# WS2: Fabricated Metal and Welded Parts Workmanship Standard

Document Number: 1000024422

# Chapter 1: References / Standards

| Reference | Description |
|---|---|
| **ASME BPV, Section IX** | Welding, Brazing, and Fusing Qualifications |
| **AWS D1.1** | American Welding Society: Structural Welding Code – Steel |
| **AWS D1.6** | American Welding Society: Structural Welding Code – Stainless Steel |
| **ISO 2768-1** | General Tolerances – Part 1. Tolerances for linear and angular dimensions without individual tolerance indications |
| **ISO 5817** | Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections |
| **ISO 8501-1** | Preparations of steel substrates before application of paints and related products |
| **ISO 9606-1** | Qualification testing of welders – Fusion welding – Part 1: Steels |
| **ISO 9712** | Non-destructive testing – Qualification — and certification of NDT personnel |
| **ISO 11666** | Non-destructive testing of welds – Ultrasonic testing -- Acceptance levels |
| **ISO 12517** | Non-destructive testing of welds – Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography – Acceptance levels |
| **ISO 13920** | Welding – General tolerances for welded constructions – Dimensions for lengths and angles – Shape and position |
| **ISO 14731** | Welding coordination. Tasks and responsibilities |
| **ISO 15607** | Specification and qualification of welding procedures for metallic materials – General rules |
| **ISO 15608** | Welding – Guidelines for a metallic materials grouping system |
| **ISO 15609** | Specification and qualification of welding procedures for metallic materials – Welding procedure specification, five parts. |
| **ISO 15610** | Specification and qualification of welding procedures for metallic materials – Qualification based on tested welding consumables |
| **ISO 15611** | Specification and qualification of welding procedures for metallic materials – Qualification based on previous welding experience |

| | |
|---|---|
| **ISO 15612** | Specification and qualification of welding procedures for metallic materials – Qualification by adoption of a standard welding procedure |
| **ISO 15613** | Specification and qualification of welding procedures for metallic materials – Qualification based on pre-production welding test |
| **ISO 15614** | Specification and qualification of welding procedures for metallic materials – Welding procedure test, 13 parts. |
| **ISO 23277** | Non-destructive testing of welds – Penetrant testing of welds – Acceptance levels |
| **ISO 23279** | Non-destructive testing of welds – Ultrasonic testing – Characterization of indications in welds |
| **ASNT-SNT-TC-1A** | Recommended Practice for Non-Destructive Testing Personnel Qualification and Certification |

# Chapter 2: General Requirements

## 2.1 Purpose

This workmanship standard defines minimum manufacturing, inspection, and testing requirements for **Fabricated Metal and Welded Parts**.

## 2.2 Scope

This workmanship standard pertains to the following:

- Fabricated metal and welded parts, which include:
  - Parts and assemblies that require welding
  - Parts fabricated from structural shapes or plate
  - Sheet metal or plate fabrication

## 2.3 Steel Surface Requirements

FLSmidth will reject steel with excessive corrosion as defined by grades C and D of **ISO 8501-1,** Preparations of steel substrates before application of paints and related products**,**. See below for reference:

Grade C: Steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting visible under normal vision.

Grade D: Steel surface on which the mill scale has rusted away and on which general pitting is visible under normal vision.

## 2.4 Dimensions

Cut-list lengths of rolled or bent items indicated on drawings are estimated lengths. Required finished lengths, if different from the cut sheet, shall be specified by specific dimensions. Allowance for rolling or bending is the responsibility of the fabricator.

Weldment drawing dimensions are finished dimensions. Allowance for shrinkage, distortion or other fabrication techniques shall be the responsibility of the fabricator.

## 2.5 Splices

No splices are permitted in structural members unless specified in FLSmidth drawings or approved by FLSmidth Engineering.

## 2.6 Fabrication Clean-Up

All flux, spatter, slag and scale shall be removed from surfaces, welds and edges. Acceptable methods for removal are chipping, grinding, chiseling or chemical (anti-spatter).

All holes, sharp edges and corners shall be ground or otherwise de-burred to a minimum radius or chamfer of 1mm unless otherwise specified on the drawing. Unsightly marks or gouges shall be blended by surface grinding.

All rust, scale and/or heat tint (stainless steel) shall be removed from surfaces by grinding, sanding, brushing or chemical means.

**NOTE**: Abrasive tools used on stainless steel and other non-ferrous alloys shall not be contaminated by another material; likewise, blast media shall be free of any contaminants.

# Chapter 3: Welding Requirements

The fabricator shall plan welding and Non Destructive Testing (NDT) to allow for required FLSmidth or FLSmidth Client inspection as required by the PSP/ITP.

## 3.1 Welding Procedures Specifications (WPS)

All welding shall be performed using qualified and FLSmidth-approved Welding Procedure Specification (WPS). The WPS shall be written by the Fabricator in accordance with the specified standard.

FLSmidth uses the following weld standards:

- AWS D1.1 , D1.6, B2.1
- ASME BPV Section IX
- ISO 15607 to 15614
- CWB 47.1 and W59

Other standards may be used when a Specification Deviation Request is approved by FLSmidth, or when specified on the purchase order.

All WPS shall be kept on file and submitted to FLSmidth for review prior to the commencement of work.

## 3.2 Weld Filler Material

Filler metals shall be stored, handled and used in accordance with the manufacturer's instructions and applicable welding code.

## 3.3 Certified Welder

All welders shall be qualified per one of the following:

- ASME BPV Section IX — Welding, Brazing, and Fusing Qualifications
- AWS D1.1 — American Welding Society: Structural Welding Code — Steel
- ISO 9606-1 — Qualification testing of welders – Fusion welding — Part 1: Steels
- CWB 47.1
- FLSmidth-approved alternate certification per documented WPS

A list of welding personnel working on FLSmidth projects, including qualifications and certifications for each individual, must be made available to and presented upon request of FLSmidth before the work commences.

Any welding performed by an unqualified welder may be subject to rejection by FLSmidth.

## 3.4 Welding Process

The welding process and weld parameters shall be selected based on allowances needed to produce the required weld.

## 3.5 Pre-Heating

Preheating, inter-pass temperature and post weld heat treatment shall be applied per requirements of the approved welding standard and associated WPS.

# Chapter 4: Weld Inspection

## 4.1 Qualifications

Non-Destructive Testing (NDT) shall be conducted by qualified and certified personnel in accordance with:

- **ISO 9712** - Non-destructive testing -Qualification and certification of personnel level II
- **ASNT SNT- TC-1A** - Recommended Practice for Non-Destructive Testing Personnel Qualification and Certification
- An FLSmidth approved internationally recognized equivalent standard

Visual inspection shall be performed by qualified inspectors. Personnel qualifications and certifications shall be made available upon request of FLSmidth and/or its customer's representatives.

## 4.2 Timing of Inspection

Final inspection of welds shall take place only **after** final thermal straightening or heat treatment. Any deviation shall be approved through written authorization from FLSmidth.

Welds and materials with a latent possibility for the formation of hydrogen cracks or other delayed crack mechanisms shall not be inspected until at least 48 hours have passed after completion of the weld.

## 4.3 Acceptance Criteria

Acceptance criteria are defined on FLSmidth drawings, ITP, or in the product-specific workmanship standard (WS-3) referred to by the drawings.

The following inspection methods may be required by FLSmidth:

| Method | Abbreviation |
|---|---|
| **Visual test** | VT |
| **Liquid penetrant test** | PT |
| **Magnetic particle inspection (MPI)** | MT |
| **Radiographic / X-Ray test** | RT |
| **Ultrasonic test** | UT |

**If** the quality level has not been indicated on FLSmidth drawings, the project ITP, or purchase order, only Visual Testing (VT) is required.

### 4.3.1 Quality Levels / Quality Level Acceptance Criteria

For fabricated metal and welded parts, FLSmidth follows **ISO 5817** Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections. FLSmidth uses three quality levels, as indicated in the table below.

| ISO 5817 | |
|---|---|
| **D** | Moderate |
| **C** | Intermediate |
| **B** | Stringent |

When not specified on drawings or other contract documents, the minimum acceptance criteria / quality level shall be per Quality Level D.

Acceptance of imperfections in welded joints and adjacent Heat Affected Zones (HAZ) shall be in accordance with **ISO 5817**. Minimum acceptance criteria are as follows (crack or crack-like indications shall not be accepted):

| **Table is an extract from ISO 17635, Nondestructive examination of welds** | | | | | |
|---|---|---|---|---|---|
| **Inspection Method** | **Quality Level ISO 5817** | **Implementation Requirements** | | **Acceptance Level** | |
| **VT** | D (Moderate) | ISO 17637 | | ISO 5817 | D |
| | C (Intermediate) | ISO 17637 | | ISO 5817 | C |
| | B (Stringent) | ISO 17637 | | ISO 5817 | B |
| **PT** | D (Moderate) | ISO 3452-1 | | ISO 23277 | 3X |
| | C (Intermediate) | ISO 3452-1 | | ISO 23277 | 2X |
| | B (Stringent) | ISO 3452-1 | | ISO 23277 | 2X |
| **MT** | D (Moderate) | ISO 17638 | | ISO 23278 | 3X |
| | C (Intermediate) | ISO 17638 | | ISO 23278 | 2X |
| | B (Stringent) | ISO 17638 | | ISO 23278 | 2X |
| **RT** | D (Moderate) | ISO 17636-1 | Level A | ISO 12517-1 | 3 |
| | C (Intermediate) | ISO 17636-1 | Level B | ISO 12517-1 | 2 |
| | B (Stringent) | ISO 17636-1 | Level B | ISO 12517-1 | 1 |
| **UT** | D (Moderate) | Not defined | | Not required ([1]) | |
| | C (Intermediate) | ISO 17640 | min. level A | ISO 11666 | 3 |
| | B (Stringent) | ISO 17640 | min. Level B | ISO 11666 | 2 |
| **([1]) UT is not recommended but can be defined in a specification (with the same requirements as quality level C)** | | | | | |

### 4.3.2 Weld Inspection Requirements

Drawings showing NDT locations and extent of testing shall be prepared by the fabricator and shall be available for review by FLSmidth. The following inspection requirements apply to each quality level:

| **Testing applies to % of length of welded seams** | | | | | |
|---|---|---|---|---|---|
| **Quality level (ISO 5817)** | **Weld type** | **Inspection method** | | | |
| | | VT | PT | MT | RT/UT([1]) |
| D (Moderate): normal test | Fillet | 100% | 0% | 0% | 0% |
| | Butt | | | | 0% |
| D (Moderate): re-testing | Fillet | 100% | 20% ([2]) | | 0% |
| | Butt | | | | 20% |
| D (Moderate): repeat re-testing | Fillet | 100% | 100% ([2]) | | 0% |
| | Butt | | | | 100% |
| C (Intermediate): normal test | Fillet | 100% | 0% | 20%([4]) | 0% ([3]) |
| | Butt | | | | 20% |
| C (Intermediate): re-testing | Fillet | 100% | 0% | 100%([4]) | 0% |
| | Butt | | | | 100% |
| B (Stringent) normal test | Fillet | 100% | 0% | 100%([4]) | 0% ([3]) |
| | Butt | | | | 100% |

([1]) Unless specified on the drawing, either UT or RT may be used, depending on suitable thickness.

([2]) Unless specified on the drawing, either PT or MT may be used for testing.

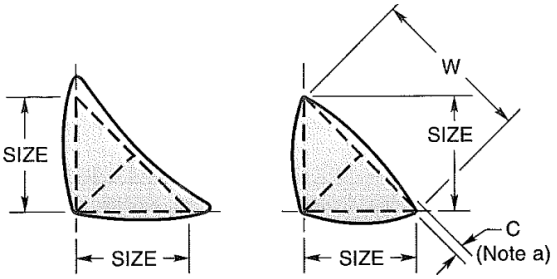
([3]) UT shall apply 20% or 100% on fillet weld according to drawing requirements.

([4]) For Stainless Steels, use PT

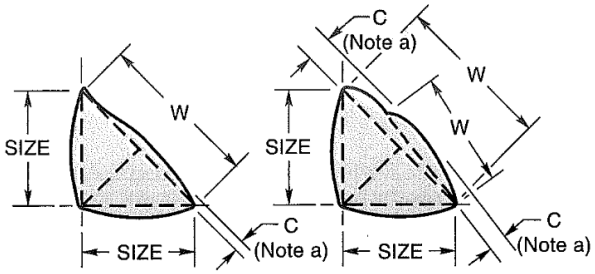
If imperfections are found resulting in:

- Non-compliance:
  Repairs shall be made, and the extent of testing shall be increased from normal test to re-testing of the weld in concern.
- Non-compliance during re-testing:
  Repairs shall be made, and the extent of testing shall be increased to 100% (repeated) re-test of the weld in concern.
- Non-compliance during a 100% test:
  Repairs shall be made and all repaired sections of the welded seams shall be examined 100%.

## 4.3.3 Acceptable and Unacceptable Weld Profiles (AWS D1.1)



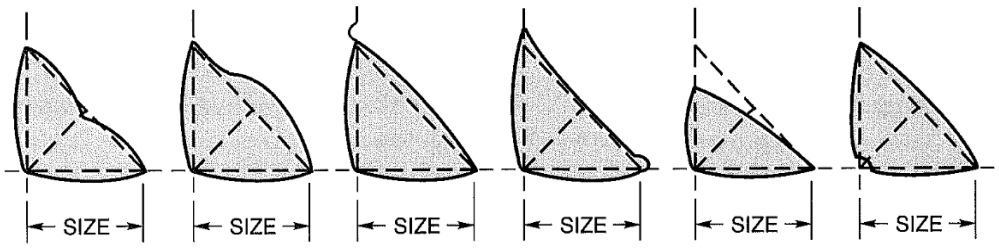

**(A) DESIRABLE FILLET WELD PROFILES**



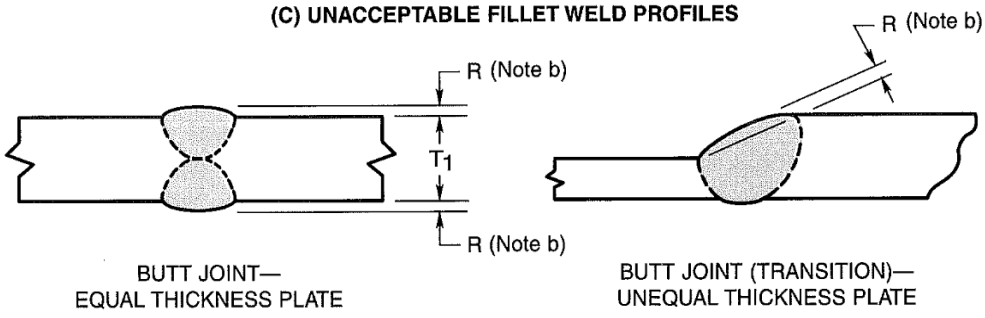

**(B) ACCEPTABLE FILLET WELD PROFILES**

[a] Convexity, C, of a weld or individual surface bead with dimension W shall not exceed the value of the following table:

| WIDTH OF WELD FACE OR INDIVIDUAL SURFACE BEAD, W | MAX. CONVEXITY, C |
|---|---|
| W ≤ 5/16 in [8 mm] | 1/16 in [2 mm] |
| W > 5/16 in [8 mm] TO W < 1 in [25 mm] | 1/8 in [3 mm] |
| W ≥ 1 in [25 mm] | 3/16 in [5 mm] |

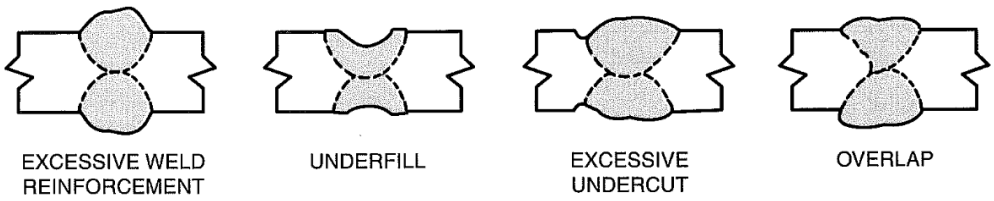



**(C) UNACCEPTABLE FILLET WELD PROFILES**




[b] Reinforcement R shall not exceed 1/8 in [3 mm]

**(D) ACCEPTABLE GROOVE WELD PROFILE IN BUTT JOINT**




**(E) UNACCEPTABLE GROOVE WELD PROFILES IN BUTT JOINTS**

Note: All welds shall meet the visual acceptance criteria

# Chapter 5: Manufacturing Fabrication Tolerance

The permissible dimensional deviations for fabricated metal and welded parts are specified in the following sections.

## 5.1 General Tolerances

Tolerances for fabricated metal and welded parts may be specified per one of the following:

1. A specific tolerance range may be called out on a dimension.
2. Sheet tolerance may be specified per **ISO 2768-1**- General Tolerances - Part 1. Tolerances for linear and angular dimensions without individual tolerance indications (see WS-1, General Workshop Instructions, for more information).
3. If options 1 and 2 (above) are not used, FLSmidth default tolerances for fabricated metal and welded parts shall apply. Those tolerances are as follows:

**Tolerances for non-locating dimensions**
For example: Outside dimensions of a structural frame

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dimension (mm)** | > | 0 | 30 | 300 | 1000 | 3500 | 5000 | 8000 | 12000 | 20000 |
| | ≤ | 30 | 300 | 1000 | 3500 | 5000 | 8000 | 12000 | 20000 | |
| **Max. deviation (mm)** | | ±2 | ±3 | ±4 | ±5 | ±6 | ±7 | ±8 | ±9 | ±10 |

**Tolerances for locating dimensions**
For example: Location holes mating to another component

| | | | | |
|---|---|---|---|---|
| **Dimension (mm)** | > | 0 | 500 | 1500 |
| | ≤ | 500 | 1500 | |
| **Max deviation (mm)** | | ± 1 | ± 1.5 | ± 2 |

**Tolerance for angular dimensions**
(Angular dimensions, 1°=60'=3600''). See ISO 13920.

| | | | | |
|---|---|---|---|---|
| **Length of the short angle leg (mm)** | > | 0 | 400 | 1000 |
| | ≤ | 400 | 1000 | |
| **Max deviation** | Angular deviation | 0° -0.33° (20') | 0° -0.25° (15') | 0° - 0.17° (10') |
| | Linear deviation mm per 100 mm | ± 6 mm | ± 4.5 mm | ± 3 mm |

**Note**: all bends to be minimum radius, unless otherwise specified on FLSmidth drawings

## 5.2 Tolerance of Holes and Slots

Holes and slots shall meet tolerance requirements throughout the entire hole or slot depth and slot width.

The cutting of holes shall not deform plates or sections.

| Tolerance for holes or slots | | | | |
|---|---|---|---|---|
| **Dimension (mm)** | > | 0 | 25 mm | 50 mm |
| | ≤ | 25 mm | 50 mm | |
| **Max deviation (mm)** | | ± 1 mm | ± 1.5 mm | ± 2 mm |

## 5.3 Tolerances of Shells, Mild Steel Panels, Ducts, Tanks, Etc.

In connection with the fabrication and assembly/installation of cyclones, bins, stacks, tanks, ducts, etc., certain types of deviation from nominal dimensions will unavoidably occur. When specified on the drawing, or other contract documents, tolerances / deviations shall comply with specified **American Petroleum Institute (API)** standards; otherwise, the following shall apply:

### 5.3.1 Deviation in Shell Shape

(Circular/rectangular or other shapes of duct, bin, chute, etc.):

| **Wall thickness t** (mm) | **Max. deviation, "W' measured on 1.0 m across circular shell weld** (mm) | **Max. deviation, "W' measured across a 2.5 plain sheet** (mm) |
|---|---|---|
| 0 < t ≤ 12.5 | 10 | 16 |
| 12.5 < t ≤ 25 | 8 | 13 |
| 25 < t | 6 | 10 |

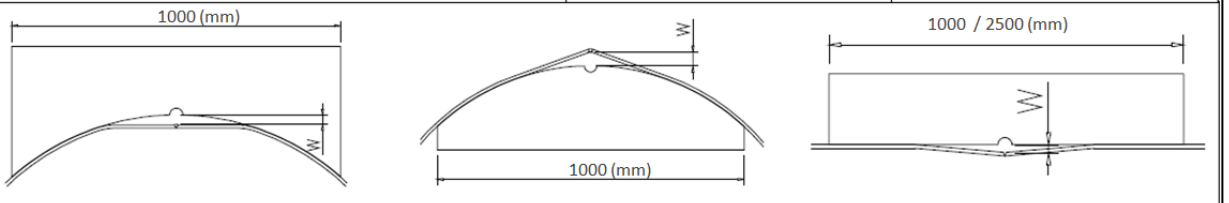



Figure 1: Shell shape deviation

Requirements apply in both vertical and horizontal directions. Inspection tools are required to have allowances (recesses) to account for convex butt welding (see Figure 1).

- A minimum of 1 m straight edge shall be used for vertical and horizontal inspections.
- 1 m plate template with the correct curvature shall be used for both outside and inside inspections of shell and sheet shape.

### 5.3.2 Offsetting Vertical Joints, Enlarging Plates, and Staggering Shell Plates

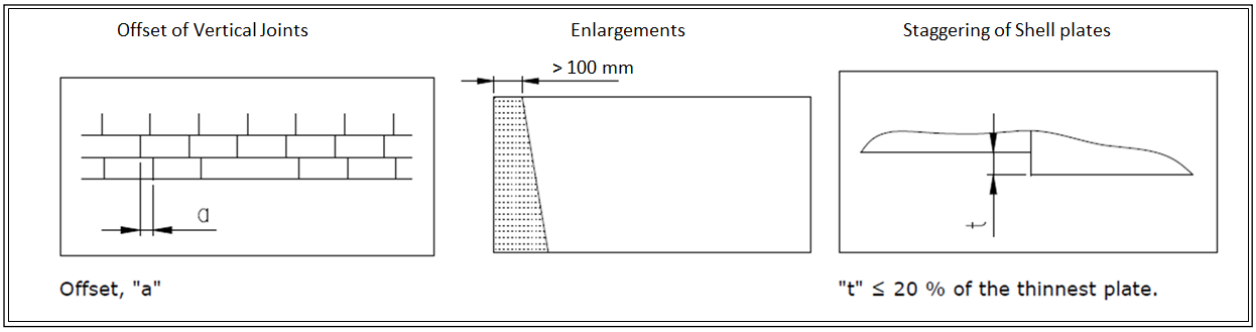



Figure 2: Offset of vertical joints, plate enlargement and staggering of shell plates

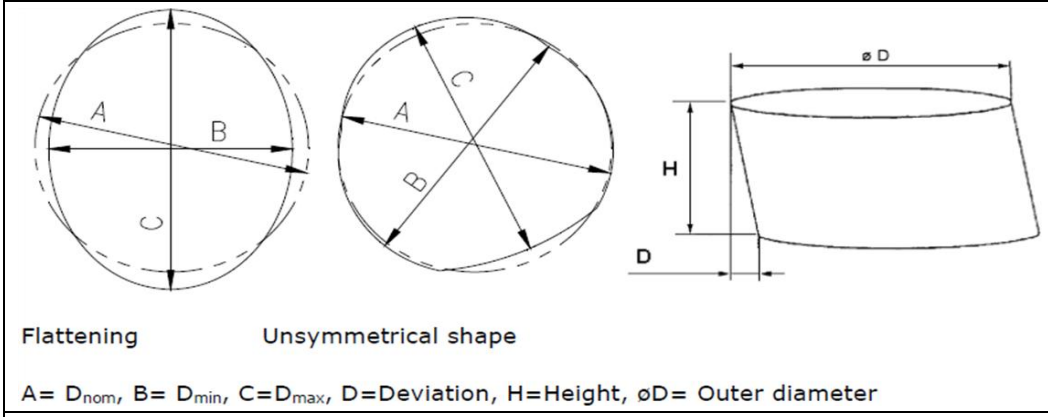
- Joints in two successive rows shall be offset ("a" in Figure 2) by the larger of:
  - Minimum of 100 mm
  - 5 x the plate thickness of the thicker course at point of offset (per API 650 sec 5.1.5.2b).

- The finished product shall be fabricated from single plates; enlargements shall only be made by adding a maximum of one additional plate. Enlargements shall meet the following:
  - Plates used to enlarge the element shall be a minimum size of 100 mm (length or height).
  - Unless otherwise noted on the drawing, plate surfaces shall be aligned to achieve a consistent/flat outside visible surface. All steps or changes in thickness at the joint shall be held to the inside or less visible surfaces.
  - The visual appearance of an enlarged plate shall be equal to the original plate (the only distinction being the weld).
  - Welds shall as a minimum, observe the welding quality level of the nearest butt weld shown on the drawing

### 5.3.3 Mountings on a Shell

Unless otherwise noted on the drawing, mountings (e.g., brackets, lifting lugs or nozzles) on a shell shall be positioned at least 150 mm from welding joints or they shall meet the requirements of API 650 or ASME Section IX.

### 5.3.4 Verticality and Ovality of Sections with Circular Cross-Section




**Max Deviation Angle: 1:200**

Figure 3: Ovality and verticality of a circular shell

**Measurement of Diameters for Assessment of Out of Roundness**

The internal diameter (Dmax and Dmin) shall be measured on each shell section at the bottom, the top, and mid-plane before the shell sections are trial-assembled or pre-assembled.

- Dmax is the maximum measured internal diameter.
- Dmin is the minimum measured internal diameter.
- Dnom is the nominal internal diameter.

| Diameter (m) | | Tolerance (Dmax-Dmin) |
|---|---|---|
| < | ≤ | |
| **0** | 12 | ± 26 mm |
| **12** | 45 | ± 38 mm |
| **45** | 75 | ± 50 mm |
| **75** | | ± 62 mm |

**Planeness on Panels, Reinforced Structure, Etc.**
The maximum variation in flatness shall be less than or equal to the following:

| Length/Width (mm) | | Planeness Tolerance |
|---|---|---|
| < | ≤ | |
| 0 | 100 | ≤ 1 mm |
| 100 | 500 | ≤ 2 mm |
| 500 | 1000 | ≤ 4 mm |
| 1000 | 1500 | ≤ 6 mm |
| 1500 | 2000 | ≤ 8 mm |
| 2000 | 2500 | ≤ 10 mm |
| 2500 | 3000 | ≤ 12 mm |
| 3000 | | ≤ L/250 or max 20 mm |
| • Tolerance is valid only for a rigid body.<br>• Planeness must not be influenced by the dead load of the body.<br>• Tolerance is valid for all heights of panel or structure. | | |

## 5.4 Fabricated Sections

Welded sections for Rectangular Hollow Section (RHS), I, H, L and channels shall not be used in products for FLSmidth if profiles are available in the country of fabrication. Exceptions are when otherwise indicated on FLSmidth drawings or when FLSmidth has authorized a deviation. The fabricator may request an exemption for bending of L profiles and channels.

The dimensions of fabricated profiles shall be in accordance with standard profiles. If the required plate thickness is not available, FLSmidth Engineering approval is required to use the next available thicker plate.

### 5.4.1 Fabricated Welded Hollow, Angle Irons and Symmetrical Sections

The values of X, Y, Z on welded hollow, angle and symmetrical sections shall have the same value as the section which is replaced.

All welds shall be full penetration; the fabricator shall provide back-up bars as required (not shown) to achieve full penetration.

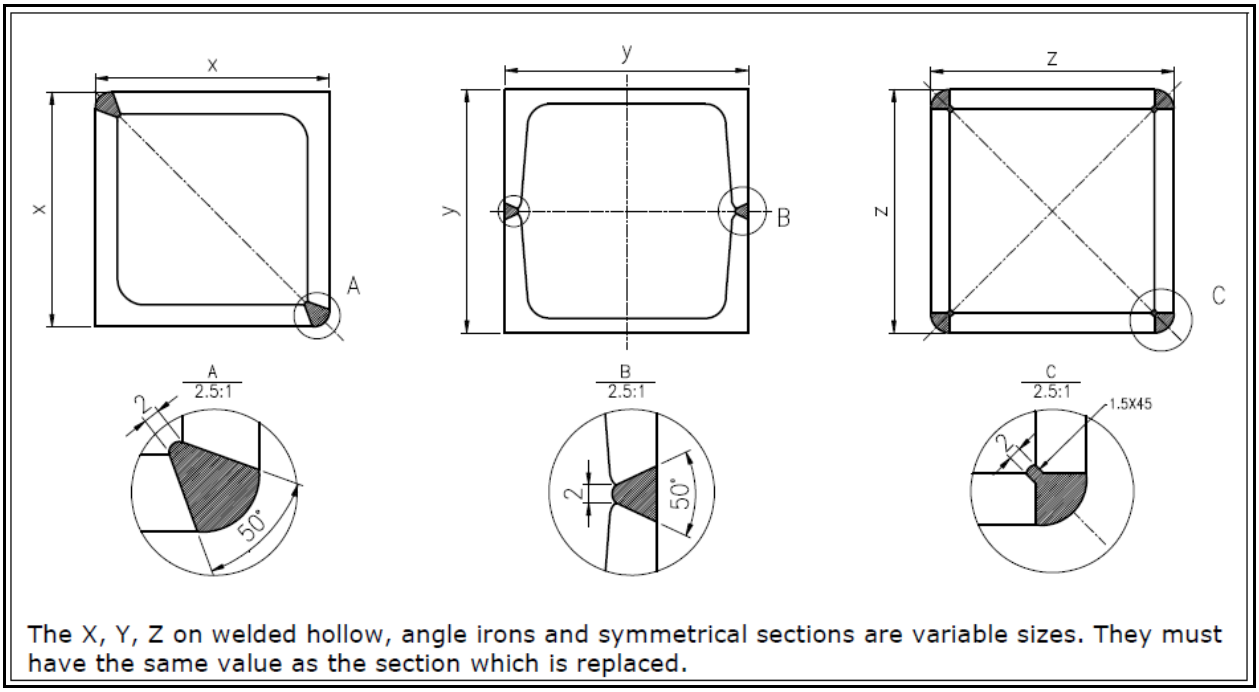



**Figure 4: Hollow sections and symmetrical profiles**

### 5.4.2 Fabricated I and H Sections, and Requirements for Symmetric Throat Welding

When two (2) fillet welds are required, the throat depth shall be a minimum of 70% of the smallest plate thickness.

### 5.4.3 Lengthening of Sections, Including Rolled, Welded and Bent

When approved by FLSmidth Engineering, L, I, H, and Channel sections, flat bars, and hollow sections shall be lengthened using full-penetration welds of welding Quality Level B (stringent), even if weld Quality Level B is not specified on the drawing (see Section 2.5).

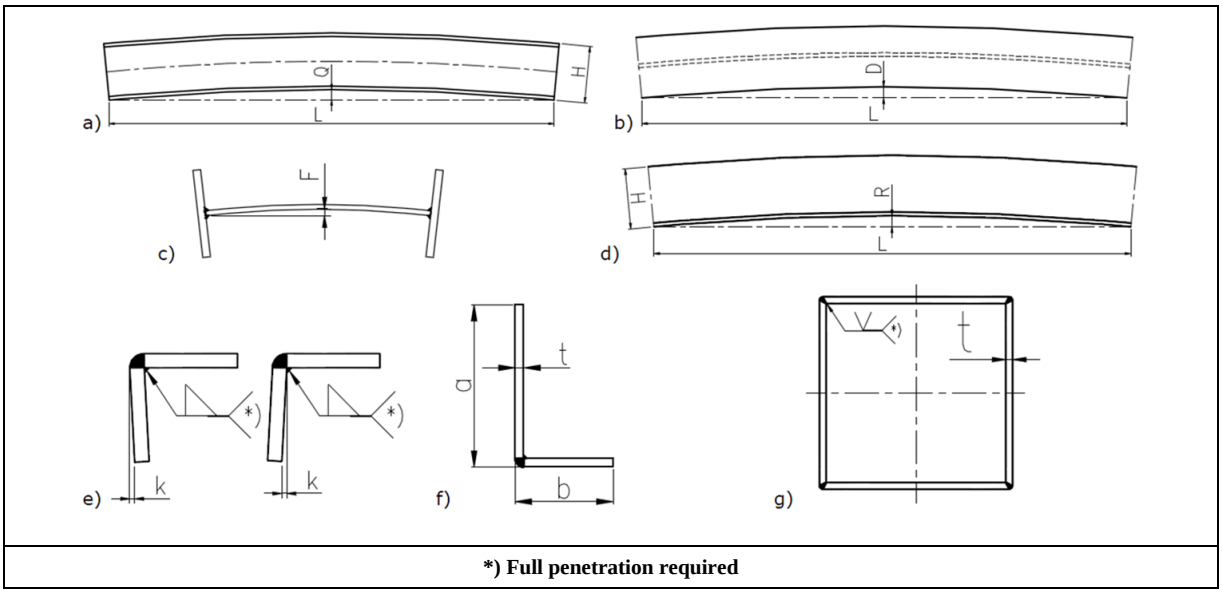
### 5.4.4 Bending Channel and L Sections

Channel and L sections bent from plate material may be used in structures delivered to FLSmidth only if the dimensions are clearly indicated on the manufacturing drawing. The fabricator of such channel and L sections is responsible for using bending parameters (pre-heating, thickness inner bending radius and steel quality) to ensure a product of the same quality with equivalent properties of the corresponding specified section.

### 5.4.5 Tolerances for Fabricated Sections

Tolerances shall follow the manufacturing drawing tolerances in conjunction with the following tables and figures.

## Straightness and Length




*) Full penetration required

**Table 1: Straightness tolerance for H and I profile and hollow section**

| Section height, H (mm) | Max. deviation, Q, D, (fig a, b) | Max. deviation, F (fig c; mm) |
|---|---|---|
| 80 < h ≤ 180 | 0.30% x L | 0.5 |
| 180 < h ≤ 360 | 0.15% x L | 1.0 |
| 360 < h ≤ 400 | 0.10% x L | 1.5 |
| 400 < h ≤ 700 | - | 2.0 |
| 700 < h ≤ 1000 | - | 3.0 |

**Table 2: Straightness, equal and unequal angle**

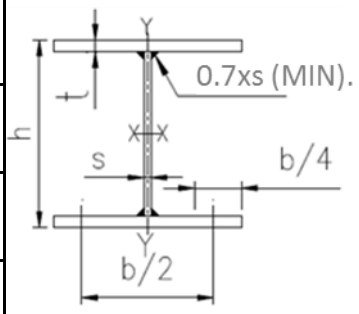
| Section height H (fig d; mm) a (fig f; mm) | Max. deviation, R (fig d) | Tolerance over any part Length considered and R, (fig d; mm) | | Max. deviation, k (fig e) | Max. deviation, a, b (fig f; mm) |
|---|---|---|---|---|---|
| a ≤ 50 | 0.4% x L | 1500 | 6 | - | ± 1.0 |
| 50 < a ≤ 100 | 0.4% x L | 1500 | 6 | ≤ 1.0 | ± 2.0 |
| 100 < a ≤ 150 | 0.4% x L | 1500 | 6 | ≤ 1.5 | ± 3.0 |
| 150 < a ≤ 200 | 0.2% x L | 2000 | 3 | ≤ 2.0 | ± 4.0 |
| 200 < a | 0.1% x L | 3000 | 3 | ≤ 3.0 | ± 6.0/-4.0 |

**Table 3: Thickness on channels, equal and unequal angle**

| Thickness, t (mm) | Max. deviation, t (fig f; mm) | RHS wall thickness, t (fig g; mm) |
|---|---|---|
| t ≤ 5 | ± 0.50 | t ≤ 5 mm: ± 10% |
| 5 < t ≤ 10 | ± 0.80 | t > 5 mm: ± 0.5 mm |
| 10 < t ≤ 15 | ± 1.00 | |
| 15 < t | ± 1.20 | |

**Table 4: Limits for thickness of web and flange of welded profiles**

| Section height h (mm) | | Section width b (mm) | | Web thickness s (mm) | | Flange thickness t (mm) | |
|---|---|---|---|---|---|---|---|
| h≤180 | +3.0 -2.0 | b≤110 | +4.0 -1.0 | s<7 | +0.7 -0.7 | t<6.5 | +1.5 -0.5 |
| 180<h≤400 | +4.0 -2.0 | 110<b≤210 | +4.0 -2.0 | 7≥s<10 | +1.0 -1.0 | 6.5≤t<10 | +2.0 -1.0 |
| 400<h≤700 | +5.0 -3.0 | 210<b≤325 | +4.0 -4.0 | 10≥s<20 | +1.5 -1.5 | 10≤t<20 | +2.5 -1.5 |
| 7000>h | +5.0 -5.0 | b>325 | +6.0 -5.0 | 20≥s<40 | +2.0 -2.0 | 20≤t<30 | +2.5 -2.0 |
| | | | | 40≥s<60 | ±2.5 | 30≤t<40 | ±2.5 |
| | | | | s≥60 | ±3.0 | 40≤t<60 | ±3.0 |
| | | | | | | t≥60 | ±4.0 |




**Flange thickness, t, is measured at b/4 respectively b/2**

**Table 5: Limits for out of shape of welded profiles**

| Flange thickness t (mm) | Profile out of square $k+k_1$ | | Web off center e $e = \frac{b_1-b_2}{2}$ | |
|---|---|---|---|---|
| **t < 40** | b≤110 | 1.5 | b≤110 | 2.5 |
| | b>110 | 0.02xb (max 6.5) | 110<b≤325 | 3.5 |
| | - | - | b>325 | 5.0 |
| **t > 40** | | | 110<b≤325 | 5.0 |
| | | | b>325 | 8.0 |

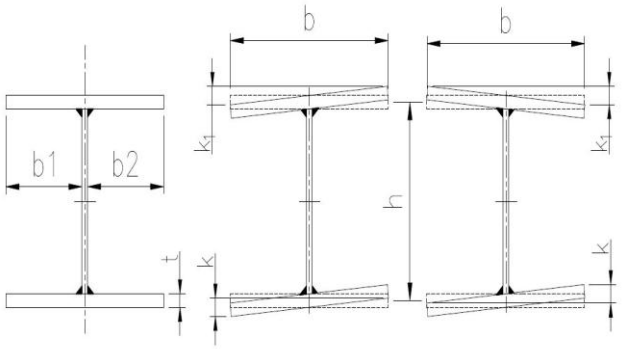


**Table 6: Limits for thickness of web and flange of welded channels**

| Section height h (mm) | | Section width b (mm) | | Web thickness s (mm) | | Flange thickness t (mm) | |
|---|---|---|---|---|---|---|---|
| h ≤ 65 | ±1.5 | b ≤ 50 | ±1.5 | s ≤ 10 | ±0.5 | t ≤ 10 | ±0.5 |
| 65 < h ≤200 | ±2.0 | 50 < b ≤ 100 | ±2.0 | 10 < s ≤ 15 | ±0.7 | 10 < t ≤ 15 | ±1.0 |
| 200 < h ≤ 400 | ±3.0 | 100 < b ≤ 125 | ±2.5 | s > 15 | ±1.0 | t > 15 | ±1.5 |
| h > 400 | ±4.0 | b > 125 | ±3.0 | | | | |
| *) Full penetration required and t to be measured at b/2. | | | | | | | |

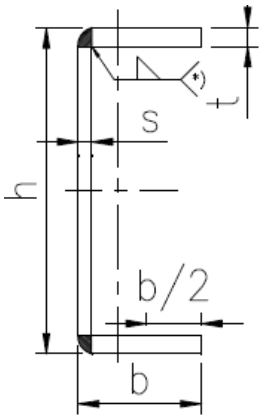
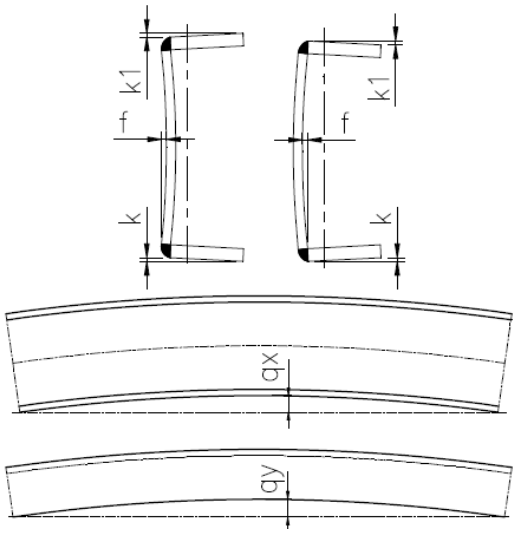


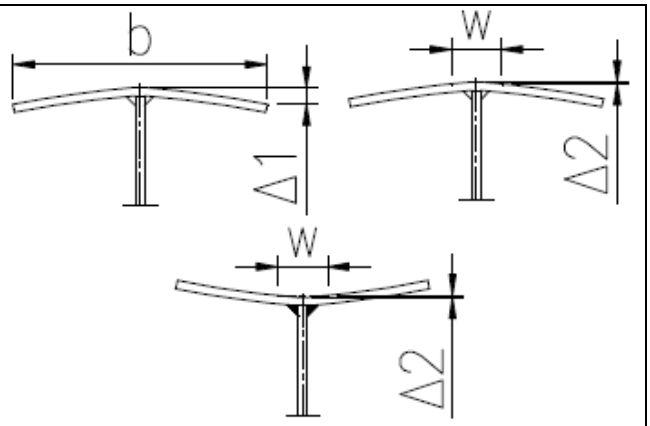
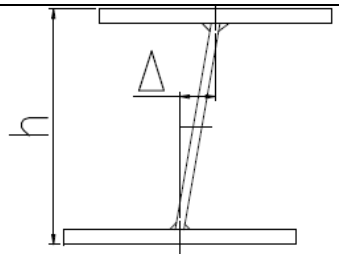
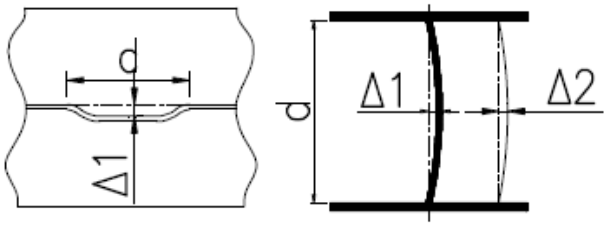
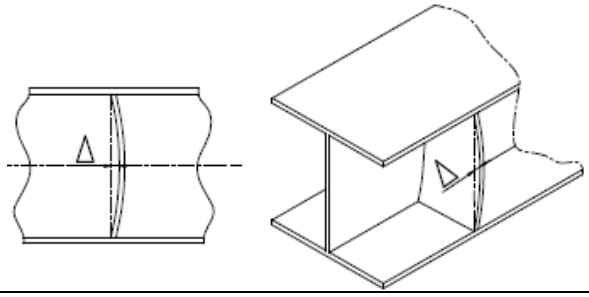

**Table 7: Limits for geometry of welded channels**

| Out of square k+k1 | | Web flatness f (mm) | | Straightness q (%) | |
|---|---|---|---|---|---|
| b ≤ 100 | 2.0 | h ≤ 100 | ±0.5 | qx [% of length] | |
| b > 100 | 2.5 % of b | 100 < h ≤ 200 | ±1.0 | h ≤ 150 | ±0.3 |
| | | 200 < h ≤ 400 | ±1.5 | 150 < h ≤ 300 | ±0.2 |
| | | h > 400 | ±1.5 | h > 300 | ±0.15 |
| | | | | qy [% of length] | |
| | | | | h ≤ 150 | ±0.5 |
| | | | | 150 < h ≤ 300 | ±0.3 |
| | | | | h > 300 | ±0.2 |



**Tolerance on flange form and web stiffeners**

**Table 8: Limits for geometry of welded profiles**

| | |
|---|---|
| Δ 1 ≤ b/100, maximum 3 mm<br>W = Rail width + 20 mm<br>Δ 2 ≤ 1 mm |  |
| Δ ≤ d/300, maximum 3 mm |  |
| d = Gauge length = Web depth<br>Δ 1 ≤ d/150, maximum 3 mm<br>Δ 2 ≤ d/500, maximum 3 mm |  |
| Δ ≤ d/250, maximum 3 mm |  |