

OITAF Seminary / Grenoble 2006

„Basic Lubrication and Re-lubrication for Steel Wire Ropes”

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Let us try to establish a catalogue of requirements a rope lubricant has to fulfill taking into account the operation of this rope in different types of ropeways.

Basic Lubrication & Re-lubrication

Why should a ropeway rope be lubricated at all?

Rope & Ropeway Consulting / in April 2006

In order to establish a list of requirements, we must first examine the goals we wish to attain.

That means the first question we need to answer is:

“why a rope must be lubricated at all?”

Basic Lubrication & Re-lubrication

To prolong service life!

Rope & Ropeway Consulting / in April 2006

The answer sounds very simple:
In order to prolong the rope's service life!

Basic Lubrication & Re-lubrication

**To prolong service life
by means of:**

- friction reduction

Rope & Ropeway Consulting / in April 2006

We can achieve this goal on the one hand by reducing the coefficient of friction between the friction partners.

This means in our case either between the individual wires or between the strands. The reduction of the coefficient of friction is achieved by means of rope lubrication.

However, exactly at this point, caution is appropriate: the friction between the individual wires should not drop to zero, as a rope whose inner friction is zero, acts almost like a bundle of parallel wires. This means that a broken wire in such a rope would not be able to carry the full load again after some lays away from the breakage.

Basic Lubrication & Re-lubrication

**To prolong service life
by means of:**

- friction reduction**
- corrosion protection**

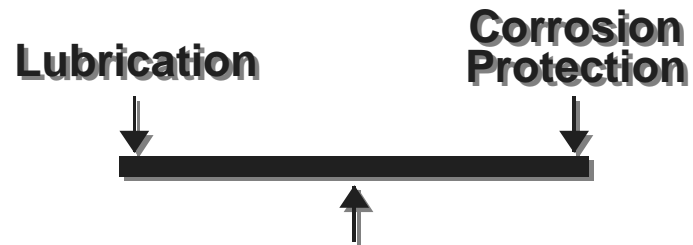
Rope & Ropeway Consulting / in April 2006

The reduction of friction is not the only method of prolonging service life!
The second method is by means of corrosion protection.

The importance of corrosion protection depends mainly on the materials used, the rope's construction and its service environment. It is achieved by preservation, which takes place at the same time as lubrication.

A third method of prolonging service life used to be the prevention of the decomposition of the hemp core, also achieved by means of rope lubrication. However, this can be readily forgotten today, as hemp is no longer used as core for ropes in ropeway applications.

Basic Lubrication & Re-lubrication



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It is interesting to mention here, that, both means of prolonging service life had more or less the same importance in the past.

Basic Lubrication & Re-lubrication



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However over the last 20 years the emphasis has been shifted more and more in favor of the lubrication.

Both the quality of the wire material and the various wire coatings have gradually reduced the importance of corrosion protection.

Conversely, the expected long rope service life together with the increased stresses and number of load cycles have definitely raised the importance of lubrication.

Basic Lubrication & Re-lubrication

Requirements with respect to:

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The requirements to be fulfilled by the lubricant and the corrosion protective are determined by the existing boundary conditions.

Basic Lubrication & Re-lubrication

**Requirements with respect to:
- the rope**

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Therefore we have to differentiate between requirements in respect to
- the rope itself

Basic Lubrication & Re-lubrication

Requirements with respect to:

- the rope**
- the installation**

Rope & Ropeway Consulting / in April 2006

Therefore we have to differentiate between requirements in respect to

- the rope itself
- the aerial ropeway facility

Basic Lubrication & Re-lubrication

Requirements with respect to:

- the rope**
- the installation**
- the operation**

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Therefore we have to differentiate between requirements in respect to

- the rope itself
- the aerial ropeway facility and finally
- the ropeway operation

Requirements with Respect to the Rope - Workable

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The first requirement with respect to the rope itself is the workability:
The lubricant must be workable during strand or/and the rope making process as well as the re-lubricant must be applicable during operation.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**

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That means that the dripping point and the viscosity of the lubricant must be properly chosen to ensure the penetration and wetting of all wire surfaces as well as the filling of all gaps, according to the requirements.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**
 - Resistance to temperature**

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During rope making fluidity generally reached by means of heating. Therefore it must be ensured that the necessary temperatures do not adversely affect either the properties of the wire or those of the lubricant, especially due to the fact, that the heating period can extend over several days.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**
 - Resistance to temperature**
 - Resistance to pressure**

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The lubricant must be able to withstand the compaction process of the strand undamaged.

Therefore a certain pressure resistance should be present also under rope manufacturing temperatures.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**
 - Resistance to temperature**
 - Resistance to pressure**
 - Compatibility to the drawing agent**

Rope & Ropeway Consulting / in April 2006

Existing remnants of drawing agent should not adversely influence the properties of the lubricant.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**
 - Resistance to temperature**
 - Resistance to pressure**
 - Compatibility to the drawing agent**
 - Emissions**

Rope & Ropeway Consulting / in April 2006

Also, no disturbing nor health-endangering emissions should arise when applying the basic lubrication during manufacture, respectively when applying the re-lubricant during maintenance.

Requirements with Respect to the Rope

- Workable**
 - Dripping point**
 - Viscosity**
 - Resistance to temperature**
 - Resistance to pressure**
 - Compatibility to the drawing agent**
 - Emissions**
 - Availability**

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Finally, availability, especially with regard to the re-lubricant, should be guaranteed in all service locations.

This means attention should also be paid to the transportability or dispatch ability of the re-lubricant during product development (keyword hereby: 'dangerous goods')

Requirements with Respect to the Rope

- **Workable**
- **With adhesive power**

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So far regarding the workability.

Once applied the lubricant should remain adhering to the respective wire surface, but at the same time wiping ability is also desired during production.

We realise, that both requirements contradict each other, therefore finding an intelligent compromise is necessary here, too.

Requirements with Respect to the Rope

- Workable**
- With adhesive power**
- Resistant to pressure**

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Resistance against high pressure is an essential property of a lubricant. In order to fulfill its role as a third body between the friction partners, the lubricant must be able to withstand operating pressures.

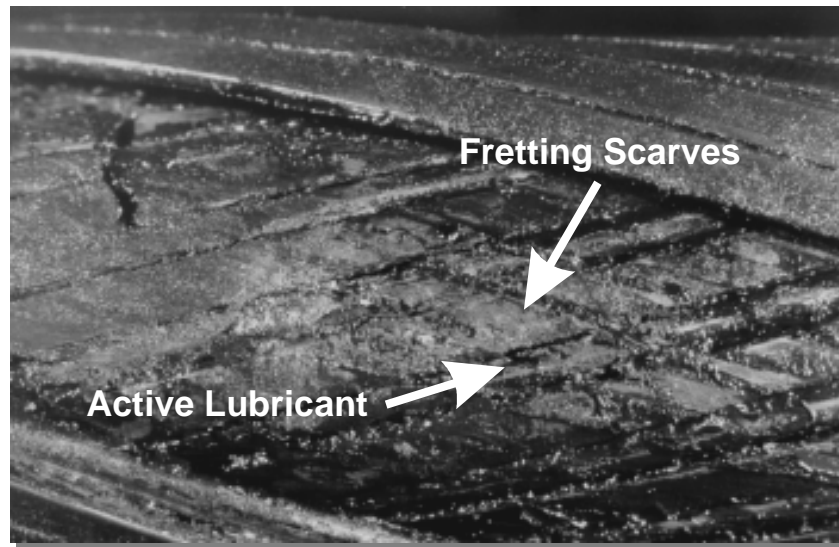
Requirements with Respect to the Rope

- Workable**
- With adhesive power**
- Resistant to pressure**
- With flow back ability**

Rope & Ropeway Consulting / in April 2006

However, we must recognized at the same time, that the flow-back ability of the lubricant is equally essential as its resistance against high pressure. This means that even when the lubricant is displaced as a result of momentarily applied too high pressure, it should be still capable to flow back between the contact surfaces after the reduction of the pressure.

Requirements with Respect to the Rope



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This property is of major importance, because it has been proved, it is almost impossible to develop a lubricant capable to withstand the pressure during the rope's whole service life respectively after a large number of load cycles.

This picture shows exactly what is happening when using a lubricant without the mentioned "flow back ability":

The red area indicates fretting scarves, an area which was exposed to local high pressure and small movements for several number of cycles.

The black area indicates an amount of lubricant which is still active but was not capable to flow back when the pressure yielded.

Requirements with Respect to the Rope

- Workable**
- With adhesive power**
- Resistant to pressure**
- With flow back ability**
- Preventing stress corrosion cracking**

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Care should also be taken that the used lubricant prevents the occurrence of stress corrosion cracking.

Requirements with Respect to the Rope

- Workable**
- With adhesive power**
- Resistant to pressure**
- With flow back ability**
- Preventing stress corrosion cracking**
- Preventing corrosion**

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Finally, as I mentioned at the beginning, corrosion protection is the second method of prolonging the service life of a rope.

However corrosion protection is a much too complex subject to be dealt with just a few words. I would only like to remind you, that corrosion protection depends, on the one hand, on the kind of materials used which are to be protected and, on the other hand, on the respective environment.

To a large extent it can be assumed that the wire materials are well-known; whereas the environment must be scrutinized each time anew, if one would like to avoid unpleasant surprises.

Requirements with Respect to the Rope

- Workable**
- With adhesive power**
- Resistant to pressure**
- With flow back ability**
- Preventing stress corrosion cracking**
- Preventing corrosion**
- Compatible with the plastics in use**

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Today, the lubricant's compatibility with plastic continues to gain in importance.

Of course, when plastics started to be used, they were chosen so as to be compatible with the lubricants in use.

However nowadays, it seems more and more important that future developments of lubricants should ensure or improve compatibility with the plastics already in use.

Requirements with Respect to the Installation

- Coefficient of friction

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While taking the installation into account, the coefficient of friction between the rope and the drive sheave is the first and most important requirement that the lubricant must fulfil under all circumstances in the case of a friction driven installation.

It is not only the function but also and particularly the safety of the facility and the passengers during operation depending on this.

Therefore it should also be always ensured, that only the lubricant suitable for each particular application is in use.

Requirements with Respect to the Installation

- Coefficient of friction**
- Compatible with the plastics in use**

Rope & Ropeway Consulting / in April 2006

Also with regard to the installation is the compatibility of the lubricant with the plastic materials in use is of great importance.

I mean in particular the compatibility of the sheaves or bull wheels lining with the basic lubricant or the re-lubricant.

Especially the compatibility with the re-lubricant that essentially consists of a base substance dissolved in solvent, it is important that not only the base substance fulfils the compatibility requirements with plastic, but also and particularly the solvent used.

Requirements with Respect to the Installation

- Coefficient of friction**
- Compatible with the plastics in use**
- Viscosity progress as a result of temperature and dampness**

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The progress of the viscosity as a result of temperature and dampness!

By this, is the effect meant, which takes place when certain climatic conditions such as a strong rise in temperature in connection with a simultaneous rise of the humidity.

This causes an abrupt decline in the viscosity of some lubricants with the result, on the one hand, that the installation is strongly soiled, and on the other hand that the clamp tongues stick to the sheaves and in extreme cases subsequently break.

Requirements in Respect to the Operation

- Viscosity

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With regard to operation, attention should be paid to the viscosity of the agent within the range of the temperature during operation. This is important to prevent the installation being soiled by the lubricant.

Requirements in Respect to the Operation

- Viscosity**
- UV - resistance**

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The lubricant's UV-resistance is of great importance in our area of application since the ropes are almost exclusively used outside and, in most cases, in higher regions where ultra-violet radiation is even more intensive.

Requirements in Respect to the Operation

- Viscosity**
- UV - resistance**
- Resistance to the techno - climate**

Rope & Ropeway Consulting / in April 2006

Resistance against polluted air environment is also gaining more and more in importance.

This is especially the case for installations operated near industrial areas.

Requirements in Respect to the Operation

- Viscosity**
- UV - resistance**
- Resistance to the techno - climate**
- Stability regarding time**

Rope & Ropeway Consulting / in April 2006

Stability of lubricant quality over long periods of time and changing temperatures should not be left out of consideration either.

Ropes used for aerial ropeways remain in service for a relatively long time. Ten years and longer are no rarity. For this reason the lubricants employed must not suffer from decomposition over these periods.

Requirements in Respect to the Operation

- Viscosity**
- UV - resistance**
- Resistance to the techno - climate**
- Stability regarding time**
- Stability regarding temperature**

Rope & Ropeway Consulting / in April 2006

Finally the continually occurring temperature changes within the permitted temperature range must not adversely affect the quality of the lubricant either.

Further Requirements

**What else is
very
important?**

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We have enumerated a number of demands that today's rope lubricant must fulfill. Of course, this list is not final and can be, depending on type of use and particular requirement, anytime supplemented.

Still, I would like to add a very important general requirement.

Further Requirements

Product consistency!

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The last but in no way unimportant demand is the constant product consistency!

The complexity of the demands and not least the fact that many of the demands are contradictory make their fulfilment very difficult.

For this reason, once a good result has been achieved, it should be treated as a valuable, but unfortunately unstable, equilibrium.

This means that, in all probability, any change carried out can destroy this equilibrium and therefore the quality of the result.

From this point of view it is to be recommended that any changes that become necessary for the most different legal, product technical or not least economic reasons should be carried out with corresponding care and, always after consulting the rope manufacturer as well as the operator of the installation.

Re-lubrication

Why should a ropeway rope be re-lubricated at all?

Rope & Ropeway Consulting / in April 2006

Now coming to the re-lubrication we can put a question very similar to the one we put at the beginning of the presentation:

“why a rope must be re-lubricated at all?”

Re-lubrication

**Both due to aging as well as
due to the enhanced stresses
especially within some
critical rope areas
it is impossible for the initial
lubricant to fulfil its task during
the entire rope service life!...**

Rope & Ropeway Consulting / in April 2006

However the answer here is not as simple as the one at the beginning:

.....

Re-lubrication

**...Due to this reason
as well as due to the raised
importance of the lubrication
among the wires and strands
is re-lubrication
essential!**

Rope & Ropeway Consulting / in April 2006

...the previous reason together with raised importance of the lubrication make the importance of the re-lubrication essential.

Re-lubrication

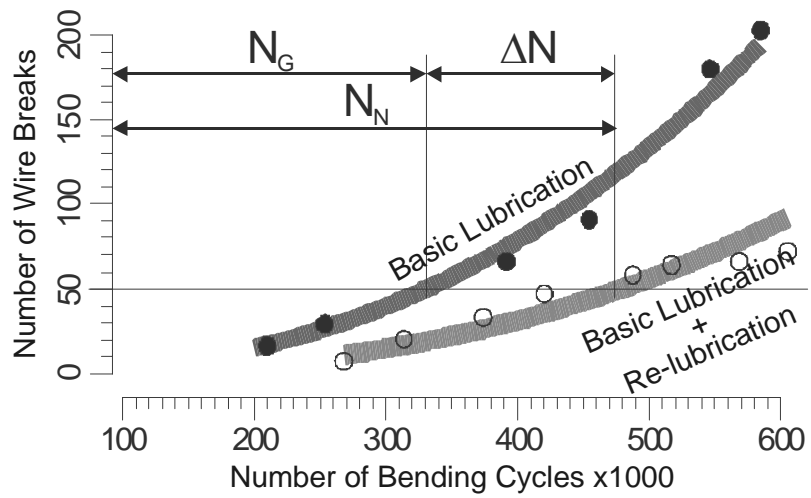
**Full size fatigue tests
as well as practical experience
proved that by means
of a proper re-lubrication process
a significant service life elongation
can be achieved!**

Rope & Ropeway Consulting / in April 2006

I know that many people in the audience very much doubt about the effect of re-lubrication.

Nevertheless full size tests.....

Re-lubrication



Rope & Ropeway Consulting / in April 2006

As we see in this example a service life elongation of about 60% can be achieved by means of **PROPER** re-lubrication

Re-lubrication

**How can we ensure that the
re-lubrication process
is proper?**

Rope & Ropeway Consulting / in April 2006

Now a new question arises: What do we mean when we say “Proper re-lubrication process”?

Re-lubrication

**The re-lubrication process
is proper when using
- the suitable re-lubricant and
- the correct re-lubrication method**

Rope & Ropeway Consulting / in April 2006

To a "Proper re-lubrication process" belongs
-the suitable relubricant as well as
-The correct re-lubrication method

Suitable Re-lubricant

The re-lubricant is suitable when

- it fulfils all previous mentioned requirements and**
- it is compatible to the initial lubricant**

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This means that the suitable re-lubricant should certainly fulfil all the requirements mentioned before and

It should also be compatible to the initial lubricant in use.

The lubrication of the core, the basic lubrication and re-lubrication should form a unit.

Many problems during ropeway operation could have been avoided if this simple demand had been met.

Correct Re-lubrication Method

**The relubricant can not
easily penetrate into
the inner layers of
a wire rope!...**

Rope & Ropeway Consulting / in April 2006

Coming to the re-lubrication method we first have to take into account that in order for the re-lubricant to fulfil the main requirement has to act as a third body between adjacent wires. Therefore the re-lubricant should be able to get there! However, as everybody knows, it is not at all easy for the re-lubricant to penetrate into the inner layers of a wire rope!

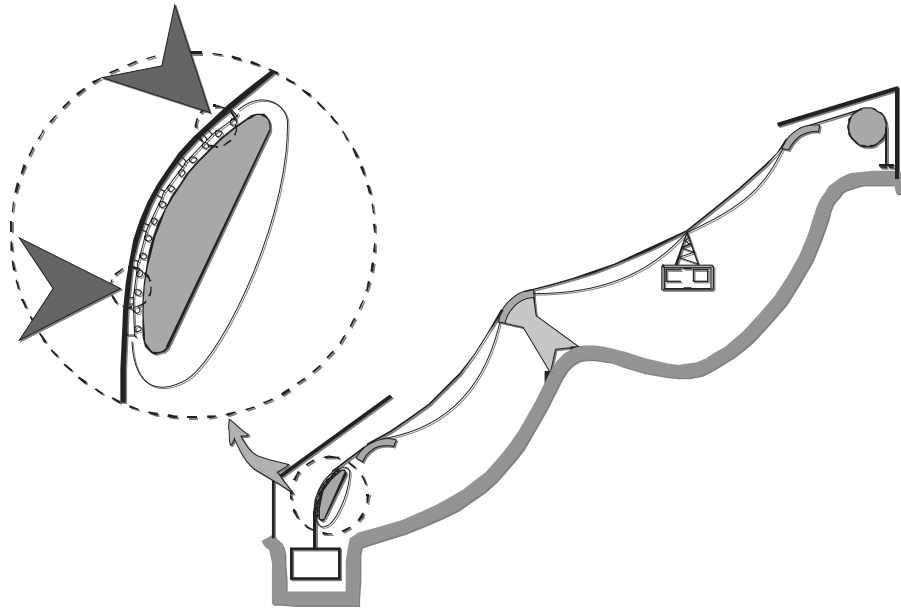
Correct Re-lubrication Method

**...This is only possible
if it is ensured that
the rope surface is
covered with a thin layer
of re-lubricant, when the
the rope is about to be
bent at a bull wheel!**

Rope & Ropeway Consulting / in April 2006

This can only occur if we can make sure that the **rope**
surface is covered
with a thin layer
of re-lubricant, when
the the rope is about
to be bent at a bull
wheel!

Correct Re-lubrication Method



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Like we see in this example of the re-lubrication process of a locked coil rope.

In this case is the penetration of the re-lubricant even more difficult due to the fact that this kind of rope has been specially made to prevent humidity penetrating to the inner layers by means of the z-shaped outer wires.

Correct Re-lubrication Method

Correct re-lubrication method ensures that the re-lubricant penetrates up to all the contact points and lines between the wires therefore preventing the occurrence of fretting!

Rope & Ropeway Consulting / in April 2006

But even in this case the change of the cross section and the shifting of the wires during bending act as a pump ensuring that the lubricant at the rope surface penetrates to the inner layers.

Correct Re-lubrication Method

**It has been proved that
even in the case of a locked coil
rope - if it is re-lubricated with
the correct method-
the relubricant penetrates
up to the king wire!**

Rope & Ropeway Consulting / in April 2006

It is important to underline here that the penetration goes up to the king wire!

Re-lubrication

Caution!

- Mind the unity of basic lubrication and re-lubrication**

Rope & Ropeway Consulting / in April 2006

Summarizing the important points regarding re-lubrication I would like to repeat the importance

Of the compatibility between re-lubricant and basic lubricant.

Re-lubrication

Caution!

- Mind the unity of basic lubrication and re-lubrication**
- Once relubrication has been started should not be stopped**

Rope & Ropeway Consulting / in April 2006

It is also important to know that once we started with the re-lubrication we should not stop.

Re-lubrication

Caution!

- Mind the unity of basic lubrication and re-lubrication**
- Once relubrication has been started should not be stopped**
- It is advisable to start relubricating from the very beginning**

Rope & Ropeway Consulting / in April 2006

As well as that it is advisable to start re-lubrication from the very beginning at least along areas which experience increased stresses and big number of load cycles.

Basic Lubrication & Re-lubrication of Steel Wire Ropes

**“It never hurts
to grease
the wheels...!! (??)”**

Rope & Ropeway Consulting / in April 2006

So I hope, you agree, that if we simply relay on this saying without taking into account all the mentioned requirements, we will most probably run into major problems....