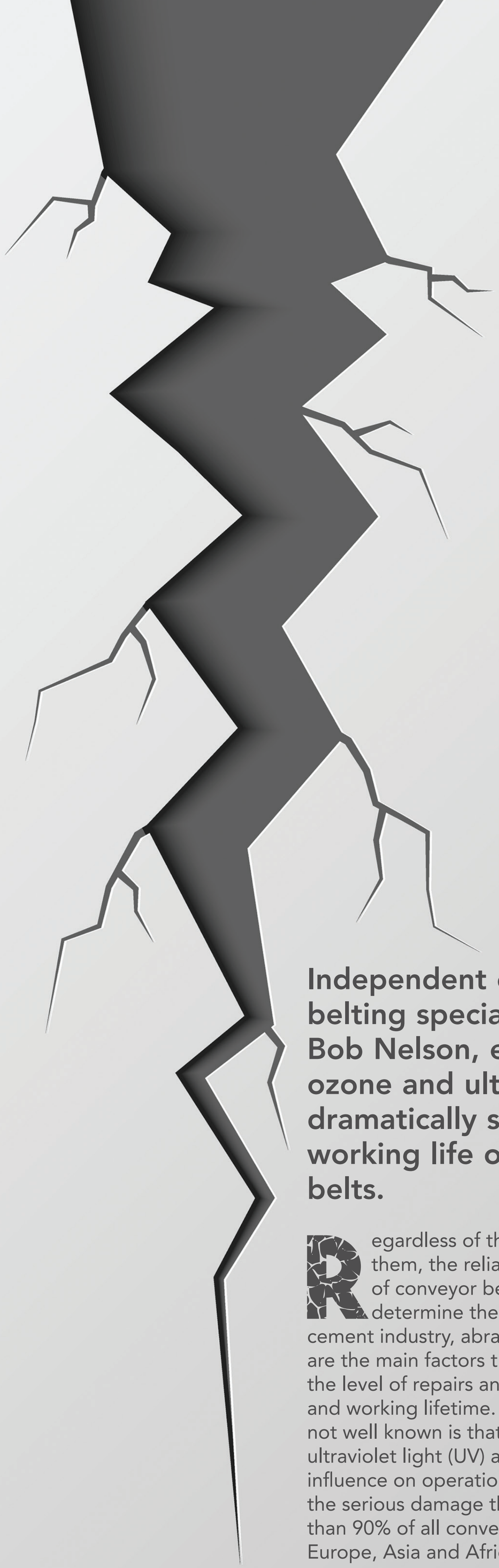
WHAT'S THE CRACK?



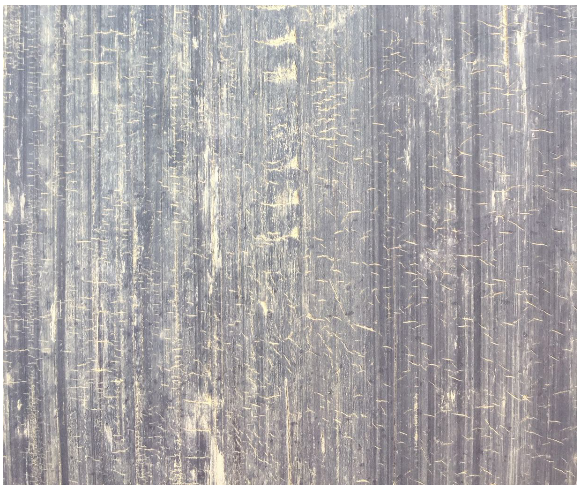
Independent conveyor belting specialist, Bob Nelson, explains how ozone and ultraviolet light dramatically shorten the working life of conveyor belts.

Regardless of the price paid for them, the reliability and longevity of conveyor belts will ultimately determine their cost. In the cement industry, abrasive wear and heat are the main factors that determine the level of repairs and maintenance and working lifetime. However, what is not well known is that ozone (O_3) and ultraviolet light (UV) also have a huge influence on operational lifetime. Despite the serious damage they cause, more than 90% of all conveyor belts sold in Europe, Asia and Africa are not ozone and

UV resistant. This article explains why it is such an important issue.

Ozone exposure: causes and effects

When developing any rubber compound, one of the first considerations should be the effect of ozone. Almost all of the rubber used in conveyor belt manufacturing is synthetic. This is because different mechanical properties and characteristics can be



The beginning of the end. 'Innocent' looking ozone cracks in the surface of the rubber.

The cracks are always oriented at right angles to the strain axis.

An increase as little as 10˚C in core temperature can cause a belt to fall apart.

specifically created depending on what the rubber will be used for and the working environments it will be subjected to.

Ozone (O_3) occurs naturally in the upper atmosphere. It is formed continuously by the action of solar ultraviolet radiation on molecular oxygen (O_2). At high altitude, ozone acts as a protective shield by absorbing harmful ultraviolet rays. Wind currents carry O_3 to the atmosphere at the Earth's surface. However, at low altitude, ozone becomes a pollutant. Ground level or 'bad' ozone is not emitted directly into the air but is created by the photolysis of nitrogen dioxide (NO_2) from sources such as automobile exhaust and industrial discharges. This is known as ozonolysis.

Ozonolysis

Ozonolysis is the reaction that occurs between the molecular structure (double bonds) and ozone.

The scientific explanation is that the immediate result is the formation of an ozonide, which then decomposes rapidly so that the double bond molecule is split. The critical step in the breakdown of molecular chains is when polymers are attacked. The strength of polymers depends on the chain molecular weight or degree of polymerisation. The longer the chain length, the greater the mechanical strengths including the highly important tensile strength of the rubber. By splitting the chain, the molecular weight drops rapidly. It is necessary to understand this because there comes a point when very little strength remains and cracks start to form. Further attacks occur inside the freshly exposed cracks, which continue to grow steadily until they complete a 'circuit' and the product separates or fails.

Exposure is unavoidable because even tiny traces of ozone in the air will attack the molecular structure of rubber. It increases the acidity of carbon black surfaces with natural rubber, polybutadiene, styrene-butadiene rubber and nitrile rubber being the most sensitive to degradation. Although the first visible sign is when cracks start to appear in the surface of the rubber, depending on the level of ozone resistance that has been built into the rubber compound, the process of ozonolysis effectively begins when the conveyor belt leaves the production line.

Although the variability of weather, airflow patterns, seasonal changes, the level of emissions and climatic conditions do mean that ozone concentrations can differ from one location to another, the fact is that ground level ozone pollution is ever-present and therefore its effects should never be under-estimated.

Hidden effects

Ozone cracks form in rubber that is under tension. This is sometimes referred to as 'dry rotting'. It is important to bear in mind that only a very small amount of tension (critical strain) is needed. Even a belt that has not yet been fitted on a conveyor has a certain amount of intrinsic tension. The cracks are always oriented at right angles to the strain axis. The dynamic stress that a conveyor belt undergoes whilst in operation is considerable and ozone attack occurs at the points where the strain is greatest.

The repeated action of the mechanical stress of the conveyor belt and the frictional process from the idlers mean that the rubber molecular chain will break to form what scientists refer to as a 'free radical'. This triggers the oxidative chain reaction that forms a chemical process that mechanically breaks the molecular chain and activates the oxidation process, magnifying a whole range of more obvious problems such as the inability to resist abrasive wear.

Ultraviolet degradation

Ultraviolet light from sunlight and artificial (fluorescent) lighting accelerates rubber deterioration because it produces photochemical reactions that promote the oxidation of the rubber surface, resulting in a loss in mechanical strength. This is known as 'UV degradation'.

Sadly, the rapid decline in the ozone layer in the upper atmosphere over the past several decades is allowing an increasing level of UV radiation to reach the earth's surface. Continuous exposure is a more serious problem than intermittent exposure, since attack is dependent on the extent and duration of the exposure.

Although worse in sunnier climates, the problem is ever-present even in the most moderate of environments. As with ozone, the damage and dust pollution it causes should not be underestimated.

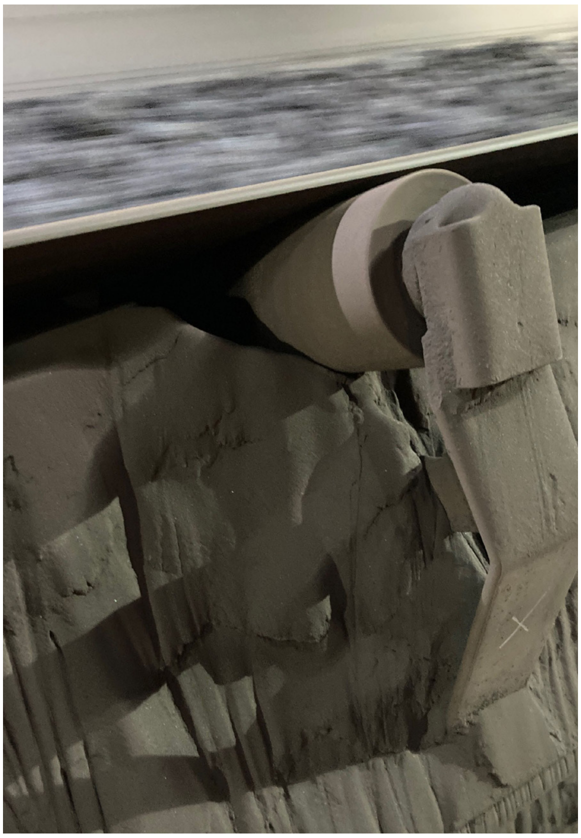
A multitude of problems

Having small cracks in the surface rubber may not seem to be a big issue but they lead to a multitude of problems. This is due to the rubber covers becoming increasingly brittle over a surprisingly short period of time. As previously mentioned, transversal cracks deepen under the repeated stress of passing over the pulleys and drums. The combined effect of the ozonolysis and UV degradation processes continue, so the cracks steadily grow until catastrophic failure occurs. One of the potential risks is that scrapers can catch on the cracks and tear off parts of the cover.

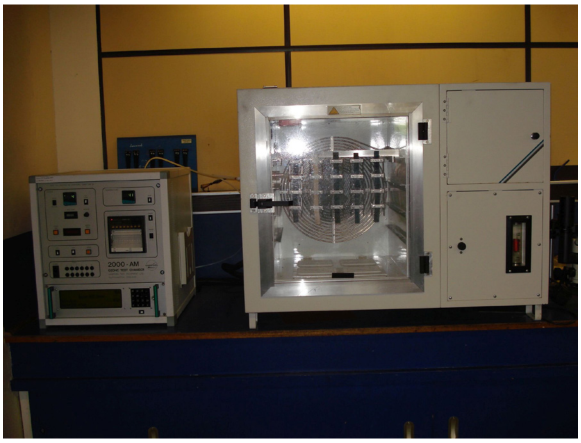
Over time, re-splicing can also become increasingly difficult as the adhesion properties of the rubber diminish.

Yet another 'hidden' problem is that moisture seeps into the cracks and penetrates down into the belt carcass. In multi-ply belts, the fibres of the weft strands of the plies expand as they absorb moisture, which in turn causes sections of the carcass to contract (shorten) as the weft strands pull on the warp strands of the ply. This can result in tracking problems, which can be difficult to pinpoint, and which no amount of steering idler adjustment can compensate for.

Last but not least, the ability of the covers to protect the inner carcass from high material temperatures can be seriously compromised because the cracks allow heat to penetrate more easily into the carcass. This is, of course, very serious seeing as even an increase as small as 10˚C in core temperature can reduce the life of the belt by as much as 50%. This is because for every 10˚C increase in temperature, the rate of rubber oxidation increases by a factor of eight. If the core temperature of the carcass becomes too high, then the bond between the covers and fabric layers



Pollution problems – fine particles of dust penetrate the cracks and are then discharged (shaken out) on the return (underside) run of the belt.



Ozone testing cabinet. Image courtesy of Fenner Dunlop, The Netherlands.

will separate (delaminate) and the belt will quite literally begin to fall apart.

Consequently, a heat resistant belt that is not resistant to ozone and ultraviolet is considerably less effective and much more likely to require premature replacement.

EN ISO 1431 testing

The EN ISO 1431 test method is used to scientifically measure resistance to ozone. Samples are placed under tension inside an ozone testing cabinet and exposed to highly concentrated levels of ozone for a period of up to 96 hours (@ 40˚C, 50 pphm and 20% strain). Samples are closely examined for evidence of cracking at two-hourly intervals and the results carefully measured and recorded.

Experience has determined that in order for the rubber to be regarded as adequately resistant, the pass criteria is that the rubber sample does not show any signs of cracking within the 96 hr period. In the majority of cases, cracks begin to appear as early as six to eight hours. In fact, it is not uncommon to see rubber samples completely disintegrate within a few hours. Typical 40 and 60 Shore sheeting and skirting rubber seems to be even worse.

Due to the size of industrial conveyor belt rolls, it is common practice to store them in the open air. Belts can sometimes be held in stock for very long periods before they are eventually put to use. During that time, they are vulnerable to the ever-present effects of ozone and UV radiation. A number of conveyor belt users have reported that surface cracking was evident at the time of delivery. It is therefore recommended that belts in storage are kept covered.

An essential part of the specification

Damage caused by ozone and ultraviolet is almost entirely preventable thanks to the use of antiozonants. Unfortunately, most manufacturers do not use them because they want to obtain a price advantage and many traders are happy that the replacement belt cycle is accelerated. Ironically, this absence of protection actually costs the unsuspecting end-users much more in terms of pollution, higher maintenance and premature replacement. When choosing a conveyor belt, always insist on certification showing that the belt in question is fully resistant to ozone and ultraviolet in accordance with the EN ISO 1431 test method. If the belt subsequently starts to crack then at least a claim for compensation or replacement can be made. ■

About the author

Bob Nelson is an independent conveyor belting specialist and a leading technical author who has been working in the industry for more than 20 years.