The invisible enemy

HOW OZONE AND ULTRA VIOLET DRAMATICALLY SHORTENS THE WORKING LIFE OF CONVEYOR BELTS

There are many things that determine the working lifetime of conveyor belts. The incessant abrasive action of the materials being conveyed; the impact of heavy, sharp lumps of rock being dropped onto them and the ripping and tearing caused when rocks or foreign objects become trapped. All of these factors are, of course, common knowledge to operators of conveyors. As I have talked about previously in Mining & Quarry World, conveyor belts can be engineered to significantly limit the amount of damage these factors can cause.

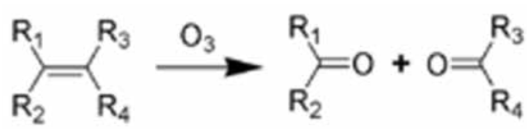
However, what is definitely *not* common knowledge is that there are also two other 'invisible' and inescapable factors that have a huge influence on the operational lifetime of a rubber conveyor belt. Those factors are ozone (O_3) and ultraviolet light (UV) and, contrary to often common misconceptions, the damage they cause is not limited to only higher altitudes or particularly sunny climates. Far from it in fact.

FROM PROTECTOR TO DESTROYER

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. 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 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:



Ozone cracks in the surface of the rubber.

Foolish to underestimate the damage caused by UV exposure.

The scientific explanation is that the immediate result is 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 polymerization. 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. There comes a point when very little strength remains and cracks starts 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.

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. The first visible sign is when cracks start to appear in the surface of the rubber.

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 its effects should therefore never be under-estimated.

A PARTNER IN CRIME

To make matters worse, 'bad' ozone has a partner in crime that also has a seriously detrimental effect on rubber. Ultraviolet light from sunlight and 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'.

Ironically, 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. As you would expect, the problem is worse in sunnier, hot climates

Transversal cracks deepen under the repeated stress of passing over the pulleys and drums.

Dunlop's ozone testing cabinet.

Samples are checked for cracking at two-hourly intervals.

Some rubber literally disintegrates.

but even in the most moderate of environments, the problem is ever-present and, as with ozone, it would be foolish to underestimate the damage it causes.

HIDDEN EFFECTS

Ozone cracks form in rubber that is under tension. However, the critical strain needed is only very small. 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 while in operation is considerable. 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 idler means 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, which mechanically breaks the molecular chain and activates the oxidation process. Who would have ever believed that rubber conveyor belts could be so scientifically complex? They are certainly not just the giant black rubber bands that so many people seem to think they are!

STRESS MAGNIFICATION

At first glance, having small cracks in the surface rubber may not seem to be a big problem but over a period of time the rubber becomes increasingly brittle. As I have just mentioned, transversal cracks deepen under the repeated stress of passing over the pulleys and drums. The ozone continues to attack so the cracks will steadily grow until catastrophic failure occurs. Cracks often present other potential risks such as scrapers catching on them and tearing off parts of the cover. Re-splicing can also become increasingly difficult over time as the adhesion properties of the rubber diminish.

Yet another 'hidden' problem is that moisture seeps into the cracks. This then penetrates down to the actual carcass of the belt. 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, there can also be significant environmental and health and safety consequences because fine particles of dust penetrate the cracks and are then discharged (shaken out) on the return (underside) run of the belt.

ENTIRELY PREVENTABLE

Fortunately, damage caused by ozone and ultraviolet is almost entirely preventable thanks to the use of modern technology. Several years ago, we at Dunlop were among the very first in the world to make use of new technology that enabled the effects of ozone to be tested and measured. We equipped our laboratory in Drachten in The Netherlands with the very latest ozone testing equipment and introduced mandatory testing to EN/ISO 1431 international standards for all Dunlop rubber products. The same testing regime was applied to samples of belts made by other manufacturers.

Ground level ozone seriously damages rubber

As a direct result, special anti-oxidant additives that act as highly efficient anti-ozonants and protect against the damaging effects of ozone and ultra violet became an essential ingredient in all Dunlop rubber compound recipes without exception. Unfortunately, for their customers, hardly any other belt manufacturers make use of these anti-oxidant additives. I will explain the reason for this shortly.

EN/ISO 1431 TESTING

To scientifically measure resistance to ozone in accordance with the EN/ISO 1431 test method, samples are placed under tension (eg. 20% elongation) 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 needs to be that the rubber sample does not show any signs of cracking within the 96-hour period.

SWEPT UNDER THE CARPET

Despite its crucial importance, in my experience, ozone and UV resistance is very rarely, if ever, mentioned by belt manufacturers and suppliers. It is a subject that is, as they say, swept under the carpet. This is almost certainly because so much of the market is dominated by those trying to undercut their competitors on price. Anti-ozonant additives are not cheap and are therefore not used in the pursuit of a price advantage. I would also argue that for many belt suppliers, anything that prolongs the working life of belts is not particularly good for business.

We have hardly ever tested a competitor's belt (and never non-European import belt in my experience) that has survived the EN/ISO 1431 specific test conditions without cracking. In the majority of cases the cracks start to appear within 6 to 8 hours rather than the target of 96 hours. Sadly, it is not an uncommon sight to see rubber samples completely disintegrate within a matter of a few hours. Typical 40 and 60 Shore sheeting and skirting rubber seems to be even worse.

Because of the sheer size of industrial conveyor belts, it is common practice amongst manufacturers and distributors to store rolls of belting in the open-air. Belts can often be held in stock for long periods, sometimes for several years, before they are eventually dispatched and ultimately 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 could be seen at the time of delivery.

NO HIDING PLACE.

The importance of having conveyor belts that are resistant to ozone and ultra violet can no longer be ignored. Unless conveyor operators start insisting on having belts that are ozone & UV resistant then the vast majority of belt manufacturers and suppliers will continue to ignore the issue.

For all buyers of rubber conveyor belts there should be **two** absolute pre-requisites when choosing any type of belt. Firstly, regardless of type, the rubber covers should have good resistance to abrasive wear. Just as importantly, they need to be fully resistant to the effects of ozone and ultra violet. Without these essential properties the belt will not provide genuine value for money because it will need to be replaced far sooner than necessary. My advice is to always insist that the manufacturer/supplier provides certification confirming that the belt they are offering is fully resistant to ozone and UV in accordance with the EN/ISO 1431 test method.

Rob van Oijen

ABOUT THE AUTHOR

Rob van Oijen is Manager Application Engineering for Dunlop Conveyor Belting in The Netherlands is one of the most highly respected application engineers in the industry. He has specialized in conveyors for over 14 years, supporting businesses throughout Europe, Africa, the Middle East and South America.