612: 2018 Specification and qualification of welding procedures for metallic materials. Qualification by adoption of a standard welding procedure specification.

BS EN ISO 15613: 2004 Specification and qualification of welding procedures for metallic materials. Qualification based on pre-production welding test.

BS EN ISO 15611: 2003 Specification and qualification of welding procedures for metallic materials. Qualification based on previous welding experience.