



# HILTI CORDLESS STUD FUSION

Technical Manual  
North America



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## PREFACE

At Hilti, we are committed to investing in technology to support and further drive productivity of the construction industry. Hilti Cordless Stud Fusion (CSF) provides customers with a fully cordless system with built-in process controls to install high quality stud welds more consistently and safely.

The objectives of this Technical Manual are the following:

- Introduce the CSF system and technology
- Provide guidance to help ensure the quality of surface preparation
- Provide guidance to help ensure the quality of stud welding
- Offer technical specifications and load data for the F-BT studs
- Provide guidance and resources for implementation of CSF on jobsites

This Technical Manual covers fusion of Hilti F-BT studs to steel base materials subject to static loading. It provides guidance relating to stud fusion, including preparation, installation, product specifications, welding procedure qualification and specification, process control, and qualification testing of operators.

This manual provides guidance for project implementation, qualification, and installation based on the following welding standards, however CSF is not solely limited to use with these standards:

- EN ISO 14555 Welding – Arc stud welding of metallic materials [6]
- AWS D1.6/D1.6M Structural Welding Code – Stainless Steel [2]

The base materials covered in this Technical Manual are the following standardized materials:

- Groups 1.1 and 1.2 according to CEN ISO/TR 15608 [3]
- ASTM A36 and ASTM A572 Grade 50 according to AWS B2.1 [1]

## 1.0 INTRODUCTION

Engineers, manufacturers, contractors, and a range of other professionals use stud welding to attach studs to a variety of steel base materials with a range of thicknesses.

The Cordless Stud Fusion (CSF) welding process is classified as a drawn arc (DA) stud welding process with shielding gas (welding process 783 according to EN ISO 14555). The drawn arc stud weld process utilizes a welding power supply to create an electric arc along a circuit created between the stud and base material. The electric arc travels between the two materials via an air gap, generating an intense, concentrated heat used to melt the stud's base and a small area of the base material. Once the materials are melted appropriately, the stud is plunged into the molten area and held in place as the metals solidify to form the welded connection.

The timing, voltage, current, plunge and other aspects of the weld process are fully controlled by the CSF system, with power turning off automatically, negating the need for fine tuning by an operator. The CSF process and tools are used to install Hilti's F-BT stainless steel studs.

Benefits of CSF:

- Compact and portable system, with no need for external power source
- Automated parameter controls to simplify the welding process
- The hand tool is able to accommodate all F-BT stud lengths
- More consistent and spark free process
- Lightweight, portable and more convenient shielding gas
- Simpler and easier to learn than traditional welding methods
- No ferrule required to protect the welding process

Welding codes and standards address design and fabrication of welding components, including welding procedure qualification, testing methods, process control, and operator qualifications. This technical manual provides guidance based on AWS D1.6 and AWS B2.1, for more information see Section 8.

## 2.0 APPLICATION INFORMATION

The purpose of CSF is to weld studs to steel workpieces to create an attachment point. Modern fastening technology is increasingly important in shipbuilding, on- and off-shore structures, the construction industry and structural engineering worldwide. Among others, CSF is used in the following application groups:

- Multi-disciplinary supports
- Welded supports for cable trays
- Modular supports for cable trays
- Individual supports
- Welded supports for pipe trays
- Modular supports for pipes
- Suspended ceilings
- Equipment fastening
- Shipbuilding fastening

### 2.1 Example Applications

Figure 2.1-1 provides visual examples of the application types provided above.

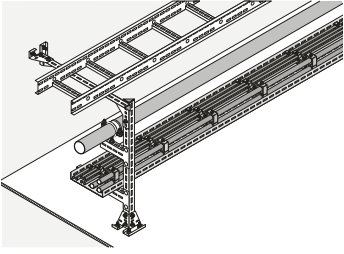
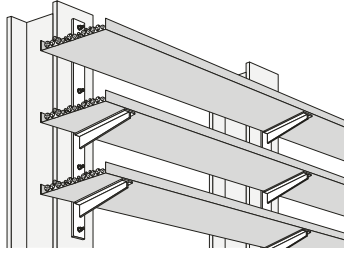
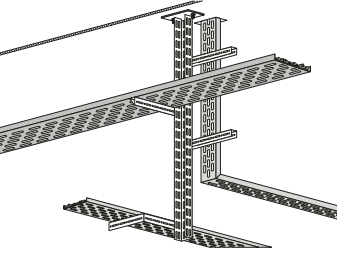
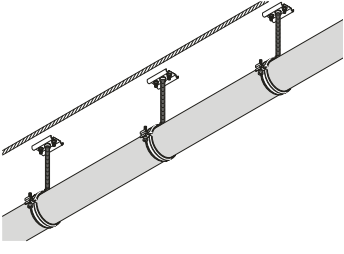
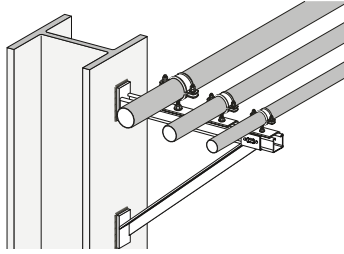
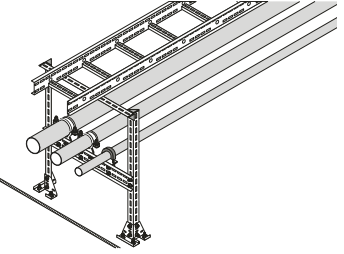
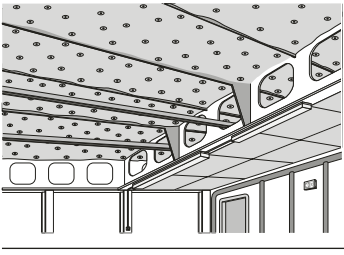
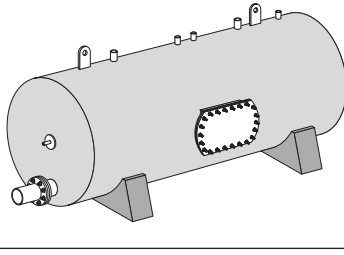
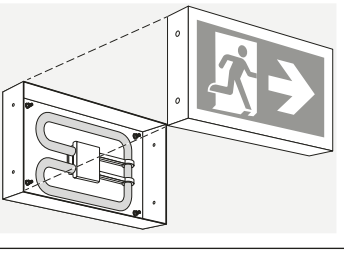
Example applications		
		
Multi-disciplinary supports	Welded supports for cable trays	Modular supports for cable trays
		
Individual supports	Welded supports for pipe trays	Modular supports for pipes
		
Suspended ceilings	Shipbuilding fastenings	Equipment fastenings

Figure 2.1-1: Example applications

## 3.0 CSF TECHNOLOGY

This section gives an overview on the CSF technology.

### 3.1 CSF equipment

In this section an overview of CSF equipment is given. It is subdivided as follows:

- Surface preparation equipment
- Stud fusion equipment
- Post weld installation equipment
- Testing equipment

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#### Surface preparation equipment

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Cordless drill driver: SF 8M-A22 or  
Cordless hammer drill driver: SF 6H-22



Surface tool FX 3-ST d14, for preparing surfaces with:

- Mill scale on bare (uncoated) steel
- Weldable primer with maximum coating thickness of 25  $\mu\text{m}$



Surface tool FX 3-ST d20, for preparing surface with:

- Non-weldable primer
- HDG coating
- Multi-layer coating
- Maximum coating thickness of 1000  $\mu\text{m}$

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Figure 3.1-1: Surface preparation equipment

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**Stud fusion equipment**

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**Cordless Stud Fusion unit FX 3-A**

- Battery powered
- Provides built in process controls to help ensure consistent weld performance
- Cordless stud fusion unit with one touch control panel



**Gas can FX 3-GC for use in the FX 3-A**

- Shielding gas (SG): ISO 14175 – M21 – ArC-18:
  - 82% Ar (CAS 7440-37-1)
  - 18% CO<sub>2</sub> (CAS 124-38-9)



**Stud fusion hand tool FX 3-HT**

- Compatible with all F-BT stud sizes
- Stud holder component is changed to adjust stud diameter
- Accommodates all F-BT stud lengths without need for adjustment
- Provides visual feedback and indicators to user



**Stud holders, which can be swapped in the FX 3-HT hand tool to accommodate the different F-BT stud diameters:**

- X-SH F3 M6-1/4" for use with F-BT studs featuring M6 or 1/4" thread diameters
- X-SH F3 M8-5/16" for use with F-BT studs featuring M8 thread diameters
- X-SH F3 M10-3/8" for use with F-BT studs featuring M10 or 3/8" thread diameters
- X-SH F3 M12-1/2" for use with F-BT studs featuring M12 or 1/2" thread diameters



**Support leg X-SL F3**

- Support leg for keeping tool perpendicular to base steel while welding



**Charger C 53**

- For charging the cordless stud fusion unit
- Quick charge button available

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**Figure 3.1-2: Stud fusion equipment – part I**



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### Stud fusion equipment

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Ground cable X-GC F3

- For connecting FX 3-A to grounding point on steel plate



Magnetic ground clamp X-MC F3

- May be used as a temporarily installed grounding point



Stud holder change tool X-SHT F3

- Used to exchange the stud holder on the FX 3-HT

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Figure 3.1-3: Stud fusion equipment – part II

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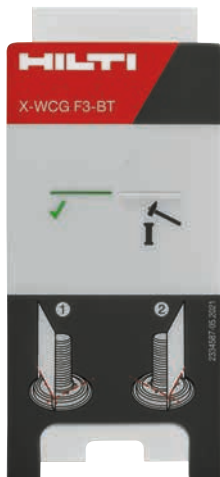
### Post weld installation equipment

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Sealing washer setting tool X-WST F3-BT

- Setting tool with different adapters can be used for metric (M6, M8, M10, M12) and imperial (3/8", 1/2") studs
  - M6: green
  - M8: yellow
  - M10/ 3/8": red
  - M12/ 1/2": blue



Washer Check Gauge X-WCG F3-BT

- For verifying sealing washer installation

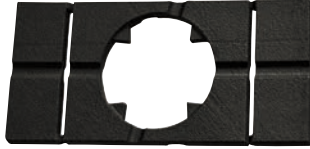
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Figure 3.1-4: Post weld installation equipment

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**Support plate**

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Support plates are available as an option to help with load distribution for F-BT-MR SN studs with sealing washers. The plate is installed at the base of the stud around the washer, to provide an even surface for the fastened material to act upon. This helps to transfer bending moment effects to the base or base material.

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**Figure 3.1-5: Support plate**

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**Sealing washer**

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**Sealing washer**

- Included with F-BT-MR SN studs to provide a seal over the prepared surface and weld joint to help prevent corrosion. For more information regarding corrosion resistance and sealing, reference Sections 4.4 and 4.5.

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**Figure 3.1-6: Sealing washer**

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**Measuring and testing equipment**

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**Pull Tester HAT 28-FX**

- The HAT 28-FX is a system for applying tensile loads to installed studs. It consists of a mechanical screw jack passing through a hydraulic load cell, which directly measure the load applied to the stud. For more information regarding testing of studs see Section 8.

**Bending bar X-BB F3**

- For bend testing studs during qualification and production activities. For more information regarding testing of studs see Section 8.

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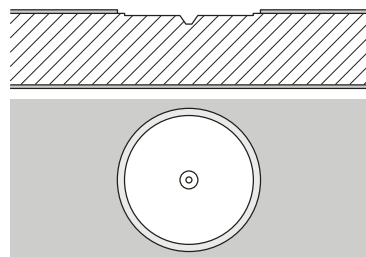
**Figure 3.1-7: Measuring and testing equipment**

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### 3.2 CSF surface preparation

Surface preparation before welding is a mandatory step to help ensure the integrity of the welded joint. It is necessary to ensure that the base material surface is clean, free from scale and coatings, dry and free from organic materials. The surface preparation process not only cleans the steel, but also provides a suitable surface profile to help achieve consistent welding results. To provide reliable weld performance across variance of coatings and steel surfaces, the welding surface needs to be prepared with Hilti surface tools. This section provides the surface preparation steps, surface tool selection and the surface inspection guidelines for different base material coating types.

#### Surface preparation



Surface should be prepared in accordance with the IFU and Visual Examination catalogue to provide an appropriate surface for welding.

Figure 3.2-1: Surface preparation

Figure 3.2-2 shows the surface tool selection for different base material, coating types and thicknesses for the corresponding studs.

#### Surface tool selection

Surface tool	FX 3-ST d14	FX 3-ST d20	FX 3-ST d20
Base material coating	Type I Weldable primer Black steel with mill scale	Type II Non-weldable primer HDG coating Duplex coating Multi-layer coating	Type II Non-weldable primer HDG coating Duplex coating Multi-layer coating
Base material coating thickness	$t_c \leq 25 \mu\text{m}$	$t_c \leq 1000 \mu\text{m}$	$t_c \leq 1000 \mu\text{m}$
Stud type	F-BT-MR	F-BT-MR	F-BT-MR SN

Figure 3.2-2: Surface tool selection

**Surface preparation dimensions**

Base material coating type I		Designation	Diameter of prepared surface, $d_p$
		FX 3-ST d14	14 mm (0.551")
Base material coating type II		Designation	Diameter of prepared surface, $d_p$
		FX 3-ST d20	20 mm (0.787")

**Figure 3.2-3: Surface preparation dimensions**

Surface preparation removes only a small amount of the base steel material, with a typical depth,  $x$ , of 0.2 mm relative to the base steel surface.

All surface preparations should be visually inspected according to the following technical documents: Hilti F-BT visual examination catalogue [7] and Instructions for use (IFU).

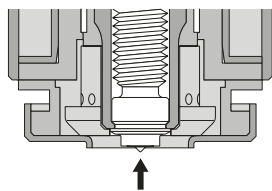
### 3.3 CSF welding process

The CSF system helps simplify stud welding compared to traditional methods by providing the following advantages:

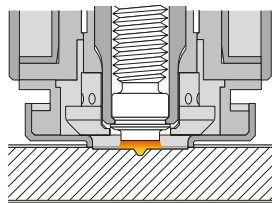
- Preprogrammed welding parameters controlled by the FX 3-A
- Built in sensors and process controls
- Easier to use ergonomics and reduced need for manual adjustments

Figure 3.3-1 below provides details on the process the CSF. For full installation details, refer to the Instructions for use (IFU). Section 3.4 provides additional information regarding welding parameters.

#### Stud fusion

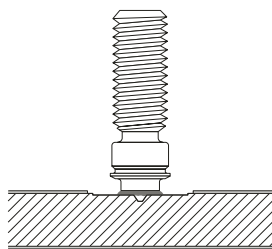
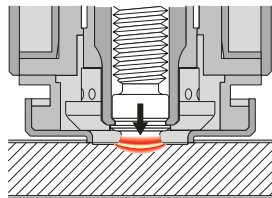


Each F-BT stud features a weld code (H-Code) on the top of its head. Once identified, the H-Code is selected on the FX 3-A unit, which will set the welding parameters for the welding process. After selecting the weld code, the stud will be inserted into the FX 3-HT hand tool.



Once setup is completed and the FX 3-HT hand tool is triggered, the following occurs without need for further user adjustment:

- Welding process is automatically started
- Stud is automatically lifted
- Arc is automatically ignited
- Arc melts stud base and base material
- Stud is automatically plunged into the molten material
- Arc is extinguished and metal cools down



After the weld process completes, the hand tool may be removed and welded stud remains on the base material. For details regarding inspection of the weld, refer to the Hilti F-BT Visual Examination Catalogue.

Figure 3.3-1: CSF welding process

### 3.4 CSF welding parameters

The basic parameters to describe the Cordless Stud Fusion (CSF) process are as follows:

- **Polarity:** In welding, polarity is the property of each piece metal used to form a circuit, which determines the flow of electrons within a circuit. The CSF system is a direct current (DC) system in which the stud acts as the negative pole and the base material acts as the positive pole, resulting in flow of electrons from the stud to the base material.
- **Welding current:** Electric current is the rate of charge flow in an electric circuit, measured in Amperes (A).
- **Welding time:** The amount of time for which the welding current is applied.
- **Protrusion:** The distance between the tip of the F-BT stud facing the base material and where the FX 3-HT tool grips the stud at the stud holder interface. See figure 3.4-1.
- **Lift:** The distance between the tip of the stud and the base material during the welding process. The FX 3-HT hand tool automatically lifts the stud to the appropriate distance prior to igniting the electrical arc.
- **Welding protective:** The method used to protect the weld process from outside environmental influence. The CSF system uses a combination of shielding gas and a magnetic field to provide protection for the weld.

**Basic parameter of CSF welding process**

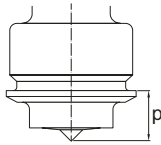
Designation	H-Code	Welding Current	Welding time	Protrusion	Lift
Metric					
F-BT-MR M6 x L (6)	H2	250 to 280 A	150 to 180 ms	4.2 to 4.6 mm	2.3 to 2.8 mm
F-BT-MR M8 x L (8)	H3		245 to 285 ms	4.4 to 4.8 mm	
F-BT-MR M10 x L (10)	H10		390 to 440 ms	4.4 to 4.8 mm	
F-BT-MR M12 x L (10)	H10		390 to 440 ms	4.4 to 4.8 mm	
F-BT-MR M6 x L SN (4)	H1	250 to 280 A	80 to 110 ms	4.2 to 4.6 mm	2.3 to 2.8 mm
F-BT-MR M8 x L SN (4)	H1		80 to 110 ms	4.2 to 4.6 mm	
F-BT-MR M6 x L SN (6)	H2		150 to 180 ms	4.2 to 4.6 mm	
F-BT-MR M8 x L SN (8)	H3		245 to 285 ms	4.4 to 4.8 mm	
F-BT-MR M10 x L SN (10)	H10		390 to 440 ms	4.4 to 4.8 mm	
F-BT-MR M12 x L SN (10)	H10		390 to 440 ms	4.4 to 4.8 mm	
Imperial					
F-BT-MR 3/8 x L SN (5/32)	H1	250 to 280 A	80 to 110 ms	4.2 to 4.6 mm	2.3 to 2.8 mm
F-BT-MR 3/8 x L (3/8)	H10		390 to 440 ms	4.4 to 4.8 mm	
F-BT-MR 1/2 x L (3/8)	H10		390 to 440 ms	4.4 to 4.8 mm	
F-BT-MR 3/8 x L SN (3/8)	H10	250 to 280 A	390 to 440 ms	4.4 to 4.8 mm	2.3 to 2.8 mm
F-BT-MR 1/2 x L SN (3/8)	H10		390 to 440 ms	4.4 to 4.8 mm	

**Table 3.4-1: Basic parameters**

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### Protrusion

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Protrusion, p

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Figure 3.4-1: Protrusion

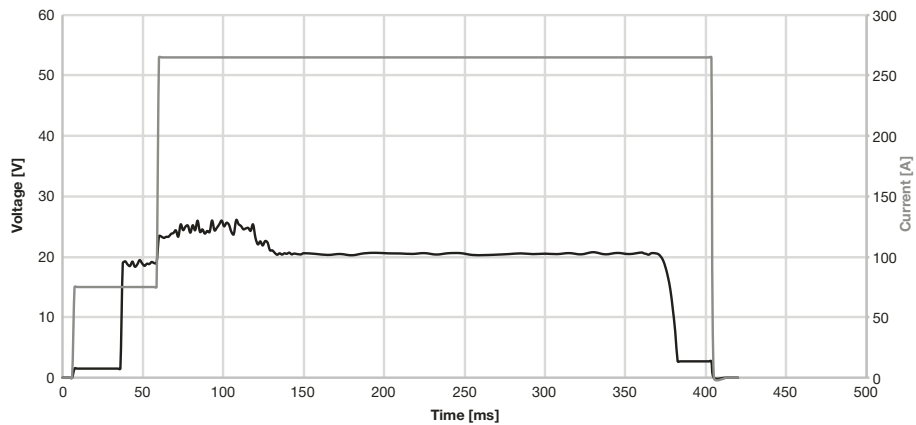
## 3.5 CSF energy regulation

The FX 3-A energy source supplies consistent power through the weld process to sufficiently melt the materials for welding. If a change in resistance occurs, the energy source automatically responds by adjusting the current and voltage accordingly, therefore regulating the power delivered. Below is a sample of energy regulation, by adjusting the power via voltage and current.

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### Power regulation over time for weld process

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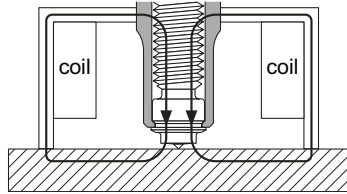


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Figure 3.5-1: Sample of power regulation over time for weld process

### 3.6 CSF magnetic arc control

#### Arc control by magnetic field



When stud welding, magnetic blowing effects due to irregular current distribution in the base material can reduce weld quality. To minimize and control magnetic blowing effects, the CSF system provides arc control through the use of a magnetic field.

Figure 3.6-1: Arc control by magnetic field

### 3.7 CSF welding protection

The welding protection is provided by a shielding gas system. The main features of the shielding gas system are the gas itself, the gas flow distribution, and the distribution ring.

#### Shielding gas

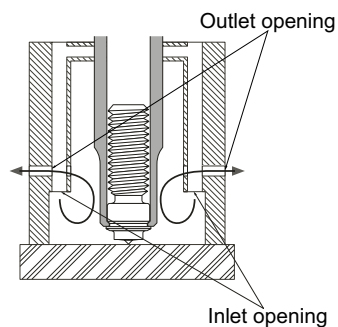
M21-ArC-18  
according to EN ISO 14175 [5]

The shielding gas has a composition of 18 % carbon dioxide in argon. The gas is denoted as M21-ArC-18 and is standardized to EN ISO 14175 Group M21. Argon is a noble gas with low reactivity, which helps to protect the welding process from reacting with the surrounding atmosphere.

Table 3.7-1: Shielding gas

The gas flow rate is 3 L/min. Figure 3.7-1 shows the gas flow distribution.

#### Gas flow distribution



The gas flow is constant and flows as shown in the diagram to the left. It covers the welding zone through the complete welding process. The arc-shaped gas flow prevents oxidation by avoiding gas turbulences.

A distribution ring within the tool functions as a gas diffuser to ensure uniform gas distribution over the stud element connected with the base material.

Figure 3.7-1: Gas flow distribution



### 3.8 One Touch Control Panel with Active Fusion Indicator (AFI)

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#### One Touch Panel with Active Fusion Indicator (AFI)

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The FX-3 A features the One Touch Control Panel, which provides the following:

- Allows user to select required H-Code, which is stamped on the top of each stud.
- Electrical and mechanical weld process parameters are pre-set based on selected H-Code
- Provides installation and status feedback to users via the AFI system.



H-Code stamped on stud

The AFI system provides the following:

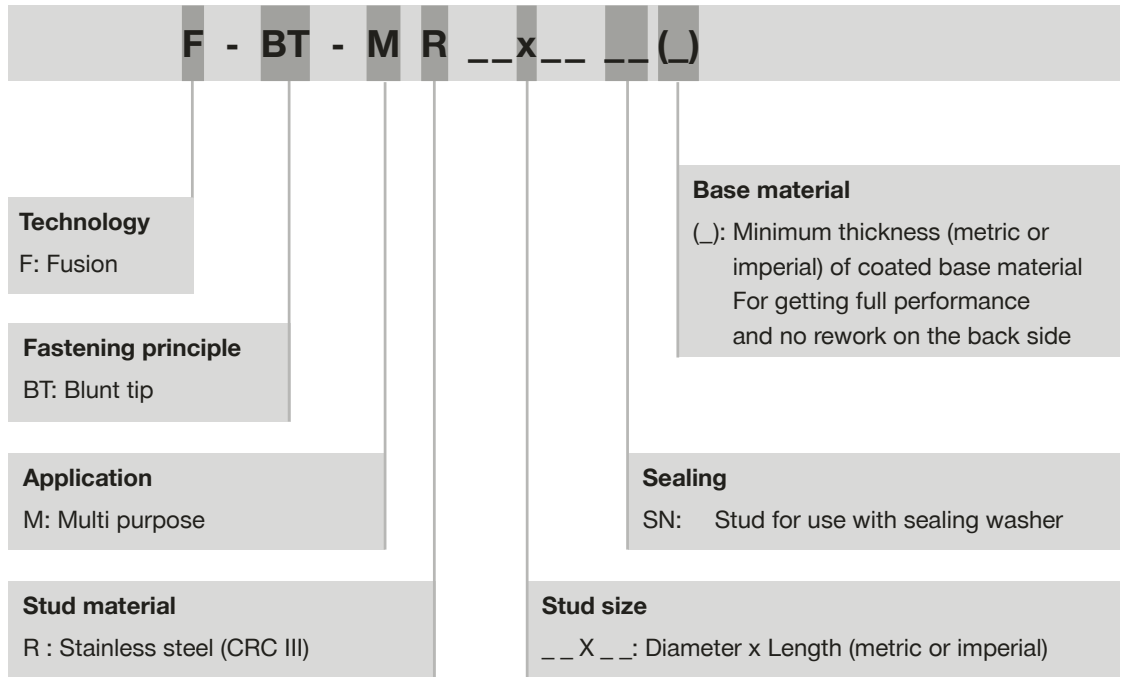
- Built in process control and sensors help to detect errors and failures before, during, or after the welding process.
- Failure is indicated via status lights and/or an F-Code on the display. Please reference the FX-3 A Instructions for Use (IFU) for more information.

---

Figure 3.8-1: One Touch Panel with Active Fusion Indicator (AFI)

## 4.0 F-BT STUD DESCRIPTION

### 4.1 Stud designation



## 4.2 Stud design principles

The F-BT stud terminology is found in figure 4.2-1 below.

### F-BT stud terminology

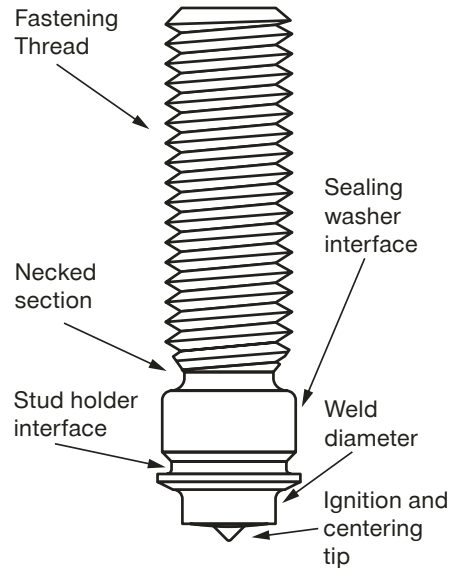


Figure 4.2-1: F-BT stud terminology

The following features of the F-BT studs combined with the CSF tooling and accessories, help provide more consistent welding and installation:

### Centering and ignition tip

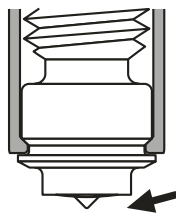


Figure 4.2-2: Centering and ignition tip

The tip of the stud serves two purposes:

- Provides a mechanical interface to center the stud in the prepared surface to help ensure proper positioning.
- Functions as an ignition tip to strike the electrical arc during the weld process.

### Stud holder interface

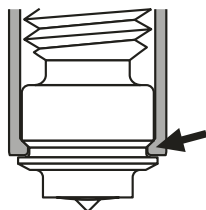
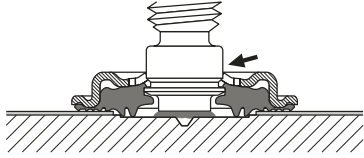


Figure 4.2-3: Stud holder interface

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**Sealing washer interface**

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- F-BT-MR SN studs feature an interface for the sealing washer.
- The sealing washer interface is an extension of the collar above the stud holder interface and provides a lock function to help prevent raising of the washer after installation.
- The sealing washer helps protect the base material against corrosion.

---

**Figure 4.2-4: Sealing washer interface**

### 4.3 Stud selection and specifications

F-BT studs are divided into two primary categories:

- F-BT-MR SN studs, which are available with sealing washers and flange nuts supplied by Hilti and are intended for installation on coated materials, with sealing achieved via the provided sealing washer. These studs are intended for use only with the supplied flange nuts.
- F-BT-MR studs, which do not include nuts and washers, and are intended for use on uncoated base materials or base materials in which a coating will be used for sealing after stud installation.

The F-BT-MR SN portfolio features studs for use with thin base materials with minimum thicknesses 4 mm (5/32"). These studs feature smaller neck and weld diameters and are designed to avoid damage of the coatings on the backside of the base material during installation.

Drawings to scale of the F-BT studs are provided in the following figures below:

- Figure 4.3-2 for F-BT-MR SN for thin base materials
- Figure 4.3-3 for F-BT-MR SN studs for standard base material thicknesses
- Figure 4.3-4 for F-BT-MR studs

For full dimensional information of the F-BT-MR SN and F-BT-MR portfolios, please reference sections 5.1 and 6.1 respectively.

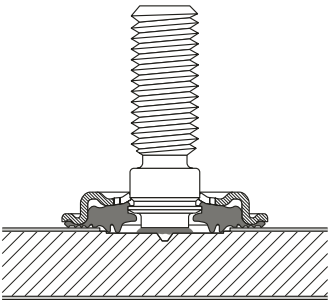
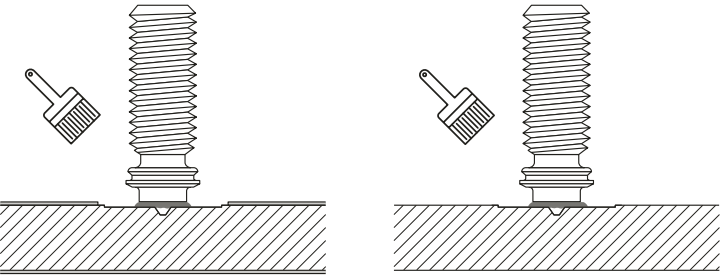
Stud with sealing washer for fastening on coated material	Stud without sealing washer for fastening on coated or uncoated material
F-BT-MR SN	F-BT-MR
Metric sizes: M6, M8, M10, M12	Metric sizes: M6, M8, M10, M12
Imperial sizes: 3/8"	Imperial sizes: 3/8", 1/2"
Sealing through washer	Sealing through painting
	

Figure 4.3-1: Stud type selection

### Stainless steel studs F-BT-MR SN with sealing washer for thin base material

Base material	Coated material, minimum base material thickness $t_{II} = 4$ mm		
Dimensions			
L	25 mm	25 mm	1"
Designation	F-BT-MR M6x25 SN (4)	F-BT-MR M8x25 SN (4)	F-BT-MR 3/8x1 SN (5/32)

Figure 4.3-2: Stainless steel studs F-BT-MR SN with sealing washer for thin base material

### Stainless steel studs F-BT-MR SN with sealing washer

Base material	Coated material, standard minimum base material thickness $t_{II}$				
Dimensions					
L	25 mm	25 mm	25 and 50 mm	1, 1-1/2, 2 and 4"	25 and 50 mm
Designation	F-BT-MR M6x25 SN (6)	F-BT-MR M8x25 SN (8)	F-BT-MR M10x25 SN (10) F-BT-MR M10x50 SN (10)	F-BT-MR 3/8x1 SN (3/8) F-BT-MR 3/8x1-1/2 SN (3/8) F-BT-MR 3/8x2 SN (3/8) F-BT-MR 3/8x4 SN (3/8)	F-BT-MR M12x25 SN (10) F-BT-MR M12x50 SN (10)

Figure 4.3-3: Stainless steel studs F-BT-MR SN with sealing washer

### Stainless steel studs F-BT-MR without sealing washer

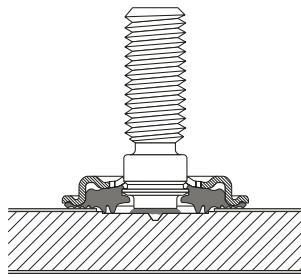
Base material	Coated and uncoated material, standard minimum base material thickness $t_{II}$					
Dimensions						
L	25 mm	25 mm	25 and 50 mm	1, 1-1/2, 2 and 4"	25 and 50 mm	1-1/2 and 2"
Designation	F-BT-MR M6x25 (6)	F-BT-MR M8x25 (8)	F-BT-MR M10x25 (10) F-BT-MR M10x50 (10)	F-BT-MR 3/8x1 (3/8) F-BT-MR 3/8x1-1/2 (3/8) F-BT-MR 3/8x2 (3/8) F-BT-MR 3/8x4 (3/8)	F-BT-MR M12x25 (10) F-BT-MR M12x50 (10)	F-BT-MR 1/2x1-1/2 (3/8) F-BT-MR 1/2x2 (3/8)

Figure 4.3-4: Stainless steel studs F-BT-MR without sealing washer

## 4.4 Corrosion resistance and durability through sealing

The corrosion resistance and durability based on the application environment must be taken into account in when designing fastening points. The correct sealing washer installation is the best way to help resist corrosion. Painting is a common sealing method in lieu of the use of sealing washers.

### Sealing through sealing washer

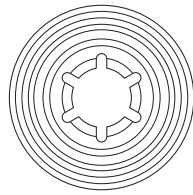


The sealing washer helps to protect the base material and the welded area against corrosion. It consists of a chloroprene rubber bonded to a specially formed stainless steel washer. The sealing washer creates a heavy duty and durable sealing solution for studs.

Temperature range in service	-40°C to 60°C (-40°F to 140°F)
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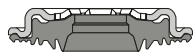
Sealing washer water tightness	56d salt spray test according to EN ISO 9227
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Sealing washer resistant to	UV, salt water, water ozone, oils, etc.
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#### Washer cap

- Stainless steel cap that houses and protects the sealing material
- Clamps the rubber gasket against the base material and stud
- Ensures correct positioning of the sealing washer
- Compression resistant



#### Sealing material

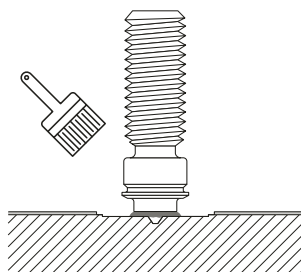
- Chloroprene rubber (CR)



- For more details on installation of the sealing washer, please refer to the Instruction for Use (IFU).

Figure 4.4-1: Sealing through sealing washer

### Sealing through painting



- Corrosion resistance and durability through painting varies and must be determined separately.

Figure 4.4-2: Sealing through painting









## 4.5 Selecting sealing methods for corrosion protection

For fasteners to be satisfactory and reliable for their service life, all the influencing factors must be identified before a suitable fastener can be selected. For example, the potential for corrosion is much higher in environments with seawater than most other areas.

Both the F-BT-MR SN and F-BT-MR fasteners are made of 1.4571 (A5, 316Ti) stainless steel, a Corrosion resistance class 3 (CRC III) material. Due to the unique installation involving surface preparation and welding, it is important to provide corrosion protection of the prepared surface and weld areas.

Figure 4.5-1 provides a comparison of the two primary sealing methods associated with the F-BT studs. The figure functions only as an initial guideline for fastener selection and does not guarantee that a stud will be free of corrosion in a given environment.

	Stud with sealing washer for fastening on coated material	Stud without sealing washer for fastening on coated material
Environmental condition	F-BT-MR SN	F-BT-MR
 Dry indoor	■	■
 Indoor with temporary condensation	■	■
 Outdoor with low pollution	■	■
 Outdoor with moderate concentration of pollutants	■	■
 Coastal areas	■	■
 Outdoor, areas with heavy industrial pollution	■	■

- Recommended solution for corrosion protection when installed according to IFU.
- May be suitable for corrosion protection with appropriate coating and sealing of the weld zone. Paint provided by others.



-  • Corrosion resistance of fastened parts should be evaluated separately.
-  • For more details, please refer to following technical document: Hilti Corrosion Handbook.

Figure 4.5.1: Selection of studs for different environmental conditions

## 4.6 Structural load types

Load direction types can be classified into five groups: tension load, compression load, shear load, bending moment and load interaction. Examples of these load types are shown in Figure 4.6.1.

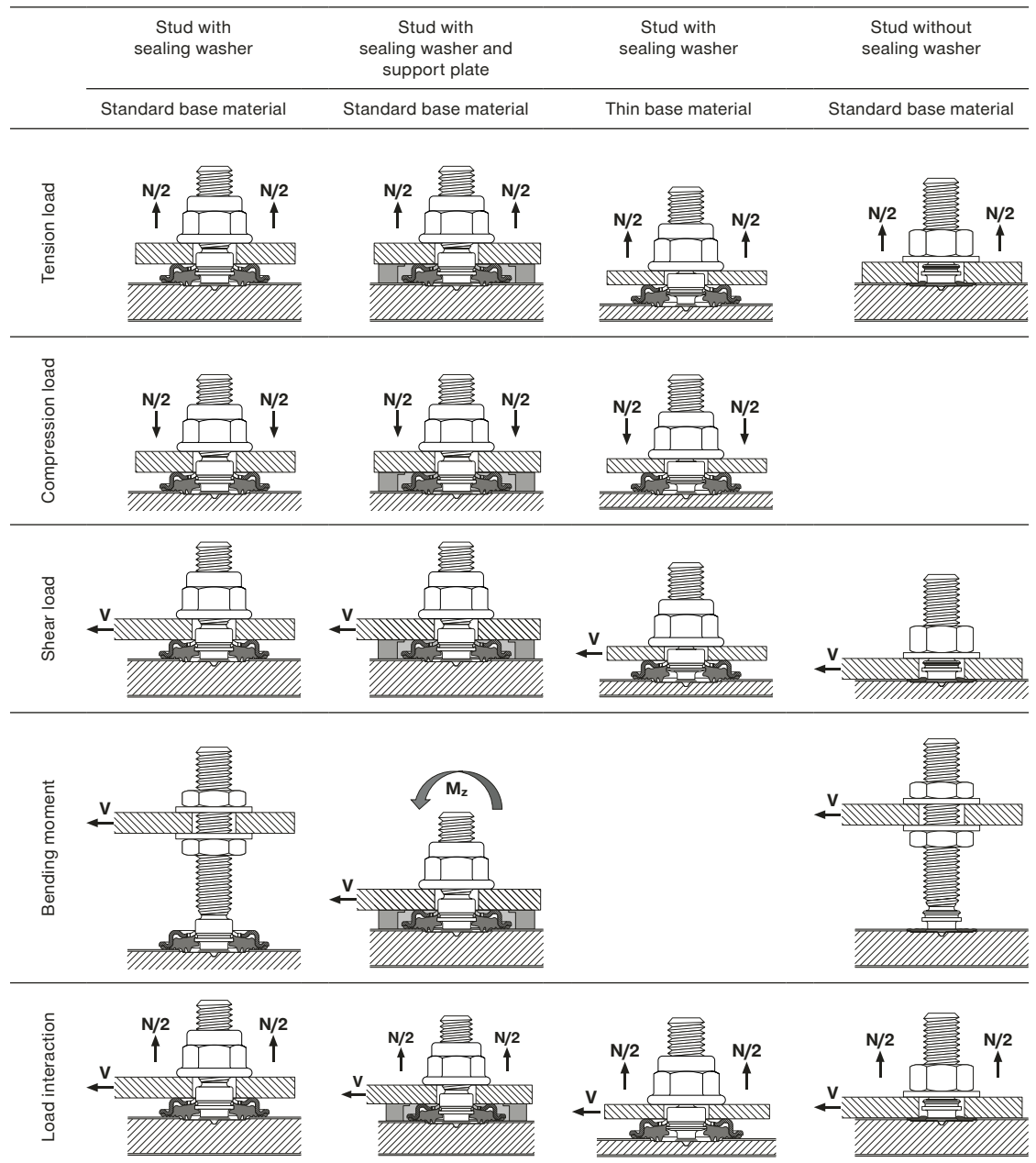


Figure 4.6-1: Load direction types

## 5.0 TECHNICAL DATA FOR F-BT-MR SN

### 5.1 Stud specifications

#### Stud dimensions

	L L <sub>1</sub> d <sub>1</sub> d <sub>2</sub> d <sub>h1</sub> d <sub>h2</sub> d <sub>n</sub>			Thread length Nominal stud length Nominal diameter, thread diameter Diameter of weld area Diameter of sealing washer interface Diameter of stud holder interface Diameter of necking area of stud			
	Designation	L	L <sub>1</sub>	d <sub>1</sub>	d <sub>2</sub>	d <sub>h1</sub>	d <sub>h2</sub>
Metric size							
F-BT-MR M6x25 SN (4)	25 mm	34 mm	M6	5 mm	7 mm	7.6 mm	4 mm
F-BT-MR M8x25 SN (4)	25 mm	34 mm	M8	5 mm	8.6 mm	9.2 mm	4 mm
F-BT-MR M6x25 SN (6)	25 mm	34 mm	M6	5 mm	7 mm	7.6 mm	4.4 mm
F-BT-MR M8x25 SN (8)	25 mm	34 mm	M8	6 mm	8.6 mm	9.2 mm	6 mm
F-BT-MR M10x25 SN (10)	25 mm	34 mm	M10	7.2 mm	10.6 mm	11.2 mm	6.8 mm
F-BT-MR M10x50 SN (10)	50 mm	59 mm	M10	7.2 mm	10.6 mm	11.2 mm	6.8 mm
F-BT-MR M12x25 SN (10)	25 mm	34 mm	M12	7.2 mm	13.4 mm	14 mm	6.8 mm
F-BT-MR M12x50 SN (10)	50 mm	59 mm	M12	7.2 mm	13.4 mm	14 mm	6.8 mm
Imperial size							
F-BT-MR 3/8x1 SN (5/32)	1"	1.339"/ 34 mm	3/8"	0.197"/ 5 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.157"/ 4 mm
F-BT-MR 3/8x1 SN (3/8)	1"	1.339"/ 34 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8x1 1/2 SN (3/8)	1 1/2"	1.850"/ 47 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8x2 SN (3/8)	2"	2.362"/ 60 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8x4 SN (3/8)	4"	4.252"/ 108 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm

Table 5.1-1: Stud dimensions

#### Stud material specification and material properties for stainless steel parts

Designation	Element	Material	Steel grade	Standard	Corrosion resistance class	Corrosion resistance standard
F-BT-MR SN	Stud	Stainless steel	1.4571 (A5)	EN 10088-3	CRC III	EN 1993-1-4
			316Ti	ASTM A240/A276	-	-

Table 5.1-2: Stud material specification and material properties for stainless steel parts

### Sealing washer dimensions

	Sealing washer outer diameter D	Sealing washer inner diameter d	Stud	Sealing washer setting tool /Adapter size
	Metric size			
	31.5 mm	6.1 mm	F-BT-MR M6xL SN	X-WST F3-BT (M6-1/4")
	31.5 mm	7.4 mm	F-BT-MR M8xL SN	X-WST F3-BT (M8-5/16")
	31.5 mm	9.2 mm	F-BT-MR M10xL SN	X-WST F3-BT (M10-3/8")
	35.1 mm	12.2 mm	F-BT-MR M12xL SN	X-WST F3-BT (M12-1/2")
	Imperial size			
1.24"/31.5 mm	0.362"/9.2 mm	F-BT-MR 3/8xL SN	X-WST F3-BT (M10-3/8")	

Figure 5.1-3: Sealing washer dimensions

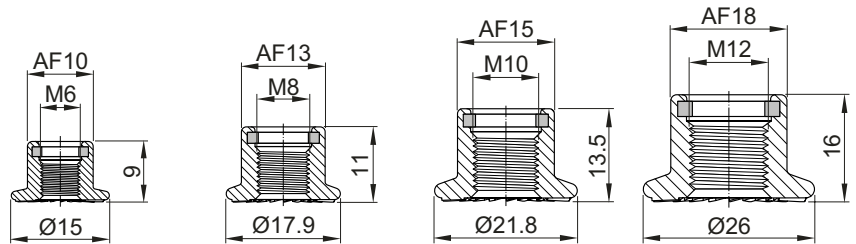
### Sealing washer material specification and material properties

Designation	Element	Material	Steel grade	Standard	Corrosion resistance class	Corrosion resistance standard
Sealing ring	Metal cap	Stainless steel	1.4404 (A4)	EN 10088-2	CRC III	EN 1993-1-4
		Stainless steel	316L	ASTM A240	-	-
Sealing ring	Sealing elastomer	chloroprene rubber (CR)				

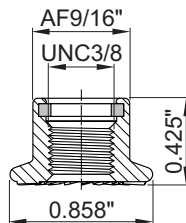
Table 5.1-4: Sealing washer material specification and material properties

### Flange lock nut dimensions

Metric size



Imperial size



• F-BT-MR SN shall only be used with the provided flange lock nut.

Figure 5.1-5: Flange lock nut dimensions

### Support plate dimensions

	Designation	Length l	Width w	Thickness t
	FX 3-SP S	100 mm	44 mm	5.5 mm
	FX 3-SP L	100 mm	47 mm	5.5 mm

Figure 5.1-6: Support plate dimensions

### Support plate material specification

Designation	Element	Material
FX 3-SP	Support plate	PA66-GF50

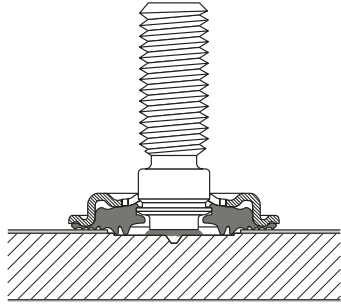
Table 5.1-7: Support plate material specification

- FX 3-SP S is compability with all F-BT-MR SN studs, with the exception of M12 sizes, which require the FX 3-SP L to accomodate the larger washer.

## 5.2 Specifications for installation

### 5.2.1 Application area

#### Intended use



- For multipurpose fastening of non-structural components
- Multiple fasteners are recommended for any attachment
- For fastening on coated unalloyed carbon steel
- Conditions during installation:
  - surface to be welded shall be maintained dry and free from condensation
  - temperature of stud and base material temperature: > 0°C (32°F)
- Service temperatures: -40°C to 60°C (-40°F to 140°F)

Figure 5.2.1-1: Intended use

### 5.2.2 Fastened material

#### Fastened material properties

Designation	Fastened material thickness		Hole tolerance	
	$t_{i,min}$	$t_{i,max}$	$d_{f,min}$	$d_{f,max}$
Metric size				
F-BT-MR M6x25 SN (4)	3.5 mm	10 mm	8 mm	9.5 mm
F-BT-MR M8x25 SN (4)		10 mm	9.5 mm	12 mm
F-BT-MR M6x25 SN (6)		10 mm	8 mm	9.5 mm
F-BT-MR M8x25 SN (8)		10 mm	9.5 mm	12 mm
F-BT-MR M10x25 SN (10)		10 mm	12 mm	15 mm
F-BT-MR M10x50 SN (10)		20 mm	12 mm	15 mm
F-BT-MR M12x25 SN (10)		10 mm	15 mm	18.5 mm
F-BT-MR M12x50 SN (10)		20 mm	15 mm	18.5 mm
Imperial size				
F-BT-MR 3/8x1 SN (5/32)	1/8" 3.5 mm	3/8" / 10 mm	0.472" 12 mm	0.571" 14.5 mm
F-BT-MR 3/8x1 SN (3/8)		3/8" / 10 mm		
F-BT-MR 3/8x1 1/2 SN (3/8)		3/4" / 20 mm		
F-BT-MR 3/8x2 SN (3/8)		3/4" / 20 mm		
F-BT-MR 3/8x4 SN (3/8)		3/4" / 20 mm		



• minimum fastened material thickness  $t_{i,min}$  may be achieved by use of multiple layers.

Table 5.2.2-2: Fastened material properties

### 5.2.3 Base material

#### Base material specification

##### Subgroup 1.1, 1.2 according to CEN ISO/TR 15608

Standard/ application area	Steel grade
EN 10025-2	S235JR +N (or +AR) to S355K2 +N (or +AR)
EN 10025-3	S275N/NL to S355N/NL
ASTM	ASTM A36, ASTM 572 Grade 50
Shipbuilding steel	A, B, D, E, AH 32, DH 32, AH 36, DH 36, EH 36
Carbon equivalent value: CEV ≤ 0.45	$CEV=C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$

**Table 5.2.3-1 Base material specification**

#### Base material thickness

	Minimum base material thickness	Maximum base material thickness
	$t_{II,min}$	$t_{II,max}$
Metric size		
F-BT-MR M6xL SN (4)	4 mm	30 mm
F-BT-MR M8xL SN (4)		
F-BT-MR M6xL SN (6)	6 mm	30 mm
F-BT-MR M8xL SN (8)	8 mm	30 mm
F-BT-MR M10xL SN (10)	10 mm	30 mm
F-BT-MR M12xL SN (10)		
Imperial size		
F-BT-MR 3/8xL SN (5/32)	5/32"/ 4 mm	1 1/8"/ 30 mm
F-BT-MR 3/8xL SN (3/8)	3/8"/ 10 mm	1 1/8"/ 30 mm

**Table 5.2.3-2: Base material properties**

#### Base material shape

Admissible base material shapes	Flat steel or curved steel with a minimum curve radius, R, of 23.5" (600 mm)
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**Table 5.2.3-3: Base material shape**

### Stud positioning on base material

Designation	Minimum spacing between studs $s_{min}$	Minimum edge distance $c_{min}$
Metric size		
F-BT-MR M6xL SN (4)	35 mm	38 mm
F-BT-MR M8xL SN (4)		
F-BT-MR M6xL SN (6)		
F-BT-MR M8xL SN (8)		
F-BT-MR M10xL SN (10)		
F-BT-MR M12xL SN (10)		
Imperial size		
F-BT-MR 3/8xL SN (5/32)	1 3/8" / 35 mm	1 1/2" / 38 mm
F-BT-MR 3/8xL SN (3/8)		

**Table 5.2.3-4: Stud positioning on base material**

## 5.3 Performance data

**Note:** The tabulated load values consider failure modes associated with the stud, weld, and base material rupture. Due to the high minimum tensile strength of the F-BT-MR studs, 87,000 psi (600 MPa), when welded to lower grade steel plates such as ASTM A36, failure may occur outside the stud during tests. Fastened materials must be evaluated separately in accordance with accepted design criteria.

### Design strength (LRFD) for tension, shear, and bending moment

Designation	Base material thickness $t_{II}$	Tension load $N_{LRFD}$	Compression load $N_{LRFD}$	Shear load $V_{LRFD}$	Bending moment $M_{LRFD}$
Metric size					
F-BT-MR M6xL SN (4)	$4 \leq t_{II} < 30$ mm	605 lb/ 2.7 kN	2700 lb/ 12 kN	335 lb/ 1.5 kN	n. a.
F-BT-MR M8xL SN (4)	$4 \leq t_{II} < 30$ mm	605 lb/ 2.7 kN	2700 lb/ 12 kN	335 lb/ 1.5 kN	
F-BT-MR M6xL SN (6)	$6 \leq t_{II} < 30$ mm	1050 lb/ 4.7 kN	2700 lb/ 12 kN	470 lb/ 2.1 kN	
F-BT-MR M8xL SN (8)	$8 \leq t_{II} < 30$ mm	1515 lb/ 6.7 kN	2700 lb/ 12 kN	675 lb/ 3.0 kN	
F-BT-MR M10xL SN (10)	$10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	2700 lb/ 12 kN	1215 lb/ 5.4 kN	22.2 lb-ft/ 30.1 Nm
F-BT-MR M12xL SN (10)	$10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	2700 lb/ 12 kN	1215 lb/ 5.4 kN	22.2 lb-ft/ 30.1 Nm
Imperial size					
F-BT-MR 3/8xL SN (5/32)	$5/32" \leq t_{II} < 1 1/8"$ $4 \leq t_{II} < 30$ mm	605 lb/ 2.7 kN	2700 lb/ 12 kN	335 lb/ 1.5 kN	22.2 lb-ft/ 30.1 Nm
F-BT-MR 3/8xL SN (3/8)	$3/8" \leq t_{II} < 1 1/8"$ $10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	2700 lb/ 12 kN	1215 lb/ 5.4 kN	22.2 lb-ft/ 30.1 Nm

**Table 5.3-1: Design strength (LRFD) for tension, shear, and bending moment**



### Allowable loads (ASD) for tension, shear, and bending moment

Designation	Base material thickness $t_{II}$	Tension load N	Compression load N	Shear load V	Bending moment M
Metric size					
F-BT-MR M6xL SN (4)	$4 \leq t_{II} < 30$ mm	405 lb/ 1.8 kN	1800 lb/ 8.0 kN	225 lb/ 1.0 kN	n. a.
F-BT-MR M8xL SN (4)	$4 \leq t_{II} < 30$ mm	405 lb/ 1.8 kN	1800 lb/ 8.0 kN	225 lb/ 1.0 kN	
F-BT-MR M6xL SN (6)	$6 \leq t_{II} < 30$ mm	700 lb/ 3.1 kN	1800 lb/ 8.0 kN	315 lb/ 1.4 kN	
F-BT-MR M8xL SN (8)	$8 \leq t_{II} < 30$ mm	1010 lb/ 4.5 kN	1800 lb/ 8.0 kN	450 lb/ 2.0 kN	
F-BT-MR M10xL SN (10)	$10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1800 lb/ 8.0 kN	810 lb/ 3.6 kN	14.7 lb-ft/ 20 Nm
F-BT-MR M12xL SN (10)	$10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1800 lb/ 8.0 kN	810 lb/ 3.6 kN	14.7 lb-ft/ 20 Nm
Imperial size					
F-BT-MR 3/8xL SN (5/32)	$5/32'' \leq t_{II} < 1\ 1/8''$ / $4 \leq t_{II} < 30$ mm	405 lb/ 1.8 kN	1800 lb/ 8.0 kN	225 lb/ 1.0 kN	14.7 lb-ft/ 20 Nm
F-BT-MR 3/8xL SN (3/8)	$3/8'' \leq t_{II} < 1\ 1/8''$ / $10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1800 lb/ 8.0 kN	810 lb/ 3.6 kN	14.7 lb-ft/ 20 Nm

Table 5.3-2: Allowable loads (ASD) for tension, shear, and bending moment

### Group fastenings

Group behaviour is affected by stud ductility and hole clearance. In order to cover unfavorable position of studs in rows or rectangular plates, the following should be taken into consideration for design:

	<p>Studs in rows:</p> <ul style="list-style-type: none"> <li>One stud of a row of n (here: n = 4) studs is considered for the total shear load of the row.</li> </ul>
	<p>Studs in rectangular plates:</p> <ul style="list-style-type: none"> <li>Rectangular plate with 4 studs in the corner and shear load introduction in center of plate.</li> <li>Two studs of a group of four studs are considered for the total shear load of the group.</li> </ul>

Figure 5.3-3: Group fastenings

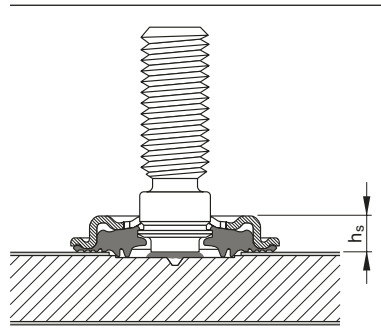
## 5.4 Installation recommendation

### 5.4.1 Stud installation

The following guidelines pertain to CSF stud installation. Typically installation will be performed in accordance with a welding code/standard such as EN ISO 14555 or AWS D1.6, which have additional requirements in regards to installation. Please see section 8 for more information regarding processes based on AWS D1.6.

### 5.4.2 Sealing washer installation inspection

#### Sealing washer inspection



Height between the top of installed sealing washer and coating surface,  $h_s$ , shall be a maximum of 6 mm (0.236"), which should be checked with the X-WCG F3-BT washer check gauge.



- For more details, please refer to the Instruction for Use (IFU).

Figure 5.4.2-1: Sealing washer inspection

### 5.4.3 Installation torque

#### Installation torque

Designation	Installation torque $T_{inst}$
Metric size	
F-BT-MR M8xL SN (4)	6 Nm
F-BT-MR M8xL SN (4)	6 Nm
F-BT-MR M6xL SN (6)	8 Nm
F-BT-MR M8xL SN (8)	20 Nm
F-BT-MR M10xL SN (10)	30 Nm
F-BT-MR M12xL SN (10)	30 Nm
Imperial size	
F-BT-MR 3/8xL SN (5/32)	4.4 lb-ft/6 Nm
F-BT-MR 3/8xL SN (3/8)	22.1 lb-ft/30 Nm



- F-BT-MR SN shall only be used with the provided flange lock-nut.
- For more details, please refer to the instructions for use (IFU).
- Only tightening tools with torque control functions shall be used. A powered tightening tool shall not be used.

Table 5.4.3-1: Installation torque

## 6.0 TECHNICAL DATA FOR F-BT-MR

### 6.1 Stud specification

#### Stud dimensions

	L L <sub>1</sub> d <sub>1</sub> d <sub>2</sub> d <sub>h1</sub> d <sub>h2</sub> d <sub>n</sub>			Thread length Nominal stud length Nominal diameter, thread diameter Diameter of weld area Diameter of stud area Diameter of stud holder interface Diameter of necking area of stud			
	Designation	L	L <sub>1</sub>	d <sub>1</sub>	d <sub>2</sub>	d <sub>h1</sub>	d <sub>h2</sub>
Metric size							
F-BT-MR M6x25 (6)	25 mm	31 mm	M6	5 mm	7 mm	7.6 mm	4.4 mm
F-BT-MR M8x25 (8)	25 mm	31 mm	M8	6 mm	8.6 mm	9.2 mm	6 mm
F-BT-MR M10x25 (10)	25 mm	31 mm	M10	7.2 mm	10.6 mm	11.2 mm	6.8 mm
F-BT-MR M10x50 (10)	50 mm	56 mm	M10	7.2 mm	10.6 mm	11.2 mm	6.8 mm
F-BT-MR M12x25 (10)	25 mm	31 mm	M12	7.2 mm	13.4 mm	14 mm	6.8 mm
F-BT-MR M12x50 (10)	50 mm	56 mm	M12	7.2 mm	13.4 mm	14 mm	6.8 mm
Imperial size							
F-BT-MR 3/8x1 (3/8)	1"	1.220"/ 31 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8x1 1/2 (3/8)	1 1/2"	1.732"/ 44 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8"x2 (3/8)	2"	2.205"/ 56 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 3/8"x4 (3/8)	4"	4.094"/ 104 mm	3/8"	0.283"/ 7.2 mm	0.417"/ 10.6 mm	0.441"/ 11.2 mm	0.268"/ 6.8 mm
F-BT-MR 1/2x1 1/2 (3/8)	1 1/2"	1.732"/ 44 mm	1/2"	0.283"/ 7.2 mm	0.528"/ 13.4 mm	0.441"/ 14 mm	0.268"/ 6.8 mm
F-BT-MR 1/2x2 (3/8)	2"	2.205"/ 56 mm	1/2"	0.283"/ 7.2 mm	0.528"/ 13.4 mm	0.441"/ 14 mm	0.268"/ 6.8 mm

Table 6.1-1 Stud dimensions

#### Stud material specification

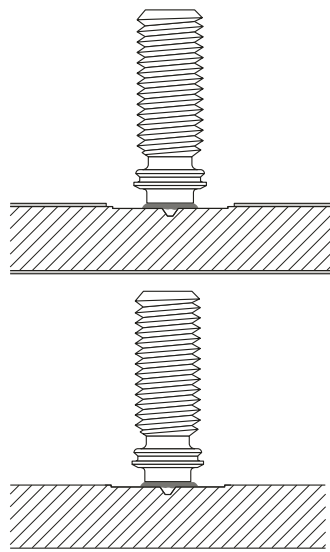
Designation	Element	Material	Steel grade	Standard	Corrosion resistance class	Corrosion resistance standard
F-BT-MR	Stud	Stainless steel	1.4571 (A5)	EN 10088-3	CRC III	EN 1993-1-4
			316Ti	ASTM A240/A276	-	-

Table 6.1-2 Stud material specification

## 6.2 Specification for installation

### 6.2.1 Application area

#### Intended use



- For multipurpose fastening of non-structural components
- Multiple fasteners are recommended for any attachment
- For fastening on coated or un-coated unalloyed carbon steel
- Conditions during installation:
  - Surface to be welded shall be maintained dry and free from condensation
  - Temperature of stud and base material temperature:  $> 0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ )
- Service temperatures  $-40^{\circ}\text{C}$  to  $60^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$  to  $140^{\circ}\text{F}$ )

Figure 6.2.1-1 Intended use

### 6.2.2 Fastened material

#### Fastened material properties

Designation	Fastened material thickness		Hole tolerance	
	$t_{i,min}$	$t_{i,max}$	$d_{f,min}$	$d_{f,max}$
Metric size				
F-BT-MR M6x25 (6)	4.5 mm	10 mm	8.5 mm	10 mm
F-BT-MR M8x25 (8)		10 mm	10 mm	12.5 mm
F-BT-MR M10x25 (10)		10 mm	12.5 mm	15.5 mm
F-BT-MR M10x50 (10)		20 mm	12.5 mm	15.5 mm
F-BT-MR M12x25 (10)		10 mm	15.5 mm	19 mm
F-BT-MR M12x50 (10)		20 mm	15.5 mm	19 mm
Imperial size				
F-BT-MR 3/8x1 (3/8)	3/16" / 4.5 mm	3/8" / 10 mm	0.492" / 12.5 mm	0.591" / 15 mm
F-BT-MR 3/8x1 1/2 (3/8)		3/4" / 20 mm		
F-BT-MR 3/8x2 (3/8)		3/4" / 20 mm		
F-BT-MR 3/8x4 (3/8)		3/4" / 20 mm	0.591" / 15 mm	0.768" / 19.5 mm
F-BT-MR 1/2x1 1/2 (3/8)		3/4" / 20 mm		
F-BT-MR 1/2x2 (3/8)		3/4" / 20 mm		

• Fastened material thickness  $t_{i,min}$  may be achieved by use of multiple layers.

Table 6.2.2-1: Fastened material properties

## 6.2.3 Base material

### Base material specification: subgroup 1.1, 1.2 according to CEN ISO/TR 15608

Standard/application area	Steel grade
EN 10025-2	S235JR +N (or +AR) to S355K2 +N (or +AR)
EN 10025-3	S275N/NL to S355N/NL
ASTM	ASTM A36, ASTM 572 Grade 50
Shipbuilding steel	A, B, D, E, AH 32, DH 32, AH 36, DH 36, EH 36
Carbon equivalent value: CEV ≤ 0.45	$CEV = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$

**Table 6.2.3-1: Base material specification**

### Base material properties

Designation	Minimum base material thickness		Maximum base material thickness	
	$t_{II,min}$	$t_{II,max}$	$t_{II,min}$	$t_{II,max}$
	(for uncoated base steel)		(for coated base steel)	
Metric size				
F-BT-MR M6xL (6)	2 mm	30 mm	6 mm	30 mm
F-BT-MR M8xL (8)	2 mm	30 mm	8 mm	30 mm
F-BT-MR M10xL (10)	2 mm	30 mm	10 mm	30 mm
F-BT-MR M12xL (10)	2 mm	30 mm	10 mm	30 mm
Imperial size				
F-BT-MR 3/8xL (3/8)	0.0787" / 2 mm	1 1/8" / 30 mm	3/8" / 10 mm	1 1/8" / 30 mm
F-BT-MR 1/2xL (3/8)	0.0787" / 2 mm	1 1/8" / 30 mm	3/8" / 10 mm	1 1/8" / 30 mm

**Table 6.2.3-2: Base material properties**

### Base material shape

Admissible base material shapes	Flat steel or curved steel with a minimum curve radius, R, of 23.5" (600mm)
---------------------------------	---

**Table 6.2.3-3: Base material shape**

### Stud positioning on base material

Designation	Minimum spacing between studs $s_{min}$	Minimum edge distance $c_{min}$
Metric size		
F-BT-MR M6xL (6)	35 mm	38 mm
F-BT-MR M8xL (8)		
F-BT-MR M10xL (10)		
F-BT-MR M12xL (10)		
Imperial size		
F-BT-MR 3/8xL (3/8)	1 3/8" / 35 mm	1 1/2" / 38 mm
F-BT-MR 1/2xL (3/8)		

**Table 6.2.3-4: Stud positioning on base material**

### 6.3 Performance data

**Note:** The tabulated load values consider failure modes associated with the stud, weld, and base material rupture. Due to the high minimum tensile strength of the F-BT-MR studs, 87,000 psi (600 MPa), when welded to lower grade steel plates such as ASTM A36, failure may occur outside the stud during tests. Fastened materials must be evaluated separately in accordance with accepted design criteria.

#### Design strength (LRFD) for tension, shear, and bending moment

Designation	Base material thickness $t_{II}$	Tension load $N_{LRFD}$	Shear load $V_{LRFD}$	Bending moment $M_{LRFD}$
Metric size				
F-BT-MR M6xL (6)	$6 \leq t_{II} < 30$ mm	1050 lb/ 4.7 kN	605 lb/ 2.7 kN	n. a.
F-BT-MR M8xL (8)	$8 \leq t_{II} < 30$ mm	1515 lb/ 6.7 kN	875 lb/ 3.9 kN	
F-BT-MR M10xL (10)	$10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	1515 lb/ 6.7 kN	22.2 lb-ft/ 30.1 Nm
F-BT-MR M12xL (10)	$10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	1515 lb/ 6.7 kN	22.2 lb-ft/ 30.1 Nm
Imperial size				
F-BT-MR 3/8xL (3/8)	$3/8" \leq t_{II} < 1 1/8"$ $10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	1515 lb/ 6.7 kN	22.2 lb-ft/ 30.1 Nm
F-BT-MR 1/2xL (3/8)	$3/8" \leq t_{II} < 1 1/8"$ $10 \leq t_{II} < 30$ mm	2700 lb/ 12 kN	1515 lb/ 6.7 kN	22.2 lb-ft/ 30.1 Nm

**Table 6.3-1: Design strength (LRFD) for tension, shear, and bending moment**

For installing studs to base materials, thinner than those listed within the table, see Section 6.3.1.

#### Allowable loads (ASD) for tension, shear, and bending moment

Designation	Base material thickness $t_{II}$	Tension load N	Shear load V	Bending moment M
Metric size				
F-BT-MR M6xL (6)	$6 \leq t_{II} < 30$ mm	700 lb/ 3.1 kN	405 lb/ 1.8 kN	n. a.
F-BT-MR M8xL (8)	$8 \leq t_{II} < 30$ mm	1010 lb/ 4.5 kN	585 lb/ 2.6 kN	
F-BT-MR M10xL (10)	$10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1010 lb/ 4.5 kN	14.7 lb-ft/ 20 Nm
F-BT-MR M12xL (10)	$10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1010 lb/ 4.5 kN	14.7 lb-ft/ 20 Nm
Imperial size				
F-BT-MR 3/8xL (3/8)	$3/8" \leq t_{II} < 1 1/8"$ $10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1010 lb/ 4.5 kN	14.7 lb-ft/ 20 Nm
F-BT-MR 1/2xL (3/8)	$3/8" \leq t_{II} < 1 1/8"$ $10 \leq t_{II} < 30$ mm	1800 lb/ 8.0 kN	1010 lb/ 4.5 kN	14.7 lb-ft/ 20 Nm

**Table 6.3-2: Allowable loads (ASD) for tension, shear, and bending moment**

For installing studs to base materials, thinner than those listed within the table, see Section 6.3.1.

### Group fastenings

Group behavior is affected by stud ductility and hole clearance. In order to cover unfavorable position of studs in rows or rectangular plates, the following should be taken into consideration for design:

	<p>Studs in rows:</p> <ul style="list-style-type: none"> <li>One stud of a row of n (here: n = 4) studs is considered for the total shear load of the row.</li> </ul>
	<p>Studs in rectangular plates:</p> <ul style="list-style-type: none"> <li>Rectangular plate with 4 studs in the corner and shear load introduction in center of plate.</li> <li>Two studs of a group of four studs are considered for the total shear load of the group.</li> </ul>

Figure 6.3-3: Group fastenings

## 6.3.1 Installing to thin base materials

When welding onto the minimum defined thicknesses of base material, the stud's neck is the weakest point, and thus dictates the failure load.

However, when welding on thinner base material, the base material rather than the neck is typically the weakest point. Therefore, the load values are reduced.

Consequently, when welding onto thin base material, a load reduction factor must be considered when calculating LRFD resistance or allowable loads.

Example:

$\alpha N_{LRFD}$  = Reduced LRFD resistance

$\alpha$  = Load reduction factor

$N_{LRFD}$  = LRFD resistance (on defined base material thickness)

From test data made using discrete base material thicknesses,  $\alpha$  load reduction factor formula has been derived for each of the stud types.

### Load reduction factor for thin base material

Designation	Thin base material thickness $t_{II}$	Load reduction factor for		
		Tension load	Shear load	Bending
Metric size				
F-BT-MR M6xL (6)	$2 \leq t_{II} < 4$ mm	$\alpha = (t_{II} + 4)/8$		n. a.
F-BT-MR M8xL (8)	$2 \leq t_{II} < 4$ mm	$\alpha = (t_{II} + 1)/5$		
F-BT-MR M10xL (10)	$2 \leq t_{II} < 6$ mm	$\alpha = (t_{II} + 1.5)/7.5$		
F-BT-MR M12xL (10)	$2 \leq t_{II} < 6$ mm			
Imperial size				
F-BT-MR 3/8xL (3/8)	$0.0787" \leq t_{II} < 0.236"$	$\alpha = (t_{II} + 0.059)/0.295$		



For metric sizes  $t_{II}$  shall be entered into the equation in mm and inches for imperial sizes.

Table 6.3.1-1: Load reduction factor for thin base material

## 6.4 Installation recommendation

### 6.4.1 Stud installation

The following guidelines provide the specifications for CSF stud installation. Typically installation will be performed in accordance with a welding code/standard such as EN ISO 14555 or AWS D1.6, which have additional requirements in regards to installation. Please see section 8 for more information regarding processes based on AWS D1.6.

### 6.4.2 Installation torque

#### Installation torque with flange lock nut

Designation	Installation torque $T_{inst}$	Recommended nut type
Metric size		
F-BT-MR M6xL (6)	8 Nm	Flange lock nut according to EN 1663
F-BT-MR M8xL (8)	20 Nm	
F-BT-MR M10xL (10)	30 Nm	
F-BT-MR M12xL (10)	30 Nm	
Imperial size		
F-BT-MR 3/8xL (3/8)	22.1 lb-ft/30 Nm	Flange lock nut with locking teeth according to ASME B 18.16.4
F-BT-MR 1/2xL (3/8)	22.1 lb-ft/30 Nm	



- For more details, please refer to the instructions for use (IFU).
- Only tightening tools with torque control functions shall be used. A powered tightening tool shall not be used.

**Table 6.4.2-1: Installation torque with flange lock nut**

#### Installation torque with Hot Dip Galvanized (HDG) nut

Designation	Installation torque $T_{inst}$	Recommended nut type
Metric size		
F-BT-MR M6xL (6)	8 Nm	HDG nut
F-BT-MR M8xL (8)	20 Nm	
F-BT-MR M10xL (10)	27 Nm	
F-BT-MR M12xL (10)	27 Nm	
Imperial size		
F-BT-MR 3/8xL (3/8)	20 lb-ft/ 27 Nm	HDG nut
F-BT-MR 1/2xL (3/8)	20 lb-ft/ 27 Nm	



- For more details, please refer to the instructions for use (IFU).
- Only tightening tools with torque control functions shall be used. A powered tightening tool shall not be used.

**Table 6.4.2-2: Installation torque with Hot Dip Galvanized (HDG) nut**



## 7.0 DESIGN CONCEPT

Both ASD and LRFD are widely used in the design of fastening on steel, and the choice of design method depends on various factors, including the application, the required level of safety, and the level of variability in the loads and material strengths. It is important to note that the design of fasteners should be performed by a qualified engineer or designer who is familiar with the relevant codes and standards.

### 7.1 Load and Resistance Factor Design (LRFD)

Under the Load and Resistance Factor Design (LRFD) Tables 5.3-1 and 6.3-1 loads were calculated by applying a factor,  $\Phi$ , to the average ultimate load of all test results or the calculated nominal strength of the stud, whichever results in a more conservative approach.

The  $\Phi$  factors applied to the F-BT LRFD resistances are  $\Phi = 0.75$  or less.

The load was therefore derived from the minimum between:

$$F_{LRFD} = \Phi_{test} * F_{test,avg}$$

or

$$F_{LRFD} = \Phi_{nominal} * F_{nominal}$$

### 7.2 Allowable Stress Design (ASD)

Allowable Stress Design (ASD) Tables 5.3-3 and 6.3-2 loads were calculated by applying a global safety factor,  $\Omega$ , to the average ultimate load of all test results or the calculated nominal strength of the stud, whichever results in a more conservative approach. The safety factor is assumed to cover expected variations in field installation conditions.

The safety factors applied to the F-BT allowable loads are  $\Omega = 2.0$  or greater.

The load was therefore derived from the minimum between:

$$F_{LRFD} = F_{test,avg} / \Omega_{test}$$

or

$$F_{LRFD} = F_{nominal} / \Omega_{nominal}$$

### 7.3 Load Interaction

Table 7.3-1 and 7.3-2 provide interaction equations where studs are loaded with tension, shear, and/or moments simultaneously.

Load combination	Load interaction equation
Shear – Tension	$\frac{V}{V_{LRFD}} + \frac{N}{N_{LRFD}} \leq 1.0$
Shear – Bending moment	$\frac{V}{V_{LRFD}} + \frac{M}{M_{LRFD}} \leq 1.0$
Tension – Bending moment	$\frac{N}{N_{LRFD}} + \frac{M}{M_{LRFD}} \leq 1.0$
Shear – Tension – Bending moment	$\frac{V}{V_{LRFD}} + \frac{N}{N_{LRFD}} + \frac{M}{M_{LRFD}} \leq 1.0$

**Table 7.3-1: Load interaction equations for LRFD**

Where:

- V = Factored shear load
- N = Factored tension load
- M = Factored bending moment
- $V_{LRFD}$  = Shear resistance from Table 5.3-1 or 6.3-1
- $N_{LRFD}$  = Tension resistance from Table 5.3-1 or 6.3-1
- $M_{LRFD}$  = Moment resistance from Table 5.3-1 or 6.3-1

Load combination	Load interaction equation
Shear – Tension	$\frac{V}{V_{ASD}} + \frac{N}{N_{ASD}} \leq 1.0$
Shear – Bending moment	$\frac{V}{V_{ASD}} + \frac{M}{M_{ASD}} \leq 1.0$
Tension – Bending moment	$\frac{N}{N_{ASD}} + \frac{M}{M_{ASD}} \leq 1.0$
Shear – Tension – Bending moment	$\frac{V}{V_{ASD}} + \frac{N}{N_{ASD}} + \frac{M}{M_{ASD}} \leq 1.0$

**Table 7.3-2: Load interaction equations for ASD**

Where:

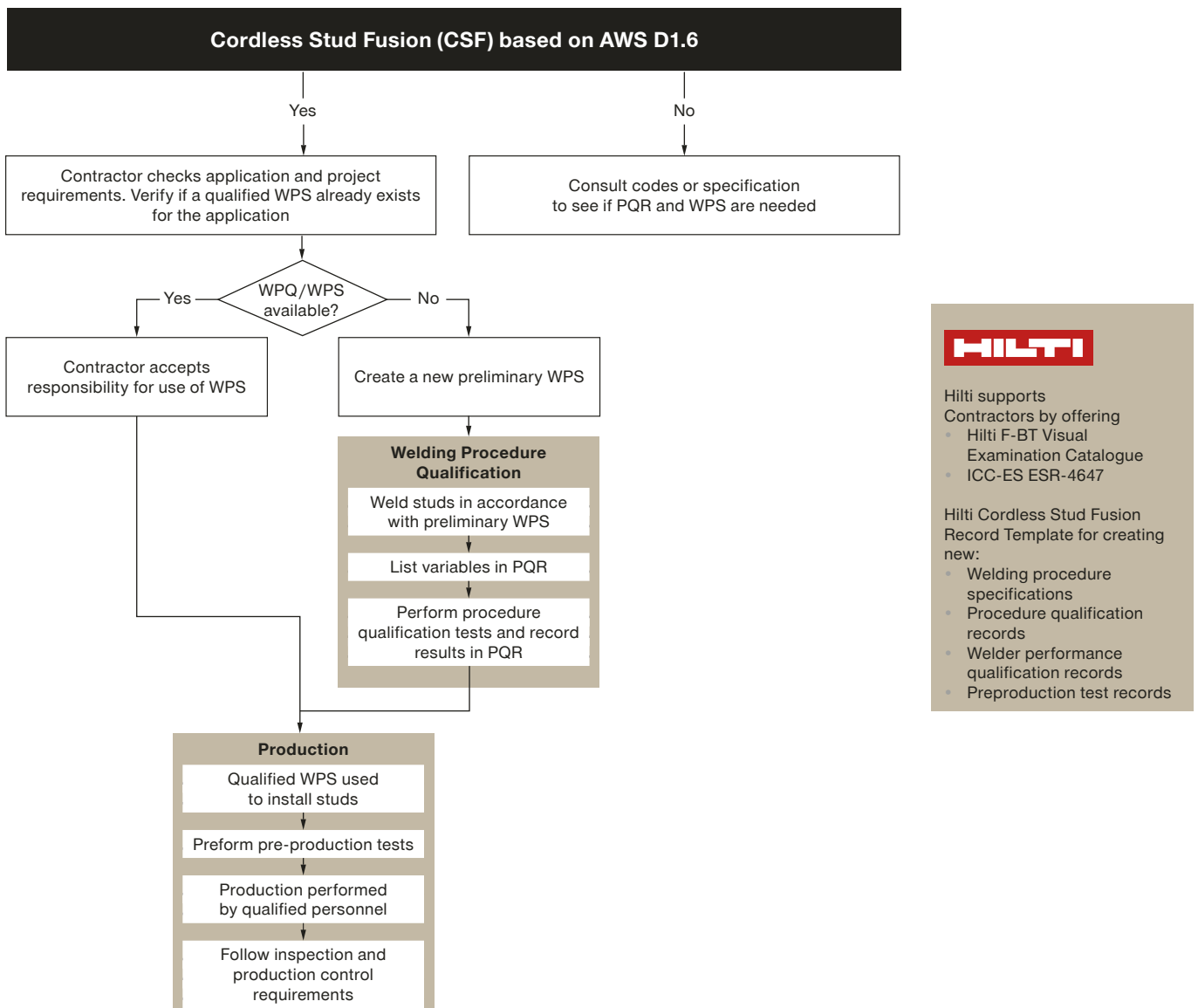
- V = Applied shear load
- N = Applied tension load
- M = Applied bending moment
- $V_{ASD}$  = Allowable shear load from Table 5.3-2 or 6.3-2
- $N_{ASD}$  = Allowable tension load from Table 5.3-2 or 6.3-2
- $M_{ASD}$  = Allowable moment from Table 5.3-2 or 6.3-2

## 8.0 CORDLESS STUD FUSION (CSF) BASED ON AWS D1.6/D1.6M AND B2.1/B2.1M

The purpose of this section is to assist users incorporate the Cordless Stud Fusion system into jobsite processes and provide basic information regarding Welding Procedure Specifications (WPS), Procedure Qualification Records (PQR), and Stud Welding Operator Performance Qualification (WPQ). The focus of this section is the use of the products based on AWS D1.6 and by extension AWS B2.1.

AWS D1.6/D1.6M, Structural Welding Code – Stainless Steel, addresses welding of stainless steel studs to stainless steel base materials, but does not specify carbon steel base materials, therefore AWS B2.1, which covers a wider array of base materials, is typically referenced. Per AWS D1.6, section 6.3.2, welding procedures qualified in accordance with AWS B2.1/B2.1M, Specification for Welding Procedure and Performance Qualification, are acceptable for use under AWS D1.6.

The information in this section does not supersede requirements as set forth by the Authority Having Jurisdiction (AHJ) or project, jobsite, and employer specific requirements.



**Figure 8-1: Cordless Stud Fusion (CSF) process implementation to production**

## 8.1 Stud Welding Procedure Qualification

### 8.1.1 Procedure Qualification Records (PQR)

Typically, procedures for welding are qualified via testing and documented within a Procedure Qualification Record (PQR). A PQR is a document that provides a record of the welding parameters and results of welding procedure qualification tests. The PQR is prepared to demonstrate that a particular welding procedure meets the requirements of a specific welding standard, such as AWS D1.6 or B2.1.

### 8.1.2 Welding Procedure Qualification Tests

When welding procedure qualification is required, tests shall be carried out and results recorded within a PQR. Test methods should be agreed upon between contracting parties. Typical methodologies may include:

**Welding procedure qualification tests based on AWS D1.6 or AWS B2.1**

Test type	Test category	No. of samples	Test acceptance criteria
Visual examination	Surface examination	10	Hilti F-BT visual examination catalogue [7]
	Stud examination		
Physical testing	Destructive testing - bend testing	10	See figure 8.4.1-2
	or		
	Destructive testing - tension testing	10	See figure 8.4.2-1
	or		
	Destructive testing - bend testing	5	See figure 8.4.1-3
	and		
	Non-destructive testing - tension testing	5	See figure 8.4.3-1

**Table 8.1.2-1: Welding procedure qualification tests**

### 8.1.3 Welding Procedure Specifications (WPS)

Welding Procedure Specifications are documents that provide the specific guidelines for performing a welding operation. The WPS outlines the welding parameters, materials, and other requirements necessary to ensure that the welding operation produces a sound weld that meets the specified quality criteria. PQR documents are used to qualify the creation of new WPS. It is possible for a single WPS to be created using multiple PQR documents, and a PQR may be retained as proof for multiple WPS documents.

Per AWS D1.6, each contractor is responsible for the qualification of welding procedures to be used, however, it is permissible to subcontract any or all the work provided the Contractor accepts full responsibility for the work. For full details on these requirements, please reference AWS D1.6 Section 6.3.1.

Note that the PQR provides a record of the precise variables tested, while a WPS may contain a range of variables. The following variables are typically recorded, however based on application and requirements it may be necessary to supplement or reduce the list.

- Identification of the contractor
- Surface preparation
- Welding process and associated tools/accessories
- Environmental conditions
- Conditions related to the base material
- Conditions related to the stud material
- Welding installation orientations

For more information regarding qualification of stud welding procedures, please reference AWS D1.6 Clause 9 and AWS B2.1 Clauses 4.11 and 4.13.

### 8.1.4 Conditions related to base material

For the base material to be used, proof of conformity shall be available. In the absence of said proof, the base material shall be subjected to additional material tests before welding.

Cordless Stud Fusion (CSF) covers material groups 1.1 or 1.2 in accordance with ISO/TR 15608. For more details, see Table 6.2.3-1: Base material specification. ICC-ES Evaluation Service Report (ESR) 4647 qualifies F-BT-MR installation to ASTM A36 and ASTM A572 Gr50 base materials, which are AWS B2.1 Annex C Material (M-Number) 1 Group 1 materials.

#### Base material conditions

Code/Standard	Specification	Material/Group Number
AWS B2.1	ASTM A36	Annex C, M-Number 1, Group 1
	ASTM A572 Grade 50	Annex C, M-Number 1, Group 1
CEN ISO/TR 15608		Subgroup 1.1
		Subgroup 1.2

**Table 8.1.4-1: Base material conditions**

Per AWS B2.1, category grouping does not imply that base metals may be substituted for other base metals within the same Material Number (M-Number) without consideration for weldability.

Table 8.1.4-2 shows the minimum base material thicknesses which have been investigated within welding procedure tests by Hilti.

<b>Minimum base material thickness</b>		
Welding process	Designation	Designation base material thickness without backside coating damage
Drawn-arc stud welding with shielding gas (Welding process 783 according to EN ISO 14555).	F-BT-MR M6x25 SN (4)	4 mm
	F-BT-MR M8x25 SN (4)	4 mm
	F-BT-MR M6x25 SN (6) F-BT-MR M6x25 (6)	6 mm
	F-BT-MR M8x25 SN (8) F-BT-MR M8x25 (8)	8 mm
	F-BT-MR M10x25 SN (10) F-BT-MR M10x50 SN (10) F-BT-MR M10x25 (10) F-BT-MR M10x50 (10) F-BT-MR M12x25 SN (10) F-BT-MR M12x50 SN (10) F-BT-MR M12x25 (10) F-BT-MR M12x50 (10)	10 mm
	F-BT-MR 3/8x1 SN (5/32)	5/32" / 4mm
	F-BT-MR 3/8x1 SN (3/8) F-BT-MR 3/8x1 1/2 SN (3/8) F-BT-MR 3/8x2 SN (3/8) F-BT-MR 3/8x4 SN (3/8) F-BT-MR 3/8x1 (3/8) F-BT-MR 3/8x1 1/2 (3/8) F-BT-MR 3/8x2 (3/8) F-BT-MR 3/8x4 (3/8) F-BT-MR 1/2x1 1/2 (3/8) F-BT-MR 1/2x2 (3/8)	3/8" / 10 mm

Table 8.1.4-2: Minimum base material thickness

### 8.1.5 Conditions related to stud material

For the stud material the proof of conformity will be provided by Hilti upon request. For stud material specifications, please reference Tables 5.1-2 and 6.1-2.

### 8.1.6 Conditions related to welding positions

The Cordless Stud Fusion (CSF) process, including the surface preparation and the Cordless Stud Fusion itself can be executed in any of the positions referenced in AWS D1.6, figure 9.3.

Table 8.1.6 below gives an overview of the welding installation positions:

Welding positions per AWS D1.6		
Position (example)	AWS D1.6 Designation	Range tolerance
Downward (floor)	1S	±45°
Horizontal (wall)	2S	
Overhead (ceiling)	4S	

Table 8.1.6-1: Welding and testing positions

Positions refer to the orientation of the stud and hand tool at the time of installation.

For procedure qualification installation orientation is an aspect of qualification. Tests on studs installed in the 2S or 4S position also qualify installations in the 1S position.

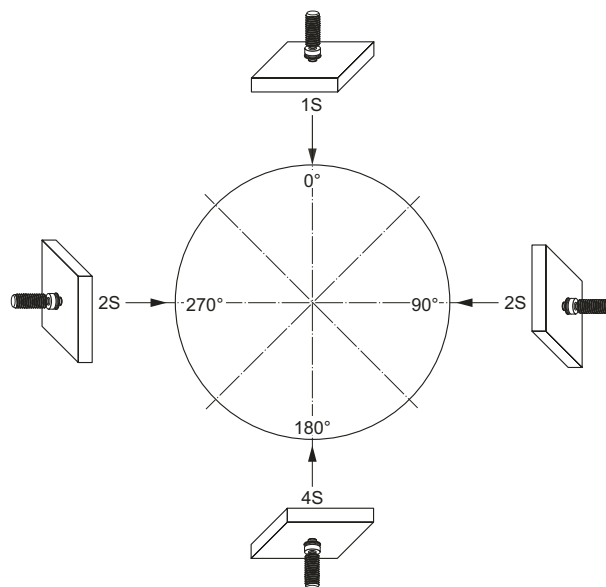


Figure 8.1.6-1: Welding and testing positions

### 8.2 Production Control

AWS D1.6 Clause 9.6 provides requirement for production welding control, including pre-production testing, technique, workmanship, repair and removal.

Cordless Stud Fusion specific workmanship and technique requirements, such as those concerning stud spacing, surface preparation and tool operation, are detailed within this manual and the Instructions for use (IFU).

## 8.2.1 Pre-production tests

Per AWS D1.6 pre-production testing is required at the start of each shift for a particular set-up with a given size and type of stud. A minimum of two studs must be welded and tested. These tests can be carried out by using actual production pieces or by using test specimens. If test specimens are utilized, they and the installation methods must correspond to production conditions. See AWS D1.6 Clause 9.6.1 for more information.

Pre-production tests based on AWS D1.6			
Test type	Test category	No. of sample	Test acceptance criteria
Visual examination	Surface examination	2	Hilti F-BT visual examination catalogue [7]
	Stud examination		
Physical testing	Destructive testing - bend testing	2	See figure 8.4.1-2
	or		
	Non-destructive testing - torque testing	2	See figure 8.4.4-1

**Table 8.2.1-1: Pre-production tests**

In the event of failure of the above tests, two additional studs must be installed and tested until two consecutive studs are found to be satisfactory before production can commence.

## 8.2.2 Inspection

All surface preparations and welds shall be visually inspected. Due to the unique tooling and weld shape, Hilti provides the F-BT visual examination catalogue [7] to help verify proper installation.

For studs that do not pass visual examination, take corrective actions from Hilti F-BT Visual Examination Catalogue or AWS D1.6. Inspection records may be required based on jobsite requirements.



### 8.3 CSF Personnel

Cordless Stud Fusion operators shall complete performance qualification testing using a qualified WPS. The purpose of welding operator performance qualification testing is to ensure the operators have the ability to produce a sound weld.

Operators may be qualified by successful completion of the pre-production testing described in section 8.2.1 or by the methods outlined in AWS D1.6 Clause 9.5 using test specimens corresponding to production conditions.

**Stud Welding Operator Performance Qualification tests based on AWS D1.6**

Test type		Test category	No. of sample	Test acceptance criteria
Visual examination		Surface examination	2	Hilti F-BT visual examination catalogue [7]
		Stud examination		
Physical testing	Per AWS D1.6, clause 9.5	Destructive testing - bend testing	2	See figure 8.4.1-2
		or		
		Non-destructive testing - torque testing	2	See figure 8.4.4-1

**Table 8.3-1: Stud Welding Operator Performance Qualification tests**

## 8.4 Visual examination and physical testing details

**Note:** It is important to note that due to the high minimum tensile strength of the F-BT-MR studs, 87,000 psi (600 MPa), when welded to lower grade steel plates such as ASTM A36, during destructive testing failure may occur outside the stud. The performance data found in Section 5.3 and 6.3 considers failure modes associated with the stud, weld, and base material rupture when welded to ASTM A36 steel.

### 8.4.1 Destructive testing – bend testing

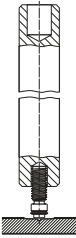
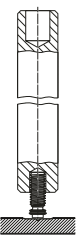
Stud type: F-BT-MR SN	Stud type: F-BT-MR	Description
		<ul style="list-style-type: none"> <li>Use bend device FX 3-SP S</li> </ul> or <ul style="list-style-type: none"> <li>Position alternative bending device above the neck at the threaded section</li> <li>Bending device shall be positioned to allow bending of the necked section. The bending device shall not make contact with the unthreaded portion of the stud during this process.</li> </ul>

Figure 8.4.1-1: Bend device

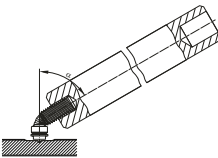
Test description	Acceptance criteria
 <ul style="list-style-type: none"> <li>Bend stud back and forth until failure with an angle 30°</li> <li>or</li> <li>bend stud to 90°</li> </ul>	<ul style="list-style-type: none"> <li>Test passes if no fracture in weld/ Heat Affected Zone (HAZ)</li> </ul>

Figure 8.4.1-2: PQR bend test according to AWS D1.6

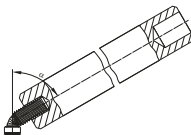
Test description	Acceptance criteria
 <ul style="list-style-type: none"> <li>Bend stud to an angle <math>\alpha \geq 15^\circ</math></li> </ul>	<ul style="list-style-type: none"> <li>Test passes if no visible separation or fracture</li> </ul>

Figure 8.4.1-3: PQR bend test according to AWS B2.1

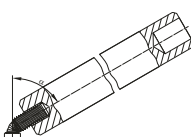
Test description	Acceptance criteria
 <ul style="list-style-type: none"> <li>Bend stud to an angle <math>\alpha \geq 30^\circ</math></li> </ul>	<ul style="list-style-type: none"> <li>Test passes if no fracture in weld/HAZ</li> </ul>

Figure 8.4.1-4: Pre-production and operator qualification bend test according to AWS D1.6

### 8.4.2 Destructive testing – tension test

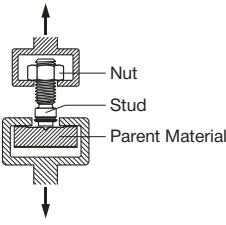
Test description		Acceptance criteria
	<ul style="list-style-type: none"> <li>• Pull welded stud until fracture</li> </ul>	<ul style="list-style-type: none"> <li>• Test passes if no fracture in weld/HAZ</li> <li>• Fracture in the stud or base material outside the HAZ is acceptable.</li> </ul>

Figure 8.4.2-1: PQR tension test according to AWS D1.6

### 8.4.3 Non-destructive testing – tension test (HAT 28-FX)


Test description		Acceptance criteria
	<ul style="list-style-type: none"> <li>• Pull welded stud until tensile proof load is reached</li> <li>• Standard tensile proof load for H-Codes               <ul style="list-style-type: none"> <li>H1: 1690 lb/ 7.5 kN</li> <li>H2: 1225 lb/ 9 kN</li> <li>H3: 3820 lb/ 17 kN</li> <li>H10: 4950 lb/ 22 kN</li> </ul> </li> <li>• These tensile proof loads are based on 87,000 psi (600 MPa), surpassing the AWS B2.1 4.11.4 minimum requirement of 35,000 psi (241 MPa).</li> </ul>	<ul style="list-style-type: none"> <li>• Test is acceptable if any of the following resulting conditions are met:               <ol style="list-style-type: none"> <li>1. Proof load is met without failure</li> <li>2. If failure occurs in the base metal outside of the weld or weld interface.</li> </ol> </li> </ul>

Figure 8.4.3-1: PQR tension test according to AWS B2.1

The standard tensile proof load within the table provided is for F-BT studs installed in the standard base materials specifications and thicknesses. To ensure all variables are accounted for, proof loads should be verified with the Engineer of Record (EoR) before application of load.

### 8.4.4 Non-destructive testing – torque test

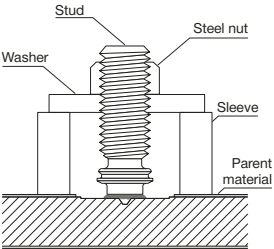
Test description	Acceptance criteria
 <ul style="list-style-type: none"> <li>• Torque nut until torque proof load is reached.</li> <li>• Torque proof load for stud sizes               <ul style="list-style-type: none"> <li>H1: 4.4 lb-ft (6 Nm)</li> <li>H2: 5.9 lb-ft (8 Nm)</li> <li>H3: 14.7 lb-ft (20 Nm)</li> <li>H10: 22.1 lb-ft (30 Nm)</li> </ul> </li> <li>• These proof torque values are based on reduced neck diameter of the F-BT studs as opposed to the thread diameter and surpass the equivalent values provided in AWS D1.6 Tables 9.2 and 9.3.</li> </ul>	<ul style="list-style-type: none"> <li>• No fracture until stud torque values are surpassed.</li> </ul>

Figure 8.4.4-1: PQR torque test according to AWS D1.6

## 9.0 CSF ORDERING INFORMATION

### 9.1 Surface preparation equipment

Item no. and description for stud fusion equipment		
Designation	Item no.	Description
SF 8M-A22	Local item: 2061288, 2061305, 2123924	Cordless drill driver
SF 6H-22	2254917	Cordless hammer drill driver
FX 3-ST d14	2270514	Surface tool for uncoated base material or weldable primer on base material
FX 3-ST d20	2270512	Surface tool for coated base material

### 9.2 Stud fusion equipment

Item no. and description for stud fusion equipment		
Designation	Item no.	Description
FX 3-BC	2257272	Base clamp
C 53	Local item: 2270521	CSF Charger
FX 3-HT	Local item: 2270527	Cordless stud fusion hand tool
FX 3-A	Local item: 2270478	Cordless stud fusion unit
FX 3-GC	2241926	Gas can
X-SR F3	2331667	Hand tool shielding ring
X-SL F3	2331668	Hand tool support leg
X-GC F3	2257272	FX ground cable
X-MC F3	2259030	Magnetic ground clamp
X-SH F3 M6 – 1/4"	2257273	Stud holder
X-SH F3 M8 – 5/16"	2257274	
X-SH F3 M10 – 3/8"	2257275	
X-SH F3 M12 – 1/2"	2257271	
X-SH F3-MIX	2294502	Stud holder mix
X-SHT F3	2293828	Stud holder change tool

### 9.3 Installation equipment

#### Item no. and description for installation equipment

Designation	Item no.	Description
X-WST F3-BT	2278582	SCF washer setting tool and adaptors for metric (M6, M8, M10, M12) and imperial (3/8", 1/2") studs
X-WCG F3-BT	2331669	Washer check gauge

### 9.4 Studs

#### Item no. and description for F-BT-MR studs without sealing washer

Designation	Item no.	Description
Metric sizes		
F-BT-MR M6x25 (6)	2293866	For fastening to standard base material thickness
F-BT-MR M8x25 (8)	2293867	
F-BT-MR M10x25 (10)	2293868	
F-BT-MR M10x50 (10)	2293869	
F-BT-MR M12x25 (10)	2293870	
F-BT-MR M12x50 (10)	2293871	
Imperial sizes		
F-BT-MR 3/8x1 (3/8)	2293890	For fastening to standard base material thickness
F-BT-MR 3/8x1 1/2 (3/8)	2293891	
F-BT-MR 3/8x2 (3/8)	2293892	
F-BT-MR 3/8x4 (3/8)	2293893	
F-BT-MR 1/2x1 1/2 (3/8)	2293895	
F-BT-MR 1/2x2 (3/8)	2293896	

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**Item no. and description for F-BT-MR SN studs with sealing washer**

Designation	Item no.	Description
Metric sizes		
F-BT-MR M6x25 SN (4)	2346394	For fastening to thin base material
F-BT-MR M8x25 SN (4)	2293865	
F-BT-MR M6x25 SN (6)	2293829	For fastening to standard base material thickness
F-BT-MR M8x25 SN (8)	2293860	
F-BT-MR M10x25 SN (10)	2293861	
F-BT-MR M10x50 SN (10)	2293862	
F-BT-MR M12x25 SN (10)	2293863	
F-BT-MR M12x50 SN (10)	2293864	
Imperial sizes		
F-BT-MR 3/8x1 SN (5/32)	2293887	For fastening to thin base material
F-BT-MR 3/8x1 SN (3/8)	2293880	For fastening to standard base material thickness
F-BT-MR 3/8x1 1/2 SN (3/8)	2293881	
F-BT-MR 3/8x2 SN (3/8)	2293882	
F-BT-MR 3/8x4 SN (3/8)	2293883	

## 9.5 Support plate

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**Item no. and description for support plate**

Designation	Item no.	Description
FX 3-SP S	2360102	CSF support plate for M6, M8, M10
FX 3-SP L	2360103	CSF support plate for M12

## 9.6 Test equipment

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**Item no. and description for test equipment**

Designation	Item no.	Description
X-BB F3	2401712	Bending bar
HAT 28-FX	2369734	Anchor tester

## 10.0 REFERENCES

- [1] AWS B2.1: Specification for Welding Procedure and Performance Qualification, 2014.
- [2] AWS D1.6/D1.6M: Structural Welding Code – Stainless steel, 2017.
- [3] CEN ISO/TR 15608: Welding – Guidelines for a metallic materials grouping system.
- [4] EN 1993-1-4: 2005: Eurocode 3 – Design of steel structures – Part 1–4: General rules – Supplementary rules for stainless steels.
- [5] EN ISO 14175: Welding consumables – Gases and gas mixtures for fusion welding and allied processes, 2018.
- [6] EN ISO 14555: Welding – Arc stud welding of metallic materials, 2007.
- [7] Hilti F-BT visual examination catalogue, OTR 5724148/02, November 14, 2022.
- [8] Hilti, Weld Procedure Specification: CSF-WPS F-BT-MR (EU), Version: 01/2022-11-02.







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