

DEP SPECIFICATION

ZINC CLAD DUPLEX TUBING MANUFACTURING SPECIFICATION

DEP 37.80.02.33-Gen.

February 2011

DESIGN AND ENGINEERING PRACTICE



© 2011 Shell Group of companies
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the recommended standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal.

The right to obtain and to use DEPs is restricted, and is granted by Shell GSI (and in some cases by other Shell Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, Shell GSI disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in Shell GSI.

TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	ABBREVIATIONS	6
1.5	CROSS-REFERENCES	7
1.6	COMMENTS ON THIS DEP	7
1.7	DUAL UNITS	7
2.	SCOPE OF WORK	8
3.	PROJECT DOCUMENTS	9
4.	QUALIFICATION OF TUBE MATERIALS	11
4.1	MATERIAL REQUIREMENTS	11
4.2	TESTING AGENCIES	11
5.	MATERIAL RECEIPT	12
5.1	PROCUREMENT AND RECEIPT OF STRIP	12
5.2	PROCUREMENT AND RECEIPT OF ZINC	13
5.3	PROCUREMENT AND RECEIPT OF WELD CONSUMABLES	13
5.4	QUARANTINED MATERIAL	13
6.	MANUFACTURE OF TUBE	14
6.1	STRIP WELDING AND RADIOGRAPHY	14
6.2	TUBE MILL CALIBRATIONS	14
6.3	TUBE MANUFACTURE	14
6.4	EDDY CURRENT INSPECTION OF TUBE	14
6.5	ULTRASONIC INSPECTION OF TUBE	15
6.6	EXAMINATION OF EDDY CURRENT AND ULTRASONIC TESTING INDICATIONS	16
6.7	MECHANICAL TESTING OF TUBE	16
6.8	TUBE DIAMETER AND WALL THICKNESS	16
6.9	ORBITAL WELDING AND RADIOGRAPHY	16
6.10	INSTRUMENT CALIBRATION REGISTER	17
6.11	PRE-EXTRUSION HYDRO TEST	17
6.12	TUBE OUTER DIAMETER BLASTING	17
6.13	ZINC EXTRUSION AND OUTER DIAMETER MARKING	17
6.14	POST EXTRUSION INSPECTION	18
6.15	ZINC COATING REPAIR	18
6.16	SPOOL ID FLUSHING	19
6.17	SPOOL FINAL (FAT) HYDRO TEST	19
6.18	SPOOL FLUID REMOVAL AND DRYING	19
6.19	TEST FITTINGS	20
6.20	WEIGHT OF REEL	20
6.21	MARKING OF REEL	20
6.22	SPOOL PACKING LIST	20
6.23	LENGTH MONITORING	20
6.24	STRAIN LIMIT	20
6.25	DELIVERY DOCUMENTATION	20
6.26	REEL INVENTORY	21
6.27	REEL LOGISTICS	21
6.28	MATERIAL TRACEABILITY	21
6.29	REEL HANDLING	21
7.	WELDING	22
7.1	WELD PROCESS	22
7.2	WELD QUALIFICATION TUBE MATERIAL	22
7.3	QUALIFICATION TEST PIECES	22
7.4	WELD PROCEDURE SPECIFICATIONS	22

7.5	WELD PROCEDURE QUALIFICATION	22
7.6	WELDER PERFORMANCE QUALIFICATION – GTAW	22
7.7	WELDER PERFORMANCE QUALIFICATION – LBW	23
7.8	REGISTER OF QUALIFIED WELDERS	23
7.9	WELD MAP	23
7.10	WELD REPAIRS	23
7.11	RETENTION OF REJECTED WELDS	23
7.12	RADIOGRAPHY EQUIPMENT	23
7.13	EQUIPMENT SET UP	23
7.14	REGISTER OF QUALIFIED NDE OPERATORS	24
7.15	PRODUCTION WELD NDE	24
7.16	IMAGE QUALITY SENSITIVITY	24
7.17	CONTRAST SENSITIVITY	25
7.18	RADIOGRAPHIC IMAGES	25
7.19	AUDIT OF RADIOGRAPHS	25
7.20	RETENTION OF RADIOGRAPHS	26
8.	TESTING OF FIRST TIME MATERIAL FOR RESISTANCE TO ENVIRONMENTAL CRACKING	27
9.	TUBE TRANSPORTATION	28
9.1	REEL QUALITY ASSURANCE	28
9.2	REEL STORAGE	28
9.3	PACKING	28
9.4	MARKING	28
9.5	LIFTING	29
9.6	LAND TRANSPORTATION	29
9.7	MARINE TRANSPORTATION	29
9.8	COORDINATION	30
9.9	DOCUMENTATION	30
10.	REFERENCES	31
11.	TABLES	33

APPENDICES

APPENDIX 1	WELD TEST MATRIX	35
APPENDIX 2	ACCEPTANCE CRITERIA FOR LABORATORY TESTS – STRIPS	37
APPENDIX 3	ACCEPTANCE CRITERIA FOR LABORATORY TESTS – SEAM WELDED TUBE	38
APPENDIX 4	DOCUMENT RETENTION AND DELIVERABLES	42
APPENDIX 5	FINAL DOCUMENTATION	44

1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the manufacture, packing, handling and shipping of zinc clad "lean" duplex stainless steel tube for umbilical service.

The content of this DEP also encompasses tube interfaces during umbilical manufacture for receipt inspection, handling, tracking and welding of zinc clad duplex umbilical tubing by the umbilical manufacturer.

Transportation from Manufacturer/Supplier's premises or intermediate transfer point may or may not be included in Manufacturer/Supplier's scope.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific Definitions

Mill Coils	Intermediate lengths forming sub-lengths of the final spool
Spool	Finished length of tubes shipped from Manufacturer/Supplier
Zinc Clad Duplex	A duplex alloy tube with an external zinc coating of a specified thickness covering 100 % of the OD of the tube

1.4 ABBREVIATIONS

CoC	Certificate of Conformance
DDR	Deviation Disposition Request
EC	Eddy Current
FAT	Factory Acceptance Test
GA	General Assembly
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HD	Hub Diameter
HRC	Hardness Rockwell C
HT	Heat Treatment
HV	High Voltage
ID	Inner Diameter
IQI	Image Quality Indicator
JSA	Job Safety Analysis
LBW	Laser Beam Welding
MAOP	Maximum Allowable Operating Pressure
NCR	Non-Conformance Request
NDE	Non-Destructive Examination
NIST	National Institute of Standards and Technology
OD	Outer Diameter
OW	Orbital Welding
PE	Polyethylene
PE	Professional Engineer
PMI	Positive Material Identification
PPE	Personal Protective Equipment
PRE _N	Pitting Resistance Equivalent Number
PQR	Procedure Qualification Request
PVC	Polyvinyl chloride
QP	Quality Plan
QW	Qualification Weld
RTR	Record to Report
SHG	Special High Grade
SMYS	Specified Minimum Yield Stress
TF	Transverse Face
TR	Transverse Root
TWI	The Welding Institute (UK Research Facility)

UNS	Unified National Standard
UT	Ultrasonic Testing
WPS	Weld Procedure Specification
WPQ	Welder Procedure Qualification
WT	Wall Thickness

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (10).

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

In this DEP, the International System of units (SI) shall be understood to prevail over US Customary (USC) units. USC units are provided in brackets following the SI units for information.

2. SCOPE OF WORK

The following project specific variables shall be specified in the project scope of work:

- a) Inner diameter (ID) and wall thickness (WT) of tubes;
- b) Specified minimum yield strength, e.g. 552 or 620 MPa (80 or 90 ksi) nominal;
- c) WT tolerances (minimum and maximum) and resultant outer diameter (OD) tolerances;
- d) Tube maximum allowable operating pressure (MAOP) so that correct hydrostatic test pressures are selected;
- e) Cleanliness requirements for tube;
- f) Zinc nominal thickness and tolerance (to satisfy service life, if different from (6.13);
- g) Type, material, and rating of end/test fittings on each spool (consistent with tube tests on project test matrix);
- h) Total quantity of each tube size, length per reel, and total number of reels;
- i) Dynamic length (if applicable) per reel and position (inner or outer) on reel;
- j) Supplier of empty reels (Manufacturer/Supplier or umbilical manufacturer);
- k) Date of receipt of empty reels (if provided by umbilical manufacturer);
- l) Size, weight, and hub diameter of reels;
- m) Maximum gross weight of reel plus spooled tube;
- n) Date(s) and location for tube delivery;
- o) Delivery quantity and date for accelerated weld qualification tubes to umbilical manufacturer;
- p) Delivery priority (for particular tube size or reels with/without dynamic length);
- q) Project specific packing instructions;
- r) Duration for retention of records (appropriate for service life).

3. PROJECT DOCUMENTS

Manufacturer/Supplier shall prepare a Project Document Register that shall include the documents and drawings listed in (Appendix 5).

The document register shall identify the documents that will be issued to the Principal. The document register shall include a description of Manufacturer/Supplier's numbering convention and revision definitions. As a minimum the document (and drawing) register shall include:

- a) Document number
- b) Document title
- c) Planned first issue date
- d) Actual first issue date and revision
- e) Subsequent issue date(s) and revision(s)
- f) Date and reference to any written Principal comments on each revision
- g) Planned subcontract Purchase Order issue date

Document Register contents (project documents and drawings required by the Principal for the Purchase Order) shall be listed in the respective project specifications. Manufacturer/Supplier shall satisfy the requirements applicable for the awarded scope.

All project designs, drawings, and procedures shall be issued for Principal review and approval prior to procurement of materials, manufacture, or application. Planned issue dates for design documents and drawings shall be at least 6 weeks before planned procurement from sub-suppliers. Duration for Principal review and comment shall be discussed and mutually agreed at the Kick Off Meeting.

Manufacturer/Supplier shall also include on the register or submit separately a register of all manufacturing procedures and specifications (MPS). Manufacturer/Supplier shall permit Principal review on site of all documents (written in English) and audit of the manufacturing procedures at any time during the execution of the Purchase Order.

Manufacturer/Supplier may propose a project document register that differs in document or drawing titles or in structure, providing the register encompasses the required deliverables.

Manufacturer/Supplier shall submit a register of all non project specific internal manufacturing procedures and specifications to the Principal and permit review on site of all documents (written in English) and audit of the manufacturing procedures at any time during the project execution.

All project management documents shall be prepared at least in draft prior to the Kick Off Meeting.

Documents shall state page X of Y and have a revision number or revision date on every page.

Manufacturer/Supplier shall issue a project specific quality plan (QP) for Principal's review and approval. The QP shall include for all manufacturing stages:

- i. Company specification references
- ii. Agreed technical clarifications/deviations to project specifications
- iii. Manufacturing procedure references
- iv. Inspection/test procedure references
- v. percentage or proportion of items to be inspected
- vi. Inspection/test frequency and quantity
- vii. Acceptance criteria
- viii. Retest criteria and procedure (if applicable)

- ix. Rework procedure (if applicable)
- x. Type and content of paperwork completed prior to release
- xi. The Principal's required review, witness, and hold points

The QP or a separate project specific document shall capture sub-supplier quality surveillance and receipt inspection and testing.

4. QUALIFICATION OF TUBE MATERIALS

4.1 MATERIAL REQUIREMENTS

Test data shall be provided to the Principal to demonstrate the following for each material and weld process combination (some tests required for each size and sensitivity to alloy content, i.e. limits of PRE_N ranges):

- a) Material tensile properties (yield, tensile, elongation) as a function of temperature to 315°C (600°F);
- b) Material tensile properties (yield, tensile, elongation) as a function of reeling history (accumulated strain) at Manufacturer/Suppliers' premises – from the mill to delivery;
- c) Low cycle plastic fatigue behaviour, repeat cyclic bending to 2 % strain;
- d) High cycle fatigue behaviour [evaluated at two (2) independent test facilities];
- e) Weld procedure qualification reports for strip splice welding (SSW), laser beam welding (LBW), and orbital welding (OW);
- f) Material austenitic/ferritic content balance for parent material, SSW, LBW, and OW accounting for sensitivity of the combination of appropriate variables such as manufacturing line speed, alloy content (PRE_N) range, and temperature limits during HT;
- g) Microstructure demonstrating no detrimental phase formation in SSW or OW in any part of production process where filler metal is used, accounting for sensitivity of the combination the appropriate variables such as manufacturing line speed, alloy content range (PRE_N), and HT limits;
- h) Tube burst pressure for samples with SSW, LBW, OW [a minimum of three (3) samples for each of the weld types];
- i) External collapse pressure tests;
- j) Dimensional tests of samples of zinc extruded tube that have been processed on the extrusion line at:
 - i. Upper allowable extremity of the tube temperature;
 - ii. Upper allowable extremity zinc feed speed;
 - iii. Lowest allowable tube feed speed;
 - iv. Other variables influencing tube ovality may also be relevant;
 - v. Crevice corrosion resistance for polyethylene (PE) tube oversheath or adjacent PE umbilical sheath;
 - vi. Crevice corrosion resistance for adjacent polyvinyl chloride (PVC) profiles;
 - vii. NACE MR0175;
 - viii. Stress Cracking Resistance in Substitute Ocean Water under Cathodic Protection Current [modified NACE test, The Principal's requirements presented in (9)].

4.2 TESTING AGENCIES

Agencies or laboratories performing non-destructive testing for qualification or production scope shall satisfy the minimum requirements of ASTM E543 Standard Practice for Agencies Performing Non-destructive Testing.

Test locations proposed or utilized by Manufacturer/Supplier may be surveyed by the Principal in accordance with ASTM E1359.

5. MATERIAL RECEIPT

5.1 PROCUREMENT AND RECEIPT OF STRIP

5.1.1 Supplier Audit

Manufacturer/Supplier shall conduct periodic audits and, if applicable, audit follow-ups of the selected strip supplier.

5.1.2 Steel Grade

Steel Grade shall be UNS S32001 or UNS S32101 in accordance with ASTM A789. See Table 1 in (11) for allowable steel composition by weight percentage

Chemical composition shall be performed by heat analysis in accordance with ASTM A751 and reported on the Steel Supplier Material Certificate. Heat analysis (chemical composition) shall be performed and recorded in accordance with Manufacturer/Supplier's specification, in lieu of an industry standard governing this process. Description of when, how, and where ladle samples are taken shall be clearly stated in Manufacturer/Supplier's document suite and shall be made available to the Principal for review upon request. Heats that do not meet the requirements of material grade shall be rejected. PRE_N shall be calculated and reported for each heat of material based on the following calculation:

$$PRE_N = (wt\%Cr) + 3.3(wt\%Mo) + 16(wt\%N)$$

Independent chemical composition shall be performed by product analysis in accordance with ASTM A751 on one (1) sample per heat of the steel strip received on Manufacturer/Supplier's premises for the Purchase Order.

5.1.3 Reporting

Manufacturer/Supplier shall include in the deliverable documents and submit to the Principal the measurements for melting (heat certificates) and the measurements of the strip (product analysis). Results of heat analysis and product analysis shall both meet the UNS grade specification for element composition, and shall report the calculated PRE_N . Discrepancies between results shall be explained.

5.1.4 Ferrite Content

Ferrite content shall be evaluated on a minimum of one (1) sample for each strip coil heat/thickness combination.

Evaluation shall be in accordance with ASTM E562 at minimum x500 magnification.

Ferrite content of the incoming strip shall be 35 – 60 % (45 – 55 % preferable).

5.1.5 Strip Thickness

Manufacturer/Supplier shall specify strip thickness and width tolerances to the strip supplier so as to meet the final tube dimensional specifications. Strip tolerance specifications shall be stated in the project QP; however, strip width shall be sufficient to allow edge prep of the strip without changing the diameter of the tube. Strip thickness shall be measured continuously for all strip coils (this may be performed by the strip supplier, providing certification is provided). Strip thickness measurements shall be confirmed by sampling at the beginning and end of every strip coil. Continuous measurement of strip thickness may also be confirmed (not replaced) with full body ultrasonic testing (UT) of the tube.

5.1.6 Positive Material Identification

Positive material identification (PMI) of each strip coil shall be performed using a portable X-ray fluorescence instrument in accordance with ASTM E1916. PMI shall be conducted either upon receipt of strip or on the mill.

5.1.7 Traceability

Traceability and tracking shall be maintained for material allocated to the Purchase Order. Strip material shall be tagged with unique reference/tracking numbers and the Principal's project name.

5.2 PROCUREMENT AND RECEIPT OF ZINC

5.2.1 Supplier Audit

Manufacturer/Supplier shall conduct periodic audits and, if applicable, audit follow-ups of the selected zinc supplier.

5.2.2 Zinc Grade

Zinc Grade shall be UNS Z13001 in accordance with ASTM B6. Chemical composition shall be Special High Grade (SHG) but with controlled/elevated iron content. See Table 2 (11) for the allowable chemical composition of zinc by weight percentage.

Chemical composition shall be performed by heat analysis in accordance with ASTM A751 and reported on the Zinc Supplier's Material Certificate.

Independent chemical composition shall be performed by product analysis on a minimum of one (1) sample per heat of the zinc rod received on Manufacturer/Supplier's premises for the Purchase Order. Testing shall be performed by a testing agency approved by the Principal.

5.2.3 Traceability

Traceability and tracking shall be maintained for material allocated to the Purchase Order. Zinc rods shall be tagged and traceable by heat/lot number to certification.

5.3 PROCUREMENT AND RECEIPT OF WELD CONSUMABLES

5.3.1 Welding Rods

Chemical composition shall be performed by heat analysis and reported on the Supplier Material Certificate.

Independent chemical composition shall be performed by product analysis on a minimum of one (1) weld rod or weld coil per heat of the filler metal received on Manufacturer/Supplier's premises for the Purchase Order.

PRE_N shall be calculated from heat analysis and from product analysis and reported by Manufacturer/Supplier.

5.3.2 Weld Shielding Gas

Certification shall provide the detailed composition of all shielding gas. Actual composition shall be stated on the weld procedure specification (WPS).

5.3.3 Positive Material Identification

PMI of the weld filler metal shall be performed using a portable X-ray fluorescence instrument in accordance with ASTM E1916. PMI shall be conducted upon receipt of material. Each heat of each delivery of weld consumables shall be checked.

5.3.4 Traceability

Traceability and tracking shall be maintained for material allocated to the Purchase Order. Weld consumables shall be tagged and traceable by heat/lot number to certification.

5.4 QUARANTINED MATERIAL

At all times, any material with an outstanding Non-Conformance Request (NCR) or Deviation Disposition Request (DDR) shall be clearly and visibly differentiated. Manufacturer/Supplier shall state how this will be implemented.

6. MANUFACTURE OF TUBE

6.1 STRIP WELDING AND RADIOGRAPHY

Strip ends shall be spliced together using full penetration gas tungsten arc welding (GTAW) or Plasma welding with or without the addition of filler metal or by LBW without the addition of filler metal.

SSW shall be heat treated with a non-oxidizing atmosphere protecting both the inside and outside surfaces.

For SSW weld procedure qualification, welder qualification, production weld test requirements, and acceptance criteria, refer to (7) and (8).

6.2 TUBE MILL CALIBRATIONS

Calibration flaws shall be prepared according to (6.4) and (6.5). The calibrations standard(s) used for flaw detection [combination of eddy current (EC) and UT] shall encompass both holes and notches.

The success of the entire flaw detection process is controlled by calibration flaws.

The connection between detection of the calibration flaw and the natural flaw shall be demonstrated. Sensitivity and phase settings cannot be determined on the sole basis of the calibration flaws but shall be cross-checked on the basis of natural material or production-specific flaws. The pass/fail threshold shall be set according to the defined artificial calibration flaw and a sensitivity correction.

Manufacturer/Supplier shall have a documented calibration method that includes cross checking of equipment sensitivity (flaw detection threshold) to calibration flaws AND natural flaws.

6.3 TUBE MANUFACTURE

The tube shall be manufactured in accordance with the requirements of ASTM A789. The tube shall be made by rolling strip and seam welding using LBW without the addition of filler metal (autogenous).

The seam welded tube shall be heat treated in a non-oxidizing atmosphere protecting both the inside and outside surfaces. ASTM A789 specifies a temperature of 982 – 1070 °C (1800 – 1950 °F) for UNS 32001 followed by rapid cooling in air or water or else a minimum temperature of 1020 °C (1870 °F) for 32101 quenched in water or rapidly cooled by other means. The HT variables shall be demonstrated to achieve the specified mechanical properties and stated on the WPS.

HT temperature shall be continuously recorded with a primary and secondary instrument, calibrated to a metrology standard that is traceable to a national standard (e.g. NIST in the USA), and line speed shall be continuously displayed.

For LBW weld procedure qualification, welder qualification, production weld test requirements, and acceptance criteria, refer to (7) and (8).

6.4 EDDY CURRENT INSPECTION OF TUBE

Non destructive EC testing shall be performed on the tube mill as well as on a testing line after tube welding. These inspections shall be done in accordance with ASTM E309 featuring both high and low frequency coils, providing the sensitivity requirements of (6.2) are achieved with the option selected.

All personnel involved with non destructive examination shall be certified in accordance with ASNT SNT-TC-1A. Equipment operators shall be EC Level I or II under the direction of EC Level III personnel.

Supervisors with responsibilities for setting up and calibrating the non-destructive examination (NDE) equipment shall be qualified to a minimum of EC Level II. Training of