Testing of UniLok BR Series Braid Terminations **November 15, 2022**

Intrinsic Devices Inc.

Introduction

Intrinsic Devices has developed a family of heat shrinkable NiTiNb shape memory alloy rings to be used to terminate cable shielding braids to connector backshells. These are meant to be a drop in replacement for TE's Tinel-Lock^{tm} product line. Intrinsic's and TE's rings are both made with a nickel titanium niobium shape memory alloy described by US patent 4770725A. Intrinsic's version of NiTiNb, Alloy H, is melted and tested to our specifications, which have been honed over years of melting and end product production. The test program reported here confirms that rings produced with Alloy H meet the original Tinel-Lock braid termination performance specifications.

Referenced Documents

PD BR UniLok Heat Shrinkable Braid Termination Rings, Intrinsic Devices
PD012 Braid Termination Barrel Drawing, Intrinsic Devices
PD013 BR Selection Guide, Intrinsic Devices
PD014 BR Installation Procedure, Intrinsic Devices
A-A-59569 Braid, Wire (copper, tin coated or silver coated, tubular or flat), US DLA – CC
MIL-STD-202G Test Method Standard Electronic and Electrical Component Parts
TR rev. E Tinel-Lock Ring, TE Customer Drawing
MPS-101 rev. H Performance Specification for Tinel-Lock Rings, Heat Recoverable for Braid Termination, TE

Dimensional Specifications, Intrinsic drawing PD BR versus TE drawing TR

BR series rings meet or exceed TE's ring specification except as noted below. See the comparison in the table that follows.

> Minimum Supplied Inside Diameter – All BR sizes are specified with a larger as-supplied diameter than the corresponding TR sizes, except the TR06BI. We believe there is a mistake in the TE's sizing of that part.
>
> Maximum Free Recovered Inside Diameter – All BR rings are specified to shrink smaller than the corresponding TR rings.
>
> As-Supplied cross section diameter - BR rings have a nominal value that is 0.003" larger than the TR rings. That will not produce a discernable difference in fit or function.
>
> Stability Temperature – We specify that BR rings will meet the Minimum Supplied ID requirement after heating to 45C versus the TR spec of 50C. We have been delivering Alloy H products for almost 30 years with the 45C specification. Our customers have not reported problems with shrinkage prior to installation.

Comparison of Dimensional Specifications for Intrinsic Devices BR rings versus TE TR rings

Size	Minimum Supplied ID		Maximum Recovered ID		Intrinsic Supplied ID above TE supplied ID	Intrinsic Recovered ID below TE recovered ID
	Intrinsic	TE	Intrinsic	TE		
04A	0.399	0.397	0.377	0.379	0.002	0.002
04B	0.417	0.416	0.394	0.398	0.001	0.004
06A	0.525	0.523	0.496	0.499	0.002	0.003
06B	0.544	0.548	0.514	0.523	-0.004	0.009
08A	0.652	0.65	0.616	0.62	0.002	0.004
08B	0.671	0.67	0.634	0.639	0.001	0.005
10A	0.783	0.782	0.740	0.744	0.001	0.004
10B	0.803	0.802	0.759	0.763	0.001	0.004
12A	0.913	0.912	0.863	0.867	0.001	0.004
12B	0.932	0.931	0.881	0.886	0.001	0.005
14A	1.041	1.04	0.984	0.988	0.001	0.004
14B	1.061	1.06	1.003	1.007	0.001	0.004
16A	1.172	1.171	1.108	1.111	0.001	0.003
16B	1.192	1.191	1.127	1.129	0.001	0.002
18A	1.302	1.301	1.230	1.234	0.001	0.004
18B	1.321	1.32	1.248	1.252	0.001	0.004

The cross section diameter of all BR rings is .076±.005
The cross section diameter of all TR rings is .073±.005

Intrinsic Devices product Drawing PD BR rev. -
TE Customer Drawing TR rev. E

Performance specification as installed

The remainder of this report documents qualification testing performed on braid to adapter joints made with BR rings. The results demonstrate that the BR rings exceed the Tinel-Lock^{tm} specification requirements, which are as follows.

Braid to adapter contact resistance – less than one milliohm
Joint tensile strength – sizes 04 to 06 150 pounds minimum
sizes 08 and larger 200 pounds minimum

If the braid breaks, rather than the ring and braid pulling off, it is considered a pass.

These requirements are to be satisfied when tested at 25C+/- 5C, -65C+3C/-0C and 150C+/-2C. The requirements shall also be met when tested at 25C following thermal shock conditioning per MIL-STD-202, Method 107, Test Condition F-2, modified to limit the low temperature to -65C+/-0C.

For our testing, we chose more severe conditions. For low temperature resistance and tensile we tested at -65C +0C/-3C. For the thermal shock test we ran the unmodified MIL-STD-202, Method 107, Test Condition F-2 with a low temperature cycle to -65C/-70C.

The Tinel-Lock^{tm} specification also calls for a salt spray test. We chose not to perform this. The salt spray does nothing to the NiTiNb ring but does corrode the braid and the adapter. The results of this test are really just a test of the adapter plating.

Test Samples
We chose to test samples at entry sizes of 04, 08 and 16. We assembled 12 samples of each size as follows. See Figure 1.

BR04A lot F4460 braid AA59569*36*0250
BR08A lot F4451 braid AA59569*36*0375
BR16A lot F4520 braid AA59569*36*0781

Figure 1 The test samples

The production Tinel-Lock adapters used were inspected prior to assembly to insure the groove pattern on the termination barrel met the requirements of PD012 Braid Termination Barrel Drawing.

All rings were resistance heated for installation using the standard American Beauty power supply and handpiece per PD014 BR Installation Procedure. The braid ends opposite the adapters were solder dipped to prevent braid fraying and to insure electrical contact between the micro-ohmmeter and all of the braid strands. The length of braid between the solder and the termination point on the adapter was nominally 7.3".

Test Equipment

Resistance measurements were all taken with a Valhalla 4300B micro-ohmmeter at a 1 amp test current.
Tensile test forces were measured with an Omega LC203-2K load cell read by an Omega Strain Gage Panel Meter, DP25B-S-A.
All tensile tests and low and high temperature resistance tests were run with the samples in a Sigma Systems Model 26 environmental chamber with a custom Eurotherm controller.
In addition to the chamber's control, sample and chamber temperature were monitored with type T and K thermocouples read by a Measurement computing USB 2408 A-to-D board.
The thermal shock test was run using the Sigma systems environmental chamber and a Shel-Lab 52201 162 convection oven. Sample temperatures in the Shel-Lab oven were monitored with a type K thermocouple read by a Barnant 600-1040 thermocouple meter.

Contact resistance test method

The pairs of current and voltage leads of the Vahalla micro-ohmmeter were clipped on the adapter at one end and on the braid at the inside edge of the solder dip on the other end, approximately 7.3" from the adapter. See Figure 2. So, all resistance measurements included the resistance of about 7.3" of braid plus the contact resistance between the braid and the adapter. To determine the contact resistance, we measured the resistances of braid samples 7.3" long between solder dipped ends. See Figure 3. The resistances of 7.3" of braid varied with the size and test temperature as below. Units are milliohms.

	-65C	23C	150C
AA59569*36*0250	.45	.714	1.067
AA59569*36*0375	.44	.73	1.06
AA59569*36*0781	.184	.317	.47

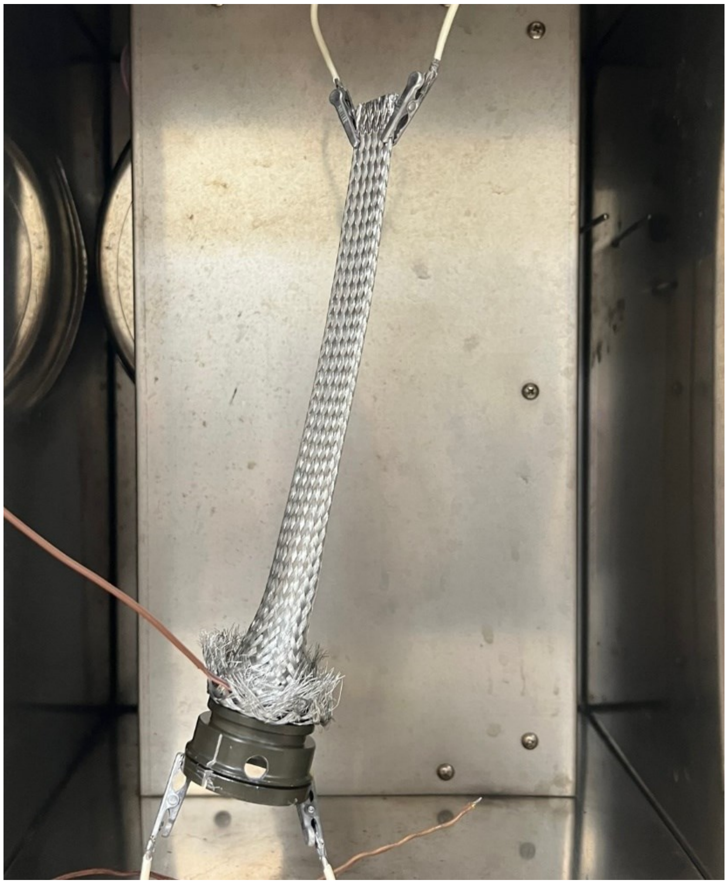

Figure 2 Resistance Measurement in Environmental Chamber

Figure 3 Resistance Measurement of the Braids

The braid resistances were subtracted from the total resistance measured to yield the braid to adapter contact resistance. There is some variability in this. The braid tails actually varied from 7.2" to 7.6". The placement of the micro-ohmmeter clips was not perfectly aligned at the edge of the solder dip. Still, this method offers a cleaner measurement of contact resistance than TE's method of clamping on the braid within 1" of the adapter. If the braid strands are not in good electrical contact with each other, less than 100% of the strands will be carrying the test current across the joint to the adapter.

Resistance measurements were performed on all samples at 23C at the start of testing and then at the specified test temperature prior to tensile testing.

Tensile Testing

All tensile tests were performed in the Sigma Systems environmental chamber. For the tests at -65C and +150C, a thermocouple was placed on the BR ring and the braid folded up to hold the thermocouple in place. The load was ramped until failure of the assembly. See Figures 4 and 5.

Figure 4   A 16 entry size sample prior to tensile at 23C

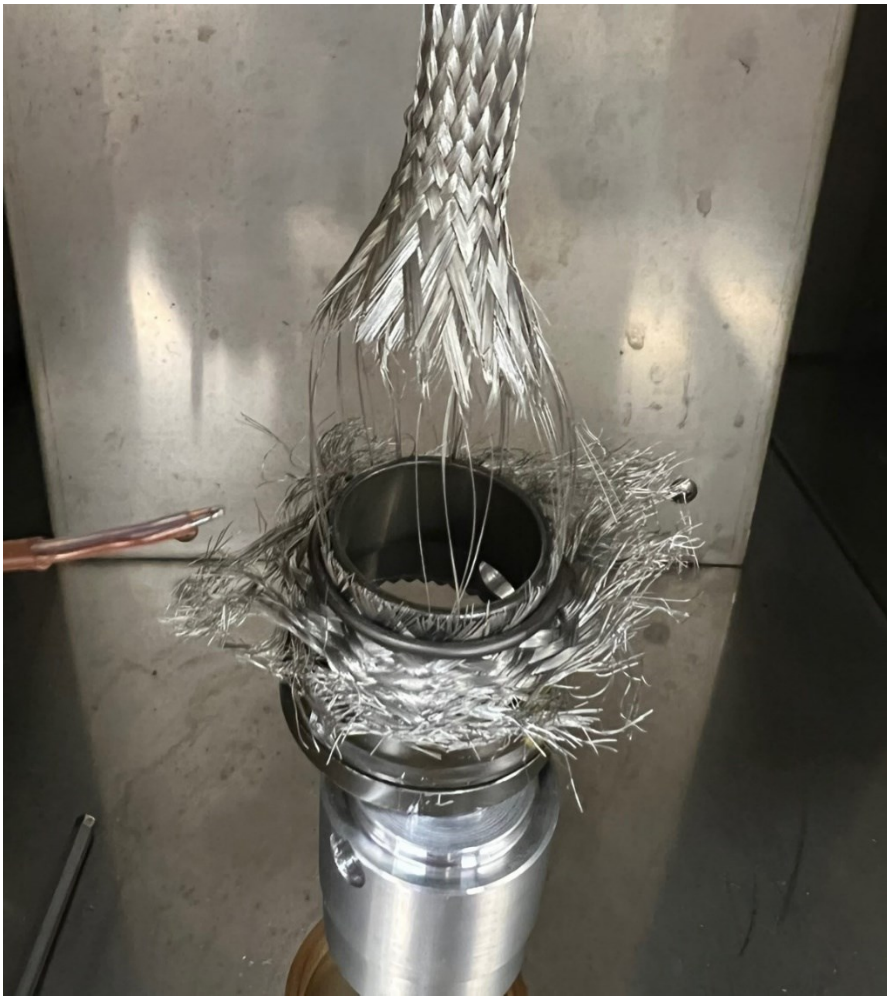

Figure 5 A 16 entry size sample after tensile

Thermal Shock Conditioning

Three samples of each size were conditioned per MIL-STD-202, Method 107, Test Condition F-2. The Sigma Systems chamber was set to -66C. The samples actually reached temperatures from -67C to -70C due to overshoot of the chamber control following placement of the samples in the chamber. The Shel-Lab convection oven was set to 155C. The samples reached temperatures between 150C and 154C on each hot cycle.

The samples were strung on a wire “trellis” to allow for good air circulation. See Figure 7. The samples were manually transferred back and forth between the cold chamber and the oven. The transfer time was less than 2 minutes.

The heat transfer coefficient in the environmental chamber is extremely high because of the liquid nitrogen injection cooling. Thermocouples held against the ring by the folded over braid showed the 16 entry size samples cooled below -65C in less than 4 minutes. The heating time of the 16 entry size samples from cold to 150C was 10 minutes, as shown by attached thermocouples. We ran the first 8 cycles with 30 minutes in each chamber. After that, we reduced the time in the cold chamber to 5 minutes and the hot chamber to 12 minutes to take advantage of the demonstrated sample cooling and heating times.

Figure 7 The samples suspended during thermal shock testing in the convection oven

Results

Below are the results by sample entry size.

sample size	Initial Resis. at 22C (mΩ)	Sample Condition	resistance (mΩ)	tensile (lb)	failure mode
04A	0.086	at 20C / 25C	0.086	189	break
04A	0.079	at 20C / 25C	0.079	182	break
04A	0.104	at 20C / 25C	0.104	191	break
04A	0.072	at -68C / -65C	0.065	221	break
04A	0.069	at -68C / -65C	0.087	229	pull off
04A	0.084	at -68C / -65C	0.068	216	break
04A	0.098	at 150C / 153C	0.113	130	break
04A	0.077	at 150C / 153C	0.13	134	break
04A	0.017	at 150C / 153C	0.059	137	break
04A	0.033	after thermal shock	0.223	168	break
04A	0.071	after thermal shock	0.219	199	break
04A	0.108	after thermal shock	0.363	189	break

sample size	Initial Resis. at 22C (mΩ)	Sample Condition	resistance (mΩ)	tensile (lb)	failure mode
08A	0.003	at 20C / 25C	0.003	189	break
08A	0.025	at 20C / 25C	0.025	184	break
08A	0.043	at 20C / 25C	0.043	192	break
08A	0.01	at -68C / -65C	0.036	201	break
08A	0.03	at -68C / -65C	0.024	207	break
08A	0.052	at -68C / -65C	0.046	201	break
08A	0.032	at 150C / 153C	0.1	155	break
08A	0.057	at 150C / 153C	0.122	148	break
08A	0.019	at 150C / 153C	0.024	164	break
08A	0.039	after thermal shock	0.04	170	break
08A	0.018	after thermal shock	0.024	194	break
08A	0.02	after thermal shock	0.035	184	break

sample size	Initial Resis. at 22C (mΩ)	Sample Condition	resistance (mΩ)	tensile (lb)	failure mode
16A	0.012	at 20C / 25C	0.012	354	break
16A	0.005	at 20C / 25C	0.005	363	break
16A	0.013	at 20C / 25C	0.013	371	break
16A	0.021	at -68C / -65C	0.019	363	pull off
16A	0.015	at -68C / -65C	0.005	362	pull off
16A	0.013	at -68C / -65C	0.0099	373	pull off
16A	0	at 150C / 153C	0	286	break
16A	0.027	at 150C / 153C	0.02	257	break
16A	0.023	at 150C / 153C	0.031	293	break
16A	0.023	after thermal shock	0.034	381	pull off
16A	0.032	after thermal shock	0.055	317	break
16A	0.018	after thermal shock	0.033	351	break

Discussion

All of the results exceed the TE specification requirements. The highest contract resistance measured, for the 04 entry size after thermal shock, of 0.363 milliohm, is well under the 1 milliohm specification. The 04 entry size tensile strength exceeds 150 pounds and appears capable of a tensile strength above 200 pounds if the braid was stronger. The 08 entry size passes the 200 pound tensile test requirement with the braid breaking on most samples at just below 200 pounds.

We ran supplemental tensile tests to see what that BR08A ring could do if not limited by a weak braid. We pulled 2 samples with AA59569*36*0500 braid at 22C. The braid broke on both samples at 260 and 292 pounds. We pulled 2 samples with AA59569*36*0781 braid at 22C. The braid and ring pulled off on both samples at 344 and 379 pounds.