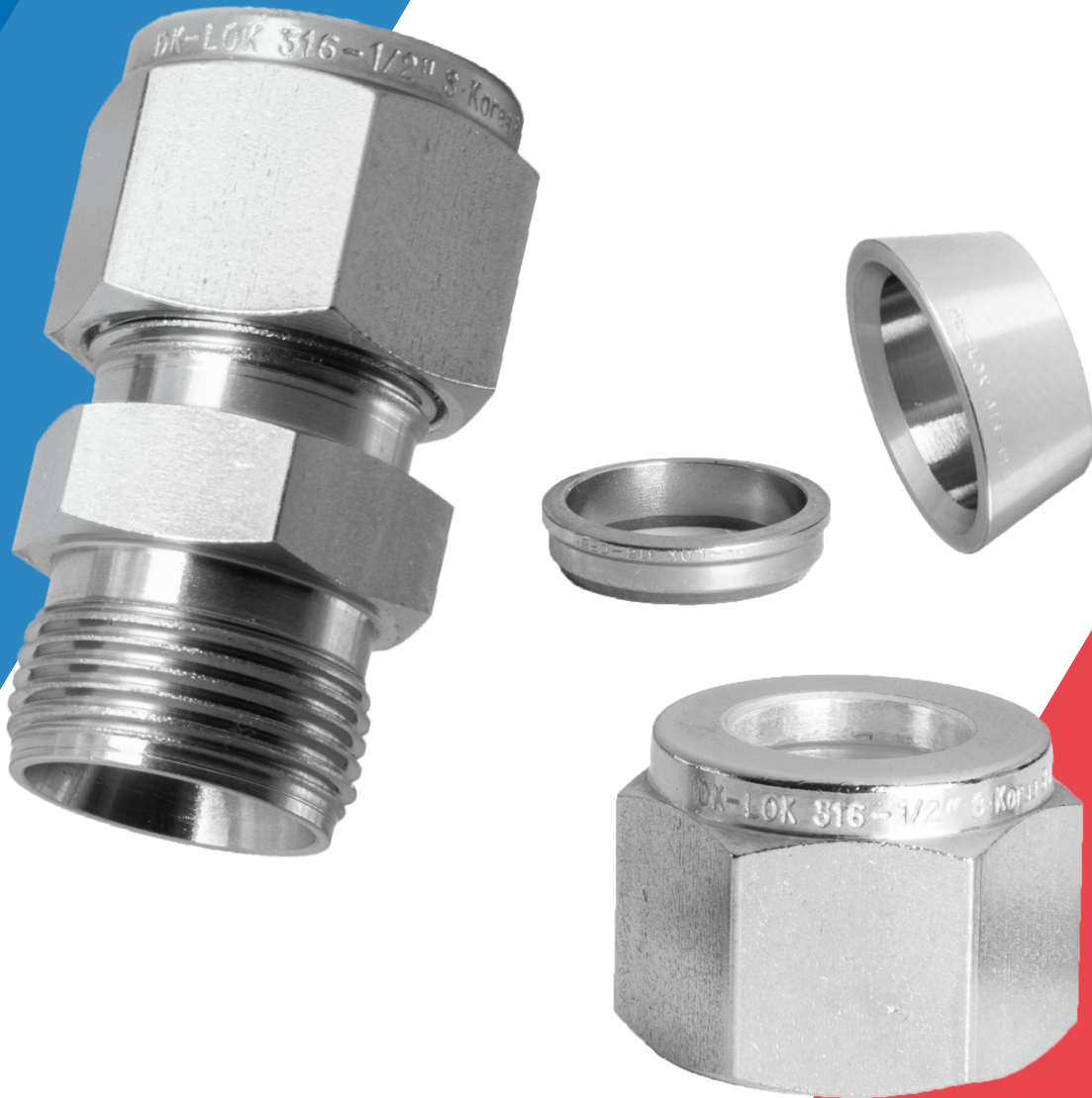




## ASTM F-1387 INTERMIX TEST

The purpose of this test procedure is to establish that any intermixed combination of DK-LOK® and Swagelok® individual components will provide leak-free performance synonymous with pure assemblies when subjected to various conditions inherent to the environments for which compression tube fittings are commonly exposed in practical everyday installations.





## About the Company

DK-LOK® strives to ensure customer satisfaction by providing products of the highest quality. We expanded the customer base with the world's leading companies in CNG & NGV, Offshore & Onshore, Shipbuilding & Marine Engine, Chemical, Petrochemical & Refinery, Semiconductor, Railway Vehicles, and Power Plant industries in 47 countries across the globe.

Here at DK-LOK®, we continue to bolster our growth through aggressive investment in production, continual employee training, and research for the development of new technologies that pioneer the future of our industry. For superior product and process quality, we acquired the certifications of ASME N, NPT, and NS stamps. Moreover, we have received product certifications from global certification agencies such as: LR, GL, ABS, DNV, RWTUV, NK, and KR. As a result, we are able to ensure high quality products and services that meet the specific needs of our global customers.

## Certifications for DK-LOK®



## Testing Specifications

### Tube Outside Diameter by Wall Thickness Combinations

Tube Size (inch)	Tube Rate Pressure (psig / bar)	Tube Hardness (HRB)
1/4 x 0.049	7,500 / 517	75 ~ 78
3/8 x 0.049	4,800 / 331	75 ~ 78
1/2 x 0.065	4,700 / 324	70 ~ 77
3/4 x 0.095	4,900 / 338	75 ~ 80
1 x 0.109	4,200 / 290	75 ~ 79

### Intermix Matrix for Swagelok® & DK-LOK®

	#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
	1A - 1E	2A - 2E	3A - 3E	4A - 4E	5A - 5E	6A - 6E	7A - 7E
	#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
	8A - 8E	9A - 9E	10A - 10E	11A - 11E	12A - 12E	13A - 13E	14A - 14E

### Tests Based on ASTM F1387 – 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	-

### Tests Based on ASTM F1387 – Supplemental 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

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.

All tests witnessed by TUV Rheinland. No failure observed.



## Pneumatic Proof Test Results – 3X F-1387 Requirements

All test data was measured and recorded with calibrated gauges in accordance with ASTM F-1387 requirements.

1. Each spool containing specimens was submerged under water.
2. Each spool was pressurized to 100 psi using **Nitrogen(N2)** for 5 minutes.
3. The first minute allowed for the dissipation of surface bubbles.
4. After 5 minutes observing no leakage, the pressure was gradually increased to **125% of the rated working pressure of the tube**, and held for 5 minutes.
5. No leakage was observed.
6. After completing the first Pneumatic Proof, each specimen was disassembled and reassembled two times.
7. Steps 1 through 6 were repeated a second and third time with no leakage.
8. The Pneumatic Proof test was conducted three times. ASTM F-1387 only requires one run. Additionally, the test was conducted at **125% of the rated working pressure of the tube**. ASTM F-1387 only requires 125% of the rated working pressure of the tube or 500 PSI – **WHICHEVER IS LOWER**.

Size / Test Pressure	Tube Rate Pressure	Pressure
1/4" T x .049"	7,500 PSI x 125%	9,375 PSI
3/8" T x .049"	4,800 PSI x 125%	6,000 PSI
1/2" T x .065"	4,700 PSI x 125%	5,875 PSI
3/4" T x .095"	4,900 PSI x 125%	6,125 PSI
1" T x .109"	4,200 PSI x 125%	5,250 PSI



## Hydrostatic Proof Test Results – 3X F-1387 Requirements

All test data was measured and recorded with calibrated gauges in accordance with ASTM F-1387 requirements.

1. Each spool containing specimens was mounted in the test chamber with one end free to move.
2. Each spool was filled with water.
3. Each spool was pressurized to 100 PSI for 5 minutes.
4. After observing no leakage, the pressure was gradually increased to **150% of the rated working pressure of the tube**, and held for an additional 5 minutes.
5. After observing no leakage, the spool was depressurized and drained.
6. Each specimen was disassembled and reassembled two times.
7. Steps 1 through 6 were then repeated with no leakage.
8. Steps 1 through 4 were then repeated. The Hydrostatic Proof test was conducted three times. After the third run, no make and break was conducted as the spools were then subjected to the Hydrostatic Burst Test.

Size / Hydro Pressure	Tube Rate Pressure	Pressure
1/4" T x .049"	7,500 PSI x 150%	11,250 PSI
3/8" T x .049"	4,800 PSI x 150%	7,200 PSI
1/2" T x .065"	4,700 PSI x 150%	7,050 PSI
3/4" T x .095"	4,900 PSI x 150%	7,350 PSI
1" T x .109"	4,200 PSI x 150%	6,300 PSI



The original specimens were subjected to all three Pneumatic Proof Tests and all three Hydrostatic Proof Tests (including 10 repeat assemblies), concluding with the Hydrostatic Burst Test (destructive test). New specimens were introduced for each of the remaining test.

## Hydrostatic Burst Test Results

All test data was measured and recorded with calibrated gauges in accordance with ASTM F-1387 requirements.

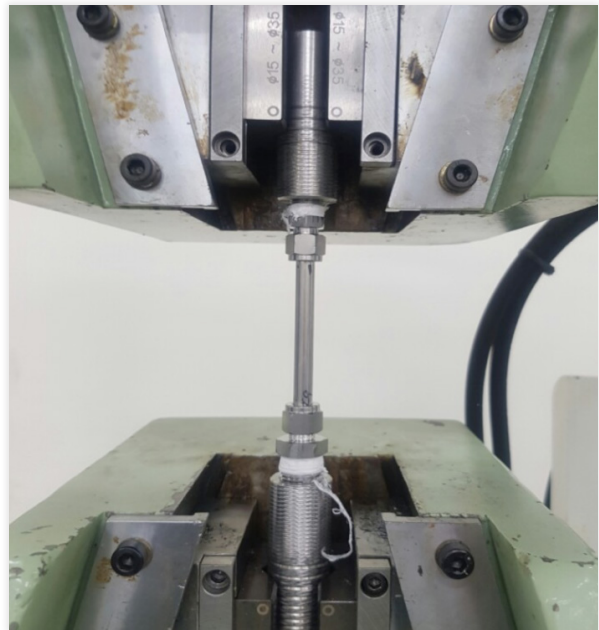
1. The spools, having completed the third Hydrostatic Proof, were immediately subjected to the Hydrostatic Burst.
2. The spool pressure was gradually increased from 150% of the rated working pressure of the tube to 4 times the rated working pressure of the tube and held for 1 minute.
3. After observing no leakage for 1 minute at 4 times the rated working pressure of the tube, the test pressure was gradually increased until the spool ruptured.
4. All ruptures took place in the tube sections.
5. All specimens held as promoted and expected to the rupture of the tube.

Size / Hydro Pressure	Tube Rate Pressure	Pressure
1/4" T x .049"	7,500 PSI x 4	30,000 PSI
3/8" T x .049"	4,800 PSI x 4	19,200 PSI
1/2" T x .065"	4,700 PSI x 4	18,800 PSI
3/4" T x .095"	4,900 PSI x 4	19,600 PSI
1" T x .109"	4,200 PSI x 4	16,800 PSI



## Tensile Pull Test Results

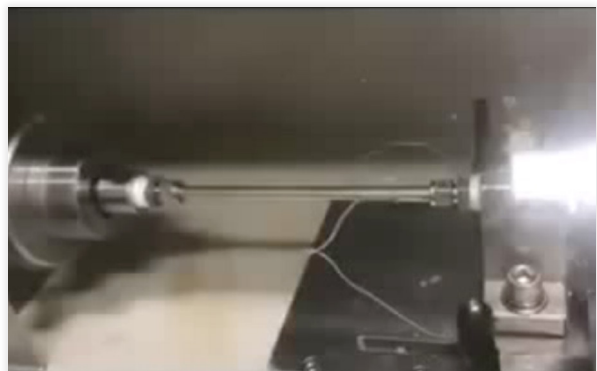
1. The significance of this test is to apply a tensile load at a controlled separation speed to establish how much load is needed to separate the test specimen.
2. The amount of tensile load applied depends upon the cross-section area and the yield strength of the tube.
3. Calculated tensile load =  $(K_t) \times (A_p) \times (S_y)$ 
  - a. Where  $K_t$  = tensile constant of 1.0;
  - b. Where  $A_p$  = actual cross-section area of the tube, mm<sup>2</sup> (in.<sup>2</sup>) based on wall thickness;
  - c. Where  $S_y$  = minimum specified yield strength of the tube.
4. The specimens pass this test when the calculated tensile load is achieved without separation of the joint. Movement within the area of the joint is acceptable as long as actual separation does not occur. This test is useful in determining the strength of the tube or MAF joint. Based upon the strength of the joint, the tube material and wall thickness can be tailored to withstand failure within the adverse environments present in fluid systems for which MAF is designed.



## Rotary Flex Test Results

All test data was measured and recorded with calibrated gauges and properly located strain gauges in accordance with ASTM F-1387 requirements.

1. The test spool containing specimens filled with water.
2. A bending moment equivalent to a minimum of 35% of the ultimate tensile strength (of the tubing material) was introduced and locked into place.
3. Each spool was pressurized to 500 PSI.
4. The specimen was flexed in a rotary motion at a minimum of 1750 rpm for 1,000,000 cycles while maintaining the bending moment and 500 PSI pressure rating.
5. After 1,000,000 cycles were completed with no leakage, the specimens were then subjected to a Hydrostatic Proof test. With no leakage after completion of the Hydrostatic Proof Test, the specimens passed the Rotary Flex Test.



## Flex Fatigue Test Results

All test data was measured and recorded with calibrated gauges and properly located strain gauges in accordance with ASTM F-1387 requirements.

1. Each spool containing specimens was filled with water.
2. Each spool was subjected to flexure while pressurized to the maximum rated working pressure of the tube.
3. The specimen was subjected to a bi-directional flexure in the same plane for 30,000 cycles to a distance range derived from the formula provided in ASTM F-1387 Section A6.3.5.
4. A complete cycle consisted of travel from neutral (zero strain) to the maximum positive strain position in one direction, to the maximum negative strain position in the opposite direction, and return to neutral.
5. At each 7,500 cycles, the spool was depressurized with the specimen being rested was disassembled and reassembled two times.
6. After 30,000 cycles were completed with no leakage, the specimens were then subjected to a Hydrostatic Proof test. With no leakage after completion of the Hydrostatic Proof Test, the specimens passed the Flexure Fatigue Test.

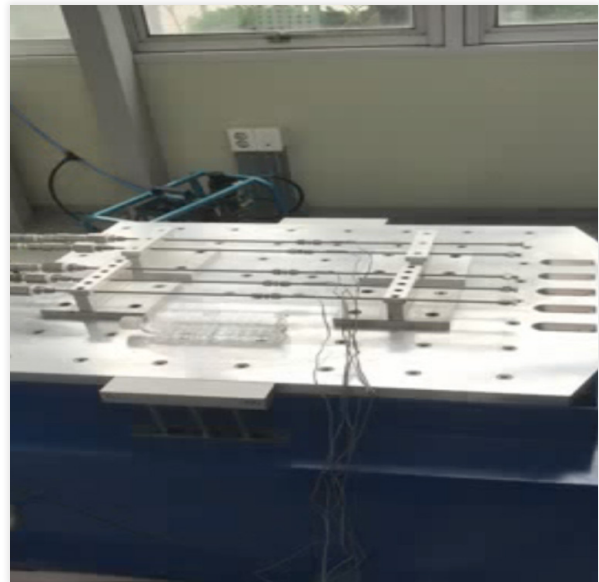
Size / Hydro Pressure	Pressure
1/4" T x .049"	7,500 PSI
3/8" T x .049"	4,800 PSI
1/2" T x .065"	4,700 PSI
3/4" T x .095"	4,900 PSI
1" T x .109"	4,200 PSI



## Vibration Test Results



All test data was measured and recorded with calibrated gauges and properly located strain gauges in accordance with ASTM F-1387 requirements.

1. The test spool containing specimens was filled with water.
2. The test fixture was equipped with supports, to be attached to the test specimen during testing. The supports were spaced in accordance with ASTM F-1387 requirements per OD size.
3. The test was conducted in each of the three principle directions (X,Y, and Z).
4. Each spool was pressurized to the maximum rated working pressure of the tube.
5. Perform the following tests: Exploratory Vibration test, Variable Frequency test, and Endurance test.
6. The specimens successfully passed the Vibration Test after meeting the test requirements and passing the subsequent Hydrostatic Proof Test.
7. No leakage was observed.





# TUV Rheinland 3<sup>rd</sup> Party Certification

Industrie Service - (KOREA) Testing Laboratory for Pressure Equipment 																																																																									
<b>3<sup>rd</sup> party witnessing intermix test report for DK-Lok Corporation</b>																																																																									
Report No. : 133050164	Name of test : Intermix test of DK-Lok & Swagelok tube fittings																																																																								
Applicant : DK-Lok Corporation 7, Golden roadno.129beon-gil, Juchon-myeon, Gimhae-si, Gyeongsangnam-do, Korea ZIP-CODE : 50969																																																																									
Trade mark :  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 <table border="1" style="width: 100%; text-align: center;"> <tr> <th></th> <th>#1</th> <th>#2</th> <th>#3</th> <th>#4</th> <th>#5</th> <th>#6</th> <th>#7</th> </tr> <tr> <td>DK Nut/DKN</td> <td>SN</td> <td>DKN</td> <td>DKN</td> <td>DKN</td> <td>SN</td> <td>DKN</td> <td>DKN</td> </tr> <tr> <td>DK Back Female - DKBF</td> <td>SN</td> <td>DKBF</td> <td>DKBF</td> <td>DKBF</td> <td>SN</td> <td>DKBF</td> <td>DKBF</td> </tr> <tr> <td>DK Front Female - DKFF</td> <td>DKFF</td> <td>DKFF</td> <td>SFF</td> <td>DKFF</td> <td>DKFF</td> <td>SFF</td> <td>SFF</td> </tr> <tr> <td>DK-Body - DKB</td> <td>DKB</td> <td>DKB</td> <td>DKB</td> <td>DKB</td> <td>DKB</td> <td>DKB</td> <td>DKB</td> </tr> <tr> <td>Swagelok Nut-SN</td> <td>SN</td> <td>DKN</td> <td>SN</td> <td>SN</td> <td>DKN</td> <td>SN</td> <td>SN</td> </tr> <tr> <td>Swagelok Back Female - SBF</td> <td>DKBF</td> <td>SBF</td> <td>DKBF</td> <td>SBF</td> <td>SBF</td> <td>DKBF</td> <td>DKBF</td> </tr> <tr> <td>Swagelok Front Female - SFF</td> <td>SFF</td> <td>DKFF</td> <td>DKFF</td> <td>SFF</td> <td>SFF</td> <td>DKFF</td> <td>SFF</td> </tr> <tr> <td>Swagelok Body - SB</td> <td>DKB</td> <td>SB</td> <td>DKB</td> <td>SB</td> <td>SB</td> <td>DKB</td> <td>SB</td> </tr> </table>			#1	#2	#3	#4	#5	#6	#7	DK Nut/DKN	SN	DKN	DKN	DKN	SN	DKN	DKN	DK Back Female - DKBF	SN	DKBF	DKBF	DKBF	SN	DKBF	DKBF	DK Front Female - DKFF	DKFF	DKFF	SFF	DKFF	DKFF	SFF	SFF	DK-Body - DKB	DKB	DKB	DKB	DKB	DKB	DKB	DKB	Swagelok Nut-SN	SN	DKN	SN	SN	DKN	SN	SN	Swagelok Back Female - SBF	DKBF	SBF	DKBF	SBF	SBF	DKBF	DKBF	Swagelok Front Female - SFF	SFF	DKFF	DKFF	SFF	SFF	DKFF	SFF	Swagelok Body - SB	DKB	SB	DKB	SB	SB	DKB	SB
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#1 ~ #14 show all possible intermix combinations 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 Female 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.)																																																																								

Industrie Service - (KOREA) Testing Laboratory for Pressure Equipment 	
Report No. : 133050164	
Documentation & Tests carried out	1. Pneumatic Proof Test & Hydrostatic Proof Test & Hydrostatic Burst Test Test report: DKTR-100418-001 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 report: 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 <div style="display: flex; justify-content: space-between;"> <div>           TUV Rheinland Korea            Industrial Service/Pressure Equipment            &amp; Plant Technology   </div> <div>  </div> </div>	
Page 2 of 2 <div style="display: flex; justify-content: space-between;"> <div>           TUV Rheinland Korea            41-40, Paryong-dong, Ulsang-gu,            Changwon, Gyeongsangnam-do, 51390, Korea         </div> <div>           Tel : +82 2 860 9850            Fax : +82 2 860 9851            Home page : www.kor.tuv.com         </div> </div>	

## Warranty Letter

**Subject: DK-LOK® Liability Statement with Intermixed Swagelok® components**

August 18, 2016

To Whom It May Concern

DK-LOK® warrants that DK-LOK® fittings are free from defects in materials and workmanship.

The nut and body threads on DK-LOK® Fitting OD are constructed in accordance with ASME B1.1 and the thread tolerances are controlled as specified in ASME B1.1. This tolerance ensures consistent make-up distance.

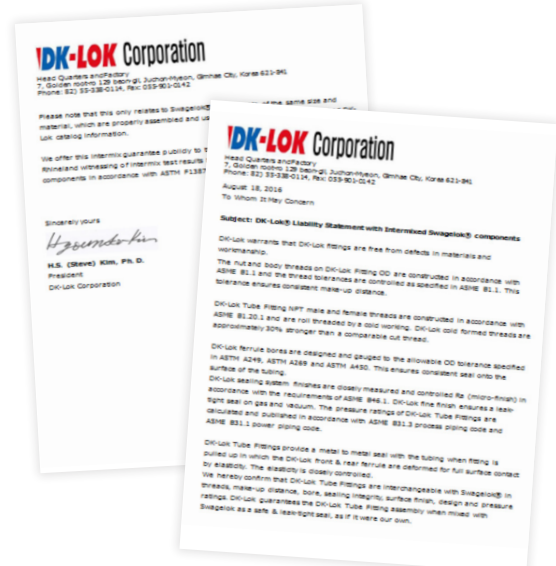
DK-LOK® Tube Fitting NPT male and female threads are constructed in accordance with ASME B1.20.1 and are roll threaded by a cold working. DK-LOK® cold formed threads are approximately 30% stronger than a comparable cut thread.

DK-LOK® ferrule bores are designed and gauged to the allowable OD tolerance specified in ASTM A249, ASTM A269 and ASTM A450. This ensures consistent seal onto the surface of the tubing.

DK-LOK® sealing system finishes are closely measured and controlled Ra (micro-finish) in accordance with the requirements of ASME B46.1. DK-LOK® fine finish ensures a leak-tight seal on gas and vacuum. The pressure ratings of DK-LOK® Tube Fittings are calculated and published in accordance with ASME B31.3 process piping code and ASME B31.1 power piping code.

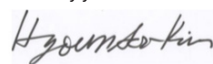
DK-LOK® Tube Fittings provide a metal to metal seal with the tubing when fitting is pulled up in which the DK-LOK® front & rear ferrule are deformed for full surface contact by elasticity. The elasticity is closely controlled. We hereby confirm that DK-LOK® Tube Fittings are interchangeable with Swagelok® in threads, make-up distance, bore, sealing integrity, surface finish, design and pressure ratings. DK-LOK® guarantees the DK-LOK® Tube Fitting assembly when mixed with Swagelok as a safe & leak tight seal, as if it were our own.

Please note that this only relates to Swagelok® components of the same size and material, which are properly assembled and used in accordance with the published DK-LOK® catalog information.



We offer this intermix guarantee publicly to the marketplace based upon TUV Rheinland witnessing of intermix test results between DK-LOK® and Swagelok® components in accordance with ASTM F1387-99(2005)

Sincerely yours

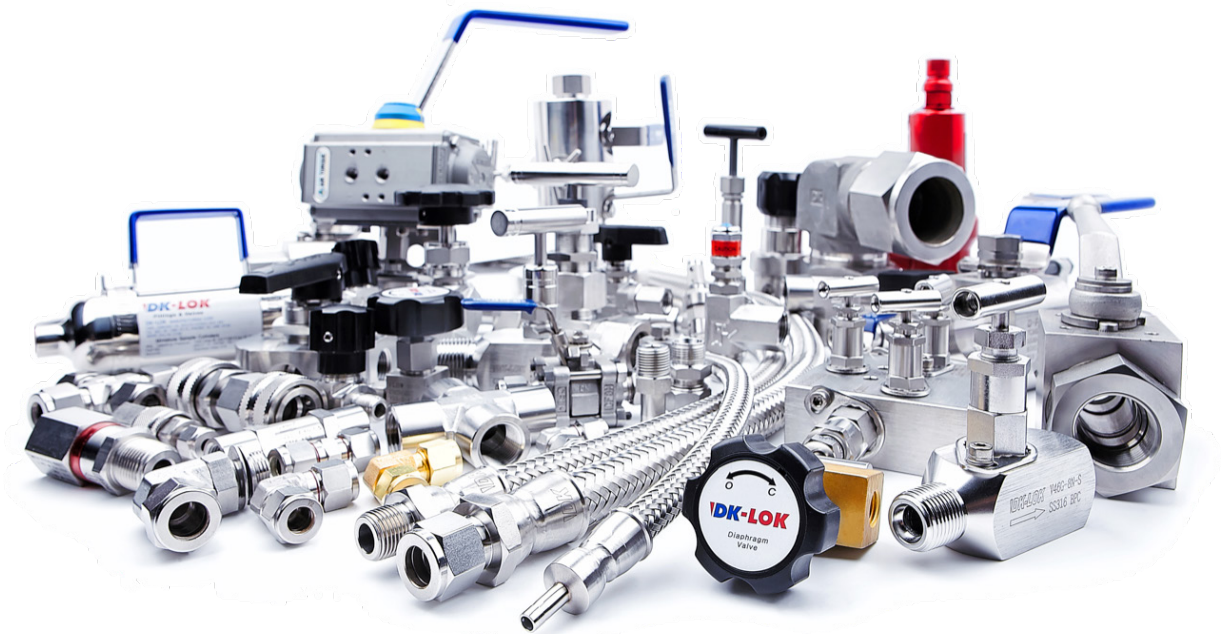


**H.S. (Steve) Kim, Ph. D.**  
 President  
 DK-LOK® Corporation

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# DK-LOK®

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DK-LOK®

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