Nexans
AmerCable

Mold-cured Rubber Jackets vs Continuous Vulcanized (CV) Jackets for Mining Applications

Tiger® Brand Mining Cables

Third-party Test Results

Mold-cured Rubber Jackets versus Continuous Vulcanized (CV) Jackets for Mining Applications

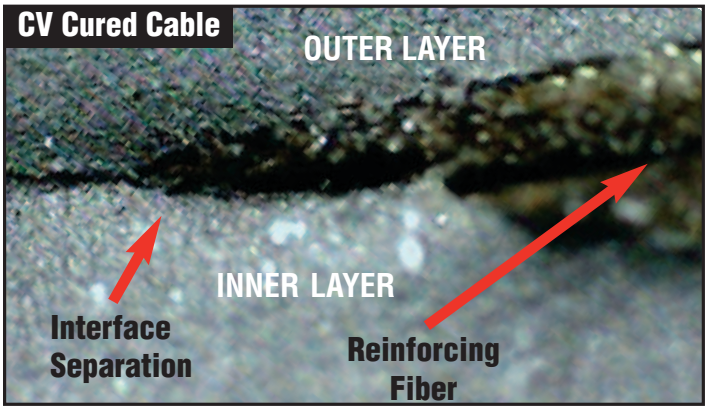
"Under the microscope – a closer look!"

There has been a strong push in recent months to bring Continuous Vulcanized (CV) cured jackets into the mining marketplace. Field trials of the CV-cured product show that it is no match for the lead/mold-cured jacket in mining applications. CV jackets are soft and contain a large number of micro-voids in the jacket's outer surface. These are a result of direct contact between the uncured rubber of the jacket and high temperature steam which is used as the heat transfer and curing medium.

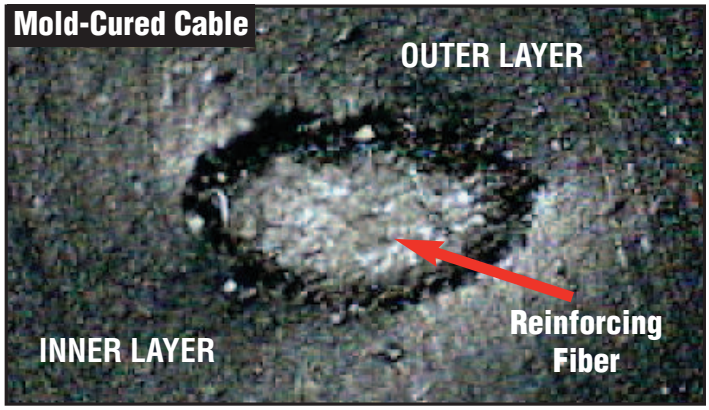
The argument has been made that the method of cure does not affect the physical properties of the jacket. This, however, has not been shown in the laboratory (see table 1). Previous field trials of CV cured products have resulted in disastrous results. Between the weak jacket and ground check wire problems, downtime went up drastically.

Nexans AmerCable jackets are extruded in two layers and bonded together with reinforcing web between the layers. A lead mold or sleeve, is extruded over the uncured rubber. Once a length of cable is completed, the entire mass is placed into a large autoclave and elevated to a moderate temperature that crosslinks the rubber. In the mold curing process the lead sleeve protects the uncured rubber and provides an excellent heat transfer medium. The lead extrusion tightly squeezes the jacket material during the vulcanization process as the uncured rubber expands. This pushes the rubber even tighter against the lead mold, creating a smooth, dense surface that is extremely resistant to abrasion. It has excellent tensile strength and tear resistance.

Continuous Vulcanized (CV) jackets are extruded onto the cable core. This assembly is then pulled through a long steam tube. With direct exposure to steam, plus high heat, crosslinking occurs in a short length of time. Steam permeates the raw rubber, with the degree of penetration affecting the jacket's abrasion resistance, tensile strength, tear resistance, and abrasion resistance.

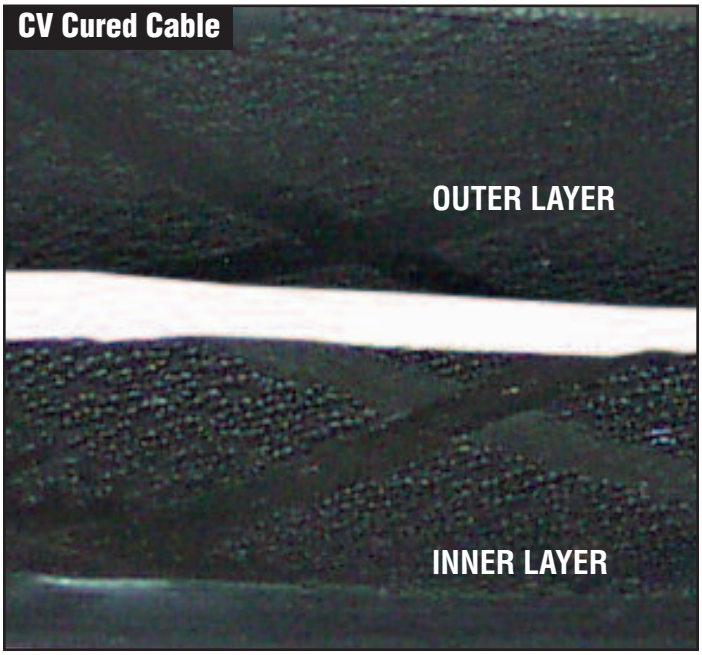


Cross section close-up of a typical CV cured jacket at the interface between the inner and outer jacket. The reinforcing fiber can be seen in the upper right and a small separation can be seen at the interface. Separations or cracks like this can often be seen in jackets when low surface pressure CV, or steam process, is used to vulcanize the jacket. These voids can cause premature jacket separation. Photo magnification: 40X



Cross section close up of a typical Tiger® Brand Mold-cured jacket at the interface between the inner and outer jacket. The interface between the inner and outer jacket runs through the oblong axis of the reinforcing fiber. The high pressure of the mold-cure results in a smooth, homogeneous, tightly bonded interface. Photo magnification: 40X

Constructions of trailing cables vary with the type of jacket cure used. Internal components of Tiger® brand cables include: flexible stranding, a strand separator, Ethylene Propylene Rubber insulation, copper/nylon braid shielding (on Type SHD-GC), two grounds, and one yellow polypropylene insulated ground check wire. In the case of the braid shield, nylon has the highest strength and moisture resistance of available textiles. Polypropylene Ground Check insulation is also the material of choice for trailing cables. Nexans AmerCable utilizes only the best materials in trailing cables. These materials are not typically used in CV cured cables. The high temperature during jacket curing can deform or possibly melt polypropylene and nylon.



This photo shows the facing contact surfaces between the inner and outer jackets of a typical CV cured cable. The low pressure of the CV cure process is often not sufficient to create a tenacious bond between jacket layers. Flexing or bending during service can cause these layers to separate, causing premature cable failure. These two layers were easily separated by hand.

Physical Properties (Table 1)

Tiger Brand mold-cured Chlorinated Polyethylene rubber jackets meet or exceed the physical properties below. Typical jacket data is shown for comparison:

Property	Nexans AmerCable Mold-cure	CV cure
Tensile (psi)	2800	1980
Elongation (%)	525	488
Tensile strength @ 200% elong.(psi)	1035	600
Tear (lb./in.)	50	41
Abrasion resistance, volume lost (cc)*	0.339	0.691

*Abrasion testing was performed per ISO 4649 using 10 Newtons force. Results are in volume loss.

Field trials of the CV-cured product show that it is no match for the mold-cured jacket in mining applications.

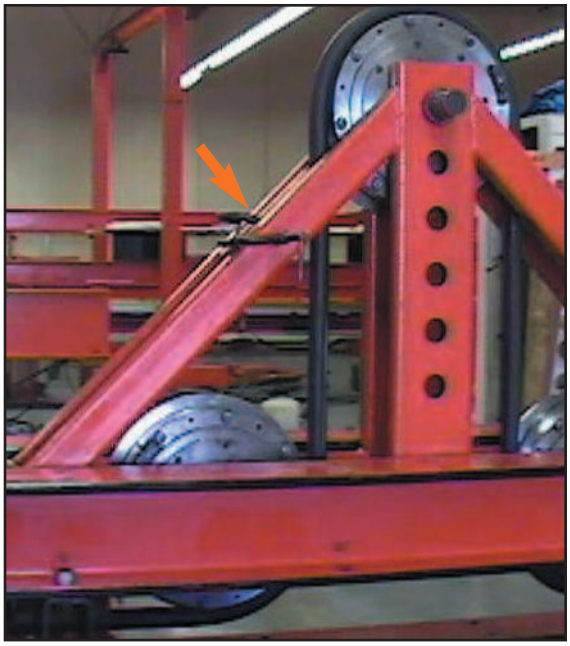
The Test

Nexans AmerCable hired a third-party testing facility to scientifically determine the performance difference between Nexans AmerCable Tiger Brand mold-cured mining cables and two of the leading CV-cured competitor's (referred to as Competitor A and Competitor B) cables.

The test was designed to simulate the normal wear- and-tear mining cables experience in everyday operating conditions.

Each cable was to be subjected to the same test conditions:

- 15000 total cycles
- Cables cycled at variable tensions from 60-100% of recommended
- Cables bending twice over 90°, 180° and 90° sheaves per machine cycle
- Abrasion device mounted on tester (see arrow on tester photo)



Tension Reeling Machine Tester
(Cable Torture Unit)

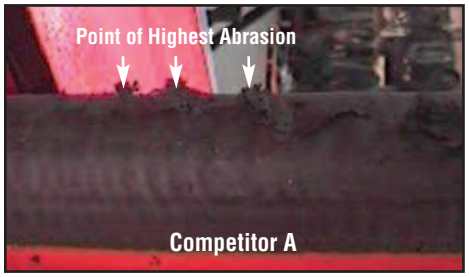
Bend Test Results

Test	Nexans AmerCable Tiger® Brand	Competitor A	Competitor B
15,000 Cycles	**15,000** No failure of any component.	2500 GC Failed. Test terminated.	4715 GC Failed. Test terminated.

Jacket Initial Physical Properties

Test	Nexans AmerCable Tiger® Brand	Competitor A	Competitor B	ICEA Minimum
Tensile, PSI	**2800**	2700	2500	2400
Tensile @200% Elongation	**1035**	650 (failure)	850	700
Tear, PPI	**50**	42	41	40

Jacket After Tension Reeling



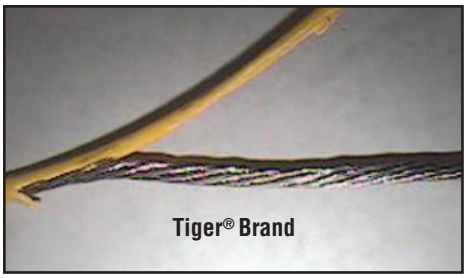
- **Tiger® Brand**
  Virtually no abrasion on jacket after 15,000 Cycles

- **Competitor A**
  Significant jacket abrasion shown at 2000 cycles. Will not glide easily over rocks and sharp objects. Cycling continued to GC failure (without abrasion tool engaged)

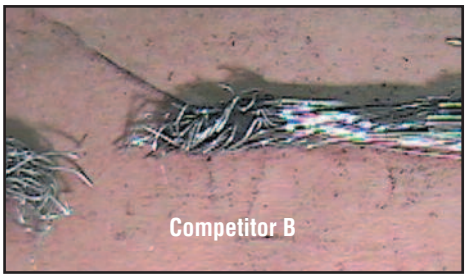
- **Competitor B**
  Jacket abraided through outer layer in 1000 cycles. Cycling continued to GC failure (without abrasion tool engaged)

The Tiger® Brand mold-cured jacket showed virtually no abrasion at the conclusion of the 15,000 cycle test

Ground Check Insulation Properties

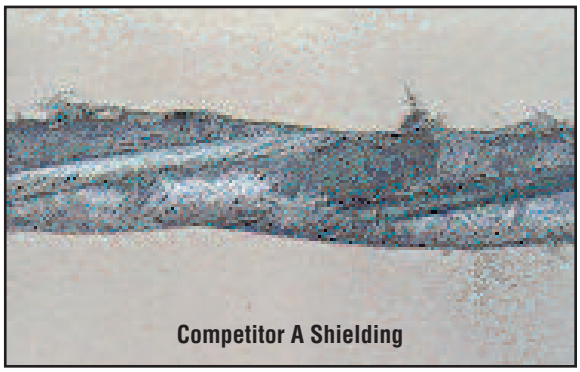

Tiger® Brand


Competitor A


Competitor B

- **Tiger® Brand**
  High modulus polypropylene insulated GC wire cycled 15,000 times with NO broken wires and passed DC test.
- **Competitor A**
  Uses soft EP rubber on GC wire. This allows rapid fatigue and penetration of the insulation (2500 cycles).
- **Competitor B**
  Uses soft EP rubber on GC wire. This also causes the strand to kink and break (4,715 cycles).

Electrical Properties After Tension Reeling Test


Competitor A Shielding

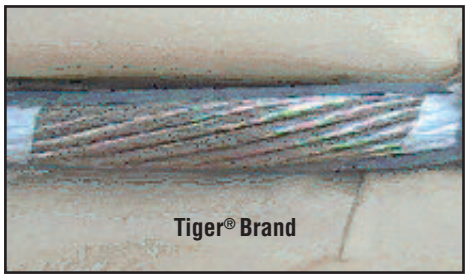
- **Tiger® Brand –** passed DC electrical tests and maintained excellent IR on all conductors after 15,000 cycles
- **Competitor A –** Herringbone strand opened up and destroyed the shielding, caused wear on insulation and subsequent DC Hipot failures on two-phase conductors and GC. This failure occurred at 2,500 cycles. (see photo)
- **Competitor B –** Test terminated after 4,715 cycles due to ground check failure. Electrical test (IR) on EP insulated power conductors was low even at this point.

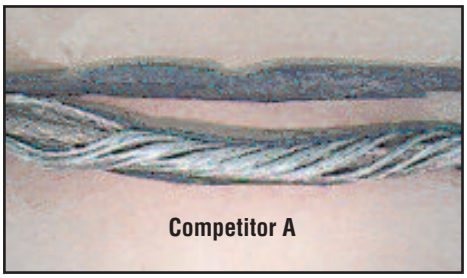
Insulation Physical Test Data

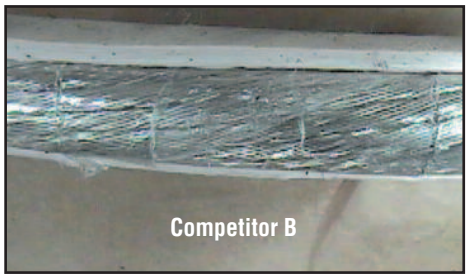
Test	Nexans AmerCable Tiger® Brand	Competitor A	Competitor B	ICEA Minimum TYPE II	ICEA Minimum TYPE I
Tensile, PSI	**1700**	1050 (failed)	1220	1200	700
Elongation @ Rupture %	**325**	229 (failure)	668*	150	250

* Indicates possible improper vulcanization

Stranding Test Results







Tiger® Brand
Stranding intact. No broken wires or insulation erosion.

Note: AmerCable's proprietary strand design resists torsion and carries tension uniformly.

Competitor A
Herringbone design sprung open.

Note: Herringbone strand does not carry tension uniformly and springs open under bending load causing insulation erosion and failure.

Competitor B
Unidirectional strand de-cables under tension.

Note: Power conductor de-cabling leads to early failure of other components in the cable.

Minesite training, education and support are value-added benefits enjoyed by Nexans AmerCable Tiger® Brand customers. Our top priorities are high levels of miner safety and mine productivity achieved through innovative cable solutions.

Conclusions

- Mold-cured jackets deliver superior, longer lasting performance which results in less downtime and more mine productivity. This is proven in laboratory tests and mines throughout the world.
- Nexans AmerCable has developed specialized stranding for each element of the cable for longer service life in harsh mining conditions.
- Nexans AmerCable has electrically- and mechanically-sound insulations for power and GC conductors.
- Nexans AmerCable shielding and assembly are specially designed for extended cable life.
- Nexans AmerCable AmerCable jacket compounds and processes are focused on the rigorous environment of mining applications.
- Nexans AmerCable value-added services, such as training, education and minesite support enhance miner safety and mine productivity.

Nexans AmerCable

350 Bailey Road • El Dorado, Arkansas USA
(870) 862-4919 • (800) 643-1516 • Fax (870) 862-9613
e-mail: mining@amercable.com • www.amercable.com