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Managing and lubricating ropes with oil

Summary

How to get the most out of your ropes! This is a true challenge!

This paper discusses the methods and techniques developed for the purpose of protecting and maintaining these valuable assets through a structured wire rope maintenance programme, which includes the value attained through oil lubrication, the methods of application, rope cleaning with dry ice and compressed air, and the ultimate control and management of the programme. It touches on some results achieved in the past and present, for ropes lubricated with oil.

Industry is continually striving to improve rope life by developing better rope lubricants/dressings, improvements to winder rope mechanisms and rope construction designs.

1 The thin film lubrication philosophy

Thin film lubrication can only be achieved when using high quality lubricating oils that have been specifically formulated to possess outstanding water resistance; have an above average high film strength; and, can handle the crushing loads typical of those experienced in winder ropes.

These lubricating oils should ideally be manufactured from high quality base stocks and unique additives that can prevent fretting corrosion and which have the ability to penetrate to the core of the wire rope through capillary action.

Some of the benefits of thin film lubrication on wire ropes are:

- The ropes remain clean; being an oil, the lubricant is not sticky, but has however an affinity to metal, e.g. steel wire ropes, and therefore does not easily attract dust, abrasive backfill, etc.
- Water cannot be trapped between the lubricant and the steel wires of the rope as in the case of standard rope dressings thereby minimising, or even preventing corrosion.
- In the presence of excessive backfill and dust, it is imperative to employ continuous cleaning methods to ensure direct application of the oil onto the ropes as described later in this paper.
- Any water in the shaft is repelled from the ropes immediately. Due to the thin film of the oil, wash-off is practically eliminated.
- Broken wires can be spotted easily.
- Fretting corrosion, a major cause of broken wires, can be reduced substantially.
- Regular application ensures that drums and sheaves are protected from wear.

- The immediate environment in and around the winder room, headgear and within the shaft remains clean, improving safety substantially.

2 The wire rope lubricating oil

The first consideration is to determine the basic requirements for a successful wire rope lubricating oil. These are enumerated as follows:

a) It must be a penetrating oil that has the ability to work its way to the core of the rope through capillary action.

b) It must have the correct adhesive properties to prevent “fling-off” during winter or summer thereby keeping the environment totally clean.

c) It must be compatible to the primary lubricant with which a rope has been manufactured.

d) It must be pure oil that does not solidify and therefore allows the rope to breathe, i.e. the rope is not sealed on the outside by the lubricant, therefore ***allowing oil in*** and ***water out***.

e) It must have the ability to prevent internal and external corrosion by repelling and displacing water.

f) The oil must have the strength to withstand the crushing loads applied to it within and on the surface of the rope.

g) It must be of such a nature that the oil can be optimally applied through spraying, rolling or brushing with minimum wastage.

3 How much lubricating oil should be applied?

For a typical winder operating under normal dry conditions, experience values indicate that the standard quantity of oil applied per 1000 metres for a 45 mm diameter rope through 5,000 cycles is approximately 25 litres of oil. For optimal application, this quantity must be spread over 30 to 50 applications, i.e. at intervals of approximately 100 and 200 cycles. Environmental or shaft conditions however, will determine the actual optimum quantities to be applied for maximum protection of the rope.

4 Practical lubricant application methods

There are two basic methods of application, viz. manual or automatic.

The method to be employed depends on:

* The number of cycles the winder or hoist operates per day.
* The load it carries.
* The operating speed of the conveyance.

- The rope lengths.
- The shaft or environmental conditions.

As a guide line, **Manual Application** is mainly used on stationary ropes such as guide ropes, stay ropes and stage ropes, on Koepe tail ropes, various Cranes such as harbour cranes, overhead cranes, lift ropes, chair lifts, and generally on light duty winders (Figure 1) operating less than 100 cycles per day.

Automatic Application would be employed on medium to heavy duty winders operating in excess of 100 cycles per day.

Please Note: This is a guide only, actual application methods must be determined on site.

4.1 Manual application

The equipment that can be used for manual application is either an “electrical powered lubricator” (drum winders (Figure 1), Koepe winders, etc.) or a “pressure vessel lubricator” using Nitrogen for stationary ropes (guide ropes, stay ropes, etc.) utilising one or two manual spray heads. A roller applicator (Figure 2) can be used for multi-rope systems such as lifts and wharf cranes.

Figure 1: Manual lubricator spray head 26 mm decline rock winder rope.

Figure 2: Manual lubrication roller applicator for 19 mm multi-rope system.

4.2 Automatic application

The operating procedure of the automatic wire rope spray lubricator can be compared to that of “spray painting” (Figures A1 and A2).

Each rope is lubricated by an independent spray head (Figure 3). Through experience it has been established that the spray heads must be mounted just below the sheaves (Figure 4). In this position, they are subjected to the least amount of whip allowing the spray nozzles to be as close as practical to achieve optimum lubrication.

A fine spray of lubricating oil is applied at full operating winder speed (Figure 3) at pre-determined cycle intervals, allowing the oil to penetrate into the rope before the next coat is applied. This prevents unnecessary wastage through fling-off as is the case with conventional rope dressings.

Figure 3: Automatic lubrication close-up of spray head in service.

Figure 4: Automatic lubrication spray head and control sensors.

4.2.1 Operating functions of the auto lube system

a) A fixed amount of oil is applied to the full length of the ropes at pre-determined cycle intervals.

b) Oil is only applied at approximately 8 bar, while the winder is operating at normal full operating speed.

c) The system is monitored and controlled by an on-board Programmable Logic Controller (PLC).

d) Information from, and changes to the PLC can be either accessed by means of a control panel mounted on the electrical board or via a ***wireless link*** - if the winder is located in a wireless link reception area.

e) Should any part of the rope show excess wear or corrosion as detected by the Electro-Magnetic Testing (EMT) procedure, these parts can be lubricated more often, over and above the standard cycle intervals via the PLC.

f) The PLC can be programmed to lubricate the ***cross-over points*** more frequently, down to every cycle if necessary, to reduce wear in these areas.

g) Part of the system includes special nozzles to lubricate the ***sheaves*** at pre-determined intervals.

4.3 Lubrication of dead turns on the drums and front ends

To achieve full protection of the winder ropes, cognisance must be taken of those sections of the winder ropes that cannot be lubricated by the automatic spray heads, that is, the dead turns on the drums and the front ends. For complete lubrication, it is therefore of utmost importance that these sections of rope are lubricated manually.

4.3.1 Dead turns on winder drums

Prior to new ropes being installed, the drums must be thoroughly cleaned, either by conventional cleaning methods or with dry ice. An initial coat of an Extreme Pressure (EP) base product must then be applied to the drums and the first layer of rope.

Due to the rope's crushing load on the drum, using the correct base product assists in creating a cushion effect between the drums and the first rope layer. This reduces wear in these vulnerable areas and will protect the first cross-over point not lubricated by the spray heads.

Depending on the number of cycles of the winder, the dead turns on the winder drums must be lubricated manually at least once a month to maintain the lubricity of the base product (Figures 5 and 6).

Figures 5 and 6: Preventative wire rope maintenance programme - lubrication of dead turns.

5 Rope and drum cleaning

Rope and drum cleaning is an essential part of any winder rope maintenance programme for increasing rope, sheave and drum life. Where ropes have previously been coated with a dressing and are to be lubricated with oil, this dressing and any abrasive backfill must first be removed from the ropes and winder drums to allow optimum penetration of the oil into the ropes preventing the now softened rope dressing from flinging off the ropes. This can easily be achieved with a dry ice cleaning process.

5.1 The dry ice cleaning process

Dry ice cleaning of ropes is a unique application that involves blasting the rope with dry ice pellets from a highly specialised blasting machine through a specially designed 4-nozzle cleaning head for winder ropes (Figure 7) or a 2-nozzle cleaning head for smaller rope diameters, (less than 26 mm) such as single rope decline winders, wharf cranes and other conventional multi-rope systems.

The benefit of cleaning with dry ice is that it removes all the old dressing from the rope with no metallurgical or physical damage to the wire rope and leaves no secondary waste. It is particularly useful when changing over from a dressing to oil lubrication or as a regular bi-annual or annual maintenance function to allow new lubricant to be applied or accumulated backfill to be removed.

Dry ice cleaning is an essential part of any rope maintenance programme when ropes have to be doubled down, to remove old dressing, grit and grime and check on tightness of (or broken) bolts on LeBus grooves before coiling the ropes onto the drums.

5.2 The compressed air cleaning process

The compressed air cleaning process (Figure 8) is a unique method of keeping the ropes clean on a daily basis during normal winder operation by removing water, abrasive backfill or dust from the ropes. It prevents premature abrasion to ropes and sheaves, and allows free access of the oil into the ropes.

The compressed air cleaning process utilises standard mine air between 4 and 6 bar and only cleans in the upward direction, i.e. the hoisting cycle. Each rope utilizes a permanent fixture cleaning head operating at normal winder speed and is controlled by the winder lubrication PLC at pre-set cycle intervals. Depending on shaft conditions, cleaning intervals can be set from 1 to 100 or more cycles.

Figure 7: Dry ice cleaning removing backfill.

Figure 8: Compressed air cleaning removing water and backfill.

6 Preventative wire rope maintenance programme

In recent years it has become clear that, with the prevailing skills shortages, mining and industry require a structured programme preferably carried out by an external focused and specialised maintenance team in order to achieve above average capital investment returns through optimal rope and equipment life. Benefits include extended rope life, reduced wear to sheaves, optimal use of shaft hoisting time, protection of the environment and safety.

An efficient programme must include the following:

- A high class ***wire rope lubricating oil*** that has penetrating capabilities is able to carry the crushing loads suspended from the ropes, prevent corrosion and substantially minimise wear.
- An efficient and effective means of ***applying*** the wire rope lubricating oil regularly (either automatically (Figures 3 and 4) and/or manually).
- Effective ***rope cleaning*** methods (Figures 7 and 8) to remove water, dust, abrasive backfill and old dressing, to maximise penetration.
- It must be ***managed and controlled*** effectively on a preventative maintenance basis with regular feedback to mine management. The programme can be implemented at any stage of the rope's life, but it stands to reason that the sooner it is started the sooner the benefits will be achieved and the greater the savings through extended rope and equipment life.

7 Field results

Some of the following practical field results have been achieved in the past by lubricating steel wire ropes with oil.

7.1 Gold Fields – Libanon GM, No. 4 SV shaft Koepe winder tail ropes

The standard rope life for the previous 10 sets of tail ropes was on average 18½ months and these had to be replaced due to excessive corrosion. The ropes were lubricated for the first time with oil after being in service for 12 months, leaving 6½ months before they would normally be due for replacement.

Special spray applicators were manufactured that were used to lubricate the tail ropes with oil. This was done every month for the last 31 months and the ropes were eventually replaced after 43 months in service with an overall rope life improvement of 24.5 additional months.

Number of ropes	4
Diameter of ropes	48 mm (non-spin fibre core)
Length of ropes	1,800 m
Rope construction	[17 RHO/LHO/LH] 11×19(9/9/1) 6×19(9/9/1)
Average rope life	18.5 months (for the past ten sets)
Achieved life with lubrication	43.0 months
Ropes lubricated with oil	31 months
Rope life improvement	**24.5 months**
Rope life factor	**2.3 ×** original average rope life

7.2 Anglogold Ashanti - Savuka Gold Mine - Koepe winder head ropes

The oil lubrication method was on display in 1998 at one of the Electra Mining Exhibitions. At that time, due to the short rope lives experienced, the Savuka Mine Engineer was interested in applying the recommended wire rope lubricating oil to the Koepe winder head ropes.

The ropes were subsequently manually lubricated, one rope at a time one day apart, in the following sequence: - rope 1 - day 1, rope 2 – day 2, etc. (N.B. The automatic lubricating system for Koepe winder head ropes has been based on this principle).

The standard rope life for the previous 5 sets of Koepe head ropes was on average 8-months and these were replaced due to excessive corrosion. The ropes were lubricated for the first time with oil after being in service for 4 months, leaving 4 months before they would normally be due for replacement. The ropes were replaced after 12 months in service, with an overall rope life improvement of 4 additional months.

Number of ropes	4
Diameter of ropes	44 mm (non-spin)
Length of ropes	2,000 m
Rope construction	15 strand fishback 9×10(8/2)16×14(8/6) WMC non-spin
Average rope life	8.0 months (for the past 5 sets)
Achieved life with lubrication	12.0 months
Ropes lubricated with oil	4.0 months
Rope life improvement	**4.0 months**
Rope life factor	**1.5 ×** original average rope life

7.3 Lonmin Platinum - Karee No. 3 Shaft – double drum rock winder

The standard rope life for the previous 7 sets of 54 mm triangular strand ropes was on average 116,800 cycles. To date, Turboplast ropes have been lubricated with an ISO 200 cSt wire rope lubricating oil automatically. At time of writing, the rope life is at 220,000 cycles, a 1.88 times rope life improvement with no evidence of broken wires during routine magnetic non-destructive testing.

The rope lubrication is applied by an automated system supported by an external rope maintenance programme.

Number of ropes	2
Diameter of ropes	54 mm
Length of ropes	1,100 m
Average rope life	116,800 cycles [Triangular Strand Ropes] (for the past 7 sets)
Rope life to date	220,000 cycles [2 × 54 mm Turboplast]
Improvement to date	103,200 cycles
Rope life factor (to date)	**1.88 ×** original average rope life

8 Conclusions

This paper has highlighted how effective oil lubrication of steel wire ropes under controlled conditions increases rope life with substantial cost savings to the user. It has discussed the methods and techniques for protecting and maintaining these valuable assets through a structured wire rope maintenance programme.

Over and above the mechanical improvements of rope systems, improved construction of rope types, oil lubrication is valuable in safeguarding, maintaining and guaranteeing an increased service life of these substantial investments.

Besides the savings achieved through longer rope life, there are the added benefits of the many hidden costs such as reduced production losses, no time lost through applying rope dressings manually, less frequent rope changes and valuable environmental and safety benefits.

9 Reference

1 Alberto, C. *Coefficient of friction testing of a 9×10(8/2)16×14(8/6) WMC non-spin rope with Elaskon spray oil lubricant,* CSIR Knowledge Services, 26th February 2007.

Appendix - Recommended lubricant specifications

A1 Drum winder ropes (Figure A1)

Temperature characteristics

As Applied: Flash Point	> 62 °C	DIN ISO 22719
In Service: Flash Point	>100 °C	DIN ISO 22719
Pour Point	< -25 °C	DIN ISO 3016

Hardness and consistency characteristics

As Applied:

Viscosity at 40 °C	55 mm²/s	DIN 53015
Density at 15 °C	0.88 g/cm²	DIN 51757

In Service:

Viscosity at 40 °C	200 mm²/s	DIN 53015
Density at 15 °C	0.90 g/cm²	DIN 51757
Temperature Range	-40 °C to 90 °C	
Timken OK Load	65 lbs. passed	ASTM D 2782

A2 Koepe winder head ropes (Figure A2)

Temperature characteristics

Flash Point	>100 °C	DIN ISO 22719
Pour Point	< -25 °C	DIN ISO 3016

Hardness and consistency characteristics

Viscosity at 40 °C	26 mm²/s	DIN 53015
Density at 15 °C	0.89 g/cm²	DIN 51757
Temperature Range	-40 °C to 90 °C	
Timken OK Load	65 lbs. passed	ASTM D 2782
Coefficient of friction (25 °C)	0.072	ASTM 4172
(20 kg load, 1800 rpm, 60 min)		
Coefficient of friction (±25 °C) (dry) [**1**]	0.27	CSIR South Africa
Coefficient of friction (±25 °C) (wet) [**1**]	0.20	CSIR South Africa
(2MPa Tread pressure)		

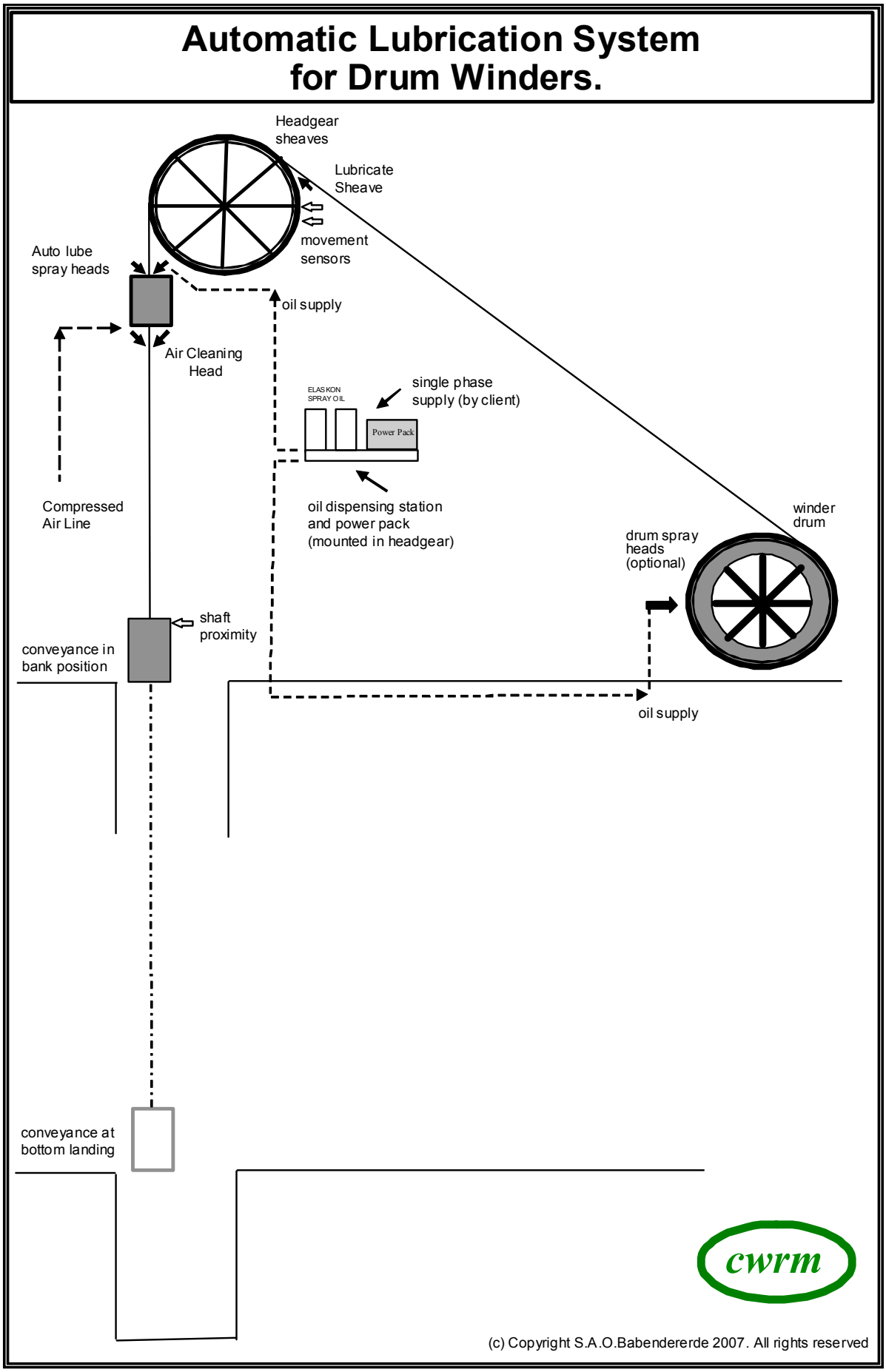
Automatic Lubrication System
for Drum Winders.
Headgear
sheaves
Lubricate
Sheave
movement
sensors
Auto lube
spray heads
oil supply
Air Cleaning
Head
ELASKON
SPRAY OIL
Power Pack
single phase
supply (by client)
Compressed
Air Line
oil dispensing station
and power pack
(mounted in headgear)
winder
drum
drum spray
heads
(optional)
shaft
proximity
conveyance in
bank position
oil supply
conveyance at
bottom landing
cwrm
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Figure A1

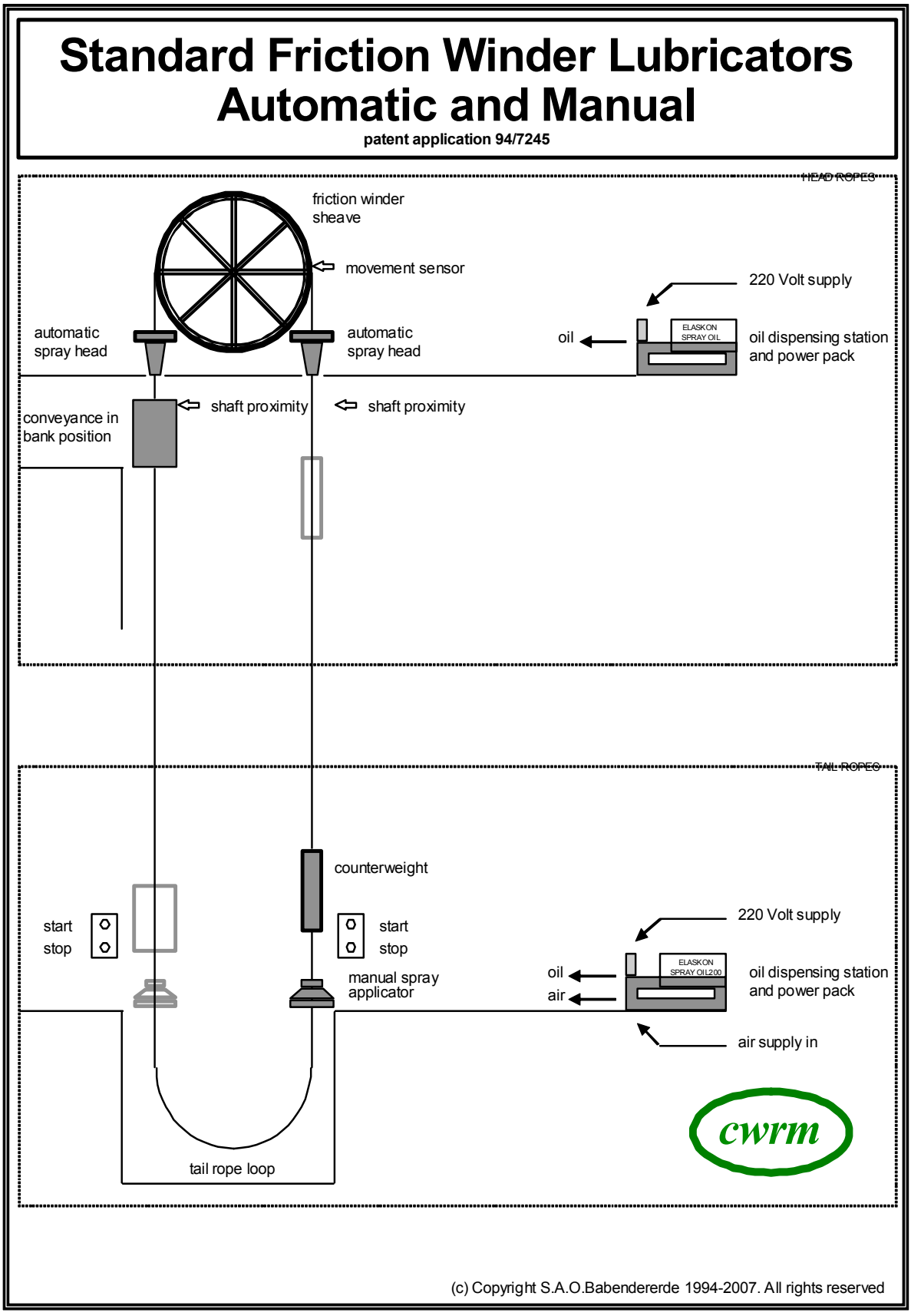
Standard Friction Winder Lubricators
Automatic and Manual
patent application 94/7245
HEAD ROPES
friction winder sheave
movement sensor
220 Volt supply
automatic spray head
automatic spray head
oil
ELASKON SPRAY OIL
oil dispensing station and power pack
conveyance in bank position
shaft proximity
shaft proximity
TAIL ROPES
counterweight
start
stop
start
stop
220 Volt supply
manual spray applicator
oil
air
ELASKON SPRAY OIL200
oil dispensing station and power pack
air supply in
cwrm
tail rope loop
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Figure A2