Hunan Standard Steel Co.,Ltd
#112,FUYUAN AVE ,XINSHA INDUSTRIAL ZONE CHANGSHA ,HUNAN.CHINA
TEL: +86-731-89878292 FAX: +86-731-84788292 Http://www.hu-steel.com

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MANUFACTURING PROCEDURE SPECIFICATION

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1.SCOPE PROCEDURE

This procedure covers the manufacturing procedure used in the fabrication ERW pipe .

2.REFERENCE DOCUMENTS

- API 5L Edition 44 – 2007.
- Pipeline Specification supplied by Customer.

3.RESPOSIBILITIES

- It is the responsibility of the project manager to ensure that the stipulations laid down in the procedure are adhered to in full.
- It is the responsibility of the material controller to ensure that the requirements contained within this document are implemented and maintained throughout the project duration.
- It is the responsibility of construction supervisors to ensure that all procedure requirements are executed, recorded and maintained throughout the project duration.

4.MATERIAL PURCHASING & RECEIVING

- Upon receiving the Coil, warehouse personnel shall check the delivery slips; surface condition of any damage caused by transportation and notifies Q.C. section for inspection.
- When notified by warehouse, Q.C. Inspector shall be in corporation with warehouse personnel to review material certificates, material test report and checking heat number, coil number as specified in material specification.
- After verifying that material meets all Code/Spec. requirements, the Q.C. inspector shall record and attach an accept label on the Coil. When material is accepted, all relevant inspection records such as mill certificates, test/inspection reports etc., shall be filed by Q.C. Dept.

5.COIL UT TEST:

- Coil runs in a straight line while probe does not move. Two probes scan the each edge of coil, and other two probes scan the middle of coil control.
- The surface for inspected shall be removed all foreign bodies which may affect the effectiveness of the detection.
- Distance between center of edge probe and coil edge is fixed about 25mm.
  Distance between center of middle probe and coil edge according the follow fomula: D=L/3+50 (mm)
  Here D is distance, L is width of coil.
- The signal band of probes is 50 mm
- The automatic trigger /alarm system combined with the automatic marking systems, the marking on suspicious region shall be automatic sprayed.
- Ultrasound equipment shall be able to inspect the 100 % area of coil.
- When 4 probes in the work station in same time, the UT equipment will in the Auto control and recording system. Then carry out the continue inspection.
- The test sample plate with serials ϕ 5mm flat bottom holes will be used for calibration.
- In case of static calibration, during the inspection increase +2dB for dynamic inspection

6. STRIP PREPARATION

- The strip preparation section is designed for the shortest possible coil joining times, constant strip tension and precise strip alignment and thus ensures the stable operation of the tube welding line. In the cross-welder, the ends of the coils are

cropped, precisely aligned and welded together. Simultaneously, a hole is punched in the center of the strip indicating the cross-weld position to be detected later at the front of the tube mill.

- The operator should confirm front and back steel coil have been leveled same together, welding line flat and trimness, the depth of weld should be more than 70% of wall thickness

7. STRIP ACCUMULATING & EDGE TRIMING

- The system is to store the coils in "externally in and internally out, top in and bottom out" form, to ensure continuous feeding and production. A continuous production process is ensured by the use of the horizontal spiral strip accumulator which bridges the standstill time in the strip preparation section during the welding of the coil ends.
- Skelp edges are sheared to pre-sopecified widths and the lead end of each coil is squared for threading into the mill.

8. FORMING

- According to the specification of ERW pipe, the forming roller and squeeze roller shall be regulated and installed properly based on the technical process. Adjusting the position of the top and side roller one by one. Q.C person will take vernier caliper to measure size of long and short shaft and the result should approach to the dimension of former.

9. WELDING & FLASH TRIMING

- The welding temperature should ensure the welding bead is completely melted.
- The operator should adjust the size of gap roller according to technical process; The Depth of Groove:
  + $t \leq 3.8$: 1.10t
  + $3.8 < t < 7.6$: 0.38mm
  + $t \geq 7.60$: 0.05t
- The flash inside and outside the pipe will be scarfed properly. The outside flash shall be trimmed to on essentially flush condition. The inside flash shall not be more than 1.5mm.

10. ONLINE- UT

- Pipe rotates and runs in a straight line while probe does not move. Total four probe , two probes control the straight seam inside ,other probes control the straight seam outside
- The surface for inspected shall be removed all foreign bodies which may affect the effectiveness of the detection.
- During detection, the device should be able to track the probe weld of pipe by maintaining the provisions of the sensitivity, so that the entire welding seam in the detection's region.
- The welding seam always in position of 12'clock. If there is any change in the operation, the probe of seam tracking shall be adjusted in a timely manner.
- Two probes in each side inspect to the wave of the weld seam
- The automatic trigger /alarm system combined with the automatic marking systems, the marking on suspicious region shall be automatic sprayed.
- Ultrasound equipment shall be able to inspect the weld ability to the entire wall thickness and able to detect the 3.2mm width on both sides of weld fusion line and its coverage adjacent materials.

11.WELD SEAM ANNEALING

- First unit-Quenching: The temperature of the first unit shall be controlled in range of 680-900°C. During the heating period there shall not be a lower variation in temperature The rate of heating need not be less than 100°F (38°C/hr) however, in all cases consideration of closed chambers and complex structural damage due to excessive thermal gradients. Holding time: 5 minutes.
- Second unit-Tempering: The temperature of the second unit shall be controlled in range of 860-1050°C. The rate of cooling need not be less than 100°F/hr (38°C/hr) however, in all cases consideration of closed chambers and complex structures may indicate reduced rate of cooling to avoid structural damage due to excessive thermal gradients. Holding time: 15 minutes.
- The tolerance of heat treatment: ±20°C

12. AIR/WATER COOLING SECTION

- In order to remove the heat induced into the tube during the welding process, the tube is first cooled in air to reduce thermal shock then prior to entering the sizing/squaring stands is cooled with water.

13. SIZING & STRAIGHTENING

- Adjust the rollers according to the dimension of template based on process regulation.
- Straightness of finished pipe should not exceed 0.2% of pipe length.
- Keeping the outside diameter of pipe except the end from 168.3mm (6.625") up to 610mm (24"), with the permit tolerance of±0.0075D; but the most largest tolerence is ± 3.2(0.125);the outside diameter of pipe end is ± 0.005D,but the most largest tolerence is ±1.6(0.063)

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14. CUTTING & END FACING:

- The rotary cutter operates with two carbide tipped cut-off blades. The cut-off ensures a very high precision in regards to length and quality of the end cut for tubes of all dimensions and wall thickness.
- Each pipe can be beveled at both ends for field welding to the customer's specification.

15. HYDROSTATIC TESTING:

- 100% of pipes should go through hydrostatic testing one by one under specification of API 5L
- Test pressure shall be calculated as the equation given below:
  - P=2S*(WT/OD)
    - P: Hydrostatic test pressure in KPa
    - S: Circumference stress in Mpa
    - S=0.90*min YS for grade X65 (≥20)

- Holding time should be as per API 5L
- Recoding the pipe's identification and corresponding result. All the unqualified pipes will be rejected.
- For pressure gauge is calibrated once a year by Bureau of Standard Measurement

16. PIPE END MANUAL UT

- The inspection unit was calibrated by means of a N10 ID/OD Longitudinal & Transverse notches reference standard pipe. Reference amplitude calibrated for ID notch at 26dB / reject threshold set at 24dB.
- Two manual UT are used to check the pipes ends 300 mm or the areas with some interference that were detect by the offline UT machine. A daily file is recorded with the calibration of the equipments and the pipes numbers that were inspected.

17. OFF LINE –UT

- The offline UT machine equipped with 8 testing transducers moving using horizontal linear rail with servo motor.
- Enable transducer positioning for different diameter of pipe using flexible adjustable mechanic system around the pipe diameter.
- Auto weld seam tracking is achieved by using linear lasers and a camera to detect the actual position of the weld. The linear lasers are interfaced via micro multiprocessor boards for high-speed data transmission to the servos to provide automatic control of the probe carriage with reference to the weld seam drift.
- The weld is tested in the 12 o'clock position and the ultrasound is coupled by mean of water. Unlike the conventional water gap coupling, this procedure does not cause the probes to wear out and allow also at an inspection rate reliable and constant test condition. In order to avoid possible irregularities during the test as a result of pipe movement, the test unit travels along the stationary pipe in a frame construction.
- The test probes of different planes are guides along the weld individually. The test probes with composite transducers allow the entire pipe length to be tested for transverse and longitudinal defects.
- The test speed amounts to 10m/min at a pulse repetition frequency of 2 kHz. The resolution is 0.25mm. The resolution is 0.25mm. The evaluation is performed every 1mm under consideration of the maximum of the corresponding values.
- All suspected areas indicated by auto UT off line must be inspect with manual UT as final recheck.
- The automatic trigger /alarm system combined with the automatic marking systems, the marking on suspicious region shall be automatic sprayed.
- Ultrasound equipment shall be able to inspect the weld ability to the entire wall thickness and able to detect the 5mm width on both sides of weld fusion line and its coverage adjacent materials.

18. VISUAL INSPECTION & APPEARANCE EXAMINATION

18.1 DIAMETER:

- The outside Diameter shall be the tolerance of ±0.0075D for OD from 6.625"up to 24"; but the most largest tolerence is ± 3.2(0.125);the outside diameter of pipe end is ± 0.005D,but the most largest tolerence is ±1.6(0.063)
- Any pipe found to be out of tolerance is cause for individual diameter measurement of all pipe back to the last and up to the next, two sequential pipes measured and found to be within the tolerance.

18.2 WALL THICKNESS:

- Each of pipe shall be measured for conformance to the specified wall thickness requirements.

- The wall thickness of any location within the tolerance of ±0.1t for pipe thickness ＞ 5.0(0.197) -＜15.0(0.591)

18.3 WEIGHT:

- The tolerance of pipe shall be follow API standard requirements.

18.4 LENGTH:

- Each length of pipe shall be measured, except that pipe made in length that is uniform within 0.1 ft (0.03m) need not be individually measured, provided that the accuracy of the length is verified at least once per 4 hours per operation shift.

18.5 STRAIGHTNESS

- All pipes shall be randomly checked for straightness: deviation from the straight line shall not exceed 0.2% of the length.
- Measurement may be made using a taut string or wire from end to end along the side of pipe, measuring the greatest deviation.

18.6 WORKMANSHIP AND DEFECT

Imperfection of the types described below that exceed the specified criteria shall be considered as defects:

- Dents:for dents,the length in any direction shall be≤0.5D and the depth, measured as the gap between the extreme point of the dent and the prolongation of the normal contour of the pipe,shall not exceed the follwoing:a)3.2mm(0.125in) for cold-formed dents with sharp-bottom gouges, b):6.4mm(0.250in) for other dents.
- Offset of plate edge: The radial offset of plate edge shall not cause the remaining wall thickness at the weld to be less than the minimum permissible wall thickness.
- Height of flash: The outside flash shall be trimmed to essentially flush condition. The inside flash shall not extend above the prolongation of the original inside surface of the pipe more than 0.06” (1.5mm)
- Hard spots: Any hard spots having a minimum dimension greater than 2” in any direction and hardness greater than or equal to 35 HRC shall be rejected.
- Cracks, sweats and leaks: All cracks. Sweats and leaks are considered defects.
- Lamination: Any laminations or inclusions extending into the face or bevel of pipe and having a visually determined transverse dimension exceeding 1/4” shall be considered a defect.
- Other defects: any imperfections having a depth greater than 12.5% of the specified wall thickness, measured from the surface of the pipes shall be considered a defect.

18.7 PIPE END:

- Beveled Angle: 30^0 + 5/-0
- Root Face: 1.6mm ±0.8mm
- The out of-squareness shall be≤1.6mm

19. TESTING:

19.1 CHEMICAL TESTING:

Heat analyses: The analyses of each heat of steel used for the production of pipes shall conform to the below requirements:

Grade	Analyses	Carbon Max	Manganese Max	Phosphorus Max	Sulfur Max	Silicon Max

X65	heat	0.12	1.60	0.030	0.030	0.45

a. The product analysis will have to fulfill the additional requirements of API 5L on carbon equivalent.
for C > 0.12% $CE(IIW) = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15$
for C≤0.12% $CE(Pcm)=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5*B$
Maximum Carbon Equivalent CE(Pcm) shall not exceed **0.25%** or CE(IIW) shall not exceed **0.43%** as indicated by both Ladle and product analysis

[b] Columbium, vanadium, titanium, or combinations thereof may be used by agreement between the purchaser and the manufacturer.

[C] Columbium, vanadium, titanium, or combinations thereof may be used at the discretion of the manufacturer.

[d] The sum of Columbium, vanadium and titanium contents shall not exceed 0.15%.

[e] Other chemical compositions may be furnished by agreement between purchaser and manufacturer, providing that lim-its of footnoted and the tabular limits for Phosphorus and sulfur are met.

Product analyses: two sample representing each heat of steel used for the production of pipes under this specification.
The result should be kept in the Technical and QA Dept for further check.

19.2 MECHANICAL TESTING:

For mechanical machine is calibrated once a year by Bureau of Standard Measurement

Spec.	Code	Grade	YS (Mpa)	TS (Mpa)
API	5L	X65	450-600	535-760

Tensile test:

- The longitudinal specimen may be taken from the skelp parallel to the rolling direction and approximately midway between edge and center.
- Tensile test shall be made at the frequency of one test per heat lot.
- Weld tensile test specimen shall be taken at the 90^o to the weld with the weld at the center.
- The sample of plate for horizontal tensile testing was cut from the position on the pipe at 180^o to the welding seam
- The sample of plate for horizontal tensile testing should be cut vertically to the welding seam and the welding seam must be in the middle of sample
- The tensile test shall be made for each heat lot. The sample may be cut from strip of pipe and testing result shall be recorded and kept for checking.

If the tensile test specimen representing a lot of pipe fails to conform to the specified requirements,the maufacturer may elect ot retest two additional lengths from the same lot. If both retested specimens conform to the specified requirements,all the lengths in lot shall be accepted ,except the length from which the initial specimen was taken,if one or both of the retested specimens fail to conform to the specified requirements,the manufacture may elect to individually test the remaining lengths in the lot, in which case

determinations are required only for the particular elements with which the specimens failed to comply in the preceding tests.specimens for retest shall be taken in the same manner as the specime that failed to meet the minimum requirements.

Flattening test:

Two samples at end of coil location shall be flattening test with weld at 0^o (180^o)

- Two samples, one from each size of weld stop shall be flatten with weld at 90^o (270^o)
- The manufacturer may elect to retest one end of each of two additional lengths of the same lot. if both retests are acceptable, ll lengths in the lot shall be accepted,except the original failed length.of one or both retests fail,the manufacturer may elect to repeat the test on specimens cut from oneend of each of the remaining individual lengths in the lot.
- For flattening machine is calibrated once a year by Bureau of Standard Measurement

Charpy Impact Tests

- Charpy impact test shall be carried out to ensure property of fracture toughness and cracking resistance.
- The testing shall be performed in accordance with ASTM A370. Three specimens from each heat will be taken for Test.
- The specimens or bars will have a rectangular paralleled piped shape with rectangular or square section. The orientation will be perpendicular to the skelp lamination direction. The bars will be slowly flattened under a press. Artificial aging is not requested. The bars will be mechanically worked at 10mm of height. If the pipe will thicker than 10 mm, the width of the bar will be equal to the wall thickness of the considered pipe.
- The bottom of the V Notch in the middle of the bar is perpendicular to the internal pipe surface. The depth is 2 mm with an angle of 45 degrees.
- The test will be performed at 0°C. None of results on the single specimen shall be lower than 20 J/cm2 and the minimum average value of each of the three set of specimens shall not be lower than 27J/cm2.
- In case of failure on the single minimum or average value, a retest will be performed on one further set of three specimens where, in case of further failure, will lead to the rejection of all the production corresponding to the heat under test.

For mechanical machine is calibrated once a year by Bureau of Standard Measurement

DWT test

DWT test shall be carried out to ensure property of fracture friability.

For each test ,the average shear fracture area shall be ≥85%,based upon a test temperature of 0 ℃ ， Such shear-fracture area ensures a sufficiently ductile fracture at or above the test temperature.

each heat will be taken for Test.

For DWT machine is calibrated once a year by Bureau of Standard Measurement

19.3 METALLOGRAPHIC EXAMINATION:

- Metallographic examination before carry out the heat treatment
    - One sample if failure then do extra sample.
    - Record for the fusion line width of the inside and outside wall thickness, the center of heat affected zone width.
- Metallographic examination after carry out the heat treatment: a sample to be inspected the heat treatment effect.
- All the record of metallographic examination shall be reported to Chief of Engineer and Technical Dept.

19.4 DIMENSION TEST

- Pipe diameter, length of each heat shall be checked at least one time each four hours per work shift
- Straightness shall be randomly checked.

20. CODE & MARKING:

- The marking shall be clearly marked as below pattern:

API 5L-LOGO ed.
3LPE DIN 30670
GR.X65 ERW- PSL2 XX.X MPa
PIPE NO: HEAT NO:
OD x WT x LENGTH mm
Additional content as per client's requirement.

21. FINAL INSPECTION:

- Final inspection will not be performed until the following inspections such as visual inspection, manual ultrasonic inspection, and chemical analyses and mechanical test have been passed.
- Visual inspection will be performed to pipe inside and outside surfaces and 100% weld seam. Multiple repairs to weld seam by welding at the same location are not permitted.
- Wall thickness, each length of pipe will be inspected. The wall-thickness will be checked by means of a micrometer. The other will be checked by mechanical caliper. The wall thickness will be measured at the ends of each pipe.
- Each pipe of any dimension, such as diameter, straightness, out-of-roundness and bevel quality, etc. will be inspected.
- If pipe inspection is acceptable shall be stenciled paint with pipe no., length etc. on its outside.

22. PACKING:

- In accordance with product's specification, characteristics and application, providing different forms of packing and bevel protecting to ensure the product's quality during transportation which ultimately meets customer's requirement.
- Pipe to be packed with the Bevel end protector.

23. DELIVERY:

- Before shipment, Q.C personnel should review all the inspection and test had following the quality plan and announce warehouse personnel prepare packing in accordance with customer's requirement.
- The product shall have necessary protector to avoid from damage during transportation.
- Q.C personnel shall check the delivery product match the packing list (delivery sheet) during the loading on truck.