



Quality Clause

Clause 03

Fabrication; Welding & NDT

General Requirements

RIG/PLANT		
ADDITIONAL CODE	SDRL CODE	TOTAL PGS 17
REMARKS		
MAIN TAG NUMBER		DISCIPLINE
CLIENT PO NUMBER		
CLIENT DOCUMENT NUMBER		

REFERENCE DEP-0000002008	REFERENCE DESCRIPTION RS 0638 QUA Assurance Global - 00011030	
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DATA CLASSIFICATION Public		
DOCUMENT NUMBER 103188871		REV 1

REVISION HISTORY

1	26-Feb-2020	Approved for Use	VIHA	HAH	LUMO
0	13-Mar-2019	Approved for Use	HAH		LUMO
Rev	Date	Reason for issue	Prepared	Checked	Approved

CHANGE DESCRIPTION

Revision	Change description
1	Overall Revision
0	

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1 PRE-WELD ACTIVITIES

Note that all material dimensions and sizes on the material lists in our drawings are net, post production sizes. Accordingly, all dimensions are given without deductions for bevelling or allowances for machining unless noted otherwise. The Supplier must therefore take the above into consideration when ordering materials.

1.1 Cold forming

Cold forming is defined as forming below 480°F (250°C).

Cold forming may be carried out by means of jacking, pressing or rolling tools. The use of hammering techniques is not acceptable.

Cold forming at ambient temperature may be permitted provided the bending diameter is following the steel mill recommendations, material standard and classification requirements.

The strain may be calculated according to the following formula:

Percent strain = Thickness x 100% / forming mid thickness diameter.

The strain rate percentage shall not exceed 5%, unless specifically approved by NOV engineering in writing.

If forming operations involving a higher degree of strain than 5%, a written request from supplier shall be supported by material manufacturers recommendation.

For structural steel with Chemical and Mechanical properties that fulfills the requirements of EN 10149 or ASTM A500 cold forming induced strains may be permitted to exceed 5%. Bending radiuses shall in such cases comply to the requirements of EN 10149 or ASTM A500. This is only allowed when the steel meets all chemical and mechanical properties of the standard; Bending qualification test shall be performed as required by the standard.

Cold forming is not permitted to replace mill made u-profiles, angle bars or similar items. Structures designed with two or more items that are intended to be joined by welding cannot be replaced by cold forming one item

1.2 Preparation and cutting of steel

Cutting and beveling of steel materials shall be carried out by thermal cutting or machining. Thermally cut edges shall be ground to sound metal before welding. Holes shall be machined, not cut by thermal cutting.

1.3 Fit-up assembly

Weld Inspection personnel shall visually inspect the fit up and check:

- The weld preparations for any surface defects
- The root gap and bevel geometry for compliance with WPS

- Max gap allowed between materials for fillet weld for compliance with WPS
- Alignment tolerances

1.4 Inspection of fit-up prior to welding

Weld inspection personnel shall visually inspect that all surfaces and parts that shall be welded are:

- Free from grease, oil, paint etc.
- Clean, dry and free from rust.
- No splatters or imperfections
- All areas subject to welding are accessible to be welded and there is enough access for NDE.

1.5 Material repairs and buttering

Surface defects which occur during the production, fit-up and welding process may be repaired by grinding, provided the thickness is not reduced by more than 7% of the nominal thickness, or 3 mm / 1/8", whichever the lesser.

The defective area shall be ground smooth and 100% checked with MT (magnetic particle examination) for ferromagnetic steel and PT (penetrant liquid examination) for other metallic materials

Buttering:

Excessive root gap shall be rectified by buttering according to a WPS which shall be prepared from one of the qualified main weld procedures (WPAR/PQR). The thickness of the buttering zone shall not exceed 75% of the plate thickness or 8 mm / 5/16", whichever is less. This means that maximum buttering for a groove can be 16 mm / 5/8" (8 mm / 5/16" from each side). All buttered groove welded geometries shall be considered as essential weld, i.e. extent of NDE shall be 100%.

Build up welding on raw or machined materials may not be considered as buttering welding. Separate evaluation or requirements will apply according to standard for overlay welding

2 WELDER QUALIFICATIONS

A written procedure shall be established for the qualification of welders. Welders and welding operators shall be qualified in accordance with relevant parts of ISO 9606, AWS D.1.1 or the latest revision of the applicable Industry Standard, Specification, or Code, subject to NOV's acceptance.

Qualification to prior editions must be accepted by NOV in writing.

The testing and welding of test pieces shall be witnessed by 3rd party examining body.

2.1 Welder identification

Each welder shall be assigned a unique reference number or identity code which allows traceability of welders to their welds. Welder traceability records shall be kept and, if required, submitted as part of the final documentation.

2.2 Continuity log

Supplier shall maintain a continuously updated record (log) of all welders' qualifications listing their approved processes and expiry dates according to class society rules or other regulations. The welder must be engaged in each welding process within six (6) months and have no specific reason to question a welder's ability, to remain qualified.

3 WELDING PROCEDURES QUALIFICATIONS AND CONTROL

The Supplier shall prepare qualified welding procedures in accordance relevant part of ASME IX, DNVGL, EN ISO 15614, ANSI/AWS D 1.1 or equivalent recognized subject to approval by NOV.

The qualification requirements are also applicable for tack welds.

The qualification is primarily valid for the workshop performing the welding test, and other workshop under the same technical and quality management. It may also be transferred to and used by a Sub-Supplier, provided the principles of EN ISO 3834-2 are implemented and documented.

3.1 Weld procedure qualification

Approved welding methods by NOV are, 136/137 Fluc Cored Arc Welding, 141 Gas Tungsten Arc Welding, 111 Shielded Metal Arc Welding, 121 Submerged Arc Welding. Other welding methods requires written approval from NOV.

No welding shall be done in the downhill position for Structural equipment.

Supplier shall prepare documented welding procedures in accordance to the relevant part of the applicable Industry Standard, Specification, or Code for welding as ANSI/AWS D1.1, ASME section IX, DNVGL and EN ISO 15614.

Additional procedure testing may be required pending on classification society requirements such as ABS CDS and DNV GL OS-E101 or other applicable requirements as specified in the PO documentation package.

New qualification test is required if the carbon equivalent for the steel to be welded increase more than 0.03 carbon equivalent units (IIW formula) over the value of the existing welding procedure approval record (WPAR/PQR).

Formula for Carbon equivalent (CEQ):

$$CE = \%C + \frac{\%Mn + \%Si}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Cu + \%Ni}{15}$$

The Supplier shall record actual WPS number in Weld & NDE log and verify the compliance of the welded material.

3.2 Weld procedure qualification review and approval

Weld Procedure Qualifications shall be documented, identify limitations and restrictions, and shall be reviewed and approved by relevant class society as ABS, DNVGL, BV or equivalent if applicable.

3.3 Control and storage of consumables

The Supplier shall establish and implement documented procedures for the control, storage, and maintenance of Consumables, in accordance with the applicable Industry Standard, Specification, or Code. (Example: AWS D1.1, Section 5.3 or equivalent). Storage ovens shall be calibrated at a minimum of every twelve (12) months. Wet consumables shall not be used, even after drying.

Only consumables listed in DNVGL "Register of type approved products no. 2" or ABS "Approved Welding Consumables" will be accepted.

3.4 Welding machine calibration

Welding Machines, instruments and inspection gages shall be calibrated at a minimum of every 12 months according to recognized industry standard; repairs to these instruments shall be per supplier's documented procedure or industry standards. Weld inspection gages shall be available on the shop floor.

4 WELDING

It is the Supplier's responsibility to comply with the specifications noted on the Purchase Order, provided drawing(s), or other NOV provided documentation. If there are discrepancies between this document and other contractual documents, the most stringent requirement shall apply.

The applicable product realization documentation (WPS or PQR procedures / requirements) shall be available to welders in the area where the work is performed.

Supplier shall establish a unique weld numbering system with traceability to each individual drawing. All welds shall be identified, recorded, and made part of the MRB.

Weld Procedures Qualification Records:

All weld procedures should be listed in the form of a matrix included in the MRB which will detail all:

- WPQR/PQR's and process
- Positions
- Consumables
- Materials
- Weld Types

Contractor shall record actual WPS/PQR number in Weld and NDE log.

Weld Procedure Qualifications shall be documented, identify limitations and restrictions, and shall be reviewed, approved, and stamped by NOV.

Inspection shall include essential variables prior to and during welding.

Final Inspection shall be done after all welding to ensure weld distortion was satisfactorily controlled.

If not specified otherwise, fillet weld dimensions on drawings shall be understood as:

a – throat thickness
z- leg dimension.

4.1 Pre-heating

The parent material surface shall be dry and have a temperature according to WPS before start of welding. Preheating $\geq 212^{\circ}\text{F}$ (100°C) shall be achieved by electric heating elements. For preheating $< 212^{\circ}\text{F}$ (100°C) Oxygen/Acetylene and Propane heating burners may be used. Cutting torches are forbidden.

The minimum interpass temperature shall not drop below the minimum required preheat temperature. If not otherwise stated in the WPS, the maximum interpass temperature shall not exceed 480°F (250°C) measured at the edge of the groove.

For C- and C/Mn - steels, a maximum interpass temperature up to 480°F (250°C) may be used, even if a lower temperature was recorded on the WPAR/ PQR.

4.2 Splice material

Material splices shall be reported in the “as built” section in the FRB. Material splices not shown on the drawing shall be welded with full penetration welds and have 100% volumetric and surface NDE examination to verify the quality. If plate formats necessitate splicing of sections (i.e. Crane jibs, columns, and primary load carrying members in general) the splice shall be staggered by at least 12 inches / 300 mm offset between web and flange or top/bottom - and side-plates respectively.

Any material splice not shown on a drawing must be approved by NOV in writing prior to release of the product to NOV

4.3 Thermal straightening of welded carbon steel structures

Out of tolerance members can be straightened by locally applied heat. Heating shall be carried out under strict controlled conditions to prevent degradation of the steel properties.

The heating shall be performed by means of special heating torches/burners suitable for the purpose; cutting torches shall not be used.

The temperature of heated areas shall be checked by the operator using temp sticks, contact Pyrometer, Resistance Coil, or other suitable means during the heating process.

For structural steel, the temperature shall normally not exceed 1100°F (590°C) except when being qualified by a separate procedure.

The parts to be heated for straightening shall be free of stress and external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

The straightened areas shall be subject to 100% Magnetic Particle Inspection after complete cooling in still air.

Thermal straightening process may be repeated a maximum of two times at the same place.
A non-conformance report shall be used to disposition parts out of tolerances.

For thermal straightening temperature above 1100°F (590°C) a qualified procedure shall include calculation of the lower transformation temperature (A1) for the actual steel shall be approved by NOV.

5 WELD REPAIR

All weld repair work shall be carried out according to a documented procedure established by the Supplier and approved by NOV. The procedure shall be available to welders where the work is being performed

5.1 Weld repair procedure

The preheat temperatures used during repair welding shall be minimum 125°F (50°C) higher than the preheat temperature used in the original weld procedure.

All repair work shall be carried out according to a repair WPS and based on an approved WPAR/PQR established by Contractor.

The WPS shall include the method of defect location and removal, preparation of weld area and NDE before and after re-welding.

Prior to excavation, the NDE operator shall mark the exact location and depth of the defect on the metal surface. If required, additional NDE techniques shall be used to determine the exact location.

The defective material shall then be removed by grinding, machining, or by air arc gouging followed by grinding to sound metal.

After completed excavation and grinding, the affected zone shall be 100% examined by MT/PT. No repair area shall be shorter than 100 mm in the defects longitudinal plane and minimum 2 inches (50 mm) in each end of defect.

The repair weld shall be given the same weld number with the suffix R1, R2 etc. to permit traceability of NDE. It shall then be subject to 100% NDE by all applicable methods. The retested area shall be the full excavated area + 4 inches (100 mm) in each end when possible due to the nature of construction.

The same area shall not be repaired more than twice without a written acceptance from NOV

6 WELD INSPECTION AND TESTING

6.1 Weld inspection qualifications

Weld Inspection personnel performing visual inspection of welding operations and completed welds shall be qualified and documented as follows:

- ISO 9712 / AWS or equivalent Certified Welding Inspector
- ISO 9712 / AWS or equivalent Certified Associate Welding Inspector, or
- A Welding Inspector qualified by the manufacturer's documented requirements

6.2 Dimensional control

The Supplier shall carry out dimensional control in accordance to tolerances specified on the drawing. If nothing is specified on the drawings EN ISO 13920 Class A and E applies. If a welded construction undergoes post machining activities the dimensions shall meet ISO 2768-m unless tolerances are specified on the drawing.

7 POST WELD HEAT TREATMENT

PWHT may be required for structural welds when the nominal thickness exceeds 2 inches (50 mm), unless adequate fracture toughness can be documented in the as welded conditions. For restrained joints of complicated design, PWHT may be required for smaller thickness. PWHT shall be performed when WPAR/PQR used is approved including the PWHT process.

PWHT shall be carried out in accordance with a procedure specification which shall include:

- heating rate
- cooling rate
- soak temperature and time
- heating facilities
- insulation
- control devices
- recording equipment
- configuration of structure to be PWHT or details if local PWHT shall be carried out.
- number and location of thermocouples to be used during PWHT

The holding temperature shall normally not exceed 1070°F (580°C) or as recommended by the steel manufacturer / Supplier. The soaking time shall be 5 min per 1/12" (2 mm) thickness.

The temperature difference between different parts of the structure during soaking time shall not exceed 85°F (30°C) within the heated area. Double-sided heating shall be used as far as possible.

The temperatures shall be continuously logged and automatically recorded by thermocouples in different positions and temperatures shall be plotted on a chart.

Regular calibration of thermocouples shall be minimum every 12 months.

Only pre-qualified PWHT procedures are accepted.

8 WELD DOCUMENTATION

The principles of EN ISO 3834-2 shall be implemented and documented

8.1 Procedure for identification of welds

The Supplier shall establish a unique numbering system with traceability to each individual drawing for welds in category above secondary or the lowest grade (see table 1 under 9.4). The numbering system shall be used for identification in Weld & NDE log.

Each welder shall be assigned a reference number or identity code which allows traceability of welders in the Weld & NDE log

8.2 Weld procedure qualification records

All weld procedures should be listed in the form of a matrix included in the FRB which will detail all:

- WPQR/PQR's and process
- Positions
- Consumables
- Materials
- Weld Types

Contractor shall record actual WPS/PQR number in Weld and NDE log.

9 NON-DESTRUCTIVE EXAMINATION

All nondestructive examination (NDE) will be performed in-house or subcontracted to an approved third party NDE company with documented qualifications. Supplier shall contact NOV and obtain approval prior to subcontracting NDE to a third party NDE Company.

NDE shall be carried out according to purchase order requirements, industry standards (API, ASNT, etc.) or rules for the actual classification body (ABS, DNV, GOST, CCS, etc.) as applicable.

NDE shall not be conducted on quench and temper steels less than 48 hours after welding

9.1 NDE reports

All final NDE shall be reported in a manner which ensures traceability and reproducibility. In addition to the classification body's requirements, the NDE report shall reference Welder ID, weld number (if applicable), drawing number and revision, part number and NOV work order/PO number (project number), and NDE procedure used, location and project.

9.2 NDE traceability

Critical welds require 100% NDE and shall be traceable to the individual part/serial number on the report and drawings.

Examined parts of welds where less than 100% extent is required, shall be marked as to where NDE is carried out.

9.3 Types of non-destructive testing

- Visual Examination (VE)
- Magnetic Particle Test (MT)
- Ultrasonic Test (UT)
- Radiographic Test (RT)
- Dye Penetrant Test (PT)

Eddy Current Testing shall only be used when approved by NOV or specifically mentioned on drawings or specifications from NOV

9.4 NDE procedures

The extent of NDE shall include 100% of critical welds as identified in the drawings. Extent shall be in accordance with table 1 below unless otherwise specified on the drawings.

The applicable NDE procedures shall be available to inspectors in the area where the work is performed.

Table 1: Inspection Categories

NOV- US/Canada/Asia	NOV- Europe	DNV	ABS	NORSOK
Primary	Essential	Essential	Primary	Category A
Secondary	Primary	Primary	Non-Primary	Category B
Miscellaneous	Secondary	Secondary	Secondary/Miscellaneous	Category D

Inspection Category – US	Type of Weld Joints	Test Method			
		VE	MT 4)	UT	RT
Primary	Butt Welds	100%	100%	100% (See Note 1)	See Note 2
	Joints and Full Penetration Welds	100%	100%	100% (See Note 1)	See Note 2
	Partial Penetration and Fillet Welds	100%	100%	----	----
Secondary	Butt Welds	100%	20%	20%	
	Joints and Full Penetration Welds	100%	20%	----	20%
	Partial Penetration and Fillet Welds	100%	20%	---	----
Miscellaneous	Butt Welds	100%	2-5%	2-5%	
	Joints and Full Penetration Welds	100%	2-5%	----	2-5%
	Partial Penetration and Fillet Welds	100%	2-5%	----	----
VE = Visual Examination MT = Magnetic Particle Test UT = Ultrasonic Test RT = Radiographic Test					

Notes:

1. Full or partial penetration welds loaded in tension to 70% or greater of their allowable stress, as determined by design shall be volumetrically examined as per AWS D1.1, Section 6.
2. Percentage of NDE shall include 100% of all connections and lugs as applicable.
3. Engineering shall be contacted for clarification on extent of classification if required.
4. Liquid penetrant testing to be adopted for ferromagnetic materials

Notes:

Ultrasonic inspection of all full and partial penetration welds shall include Non-Destructive Examination (NDE) Procedure for Identification of Transverse Indications.

100% RT and weld maps are required for all high-pressure piping (over 500 psi rating).

All Lugs and Pad-eyes and Handling Pad-eyes require 100% NDE. All NDE records shall reference the unique number assigned to the lug and/or pad-eye as defined in the drawings.

9.5 NDE acceptance criteria

Acceptance criteria shall be according to specified requirements ref. Drawings and rules for the actual classification society (see P/O). If there are any doubt or mismatch between the specifications, the most severe criteria shall apply.

For visual examination, the weld quality shall comply with EN ISO 5817 - level C if not specified otherwise in the drawings.

If nothing is specified on drawings, specifications or in other ways specified from buyer the following shall apply:

Structural and Piping Non-Destructive Testing Acceptance:

Test Method	Acceptance Criteria
VE: AWS D.1.1- <i>Latest Edition</i>	AWS D.1.1 Sect. 6 statically loaded
MT: ASTM-E709- <i>Latest Edition</i>	AWS D.1.1 Sect. 6 statically loaded
UT: AWS D.1.1- <i>Latest Edition</i>	AWS D.1.1 Sect. 6 statically loaded
ANSI B31.3 – <i>Latest Edition</i>	Table K341.3.2
ASTM-A578- <i>Latest Edition</i>	Level II
ASTM-A898- <i>Latest Edition</i>	Level II

Structural and Piping Non-Destructive Testing Acceptance - PSL 2
(API 4F PSL: Product Specified Quality Level)

PSL 2: The acceptance criteria of AWS D1.1 for cyclically loaded structures applied to critical welds of masts, substructures, derricks, and crowns when specified.

9.6 NDE personnel qualifications

Qualifications must be approved by an ASNT or ASNT Central Certification Program (ACCP) Level III individual, ISO 9712 level III, or NOV approved written practice.

All NDE inspection personnel shall be at least ASNT level II. ISO 9712 level II or equivalent.

Eye Exams:

Inspection personnel conducting visual examinations on final product, including welded product, shall have an eye exam every twelve (12) months.