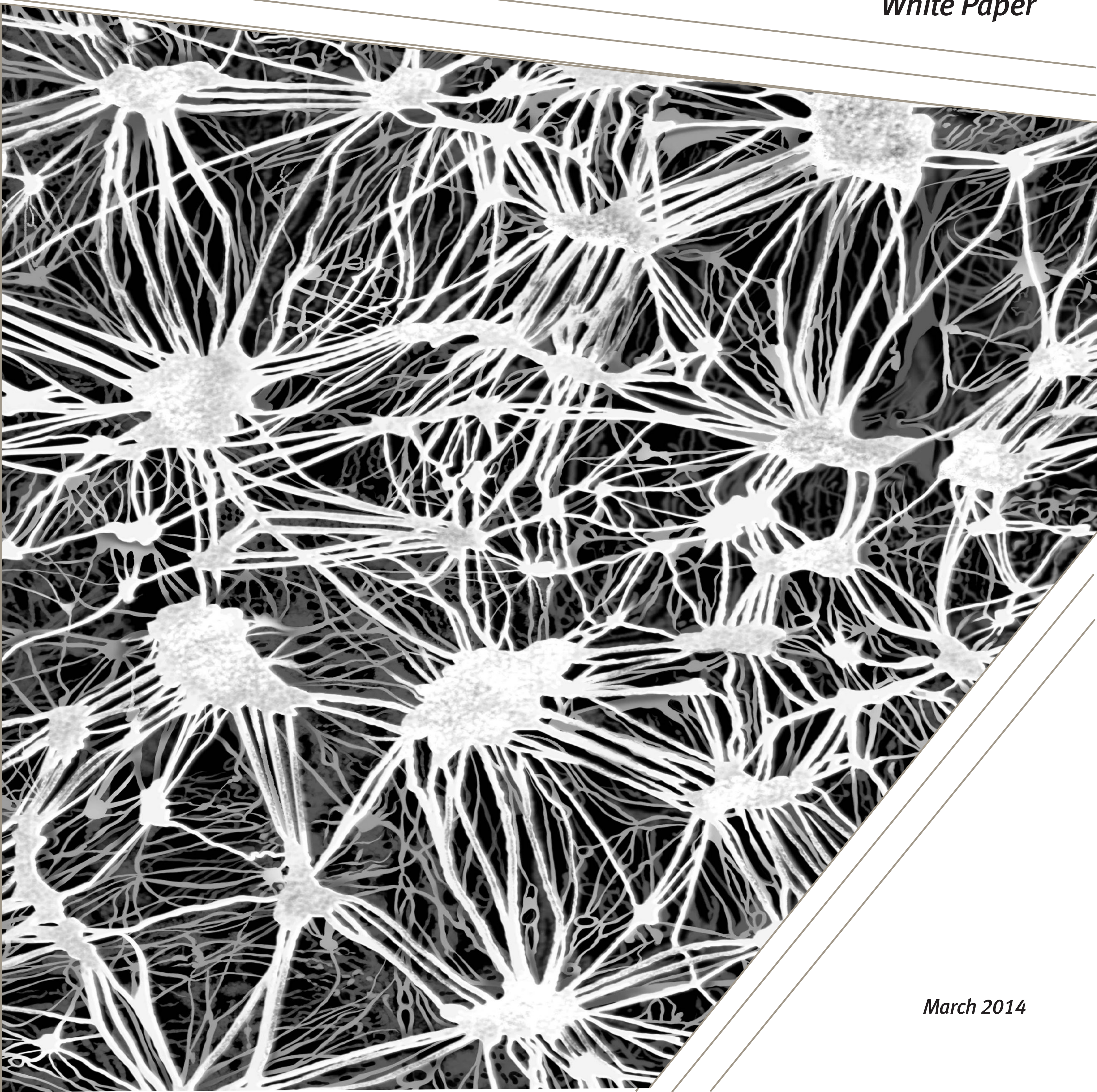
Selecting Microwave/RF Cable Assemblies for Reliable Performance Over Time

White Paper



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Abstract:

A recent study showed that users of microwave/RF cable assemblies expect high-quality, long-lasting performance; however, more than 75 percent of these users are replacing their assemblies frequently, with the most common cause of failure identified as damage during installation or operation. Depending on the frequency, the direct cost for replacing cable assemblies on a single piece of equipment can reach $250,000 over the life of the system — and this does not include the indirect costs such as delayed production schedules, bad products, or retesting and calibration.

W. L. Gore & Associates evaluated the durability and performance over time of several 18-GHz microwave/RF cable assemblies described as having a ruggedized construction with similar specifications. This testing showed that the performance of a new microwave/RF cable assembly does not necessarily ensure reliable performance for the life of a system. Selecting a durable cable assembly that has been tested to survive real-world conditions is the key to reducing replacement costs and the only way to ensure reliability over time.

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Introduction

A recent study showed that globally more than 75 percent of microwave/RF cable assemblies are replaced frequently. There are a variety of reasons for why this is happening — damage during installation or use, poor quality construction, connector termination issues, or failure when exposed to outdoor environmental conditions. However, the most common reason by far was damage during installation or use. The study found that overall 36 percent were replaced once a year and 20 percent were replaced at least twice a year.

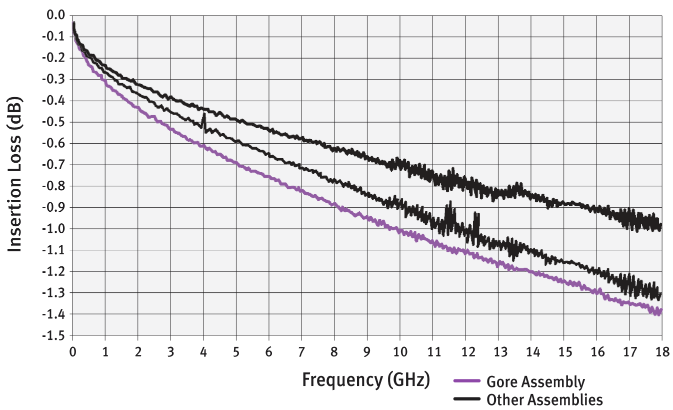
In addition, the impact of replacing cable assemblies varied in different regions. The study showed that in Europe, 49 percent of manufacturers had to replace their cables once a year. In the United States, 70 percent of manufacturers were replacing their cables frequently, with 35 percent being replaced at least once a year and 12 percent being replaced once a quarter. However, the most significant impact was in Asia Pacific with 32 percent of cables replaced once a year, 21 percent replaced once a quarter, and 11 percent replaced at least monthly.

When asked to rank the criteria most valued when selecting a cable assembly, the majority selected quality as the most important criteria. However, the results of this study indicate that most cable assemblies are not lasting for the life of the equipment, and manufacturers are accustomed to replacing the assemblies frequently.

W. L. Gore & Associates (Gore) evaluated the durability and performance over time of several microwave/RF cable assemblies typically used in the industry. Gore selected three new 18-GHz cable assemblies described as having a ruggedized construction with similar specifications.

Gore tested the insertion loss of these cable assemblies to see how they performed when brand new. Although the insertion loss of the other cable assemblies was slightly better than the GORE® PHASEFLEX® Microwave/RF Test Assemblies, the test results showed that the traces of the other assemblies were slightly irregular, which might indicate future electrical problems (Figure 1).

Figure 1: Insertion Loss



Signal Integrity with Flexure

While many cable assemblies perform well when brand new, Gore wanted to determine whether their performance changed or remained stable during flexure and after repeated use.

Gore compared the signal integrity of these new cable assemblies when flexed. Specifically, phase and loss stability was measured to determine the amount of signal distortion and loss of measurement accuracy. Gore used the following test method:

1. The cable assembly was connected to a network analyzer.
2. The analyzer was normalized for the testing.
3. A mandrel with a 57-mm (2.25-in) radius was placed adjacent to one side of the cable assembly, approximately at its midpoint.
4. The cable assembly was coiled 360º around the mandrel and held in this position for one full sweep (Figures 2 and 3).
5. The maximum deviation over the frequency range of analysis was recorded.
6. The cable assembly was returned to its initial straight position, and the VNA was normalized again.
7. The mandrel was placed on the opposite side of the cable assembly, and the test was repeated.

Figure 2

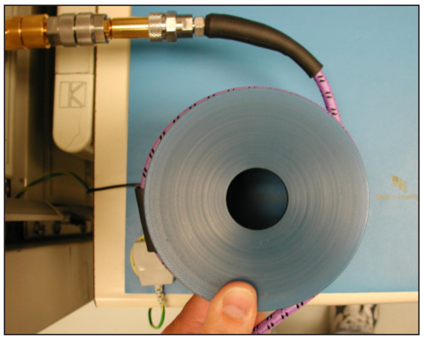
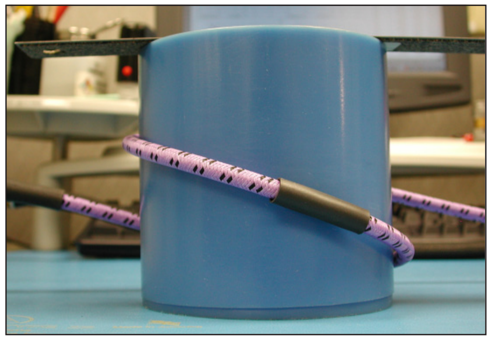


Figure 3



This test showed that the other cable assemblies experienced significant changes in loss and phase stability with flexure. Therefore, their electrical performance was compromised, and these other cable assemblies would provide very inconsistent results, particularly as they reached their maximum frequency. However, GORE® PHASEFLEX® Microwave/RF Test Assemblies successfully maintained loss and phase stability with flexure and, as a result, they will provide consistent, repeatable electrical performance, even during movement.

Loss stability of these new cable assemblies was remarkably different. The test showed that the other cable assemblies were much less stable; however, GORE® PHASEFLEX® Microwave/RF Test Assemblies changed less than 0.005 dB (Figure 4). The test showed similar phase stability results, with the other cables experiencing significant changes. GORE® PHASEFLEX® Microwave/RF Test Assemblies only changed 0.5 degrees through 18 GHz (Figure 5). These results directly relate to the ability of these assemblies to perform reliably without frequent recalibration.

Figure 4: Loss Stability with Flexure of New Cables

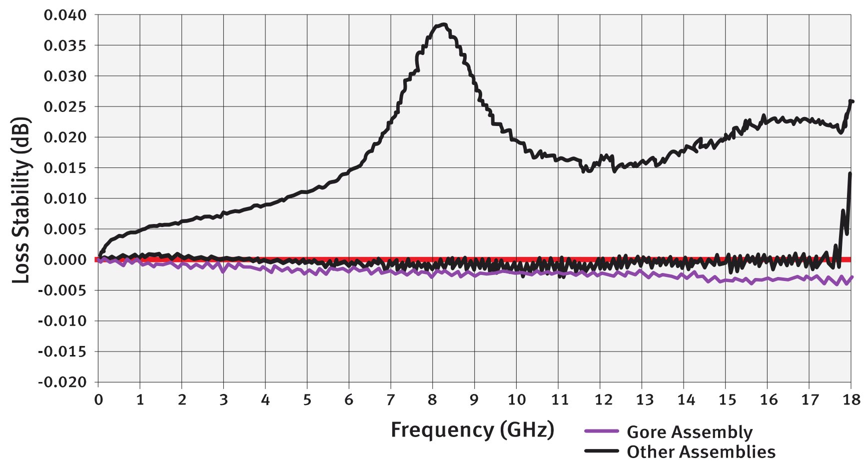
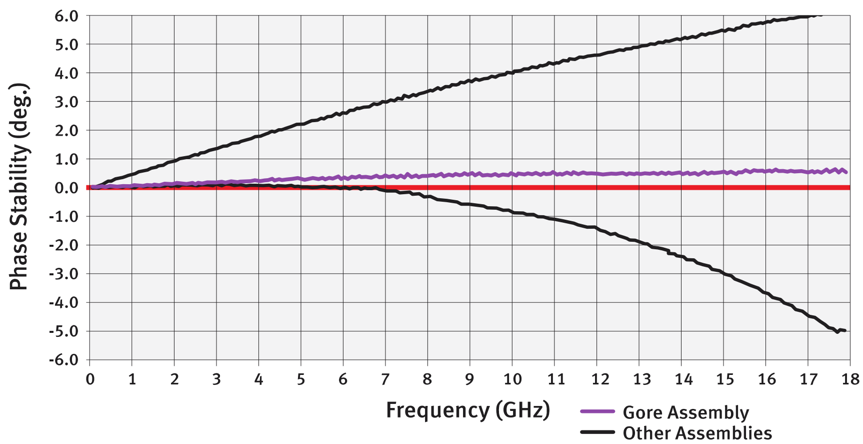


Figure 5: Phase Stability with Flexure of New Cables



Durability Over Time

Gore used an accelerated life test simulating conditions typically encountered during installation and use such as movement and vibration. For the purpose of this test, failure was defined as the inability to meet Gore's performance specifications for their new assemblies:

1. The loss and phase stability with flexure was measured for each assembly using the mandrel method (see Signal Integrity with Flexure, page 4).
2. The assemblies were then attached to a tick-tock machine that rotated 90 degrees clockwise and 90 degrees counter-clockwise to simulate flexing of the cable (Figures 6 and 7). The assemblies were flexed at a rate of 20 cycles per minute.
3. After every 100 flex cycles, the insertion loss and phase stability during flexure was tested again.
4. The assemblies were reattached to the tick-tock machine, and testing was repeated until the cable assemblies failed. The number of completed cycles was recorded.

Figure 6

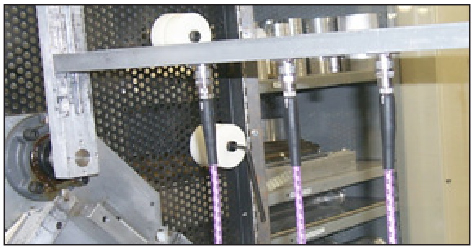


Figure 7

Using Gore's loss and phase stability specifications for new assemblies, the other cable assemblies failed after only 100 and 300 flex cycles (Figures 8 and 9). However, GORE® PHASEFLEX® Microwave/RF Test Assemblies were tested for 10,000 flex cycles, at which point the test was halted because there was no change in performance.

Figure 8: Loss Stability Over Time

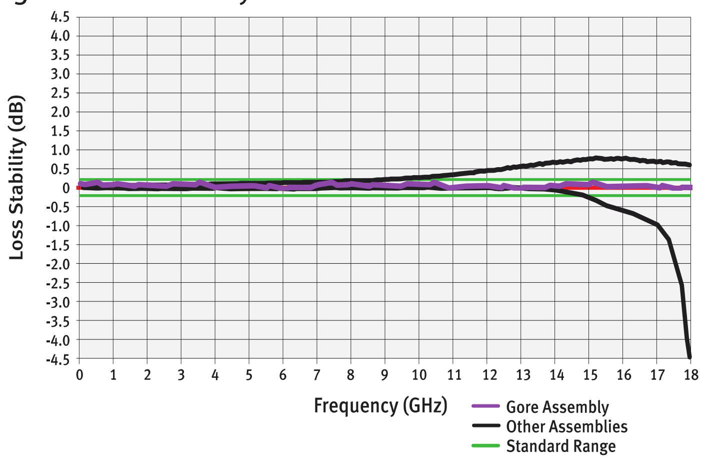
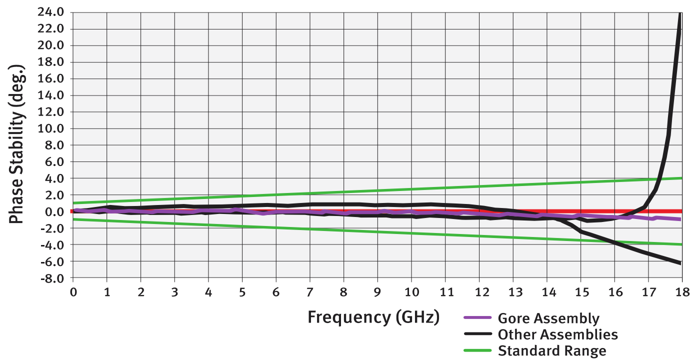


Figure 9: Phase Stability Over Time



Performance Over Time

These tests showed that the failure rate of cables varied when new and after accelerated life testing was done. The internal construction of the other cable assemblies physically changed (i.e., stretched and distorted) after repeated use, which compromised their electrical performance. However, GORE® PHASEFLEX® Microwave/RF Test Assemblies performed significantly better over time without any physical changes, which means that these cable assemblies maintained electrical and mechanical integrity in environments where the other assemblies were compromised. Their unique dielectric and durable construction enabled them to withstand continuous movement, flexing, and exposure to harsh conditions while still maintaining excellent signal integrity.

Using a real-world example, if each cable assembly was flexed 4 times daily during operation for an extended period of time, Assembly X failed after 300 cycles, which translates to only 75 days of performance. Assembly Y failed after 100 cycles, so this cable assembly would need to be replaced every 25 days. However, GORE® PHASEFLEX® Microwave/RF Test Assemblies continued to perform reliably even after 10,000 cycles, which is nearly 7 years, while still providing phase and amplitude stability and minimal loss well within specifications. If each cable assembly was flexed 25 cycles per day, Assembly X would need to be replaced every 12 days and Assembly Y would need to be replaced after only 4 days. However, GORE® PHASEFLEX® Microwave/RF Test Assemblies performed reliably for over a year (Table 1).

Table 1: Performance Over Time

Cycles per Day	Test Assembly X (300 Cycles)	Test Assembly Y (100 Cycles)	GORE® PHASEFLEX® Microwave/RF Test Assemblies (10,000 plus Cycles)
4	2 months, 15 days	25 days	6 years, 10 months, 10 days
10	30 days	10 days	2 years, 9 months
25	12 days	4 days	1 year, 1 month, 5 days

Cost Over Time

For a system based on 4 cycles per day for an expected system life of 10 years, each Assembly X will need to be replaced approximately 50 times over the life of the equipment, and each Assembly Y will need to be replaced approximately 150 times. However, the GORE® PHASEFLEX® Microwave/RF Test Assemblies will only need to be replaced once over the 10-year period (Table 2).

If the average cost of these cable assemblies is between $200 and $400 and the system requires four cable assemblies, you will spend between $40,000 and $240,000 to replace Assemblies X and Y over 10 years, but only $200 to $400 to replace GORE® PHASEFLEX® Microwave/RF Test Assemblies (Table 3).

Table 2: Replacement Over Time

	Replacement Frequency (based on 4 cycles per day)		
	Test Assembly X	Test Assembly Y	GORE® PHASEFLEX® Microwave/RF Test Assemblies
Annual replacement per cable	5	15	0
Cable replacement per cable over 10-year life of the system	50	150	1

These totals represent only the direct replacement costs. They do not include the additional costs due to downtime, maintenance, recalibration, and retesting. For example, a research laboratory recently explained the complex test setup of its antenna range in which the calibration process takes two days; getting to the end of that process to learn that there is a defective cable in the system is very costly. Also, a chip manufacturer has estimated that its downtime costs can exceed $50,000 per hour. Even more serious is the potential impact on brand integrity if bad products are shipped before you realize that the test results were compromised. The indirect costs for each application will vary; therefore, a cost analysis should be completed to consider the full impact of cable failure and replacement before selecting microwave/RF cable assemblies.

Table 3: Cost Over Time

	Test Assembly X	Test Assembly Y	GORE® PHASEFLEX® Microwave/RF Test Assemblies
Annual cost per cable	$1,000 - $2,000	$3,000 - $6,000	$0
Annual cost per system	$4,000 - $8,000	$12,000 - $24,000	$0
Lifetime cost per system	$40,000 - $80,000	$120,000 - $240,000	$200 - $400

Conclusion

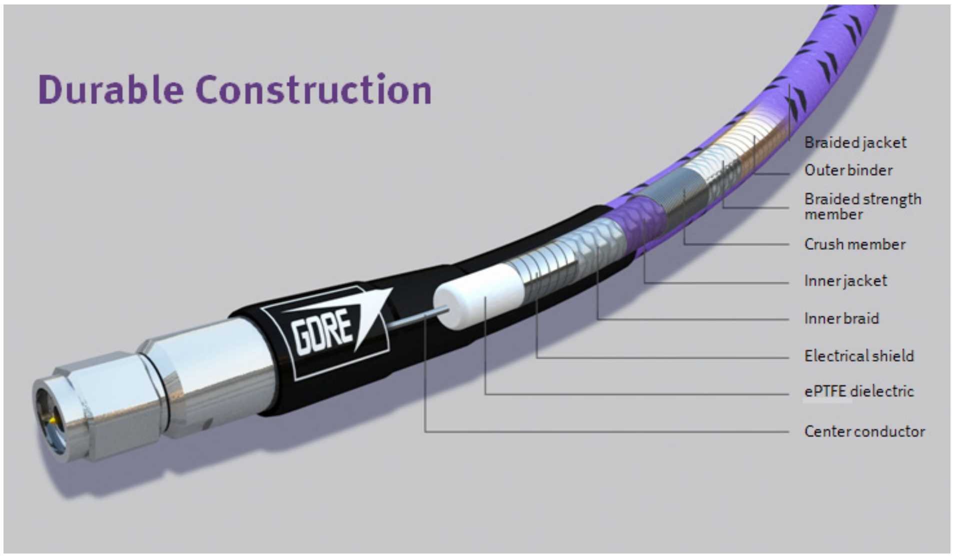
The performance of a new cable assembly does not necessarily ensure reliable performance over the lifetime of a system. Although microwave/RF users expect long-lasting, reliable performance from their assemblies, the testing done by Gore showed that many new microwave/RF cable assemblies do not deliver consistent signal stability, and their performance degrades rapidly, causing frequent replacements. Therefore, when assemblies are replaced monthly or quarterly, any savings gained from a lower purchase price are quickly lost.

In addition to the increase in your overall purchasing costs, a greater impact could be from delayed production schedules, compromised system performance, additional retesting and calibration, and compromised brand integrity. Selecting a cable assembly with a durable construction that has been tested to survive real-world conditions is the key to reducing replacement costs and the only way to ensure reliability over time. GORE® PHASEFLEX® Microwave/RF Test Assemblies are more reliable and last longer than typical cable assemblies used in the industry — years rather than months.

About GORE® PHASEFLEX® Microwave/RF Test Assemblies

GORE® PHASEFLEX® Microwave/RF Test Assemblies have a durable construction with inner layers that provide excellent electrical performance, as well as outer layers that provide mechanical protection to allow these test assemblies to perform throughout the life of a system (Figure 10), and reduce the need for replacement cables. They are crush resistant and provide greater than 250 pounds per linear inch of protection. These test assemblies perform reliably even after extensive flexing with some cables exceeding 100,000 flex cycles. They can also withstand frequent connecting and disconnecting in laboratory, production, and field testing. In addition, GORE® PHASEFLEX® Microwave/RF Test Assemblies provide excellent loss and phase stability with flexure for test applications that require precise, repeatable measurements, and electrical performance up to 110 GHz.

Figure 10: Performance Over Time



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W. L. Gore & Associates, Inc.

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