White Paper

Cat. 6 modules and patch cords: A competitive analysis

R&M

Convincing cabling solutions

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Contents

Convincing cabling solutions

1. Introduction

Application:	Enterprise Cabling, Industrial Cabling, Residential Cabling
Technology:	Category 6 LAN / RJ45 connection modules and patch cords for Class E cabling systems
Format:	White Paper
Topics:	Comparison of RJ45 connection modules and patch cords from different manufacturers
Objective:	Quality comparison, especially in terms of mechanical characteristics
Target audience:	Planners, decision-makers, Installers
Authors:	Regina Good-Engelhardt, René Troesch
Published:	May 2005

Considering the quality of components in a cabling system, one might tend towards thinking in terms of transmission characteristics – which is clearly an important aspect. The overall quality of a connection module or patch cord, however, also depends on other features like reliability, durability and usability.

This is why R&M decided to run a comprehensive test of 40 products from leading manufacturers, including R&M, focusing on these features. This White Paper summarizes the results in four sections covering patch cord quality, mechanical durability, electrical discharge and usability. Only by considering all of these aspects can customers be sure that the product they choose is of top quality and offers the best investment protection.

2. Patch cord quality

In recent years, as the performance of cabling systems has increased, patch cords have been recognized as an integral part of the overall system. Earlier considered only as a second thought, studies have shown that when performance problems arise, they can often be traced back to the patch cord. It is thus crucial to use high quality cords.

This section of the analysis looks at three important aspects of a high quality cord:
– Performance,
– Contact height of the plug and
– Strain relief.

R&M has tested 22 types of patch cords with 20 samples each. The cords were randomly coded and assigned a Vxx (“vendor”) number. All the products tested are specified to be Cat. 6 compliant.

2.1. Performance of cords

The ISO/IEC 11801:2002 standard specifies the RL (Return Loss) and NEXT (Near-end Crosstalk) limits which patch cords must meet in order to reach the expected performance. If the cords are compliant, then the installer can be sure that connecting the cords with his compliant permanent link will result in a compliant channel. If the limits are not achieved, then the “generic” approach is not possible and the installer must retest the channels to ensure compliance, requiring a significant investment in time.

Results

Several samples of each patch cord brand and type have been measured. The results are presented in the following graphs, referenced to the relevant limit value. The green dot (mean value) indicates the average headroom to the limit. The length of the line is determined by the minimum / maximum values, thus representing a measure for the variance. A larger variance means a higher probability to fail.

Shielded patch cords (STP)

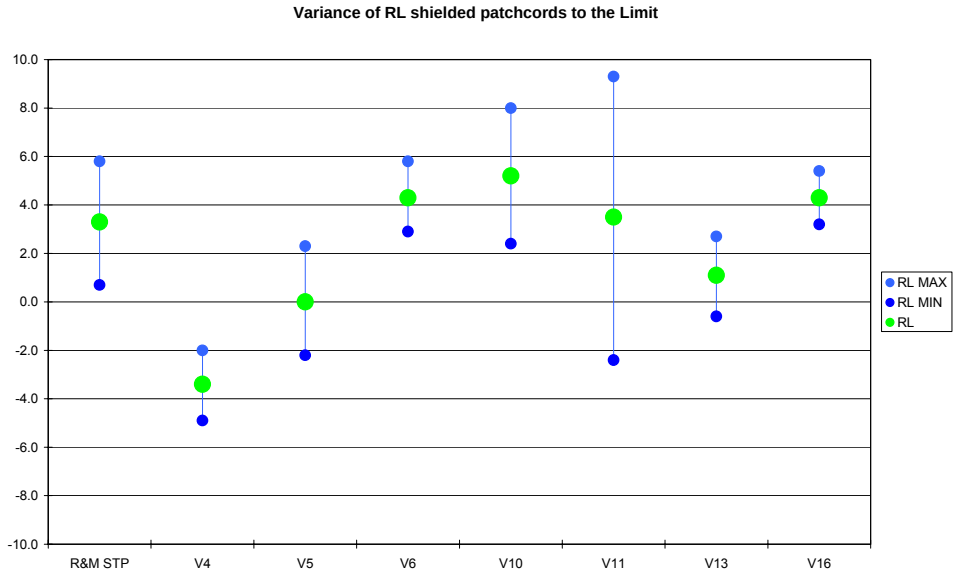


Fig 1: RL headroom, max / min and mean values. Y-scale in dB, referenced to the limit value.

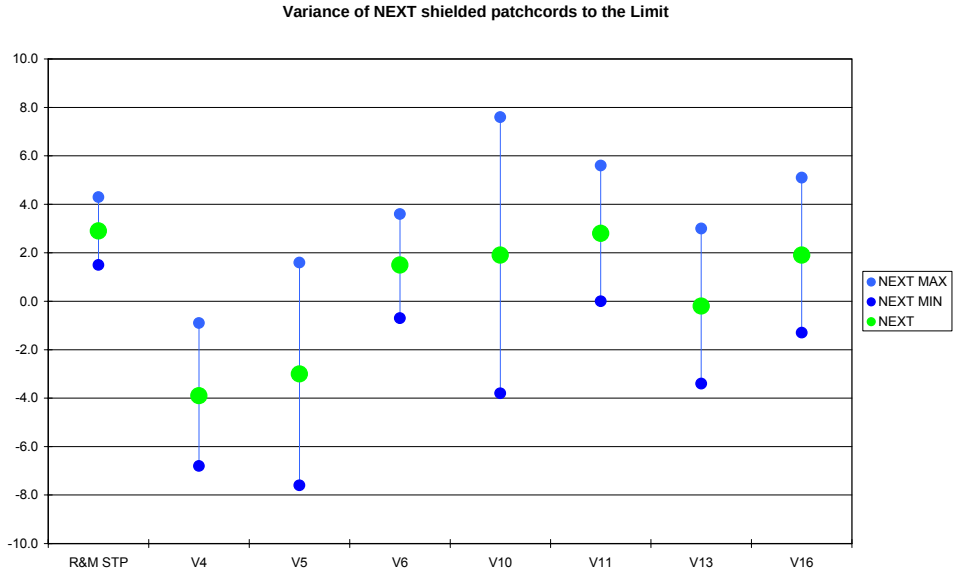


Fig. 2: NEXT headroom, max / min and mean values. Y-scale in dB, referenced to the limit value.

Only the R&M cords meet both requirements. Some cords do not reach Cat. 6 values at all. Others have a very large variance which indicates poor production control. That means that customers can get cords which do not comply with the Cat. 6 standards even if they have paid for Cat. 6.

Unshielded patch cords (UTP)

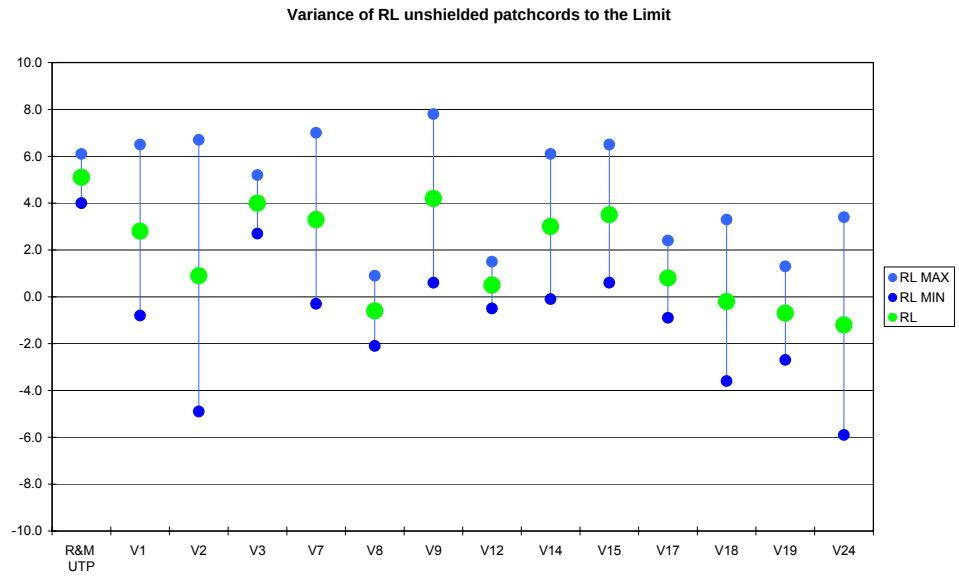


Fig. 3: RL headroom, max / min and mean values. Y-scale in dB, referenced to the limit value.

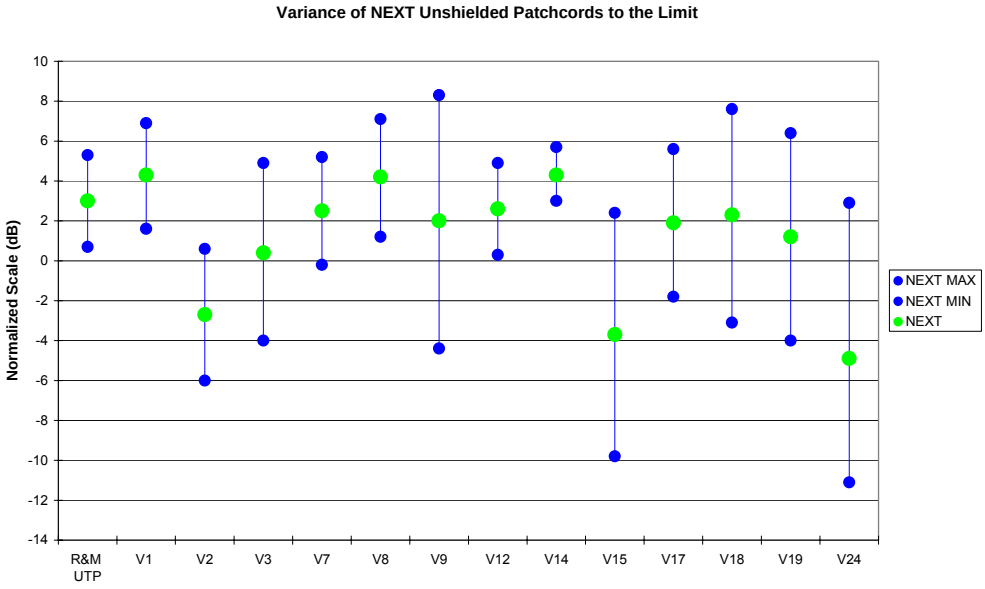


Fig. 4: NEXT headroom, max / min and mean values. Y-scale in dB, referenced to the limit value and normalized, taking testing conditions into account which do not occur in the field.

The R&M cords show the best overall performance. Again some cords do not achieve the values specified by the standards and thus cannot be considered Cat. 6 cords. Others have a very large variance or the average margin is at zero, indicating that half of the cords shipped would not meet the standard.

R&M's superior manufacturing process control results in quality you can count on, 100% of the time.

2.2. Plug contact height (contact zone)

In order to achieve a good contact between the jack and the plug, the contact zone between the jack and the plug must be within defined limits.

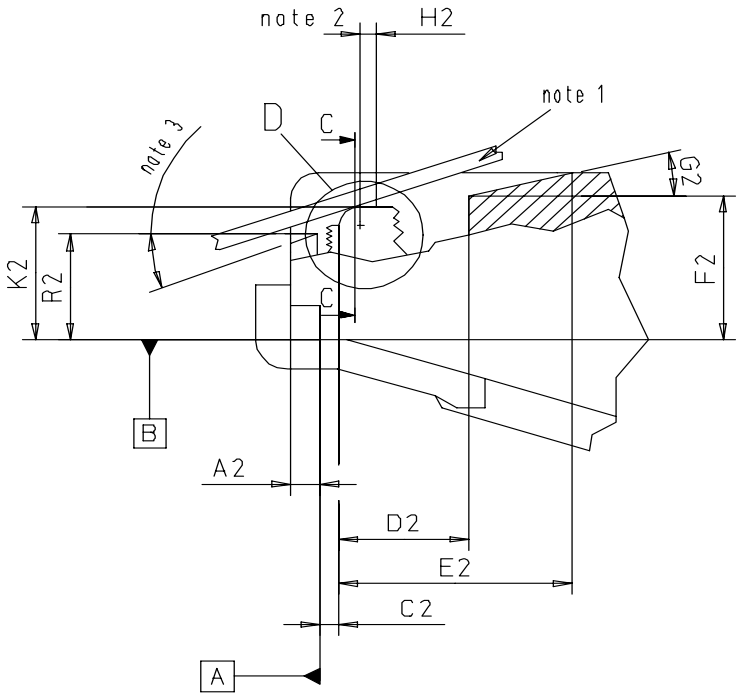


*Fig. 5: Plug contact height. K2 is one of the critical parameters which must be within **5.89 to 6.15 mm***

Test equipment

R&M has developed a special tool to measure the contact height. This tool is used in our own production control.

Results

20 samples of each patch cord brand and type have been measured. The results are presented in the following graphs, showing the number of failures.

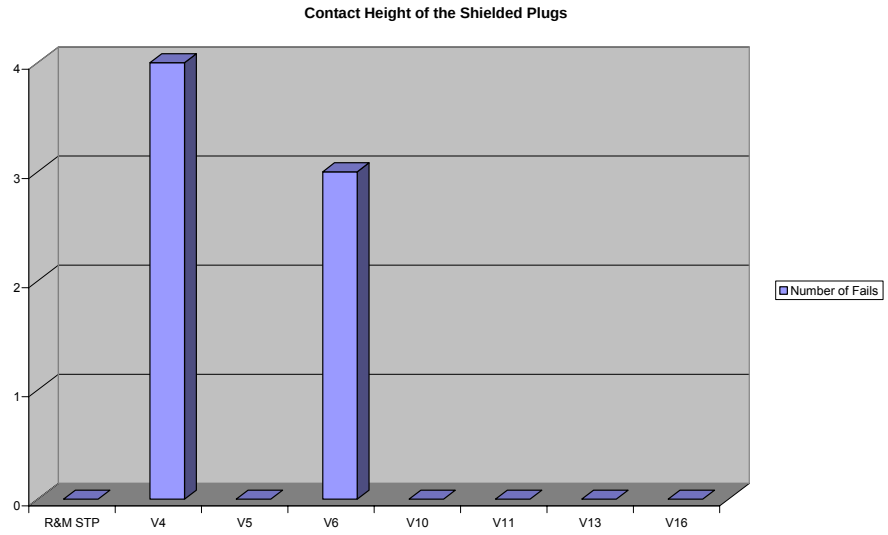


Fig. 6: Contact height of shielded plugs

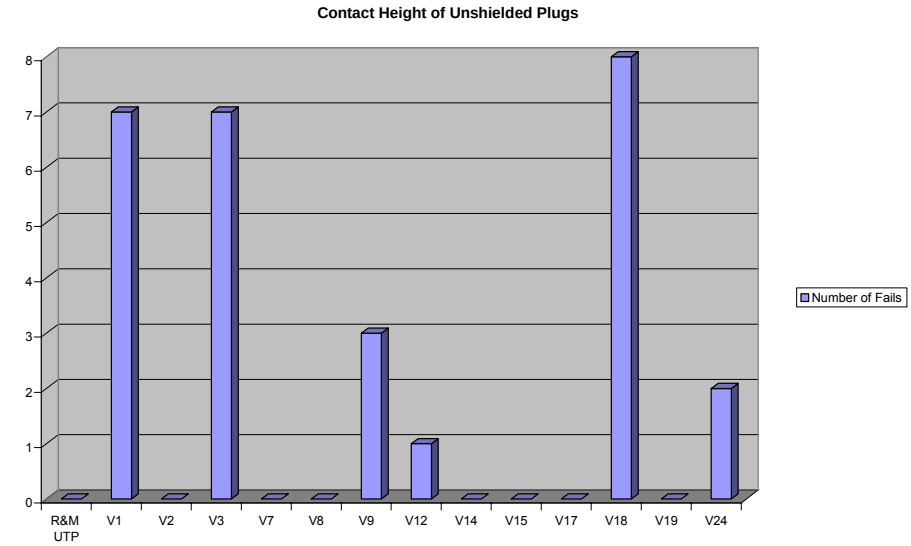


Fig. 7: Contact height of unshielded plugs

Eight vendors of 22, or about 30%, were unable to manufacture their plugs according the standard. Because R&M uses an IDC (Insulation Displacement Connection), the contact zone height is constant and not affected by the termination process. This unique design ensures that every plug delivered will make optimum contact with the jack and thus provide a reliable connection.

2.3. Testing the strain relief and antikink

This test is often forgotten, but it is essential for the reliability of a cabling system. You will often find patch cords in a cabinet that have been bent around corners, or see technicians pull out a cord without releasing the plug first. Behind the desk the cable might be bent by pushing furniture against the outlet. A well-designed strain relief can efficiently protect the cable and its performance, even under sub-optimum conditions.

Test setup

The test was adopted from a fiber optic standard. The patch cord under test is fixed to the holding plate of an automatic test setup. The plate is turned +/- 90° from the upright position while a weight is attached to the cord resulting in a well defined pulling force along the cord. Thus the test simulates the stress a patch cord has to endure by repetitive patching in a rack. Test conditions:

Weight 2 kg for unshielded cords
Weight 1 kg for shielded cords
250 flexing cycles

The NEXT and RL performance was measured before and after the test.

Results

The graphs show how much the performance degraded after the testing. Negative values indicate that the performance improved.

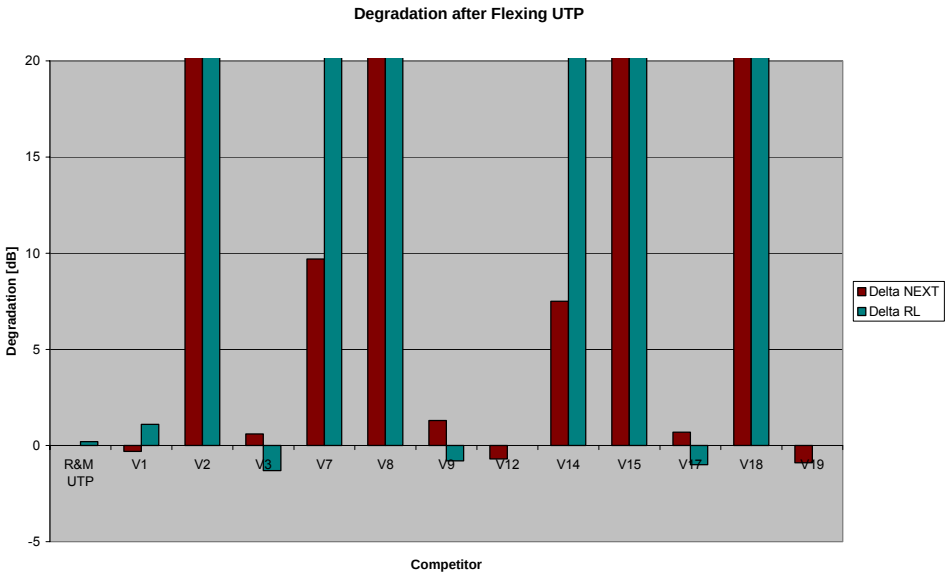


Fig. 8: Unshielded patch cords (UTP), degradation after 250 flexing cycles

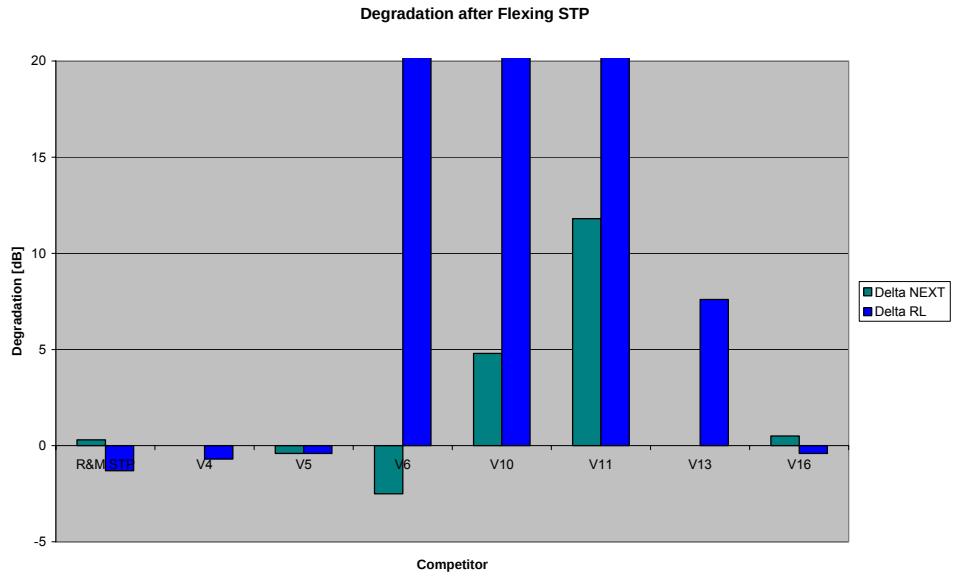
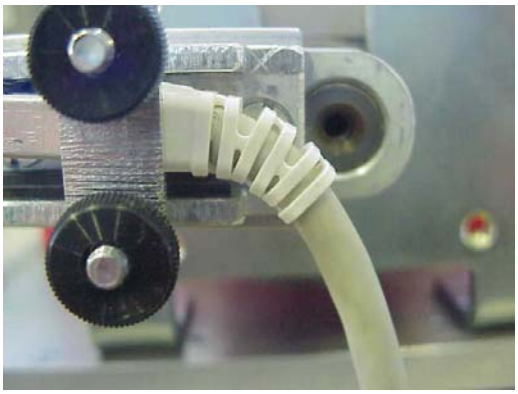


Fig. 9: Shielded patch cords (STP), degradation after 250 flexing cycles

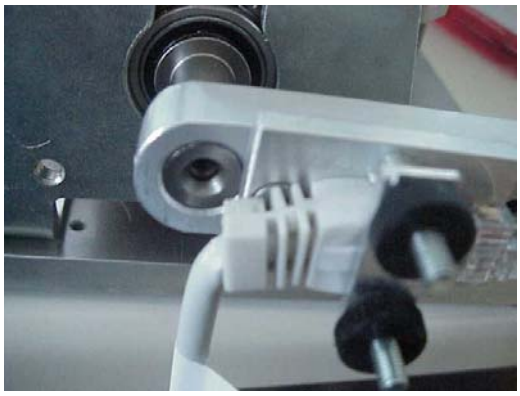
RL results exceeding +20 dB indicate that the cable actually broke during the test. This occurred with 9 of the 21 cord types that were tested, or more than 40%! In some cases the results were marginally better after the flexing. R&M's excellent results can be traced to a superior strain relief and antikink design with perfect cable retention.

The pictures below provide some examples of good and bad outcomes.

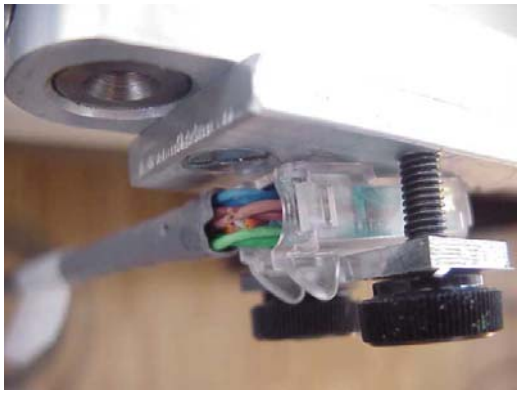
R&M – excellent strain relief function:



No antikink function results in performance degradation:



No strain relief at all, resulting in broken wires:



2.4. Summary – patch cord testing

The three tests performed in this review give a good indication of the quality of a patch cord. The table below summarizes the results and shows the overall performance of each cord.

Vendor	Performance		Plug height	Strain relief
	NEXT min Limit 0.0	RL min Limit 0.0		
R&M UTP	0.7	4.0		
V1	1.6	-0.8	Failed	
V2	-6.0	-4.9		Failed
V3	-4	2.7	Failed	
V7	-0.2	-0.3		Failed
V8	1.2	-2.1		Failed
V9	-4.4	0.6	Failed	
V12	0.3	-0.5	Failed	
V14	3	-0.1		Failed
V15	-9.8	0.6		Failed
V17	-1.8	-0.9		
V18	-3.1	-3.6	Failed	Failed
V19	-4	-2.7		
V24	-11.1	-5.9	Failed	Not tested

Table 1: Unshielded patch cords (UTP) summary

Vendor	Performance		Plug height	Strain relief
	NEXT Limit 0.0	RL Limit 0.0		
R&M STP	1.5	0.7		
V4	-6.8	-4.9	Failed	
V5	-7.6	-2.2		
V6	-0.7	2.9	Failed	Failed
V10	-3.8	2.4		Failed
V11	0.0	-2.4		Failed
V13	-3.4	-0.6		
V16	-1.3	3.2		

Table 2: Shielded patch cords (STP) results

The UTP and STP patch cords from R&M are the only ones of 22 cord types which passed all of the tests. The superior quality of R&M's patch cords ensures the high performance of your overall system.

3. Mechanical performance

A cabling system is a long-term investment so durability is an important feature. The components of the system must be sturdy and robust to ensure high performance during years of use. Moves, extensions, changes or modifications should not cause degradations. The best way to test the durability is to stress the components and to see how they react. This is just what we did in this test.

3.1. Mechanical operations

All the plugs and jacks were mounted on an automatic mating and unmating test setup to test the mechanical durability of the connections. This test was done without electrical load. The mounting of the components represented the situation seen in real installations. The locking device on the plug was made inoperable during the test.

Because the connectors are susceptible to the ingress of particles, the test run was stopped regularly and the amount of metallic and plastic particles was checked, as well as the damages on the surface layer of the shield and the contacts themselves.

A scale was defined to judge the severity of the damages. The results are given separately for shielded (STP) and unshielded (UTP) plugs and jacks.

Severity

Scale	Metallic surfaces (abrasion after x cycles)	Residual material (after x cycles)
0 =	No damage	No residual material
1 =	Light marking	
2 =	Heavy marking	
3 =	Layer pierced through	
4 =	Layer away	
5 =	Metal ground away	Much residual material

Table 3: Scale used to measure damage on the metallic surfaces and residual material abrasion.

The plug and the jack have been assessed separately. For a well performing connection, however, both the plug and the jack must be in good condition to ensure reliable contact. Therefore, the results table is composed of worst case values for the abrasion of the plug/jack pairs and average values for residual material of the plug/jack pairs. For the comparison of products, the number of damage points was added and averaged over the different stress levels. This value gives an indication of the durability of a product over its lifetime.

Results

Plug UTP	Metallic surfaces (abrasion after x cycles)				Residual abrasion material (after x cycles)			Damage points	Average
Code	New	250	750	1500	250	750	1500		
R&M	0	1	2	3	0.5	0.5	1.5	8.5	1.2
V03	1	2	2	3	0	0	1.5	9.5	1.4
V07	1	1	2	2	0	0.5	2.5	9	1.3
V08	0	1	2	3	0	0.5	1	7.5	1.1
V12	0	1	4	4	0	2	3	14	2.0
V14	2	2	2	2	0.5	0.5	0.5	9.5	1.4
V15	0	3	4	4	1	2	3.5	17.5	2.5
V17	2	2	3	3	0.5	1	1.5	13	1.9
V18	0	1	2	2	0.5	1	2	8.5	1.2
V19	0	1	2	4	0	0	1	8	1.1
V21	1	1	2	2	0.5	1.5	1.5	9.5	1.4
V23	1	2	3	3	1	1	2.5	13.5	1.9

Table 4: Plug with unshielded jacks

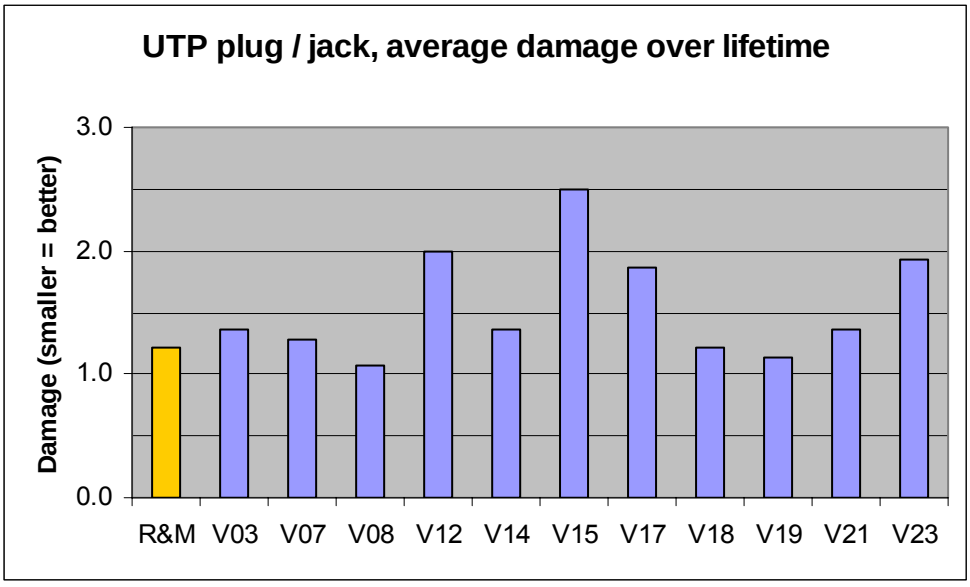


Fig. 10: The R&M unshielded plug / jack exhibits very good results

Plug STP	Metallic surfaces (Abrasion after x cycles)				Residual abrasion material (after x cycles)			Total points	Ranking
Code	new	250	750	1500	250	750	1500		
R&M	0	1	3	4	0	1.5	2	11.5	1.6
V04	1	1	2	3	0.5	1.5	2	11	1.6
V05	1	2	3	4	0.5	1	2	13.5	1.9
V06	1	4	4	4	0	0.5	1.5	15	2.1
V10	1	2	3	4	0.5	0.5	1	12	1.7
V11	1	2	3	3	1	1.5	2	13.5	1.9
V16	1	2	3	4	0.5	1	2.5	14	2.0
V20	1	3	4	5	1.5	2	3	19.5	2.8
V22	1	1	3	4	1.5	2	3.5	16	2.3

Table 5: Plug with shielded jacks

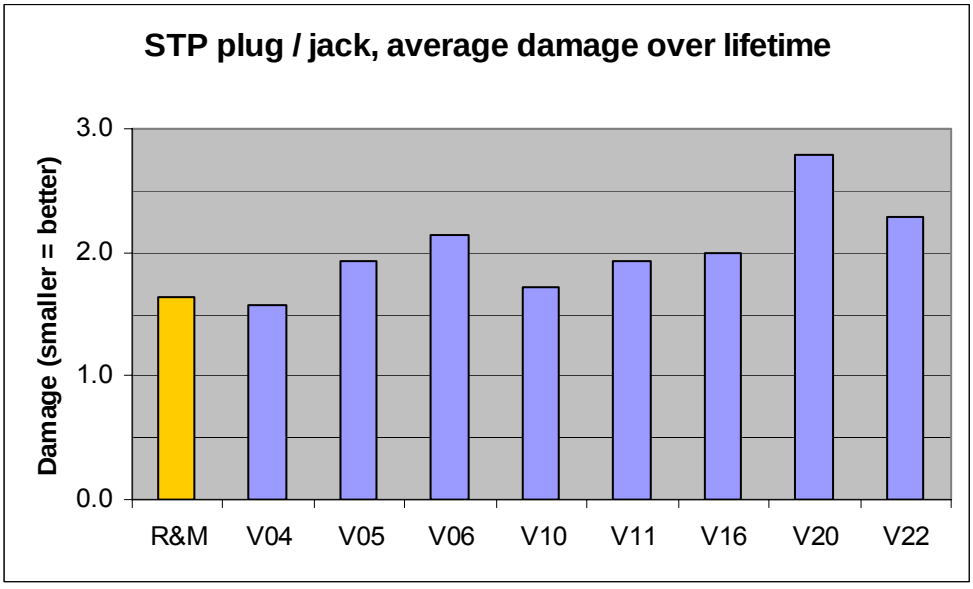
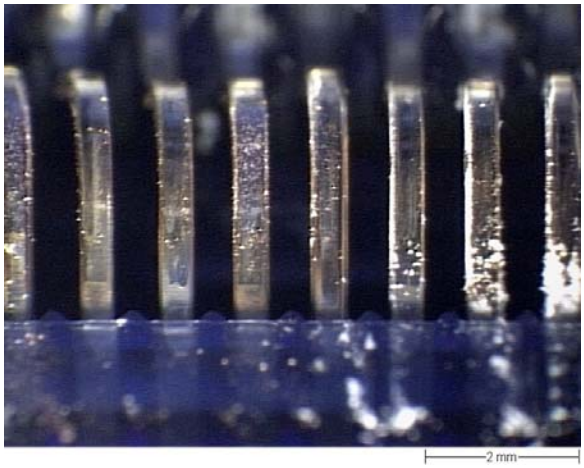


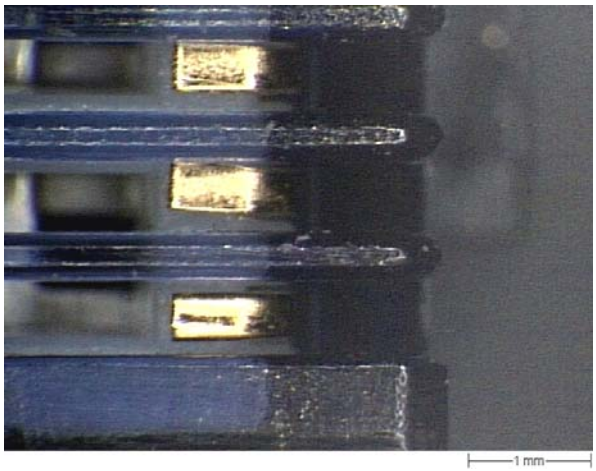
Fig. 11: The R&M shielded plug / jack exhibits excellent results

These results clearly show that R&M's shielded and unshielded jacks and plugs are very durable and offer reliable connections over their entire lifetime.

R&M

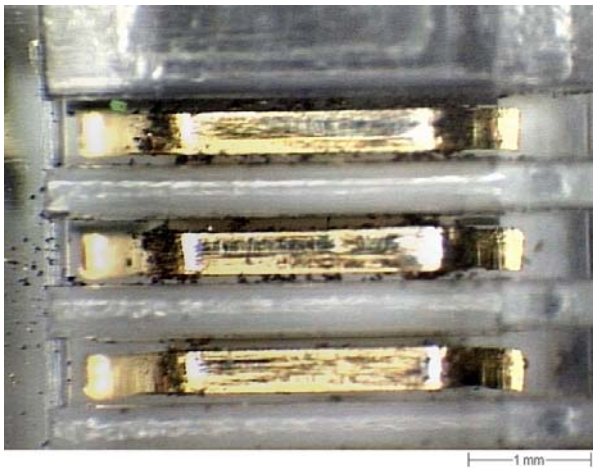
All of the R&M plugs are shielded and have been designed to fit very well into the R&M jacks, resulting in overall very good results. The gold contact surface stays essentially intact and still offers protection against aggressive environments even after such a large number of plugging cycles. Here are some photographs: The R&M shielded jack (left) and plug (right) after 1500 plugging cycles:

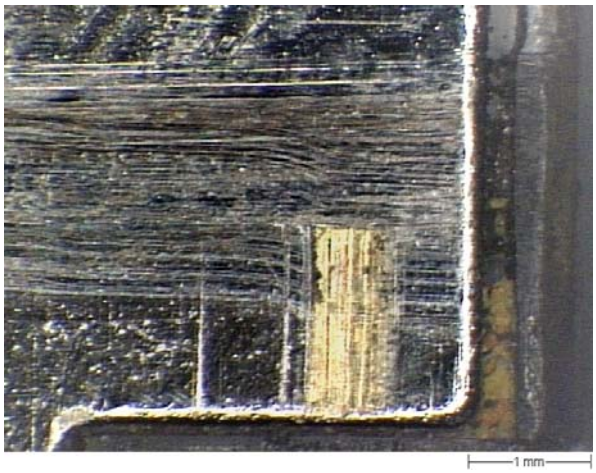




Some examples of other vendors

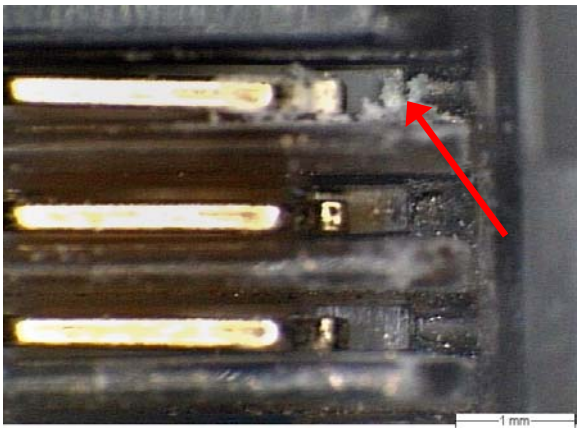
Shielded plug V4 (left) with damaged gold layer and residual material around the contacts after 1500 plugging cycles. The shield of the plug overlay is strongly wiped (right).

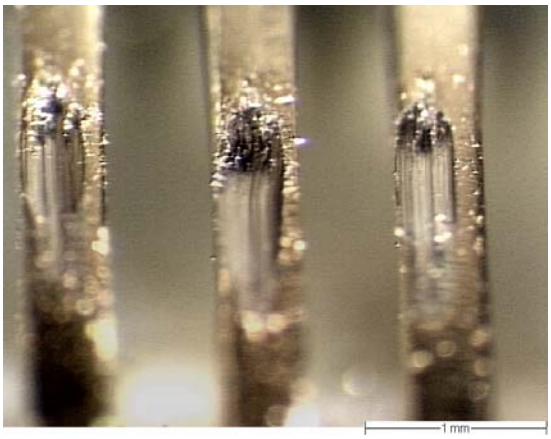




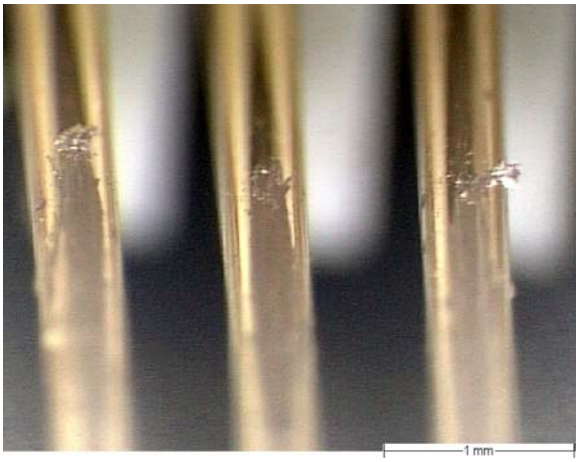
Some examples of other vendors (cont.)

Unshielded plug V12 with plastic residual material in room 1 after 1500 plugging cycles (left). Shielded jack V10 after 1500 plugging cycles (right).





Unshielded jack V15 after 250 plugging cycles (left). Unshielded jack V12 after 750 plugging cycles (r).



4. Is your jack ready for “hot plug and play”?

The driving force behind the IEEE 802.3af, or Power over Ethernet (PoE), standard was to bring power over twisted pair cable to IP telephones. This helps to reduce the number of power adapters on the desk and therefore also the number of cables under the desks. The standard may also be used for cameras, security systems or any other low-power device. Clearly, transferring 15 watts of power over data lines may have an impact on the cabling infrastructure.

Have you ever considered if your connector is designed to handle around 50 V and hundreds of mA of current? Although 15 W may not sound like a lot, a study group in IEEE was recently formed to study a Power over Ethernet Plus standard which will support a load power of 30-40 W in order to directly supply laptops, wireless LAN hotspots and so on.

R&M has tested several connectors from different manufacturers including our own to understand how they hold up under realistic PoE conditions. The following chapter discusses the IEEE standard in depth and, more importantly, the standard for the connector itself, the IEC 60603-7 series. With this we will see that the construction of connectors that can support PoE may not be as easy as it seems.

4.1. Power over Ethernet

The PoE standard 802.3af was released at the end of 2003. A maximum of 15.4 watts of power in three different classes was defined. The power is transmitted for switches on pairs 12-36 and for the midspan in the spare pairs 45-78. Therefore we are talking about 350 mA per pair using one pair for plus and one pair for minus. The minimum operating voltage is 44 V.

4.2. Hot plug and play

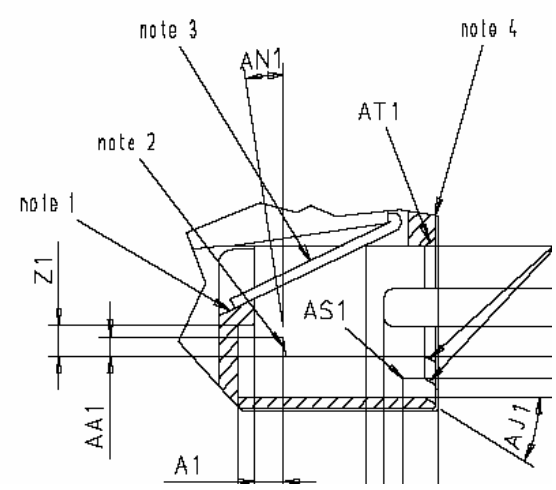
Hot plug and play refers to the easy exchange of cables and active components in the Bill Gates world. Since it works most of the time, we never think about what happens when a cable is plugged in or unplugged. But we should know from the old days that power connectors may sound and spark when they are not fitted correctly. This effect also happens on trains when the brake is applied. Generally we can say that under all circumstances where a live connection is made or more importantly is broken this sparking effect will take place.

4.3. The connector issue

In the EN 50173 series a maximum voltage of 72 V, a maximum current of 175 mA per pair at all temperatures where it is used, and a maximum power capacity of 10 W per pair are described for the channel. Also the DC loop resistance of 25 Ohms is important, as these 25 Ohms will generate a loss of power and a certain heat in the conduit.

The IEC 60603-7 standard for RJ45 connectors specifies different parameters, which seem to have less priority compared to NEXT, but with power they are essential.

Fig. 12 shows the details of an RJ45 connector. Note 3 is very important:



Note 3: Contacts shown at rest.
Contacts shall always be contained inside guide slots and shall move freely within their individual slots.

Fig. 12

This is required in order to prevent short circuits, which could occur if a bad plug is inserted. We can imagine what would happen if a short occurs with 350 mA.
One cannot assume that the jack follows this very important rule. We found that 3 of 14 did not meet this test.

4.4. Voltage proof and current carrying capacity

A maximum voltage proof of 1000 V DC or AC peak is allowed between contacts. Also, 1500 V DC or AC peak between the contacts and screen or the panel is a must for IEC compliant RJ45 connectors. This is also one of the safety requirements, so that overvoltages which can occur will not damage other surrounding parts. Meeting these requirements could be an issue with some PCB boards or special contact designs.

The current carrying capacity is the most important parameter for PoE. The following graph shows the current flowing through all 8 pins in series:

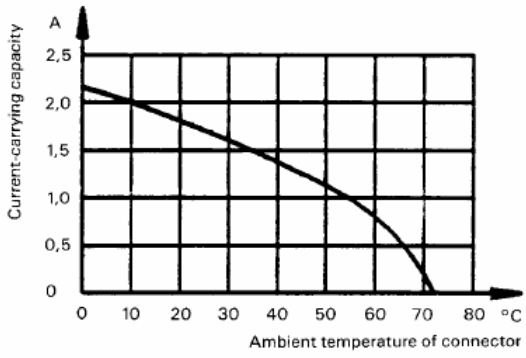


Figure 10 – Connector de-rating curve

Fig. 13: 30° C maximum temperature rise when applying 0.75 A at ambient 60° C

At 0° C, 2.2 A shall flow through the connector without any damage. If the PCB layout is too small, or the connections are shoddy, the heat will increase and melt down the mated jack-plug combination. Even at 60° C the temperature increase should be lower than 30 Kelvin. But even then, at 90° C the connector will be very hot.

For PoE we are talking about 350 mA at all temperatures, which is the half of the maximum value. PoE Plus will go to the limits of the standard with 750 mA at all temperatures.

Have you looked at different jacks to see if they meet these requirements?

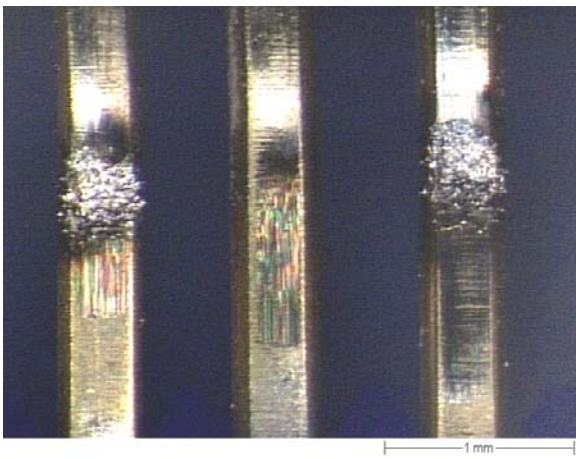
The above mentioned tests are all related to safety and preventing any harm to people, animals or buildings. The following test ensures that the jack-plug combination runs after several hot plug and play cycles.

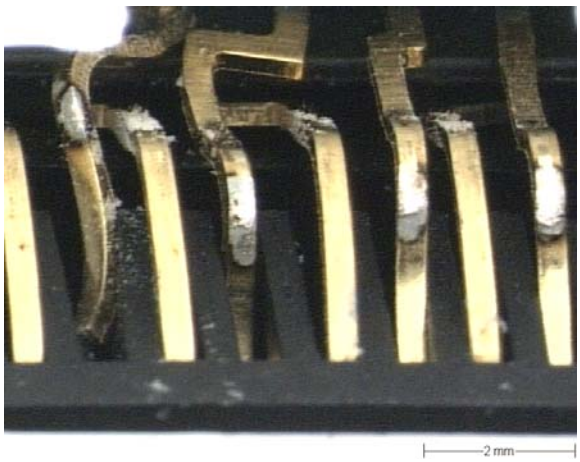
4.5. Mechanical operations with electrical load

This test is described in the following standard:
IEC 60512-9-3:2004 Test 9c: Mechanical operations with electrical load.

With a simple resistor and a capacitance a little spark is generated which can influence the contact. Depending on the connector design the spark can occur in the contact zone, which will result in a poor contact and inferior reliability.

In a good contact design the spark will not affect the contact zone (left). In a bad contact design, for example, the contacts are folded and the damage is in the contact zone (right).





4.6. Tested samples and results

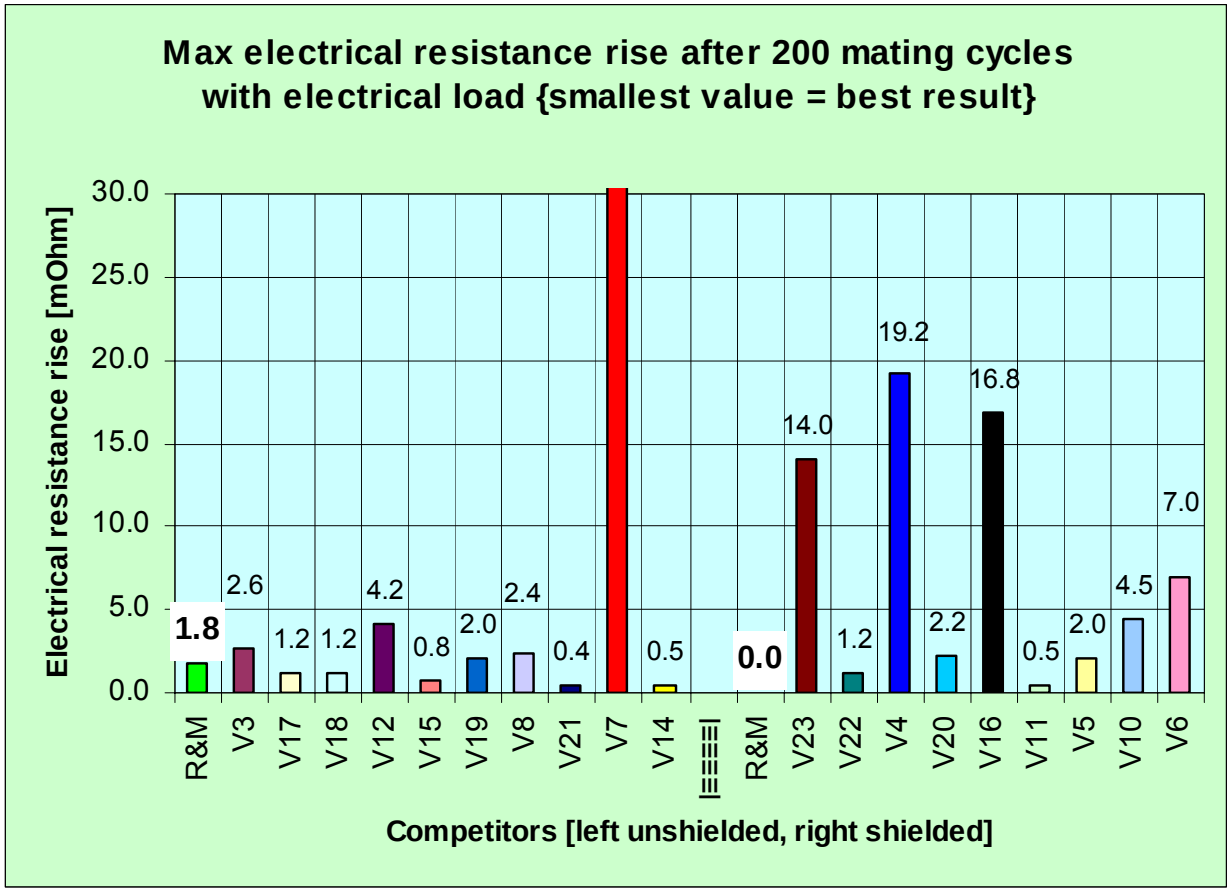


Fig. 14 Change in electrical resistance after 200 mating cycles with electrical load (in mOhm)

One of the 21 tested products does not comply with the requirement for a resistance increase of less than 20 mOhm. Three others are very close to that limit and it stands to reason that these products will fail over time due to oxidation effects in the now damaged contact zone.

This means that every fourth module cannot support today's hot plug and play!

With future developments like PoE plus this ratio will become even worse.

4.7. Three questions

1. Is your system ready for hot plug and play?
2. Is your system safe from short circuits?
3. Can your system take 1.75 A without damage?

With the R&M System all three questions can be answered with a clear **Yes!**

5. Jack usability

Everyone can agree that the performance values of a connector jack are critical to the operation of the overall cabling system. However, if the module is difficult and inconvenient to terminate or the process takes too long it will not make economical sense to install it, regardless of its performance. It therefore makes sense to test the main usability features of top UTP and STP connecting hardware in the market to complete the overall evaluation of the modules.

5.1. Important characteristics of a good jack / Ranking methodology

Many aspects need to be considered when evaluating the usability of a connector jack. In order to have a complete picture of how leading jacks in the market compare with each other, we assigned values to each variable as described below.

Termination time (3 points maximum): The time it takes to terminate a jack can significantly impact the overall cost of a project. If the process is complicated and time-consuming it can actually delay the project schedule. Of course, we also recognize that with practice the termination time of any module can be reduced. However, it is still valid to review the differences since this phenomenon would likely affect all modules equally, e.g. practice may result in a 5-10% time reduction for every module.

The vendors were ranked in increasing order of the calculated time for termination, e.g. the shortest termination time was given rank 1. Twelve UTP modules were tested so the possible three points are assigned according to overall rank as listed below:

Rank	Points
1	3.00
2	2.75
3	2.50
4	2.25
5	2.00
6	1.75
7	1.50
8	1.25
9	1.00
10	0.75
11	0.50
12	0.25

Ten STP modules were tested, so in this case the maximum three points are assigned as follows:

Rank	Points
1	3.00
2	2.70
3	2.40
4	2.10
5	1.80
6	1.50
7	1.20
8	0.90
9	0.60
10	0.30

Manual: It is important that the manual is readily available when it is needed. Often untrained technicians will be given the job of terminating the connector modules, or some technicians use the manual to double-check their work. Thus, full points were awarded to those vendors who provide paper manuals or include it on the packaging. One point was awarded to those vendors who provide the manual electronically since often there is no Internet access at the installation site. Zero points were awarded if no manual was provided.

Form	Points
Paper	2
Packaging	2
Electronic	1
None	0

Tool-less termination: Tool-less termination of the module not only saves the installer the cost of a special tool. It also avoids the inconvenience when the tool is not where you need it at the moment, saving the time of looking for it.

Tool-less	Points
Yes	2
No	0

Strain relief: With ever increasing performance, the importance of protecting the cable from bending and pulling is critical. The strain relief of the conductor is therefore an essential factor in the performance of a channel.

Strain-relief	Points
Yes	2
No	0

Re-termination: The ability to re-terminate a module is an important feature. If a mistake is made, the entire connector does not need to be thrown away, but rather can be simply re-terminated correctly, saving costs and stress. On jobs where apprentices are learning the business, this feature can result in significant savings. This factor was only taken into account for the STP modules, since the UTP modules all supported this feature.

Re-Termination	Points
Yes	2
No	0

5.2. UTP termination

UTP Procedure: For every vendor, 2x15 m links were created using 4 jacks. The R&M Freenet UTP 250 MHz 4x2x0.55 mm cable was used in all cases. The termination process was divided into 4 steps, as follows:

1. Prepare cable
2. Position wires
3. Cut wires
4. Terminate wires (make contact)

An average value was used for step 1 in all cases since preparing the cable is the same process for all jacks. Also, in some cases, steps 3 and 4 were combined in one step. Four measurements were made for each step and the average of these values was calculated. These were then added together for the total calculated time.

UTP Code	1. Prepare cable	2. Position wires	3. Cut wires	4. Terminate wires	**Total calculated time**	Rank	Points Awarded
R&M UTP	25.8	65.2	9.5	5.4	105.9	3	2.50
V2	25.8	72.1	7.3	11.3	116.5	6	1.75
V3	25.8	73.5	7.4	14.1	120.8	7	1.50
V7	25.8	47.4	19.5	39.7	132.4	9	1.00
V8	25.8	93.8	13.9	42.5	176.0	12	0.25
V12	25.8	67.2	15.7	19.5	128.2	8	1.25
V14	25.8	58.2	10.4	11.6	106.0	4	2.25
V15	25.8	68.9	8.5	35.4	138.5	10	0.75
V17	25.8	116.3		9.0	151.1	11	0.50
V18	25.8	43.5		22.1	91.4	1	3.00
V19	25.8	52.2	8.9	21.1	108.0	5	2.00
V21	25.8	49.0		28.0	102.8	2	2.75

Table 6: UTP jack termination steps

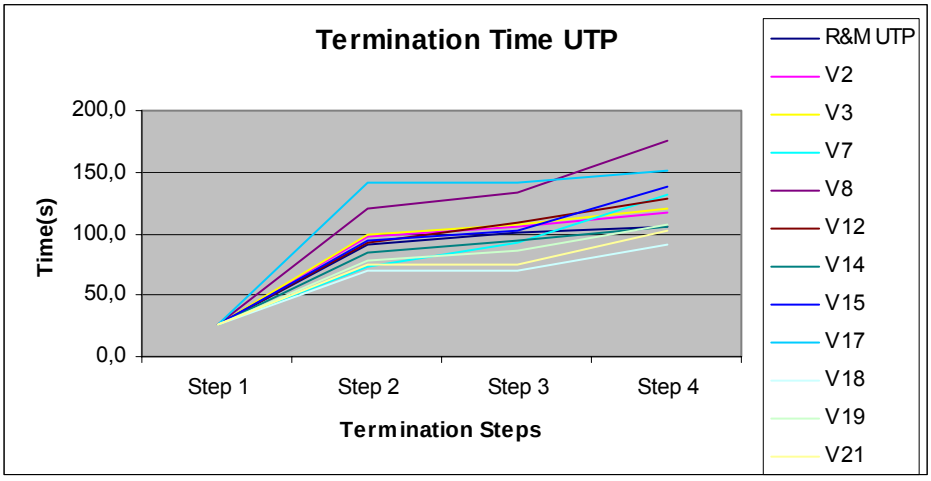


Fig. 15: Time to terminate a UTP jack

5.3. STP termination

STP Procedure: For every vendor, 2x15m links were created using 4 jacks. The R&Mfreenet S-STP 600 MHz 4x2x0.55mm cable was used in all cases. The termination process was divided into 5 steps, as follows:

1. Prepare cable
2. Position wires
3. Cut wires
4. Terminate wires (make contact)
5. Shield assembly

An average value for step 1 could not be used since with shielded systems the time is dependent on the type of shield contact. In one case, steps 3 and 4 were combined in one step. Four measurements were made for each step and the average of these values was calculated. These were then added together for the total calculated time.

STP Code	1. Prepare cable	2. Position wires	3. Cut wires	4. Terminate wires	5. Shield assembly	**Total calculated time**	Rank	Points Assigned
R&M STP	57.4	51.3	10.1	14.8	12.5	146.1	2	2.70
V4	60.3	72.6	10.1	66.7	15.5	225.1	7	1.20
V5	71.7	85.0	8.8	23.5	44.9	233.9	9	0.60
V6	14.4	111.3	12.2	31.6	27.8	197.3	5	1.80
V10	53.4	65.3	8.6	19.6	69.9	216.8	6	1.50
V11	47.7	133.6	16.1	41.2	19.4	258.0	10	0.30
V16	68.5	64.3	9.4	16.3	23.5	182.0	4	2.10
V20	52.8	66.6	10.2	17.2	8.5	155.3	3	2.40
V22	46.6	62.3	6.5	11.8	9.0	136.2	1	3.00
V23	52.5	37.3		63.6	79.3	232.7	8	0.90

Table 7: STP jack termination steps

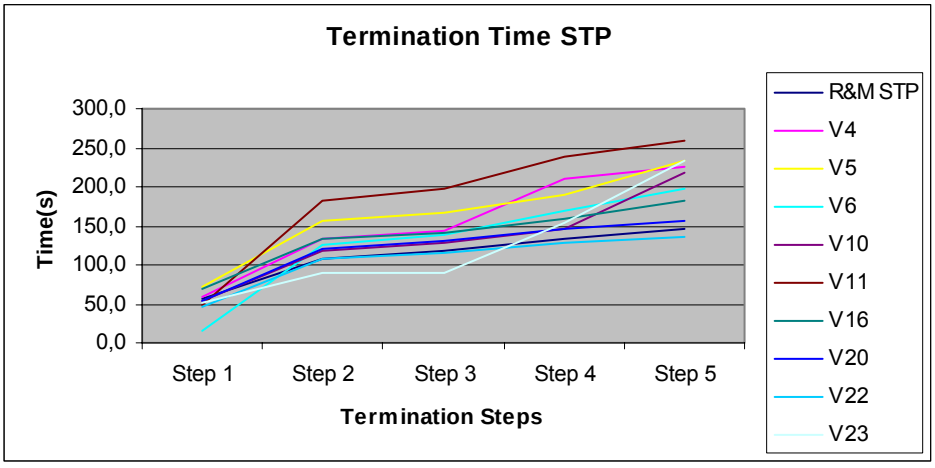


Fig. 16: Time to terminate a STP jack

5.4. UTP summary results

The results for the remaining variables, meaning the type of manual, whether the termination is tool-less and whether strain-relief is incorporated, are given in the table below for the UTP jacks tested. The "Points" column indicates the points attained from these three features. The "Total points" column includes the points assigned from the time termination testing (see above) for the overall rating.

UTP	Manual	Tool-less	Strain-relief	Points	Total points
R&M UTP	Paper	Yes	Yes	6	**8.50**
V2	Electronic	No	No	1	**2.75**
V3	Packaging	Yes	No	4	**5.50**
V7	Electronic	No	No	1	**2.00**
V8	Packaging	Yes	No	4	**4.25**
V12	None	Yes	No	2	**3.25**
V14	Electronic	Yes	Yes	5	**7.25**
V15	Paper	Yes	No	4	**4.75**
V17	Packaging	No	No	2	**2.50**
V18	Packaging	No	No	2	**5.00**
V19	None	Yes	No	2	**4.00**
V21	None	No	No	0	**2.75**

Table 8: Summary results for UTP jack usability

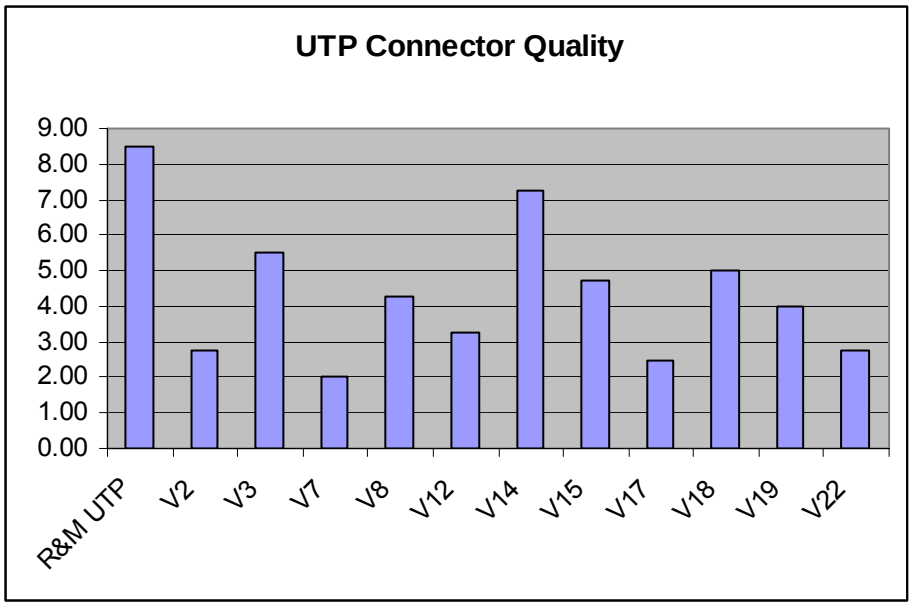


Fig. 17: R&M's UTP jack shows the best overall usability rating

5.5. STP summary results

The results for the remaining variables, meaning the type of manual, whether the termination is tool-less, whether strain-relief is incorporated and whether the jack can be re-terminated, are given in the table below for the STP jacks tested. The “Points” column indicates the points attained from these four features. The “Total points” column includes the points assigned from the time termination testing (see above) for the overall rating.

STP	Manual	Tool-less	Strain-relief	Re-termination	Points	Total points
R&M STP	Paper	Yes	Yes	Yes	8	**10.70**
V4	Electronic	No	Yes	No	3	**4.20**
V5	Electronic	No	Yes	No	3	**3.60**
V6	None	Yes	Yes	No	4	**5.80**
V10	Electronic	Yes	Yes	Yes	7	**8.50**
V11	Packaging	Yes	No	Yes	6	**6.30**
V16	Paper	Yes	Yes	Yes	8	**10.10**
V20	Electronic	Yes	Yes	Yes	7	**9.40**
V22	Electronic	Yes	Yes	No	5	**8.00**
V23	Electronic	No	No	No	1	**1.90**

Table 9: Summary results for STP jack usability

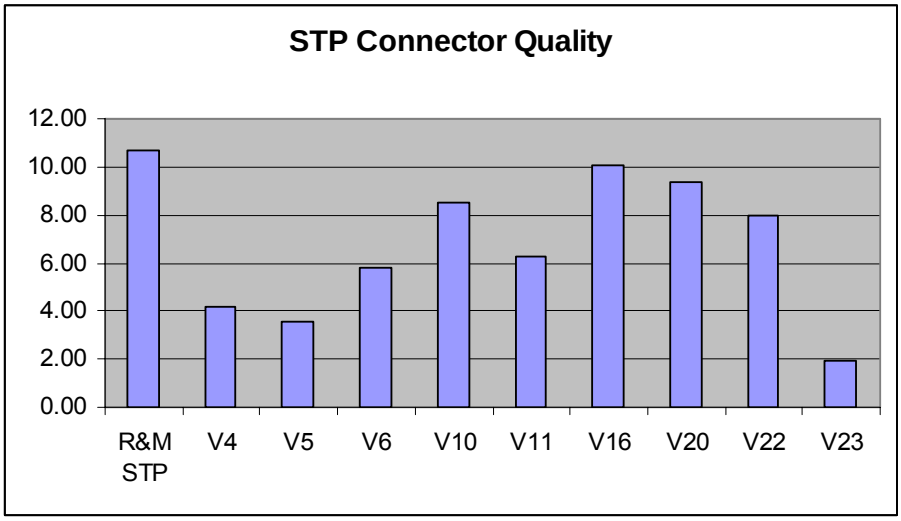


Fig. 18: R&M’s STP jack shows the best overall usability rating

Clearly, when all of the important aspects of the usability of a jack are considered together, R&M’s UTP and STP modules offer superior ease of use features which translate into time and cost savings for the customer.

6. Summary

We have seen that when it comes to features such as reliability, durability and usability, the performance of the leading patch cords and jacks on the market can vary significantly. It obviously pays off to carefully consider these characteristics when choosing a cabling system in order to ensure long-life operation.

The testing results presented in this White Paper convincingly show that R&M components have been designed from the ground up to provide not only excellent electrical performance, but also outstanding robustness. This gives R&M customers the assurance of optimum investment protection through extended life and problem-free operation.

7. Additional information

For additional information on R&M products and solutions, please visit our website at www.rdm.com