Repair welding preheat shall be 50°C above that required by the approved welding procedure for a butt weld of the same thickness up to a maximum of 150°C.

Inspection and NDT requirements for repairs shall be identical to those originally applied to detect the defects, and shall include the weld metal and fusion faces within 100mm of the repair in all directions.

Purchaser agreed records shall be kept by the contractor/sub-contractor which detail the location of all repairs, the defect, the WPS number, the names of the original welders, dates and repair procedures.

5.3.8 Welding restrictions on PWHT items

Welding to PWHT items is prohibited except in the following instances:

- where defects are found in PWHT welds. Following the repair, the complete weld shall be subject to PWHT and the specified NDT;
- welding to existing doubler plates, or for assembly of a node into the main structure;
- attachments to PWHT items where the throat thickness of the attachment weld does not exceed 40mm for nodal joints or 50mm for other joints, and provided the toe of the weld is not less than 75mm from a PWHT weld (see 5.4.1).

5.3.9 Weld profile, surface finish and clean-up

Welds shall be of the specified size and shape unless otherwise agreed by the purchaser, and shall blend smoothly into the parent metal without overlap or unacceptable undercut. The weld profile shall not interfere with the NDT technique specified.

Grinding of the cap (except for minor cosmetic grinding) shall not be undertaken unless specified by the purchaser or required for the purposes of NDT. However, where a weld has to be crossed by another member, the cap shall be ground flush with the plate surface.

Where toe grinding is specified, the technique shall be submitted to the purchaser for approval. A burr grinder with a diameter of at least 10mm shall be used, and final grinding marks shall be transverse to the weld toe. Grinding penetration into the base metal shall not be less than 0·5mm or more than 1·5mm unless otherwise specified on the purchaser approved drawings. Rotary discs shall not be permitted for use on weld toe grinding.

The purchaser may require the contractor/sub-contractor to demonstrate the ability of individual operators to apply the technique satisfactorily.

Arc strikes, burrs and weld spatter shall be ground smooth and checked by MPI in accordance with Section 7. Flame cut ends not incorporated into a welded joint shall be ground smooth with radiused edges.

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5.3.10 Production controls

The contractor/sub-contractor shall institute a system of weld checks which shall be subject to approval and audit by the purchaser. These should incorporate a permanent record of the voltage, current, travel speed or run out length, and heat input being used by the welder. The permanent record shall also include welder's or welding operator's identity, WPS number, consumable identity and size, and, the welding position.

The monitoring schedule shall provide for the random monitoring of an agreed percentage of all welders/welding operators at work in each shift where inspection category I or II welds (Table 5) are being made, but shall not be less than 10% at the commencement of the contracted work. Subject to the prior approval of the purchaser the absolute number of welders/welding operators monitored per shift may be reduced once good performance has been established. The schedule shall also ensure that the sample monitors as large as possible selection of welders/welding operators active on the identified welds over the total period of work.

Records shall be made for each monitored welder or welding operator covering a period of continuous welding. The records shall be in a format approved by the purchaser.

For SMAW within the nominal current and voltage ranges, only the ROL and electrode stub length for each pass need be recorded. For other processes, the records may be made on an automatic electronic monitor capable of capturing and printing records of voltage, current, travel speed, wire feed speed and heat input. Alternatively, by agreement with the purchaser, calibrated manual monitoring equipment may be utilised. Monitoring reports shall be submitted to the purchaser within 24 hours.

If such checks, either by the contractor/sub-contractor or the purchaser, detect welders or welding operators working outside their WPS parameter limits, the contractor/sub-contractor shall undertake an additional procedure test(s) in accordance with the actual parameters measured. If this meets the requirements of Section 4, the purchaser may permit an extension of the welding parameter limits. If the procedure test fails to meet the specified properties, any production welds made to the suspect procedure shall be identified and may be required to be removed, unless a satisfactory technical basis for concession can be established.

When the contractor/sub-contractor elect not to institute a monitoring system, production tests shall be performed on all butt welds greater than 20mm thick.

One production test weld shall be carried out for every 25 circumferential and longitudinal seams on tubulars. For items other than tubulars, the production test frequency shall be one test coupon for each 30m of weld.

Production weld test coupons shall be tested as for welding procedure qualification, but excluding CTOD test(s).

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5.4 Post Weld Heat Treatment (PWHT)

5.4.1 Welds requiring PWHT

The purchaser approved drawings should specify those welds or fabricated items which are to be heat treated. Where the purchaser approved drawings give no indication, all welds with a design throat thickness exceeding 40mm on nodes and 50mm elsewhere shall be post-weld heat treated. Any dispensation from the above requirements for PWHT will be subject to CTOD testing and a full ECA of the welds under consideration. However, if a CTOD level ≥0·25mm is achieved on testing an ECA is not required unless advised otherwise by the purchaser. Welding procedure qualifications for PWHT welds shall take into account the potential need for multiple heat treatment cycles associated with repair welds.

5.4.2 PWHT procedures

The contractor/sub-contractor shall prepare detailed procedures for PWHT and submit these to the purchaser for approval. They shall include a sketch of the item to receive PWHT, illustrating the method of support and the locations of all thermocouples. In calculating the locations of supports, the contractor/sub-contractor shall assume a yield strength at soaking temperature of 35 N/mm^2 for all grades of material.

Nodes shall be heat treated in furnaces, complete with doubler plates and attachments; this method is also preferred for other fabricated items requiring PWHT. The procedures employed shall be in accordance with the relevant sections of established international standards, e.g. PD 5500:2012+A2:2013[(64)], and shall be submitted to the purchaser for approval. Unless specified otherwise, the soaking temperatures shall be 580 ± 20°C.

The purchaser may permit local heat treatment of circumferential welds provided, again, the procedures are in accordance with established international standards.

Note 1: For Q & T steels, the purchaser is encouraged to utilise the steelmaker's data to determine the optimum PWHT temperature. As a general rule this should be at least 25ºC below the tempering temperature used for the steel.

Note 2: For TMCR steels, the purchaser should be aware that PWHT may reduce the mechanical properties of the steel. The purchaser should seek the advice of the steelmaker before specifying PWHT.

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Table 5 Recommended inspection/NDT categories

Inspection/ NDT Category	Application	Typical areas of application (Jackets)	Typical areas of application (Decks)
I	Highly stressed welds where alternative load paths are not available in case of failure, and welds which have relatively low fatigue lives.	All node welds. All lift points. Girth welds in legs and pile sleeves. Brace to leg, and sleeve and brace closure welds. Riser guides and supports. Girth welds in piles. All attachments to the above.	Main columns and main column nodes (except longitudinal and flange weld joints where structural redundancy exists). Lift points. Crane pedestals. Riser supports. Plate girder and flange splices where there is no structural redundancy. All attachments to the above.
II	Less highly stressed welds which have relatively high calculated fatigue lives and where adequate alternative structure load paths exist.	Some circumferential brace welds remote from nodes. Structural installation aids. Girth welds in caissons and J-tubes. Conductor guides. Internal stiffeners to legs.	Nodes (other than those specified in Category I). Some circumferential brace welds remote from nodes. Structural installation aids (excluding lift points). Vent boom flare towers. Runway beams.
III	Low stressed welds, welds in shear and welds with relatively high calculated fatigue lives.	Longitudinal welds in tubular members (including caissons, J-tubes, piles and pile sleeves). All attachments to tubular members (including doubler plates). Sea fastenings.	Longitudinal welds in tubular members and fabricated primary sections. Sea fastenings.
IV	Low stressed welds which are not subject to any significant cyclic loading.	Mudmats. Installation aids other than those in Category II.	Welds in module structures other than those in Categories I, II and III.
V	Other low criticality, very low stressed welds which are not subject to cyclic loading.	Pile grout beads. Non-structural attachments. Temporary attachments. Minor installation aids.	Non-structural attachments. Deck plates. Under-deck stringers. Walkways. Major pipe supports.

5.4.3 Certification

On completion of PWHT, the contractor/sub-contractor shall prepare a heat treatment certificate for each item. This shall give the unique identification of the item, the date, the heating and cooling rates, and soaking temperatures and times. It shall be submitted to the purchaser together with the temperature chart or digital record.

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5.5 Bolted connections

5.5.1 General

Bolted connections shall comply with the requirements of 5.5.2. Holes shall not be drilled in structural members other than at locations indicated on the purchaser approved drawings, unless otherwise approved by the purchaser.

5.5.2 Bolting details

The following bulleted list details bolting requirements:

- All holes for bolted connections shall be 2mm larger in diameter than the specified bolts, unless otherwise agreed with the purchaser. Bolt holes shall be drilled to size, or drilled and reamed if necessary. Enlarging by thermal means is not permitted. Holes shall be clean cut without burrs, or torn or ragged edges. All holes shall be finished prior to the application of any protective coating;

- Bolts shall be of sufficient length to protrude by a minimum of two full threads beyond the nut. Fitted bolts shall clear the hole before the thread starts. Bolts and nuts shall rest squarely against the metal. All misalignments shall be reported to the purchaser who may allow the hole to be reamed;

- Bolt heads and nuts shall be drawn tight against the work by a method approved by the purchaser. Bolt heads shall be tapped with a hammer while the nut is being tightened;

- All high strength bolts shall be pre-tensioned to the proper proof load or specified torque;

- All bolts, with the exception of friction grip bolts, shall have a locking washer or other locking device. All bolt locking devices shall be approved by the purchaser;

- Where friction grip bolting is specified it shall be the load-indicating washer type and shall be pre-tensioned to the correct proof load. In the event of a friction grip bolt being loosened after application of proof load, the complete bolt shall be removed;

- Bolts transmitting shear shall have plain shanks and be threaded to such a length that not more than one thread shall lie within the structural members, i.e. that part of the bolt under shear shall not contain more than one thread;

- Washers shall be provided at slotted holes and elsewhere as specified by the purchaser. On galvanised steelwork, washers shall be under both the head and nut. Square taper washers shall be provided for all bolts and nuts bearing on to surfaces with tapers exceeding 3^{o};

- Where, for the connection of equipment or piping, holes are provided which may affect major structural items, these members shall be reinforced adequately; and

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- Bolts and nuts shall not be welded under any circumstances.

5.6 Piles and followers

The surface of piles and followers shall be bare metal, free from mill varnish, oil and paint, except for specified markings. The area of the surface used for markings shall be the minimum required consistent with adequate identification.

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6 Fabrication tolerances

6.1 General

The contractor/sub-contractor shall provide qualified personnel, equipment and the instruments necessary to set out, monitor and control dimensions and tolerances.

The dimensional controller shall be either a qualified surveyor or shall have had at least five years' experience of similar work. The qualifications and CV of the dimensional controller shall be available for purchaser review and approval.

The instruments used shall be in accurate adjustment and shall have current valid calibration certificates.

Prior to commencing fabrication, the contractor/sub-contractor shall submit for the purchaser's approval, procedures for control of tolerances during fabrication together with his construction method philosophy. The fabrication procedures proposed by the contractor/sub-contractor and approved by the purchaser shall stipulate the frequency of inspection of all tolerances defined in this Section, in Figures 16 to 40 of this Specification, at all the stages at which such tolerances are to be checked for each sub-assembly, and during the erection sequence.

Tolerances shall be checked at each stage in accordance with the fabrication procedures, and the final survey shall meet the defined tolerances. The final survey shall be on complete sub-assemblies and on the completed structure after PWHT, if applicable, and shall be carried out by the contractor/sub-contractor.

Where the frequency or location of tolerance measurement is not defined in this Specification, the tolerances shall be taken to apply to the whole structure.

The frequency of tolerance checks defined in this Specification may be modified for specific locations subject to conforming to the structural design requirements and agreement between the contractor/sub-contractor and the purchaser.

The contractor/sub-contractor shall work within the tolerances listed in this Specification unless otherwise specified in the purchaser approved drawings. No forcing or constraining of components shall be undertaken to obtain the required tolerance without the prior approval of the purchaser.

Tolerances shall be based on theoretical setting-out points and centre lines of the structure referenced to permanent approved datum points (e.g. co-ordinated survey stations) and corrected to a temperature of +20ºC.

Permanent survey stations shall be protected from disturbance, and a means for confirming their accuracy shall be established. The accuracy of all survey measurements shall be demonstrated to the purchaser at the beginning of the contract prior to any setting out of temporary or permanent works. As a guide, setting out points should be accurate to within 1mm on levels and 2mm on position.

All setting out and fit-ups shall be subject to a tolerance measurement. Where local or global tolerances are not detailed in this Specification the item in question

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shall not deviate from the nominal design size, shape or position by more than ±15mm.

The purchaser shall have the right to employ independent dimensional control sources as a cross-check whenever considered necessary throughout the fabrication programme.

Fabrication and yard assembly supports shall be set to within 5mm of the appropriate position shown on the contractor/sub-contractor purchaser approved setting-out drawings. Where no such drawings exist, fabrication shall be carried out from a level plane to within 5mm.

As soon as field erection of the structure commences, the contractor/sub-contractor shall monitor the position of the supports to ensure that they remain within tolerance. This shall be done on a monthly basis and on any other occasion when weld-out of a member will fix one support relative to another. All findings shall be passed to the purchaser. Where there is settlement of supports outside the tolerance given above, this should be immediately reported to the purchaser and remedial action undertaken. Where required to meet the tolerances of this Specification, e.g. for stab-in nodes (Section 6.3.1), such settlement shall be corrected by shimming and therefore fabrication and yard assembly supports shall be designed to allow such adjustment.

The dimensional tolerance of launch-way centre lines shall be within 20mm of the theoretical position, but shall also be within 6mm of the reference elevation. The variation in elevation between any two points on a launch-way shall not exceed 3mm within any 3m.

Tolerances specified in Section 6.1 and 6.2 of this Specification shall be controlled for structural components and sub-assemblies so that the cumulative effect of such tolerances does not negate the global tolerance requirements of Section 6.3. The required tolerances shall apply at all stages of fabrication and assembly.

The contractor shall ensure that components fabricated by sub-contractors meet, where applicable, all tolerances specified in this Specification.

Allowance shall be made for weld gap tolerances and weld shrinkage in all component, sub-assembly and global tolerance calculations.

Where tolerances have to be derived from a formula (i.e. tolerances expressed in terms of a dimension of the component, e.g. wall thickness) the results shall be taken to the nearest mm. All component dimensions in this Specification shall be assumed to be in mm unless otherwise stated. In Section 6.2.2 (rectangular plated sections) and Section 6.2.3 (stiffened plate panels) the calculated tolerance shall apply where this is less than the specified limiting value, otherwise the maximum tolerance shall apply.

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6.2 Local tolerances for structural components and sub-assemblies

6.2.1 Fabricated tubulars and cones

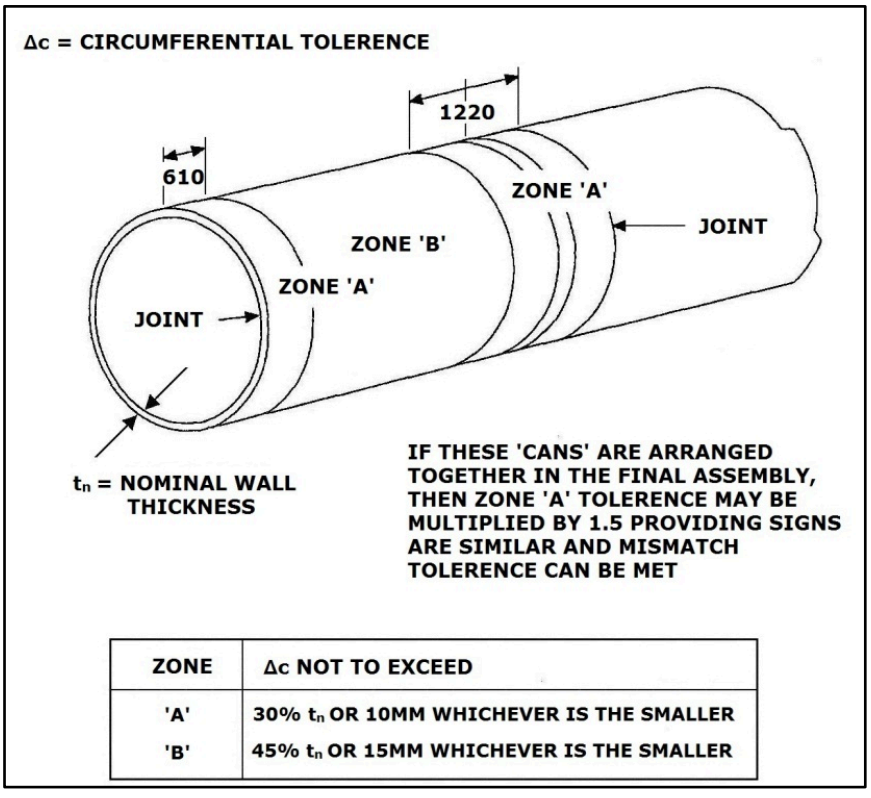
6.2.1.1 Circumference

The external circumference, as shown in Figure 16, shall not differ from the nominal external circumference by more than the following limits:

(a) In Zone A (at joints or within 610mm from the joint), 30% of the nominal wall thickness or 10mm whichever is the smaller;

(b) In Zone B (the remaining length of the tubular), the tolerances in (a) may be multiplied by 1.5 (i.e. to 45%);

(c) Where it can be demonstrated to the satisfaction of the purchaser that particular tubulars will be butt welded together in the completed assembly, then the Zone A tolerance in (a) above may be multiplied by 1.5 provided the individual tolerances are of the same sign (i.e. both positive or both negative). In addition, the misalignment tolerance of 4.5.2 shall be met.



ZONE	Δc NOT TO EXCEED
'A'	30% t_n OR 10MM WHICHEVER IS THE SMALLER
'B'	45% t_n OR 15MM WHICHEVER IS THE SMALLER

Figure 16 Circumferential tolerance

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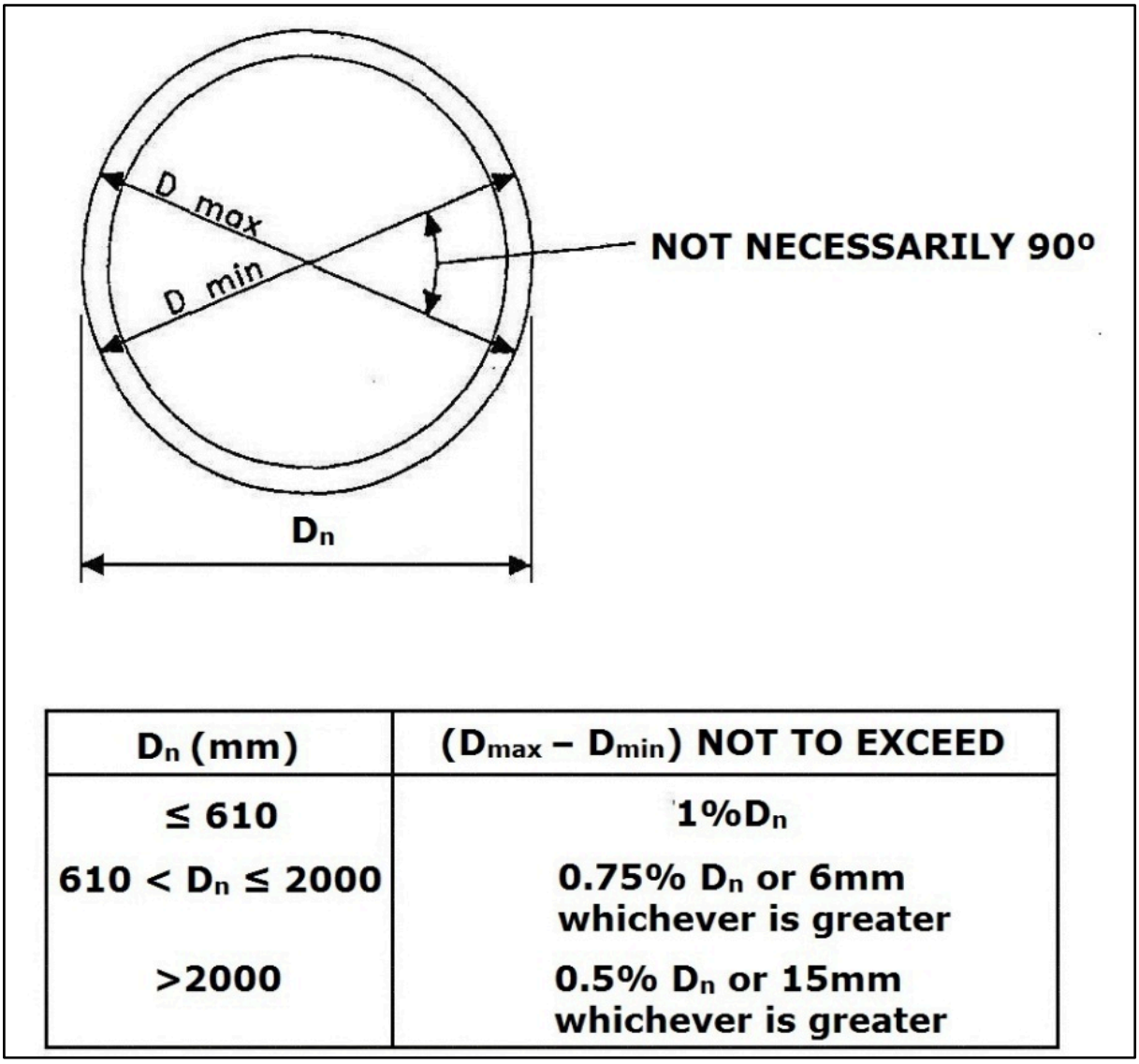
6.2.1.2 Ovality

Ovality of tubulars is defined as the difference between the measured maximum and minimum external (or internal) diameters, as shown in Figure 17, and shall not be more than as shown in the following Table 6 and Table 7:

Table 6 Allowable ovality

Nom. Dia. (mm)	Allowable ovality
≤ 610	1% of nominal diameter
>610≤2000	greater of 6mm or 0·75% of nom. dia.
>2000	greater of 15mm or 0·5% of nom. dia.



D_n (mm)	($D_{max} - D_{min}$) NOT TO EXCEED
≤ 610	1%D_n
610 < D_n ≤ 2000	0.75% D_n or 6mm whichever is greater
>2000	0.5% D_n or 15mm whichever is greater

Figure 17 Ovality tolerence
(see Table 7 for checking positions)

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