TELEDYNE LECROY TEST SERVICES
Everywhereyoulook™

TEP-3-013
REVISION 13

TECHNICAL ENGINEERING PROCEDURE

TITLE:

INSTALLATION PROCEDURE FOR TELEDYNE QUICK STEM SENSOR (QSS) ON VALVE STEMS FOR MEASUREMENT OF THRUST AND TORQUE

Originator: J. Meier Date: 4/4/19

Reviewed: Project or Engineering Manager Date: 4/4/19

Approved for Release: Quality Assurance Department Date: 04/04/19

TABLE OF CONTENTS **PAGE**

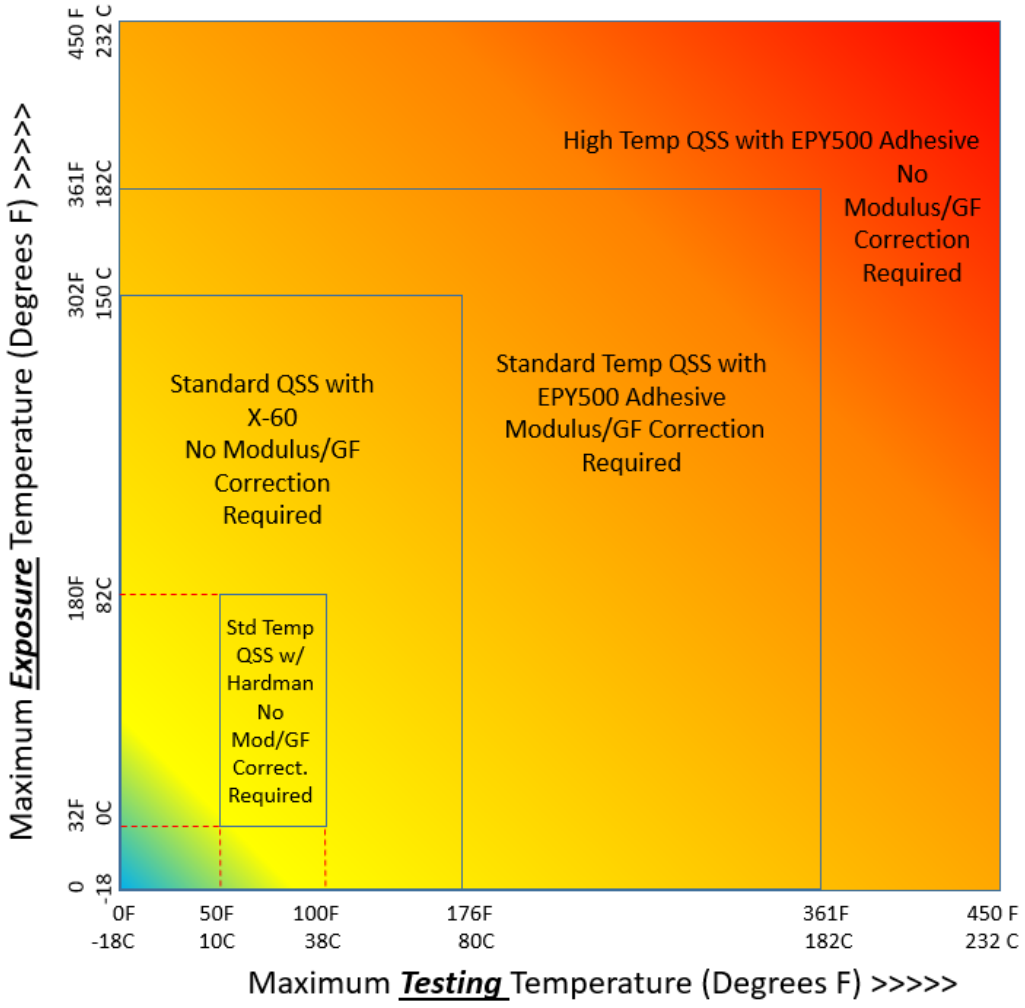
Revision Record

REV	DATE	SECTION(S)	DESCRIPTION
13	April 4, 2019	1.1	Added QSS Max Temperature Testing Chart. Reformatted Section 2.2 and 2.3

1.0 SCOPE

1.1 This procedure provides instructions for the installation of Teledyne LeCroy Test Services (TLTS) Quick Stem Sensors (QSS) on the stems of Motor Operated and/or Air Operated Valves (MOV/AOV). This procedure applies to all TLTS Quick Stem Sensors (QSS) installed on rising stem and rotating-rising stem valves and the stems of butterfly valves.

The QSS is a strain gage transducer that measures Torque and Thrust of MOV or AOV valve stems. TLTS classifies QSS installations as permanent or temporary and low, standard or high temperature. Temporary QSS installations are typically not exposed to high operating temperatures. Permanent or long-term installations require special consideration of not only the off-line temperature conditions under which testing will occur but also the temperature that the stem will see on-line between refueling outages assuming the user wishes to leave the QSS in place and perform as found (AF) testing at a subsequent outage. The chart below should be used as a guide to QSS and adhesive selection based on potential testing and exposure temperatures.



2.0 APPLICATION

2.1 The QSS installation classifications differ in the materials used to build the QSS and how the appropriate adhesive is mixed and cured. Each classification of installation requires the use of different equipment, materials and methods.

2.2 Standard and High Temperature QSS

2.2.1 A standard temperature QSS consists of a QSS, Part Numbers TES-xxxxTT350CD, TES-xxxxTQ350CD, or TES-xxxxTH350CD. The QSS foil backing material and solder connections of the lead wire to the QSS establishes the 0°F to 361°F maximum testing and exposure temperature of the QSS. Modulus and Gage Factor (GF) correction should be performed on test data taken over 176°F.

2.2.2 A high temperature QSS Installation consists of a QSS, Part Numbers TES-xxxxTT350HTCD, TES-xxxxTQ350HTCD, or TES-xxxxTH350HTCD. The HT QSS uses different foil material and solder and has a 0 to 450°F temperature range and because of the match of GF temperature coefficient and temperature effect on material modulus, no temperature correction is necessary.

2.3 Low, Standard, and High Temperature Adhesive

2.3.1 A low temperature, permanent QSS Installation consists of a standard QSS (Section 2.2.1) installed with X60 Adhesive. X60 has a test temperature range of –328 to +176 degrees Fahrenheit. This adhesive does not require a heat cure; see its curing schedule in Section 8.0. X60 can sustain exposure to 302°F between tests.

A low temperature, permanent QSS installation can also consist of a standard QSS (Section 2.2.1) installed with Hardman EPOWELD – 3672 Adhesive. The adhesive is the factor that limits the testing temperature to 50-100°F. Hardman EPOWELD – 3672 Adhesive can be exposed to a temperature range of 0 to 180 degrees Fahrenheit. This adhesive does not require a heat cure; see its curing schedule in Section 8.0.

2.3.2 A standard temperature, permanent QSS installation consists of a standard QSS (Section 2.2.1), installed with EPY-500 adhesive. The EPY-500 adhesive is heat cured per the cure requirements of Section 8.0.

2.3.3 A high temperature, permanent QSS installation consists of a high temperature QSS (Section 2.2.2) installed with EPY-500 adhesive. The EPY-500 adhesive is post-cured for this installation; see its curing and post cure requirements in Section 8.0

2.4 Most QSS installations utilize a “calculated” Thrust and Torque sensitivity calibration which is based on stem material properties, stem diameter and QSS Gage Factor. When a calculation is used instead of a physical calibration, the Plant’s Design Engineering Department or equivalent shall provide the values of E and μ. The basis document shall be referenced on the calculation sheet.

2.5 Most QSS installations utilize a “calculated” Thrust and Torque sensitivity calibration which is based on stem material properties, stem diameter and QSS Gage Factor. When a calculation is used instead of a physical calibration, the Plant’s Design Engineering Department or equivalent shall provide the values of E and μ. The basis document shall be referenced on the calculation sheet.

2.6 The Sensitivity Calculation Worksheets in Section 9.0 are used to calculate the torque sensitivity and/or the thrust sensitivity of the QSS Installation. The stem material properties (Young's Modulus and Poisson's Ratio) in Section 10.0 can be used when the stem material property information is not available and/or the plant Engineering Department accepts the TLTS Stem Material Properties Recommendations.

This stem material listing is referenced from TLTS Calculation Package Document, CP-A-722-2.

To calibrate a QSS Installation, see Teledyne Engineering Procedure TEP-3-023, titled "In-Situ Calibration of Plant Valve Stems Instrument with Thrust and Torque-Sensing Strain Gage Bridges Using QUIKCAL".

3.0 PRE-REQUISITES

3.1 The following prerequisites must be satisfied prior to the start of QSS installation:

- The valve(s) to be instrumented should be taken out of service by the utility following its established procedures. If the valves cannot be taken out of service, coordination with the control room shall be obtained.
- Drawings of the valve(s) must be available to determine the stem or shaft material.
- The location on the stem where the QSS is to be mounted must have a smooth surface.
- The personnel must be certified to the level required for the task to be performed.
- Access to the valve(s) must be provided (including staging, if required).
- Electric power must be available at the valve.
- The Radiological Condition Report for the valve and its surroundings must be available.
- Radiological protection commensurate with the existing site conditions must be used.

3.2 The following personnel responsibilities apply:

a. Project Manager
   i. Ensure that valve walk-down data requested by the MOV QSS Installation Log (Section 9.0) is available to the field QSS installation personnel .
   ii. Designate an On-site Installation Supervisor
   iii. Provide justification for all QSS Installations that are close to a transition (Section 6.1.4 a).

b. On-Site Installation Supervisor
   i. Verify that QSS sensor installation and documentation are correct and complete (Section 9.0).
   ii. Approve the QSS sensor installation.

c. Technician
   i. Perform surface preparation and QSS Installation in accordance with the requirements of this procedure.
   ii. Obtain approval from Project Manager for QSS Installations that are closer to stem transitions than the required axial distance of two times the radial depth of the transition (Section 6.1.4 b).

d. Client
   i. Provide safe and adequate access to all locations designated by the TLTS On-Site Supervisor.
   ii. Complete client portion of installation log for each valve, prior to installation team deployment.

4.0 EQUIPMENT

a. Ball Point Pens, Pencils

b. Lights

c. Inspection Mirror (if necessary)

d. Calibrated Micrometer

e. P-3500 Vishay Strain Indicator or equivalent (NOTE: Quiklook is acceptable alternative)

f. QSS Holder (Optional)

5.0 MATERIAL

Materials needed for QSS installations are below. Note that the required adhesive is dependent on exposure and testing temperature as shown in 1.1.

QSS Installation Materials	Exposure Temperature>>	<180°F	<302°F	<450°F
	Testing Temperature>>	<100°F	<176°F	<450°F
TLTS P/N	Description Adhesive>>	Hardman	X-60	EPY500
159228*	Epoweld 3672*, Hardman Epoxy - Box of 100	X		
159230-10	X60 Adhesive, Box of 10		X	
159206	EPY-500, (5) 10 gram packages			X
159403	100 Grit Silicon Carbide Paper, 1 x 25 Yards	X	X	X
159424	220 Grit Silicon Carbide Paper, 1 x 25 Yards	X	X	X
159402	Gauze Pads, 200 Ct.	X	X	X
159401	Cotton Swabs, 100 Ct.	X	X	X
159318-10	Clamping Device, Low Tension QSS Clamp 10 Pack	X	X	X
159218	Degreaser, CSM, 20 Oz Spray Can	X	X	X
159201	M-Prep Metal Conditioner, 16 Oz Bottle	X	X	X
159202	M-Prep Neutralizer, 16 Oz Bottle	X	X	X
159204	M-Coat C, (4) 1 Oz Bottles	X	X	X
159203	RTV 3145, 3 Oz Tube	X	X	X
159105	Heater, Temperature Controller			X
159146	Heating Tape			X
TES-QSS-Blank**	QSS Blank for Installation training - 5 Pack	Optional		

*Use Epoweld adhesive only for room temperature applications such as feedwater valves where extra time is necessary to properly position the QSS

**Specify stem diameter when ordering QSS Blanks

6.0 **METHOD**

6.1 Determine Location of QSS Installation

6.1.1 Interference of the QSS Installation with the packing, packing retainer, or actuator must be avoided. Approximately 1/8 inch radial clearance is required if the installation must enter an enclosed space such as the packing retainer.

6.1.2 Mark the stem at the point where it enters the packing and where it enters the actuator. Stroke the valve to the opposite position, i.e., closed if originally open; or open if originally closed, and again mark the stem where it enters the packing and actuator. The length of the stem between the inner pair of the four marks on the stem will be the area available for the installation of the QSS.

Note: If the valve is unavailable for stroking, the length of stem travel may be provided by client. From the length of stem travel, determine the section that will be clear of the actuator and packaging. This will be the location of the QSS Installation.

6.1.3 Using a calibrated micrometer, measure the stem diameter and record it on the QSS Installation Log (Section 9.0).

6.1.4 The following guidelines are to be followed when installing a QSS on or near a stem transition. Typical stem transitions include anti-rotation devices, keyways, threads, shoulders and undercuts.

- Uncalibrated: When calculating thrust and torque output sensitivities, the QSS must be installed on a smooth section of the stem and located at a axial distance of at least two times the radial depth of the transition away from the transition. The QSS may be placed on or closer to the transition with approval of the TLTS Project Manager when justification can be provided, based on either finite element analysis and/or a laboratory verification test, that the discontinuities do not affect the calculated sensitivities.
- Calibrated: When the thrust and torque sensitivities are to be determined by in-situ calibration, the QSS may be placed closer to the stem transition than stated above or on stem transition areas with no effect on the calibrated sensitivities. For such installations, the installation logs (Section 9.0) must be reviewed and approved by the Project Manager.

6.2 Surface Preparation for QSS Installation

Note: Surface temperature shall be 77°F ±7°F when using Hardman Epoweld 3672.

6.2.1 Degrease the surface to which the strain gage is to be bonded with acetone, methyl ethyl keytone (MEK), or an approved degreasing solvent.

Note: If acetone or MEK is not approved for use in the Plant, alcohol (20 oz can) is acceptable.

6.2.2 Abrade the specimen surface with 80 or 100 grit silicon carbide paper, removing all rust, corrosion, or oxidation.

6.2.3 Degrease the surface removing all residue left from the abrading process.

6.2.4 Cut several strips of 220 or 240 grit silicon carbide paper. Wet the paper with M-Prep metal conditioner and abrade the surface.

6.2.5 Remove the M-Prep Conditioner and abrasive residue with a tissue or gauze pad over the specimen area. This step may have to be repeated to ensure that the conditioner has been removed.

6.2.6 Clean and scrub the specimen with M-Prep Neutralizer. This step should be repeated until there is no evidence of contamination on the specimen surface. The scrubbing is normally performed with cotton swabs, gauze, or a clean wiping material (e.g.: cloth, tissue, etc.).

6.2.7 If possible, do not allow the conditioner or neutralizer to dry on the surface by evaporation. Wipe the surface with a dry tissue or gauze pad before proceeding to the next step.

6.2.8 Technician shall sign installation log when surface preparation is complete (Section 9.0).

6.3 Prepare the QSS for Installation

6.3.1 Abrade the inside or rear surface of the QSS lightly using 220 or 240 grit silicon carbide paper. Clean using degreaser and tissue.

6.3.2 Clean surface with M-Prep Metal Conditioner. Apply sparingly, spread and scrub lightly until beads disappear. Do not let excess conditioner migrate to other side of QSS. Dry with tissue.

6.3.3 Apply M-Prep Neutralizer to the back of the QSS. Dry using tissue or gauze pad.

6.4 QSS Installation

6.4.1 Select the adhesive to be used on the basis of the QSS Installation Classification, see Section 2.0, steps 2.2 through 2.6.

6.4.2 Prepare the adhesive for use following the manufacturer's instructions summarized in Section 8.0 of this procedure.

NOTE: Hardman Epoweld 3672 Adhesive (Skip to Step 6.5).

X-60 QSS Adhesive (Skip to Step 6.6).

6.4.3 Apply the EPY-500 Epoxy in a continuous band completely around the stem at the desired location; the band should be slightly wider than the QSS. Also apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.4.4 Carefully apply QSS to stem; open sensor only enough to clear stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (Section 7.0, Figure 1).

6.4.5 Remove excess adhesive.

6.4.6 To cure the EPY-500 Epoxy, install heaters and a thermocouple as close as possible to the QSS. Secure the thermocouple so that it is held in intimate contact with the stem, preferably between the heater and the QSS. Follow the cure schedule summarized in Section 8.0.

6.4.7 Monitor the stem temperature with a thermocouple until the cure temperature is reached and let the installation remain at that temperature until fully cured. If the installation is a high temperature application follow the cure schedule and do a post cure.

6.4.8 After curing unplug the heater and let the valve stem cool to approximately 100^{o}F to permit heater removal.

6.4.9 Remove heater, thermocouple, and clamps. Inspect the QSS Installation and, if it is acceptable, abrade the excess cement away from the perimeter and clean with solvent.

6.5 Hardman EPOWELD 3672 Adhesive

6.5.1 Apply the epoxy in a continuous band completely around the stem at the desired location; the band should be slightly wider than the QSS. Also apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.5.2 Carefully apply QSS to stem; open sensor only enough to clear stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (Section 7.0, Figure 1).

6.5.3 Remove excess adhesive.

6.5.4 No heater or temperature indication is needed as long as the stem temperature remains at room temperature, 77 degrees, ±7 degrees Fahrenheit.

6.5.5 Follow cure schedule as outlined in Section 8.0.

6.5.6 After cure inspect the QSS Installation and, if it is acceptable, abrade the excess cement away from the perimeter and sparingly clean with solvent.

6.6 X-60, QSS Adhesive

6.6.1 Apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.6.2 Carefully apply the QSS to the stem; open the sensor only enough to clear the stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (see Section 7, Figure 1).

6.6.3 Remove excess adhesive.

6.6.4 No heater or temperature indication is required. Curing is complete after 15 – 20 minutes.

6.7 QSS Post-Installation Checks

6.7.1 The installation log should be filled in completely, including the installer, date, QSS part and serial numbers, products used, expiration dates and lot numbers. The as-built section of the installation log shall show the final configuration of the valve stem with the QSS installed. Record all relevant dimensions.

6.7.2 Monitor the QSS signal through a strain indicator or equivalent data acquisition platform. Probe the QSS strain gages with your finger. The strain indicator (or equivalent) will change slightly, but when the pressure from your finger is released, the indicator should return to its initial reading within 0.020 mV/V indicating there is an adequate bond between the QSS and the valve stem. If a shift greater than 0.050 mV/V remains after the probe test, then the QSS should be replaced.

6.7.3 The On-Site Supervisor or his designee shall review the installation and test results and signify his acceptance by signing off on the QSS Installation Log at the “Inspected By” section.

6.8 Moisture Proofing the QSS Installations

6.8.1 Degrease the area around the QSS Installations.

6.8.2 Apply M-Coat C over the QSS and over a 360-degree band around the valve stem QSS location including an area of up to ¼ inch on the stem above and below the QSS. Allow 20-30 minutes to dry.

6.8.3 After the M-Coat C has dried, apply RTV 3145 over the installation.

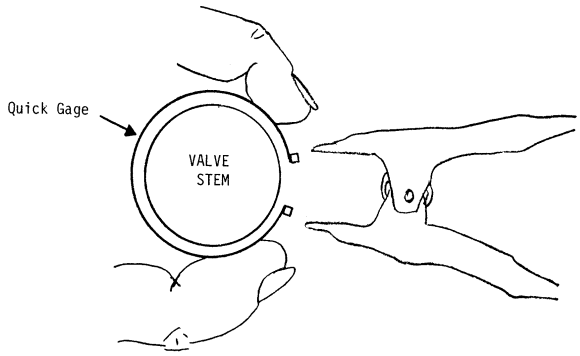
6.8.4 Repeat the thrust and/or torque bridge tests after waterproofing and record results on the log sheet (Section 9.0).

6.9 QSS Sensitivity

6.9.1 The QSS sensitivity must be determined either by calibration or by calculation.

- The sensitivity calculation Section 9.0 can be performed for QSS installations on solid stems, subject to the location limitations in Section 6.1.4. The sensitivity derived from this calculation will provide an inaccuracy statement for the QSS installation of +/-8.1 per cent.
- The sensitivity calculation on Section 9.0 must be performed when a SMARTSTEM has been repaired by replacing the original strain gages with a QSS or singular bonded strain gages. The sensitivity derived from this calculation will provide an inaccuracy statement for the repaired installation of +/-5%. Reference: TLTS Technical Report TR-A100-18.
- Laboratory testing of a model is required when the QSS is located close to or in a stem transition area as stated in Section 6.1.4). The model is made from the same material and machined to the same geometry of the valve stem. A test report is provided that documents what the inaccuracy statement is for this QSS installation only.
- Calibration may be performed to achieve a higher accuracy for the QSS installed on a smooth section of the stem or to derive the sensitivity for a QSS located in a transition zone. Typical inaccuracy statements for calibrated installation are 3 to 5%. See TLTS Procedure TEP-3-023, titled “In-Situ Calibration of Plant Valve Stems Instrument with Thrust and Torque Sensing Strain Gage Bridges”.

7.0 FIGURE 1 - QSS INSTALLATION TECHNIQUE



8.0 EPOXY MIXING INSTRUCTIONS AND CURE SCHEDULE

8.1 BLH EPY-500 Mixing Instructions

a. Knead the resin and powder prior to releasing the clamp that separates the hardener from the resin.
b. Release the clamp and knead the bag until the parts are thoroughly mixed and a uniform color results. Special attention should be given to the corners of the bag.
c. Snip off one corner of the bag. The adhesive may be squeezed out as desired.
d. The viscosity of the adhesive may be lowered to facilitate mixing or application by heating. Immersion of the package in warm water (120-140F/49-60C) prior to mixing or exposure to a heat lamp at the same temperature after mixing and removal from the package will yield the desired viscosity. Be sure to wipe the package free of moisture before opening if immersed.
e. The pot life (after mixing at normal ambient conditions) is approximately 24 hours. Pot life may be extended to one month if kept frozen when not in use. Moisture may condense on the package after removal from cold storage. This moisture must be removed before the package is opened to avoid contamination.

8.2 BLH EPY-500 Cure Schedule

Use any of the following:

- 26 hours at 200°F
- 4 Hours at 250°F
- 1 Hour at 350°F
- Post Cure – 1 Hour at 450°F for applications above 450°F or 1 Hour at 50°F above the stem's normal operating temperature.

8.3 Hardman EPOWELD 3672 Mixing Instructions and Cure Schedule

a. The individual components containing fillers should be stirred or agitated without introducing excessive air before use to ensure that all fillers are properly dispersed. To obtain best cured properties, accurate proportioning and thorough mixing are essential.
b. Mix Ratio:

	Parts By Weight	Parts By Volume
Part A	100	8
Part B	60	5

c. Cure Schedule: 24 Hours at 77°F.
d. ** Use of the Hardman two component pre-measured packages is encouraged.

8.4 X60 Mixing Instructions and Cure Schedule

Cut off the bottom of the outside plastic envelope (at the end with the green plastic divider) and remove the package of adhesive
Grasp both ends of the adhesive package and pull apart firmly to remove the plastic divider.
Pull the adhesive package back and forth over any exposed right angled corner (e.g., table top, box) until the parts are thoroughly mixed. This takes only about 10 – 15 seconds.
Snip off one corner of the bag. The adhesive may be squeezed out as desired.
The pot life (after mixing at normal ambient conditions) is approximately 2 to 5 minutes. The cure time is 15 to 20 minutes at ambient temperature.

9.0 Quick Stem Sensor Installation Log(s)

QUICK STEM SENSOR (QSS) INSTALLATION LOG – Bridge Installation Data

Client: _____ Station: _____

Valve Tag No.: _____ Date: _____

TLTS QSS Part No: _____ Serial No.: _____

THRUST BRIDGE (TH)

TLTS QSS Part No: _____ Serial No: _____

TH Gage Factor: _____

TORQUE BRIDGE (TQ)

TQ Gage Factor: _____

Adhesive: _____ Expiration Date: _____

Lot No: _____

Encapsulation: _____ Expiration Date: _____

Lot No: _____

Encapsulation: _____ Expiration Date: _____

Lot No: _____

Encapsulation: _____ Expiration Date: _____

Lot No: _____

APPROVAL

Installation Completed By: _____ Date: _____

Page 1 of 1 TELEDYNE LECROY TEST SERVICES FRM-QSSIL(BID) R1

QUICK STEM SENSOR INSTALLATION LOG – Bridge Inspection Report

Client: _____ Date: _____

Valve Tag No.: _____ QSS Serial No.: _____

	THRUST (TH)		TORQUE (TQ)	
	BEFORE WATERPROOF	AFTER WATERPROOF	BEFORE WATERPROOF	AFTER WATERPROOF
Probe Test	SAT / UNSAT	N/A	SAT / UNSAT	N/A

INSTRUMENT M&TE

NOTE: If M&TE information is included in plant QSS Installation Records, do not duplicate

Multimeter:

Mfr. _____ Model _____ S/N _____ Next Cal _____

Strain Indicator:

Mfr. _____ Model _____ S/N _____ Next Cal _____

Micrometer:

Mfr. _____ Model _____ S/N _____ Next Cal _____

APPROVAL

QSS Installation By: _____ Date: _____

Inspected By: _____ Date: _____

Page 1 of 1 TELEDYNE LECROY TEST SERVICES FRM-QSSIL(BIR) R1

QSS AS-BUILT SKETCH

Valve Tag: _____

QSS Serial Number: _____

Completed By: _____ Date: _____

Project Manager Approval (as required): _____ Date: _____

Top of Valve Stem

Sketch in the installed location of the QSS and provide the following dimensions:

1. _____ Stem diameter @ QSS location
2. _____ Depth of nearest stem transition
3. _____ 2.0 x #2 (above)
4. _____ Edge of QSS to nearest stem transition.

QSS located INSIDE/OUTSIDE transition zone:

If #3 above > #4 above, circle “INSIDE” otherwise, circle “OUTSIDE”

For all QSS installations INSIDE transition zones, obtain approval from the Project Manager.

SENSITIVITY CALCULATIONS (Optional)

When using TLTS stem strain gages with MOV diagnostic systems other than Teledyne's, calculate torque and thrust sensitivity in accordance with the following equations:

$$\text{Torque Sensitivity} = 16.363\ \frac{D^3E}{(G.F.)(1+\mu)} \qquad \frac{lb-ft}{mV/Vexc}$$

$$\text{Thrust Sensitivity} = 1570.8\ \frac{D^2E}{(G.F.)(1+\mu)} \qquad \frac{lbf}{mV/Vexc}$$

Stem Material =_____ _____
Reference Document

D = Stem Diameter =_____inches

E = Young's Modulus of Stem Material/10^6 =_____ lb_f/in^2 _____
Reference Document

μ = Poisson's Ratio of Stem Material =_____ _____
Reference Document

G.F. = Gage Factor of Strain Gage

Thrust G.F. _____ Torque G.F._____

Vexc = Excitation Voltage = (volts d.c.)

NOTE: Vexc, the strain gage excitation voltage, should be verified and recorded as part of the test procedure.

$$\text{Torque Sensitivity} = 16.363\ \frac{(\quad)^3\ (\quad)}{(\quad)\ (1+\quad)} = \frac{\quad}{\quad}\ \frac{lbf\text{-}ft}{mV/Vexc}$$

$$\text{Thrust Sensitivity} = 1570.8\ \frac{(\quad)^2\ (\quad)}{(\quad)\ (1+\quad)} = \frac{\quad}{\quad}\ \frac{lbf}{mV/Vexc}$$

Valve Tag: _____

Calculation Performed By _____ Date _____

Calculation Verified By _____ Date _____

SMARTSTEM REPAIR SENSITIVITY CALCULATION

Utility: _____ Site: _____ Project No. _____

TELEDYNE SMARTSTEM: Serial No._____ Model No._____

Replaced original strain gages with: ☐ Individual gages ☐ QSS

Part No._____ Serial No. _____

Thrust Gage Factor _____ Torque Gage Factor_____

Performed by: _____ Date: _____

THRUST: Capacity _____ lbs.

Original data: Gage factor _____ Sensitivity _____ lbs/mV/V

New data: Gage factor _____

New sensitivity = original sensitivity x old gage factor / new gage factor

= _____ x _____ = _____ V

TORQUE: Capacity _____ ft-lbs

Original data: Gage factor _____ Sensitivity _____ ft-lbs/mV/V

New data: Gage factor _____

New sensitivity = original sensitivity x old gage factor / new gage factor

= _____ x _____ = _____ V/V

Performed by:_____ Date:_____

Verified by: _____ Date:_____

10.0 MATERIAL PROPERTIES LISTING

The following table summarizes the overall combined mean values of E/(1+m) as determined by the SMARTSTEM database query. The value of E (modulus of elasticity) for each material is selected to correspond with the E at 70°F from the Aerospace Structural Metal Handbook. Then the value of m (Poisson's ratio) is derived from the expression, m = [(E at 70°F)/(E/(1+m)result)-1]. Note that these values values are for reference only, and are to be only be used if not specified by the Plant's responsible engineering group.

Specification	E (10^6)	m	E/(1+m)	Reference
(Tested) Alloy 17-4 PH	29.1	.271	22.90	App. A
(ASMH, Alloy 17-4 PH)	29.1	.291	22.54	App. I, 1501
(Tested) Type 410	31.6	.277	24.75	App. B
(ASMH, Type 410)	31.6	.27	24.88	App. I, 1401
(Tested) Type 416	31.6	.286	24.57	App. C
(ASMH, 416: 410 Mod)	31.6	.27	24.88	App. I, 1401
(Tested) Type XM19	28.0	.291	21.69	App. D
(ASMH, Type XM19)	N/A	N/A	N/A	App. I Index
(Tested) Alloy A-286	29.0	.281	22.63	App. E
(ASMH, Type A-286)	29.0	.292	22.44	App. I, 1601
(Tested) Type 316	28.2	.285	21.95	App. F
(ASMH, Type 316)	28.2	.294	21.79	App. I, 1307
(Tested) Allow L-605	33.5	.279	26.19	App. G
(ASMH, Alloy L-605)	33.5	.286	26.05	App. I, 4302
(Tested) Alloy 718	29.0	.258	23.06	App. H
(ASMH, Alloy 718)	29.0	.294	22.41	App. I, 4103

N/A: Specific Data not available.

TLTS recommends the following values of E/(1+m) for these materials when calculating the thrust and/or torque sensitivities for Quick Stem Sensors™ to maintain the uncalibrated accuracy of ±8.2%. Use of other values of E/(1+m) are allowed if within the ±3.50% of the recommended values.

Common Alloy Name	Alternate ASTM / Other Designations	Alternate ASME Designations	E/(1+m)
Alloy 17-4 PH (annealed and all heat treat's)	A461 Type 630 A564 Type 630 A705 Type 630	 SA564 Type 630 SA705 Type 630	22.90
Type 410 (annealed and all heat treat's)	A182 Gr. F6 A182 Gr. F6a A182 Gr. F6a Cl 1, 2, 3, 4 F182 Type 410 A276 Type 410 A314 Type 410 A473 Type 410 A479 Type 410	SA182 Gr. F6 SA182 Gr. F6a SA182 Gr. F6a Class 1, 2 SA479 Type 410	24.75
Type 416 (annealed and all heat treat's)	A314 Type 416 A473 Type 416 A693 Type 416		24.57
Type XM19	A182 Type FXM19 A479 Type XM19	SA182 Type FXM19 SA479 Type XM19	21.69
Alloy A-286	A638 Type 660 A-186	SA638 Type 660	22.63
Type 316 (annealed and all heat treat's)	A182 Gr. F316 A276 Type 316 A473 Type 316 A479 Type 316	SA182 Type F316 & F316H SA479 Type 316 & 316H	21.95
Alloy L-605	Haynes 25 CA-7 L-605	N/A	26.19
Alloy 718	B637-N07718 Inconel 718	N/A	23.06