DK-Lok vs. Swagelok Intermix Test

2018. 1. 5

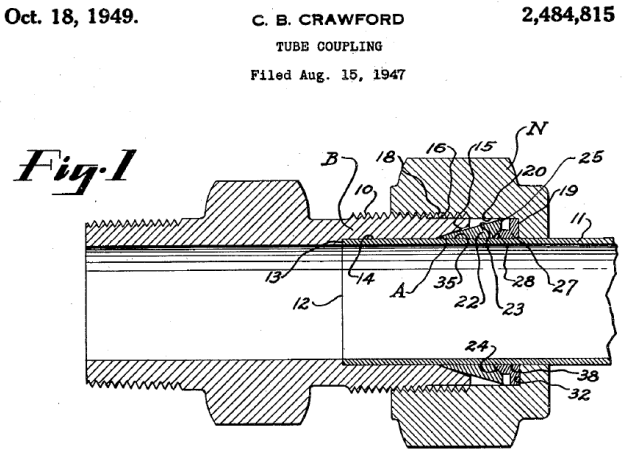
DK-LOK
Fittings & Valves

Why Intermix with Swagelok

- **The original two-ferrule fitting patent**

  Invented by Crawford in 1947,

  Owned by Swagelok since then.



- **De facto Standard for the industry**

  Market share more than 60% (best guess)

- **Approval from all the major customers in every application**

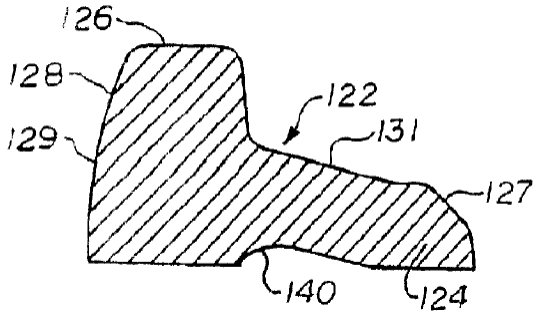
  Oil and gas, analytical instrumentation, chemical and petrochemical, pulp and paper, process instrumentation, power generation, shipbuilding, semiconductor, and alternative fuels

- **Swagelok-only patented ferrule design**

  Uniquely modified back ferrule design since late 1990s.

  -> prove same leak-tight performance

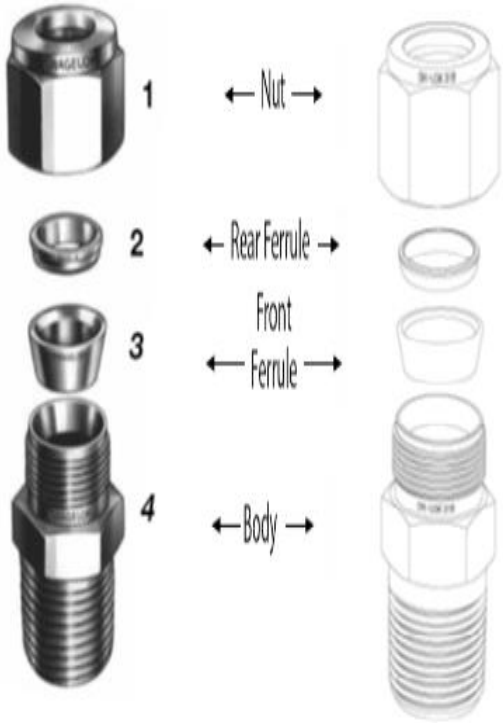
  with DK-Lok own back ferrule design



Test Specimens

Components	Swagelok	#1	#2	#3	#4	#5	#6	#7
Swagelok Nut - SN	SN	SN	DKN	DKN	DKN	SN	DKN	DKN
Swagelok Back Ferrule - SBF	SBF	DKBF	SBF	DKBF	DKBF	SBF	SBF	DKBF
Swagelok Front Ferrule - SFF	SFF	DKFF	DKFF	SFF	DKFF	DKFF	SFF	SFF
Swagelok Body - SB	SB	DKB	DKB	DKBF	SB	DKB	DKB	SB

Components	#8	#9	#10	#11	#12	#13	#14	DK-Lok
DK Nut -DKN	SN	DKN	SN	SN	DKN	SN	SN	DKN
DK Back Ferrule - DKBF	DKBF	SBF	DKBF	SBF	SBF	SBF	DKBF	DKBF
DK Front Ferrule - DKFF	SFF	DKFF	DKFF	SFF	SFF	DKFF	SFF	DKFF
DK Body - DKB	DKBF	SB	SB	DKB	SB	SB	SB	DKB



- #1 ~ #14 show all possible intermix combinations between DK-Lok and Swagelok fittings.

- Five different sizes (1/4", 3/8", ½", ¾", 1") of the fourteen combinations (#1 ~ #14) make 70 intermixed fittings to be tested.

- Thick wall thickness tube (the harsher tube condition than most) used for all test procedures.

ASTM F1387

ASTM (American Society of Testing and Materials) F1387 establishes the performance characteristics required for mechanically attached fittings (MAF) for use in piping and tubing systems.

Mandatory Tests

ASTM 1387 section No.	Procedure	Comments
A2	Examination of Specimen	Done
A3	Pneumatic Proof Test	Done
A4	Hydrostatic Proof Test	Done
A5	Impulse Test	Done
A6	Flexure Fatigue Test	Done
A7	Tensile Test	Done
A8	Hydrostatic Burst Test	Done
A9	Repeated Assembly Test	Done
A10	Rotary Flex Test	Done
A11	Mercurous Nitrate Test	N/A

Supplement Tests

ASTM 1387 section No.	procedure	Comments
S2	Thermal Cycling Test	Done
S3	Elevated Temperature Soak Test	-
S4	Stress-Corrosion Test	-
S5	Torsion Test	-
S6	Shock Test	-
S7	Fire Test	-
S8	Vibration Test	Done

All tests witnessed by TUV Rheinland.
No failure observed.

Test Procedures (I)

*Tube Working Pressure

Specimen Preparation

Examination of Specimen (A2) Visual Inspection

Pneumatic Test (A3) @ 1.25 x W.P.*

Remake Test (A9) Disassemble/ Re-assemble 2 times

Pneumatic Test (A3) @ 1.25 x W.P.

Remake Test (A9) 3 times

Test Procedures (II)

Hydrostatic Test (A4)
@ 1.5 x W.P.

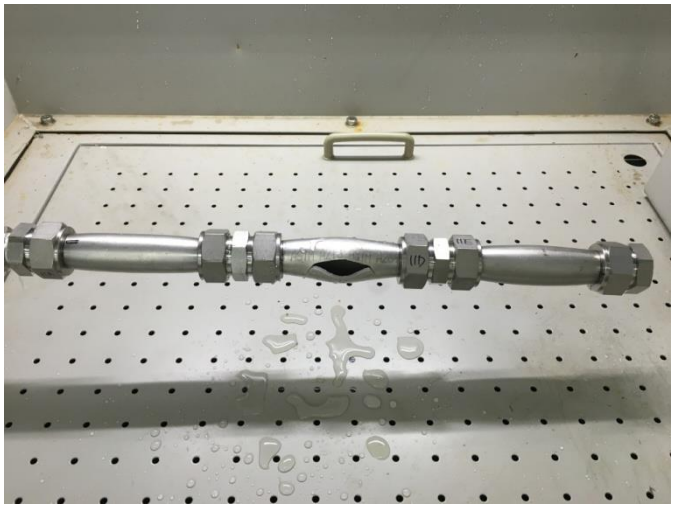
Remake Test (A9)
1 time

Hydrostatic Test (A4)
@ 1.5 x W.P.

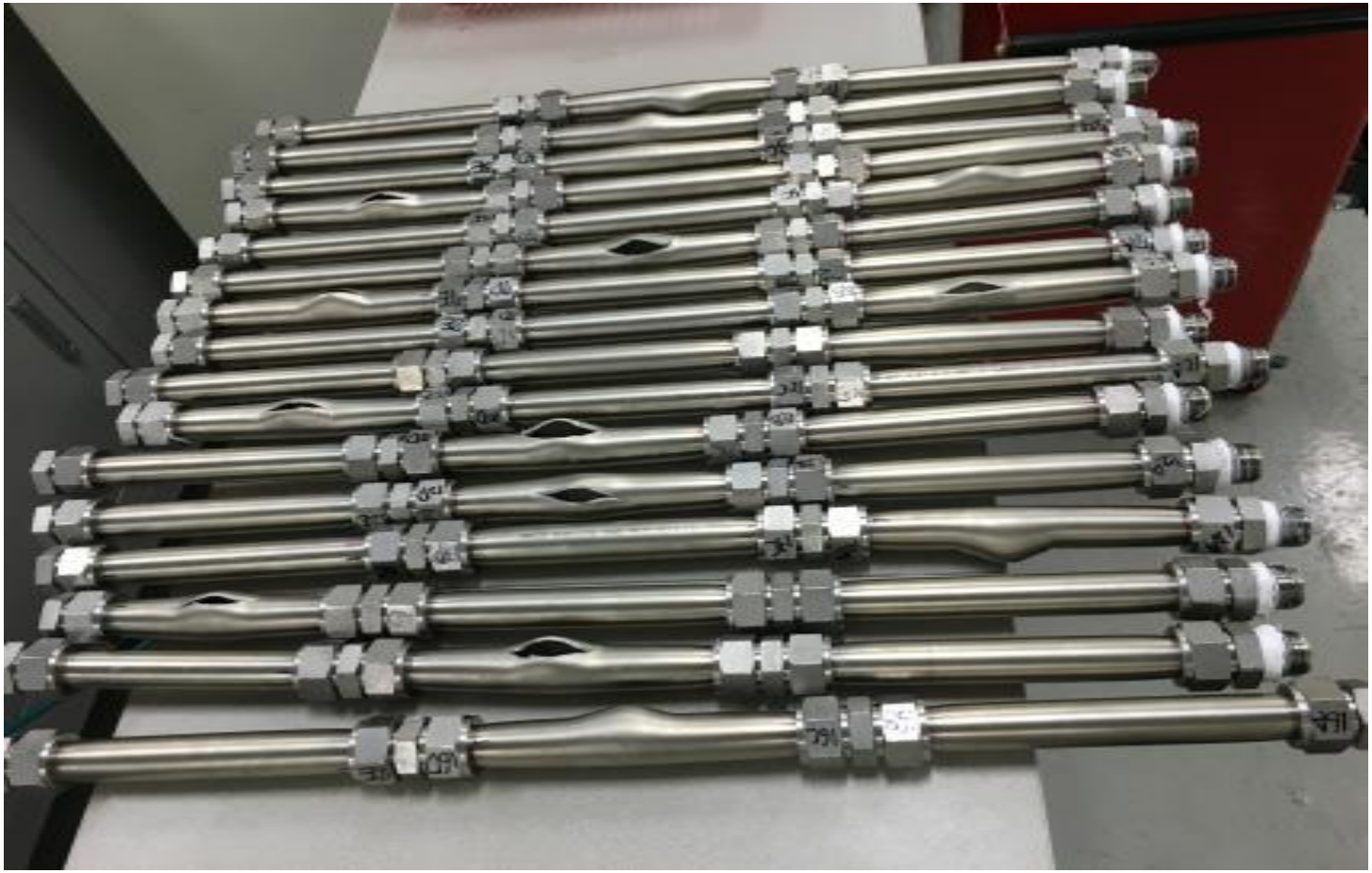
Remake Test (A9)
2 time

Hydrostatic Test (A4)
@ 1.5 x W.P.

Hydrostatic Burst Test (A8)
@ 4 x W.P.

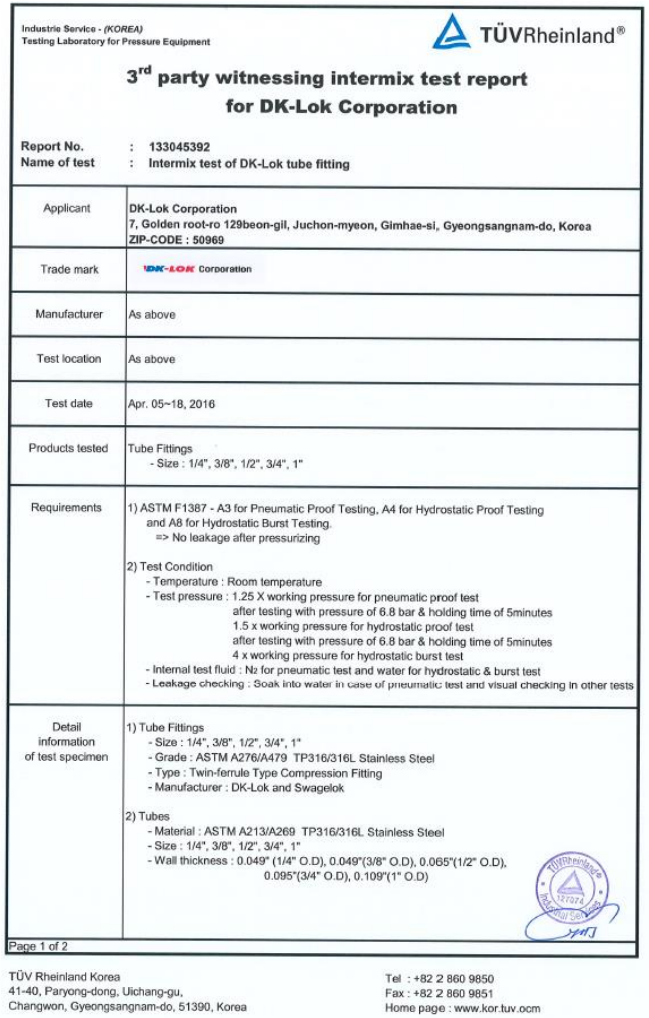


Burst Test Results for All 70 Specimen



Test Results (witnessed by TUV Rheinland)

Test order	Section No.	Description	Results	Comment
1	A2	Visual Examination	Pass	All witnessed by TUV Rheinland
2	A3	Pneumatic Proof Test	Pass	
3	A9	Repeated Assembly Test x 2	Pass	
4	A3	Pneumatic Proof Test	Pass	
5	A9	Repeated Assembly Test x 3	Pass	
6	A4	Hydrostatic Proof Test	Pass	
7	A9	Repeated Assembly Test x 1	Pass	
8	A4	Hydrostatic Proof Test	Pass	
9	A9	Repeated Assembly Test x 2	Pass	
10	A4	Hydrostatic Proof Test	Pass	
11	A8	Hydrostatic Burst Test	Pass	



Industrie Service - (KOREA)
Testing Laboratory for Pressure Equipment

TÜVRheinland®

3rd party witnessing intermix test report for DK-Lok Corporation

Report No. : 133045392
Name of test : Intermix test of DK-Lok tube fitting

Applicant	DK-Lok Corporation 7, Golden root-ro 129beon-gil, Juchon-myeon, Gimhae-si, Gyeongsangnam-do, Korea ZIP-CODE : 50969
Trade mark	DK-LOK Corporation
Manufacturer	As above
Test location	As above
Test date	Apr. 05~18, 2016
Products tested	Tube Fittings - Size : 1/4", 3/8", 1/2", 3/4", 1"
Requirements	1) ASTM F1387 - A3 for Pneumatic Proof Testing, A4 for Hydrostatic Proof Testing and A8 for Hydrostatic Burst Testing. => No leakage after pressurizing 2) Test Condition - Temperature : Room temperature - Test pressure : 1.25 X working pressure for pneumatic proof test after testing with pressure of 6.8 bar & holding time of 5minutes 1.5 x working pressure for hydrostatic proof test after testing with pressure of 6.8 bar & holding time of 5minutes 4 x working pressure for hydrostatic burst test - Internal test fluid : N2 for pneumatic test and water for hydrostatic & burst test - Leakage checking : Soak into water in case of pneumatic test and visual checking in other tests
Detail information of test specimen	1) Tube Fittings - Size : 1/4", 3/8", 1/2", 3/4", 1" - Grade : ASTM A276/A479 TP316/316L Stainless Steel - Type : Twin-ferrule Type Compression Fitting - Manufacturer : DK-Lok and Swagelok 2) Tubes - Material : ASTM A213/A269 TP316/316L Stainless Steel - Size : 1/4", 3/8", 1/2", 3/4", 1" - Wall thickness : 0.049" (1/4" O.D), 0.049"(3/8" O.D), 0.065"(1/2" O.D), 0.095"(3/4" O.D), 0.109"(1" O.D)

Page 1 of 2

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Pass: No leakage observed for all the 14 intermixed fittings for the 5 different sizes.

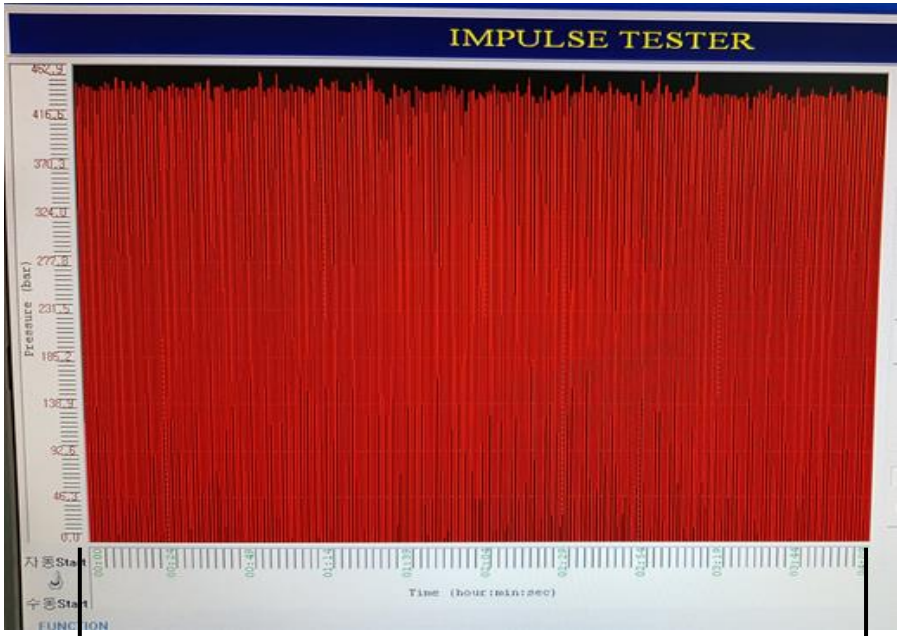
Additional Tests

section No.	Procedure	Description
A5	Impulse Test	1,000,000 cycle x 1 (sec/cycle), Remake at 25%, 50%, 75% of the full cycle
A6	Flexure Fatigue Test	30,000 cycle x 0.5 (sec/cycle), Remake at 25%, 50%, 75% of the full cycle
A7	Tensile Test	Tensile Load > minimum
A10	Rotary Flex Test	1,000,000 cycle x 1750 rpm
S2	Thermal Cycling Test	3 x High Temp. (204℃ = 400°F) cycling (6hr/cycle), 3 x Low Temp. (-17.8℃ = 0°F) cycling (6hr/cycle)
S8	Vibration Test	4Hz -> 60Hz by 1Hz at 5 min/Hz, 60Hz for 2 hours (Endurance Test)

Impulse Test (A5)

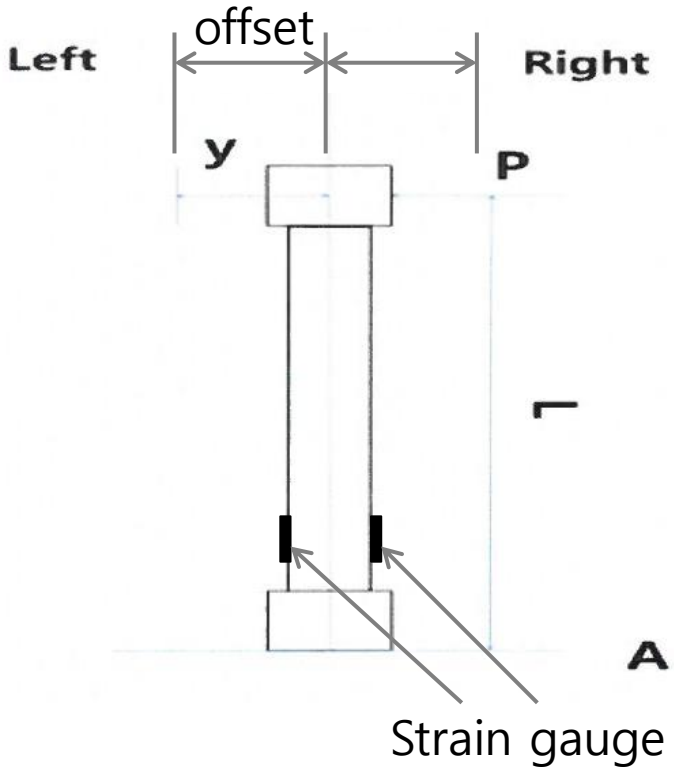
Section No.	Description
A5	1,000,000 cycle x 1 (sec/cycle) → (11.6 days), Pressure up to 133 ± 5% of working pressure & down to no greater than 20 ± 5%, Remake at 250K, 500K, 750K cycles.

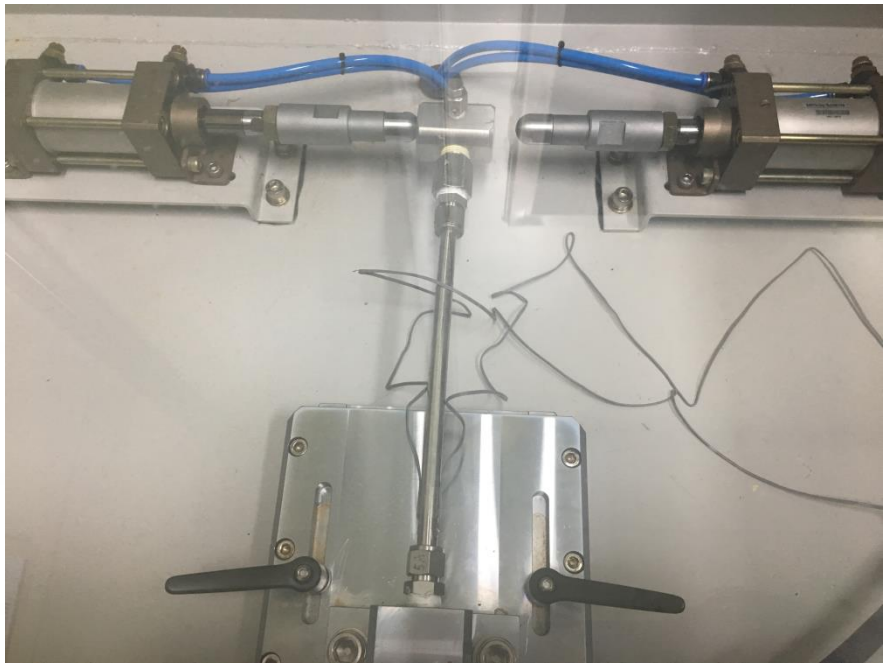
Pressure impulse shown in the test machine screen



Flexure Fatigue Test (A6)

Section No.	Description
A6	30,000 cycle (1 cycle = 1 left and 1 right move), Remake at 25%, 50%, 75% of the full cycle

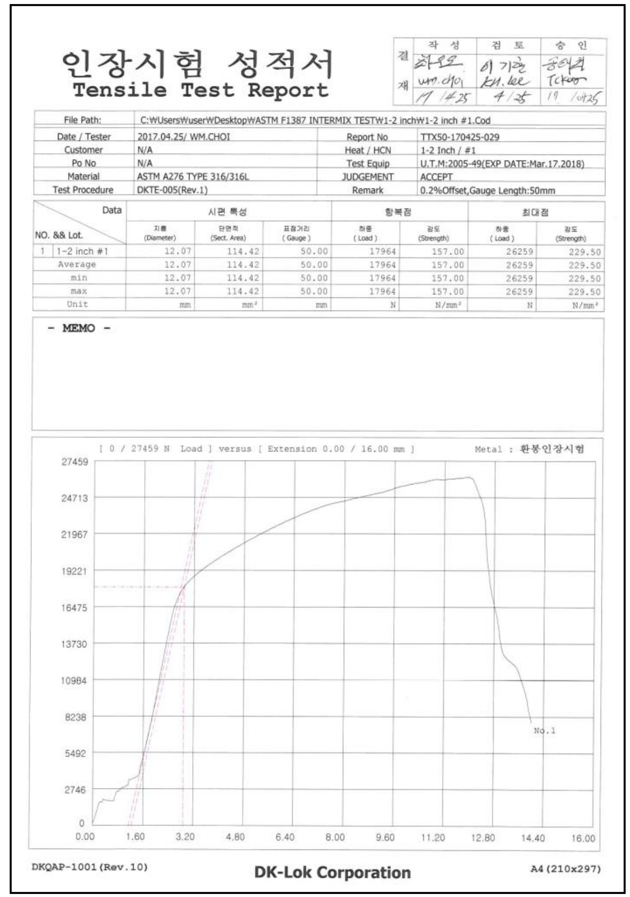




Offset to ensure tube strain larger than preset minimum

Tensile Test (A7)

Section No.	Description
A7	Tensile Load larger than minimum



인장시험 성적서
Tensile Test Report

결재	작 성	검 토	승 인

File Path:	C:₩Users₩user₩Desktop₩ASTM F1387 INTERMIX TEST₩1-2 inch₩1-2 inch #1.Cod		
Date / Tester	2017.04.25/ WM.CHOI	Report No	TTX50-170425-029
Customer	N/A	Heat / HCN	1-2 Inch / #1
Po No	N/A	Test Equip	U.T.M:2005-49(EXP DATE:Mar.17.2018)
Material	ASTM A276 TYPE 316/316L	JUDGEMENT	ACCEPT
Test Procedure	DKTE-005(Rev.1)	Remark	0.2%Offset,Gauge Length:50mm

Data / NO. && Lot.	시편 특성			항복점		최대점	
	지름 (Diameter)	단면적 (Sect. Area)	표점거리 (Gauge)	하중 (Load)	강도 (Strength)	하중 (Load)	강도 (Strength)
1 1-2 inch #1	12.07	114.42	50.00	17964	157.00	26259	229.50
Average	12.07	114.42	50.00	17964	157.00	26259	229.50
min	12.07	114.42	50.00	17964	157.00	26259	229.50
max	12.07	114.42	50.00	17964	157.00	26259	229.50
Unit	mm	mm²	mm	N	N/mm²	N	N/mm²

- MEMO -

[0 / 27459 N Load] versus [Extension 0.00 / 16.00 mm]   Metal : 환봉인장시험

27459, 24713, 21967, 19221, 16475, 13730, 10984, 8238, 5492, 2746, 0

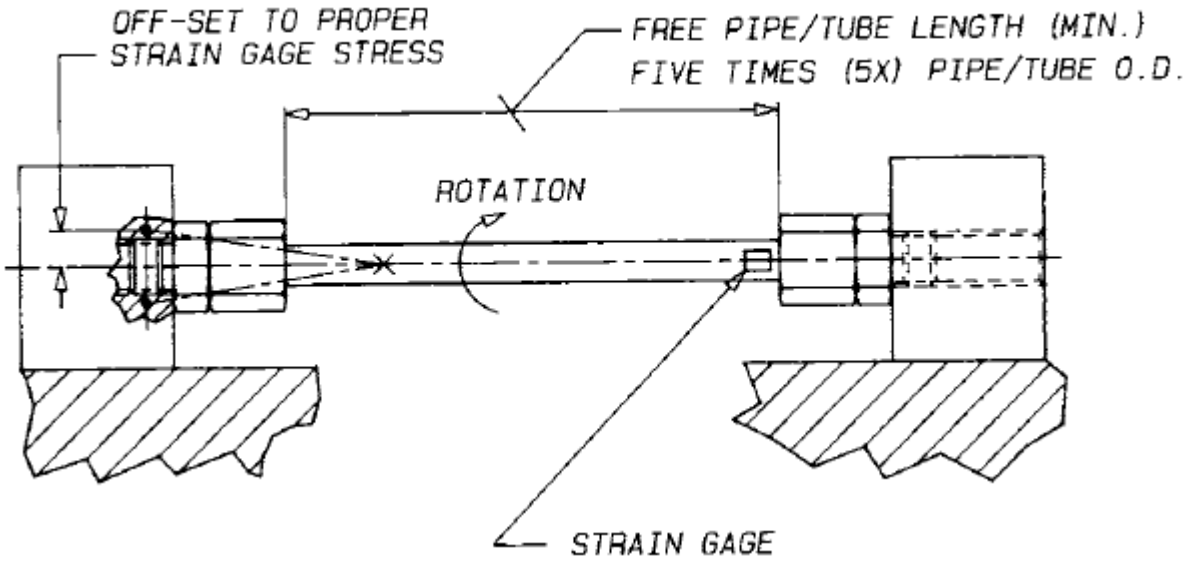
0.00, 1.60, 3.20, 4.80, 6.40, 8.00, 9.60, 11.20, 12.80, 14.40, 16.00

No.1

DKQAP-1001 (Rev.10)   DK-Lok Corporation   A4 (210x297)

Rotary Flexure Test (A10)

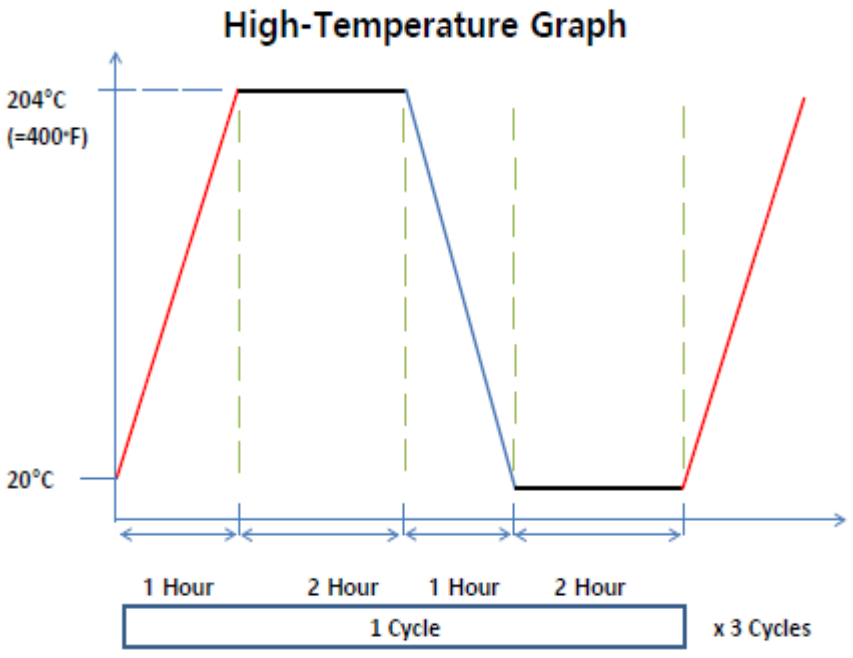
Section No.	Description
A10	1,000,000 cycle x 1750 rpm

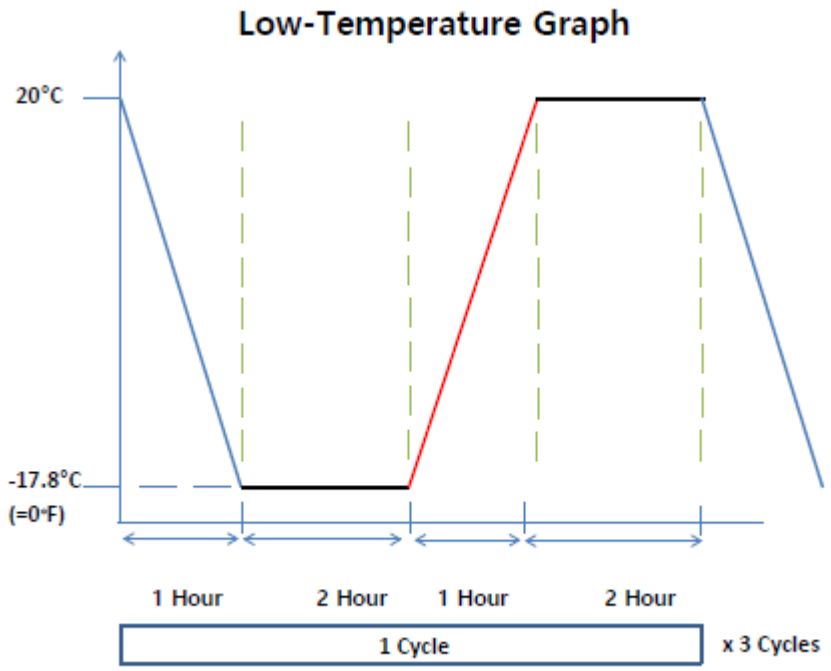


Axial offset to ensure tube strain larger than preset minimum

Thermal Cycling Test (S2)

Section No.	Description
S2	3 x High Temp. (204℃= 400°F) cycling, (6hr/cycle), 3 x Low Temp. (-17.8℃ = 0°F) cycling, (6hr/cycle)





Vibration Test (S8)

Section No.	Description
S8	4Hz -> 60Hz by 1Hz at 5 min/Hz (Frequency Increase) x, y, z axis respectively, 60Hz for 2 hours (Endurance at maximum frequency) at z axis

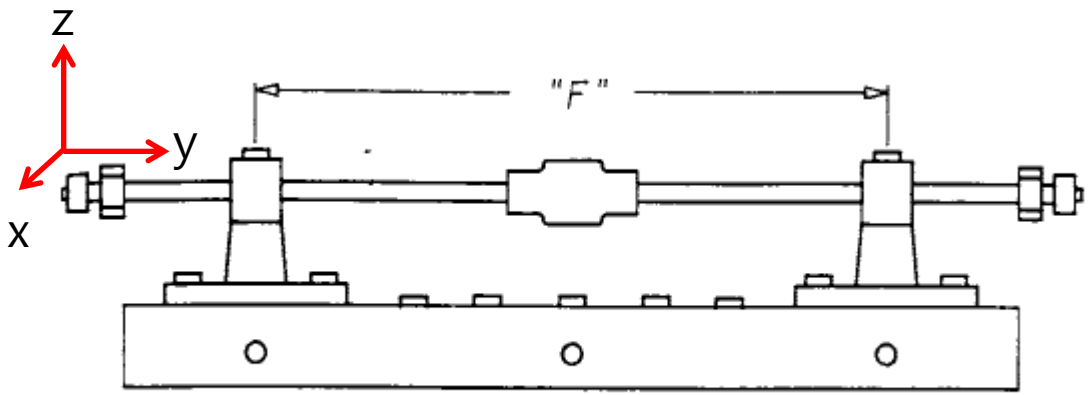
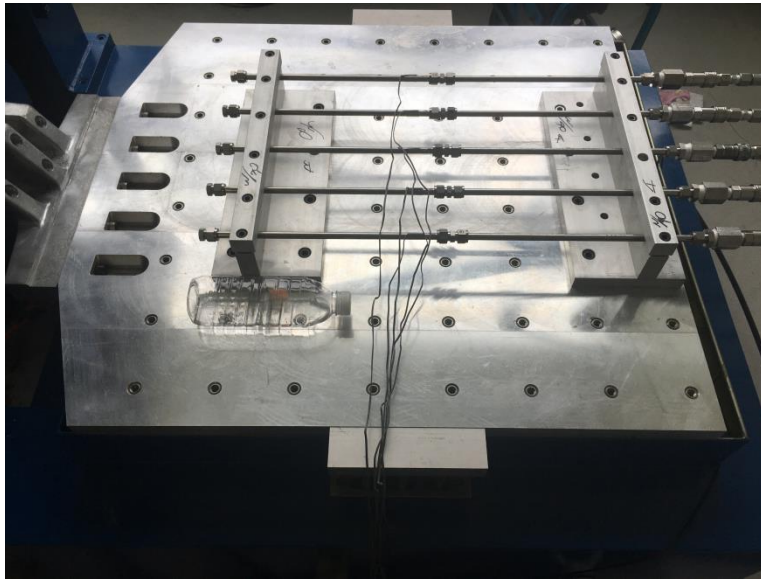


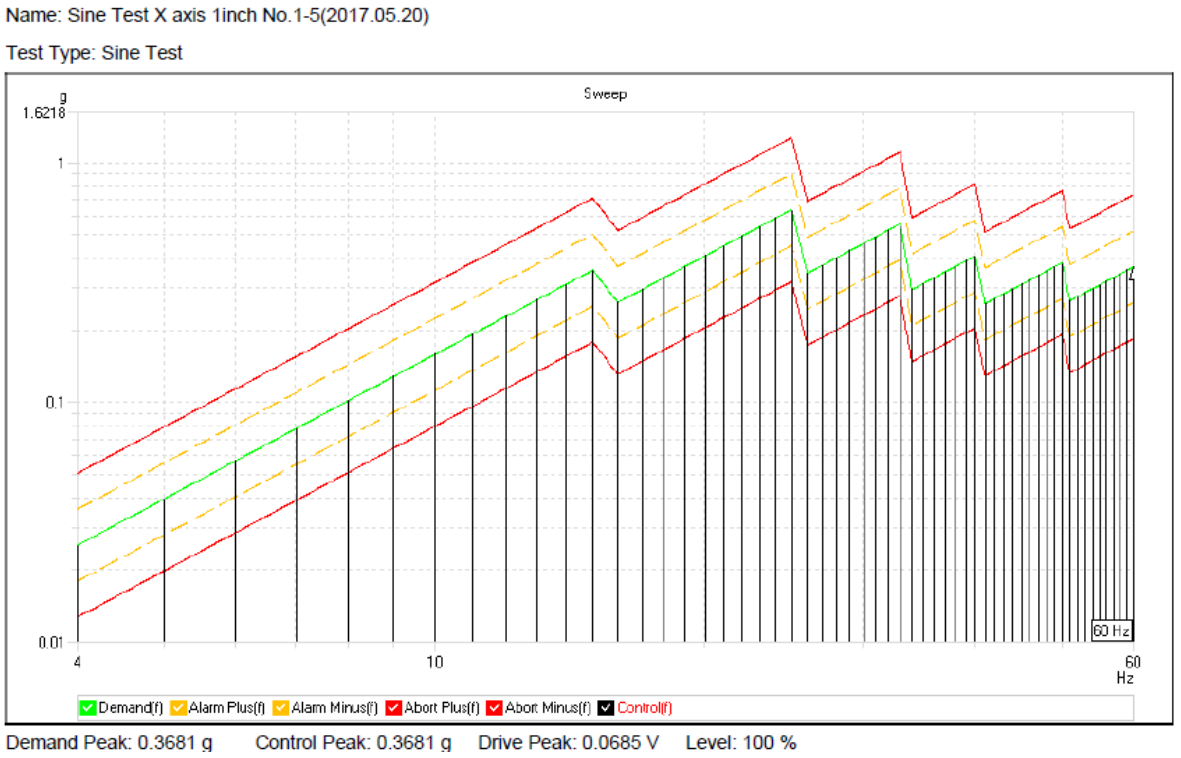
FIG. S8.1 Vibration Test Specimen Geometry

Frequency Range (Hz)	Amplitude (inch)
4 to 15	0.031±.006
16 to 25	0.020±.004
26 to 33	0.010±.002
34 to 40	0.005±.001
41 to 50	0.003±.000
50 to 60	0.002±.000

Vibration Test Bed & Graph



Vibration Test Equipment



Acceleration vs. Frequency (4~60Hz)

TUV Rheinland Test Report

Industrie Service - *(KOREA)*
Testing Laboratory for Pressure Equipment

TÜVRheinland®

3rd party witnessing intermix test report for DK-Lok Corporation

Report No. : **133050164**
Name of test : **Intermix test of DK-Lok & Swagelok tube fittings**

Applicant	**DK-Lok Corporation** **7, Golden root-ro 129beon-gil, Juchon-myeon, Gimhae-si, Gyeongsangnam-do, Korea** **ZIP-CODE : 50969**
Trade mark	DK-LOK Corporation
Manufacturer	As above
Test location	As above
Test date	April 05 ~ 18, 2016 / April 25 ~ December 18, 2017
Products tested	DK-Lok & Swagelok Tube Fittings - Size : 1/4", 3/8", 1/2", 3/4", 1"
Requirements	1) ASTM F1387-99 Standard Specification for Performance of Piping and Tubing Mechanically Attached Fittings - A3 for Pneumatic Proof Test - A4 for Hydrostatic Proof Test - A5 for Impulse Test - A6 for Flexure Fatigue Test - A7 for Tensile Test - A8 for Hydrostatic Burst Test - A9 for Repeated Assembly Test - A10 for Rotary Flex Test - S2 for Thermal Cycling Test - S8 for Vibration Test 2) Test Condition

Intermix Matrix	#1	#2	#3	#4	#5	#6	#7
DK Nut-DKN	SN	DKN	DKN	DKN	SN	DKN	DKN
DK Back Ferrule - DKBF	DKBF	SBF	DKBF	DKBF	SBF	SBF	DKBF
DK Front Ferrule - DKFF	DKFF	DKFF	SFF	DKFF	DKFF	SFF	SFF
DK-Body - DKB	DKB	DKB	DKB	SB	DKB	DKB	SB
	#8	#9	#10	#11	#12	#13	#14
Swagelok Nut-SN	SN	DKN	SN	SN	DKN	SN	SN
Swagelok Back Ferrule - SBF	DKBF	SBF	DKBF	SBF	SBF	SBF	DKBF
Swagelok Front Ferrule - SFF	SFF	DKFF	DKFF	SFF	SFF	DKFF	SFF
Swagelok-Body - SB	DKB	SB	SB	DKB	SB	SB	SB

#1 ~ #14 show all possible intermix conbinations between DK-Lok and Swagelok fittings.
Five different sizes (1/4", 3/4", 1/2", 3/4", 1") of the fourteen combinations (#1 ~ #14) make 70 intermixed fittings to be tested.

Detail information of test specimen	1) Tube Fittings - Size : 1/4", 3/8", 1/2", 3/4", 1" - Grade : ASTM A276/A479 TP316/316L Stainless Steel - Type : Double Ferrule Compression Fitting - Manufacturer : DK-Lok and Swagelok 2) Tubes - Material : ASTM A213/A269 TP316/316L Stainless Steel - Size : 1/4", 3/8", 1/2", 3/4", 1" - Wall thickness : 0.035" (1/4" O.D), 0.049"(3/8" O.D), 0.065"(1/2" O.D), 0.095"(3/4" O.D), 0.109"(1" O.D)

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Industrie Service - (KOREA)
Testing Laboratory for Pressure Equipment

TÜVRheinland®

Report No. : **133050164**

Documentation & Tests carried out	1. Pneumatic Proof Test & Hydrostatic Proof Test & Hydrostatic Burst Test Test report: DKTR-160418-001 Reference ASTM F1387 Annex A3,A4,A8 2. Impulse Test Test report: DKTR-INT-17-005 Reference ASTM F1387 Annex A5 3. Repeated Assembly Test (Included Flexure Fatigue & Impulse Test) Test report: DKTR-INT-17-004~005 Reference ASTM F1387 Annex A9 4. Tensile Test Test report: DKTR-INT-17-002 Reference ASTM F1387 Annex A7 5. Flexure Fatigue Test Test report: DKTR-INT-17-004 Reference ASTM F1387 Annex A6 6. Rotary Flex Test Test repot: DKTR-INT-17-003 Reference ASTM F1387 Annex A10 7. Thermal Cycling Test Test report: DKTR-INT-17-006 Reference ASTM F1387 Annex S2 8. Vibration Test Test report: DKTR-INT-17-001 Reference ASTM F1387 Annex S8
Test results	Requirements No leakage from the above tests. Results **There was no observable leakage during the above tests.**
Final decision	**All the test specimens meet the above requirement of ASTM F1387-99.**

Changwon, Korea / Dec. 18, 2017

TÜV Rheinland Korea
Industrial Service/Pressure Equipment
& Plant Technology

J.H.Jeong(Inspector)

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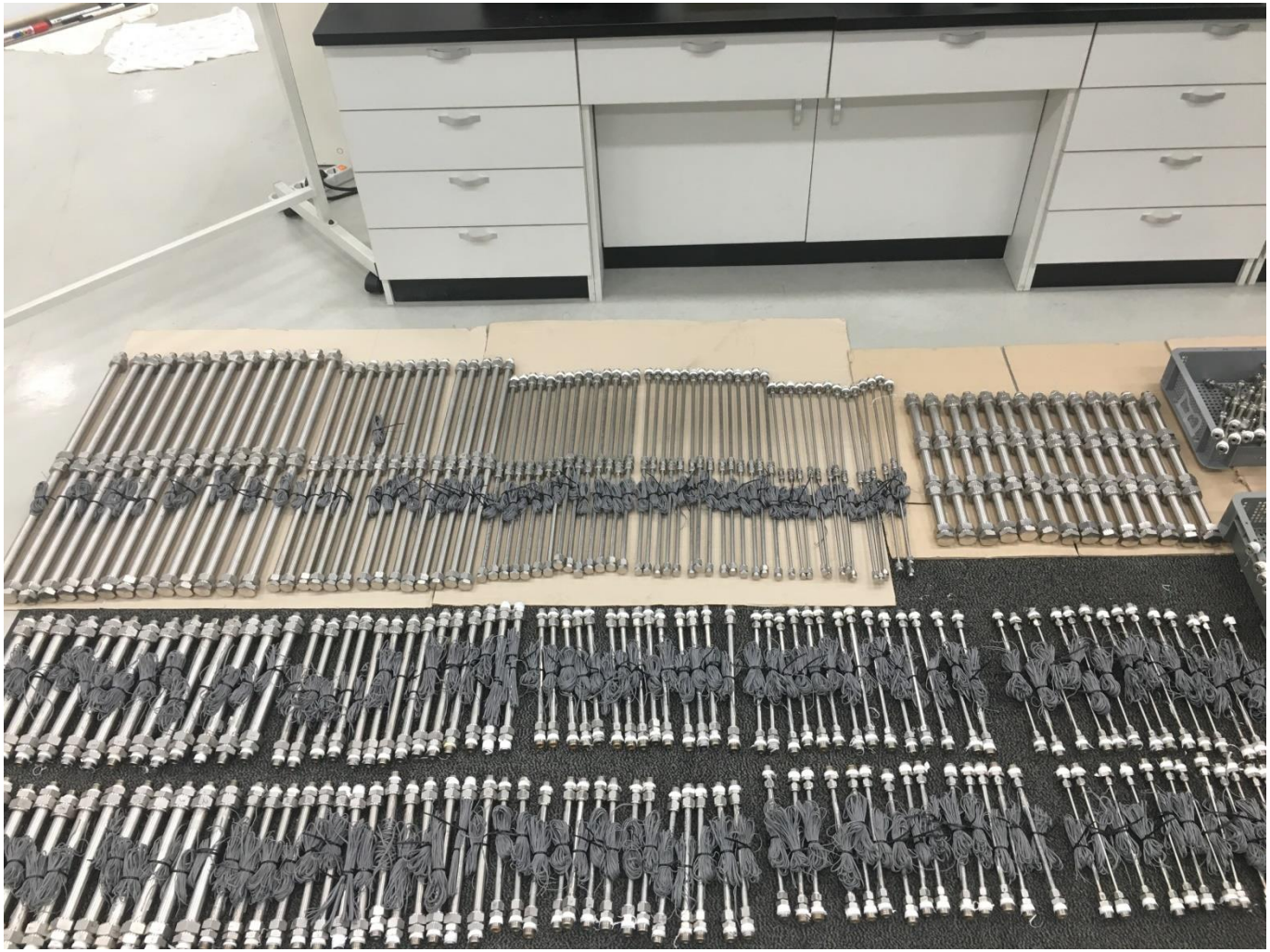
3rd-party witnessing test report, showing no leakage during all the tests.

Test Specimen, Partially Shown



Q&A