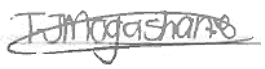
TRANSNET

freight rail

TECHNOLOGY MANAGEMENT
WHEELSET AND MATERIALS TECHNOLOGY SPECIFICATION

"U" TYPE TRACTION MOTOR CASING

Author:	Engineer-in-Training Wheelset and Material Technology	TJ Mogashane	
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Transnet SOC Ltd. and Relevant Third Parties

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1.0 PURPOSE

1.1. The purpose of this document is to specify the required minimum standard for “U” type traction motor casing used on Transnet Freight Rail traction and trailing stock.

2.0 SCOPE

2.1 This specification details the required chemical properties, mechanical properties, heat treatment and quality of newly cast steel “U” type traction motor casings used on Transnet Freight Rail locomotives.

3.0 REFERENCES

3.1. AAR Manual of Standards and Recommended Practices Casting Details, Steel Casting Specification, AAR M-201:2018

3.2. Metallic materials-Tensile testing, Part 1: Method of test at room temperature, SANS 6892- 1:2010

3.3. Metallic materials-Charpy pendulum impact test, Part 1: Test method, SANS 148 1:2007

3.4. The Izod impact test for metallic materials, SANS 6223:2010

3.5. Metallic materials-Brinell hardness test, Part 1: Test method, SANS 6506-1:2009

3.6. Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness, ASTM E446-10: 2010

3.7. Standard Reference Radiographs for Heavy-Walled (2 to 4½ in. (50.8 to 114-mm)) Steel Castings, ASTM E186-10: 2010

3.8. Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings, ASTM E125-63 (Reapproved 1980)

3.9. 6E and 6E1 U-tube Critical Areas Visual Requirements, RSE/TE/PRO/0093: Latest

4.0 DEFINITIONS

4.1 Melt or heat: the product of single furnace

4.2 Cast: the product of a single ladle. If a melt is tapped into two or more ladles, the product of ladle shall be considered as a separate cast.

4.3 Heat treatment batch: the product of a single heat treatment cycle. To be kept in melt and cast lots as far as possible.

4.4 Cast data: data required on each casting to enable positive identification of the casting with the cast number and date of manufacture

4.5 U-tube: “U”-type traction motor casing or motor suspension unit (MSU).

4.6 Defective: Any U-tube which does not meet the requirements specified in accordance with this specification due to a manufacturer’s defect.

5.0 QUALIFICATION AS A MANUFACTURER

5.1 Qualification as a manufacturer of U-tubes that are to be used by Transnet Freight Rail must be approved by the Transnet Freight Rail Quality Evaluation Committee. The Transnet Freight Rail Quality Evaluation Committee will consist of at least the following members:

a. A representative from Wheelset and Materials Technology, Transnet Freight Rail
b. A representative from Product Development, Transnet Engineering
c. A representative from Supply Chain Services, Transnet SOC Ltd

5.2 All candidates who wish to qualify as a manufacturer shall participate in all the stages of the evaluation program, which is as follows:

a. **Quality Plan** - Submission of a quality plan for U-tubes manufactured by them.
b. **Product Evaluation** - Submission of a cast U-tube and test coupons for metallurgical analysis in terms of Transnet Freight Rail specification.
c. **Process and Quality system evaluation** - If successful in the first 2 stages, a site process and facilities audit will to be performed.

5.3 Following the successful completion of the evaluation program; conditional approval for the supply of U-tubes shall be awarded to the manufacturer, where all U-tubes supplied to Transnet SOC Ltd are subjected to 100% radiography for a period of 6 months. If the U-tubes supplied within the 6 months period conform to all the requirements of this specification, then the manufacturer shall be awarded unconditional approval as a U-tube supplier.

5.4 Qualification is effective until revoked by Transnet Freight Rail. The cause of revocation is the failure of the manufacturer to maintain the requirements of this specification or any contractually agreed exceptions thereto. The manufacturer is unconditionally approved for a period of five years, thereafter Transnet SOC Ltd reserves the right to re-audit the manufacture’s facility or conduct tests on U-tubes prior to commencement of a new contract.

5.5 Manufacturers that have been previously approved by Transnet Freight Rail but have not supplied for 5 years or more must be re-qualified. Manufacturers shall provide the Transnet Freight Rail Quality Evaluation Committee with a test coupon that meets the requirements of this specification and relevant test certificates as evidence of compliance to this specification. A re-audit of the manufacturer facilities shall be conducted to ensure that the manufacturing process has not changed.

6.0 REQUIREMENTS

6.1 The U-tube shall strictly conform to relevant drawing(s) enumerated in the order contract that shall be supplied by Transnet SOC Ltd and no deviations from this drawing and contract are permitted without the written permission of Transnet SOC Ltd.

6.2 The approved concession forms shall be the only recognised manner of communication between the manufacture and Transnet SOC Ltd to deviate from the specification or contract.

7.0 MANUFACTURE

7.1 The steel shall be made in an electric furnace. Other processes shall be considered provided that full details of such processes are first submitted to Wheelset and Materials Technology, Transnet Freight Rail for approval.

8.0 CHEMICAL COMPOSITION

8.1 The steel shall have the following chemical composition:

Table 1: Chemical composition

Elements/Properties	AAR M201, Grade C
%Carbon	0.32 max
%Silicon	1.50 max
%Manganese	1.85 max
%Sulphur	0.04 max
%Phosphorus	0.04 max

9.0 MECHANICAL PROPERTIES

9.1 A sufficient number of test coupons to meet the entire test and re-test requirements shall be provided for each cast and heat treatment batch.

9.2 The test coupons shall meet the following requirements:

a) These test coupons, from which test specimens must be prepared, shall remain attached to the castings they represent and shall be heat treated together with the casting.

b) The test coupons shall be approximately 150 mm long and shall have a cross sectional area of approximately 3750 mm^2 and shall not be less than 30 mm in thickness.

c) Each test coupon and each casting shall reflect the cast data.

9.3 For tensile testing, the test piece shall not be smaller in diameter than 10 mm and shall be machined from the test coupon. The steel casting shall conform to the minimum requirements shown in Table 2.

Table 2: Mechanical properties

Mechanical Property	Required Value	Test Method
Yield Strength or 0.2% Proof Stress	410 MPa minimum	SANS 6892-1:2010
Ultimate Tensile Strength	620 MPa minimum	
Elongation $L_o = 5.64\sqrt{S_o}$	17% minimum	
Reduction in Area	40% minimum	
Charpy V-Notch @25°C	27.5 J minimum	SANS 148-1:2007
Izod V-Notch @ 25°C	33 J minimum	SANS 6223:2010
Brinell Hardness	179 to 217 HB(10/3000)	SANS 6506-1:2009

9.4 One tensile test shall be conducted on the test coupon for each cast included in each heat treatment batch. If tensile test specimen exhibits flaws before or after testing, it shall be discarded and another specimen substituted

10.0 HEAT TREATMENT

10.1. The U-tubes shall be suitably heat treated to provide a uniform fine grained structure and to remove injurious stresses.

10.2. All the U-tubes of a cast shall be heat treated in batches or consecutively in the case of continuous heat treatment furnace. Uniform temperatures shall be maintained at each stage of the heat treatment cycle.

10.3. The temperatures shall be recorded on continuous recording pyrometers. The cast numbers and quality of U-tubes in each cast undergoing heat treatment shall be recorded on the relevant chart. The charts shall be retained by the manufacturer for a minimum of period of one year. They shall be made available to the Transnet Freight Rail Quality Evaluation Committee representative upon request.

10.4. The steel casting may not be re-heat treated more than twice. All applicable tests, as specified, shall be conducted on castings which have been re-heat treated.

11.0 DEFECT CLASSIFICATION

11.1. Minor defect:
A minor defect allows for a maximum area of 500 mm^2 that may be excavated to a maximum depth of 30% of the casting thickness.

11.2. Major defect:
A major defect is a defect with an area greater than 500 mm^2 and one which is excavated to a depth exceeding 30% of the casting thickness.

12.0 QUALITY LEVELS

12.1. Quality level I (Critical):
This area of the casting is highly stressed in service. Defects in this area are likely to initiate fatigue or brittle fractures.

12.2. Quality level II (Major):
This area of the casting is less highly stressed in service. Certain types of defects may initiate failure.

12.3. Quality level III (Minor):
This area of the casting has low stress in service and defects should not have an adverse effect.

12.4. The Figure 1 shows the areas on a U-tube that represent the various quality levels and Table 3 shows the allowed weld repair for minor and major defects at the various quality levels. Repair through welding shall be done prior to final heat treatment.

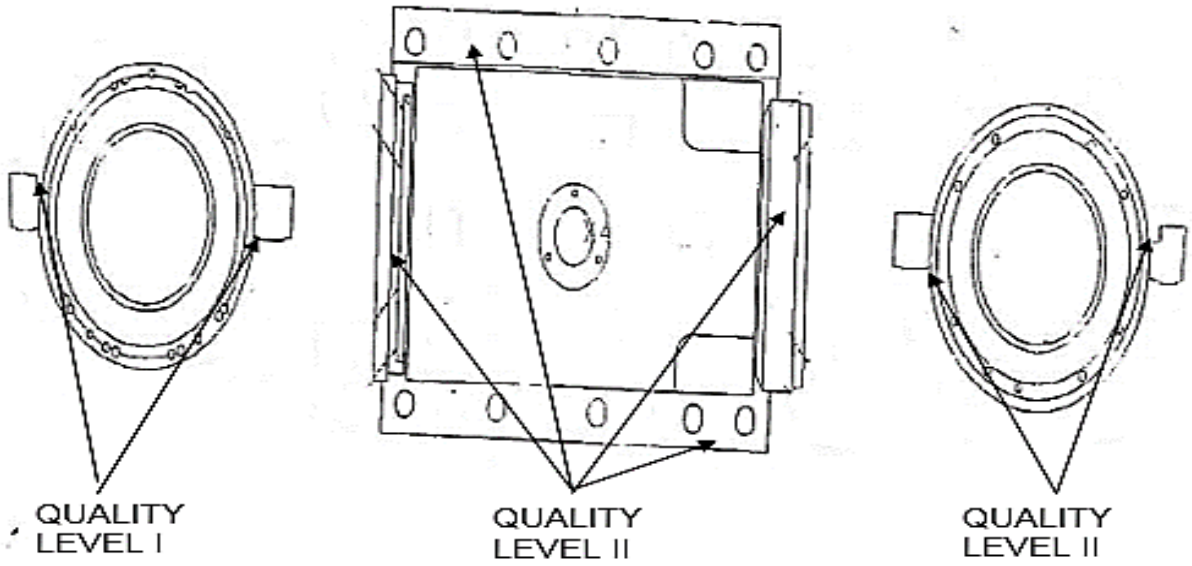

Figure 1: Quality levels on U-tube

Table 3: Welding repair procedure

Quality level	Minor Defects	Major Defects
	Condition	**Condition**
I	Record details on report form	Not permitted
II	Weld allowed without authorisation. Record details on report form	Weld without authorisation. Record details on report form
III	Weld without authorisation	Weld without authorisation. Record details on report form

13.0 INSPECTION METHOD AND TESTS

13.1. Prior to the inspection methods shown in Table 4, the casting shall be dressed and shot blast or rough machined.

Table 4: Application of inspection method to quality level:

Inspection method	Quality level		
	I	**II**	**III**
Radiography	1 casting/ cast	1 casting/ cast	1 casting/ cast
Magnetic Particle/ Dye penetrant testing	100%	100%	Not required
Visual	100%	100%	100%
Dimensional	100%	100%	100%

13.1. RADIOGRAPHY

13.1.1. Defect levels shall not exceed those laid down in ASTM E446-10 and ASTM E186-10 as shown in **Table 5** below. Refer to **clause 16.2** for reporting of the test results.

Table 5: Acceptance criteria for radiography

DEFECT TYPE	ASTM E446 FOR THICKNESS UP TO 50 mm. Sources:250 KV X-Rays Iridium: 192 GAMMA Rays Cobalt: 60 GAMMA rays			ASTM E186 FOR THICKNESS ABOVE 50mm TO 115 mm. Sources:1-24 MV X-Rays Cobalt: 60 GAMMA Rays		
	Quality level I	Quality level II	Quality level III	Quality level I	Quality level II	Quality level III
Gas holes and porosity	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5
Non-metallic inclusions	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5
Shrinkage CA CB CC CD	 Class 3 Class 3 Class 3 Class 3	 Class 5 Class 5 Class 5 Class 5	 Class 5 Class 5 Class 5 Class 5	 Class 3 Class 3 Class 3 -	 Class 4 Class 4 Class 4 -	 Class 5 Class 5 Class 5 -
Surface defects, cracks, hot tears, etc., unfused chaplets, chill or inserts	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable

13.2. MAGNETIC PARTICLES FLAW DETECTION

13.2.1. Hot tears, cracks, chills and fused chaplets are not acceptable and castings exhibiting such defects shall be repaired or rejected. The extent of other defects shall not exceed the discontinuities as laid down in ASTM E125-63 as shown in **Table 6** below:

Table 6: Acceptance criteria for magnetic particle inspection

Quality Level I		Quality Level II and Level III	
Type III	Degree I	Type II	Degree 2

Type IV	Degree I	Type IV	Degree 2

13.2.2. The casting shall be subjected to wet magnetic particle inspection method.

13.2.3. After final machining is complete, the casting shall be dye penetrant inspected on machined critical area surfaces. Refer to specification RSE/TE/PRO/0093 for the visual requirements of 6E and 6E1 U-tube critical areas

13.3. VISUAL EXAMINATION

13.3.1. Casting shall be free from the following defects:

a) Cracks

b) Tears

c) Cold shuts

d) Short runs

e) Surface scabs or obvious defects

13.4. DIMENSIONAL EXAMINATIONS

13.4.1. The U-tube shall comply with the dimension and tolerances shown on the relevant drawing(s) enumerated in the order contract. All dimensions must be measured. Measuring equipment must have the required permission and must be calibrated.

14.0 WELD REPAIR

14.1. If defects are removed through welding, the manufacture shall submit a welding procedure specification to Wheelset and Materials Technology, Transnet Freight Rail for approval. The welding procedure specification for repair welding shall include the following information:

a) Welding consumables: Make and type

b) Method of preparation: Carbon arc air gouging or grinding.

c) Inspection of preparation before welding, dye penetrant or visual inspection etc.

d) Welding process

e) Pre-heat

f) Technique

14.2. The manufacturer may not deviate from the repair procedure given in clause 14.1 without written consent from the Wheelset and Materials Technology, Transnet Freight Rail.

14.3. Weld repairs are to be carried out by welders who can maintain the standards specified in welding methods clause 13.0 of AAR M-201:2018 for casting repairs.

14.4. After weld repair, the weld metal shall be ground flush with the parent metal and dye penetrant or magnetic particles inspected for sound repair in major and critical areas. Refer to specification **RSE/TE/PRO/0093** for the visual requirements of 6E and 6E1 U-tube critical areas

14.5. Castings must receive a final heat treatment after weld repairs.

15.0 WELDING PROCEDURE SPECIFICATION

15.1. Refer to specification **BBH1603** for the repair welding of AAR M201 Grade C U-tubes and specification **RS/ME/PR/049** for the repair welding of BS3100 grade A3 U-tubes.

16.0 CERTIFICATION

16.1. The manufacturer must provide a certificate of conformance to this specification. The certificate must certify that the batch of U-tubes was manufactured and tested in accordance with the requirements of this specification. A report of all the test results shall accompany the test certificate. The certificate and the report shall be submitted to the Wheelset and Materials Technology, Transnet Freight Rail prior to acceptance and delivery. The report of the test results shall be traceable to the cast and heat treatment batch.

16.2. The required test and examination results are listed in Table 7. The information required for each individual heat, cast and the information required for each individual U-tube must be handed to the Wheelset and Materials Technology, Transnet Freight Rail for every delivery. Radiography shall be done at the exposure positions shown in Figure 2 and the test results shall reference those positions. Radiography films shall be made available upon request and the manufacturer shall retain these radiography films for a period of ten years from the date of manufacture.

Table 7: Required test and examination results

1 U-TUBE / EVERY HEAT TREATMENT BATCH		100% U-TUBE		1 U-TUBE / CAST	
Chemical analysis	Clause 8.0	Magnetic Particle	Clause 13.2	Radiography	Clause 13.1
Tensile Test	Clause 9.0	Visual	Clause 13.3		
Charpy V-Notch or Izod V-Notch @ 25°C		Dimensional	Clause 13.4		
Brinell Hardness					
Microstructure examination					
Steel cleanliness					

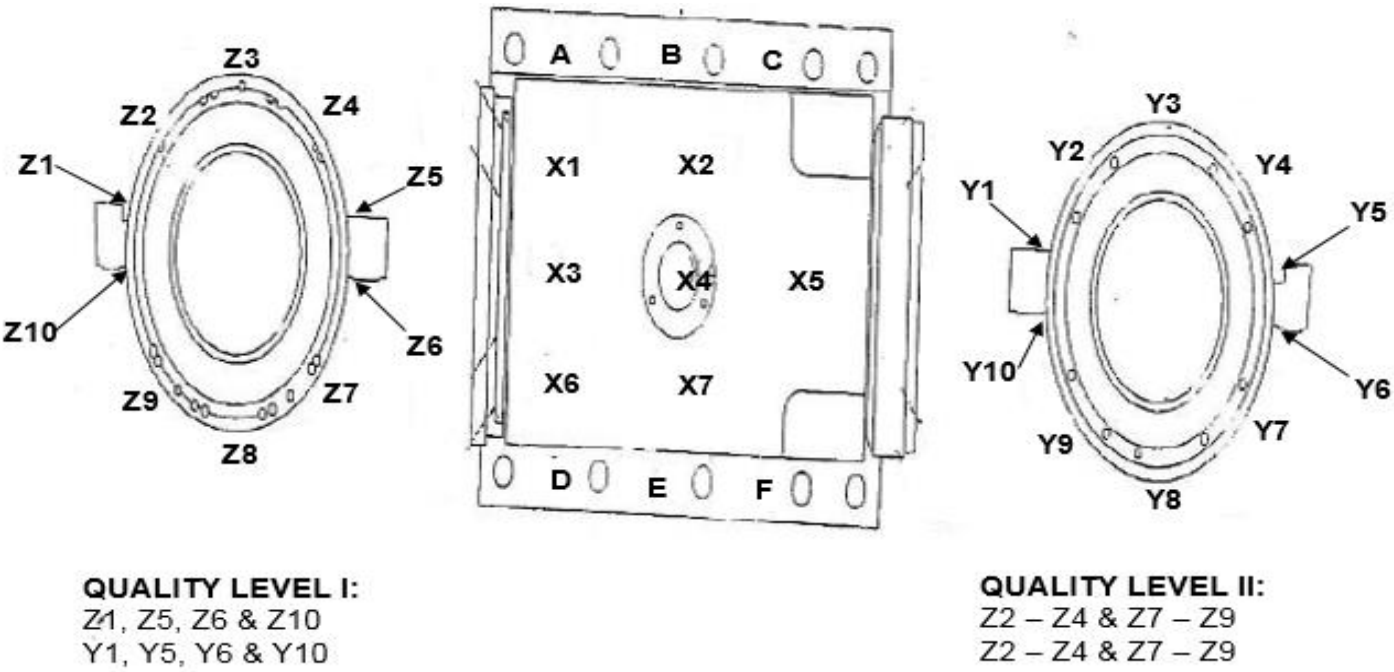

Figure 2: U-tube Exposure Positions

17.0 DELIVERY

17.1. The U-tubes shall be provided with effective protection against mechanical damage prior to despatch for instance, mounting U-tubes on pallets.

17.2. U-tubes that have undergone final machining shall be protected from corrosion through the use of paint or anti-rust coating.

18.0 GUARANTEE

18.1. If a newly delivered U-tube is found to be defective during final machining, the entire batch of delivered U-tubes shall be returned to the manufacturer and all the U-tubes that make up the batch shall be subjected to radiography, and or any other test, at the expense of the manufacturer to ensure that the remaining U-tubes are not defective. This clause shall take full effect regardless of the fact that representative U-tubes may have passed the tests prescribed in this specification and may have been accepted by the Transnet SOC Ltd

18.2. The manufacturer must guarantee the U-tubes for a period of n+10 years against any manufacturing defect that was not revealed during inspection where n is the year of manufacture. This period will be reckoned from the year of manufacture of the U-tube.

18.3. U-tubes that prove to have manufacturing defects that do not conform to the requirements of this specification during the guarantee period will be rejected by Wheelset and Materials Technology, Transnet Freight Rail. Wheelset and Materials Technology, Transnet Freight Rail, on request, will undertake to supply the manufacturer with sample portions of the defective U-tubes for the purpose of a counter examination. The sample portions will be cut from the U-tube at positions agreed to by Wheelset and Materials Technology, Transnet Freight Rail and the manufacturer.

18.4. If the U-tube is rejected, then the U-tube(s) must be replaced or refunded at their new replacement value. The defective U-tube(s) will remain as the property of Transnet Freight Rail.

19.0 REVISION HISTORY

Revision date	Version number	Details of changes	Remarks
Feb 2013	02	Revision history added. Note: **Material grade:** The chemical composition of the casting is AAR, M201, grade C. **Welding Procedure:** The casting weld repairs will be done according to specification: RW/TE/PRO/0068 **Mechanical test SANAS specification**: Tensile test: SANS 6892-1:2010 Impact charpy: SANS 148-1:2007 Hardness test: SANS 6506-1:2009	
June 2019	03	Motor Suspension Tube Steel Casting	Former Title
June 2019	03	**2.0 Scope:** This specification *covers the chemical composition, minimum materials strength requirements, heat treatment, and quality requirements* of new cast steel "U" type traction motor castings used on Transnet freight rail electric locomotives.	Changes made to text in italics
June 2019	03	***3.0 References***	Addition in italics
June 2019	03	**4.0 Definitions** *"U" type traction motor casting:* *"U" type traction motor castings will be referred to as U-tube hereafter on this specification.*	Removed text in italics
June 2019	03	***5.0 Qualification As a Manufacturer***	Addition in italics
June 2019	03	***7.0 Manufacture*** 7.1 The steel shall be made in an electric furnace. Other processes shall be considered provided that full details of such processes are *first submitted to Wheelset and Materials Technology, Transnet Freight Rail for approval*.	Addition in italics

<table>
<tr><td>June 2019</td><td>03</td><td>9.0 Mechanical Properties

“Each casting shall be hardness tested in accordance with specification SANS 6506-1:2009 and shall be within the Brinell hardness range specified.”

11.0 Inspection method and tests
The four methods of inspection and testing are listed below:</td><td>Removed text in italics</td></tr>
<tr><td>June 2019</td><td></td><td>Figure 1: Quality levels on U-tube</td><td>Changed picture</td></tr>
<tr><td>June 2019</td><td>03</td><td>13.2. Magnetic Particles Flaw Detection

Table 6: Acceptance criteria for magnetic particle inspection
<table>
<tr><td colspan="2">Quality Level I</td><td colspan="2">Quality Level II and Level III</td></tr>
<tr><td>Type I</td><td>Degree I</td><td>Type I</td><td>Degree 2</td></tr>
<tr><td>Type III</td><td>Degree I</td><td>Type II</td><td>Degree 2</td></tr>
<tr><td>Type IV</td><td>Degree I</td><td>Type IV</td><td>Degree 2</td></tr>
</table></td><td>Removed row with text in bold and italics</td></tr>
<tr><td>June 2019</td><td>03</td><td>13.0 Magnetic Particle Inspection/Dye penetrant

13.3. After final machining is complete, the casting shall be dye penetrant inspected on machined critical area surfaces. Refer to specification RSE/TE/PRO/0093 for the visual requirements of 6E and 6E1 U-tube critical areas.</td><td>Addition in italics</td></tr>
<tr><td>June 2019</td><td>03</td><td>14.0 Weld Repair

14.1. If defects are removed through welding, the manufacture shall submit a welding procedure specification to Wheelset and Materials Technology, Transnet Freight Rail for approval. The welding procedure specification for repair welding shall include the following information:

14.3. Weld repairs are to be carried out by welders who can maintain the standards specified in welding methods AAR M-201 clause 12.0 for casting repairs.</td><td>Additions and changes in italics</td></tr>
</table>

June 2019	03	**Changed: Annexure A (Welding procedure specification) to:** ***15.0 WELDING PROCEDURE SPECIFICATION*** Please refer to *specification* ***BBH1603*** *for the repair welding of AAR M201 Grade C U-tubes and specification* ***RS/ME/PR/049*** *for the repair welding of BS3100 grade A3 U-tubes.*	Additions and changes in italics
June 2019	03	***16.0 Certification*** ***17.0 Delivery*** ***18.0 Guarantee***	Addition in italics
June 2019	03	DEFECTIVE=Any U-tube which does not meet the requirements specified in accordance with this specification due to a manufacturer's defect.	Moved to Definitions
June 2019	03	**DEFECTIVE U-TUBES** *Any U-tube found to be defective after a delivery may be returned to the manufacturer at his expense, for replacement not withstanding that* representative U-tubes may have passed the tests prescribed in the specification and have been accepted by the client.	text in bold moved to guarantee text in italics changed