October 10, 2017

Subject: Static and Seismic Performance Evaluation of the S-BT Fastening System

Hilti developed an entirely new fastening system, designated as “S-BT fastening system”. The S-BT fasteners are threaded studs manufactured from hardened carbon steel and AISI 316 equivalent stainless steel. It is a screwable stud which is installed into a pre-drilled hole. The screwable tip will tap its own mating threads when installed into the base material. The S-BT fastening system can be used as an alternative to welds and bolts used to attached materials to structural steel

Extensive testing has been carried out in Hilti North America to evaluate both static and seismic performances of the S-BT fasteners. The tests were performed in Hilti Western Hemisphere Product Development and Tool Service Center and witnessed and supervised by a third-party testing agency, Specialized Testing Inc. Because the S-BT fastener is a new product category, standards and acceptance criteria which can be used for testing and evaluation are limited. Therefore, we rely on recognized standards such as ASTM E1190 as the basis for developing a testing and evaluation program for both the static and seismic load performance of the S-BT fasteners.

Both static test report (03-16-A-R) and seismic test report (03-16-B-R) are enclosed. From the static test report, detailed information regarding how the static load is developed can be found. In the seismic test report, the test results show that the S-BT fasteners meet or exceed the established performance requirements. The recommended allowable loads which are applicable to both static and seismic conditions are tabulated in the enclosed Hilti Product Technical Guide (PTG). Installation guidance and other technical information can be found in the PTG as well which follows this letter.

If you have any questions or concerns, I can be reached by phone at (972) 403-5947 or by electronic mail at chenkai.li@hilti.com.

Regards,

Chenkai Li

Chenkai Li, P.E.
Technical Services Engineer
Hilti, Inc.

Encl.

[1] Hilti (2017): ***Hilti Product Technical Guide Supplement S-BT Screw-in Threaded Studs,*** October, 2017

[2] Specialized Testing, Foster, T. (2017): ***Hilti Report #03-16-A-R, Hilti Inc. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MR W10/15 AN6 and S-BT-MF M8/7 AN6 Screw-in Threaded Stud Fasteners Static Tension and Shear Tests in ASTM A36 and A572 Steels,*** revised September, 2017

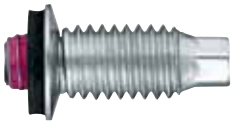
[3] Specialized Testing, Foster, T. (2017): ***Hilti Report #03-16-B-R, Hilti Inc. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MR W10/15 AN6 and S-BT-MF M8/7 AN6 Screw-in Threaded Stud Fasteners Seismic Tension and Shear Tests in ASTM A572 Steels,*** revised September, 2017

Hilti, Inc.
7250 Dallas Parkway, Suite 1000
Plano, TX 75024

1-800-879-8000
www.hilti.com

HILTI PRODUCT TECHNICAL GUIDE SUPPLEMENT S-BT SCREW-IN THREADED STUDS

Supplement to Hilti North American Procuct Technical Guide Volume 1: Direct Fastening Technical Guide, Edition 17



Listings/Approvals

ABS (American Bureau of Shipping)
LR (Lloyd's Register)
DNV-GL
RS (Russian Maritime Register of shipping)
BV (Bureau Veritas)

3.2.11 S-BT Fastening Systems

3.2.11.1 Product Description

The Hilti S-BT Fastening System is an innovative method of fastening to steel or Aluminum base materials. The system consists of a Hilti installation tool equipped with depth gauge for use with setting the S-BT studs.

The S-BT fasteners are threaded studs manufactured from carbon steel or stainless steel with thread diameters 8 mm (M8) and 3/8" (W10). Carbon steel studs are supplied with an aluminum sealing washer Ø10 mm, stainless steel studs are supplied with a stainless steel sealing washer Ø12, both with an EPDM sealing ring, are cleanly set in a pre-drilled hole in the base steel. The S-BT system is designed to work on carbon steels from 1/8'' to 3/16'' and Aluminum base materials from 0.2 to 1/4'' thick with a pre-drilled through hole and both carbon steels and Aluminum base materials ≥ 1/4'' with a pre-drilled pilot hole.

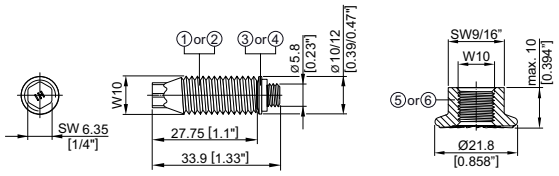
Product Features

- No propellants required.
- No through penetration of steel and aluminum base materials 1/4" and thicker.
- No rework of coated steel required for non-through hole applications with base material thickness larger than 1/4''.
- Offer fastening options for both stainless and carbon steel materials.
- Easy removal - S-BT fastener is removable.

3.2.11.2 Material Specifications

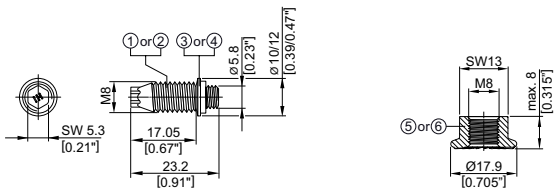
Product	Part	Material Designation	Tensile Strength, F_u ksi (N/mm2)
Stainless Steel (S-BT-_R)	① **Shank**	Corrosion Resistant Stainless Steel S 31803 (1.4462)	≥ 190 (320)
	③ **SN washer**	Corrosion Resistant Stainless Steel S 31603 (1.4404)	N/A
	⑤ **Serrated Flange Nut**	Corrosion Resistant Stainless Steel grade A4 – 70/80	≥ 100 (700)
Carbon Steel (S-BT-_F)	② **Shank**	Carbon Steel 1038 duplex coated	≥ 130 (900)
	④ **AN washer**	Aluminum	N/A
	⑥ **Serrated Flange Nut**	Carbon Steel HDG	≥ 125 (870)
Both Stainless Steel (S-BT-_R) and Carbon Steel (S-BT-_F)	**Sealing Washer**	Elastomer, black resistant to: UV, water, ozone, oils, etc.	N/A

S-BT-MF W10/15 AN6



S-BT-GR M8/7 SN 6*)
S-BT-GF M8/7 AN 6*)

*): package does not include serrated flange nuts



3.2.11.3 Technical Data

Allowable Loads in Minimum ASTM A36 (F_y ≥ 36 ksi; F_u ≥ 58 ksi) Steel[1,2]

Fastener	Steel Thickness in.					
	1/8		3/16		≥ 1/4	
	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
S-BT-GR M8/7 SN 6	225 (1.00)	340 (1.50)	225 (1.00)	340 (1.50)	405 (1.80)	540 (2.40)
S-BT-GF M8/7 AN 6 S-BT MF W10/15 AN 6	225 (1.00)	340 (1.50)	225 (1.00)	340 (1.50)	405 (1.80)	540 (2.40)

1 The tabulated allowable values are for the S-BT fasteners only, using a safety factor that is greater than or equal to 5.0.
2 Multiple fasteners are recommended for any attachment.

Allowable Loads in Minimum ASTM G50 (F_y ≥ 50 ksi; F_u ≥ 65 ksi) Steel[1,2]

Fastener	Steel Thickness in.					
	1/8		3/16		≥ 1/4	
	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
S-BT-GR M8/7 SN 6	295 (1.30)	430 (1.90)	295 (1.30)	430 (1.90)	520 (2.30)	610 (2.70)
S-BT-GF M8/7 AN 6 S-BT MF W10/15 AN 6	295 (1.30)	430 (1.90)	295 (1.30)	430 (1.90)	520 (2.30)	510 (2.25)

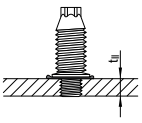
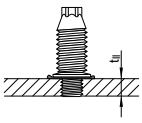
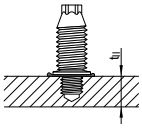
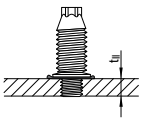
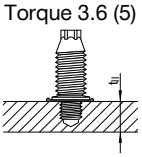
1 The tabulated allowable values are for the S-BT fasteners only, using a safety factor that is greater than or equal to 5.0.
2 Multiple fasteners are recommended for any attachment.

Allowable Loads in Minimum F_u ≥ 39 ksi Aluminum[1]

Fastener	Aluminum Thickness t_{II} in.			
	0.2 ≤ t_{II} < 1/4		t_{II} ≥ 1/4	
	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
S-BT-GR M8/7 SN 6 S-BT-GF M8/7 AN 6 S-BT-MF W10/15 AN 6	135 (0.60)	205 (0.90)	135 (0.60)	205 (0.90)

1 The Tabulated allowable values are for the S-BT fasteners only, using a safety factor that is great than or equal to 5.0.

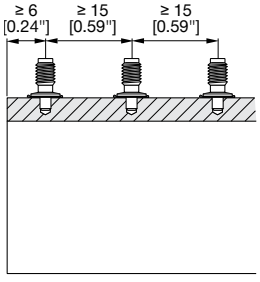
Maximum Tightening Torque on Serrated Flange Nut, ft-lb (Nm) and Type of Bore Hole

Fastener	Steel Thickness t_{II} in.			Aluminum Thickness t_{II} in.	
	1/8 ≤ t_{II} < 3/16	3/16 ≤ t_{II} < 1/4	t_{II} ≥1/4	0.2 ≤ t_{II} < 1/4	t_{II} ≥1/4
S-BT-GR M8/7 SN 6 S-BT-GF M8/7 AN 6 S-BT-MF W10/15 AN 6	Torque 3.6 (5)  Drill through hole*	Torque 5.9 (8)  Drill through hole*	Torque 5.9 (8)  Pilot hole*	Torque 3.6 (5)  Drill through hole*	Torque 3.6 (5)  Pilot hole*

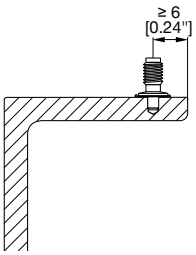
* In case of a drill through hole, or a pilot hole with thickness of 1/4 inch, rework of the coating on the back side of the plate / profile may be needed.

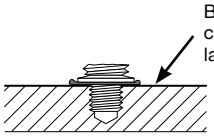
Spacing and Edge Distances

Spacing: ≥ 15 mm



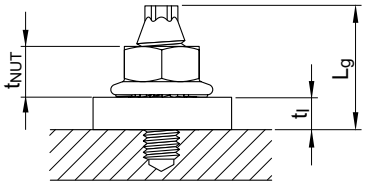
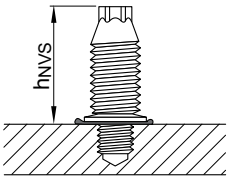
Edge distance: ≥ 6 mm



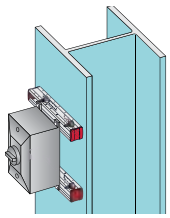
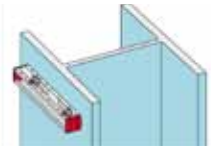
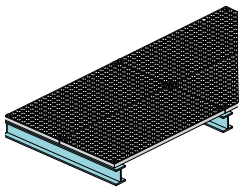


Remark: thickness of base material corrosion protection layer ≤ 0.8 mm [0.032"].
For thicker coatings, please contact Hilti.

Application Requirements

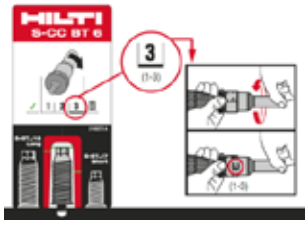
Thickness of Fastened Materials	Checking Stand-off from the Base Material
	
S-BT-MF W10/15 AN6 1.6 mm [0.063''] ≤ t_I ≤15.0 mm [0.59'']	S-BT-MF W10/15 AN6 h_{NVS} = 29.3 mm to 29.8 mm [1.15'' to 1.17'']

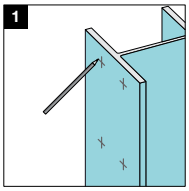
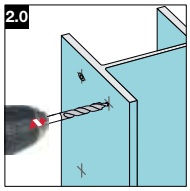
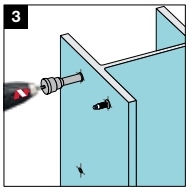
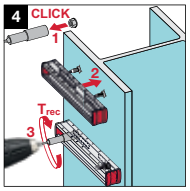
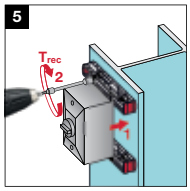
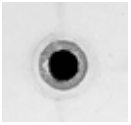
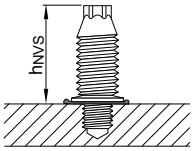
Applications

Multipurpose Fastening			Grating with X-FCM*)
S-BT-MF W10/15 AN6			S-BT-GR M8/7 SN6 S-BT-GF M8/7 AN6
			
Junction box, etc.	Channel installation	Signage	Grating fastening

* Load data, application requirements, corrosion information, fastener selection, system recommendation, material specification and coating refer to section X-FCM Grating Fastening

3.2.11.4 Installation Instructions

 S-DG BT mechanical depth gauge	In order to help ensure the exact screw-in depth and a proper compressed sealing washer, the S-BT studs have to be installed with the appropriate depth gauge for M8 or M10/W10 S-BT fasteners. With this tool the screw-in depth can be adjusted in a range of 0 - 1.5 mm (3 steps, 0.5mm per step).
 Design and functionality of the mechanical calibration card S-CC BT	The S-CC BT calibration card is needed to check the initial stand-off of the S-BT stud and to adjust/calibrate the S-DG depth gauge. After finding the right adjustment level for the S-DG depth gauge, the gauge can be adjusted to the level number shown in the calibration card accordingly and the studs can be installed without additional check of the S-DG depth gauge. The depth gauge has to be re-adjusted (calibrated) at following times: • Start of the installation process • Change of the working position (upwards, downwards, horizontal) • Installer change The lifetime of the S-DG BT depth gauge is ≥ 1000 settings.

① Mark location for each fastening	② Pre-drill with TS-BT stepped drill bit	③ Screw-in S-BT studs into drilled hole	④ Fasten channel on base material	⑤ Fasten accessory on channel
				
	Usage of SF BT 18-A or SF BT 22-A. Pre-drill until the shoulder grinds a shiny ring to assure proper drilling depth.  **Before fastener installation:** The drilled hole and the area around the drilled hole must be clear of liquids and debris.	Usage of SFC 18-A or SFC 22-A in combination with the calibrated depth gauge S-DG BT. Verify stud stand-off h_{NVS} with check gauge S-CG BT  Sealing washer must be properly compressed!	Position channel on S-BT studs and hold in place. Tighten the nuts with the suited tightening torque T_{rec}. T_{rec} ref. to table below. Tighten the nuts using • SFC 18-A / 22-A with socket S-NS • torque tool X-BT 1/4", 5.9 ft-lbf (8Nm) or S-BT 1/4", 3.6 ft-lbf (5 Nm) • torque wrench	Tighten the bolts with the suited tightening torque T_{rec} (see IFU of the Hilti wing nuts).

Hilti screwdriver:	T_{rec} (ft-lbs)	
	3.6	5.9
	Torque setting:	
SFC 18-A SFC 22-A	4	5

3.2.11.5 Ordering information

S-BT threaded studs

Ordering designation	Thread diameter	Thread length in. (mm)	Maximum thickness of fastened material (mm)	Package contents
S-BT-GF M8/7 AN 6 (use with X-FCM-M grating disc, serrated flange nut not included)	**M8**	**11/16** (17.05)	7	100
S-BT-GR M8/7 SN 6 (use with X-FCM-R grating disc, serrated flange nut not included)	**M8**	**11/16** (17.05)	7	100
S-BT-MF W10/15 AN 6 (incl. serrated flange nut)	**W10**	**1-1/16** (27.75)	15	100

Box includes: 100 studs, 100 flange nuts (except S-BT-GF and S-BT-GR), M8 or W10 check gauge and 1 TS-BT step drill bit for steel base material.

TS-BT drill bits for S-BT threaded studs

5.5 mm drill bit diameter

Ordering designation	Bit length in. (mm)	Drilling depth in. (mm)	Package contents	For use with
TS-BT 5.5-74 S	2-7/8 (74)	0.185 (4.7)	10	Steel Base Material
TS-BT 5.5-74 AL	2-7/8 (74)	0.185 (4.7)	10	Aluminum Base Material

Tool sets

Ordering designation	Package contents	For use with
S-BT Set	1	S-BT fastener

Set includes: 1 SFC 18/22-A cordless setting tool, 1 SF BT 18/22-A cordless drill, 1 charger, 2 compact batteries, 1 information sheet, packed complete in a Hilti softbag.

Tool sets

Ordering designation	Package contents	For use with
SFC 22-A cordless setting tool	1	S-BT Depth Gauge

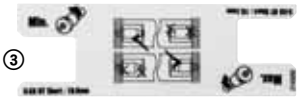
Ordering designation	Package contents	For use with
SF BT 22-A cordless drill	1	TS-BT drill bits
Supplied in an impact-resistant plastic toolbox		

Accessories

Ordering designation	Part	Package contents	For use with
S-DG BT M8/7 Short 6 Depth Gauge	①	1	SFC 22-A
S-DG BT M10-W10/15 Long 6 Depth Gauge	①	1	SFC 22-A
S-CC BT 6 Calibration Card	②	1	S-DG BT
S-CG BT / 7 Short 6 Check Gauge	③	1	S-BT
S-CG BT / 15 Long 6 Check Gauge	③	1	S-BT
X-BT 1/4'' Manual Torque Tool - 8 Nm	④	1	X-NSD sockets
S-BT 1/4'' Manual Torque Tool - 5 Nm	④	1	X-NSD sockets
S-NS 9/16'' C 95/3 3/4'' X-NSD socket	⑤	1	W10 nut with flange

① 

② 

③ 

④ 

⑤ 

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en español 1-800-879-5000
www.hilti.com

Hilti (Canada) Corporation 1-800-363-4458
www.hilti.com

BB • 09/17

SPECIALIZED TESTING
10600 Pioneer Boulevard, Suite G • Santa Fe Springs, California 90670 • (562) 903-0032 • Fax (562) 903-3534
ACCREDITED

September 21, 2017

Re: Hilti, Inc. - Plano, TX
Hilti Report No.: 03-16-A-R
Report Date: August 16, 2016

To Whom It May Concern,

The attached report number 03-16-A-R entitled "Hilti, Inc. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 Screw-in Threaded Stud Fasteners Static Tension and Shear Tests in ASTM A36 and A572 Steels" presents documentation of static tension and shear test of Hilti S-BT fasteners installed in plate steel test members. The tests were performed pursuant to ASTM E1190 "Standard Test Methods of Strength of Powder-Actuated Fasteners Installed in Structural Members", dated 2011 and as noted in the test procedure discussed in Section 5.0 of the test report. The report is of 8 pages, inclusive of this cover letter.

The tests described in this report were performed from February 25, 2016 through May 12, 2016 at the Hilti Testing Laboratory in Irving, Texas. The tests were performed by Hilti personnel using Hilti test equipment. All tests were supervised and witnessed by Specialized Testing. The International Accreditation Service has accredited Specialized Testing's supervisory functions at the Hilti Testing Laboratory in Irving, Texas for scope specific tests.

The test report was prepared by Hilti, Inc. and reviewed by Specialized Testing for accuracy. To the best of our knowledge the test report is an accurate and factual representation of the conditions, procedures, and results of the specific tests described herein.

Note that the report applies only to the standards and procedures indicated and to the test specimens observed and is not necessarily indicative of the performance of apparently identical or similar specimens. Note additionally that the test report may include assessment, assumptions, calculations, and recommendations by Hilti which are not part of Specialized Testing's laboratory supervisory function or part of our report review.

This report shall not be reproduced, except in full, without the written approval of Specialized Testing.

Respectfully submitted,

REGISTERED PROFESSIONAL ENGINEER TIMOTHY M FOSTER NO. C-056556 Exp. 6/2019 CIVIL STATE OF CALIFORNIA

Tim Foster, P.E.
Specialized Testing

Test Report

Number: 03-16-A-R
Date: September 18, 2017
Ref:

HILTI, INC. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 SCREW-IN THREADED STUD FASTENERS STATIC TENSION AND SHEAR TESTS IN ASTM A36 and A572 STEELS

1.0 INTRODUCTION

This test report presents the tension and shear capacity of Hilti S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 screw-in threaded stud fasteners in 1/8-inch, 3/16-inch, 1/4-inch thick ASTM A36 steel and 1/8-inch, 3/16-inch ASTM A572 steel. The tests were conducted in accordance with modified ASTM E1190. Test results for static tension and shear loading are located in **Table 4 and Table 5**.

Testing was conducted on February 25th through May 12th, 2016 at the Hilti Western Hemisphere Product Development and Tool Service Center, 3701 West Royal Lane, Irving, Texas 75063; telephone (800) 879-8000. Tests were witnessed and supervised by Specialized Testing Inc. (STI), an independent, ICC-ES listed testing agency located at 10600 Pioneer Boulevard, Suite G, Santa Fe Springs, California 90670; telephone (562) 903-0032. The IAS listing number for Specialized Testing Inc. is TL-228.

2.0 PRODUCT DESCRIPTION

The S-BT fasteners are threaded studs with a 0.23-inch (5.7-mm) tapping thread (Ref. Figure 1). The S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5 fasteners are made from proprietary stainless steel (1.4462 acc. EN 10088-3, duplex stainless steel) with corrosion resistance equivalent to ASTM 240 UNS S31803. The microstructures of duplex stainless steels consist of a mixture of austenite and ferrite phases. Compared to the austenitic stainless steel grades, duplex stainless steels are magnetic. The surface of the S-BT stainless steel fasteners is zinc plated (anti-friction coating) in order to reduce the thread forming torque when the stud is screwed in into the base material.

The S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 fasteners are made from ASTM A510M equivalent carbon steel. The S-BT fasteners made of stainless steel are assembled with a pre-mounted stainless steel washer Ø 0.47 inch (12 mm) with bonded chloroprene rubber sealing washer. The S-BT fasteners made of carbon steel are assembled with a pre-mounted aluminum washer Ø 0.39 inch (10 mm) with bonded chloroprene rubber sealing washer. The studs for multipurpose fastenings are supplied with HDG carbon steel or stainless steel serrated flange nuts of M8, M10 or W10 thread sizes. To increase the loosening torque of the stud from the base material, glue-based coating is used on the tapping thread for micro encapsulation.

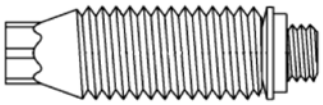

Figure 1 – Hilti S-BT Screw-in Threaded Fastener

3.0 FASTENER INSTALLATION PROCEDURE

Fasteners for this test were installed vertically downward with a Hilti SFC 18-A screwdriver with the appropriate depth gauge into holes pre-drilled using an SF BT 18-A Cordless Drill.

TS-BT 4.3-74 S stepped shank drill bit was used on the SF BT 18-A Cordless Drill for testing in 3/16-inch steel only and TS-BT 5.5-74 S steeped shank drill bit was used for all other steel thicknesses. Each hole was pre-drilled until the shoulder of the step ground a shiny ring on the surface of the steel (to ensure proper drilling depth), and cleaned of any liquids and debris.

Trial fastenings were made before each test series to determine the proper clutch setting of the depth gauge (calibration of the depth gauge). The clutch level was set to default 0 for the first installation. Then the S-BT stud was checked using a mechanical calibration card S-CC for clutch level adjustment. The fastener will be fastened again by adjusting the clutch level to what is showed in the mechanical calibration card. After that, if the gauge shows a green check mark (See **Figure 2**), the fastener embedment is within the recommended range. Stand-off height of each tested fastener was determined by measuring the distance between the top of the fastener and the metal surface by using a Digital caliper or a Tripod Digital Caliper.

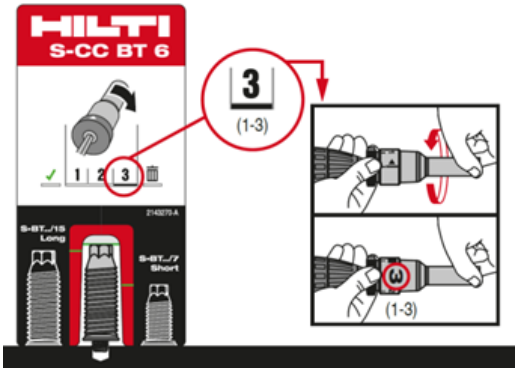

Figure 2 – Hilti S-CC BT 6 Mechanical Calibration Card

4.0 TEST MATERIALS

Fasteners were installed into the 1/8-inch, 3/16-inch, and 1/4-inch thick ASTM A36 steel base material and 1/8-inch and 3/16-inch thick ASTM A572 steel base material. The steel base material plates are measured 24-inch by 48-inch with a smooth and scale free test surface.

5.0 TEST PROCEDURE

Testing was conducted in accordance with modified ASTM E1190-11 “Standard Test Methods of Strength of Powder-Actuated Fasteners Installed in Structural Members”.

Fastener sample size was in accordance with Section 8.1 of ASTM E1190. Data and specific details for the above test procedures are summarized in **Table 1 and Table 2**.

Static Tension

Fasteners were tested to ultimate tension capacity using a reaction bridge, hollow core hydraulic cylinder and through-hole load cell. The tension force was applied axially through the center of the fastener through a threaded spindle, beginning with five percent pre-load, and then a uniformly increasing load until failure occurred at a minimum of thirty seconds (See **Figure 3** and **Figure 4**).

Static Shear

Fasteners were tested to ultimate shear capacity using a shear reaction bridge, hollow core hydraulic cylinder and through-hole load cell. The shear force was transferred to the fastener through a hardened steel threaded insert. Loading was applied axially through the center of the shear rod, beginning with a five percent pre-load, and then a uniformly increasing load until failure occurred at a minimum of thirty seconds (See **Figure 5** and **Figure 6**).

All fasteners were installed at edge distances and spacings equal to or greater than 1/4-inch and 5/8-inch, respectively, in accordance with the manufacturer's recommendations.

6.0 TEST EQUIPMENT

Testing was conducted using equipment designed in compliance with ASTM E1190, Section 5.0.

Static Tension

Fasteners were tested to ultimate tension capacity using an MTS control and data acquisition system, Enerpac Hydraulic Cylinder, and Houston Scientific brand through hole load cell with a capacity of 7.5 kips.

A typical equipment set-up for tension loading may be seen in **Figure 3** and **Figure 4**.

Figure 3 – Tension Test Setup

Figure 4 – Tension Test Fixture Setup

Static Shear

Fasteners were tested to ultimate shear capacity using an MTS control and data acquisition system, Enerpac Hydraulic Cylinder, and Houston Scientific brand through hole load cell with a capacity of 7.5 kips. A typical equipment set-up for shear testing may be seen in **Figure 5** and **Figure 6**.

Figure 5 – Shear Test Equipment

Figure 6 – Shear Test Fixture

All load cells were calibrated by MTS Field Service, an ISO-17025 accredited calibration laboratory.

7.0 TEST RESULTS

Mean ultimate tension and shear load values for Hilti S-BT screw-in threaded stud fasteners in ASTM A36 and ASTM A572 steels are summarized in **Table 1 and Table 2**.

Failure Modes

The typical tension test failure mode was fastener pullout failure from the base steel.

The typical shear test failure mode was fastener shear pull-out failure from the base steel.

Examples of typical failures are found in **Figure 7** and **Figure 8**.

Figure 7 - Typical Tension Pullout Failure

Figure 8 - Typical Fastener Shear Fracture Failure

Respectfully Submitted:

Chenkai Li

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Chenkai Li, P.E.
Technical Services Engineer
Hilti, Inc.

Table 1 – Hilti S-BT Threaded Stud Fasteners Static Tension and Shear Testing in ASTM A36 Steels

Test Series Number	Fastener Type	Steel Thickness (in.)	Test Date	Load Direction	No. of Tests	Average Ultimate Load (lb)	Cv (%)	Failure Modes
1	S-BT-MR M8/7 SN6	1/4	3/31/2016	Tension	10	2972	4.35	Pull-out
2			3/9/2016	Shear	10	3190	5.79	Shear Fracture
3	S-BT MF W10/15 AN 6	1/4	3/8/2016	Tension	10	2781	7.34	Pull-out
4			2/25/2016	Shear	10	2797	4.71	Shear Fracture
5	S-BT MF M8/7 AN 6	1/4	3/8/2016	Tension	10	3189	6.47	Pull-out
6			3/9/2016	Shear	10	2663	12.07	Shear Fracture
7	S-BT-MR M8/7 SN6	10 Ga.	3/22/2016	Tension	10	1307	7.15	Pull-out
8			4/12/2016	Shear	10	2906	2.75	Shear Fracture
9	S-BT MF W10/15 AN 6	10 Ga.	3/23/2016	Tension	10	1300	4.74	Pull-out
10			3/29/2016	Shear	10	2234	5.58	Shear Fracture
11	S-BT MF M8/7 AN 6	10 Ga.	3/22/2016	Tension	10	1409	3.81	Pull-out
12			3/11/2016	Shear	10	2157	6.82	Shear Fracture
13	S-BT-MR M8/7 SN5	3/16	5/12/2016	Tension	10	1377	6.37	Pull-out
14			5/12/2016	Shear	10	2559	2.74	Shear Fracture
15	S-BT MR M8/7 SN 6*	1/4	3/31/2016	Tension	10	2921	5.45	Pull-out
16	S-BT MR M8/7 SN 6*	10 Ga.	3/23/2016	Tension	10	1304	6.43	Pull-out

Table 2 – Hilti S-BT Threaded Stud Fasteners Static Tension and Shear Testing in ASTM A572 Steel

Test Series Number	Fastener Type	Steel Thickness (in.)	Test Date	Load Direction	No. of Tests	Average Ultimate Load (lb)	Cv (%)	Failure Modes
17	S-BT-MR M8/7 SN6	10 Ga.	4/20/2016	Tension	10	1851	4.39	Pull-out
18			4/18/2016	Shear	10	3252	2.17	Shear Fracture
19	S-BT MF W10/15 AN 6	10 Ga.	4/20/2016	Tension	10	1805	4.10	Pull-out
20			4/19.2016	Shear	10	2581	3.37	Shear Fracture
21	S-BT MF M8/7 AN 6	10 Ga.	4/20/2016	Tension	10	1787	5.17	Pull-out
22			4/19/2016	Shear	10	2423	3.93	Shear Fracture
23	S-BT-MR M8/7 SN5	3/16	5/11/2016	Tension	10	1721	6.83	Pull-out
24			5/11/2016	Shear	10	2718	2.60	Shear Fracture

SPECIALIZED TESTING
10600 Pioneer Boulevard, Suite G • Santa Fe Springs, California 90670 • (562) 903-0032 • Fax (562) 903-3534
IAS ACCREDITED

September 21, 2017

Re: Hilti, Inc. - Plano, TX
Hilti Report No.: 03-16-B-R
Report Date: August 16, 2016

To Whom It May Concern,

The attached report number 03-16-B-R entitled "Hilti, Inc. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 Screw-in Threaded Stud Fasteners Seismic Tension and Shear Tests in A572 Steels" presents documentation of simulated seismic tension and shear test of Hilti S-BT fasteners installed in plate steel test members. The test procedures are discussed in Section 5.0 of the test report. The report is 17 pages, inclusive of this cover letter.

The tests described in this report were performed from May 23, 2016 through July 26, 2016 at the Hilti Testing Laboratory in Irving, Texas. The tests were performed by Hilti personnel using Hilti test equipment. All tests were supervised and witnessed by Specialized Testing. The International Accreditation Service has accredited Specialized Testing's supervisory functions at the Hilti Testing Laboratory in Irving, Texas for scope specific tests.

The test report was prepared by Hilti, Inc. and reviewed by Specialized Testing for accuracy. To the best of our knowledge the test report is an accurate and factual representation of the conditions, procedures, and results of the specific tests described herein.

Note that the report applies only to the standards and procedures indicated and to the test specimens observed and is not necessarily indicative of the performance of apparently identical or similar specimens. Note additionally that the test report may include assessment, assumptions, calculations, and recommendations by Hilti which are not part of Specialized Testing's laboratory supervisory function or part of our report review.

This report shall not be reproduced, except in full, without the written approval of Specialized Testing.

Respectfully submitted,

REGISTERED PROFESSIONAL ENGINEER TIM FOSTER NO. C-056556 Exp. 6/19 CIVIL STATE OF CALIFORNIA

Tim Foster, P.E.
Specialized Testing

Test Report

Number: 03-16-B-R
Date: September 18, 2017
Ref:

HILTI, INC. S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6
SCREW-IN THREADED STUD FASTENERS
SEISMIC TENSION AND SHEAR TESTS IN ASTM A572 STEELS

1.0 INTRODUCTION

This test report presents simulated seismic tension and shear tests for Hilti S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5, S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 screw-in threaded stud fasteners in 1/8-inch, 3/16-inch and1/4-inch thick ASTM A572 steel. The tests were conducted in accordance with the modified ASTM E1190 and seismic testing method explained in Section 5 of this test report. **Table 1** presents the test program scope. Test results for seismic tension and shear loading are located in **Table 3** and **Table 4**, respectively.

Testing was conducted on May 23rd through July 26th, 2016 at the Hilti Western Hemisphere Product Development and Tool Service Center, 3701 West Royal Lane, Irving, Texas 75063; telephone (800) 879-8000. Tests were witnessed and supervised by Specialized Testing Inc. (STI), an independent, ICC-ES listed testing agency located at 10600 Pioneer Boulevard, Suite G, Santa Fe Springs, California 90670; telephone (562) 903-0032. The IAS listing number for Specialized Testing Inc. is TL-228.

2.0 PRODUCT DESCRIPTION

The S-BT fasteners are threaded studs with a 0.23-inch (5.7-mm) tapping thread (Ref. **Figure 1**). The S-BT-MR M8/7 SN6, S-BT-MR M8/7 SN5 fasteners are made from proprietary stainless steel (1.4462 acc. EN 10088-3, duplex stainless steel) with corrosion resistance equivalent to ASTM 240 UNS S31803. The microstructures of duplex stainless steels consist of a mixture of austenite and ferrite phases. Compared to the austenitic stainless steel grades, duplex stainless steels are magnetic. The surface of the S-BT stainless steel fasteners is zinc plated (anti-friction coating) in order to reduce the thread forming torque when the stud is screwed in into the base material. The S-BT-MF W10/15 AN6 and S-BT-MF M8/7 AN6 fasteners are made from ASTM A510M equivalent carbon steel. The S-BT fasteners made of stainless steel are assembled with a pre-mounted stainless steel washer Ø 0.47 inch (12 mm) with bonded chloroprene rubber sealing washer. The S-BT fasteners made of carbon steel are assembled with a pre-mounted aluminum washer Ø 0.39 inch (10 mm) with bonded chloroprene rubber sealing washer. The studs for multipurpose fastenings are supplied with HDG carbon steel or stainless steel serrated flange nuts of M8, M10 or W10 thread sizes. To increase the loosening torque of the stud from the base material, glue-based coating is used on the tapping thread for micro encapsulation.

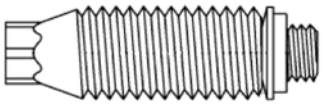

Figure 1 – Hilti S-BT Screw-in Threaded Fastener

3.0 FASTENER INSTALLATION PROCEDURE

Fasteners for this test were installed vertically downward with a Hilti SFC 18-A screwdriver with the appropriate depth gauge into holes pre-drilled using an SF BT 18-A Cordless Drill.

TS-BT 4.3-74 S stepped shank drill bit was used on the SF BT 18-A Cordless Drill for testing in 3/16-inch steel only and TS-BT 5.5-74 S steeped shank drill bit was used for all other steel thicknesses. Each hole was pre-drilled until the shoulder of the step ground a shiny ring on the surface of the steel (to ensure proper drilling depth), and cleaned of any liquids and debris.

Trial fastenings were made before each test series to determine the proper clutch setting of the depth gauge (calibration of the depth gauge). The clutch level was set to default 0 for the first installation. Then the S-BT stud was checked using a mechanical calibration card S-CC for clutch level adjustment. The fastener will be fastened again by adjusting the clutch level to what is showed in the mechanical calibration card. After that, if the gauge shows a green check mark (See **Figure 2**), the fastener embedment is within the recommended range. Stand-off height of each tested fastener was determined by measuring the distance between the top of the fastener and the metal surface by using a Digital caliper or a Tripod Digital Caliper.

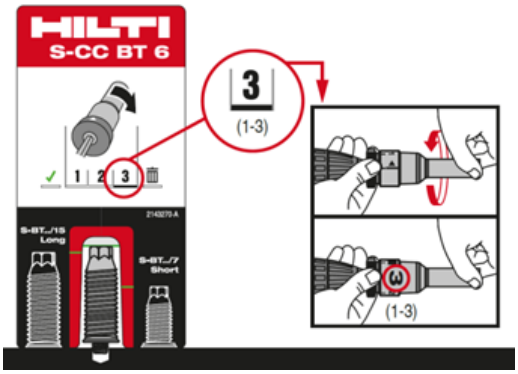

Figure 2 – Hilti S-CC BT 6 Mechanical Calibration Card

4.0 TEST MATERIALS

Fasteners were installed into the 1/8-inch, 3/16-inch, and 1/4-inch thick ASTM A572 steel base material. The steel base material plates are measured 24-inch by 48-inch with a smooth and scale free test surface.

5.0 TEST PROCEDURE

The simulated seismic tension and shear reference load levels in 1/8, 3/16 and 1/4-inch thick steel base materials were established from published static tension and shear allowable load data in the S-BT Static Test Report 03-16-A-R. The initial

reference static allowable load data was factored to account for the ultimate tensile strength of the steel base material utilized in the simulated seismic cyclic load test program ($F_{u, test}$).

Simulated Seismic Tension Test Procedure

The factored static tension load was defined as N_{ref}. The cyclic seismic tension load levels were calculated as follows:

a) $N_{eq} = 0.5\ N_{ref}$
b) $N_i = 0.375\ N_{ref}$
c) $N_m = 0.25\ N_{ref}$

Ten simulated seismic tension cycles were applied to the test fastener at the N_{eq} load level, 30 cycles were applied to the test fastener at the N_i load level and 100 cycles were applied to the test fastener at the N_m level. Load reference lines included on all data plots indicate that each load level was met or exceeded. A sample data plot for seismic shear test can be found in **Appendix A**.

All simulated seismic tension load cycles fully satisfied the requirements above..

Table 6 presents a summary of the simulated seismic tension loading utilized in the test program, including N_{ref}, N_{eq}, N_i and N_m values.

Residual Static Tension Test Procedure

At the conclusion of the simulated seismic tension cyclic loading, a residual static tension test was conducted to determine the residual static tension load capacity of each fastener. The average residual static tension value of each test series in the specified steel base material is defined as N_{res}.

Simulated Seismic Shear Test Procedure

The factored static shear test load was defined as V_{ref}. The cyclic seismic shear load levels were calculated as follows:

a) $V_{eq} = 0.5\ V_{ref}$
b) $V_i = 0.375\ V_{ref}$
c) $V_m = 0.25\ V_{ref}$

Ten simulated seismic shear cycles were applied to the test fastener at the V_{eq} load level, 30 cycles were applied to the test fastener at the V_i load level and 100 cycles were applied to the test fastener at the V_m level. Load reference lines included on all data plots (see **Appendix A**), indicate that each load level was met or exceeded. A sample data plot for seismic shear test can be found in **Appendix A**.

All simulated seismic shear load cycles fully satisfied the requirements above.

Table 6 presents a summary of the simulated seismic shear loading utilized in the test program, including V_{ref}, V_{eq}, V_i and V_m values.

Residual Static Shear Test Procedure

At the conclusion of the simulated seismic shear cyclic loading, a residual static shear test was conducted to determine the residual static shear load capacity of each fastener. The average residual static shear value of each test series in the specified steel base material is defined as V_{res}.

6.0 TEST EQUIPMENT

Testing was conducted using equipment designed for the simulated seismic loading protocol specified in Annex A of ICC-ES AC70. The test system was set-up to deliver the required number of test cycles within the specified frequency range from 0.1 Hz to 2 Hz

Simulated Seismic Tension and Residual Static Tension in Steel – The simulated seismic tension and residual static tension test apparatus consisted of a 30 ton Parker bi-directional stud style hydraulic actuator, and an Interface 5K internally threaded bi-directional load cell, mounted on a tripod with feet in an 18 inch equilateral triangle configuration, as well as an LVDT apparatus placed with the contact point on a tensile bell. These instruments were connected to an MTS control and data acquisition system.

A typical equipment set-up for simulated seismic tension and residual static tension testing in steel may be seen in **Figure 3**.

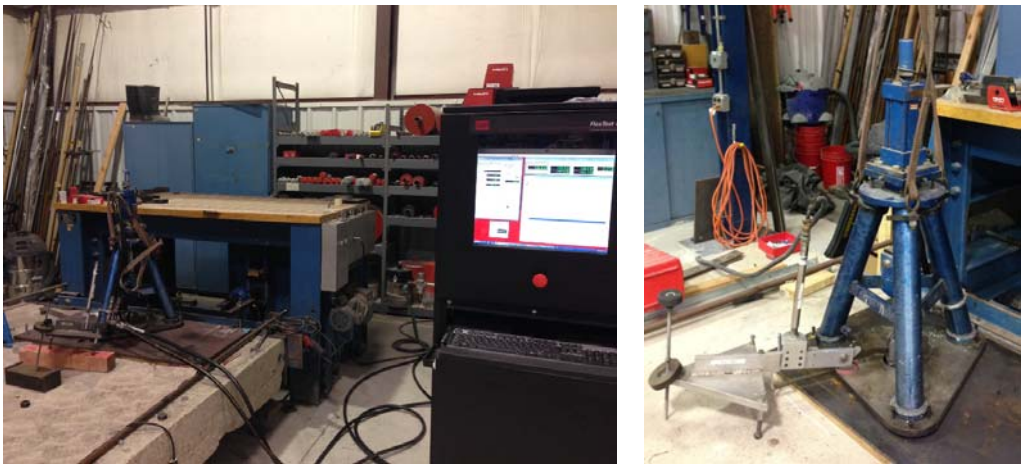

Figure 3 – Simulated Seismic and Residual Static Tension Test Setup

Simulated Seismic Shear and Residual Static Shear in Steel - The simulated seismic shear and residual static shear test apparatus consisted of a 30 ton Parker bi-directional stud style hydraulic actuator, and an Interface 25K internally threaded bi-directional load cell, as well as an LVDT apparatus placed with the contact point on the shear fixture. These instruments were connected to an MTS control and data acquisition system.

A typical equipment set-up for simulated seismic shear and residual static shear testing in steel may be seen in **Figure 4**.

Figure 4 – Simulated Seismic and Residual Static Shear Test Setup

All load cells were calibrated by MTS Field Service, an ISO-17025 accredited calibration laboratory.

7.0 TEST RESULTS

The test program results are summarized in **Table 3** and **Table 4**.

Failure Modes

All fasteners performed satisfactorily when subjected to the simulated seismic cyclic loading. No test fastener failures were observed during the simulated seismic tension or seismic shear loading. After the simulated seismic cyclic loading, residual static tension and shear tests were conducted to failure.

The typical residual static tension test failure mode was fastener pull-out from the base steel.

The typical residual static shear test failure modes were fastener shear fracture and shear pull-out from the base steel.

Examples of typical failures are found in **Figure 5**, **Figure 6** and **Figure 7**.

Figure 5: Typical Seismic Tension Failure – Fastener Pullout

Figure 6: Typical Seismic Shear Failure – Fastener Shear Fracture

Figure 7: Typical Seismic Shear Failure – Fastener Shear Pull-out

Seismic Reliability Verification

From Table 3, the Coefficient of Variance (COV) of all the seismic tension test series are less than 15 percent and N_{res}/N_{ref} is always larger than 80 percent. The seismic tension reliability can be verified using,

$$N_{a\ (seismic)} = (R)N_{ref}/5 \leq P_a$$

Similarly, from Table 4, the Coefficient of Variance (COV) of all the seismic shear test series are less than 15 percent and V_{res}/V_{ref} is always larger than 80 percent. The seismic shear reliability can be verified using,

$$V_{a\ (seismic)} = (R)V_{ref}/5 \leq P_a.$$

After verification of all the test series, it can be concluded that for both tension and shear, the published allowable load P_a can be used under seismic conditions.

This report shall not be reproduced except in full, without the written approval of the Hilti Testing Laboratory. The results of this test relate only to the products that were tested.

Respectfully Submitted:

Chenkai Li

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Chenkai Li, P.E.
Technical Services Engineer
Hilti, Inc.

Table 1 – Test Program Scope

Seismic Tension Tests			
Test Numbers	Fastener Nomenclature	Base Material Specification	Specified Number of Tests
1-10	S-BT-MF M8/7 AN6	1/8-in ASTM A572	10
11-20	S-BT-MF M8/7 AN6	1/4-in ASTM A572	10
21-30	S-BT-MR M8/7 SN6	1/8-in ASTM A572	10
31-40	S-BT-MR M8/7 SN6	1/4-in ASTM A572	10
41-50	S-BT-MR M8/7 SN5	3/16-in ASTM A572	10
51-60	S-BT-MF W10/15 AN6	1/8-in ASTM A572	10
61-70	S-BT-MF W10/15 AN6	1/4-in ASTM A572	10
Seismic Shear Tests			
Test Numbers	Fastener Nomenclature	Base Material Specification	Specified Number of Tests
71-80	S-BT-MF M8/7 AN6	1/8-in ASTM A572	10
81-90	S-BT-MF M8/7 AN6	1/4-in ASTM A572	10
91-100	S-BT-MR M8/7 SN6	1/8-in ASTM A572	10
101-110	S-BT-MR M8/7 SN6	1/4-in ASTM A572	10
111-120	S-BT-MR M8/7 SN5	3/16-in ASTM A572	10
121-130	S-BT-MF W10/15 AN6	1/8-in ASTM A572	10
131-140	S-BT-MF W10/15 AN6	1/4-in ASTM A572	10

Table 2 – Summary of Simulated Seismic Loading

Seismic Tension Loads									
Test Number	Fastener Nomenclature	ASTM Steel Grade	ASTM Steel Thickness (in.)	Steel Strength Reduction Factor R	Published Allowable Load P_a (lbs)[1]	N_{ref}[2] (lbs)	N_{eq} (lbs)	N_i (lbs)	N_m (lbs)
1-10	S-BT-MF M8/7 AN6	A572	1/8	0.930	295	1586	793	595	397
11-20	S-BT-MF M8/7 AN6	A572	1/4	0.960	520	2708	1354	1016	677
21-30	S-BT-MR M8/7 SN6	A572	1/8	0.930	295	1586	793	595	397
31-40	S-BT-MR M8/7 SN6	A572	1/4	0.960	520	2708	1354	1016	677
41-50	S-BT-MR M8/7 SN5	A572	3/16	0.905	300	1657	829	622	414
51-60	S-BT-MF W10/15 AN6	A572	1/8	0.930	295	1586	793	595	397
61-70	S-BT-MF W10/15 AN6	A572	1/4	0.960	520	2708	1354	1016	677
Seismic Shear Loads									
Test Number	Fastener Nomenclature	ASTM Steel Grade	ASTM Steel Thickness (in.)	Steel Strength Reduction Factor R	Published allowable Load P_a (lbs)[1]	V_{ref}[2] (lbs)	V_{eq} (lbs)	V_i (lbs)	V_m (lbs)
71-80	S-BT-MF M8/7 AN6	A572	1/8	0.930	430	2312	1156	867	578
81-90	S-BT-MF M8/7 AN6	A572	1/4	0.960	520	2708	1354	1016	677
91-100	S-BT-MR M8/7 SN6	A572	1/8	0.930	430	2312	1156	867	578
101-110	S-BT-MR M8/7 SN6	A572	1/4	0.960	610	3177	1589	1191	794
111-120	S-BT-MR M8/7 SN5	A572	3/16	0.905	430	2376	1188	891	594
121-130	S-BT-MF W10/15 AN6	A572	1/8	0.930	430	2312	1156	867	578
131-140	S-BT-MF W10/15 AN6	A572	1/4	0.960	540	2813	1406	1055	703

1. Reference Hilti Product Technical Guide (PTG).
2. N_{ref} and V_{ref} are based on the initial N_{ref} and V_{ref} values adjusted for $F_{u,\,test}$.

Table 3 – Summary of Seismic Tension Results

Test No.	Fastener Nomenclature	Steel Base Material Thickness (in.)	Loading	N_{ref} (lbs)	Residual Load N_{res} (lbs)	Mean Residual Load N_{res} (lbs)	Std. Dev. N_{res} (lbs)	COV N_{res} %	N_{res}/N_{ref} %	Failure Mode
1	S-BT-MF M8/7 AN6	1/8	Cyclic Tension	1586	1452	1387	70	5.04	87	Pull-out
2					1484					Pull-out
3					1385					Pull-out
4					1325					Pull-out
5					1444					Pull-out
6					1256					Pull-out
7					1426					Pull-out
8					1368					Pull-out
9					1324					Pull-out
10					1405					Pull-out
11	S-BT-MF M8/7 AN6	1/4	Cyclic Tension	2708	2071	2308	291	12.61	85	Pull-out
12					2989					Pull-out
13					2391					Pull-out
14					2119					Pull-out
15					2238					Pull-out
16					2097					Pull-out
17					1972					Pull-out
18					2336					Pull-out
19					2484					Pull-out
20					2386					Pull-out
21	S-BT-MR M8/7 SN6	1/8	Cyclic Tension	1586	1504	1321	153	11.56	83	Pull-out
22					1265					Pull-out
23					1414					Pull-out
24					1196					Pull-out
25					1452					Pull-out
26					1306					Pull-out
27					1322					Pull-out
28					1253					Pull-out
29					1007					Pull-out
30					1490					Pull-out
31	S-BT-MR M8/7 SN6	1/4	Cyclic Tension	2708	2560	2822	199	7.05	104	Pull-out
32					2618					Pull-out
33					2808					Pull-out
34					3137					Pull-out
35					2936					Pull-out
36					2730					Pull-out
37					2663					Pull-out
38					2719					Pull-out
39					3081					Pull-out
40					2971					Pull-out
41	S-BT-MR M8/7 SN5	3/16	Cyclic Tension	1657	2018	2002	160	7.97	121	Pull-out
42					1810					Pull-out
43					1930					Pull-out
44					1773					Pull-out
45					1970					Pull-out
46					1879					Pull-out
47					2111					Pull-out
48					2162					Pull-out
49					2104					Pull-out
50					2267					Pull-out

Table 3 – Summary of Seismic Tension Results (Cont.)

Test No.	Fastener Nomenclature	Steel Base Material Thickness (in.)	Loading	N_{ref} (lbs)	Residual Load N_{res} (lbs)	Mean Residual Load N_{res} (lbs)	Std. Dev. N_{res} (lbs)	COV N_{res} %	N_{res}/N_{ref} %	Failure Mode
51	S-BT-MF W10/15 AN6	1/8	Cyclic Tension	1586	1588	1443	74	5.10	91	Pull-out
52					1424					Pull-out
53					1390					Pull-out
54					1514					Pull-out
55					1477					Pull-out
56					1468					Pull-out
57					1336					Pull-out
58					1434					Pull-out
59					1429					Pull-out
60					1366					Pull-out
61	S-BT-MF W10/15 AN6	1/4	Cyclic Tension	2708	1912	2258	200	8.85	83	Pull-out
62					1961					Pull-out
63					2401					Pull-out
64					2497					Pull-out
65					2336					Pull-out
66					2378					Pull-out
67					2100					Pull-out
68					2337					Pull-out
69					2245					Pull-out
70					2408					Pull-out

Table 4 – Summary of Seismic Shear Results

Test No.	Fastener Nomenclature	Steel Base Material Thickness (in.)	Loading	V_{ref} (lbs)	Residual Load V_{res} (lbs)	Mean Residual Load V_{res} (lbs)	Std. Dev. V_{res} (lbs)	COV V_{res} %	V_{res}/V_{ref} %	Failure Mode
71	S-BT-MF M8/7 AN6	1/8	Cyclic Shear	2312	2298	2273	109	4.78	98	Shear Fracture
72					2228					Shear Fracture
73					2235					Shear Fracture
74					2255					Shear Fracture
75					2385					Shear Fracture
76					2182					Shear Fracture
77					2417					Shear Fracture
78					2419					Shear Fracture
79					2082					Shear Fracture
80					2227					Shear Fracture
81	S-BT-MF M8/7 AN6	1/4	Cyclic Shear	2708	2385	2578	183	7.11	95	Shear Fracture
82					2673					Shear Fracture
83					2845					Shear Fracture
84					2784					Shear Fracture
85					2491					Shear Fracture
86					2589					Shear Fracture
87					2773					Shear Fracture
88					2332					Shear Fracture
89					2410					Shear Fracture
90					2493					Shear Fracture
91	S-BT-MR M8/7 SN6	1/8	Cyclic Shear	2312	3173	3050	236	7.72	132	Shear Fracture
92					3060					Shear Fracture
93					2805					Shear Fracture
94					2863					Shear Fracture
95					3295					Shear Fracture
96					2773					Shear Fracture
97					2942					Shear Fracture
98					3113					Shear Fracture
99					2951					Shear Pull-out
100					3527					Shear Fracture
101	S-BT-MR M8/7 SN6	1/4	Cyclic Shear	3177	2991	3075	158	5.14	97	Shear Fracture
102					3087					Shear Fracture
103					2825					Shear Fracture
104					3160					Shear Fracture
105					3012					Shear Fracture
106					3117					Shear Fracture
107					2986					Shear Fracture
108					3151					Shear Fracture
109					3425					Shear Fracture
110					2999					Shear Fracture
111	S-BT-MR M8/7 SN5	3/16	Cyclic Shear	2376	2996	3083	157	5.10	130	Shear Fracture
112					3259					Shear Fracture
113					2833					Shear Fracture
114					3079					Shear Fracture
115					3099					Shear Fracture
116					3348					Shear Fracture
117					3124					Shear Fracture
118					2947					Shear Fracture
119					3200					Shear Fracture
120					2950					Shear Fracture

Table 4 – Summary of Seismic Shear Results (Cont.)

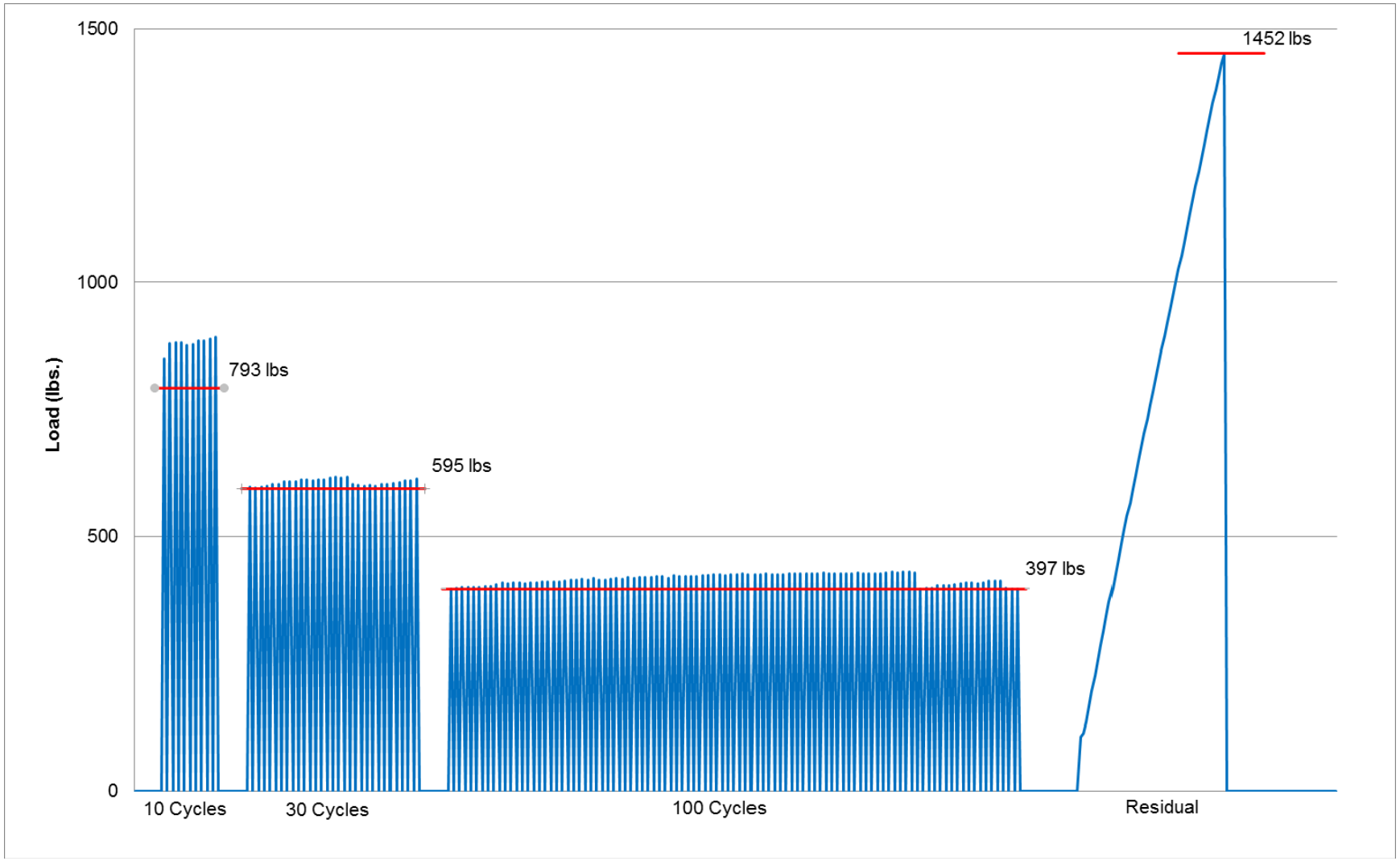
Test No.	Fastener Nomenclature	Steel Base Material Thickness (in.)	Loading	V_{ref} (lbs)	Residual Load V_{res} (lbs)	Mean Residual Load V_{res} (lbs)	Std. Dev. V_{res} (lbs)	COV V_{res} %	V_{res}/V_{ref} %	Failure Mode
121	S-BT-MF W10/15 AN6	1/8	Cyclic Shear	2312	2470	2326	134	5.76	101	Shear Fracture
122					2278					Shear Fracture
123					2578					Shear Fracture
124					2329					Shear Fracture
125					2167					Shear Fracture
126					2294					Shear Fracture
127					2270					Shear Fracture
128					2354					Shear Fracture
129					2127					Shear Pull-out
130					2397					Shear Fracture
131	S-BT-MF W10/15 AN6	1/4	Cyclic Shear	2813	2394	2529	185	7.30	90	Shear Fracture
132					2348					Shear Fracture
133					2293					Shear Fracture
134					2811					Shear Fracture
135					2342					Shear Fracture
136					2649					Shear Fracture
137					2630					Shear Fracture
138					2482					Shear Fracture
139					2572					Shear Fracture
140					2768					Shear Fracture

Appendix A

Sample Data Plot Graphs

Hilti, INC. POWER-DRIVEN FASTENER SIMULATED SEISMIC LOAD TEST PROGRAM

TEST NO.1 – SEISMIC TENSION TEST OF S-BT-MF M8/7 AN6 FASTENER IN 1/8'' STEEL



Hilti, INC. POWER-DRIVEN FASTENER SIMULATED SEISMIC LOAD TEST PROGRAM

TEST NO.71 – SEISMIC SHEAR TEST OF S-BT-MF W10/15 AN6 FASTENER IN 1/8" STEEL