

## S272

### Project 8, Pirate Ship, No. 38477, Year of manufacture: 1980

- Alton Towers Resort, Alton, Staffordshire, UK
- Different cracks have been found at both sides of the hub flanges at the bearing seats, see pictures 1 to 7.
- The cracks were noticed during maintenance inspection.
- Drawing-No.: 1-8.7

#### 1 Pictures:



Picture 1

Overview, Hub

Area of cracks



Picture 2

Overview, Hub

Area of cracks



Picture 3

Detail view, Hub

Area of cracks



Picture 4

Detail view, Hub

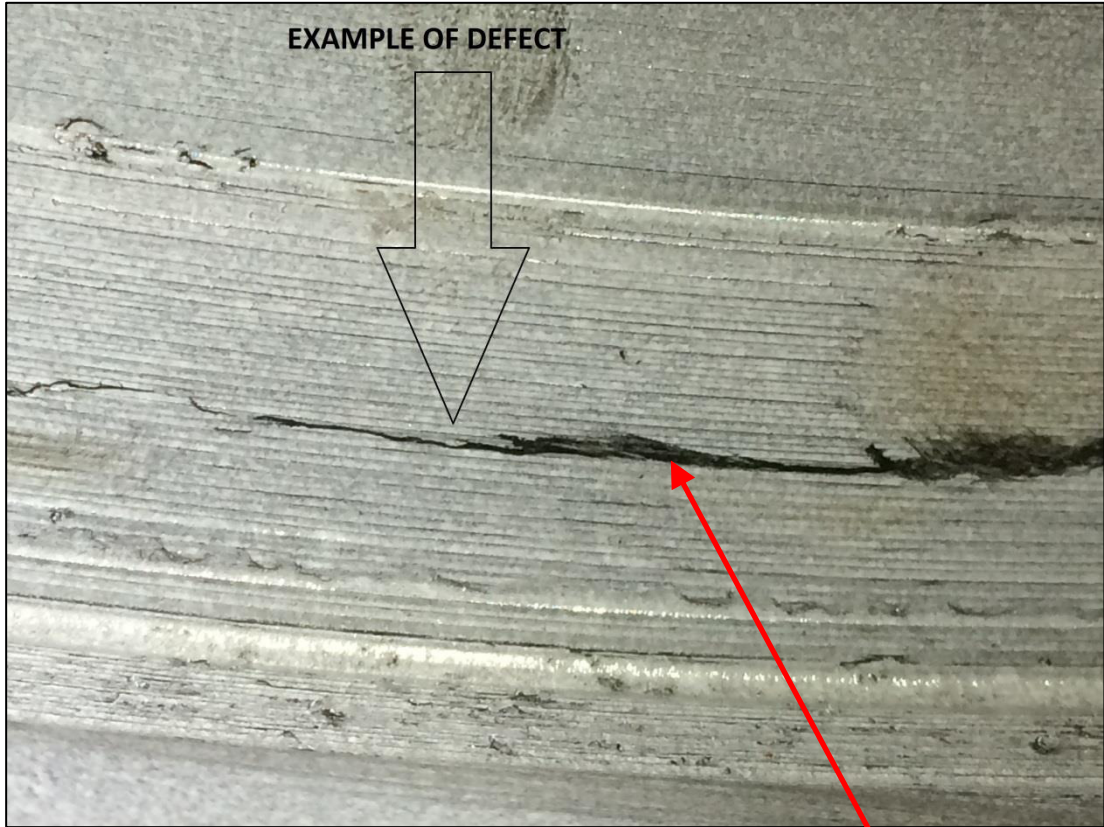
Area of cracks



Picture 5

Detail view, Hub

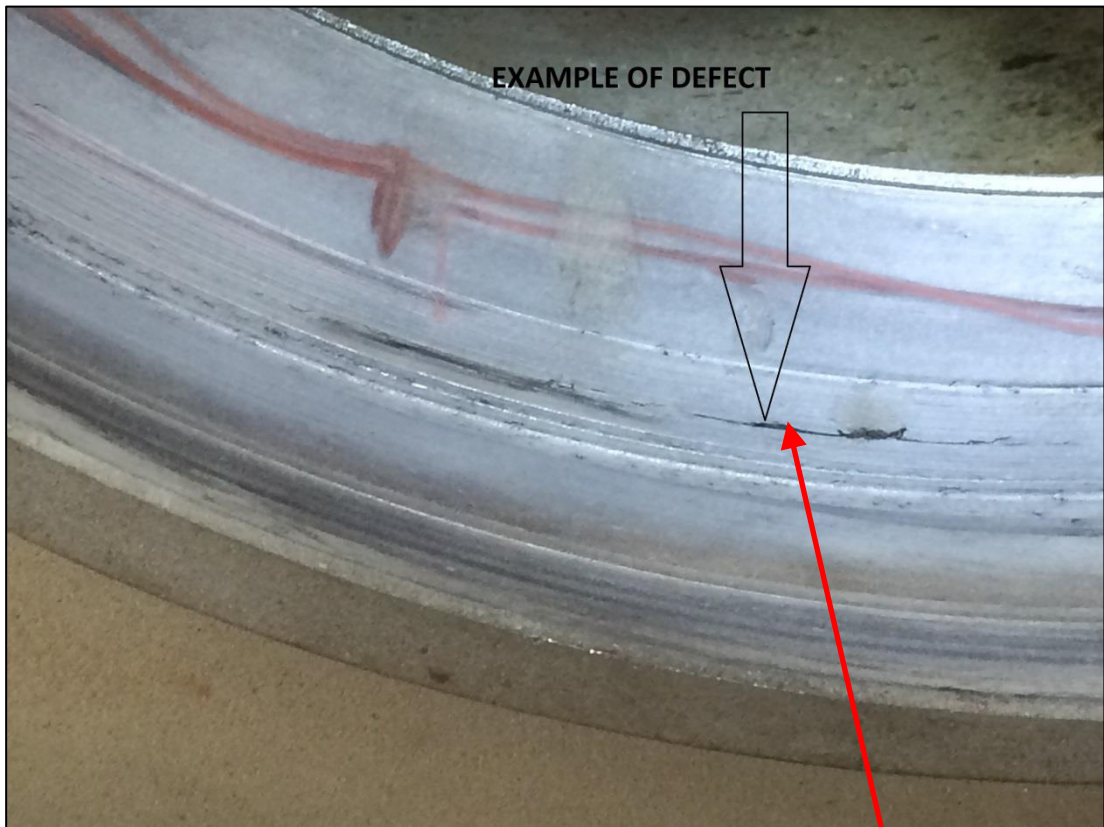
Area of cracks



Picture 6

Detail view, Hub

Crack



Picture 7

Detail view, Hub

Crack

## **2 Statement:**

- The cracks are caused by fatigue loads and old age (36 years!).
- A repair by welding is possible.

## **3 Qualification:**

- The company which will carry out the repair welding has to qualify the attached pWPS according to ISO 15607 by an accredited test body. The result is a Welding Procedure Qualification Record (WPQR).
- The welding company needs a suitable welding permission according to the local requirements of the UK, minimum standard according to EN 1090 execution class 3.
- The welder who will carry out the repair welding needs a suitable welding certificate according to the local requirements of the UK, minimum standard according to ISO 9606-1.
- The inspection company shall be a qualified inspection laboratory, which is accredited in accordance with the EN ISO/IEC 17025.
- The inspection personnel shall be qualified and certified to the local requirements of the UK, minimum standard is level II in accordance with ISO 9712.

## **4 Non-destructive testing (NDT) of welds:**

- Quality level for imperfections of the welding seams: Quality class B according to ISO 5817.
- Visual testing (VT) according to ISO 17637 acceptance level B.
- Ultrasonic testing (UT) according to ISO 17405, ISO 17640 and ISO 23279, acceptance level 2 according to ISO 11666 or Radiographic testing (RT) acc. to ISO 17636-1, acceptance level 2 according to ISO 10675-1.
- Magnetic particle testing (MT) according to ISO 17638 and ISO 9934, acceptance level 1 according to ISO 23278 or Penetrant testing (PT) according to ISO 3452, acceptance level 1 according to ISO 23277.

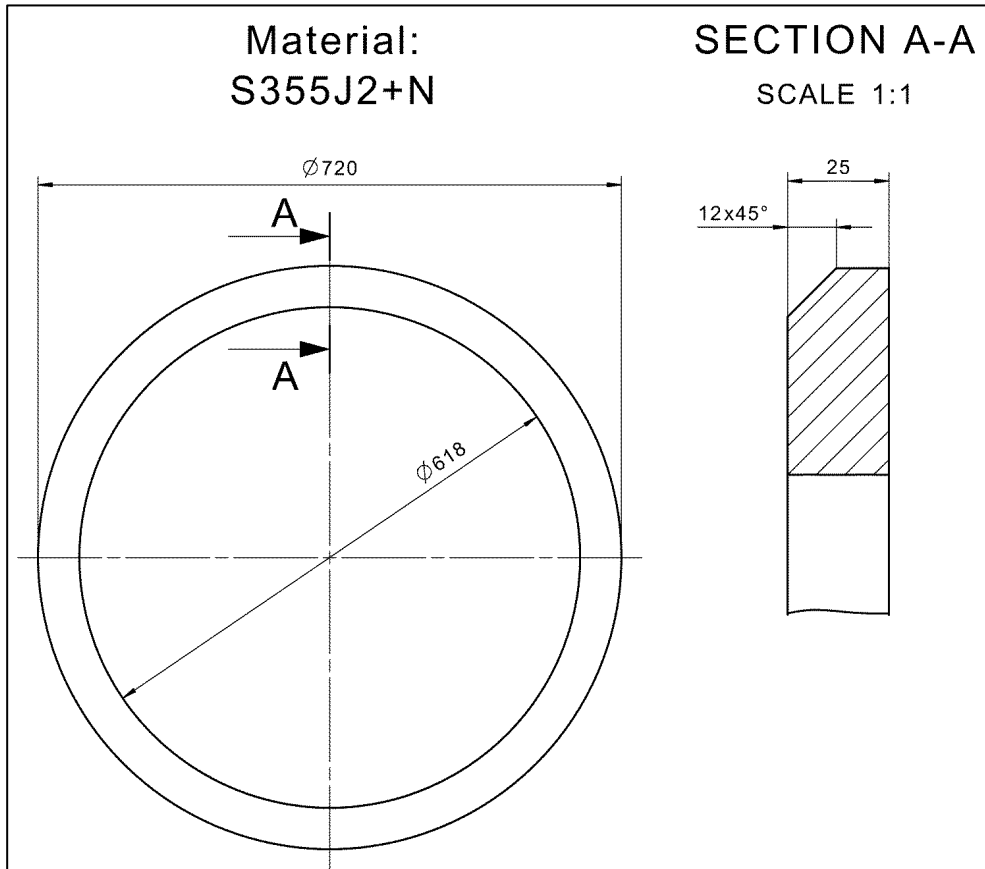
## **5 Welding execution:**

- Manufacture two new flanges according to sketch 1.
- Remove both cracked flanges by grinding.
- Check with Magnetic particle testing (MT) or Penetrant testing (PT), if the surfaces of the bearing tubes are free of cracks.
- Place both new flanges into the hub.
- The outdoor temperature must be higher than 5°C during welding; otherwise a “winter site” (e.g. heated tent) has to be set up.
- Weld the build-up layers into the bearing tubes with basic covered stick electrode according to pWPS S272-1. If necessary drying of the electrode before welding.  
**Attention: Preheat to 100°C!**
- Requirements for the new welds: No notches, no welding spatters are allowed, continuous undercut and intermittent undercut according to ISO 5817 max. 0,5 mm.
- Visual testing (VT) of the new welds, scope: 100%.
- Machine the welded areas of the bearing tubes to a diameter of  $\varnothing 722$  mm.
- After machining check the repaired areas with UT and MT or PT, scope: 100%.
- Install both new flanges at the correct position according to sketch 2.
- Weld both new flanges at the inside with basic covered stick electrode according to pWPS S272-2. If necessary drying of the electrode before welding. **Attention: Preheat to 100°C!**
- Weld both new flanges at the outside with basic covered stick electrode according to pWPS S272-3. If necessary drying of the electrode before welding. **Attention: Preheat to 100°C!**
- Requirements for the new welds: No notches, no welding spatters are allowed, continuous undercut and intermittent undercut according to ISO 5817 max. 0,5 mm.
- Visual testing (VT) of the new welds, scope: 100%.
- 24 hours after welding check the repaired areas by MT or PT, scope: 100%.
- All new welds must comply with quality class B according to ISO 5817.
- Machine the bearing seats inside the bearing tubes and both new flanges according to sketch 2.
- Assemble the bearings according to sketch 3.
- Repair the outside surfaces coating, dry layer thickness 250  $\mu\text{m}$ .

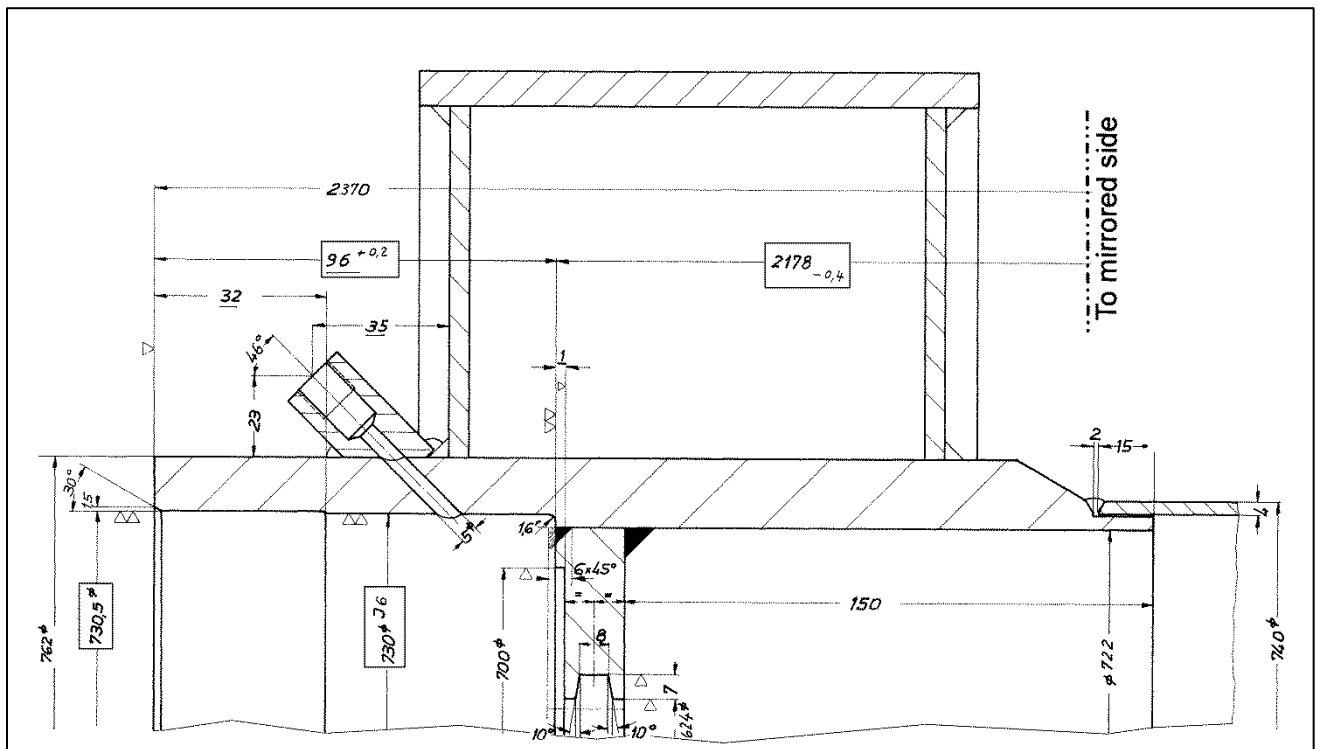
## **6 Requirements:**

- Monthly Visual testing (VT) according to ISO 17637 acceptance level B of the new welds, scope: 100%.
- Annual Magnetic particle testing (MT) according to ISO 17638 and ISO 9934, acceptance level 1 according to ISO 23278 or Penetrant testing (PT) according to ISO 3452, acceptance level 1 according to ISO 23277 of the new welds, scope: 100%.

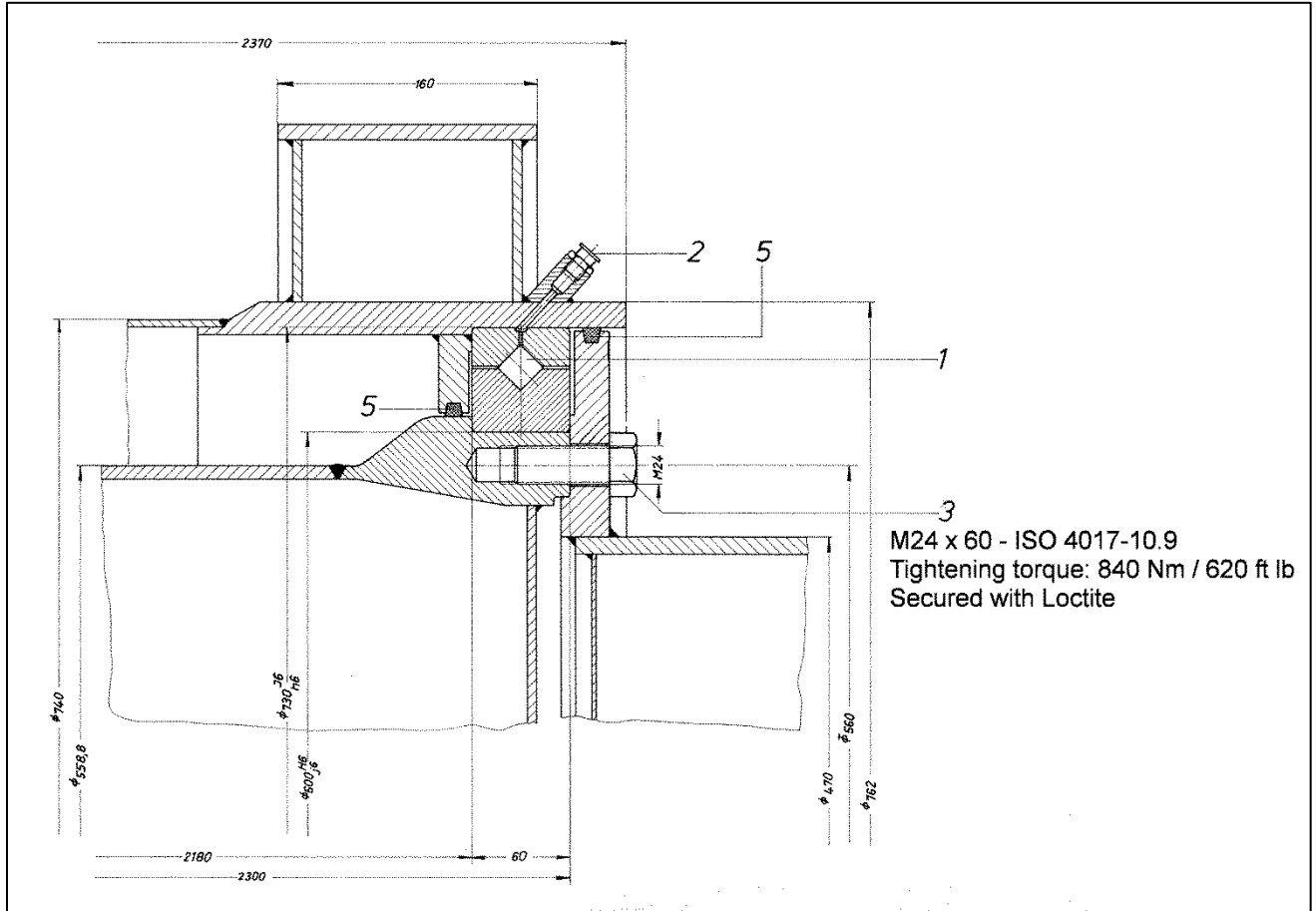
**7 Sketches:**



Sketch 1 Detail drawing of the new flange for the bearing seat of the hub



Sketch 2 Section view of the bearing seat



Sketch 3 Section view of the assembled hub bearing



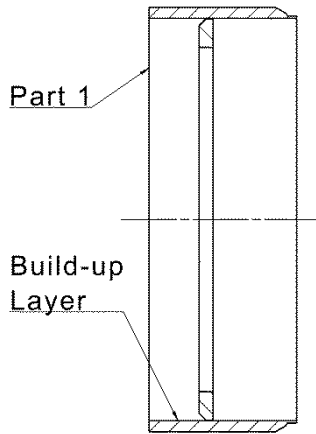


# preliminary-Welding-Procedure-Specification

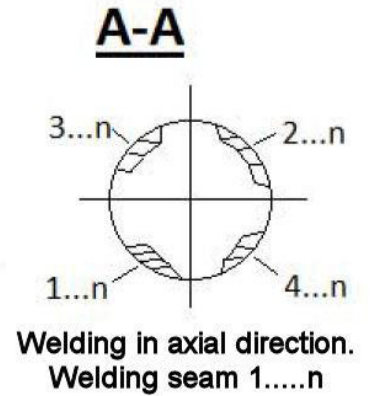
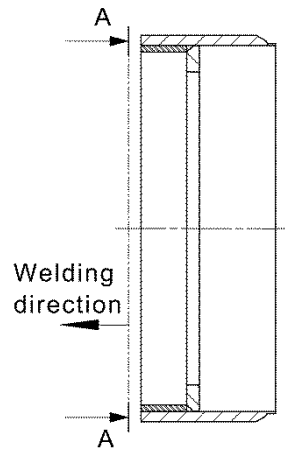
pWPS-No. **S272-1 / 2017** according to EN ISO 15609-1

Project	P8 Pirate Ship, #38477	Manufacturer	HUSS Maschinenfabrik GmbH
Welding site	Alton Towers Resort, Alton, Staffordshire, UK	Controller / -board	to be defined by Customer
<b>Part 1</b>		<b>Part 2</b>	
Material	S235JR	Material	---
acc. to	EN 10025-2	acc. to	---
Group-No.	1.1	Group-No.	---
acc. to	CR ISO 15608	acc. to	---
Thickness	16 mm	Thickness	---
Tube-Ø	762	Tube-Ø	---
Part temperature	min. 5°C	Electrode re-drying	300°C - 350°C / min. 2h
Preheat temperature	100°C	Tungsten electrode	---
Interpass temperature	max. 250°C	Shielding gas	---
Soaking temperature	---	Gas flow rate	---
Low hydrogen annealing	---	Nozzle-Ø	---
Post heat treatment	---	Rate of cooling	on air
Holding time before NDT	24 h	Type of weld seam	Build-up welding

### Welding edge preparation according to ISO 9692-1



### Welding layer sequence



Layer sequence	1 - n	2 - n	3 - n	4 - n		
Welding process (ISO 4063)	111	111	111	111		
Welding position (ISO 6947)	PA - PE	PA - PE	PA - PE	PA - PE		
Pitch angle	10°	10°	10°	10°		
Filler metal-Ø [mm]	3,2	3,2	3,2	3,2		
Electrode length [mm]	350	350	350	350		
Current [A]	100 - 140	100 - 140	100 - 140	100 - 140		
Polarity	DC+	DC+	DC+	DC+		
Heat input [kJ/mm]	1,0 - 1,4	1,0 - 1,4	1,0 - 1,4	1,0 - 1,4		
Run length [mm]	170 - 120	170 - 120	170 - 120	170 - 120		
Wire-feed	manual	manual	manual	manual		
Hand-feet	manual	manual	manual	manual		

### General

No welding spatter allowed. The welding seam has to be grinded free of notches. After machining UT- and MT- or PT-Inspection, scope: 100%

Created by:	Jens Lütkeniehoff (IWE)	Approved by:	Jens Lütkeniehoff (IWE)	Controller / -board	
Date	2016-02-11	Date	2016-02-11	Date	

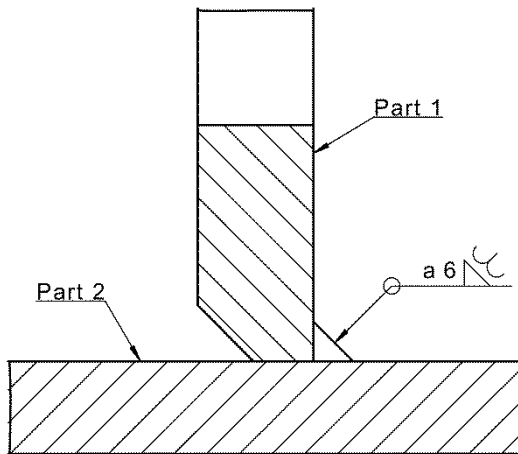


# preliminary-Welding-Procedure-Specification

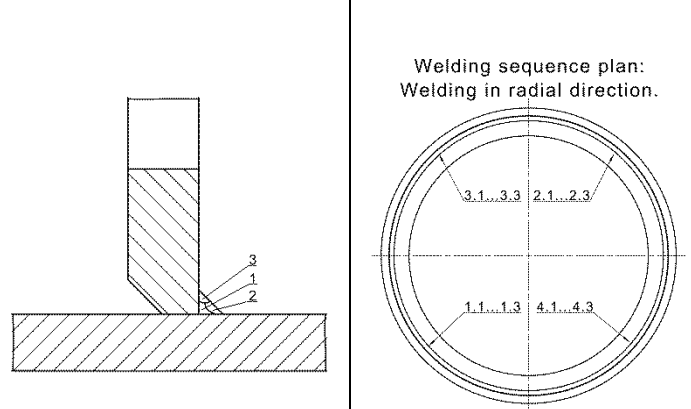
pWPS-No. **S272-2 / 2017** according to EN ISO 15609-1

<b>Project</b>		P8 Pirate Ship, #38477		<b>Manufacturer</b>		Huss Maschinenfabrik GmbH	
<b>Welding site</b>		Alton Towers Resort, Alton, Staffordshire, UK		<b>Controller / -board</b>		to be defined by Customer	
<b>Part 1</b>		<b>Part 2</b>		<b>Edge preparation</b>		Grinding, metallically bright, degreased	
<b>Material</b>	S355J2+N	<b>Material</b>	S235JR	<b>Welding preparation</b>		Tack welding acc. to EN 1011-2	
<b>acc. to</b>	EN 10025-2	<b>acc. to</b>	EN 10025-2	<b>Weld pool backup</b>		---	
<b>Group-No.</b>	1.2	<b>Group-No.</b>	1.1	<b>Gas backing</b>		---	
<b>acc. to</b>	CR ISO 15608	<b>acc. to</b>	CR ISO 15608	<b>Filler metal</b>		ISO 2560-A / E 38 4 B 42 H5	
<b>Thickness</b>	25 mm	<b>Thickness</b>	20 mm	<b>Filler metal name</b>		BÖHLER FOX EV 47	
<b>Tube-Ø</b>	---	<b>Tube-Ø</b>	762	<b>Electrode re-drying</b>		300°C - 350°C / min. 2h	
<b>Part temperature</b>		min. 5°C		<b>Tungsten electrode</b>		---	
<b>Preheat temperature</b>		100°C		<b>Shielding gas</b>		---	
<b>Interpass temperature</b>		max. 250°C		<b>Gas flow rate</b>		---	
<b>Soaking temperature</b>		---		<b>Nozzle-Ø</b>		---	
<b>Low hydrogen annealing</b>		---		<b>Rate of cooling</b>		on air	
<b>Post heat treatment</b>		---		<b>Type of weld seam</b>		Fillet Weld (FW)	
<b>Holding time before NDT</b>		24 h					

### Welding edge preparation according to ISO 9692-1



### Welding layer sequence



Layer sequence	1	2 – 3				
<b>Welding process (ISO 4063)</b>	111	111				
<b>Welding position (ISO 6947)</b>	PA – PE	PA – PE				
<b>Pitch angle</b>	10°	10°				
<b>Filler metal-Ø [mm]</b>	2,5	3,2				
<b>Electrode length [mm]</b>	350	350				
<b>Current [A]</b>	80 – 110	100 – 140				
<b>Polarity</b>	DC+	DC+				
<b>Heat input [kJ/mm]</b>	0,8 – 1,2	1,0 – 1,4				
<b>Run length [mm]</b>	130 – 85	170 – 120				
<b>Wire-feed</b>	manual	manual				
<b>Hand-feet</b>	manual	manual				

### General

No welding spatter allowed. The welding seam has to be grinded free of notches. After welding MT- or PT-Inspection, scope: 100%

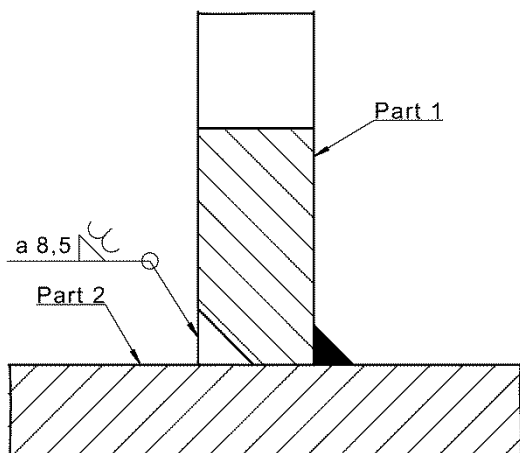
<b>Created by:</b>	Jens Lütkeniehoff (IWE)	<b>Approved by:</b>	Jens Lütkeniehoff (IWE)	<b>Controller / -board</b>	
<b>Date</b>	2017-02-11	<b>Date</b>	2017-02-11	<b>Date</b>	

# preliminary-Welding-Procedure-Specification

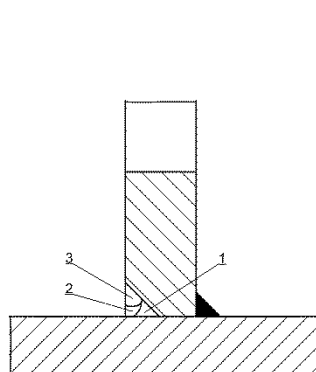
pWPS-No. **S272-3 / 2017** according to EN ISO 15609-1

<b>Project</b>		P8 Pirate Ship, #38477		<b>Manufacturer</b>		Huss Maschinenfabrik GmbH	
<b>Welding site</b>		Alton Towers Resort, Alton, Staffordshire, UK		<b>Controller / -board</b>		to be defined by Customer	
<b>Part 1</b>		<b>Part 2</b>		<b>Edge preparation</b>		Grinding, metallically bright, degreased	
<b>Material</b>	S355J2+N	<b>Material</b>	S235JR	<b>Welding preparation</b>		Tack welding acc. to EN 1011-2	
<b>acc. to</b>	EN 10025-2	<b>acc. to</b>	EN 10025-2	<b>Weld pool backup</b>		---	
<b>Group-No.</b>	1.2	<b>Group-No.</b>	1.1	<b>Gas backing</b>		---	
<b>acc. to</b>	CR ISO 15608	<b>acc. to</b>	CR ISO 15608	<b>Filler metal</b>		ISO 2560-A / E 38 4 B 42 H5	
<b>Thickness</b>	25 mm	<b>Thickness</b>	20 mm	<b>Filler metal name</b>		BÖHLER FOX EV 47	
<b>Tube-Ø</b>	---	<b>Tube-Ø</b>	762	<b>Electrode re-drying</b>		300°C - 350°C / min. 2h	
<b>Part temperature</b>		min. 5°C		<b>Tungsten electrode</b>		---	
<b>Preheat temperature</b>		100°C		<b>Shielding gas</b>		---	
<b>Interpass temperature</b>		max. 250°C		<b>Gas flow rate</b>		---	
<b>Soaking temperature</b>		---		<b>Nozzle-Ø</b>		---	
<b>Low hydrogen annealing</b>		---		<b>Rate of cooling</b>		on air	
<b>Post heat treatment</b>		---		<b>Type of weld seam</b>		Fillet Weld (FW)	
<b>Holding time before NDT</b>		24 h					

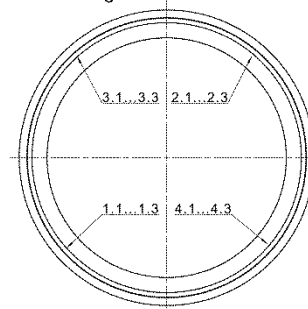
### Welding edge preparation according to ISO 9692-1



### Welding layer sequence



Welding sequence plan:  
Welding in radial direction.



Layer sequence	1	2 - 3				
<b>Welding process (ISO 4063)</b>	111	111				
<b>Welding position (ISO 6947)</b>	PA - PE	PA - PE				
<b>Pitch angle</b>	10°	10°				
<b>Filler metal-Ø [mm]</b>	2,5	3,2				
<b>Electrode length [mm]</b>	350	350				
<b>Current [A]</b>	80 - 110	100 - 140				
<b>Polarity</b>	DC+	DC+				
<b>Heat input [kJ/mm]</b>	0,8 - 1,2	1,0 - 1,4				
<b>Run length [mm]</b>	130 - 85	170 - 120				
<b>Wire-feed</b>	manual	manual				
<b>Hand-feet</b>	manual	manual				

### General

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<b>Created by:</b>	Jens Lütkeniehoff (IWE)	<b>Approved by:</b>	Jens Lütkeniehoff (IWE)	<b>Controller / -board</b>	
<b>Date</b>	2017-02-11	<b>Date</b>	2017-02-11	<b>Date</b>	

## Classifications

EN ISO 2560-A	EN ISO 2560-B	AWS A5.1	AWS A5.1M
E 42 5 B 4 2 H5	E 4918-1 A U H5	E7018-1H4R	E4918-1H4R

## Characteristics and typical fields of application

Basic electrode engineered for high-quality welds. Excellent strength and toughness properties down to -50°C. Metal recovery approx. 110%. Good weld ability in all position except for vertical-down. Very low hydrogen content (acc. AWS condition HD < 4 ml/100g weld metal). Suitable for welding steels with low purity and high carbon content. Welding in steel construction, boiler and tank manufacture, vehicle construction, shipbuilding, and machine construction as well as for buffer layers on build ups on high carbon steels. Especially suitable for off-shore construction, CTOD tested at -10°C. BÖHLER FOX EV 50 can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

## Base materials

Steels up to a yield strength of 420 MPa (60 ksi)

S235JR-S355JR, S235JO-S355JO, S235J2-S355J2, S275N-S420N, S275M-S420M, S275NL-S420NL, S275ML-S420ML, P235GH-P355GH, P275NL1-P355NL1, P275NL2-P355NL2, P215NL, P265NL, P355N, P285NH-P420NH, P195TR1-P265TR1, P195TR2-P265TR2, P195GH-P265GH, L245NB-L415NB, L245MB-L415MB, GE200-GE240, GE300

Ship building steels: A, B, D, E, A 32-F 36, A 40-F 40

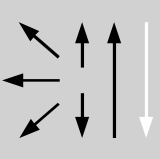
ASTM A 106 Gr. A, B, C; A 181 Gr. 60, 70; A 283 Gr. A, C; A 285 Gr. A, B, C; A 350 Gr. LF1, LF2; A 414 Gr. A, B, C, D, E, F, G; A 501 Gr. B; A 513 Gr. 1018; A 516 Gr. 55, 60, 65, 70; A 573 Gr 58, 65, 70; A 588 Gr. A, B; A 633 Gr. A, C, D, E; A 662 Gr. A, B, C; A 707 Gr. L1, L2, L3; A 711 Gr. 1013; A 841 Gr. A, B, C; API 5 L Gr. B, X42, X52, X56, X60

## Typical analysis of all-weld metal (wt.-%)

	C	Si	Mn
wt.-%	0.08	0.4	1.2

## Mechanical properties of all-weld metal

Condition	Yield strength R <sub>e</sub>	Tensile strength R <sub>m</sub>	Elongation A (L <sub>0</sub> =5d <sub>0</sub> )	Impact work ISO-V KV J		
	MPa	MPa	%	+20°C	-20°C	-50°C
u	<b>460</b> (≥ 420)	<b>560</b> (500 – 640)	<b>27</b> (≥ 20)	<b>190</b>	<b>160</b>	<b>70</b> (≥ 47)
s	<b>430</b>	<b>520</b>	<b>28</b>	<b>200</b>		<b>90</b>
u	untreated, as welded					
s	stress relieved 600°C/2h / furnace down to 300°C / air					

Operating data						
	<b>Polarity:</b> DC ( + )	<b>Redrying if necessary:</b> 300 – 350°C, min. 2 h	<b>Electrode identification:</b> FOX EV 50 7018-1 E 42 5 B	<b>ø mm</b>	<b>L mm</b>	<b>Amps A</b>
				2.0	250	50 – 70
				2.5	250/350	80 – 110
				3.2	350/450	100 – 140
				4.0	350/450	130 – 180
				5.0	450	180 – 230
				6.0	450	240 – 290
Approvals						
TÜV (0426.), DB (10.014.02), ABS (3H5, 4Y), BV (3YHHH), DNV (3YH10), GL (4Y40H15), LR (3, 3YH5), RMR (3YHH), RINA (4YH5 / 4H5), CRS (3YH5), NAKS, CWB (Ø3,2-6,0 mm), CE						

EN ISO 2560-A: E 38 4 B 42 H5  
 EN ISO 2560-B: E 49 16-1 A U H5  
 AWS A5.1: E7016-1H4R  
 AWS A5.1M: E4916-1H4R

# BÖHLER FOX EV 47

**SMAW electrode, mild steel**

## Description

Basic electrode for high-quality welds. Good weldability in all positions except vertical-down. Metal recovery about 110%. Very low hydrogen content (according AWS condition HD <4 ml/100g weld metal). Weld metal extremely ductile, crack resistant and ageing resistant thus especially suited for rigid weldments with heavy seam cross sections.

## Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	<b>0.06</b>	<b>0.5</b>	<b>0.7</b>

## Mechanical Properties of All-weld Metal

	u	s
yield strength $R_e$ N/mm <sup>2</sup> (MPa):	<b>460</b> (≥400)	<b>400</b> (≥360)
tensile strength $R_m$ N/mm <sup>2</sup> (MPa):	<b>530</b> (490-600)	<b>500</b> (450-580)
elongation A ( $L_0=5d_0$ ) %:	<b>27</b> (≥22)	<b>29</b> (≥22)
impact work ISO-V KV J	+20°C: <b>190</b> (≥110)	<b>200</b> (≥110)
	-20°C: <b>110</b>	<b>150</b>
	-40°C: <b>90</b> (≥47)	<b>100</b>
	-45°C: (≥27)	

*u untreated, as-welded*

*s stress relieved 600°C/2h/furnace down to 300°C/air*

## Operating Data



re-drying if necessary:

**300- 350°C, min. 2 h**

electrode identification:

**FOX EV 47 7016-1 E 38 4 B**

ø mm	L mm	amps A
2.5	250/350	80-110
3.2	350/450	100-140
4.0	450	130-180
5.0	450	180-230



## Base Materials

steels up to a yield strength of 380 N/mm<sup>2</sup> (52 ksi)

S235JR-E295, S235J2G3 - S355J2G3, C22, P235T1-P275T1, P235T2, P275T2, L210 - L320, L290MB - L320MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, S255NL - S355NL, GE200-GE240

ASTM A 27 u. A36 Gr. alle; A214; A 242 Gr.1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all, A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42-X52

## Approvals and Certificates

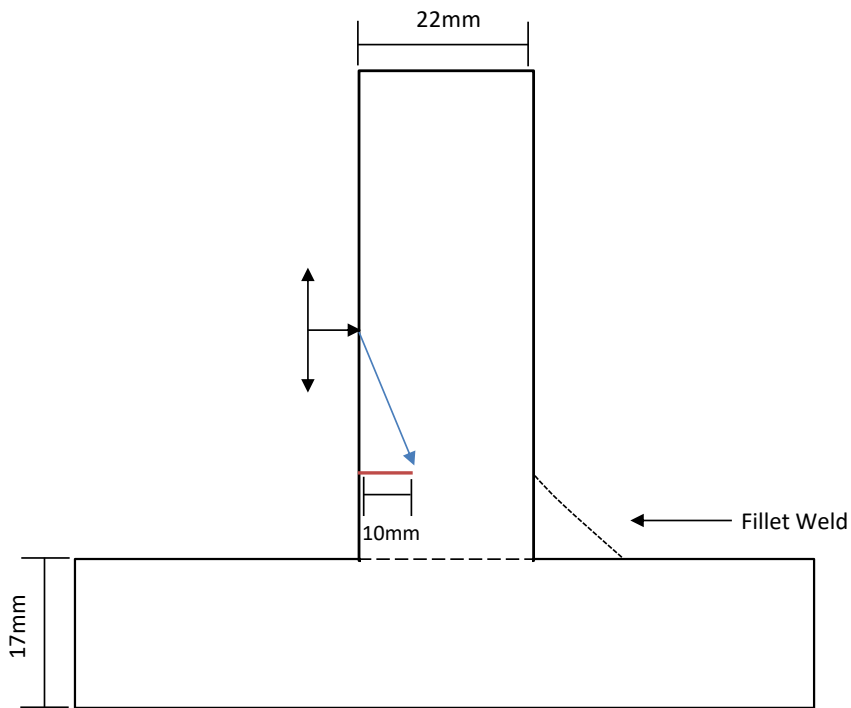
TÜV-D (1098.), DB (10.014.09), ÖBB, TÜV-A (72), ABS (3H5), BV (3HHH), DNV (3H10), GL (3H5), LR (3m H5), RMR (2), RINA (3YH5, 3H5), LTSS, VUZ, SEPROZ, CE

# S. T & W Inspections LTD


## Blade - Axil Hub Defects - Alton Towers

<b>Client Name</b>	Leisure Technical Consultants LTD	<b>Report Number:</b>	Alton Towers Blade - Axil Hub 07.02.17
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An ultrasonic examination was carried out to appraise the surface defects found on the axil hub. The largest cross section of the defect was found to be 10mm. This is represented on the below drawing.



**KEY:**  
— = Defect

<b>OPERATOR'S SIGNATURE:</b>		<b>AUTHORISED:</b>	N/A
<b>COMPANY:</b>	S.T & WI	<b>DATE:</b>	07/02/2017

*This report signifies acceptance or otherwise to the stated acceptance standard. The compliance with the standard does not imply suitability or fitness for any particular use or purpose. No other communication from S.T & W Inspections Ltd shall be used as an opinion to whether the weld or other components inspected should be accepted or rejected.*

