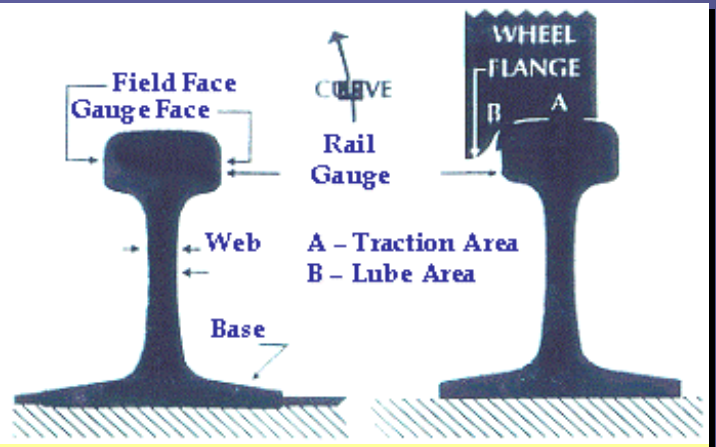
High-performance, Biodegradable Synthetic Ester Lubricants for Railway Systems

THE PROBLEM

- Wear of wheel flanges
- Wear of gauge rail face
- Significant maintenance costs attributed to re-profiling
- Loss of availability of the train due to outages for re-profiling wheels
- Screeching on curves due to lack of, or poor lubrication
- Greater track resistance due to un-lubricated contact with the wheel flange radius

Wheel/Rail contact for :-

- Traction forces
- Braking forces
- Electrical signals which are transferred during this contact



Lateral forces caused by :-

- Centrifugal effects when negotiating curves
- Dynamic interaction between vehicle and track
- Vibrations/Shock loads due to gauge variations which lead to heavy contact in zone B.

Zone B needs effective lubrication to reduce friction and wear.

Absolutely no lubricant requirement in Traction Area A

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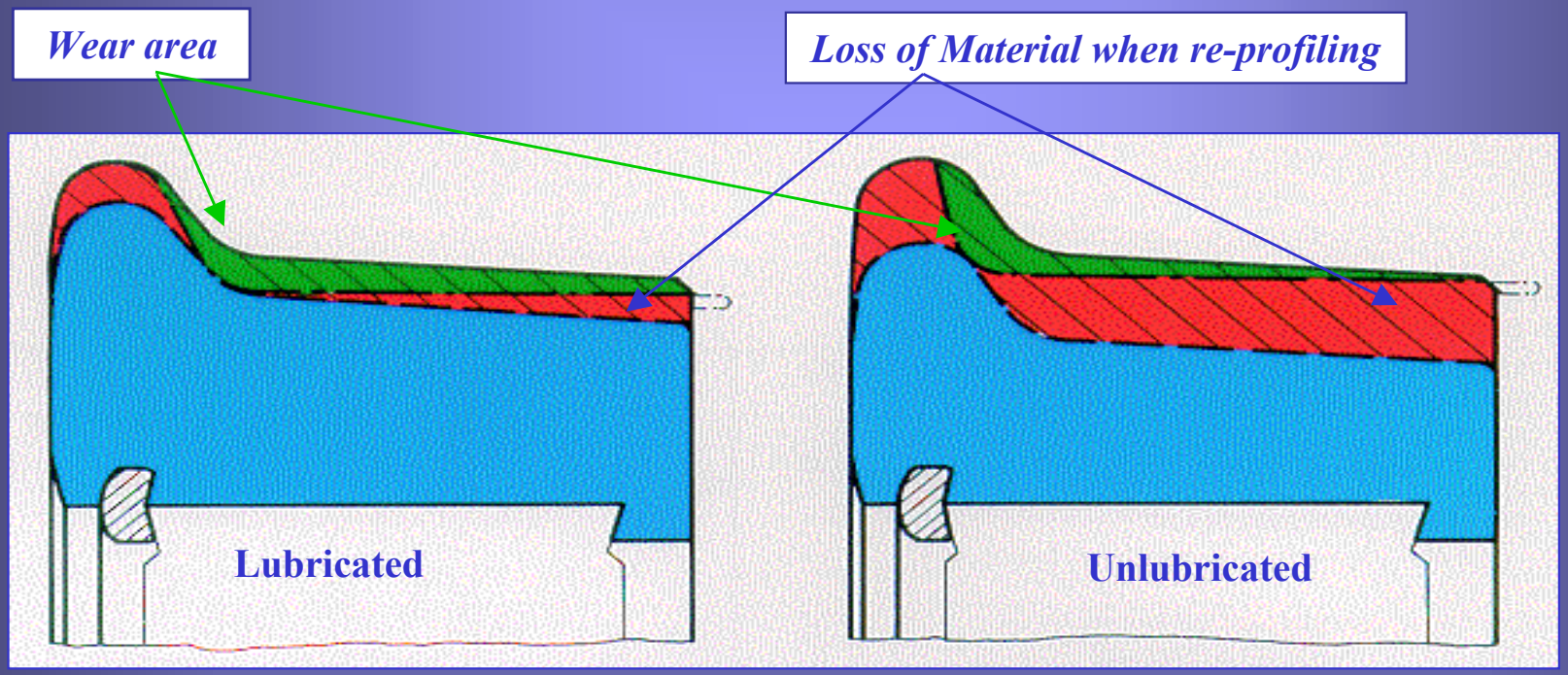
Influence of Lubrication on Wheel Flange Wear



Wheel Flange Lubrication Requirements

Primary Requirements:-

- Reduction of friction between wheel and rail flange to reduce the risk of derailment and to minimise rolling noises generated in the contact zones.
- Reduction of wear of wheel and rail to minimise maintenance work and life cycle costs, and to increase the availability of the rolling stock.

Secondary Requirements :-

- Excellent adhesive properties are required and become more important with the introduction of high speed trains.
- Lubricity and sprayability should be independent of temperature change which is not the case with bituminous products.
- Good resistance against ageing.

What lubricant should be selected ?

The traditional choice was usually based on bitumen, but this can be a health hazard

Bitumen
Solvents

ALL CAN BE CARCINOGENIC !

Heavy Metals

Bitumen Based Greases

The apparent viscosity of the grease is totally dependent on temperature and temperature change This behaviour seriously affects the film thickness and subsequent strength; therefore, large volumes of lubricant will be required with poor results.

- @ *50 to 80°C it drips off*
- @ *15°C the material hardens*
- @ *5 to 8°C depending on quality, it solidifies*

The Ecological Aspect

Estimated Oil Resource:
135 billion tonnes

Lubricants in the Environment in Tonnes Per Annum

- **Western Europe circa 2,700, 000**
- **World circa 37,000,000:**
- **Of which Base Oils are 95%**
- **And Chemical Additives 5%**

BIODEGRADABLE SYNTHETIC ESTERS?

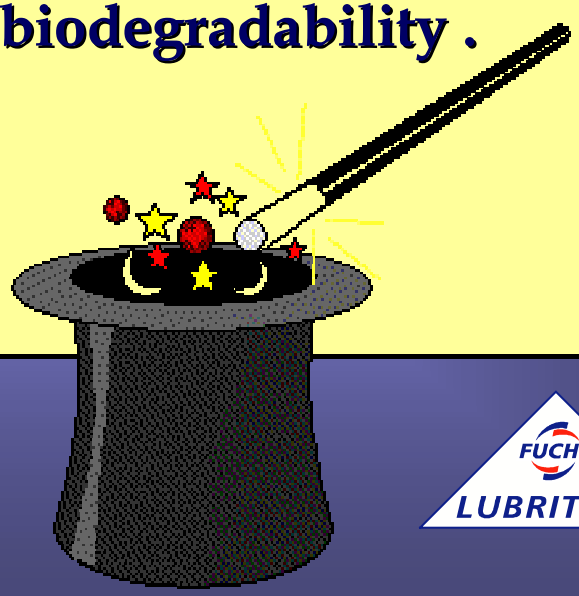
The Solution "High Performance" Biodegradable Synthetic Lubricants

Basic formulation of the lubricant :-

For these applications soft free-flowing greases should be used, which may contain special solid lubricants.
Even though the base oil is by far the biggest portion of the lubricant, it is important that all single components of the additive and thickening system are checked regarding their environmental potential if they are to meet the appropriate standard for biodegradability .

Base oil selection:-

- **Synthetic Esters**
- **Low-viscous Polyglycols**
- **Low-viscous Synthetic Hydrocarbons**

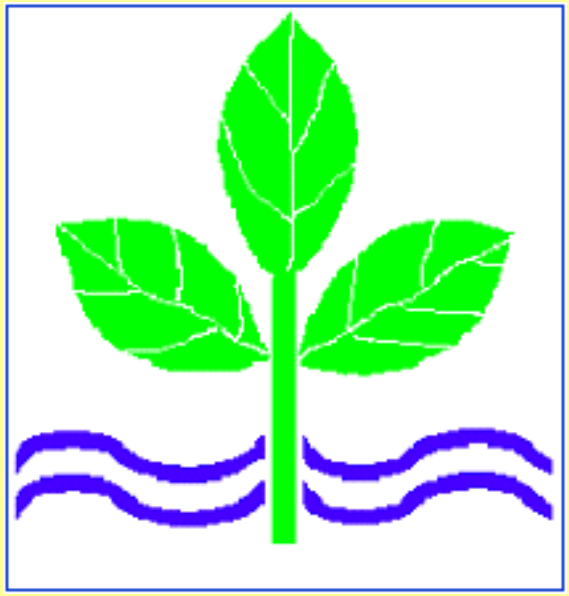


Esters - what are they ?

Very high performance, very long life lubricants developed from a natural resource and alcohols

Objectives For A Wheel Flange Lubricant

- Environmentally harmless
- No toxic components
- Low water pollution
- Solvent-free
- High performance
- Long Life
- High biodegradability



Biodegradability test methods are not homogeneously regulated, CEC L-33-A-93 is the standard most commonly used.

The solution is a kind of jigsaw puzzle

Besides biodegradability, the following properties have to be considered when selecting the base oils:-

- *Lubricity*
- *Flow behaviour at low temperatures*
- *Thermal resistance*
- *Solubility*
- *Miscibility of additives*
- *Compatibility with materials to which applied*

The following thickening systems can be used in biodegradable lubricants:-

- *Lithium soap*
- *Calcium soap*
- *A blend of Li-/Ca- soap*
- *Inorganic thickeners, e.g. Bentonite*

Additives and Solid Lubricants:-

EP additives play an important role because wheel flange lubrication is working under boundary or extreme mixed friction conditions.

Selection of additives must take into consideration and fulfil all the tribological demands as well as the important environmental aspects.

Long-term experience in this area has shown that solid lubricants can be extremely helpful in these applications. Solid lubricants such as special graphite types, and a combination of white solids and graphite are frequently used.

Solution:- Locolube ECO

Colour	Dark Grey	
Temperature Range	-30°c to +80°c	DIN 51 825
Base Oil Viscosity @ 40°c	35 mm^2/s	DIN 51 562-1
Pour Point of Base Oil	< - 40°c	DIN ISO 3016
Stirring Properties @ - 30°c	Good Quality Rate	DB-TL 950.103
Un-worked Penetration (-30°c,24h)	240 1/10mm	DIN ISO 2137
NLGI Grade	000	DIN 51 818
Water Resistance	1-60 Value Step	DIN 51 807
Oil Separation (40°c, 18 H)	< 2%	DB Specification
4-ball Test, Weld Load	2,600/2,800 N	DIN 51 350-4
Tannert Coefficient of Friction	0.12	Fuchs Lab. Proc.
Biodegradability	90% after 21 Days	CEC L-33 A 94

Comparison Between Conventional & Locolube ECO

Data	Standard Lube	Locolube ECO
Base Oil	Mineral Oil	Saturated Synthetic Ester
Base Oil Viscosity @ 40°c	21.3 mm^2/s	35 mm^2/s
Additives	AC,AW,EP	AC,AW,AO,EP
Solids	Graphite	Graphite & White Solids
Temperature Range	-25 to + 60°c	-30 to + 80°c
Thickener	Calcium Soap	Bentonite
NLGI Grade	NLGI 1	NLGI 000
4 Ball Test Weld Load	1,500 N	2,600/2,800 N
Amount Applied Per Cycle	30 mg	30 mg
Cycles Per 500 Metre (546 Yards)	4	1

AC = Anti-corrosion, AW = Anti-wear,
AO = Anti-oxydant, EP = Extreme Pressure

To enable us to hit the target we have utilized the following tests and testing procedures

Friction value

- Tannert
- Timken
- Almen-Wieland

Adhesion power

- Tannert
- Timken-Retention
- Fling-off test

Environment

- CEC L-33-A93
- OECD 301 A-E
- RAL-UZ 64

Wear

- FBT welding load
- FBT wear
- Timken

Corrosion protection

- Erichsen
- Water resistance
- Emcor

Summary of Biodegradable Lubricants for Wheel Flanges

- *Biodegradable lubricants have surpassed, technically and environmentally, mineral oils and greases.*
- *Biodegradable lubricants, due to their performance, have completely replaced mineral oils and greases in many applications due to :-*

- *A reduction in driving power of up to 15%*
- *A reduction of wear, noise and friction*
- *An increase in the maintenance intervals*
- *A reduction of maintenance activity*
- *A reduction of lubricant consumption*
- *A reduction of the risk of derailment*

Lubrication Is a Two-fold Problem

- Choice of lubricant
- Means of application

A wrong choice will lead inevitably to under-performance and higher costs

Application

Wheel Flange Lubrication vs Track Lubrication

Wheel Flange Lubrication

- Continuous lubrication of the whole network with very small amounts of lubricant (0.03g/per cycle).
- 100% of lubricant is used for lubrication - no contamination of the track area.
- Self-regulating lubrication management by curve, distance or time, depending on the control unit employed, which is independent of the driver or maintenance team.

Track Side Lubrication

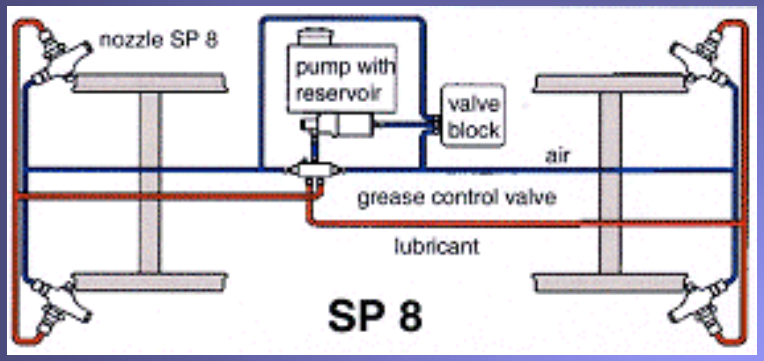
- Re-filling intervals difficult to determine.
- High concentration of lubricant in the curve sections causes vehicle and environmental pollution.
- Correct lubrication of the whole network is not possible.

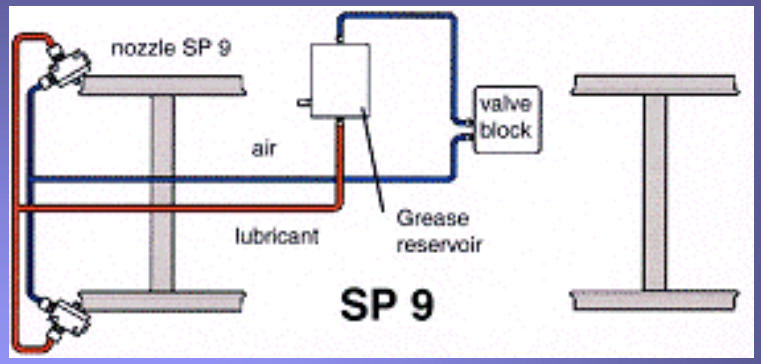
For decades Willy Vogel AG have been producing and supplying different types of wheel-flange lubrication systems for installation on rail vehicles. Vogel wheel-flange systems are renowned for the high degree of metering accuracy, regardless of fluctuations in air pressure and temperature, and this is one of the main advantages of, and reason for, their worldwide acceptance.

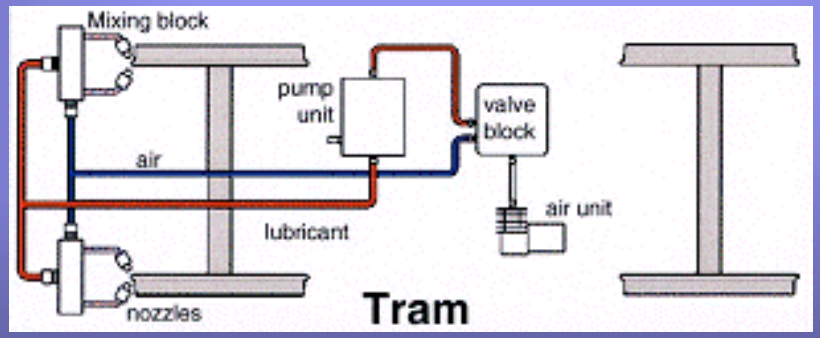
Due to the large number of possible combinations and a perfected control technology, it is possible to choose the exact wheel-flange lubrication system for a variety of operating conditions.

Wheel-flange lubrication, which includes the correct choice of lubricant, is a major factor when it comes to increasing the service life of wheel sets and tracks and cutting life cycle costs.
Wheel sets can often cover 8-900,000 km before they have to be re-profiled, so the installation of wheel-flange lubrication systems quite often pays off within a year of installation, without taking into account the savings resulting from longer rail life, particularly in the curved areas.

Vogel Systems Overview

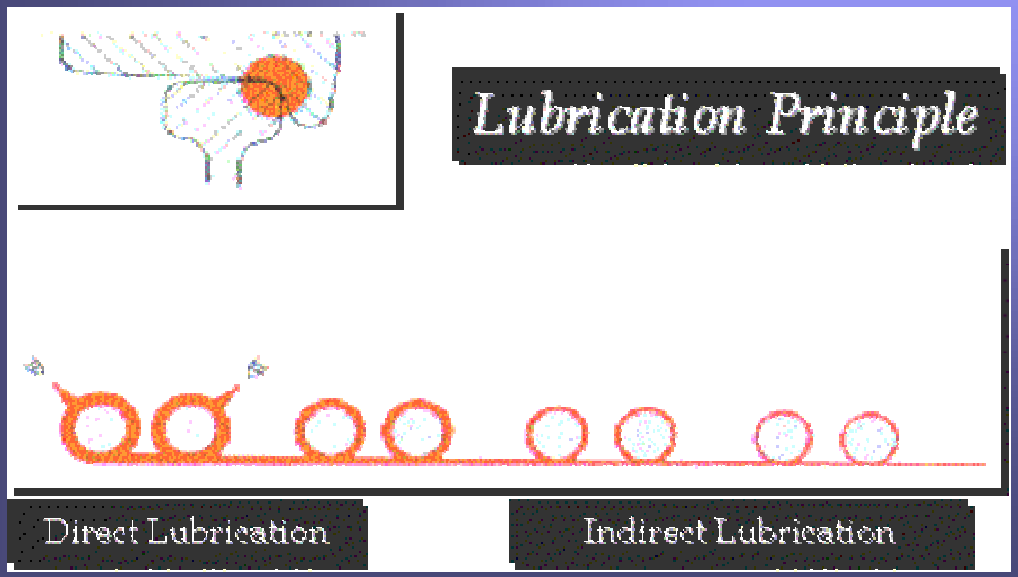






Application of Wheel Flange Lubricant Utilizing Automatic Lubricators

- Automatic lubricators spray extremely small quantities of lubricant onto the wheel flanges
- The control of the system is divided into:-
  Path Controlled
  Time Controlled and
  Curved Controlled Systems



- Nozzle directs lubricant to the radius of the wheel (not the track!)
- The wheel transfers lubricant to the track
- The track then transfers lubricant to the following wheels

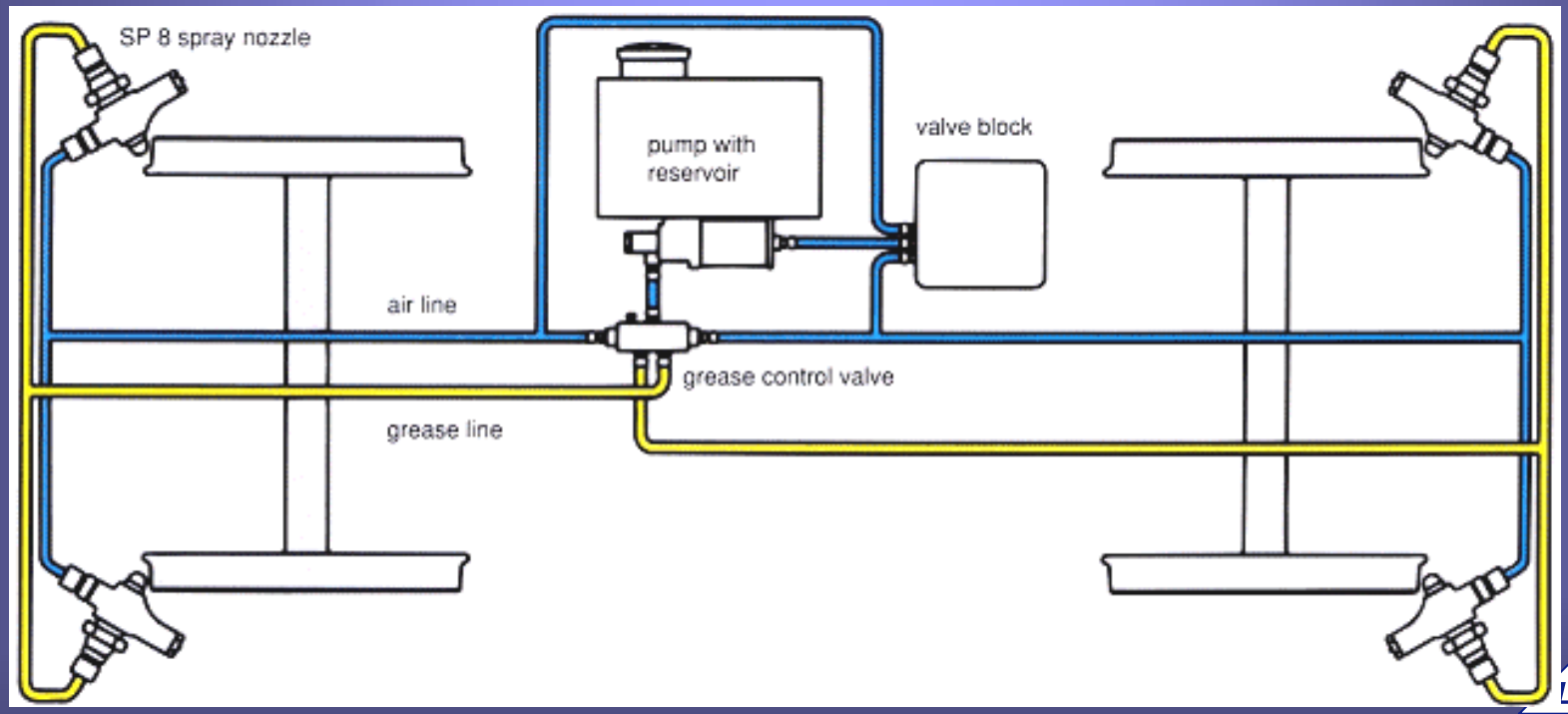
Vogel WFL Systems SP 8

Systems SP 8 – System with Pump

- Expansive system for universal use
- Pneumatic pump for long line lengths
- Sturdy reliable design
- Requires little maintenance

Technical Data

Distribution	up to 20m main line (pump/nozzle)
Operating pressure	100 bars
Reservoir size	customer
Temperature range	-25 to 80° C
Lubricant	fluid grease NLGI grade 000 or 00
Metering	0.15; 0.05; 0.03 ccm/spray
Application frequency max	2min



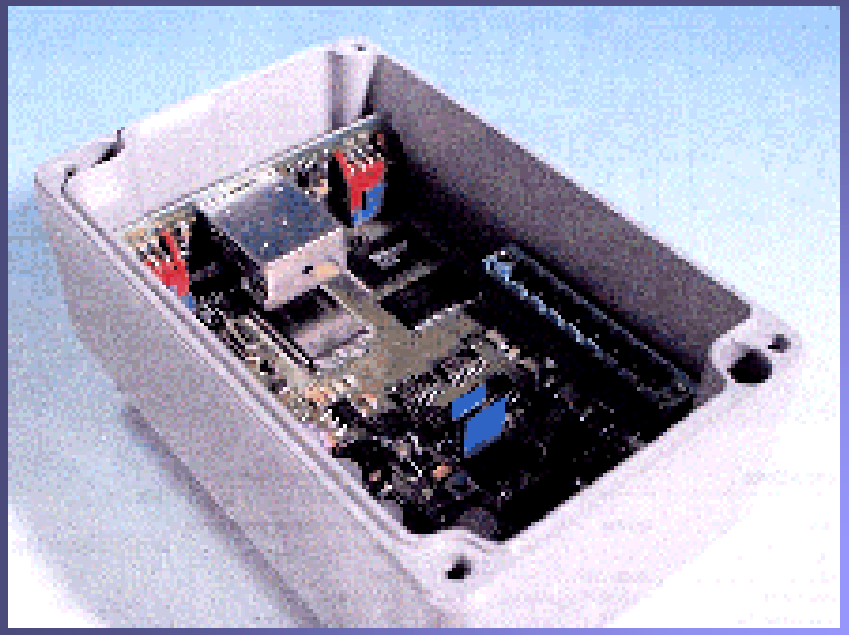
Tangent track lubrication

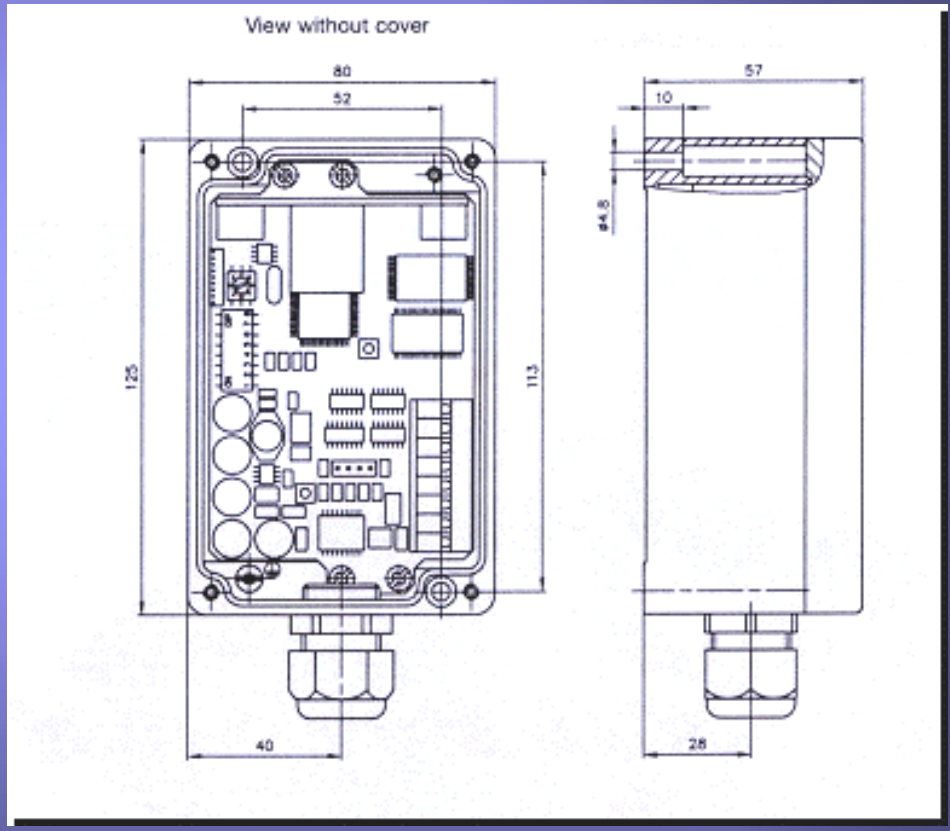
•Optimal supply throughout entire rail road network
•Adjustable for 100, 200 and 300 meter lubrication interval

Curve sensitive lubrication

•Lubricates only in critical areas of curves
•Self contained system – no locomotive interface required
•Electronic curve sensor – no moving part
•Minimal lubricant consumption

CS200 Curve Sensor Control Unit



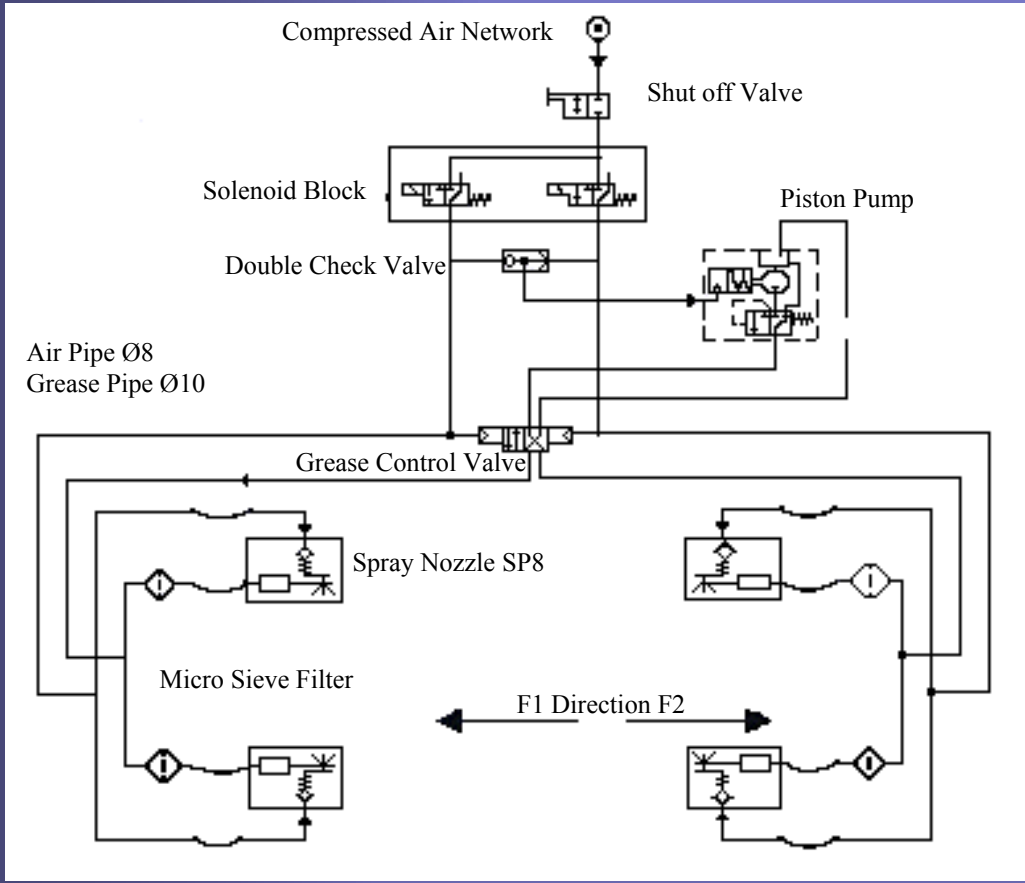


- **Modes of Operation**
  Curve lubrication
  Time controlled lubrication
  Distance controlled lubrication
  Curve / time controlled lubrication
  Randomly controlled lubrication after power up
  Curve sensor for external control unit
- **Powerful valve outputs**
- **Adjustable sensitivity**
  depending on practical needs

Practical examples

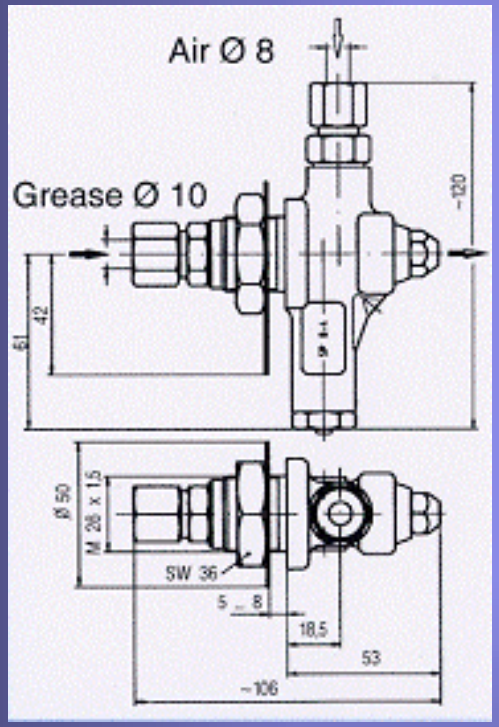
Stand-alone wheel flange control unit
Curve sensor to supplement wheel flange control units
Curve sensor for lubrication control by railway SPC

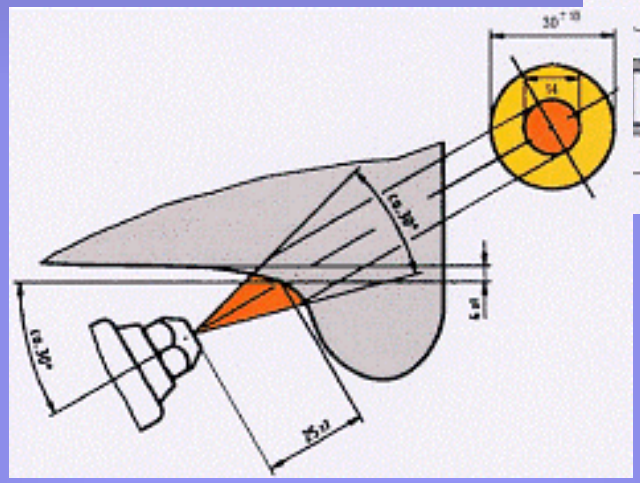
VOGEL – Wheel Flange Lubrication Systems SP 8

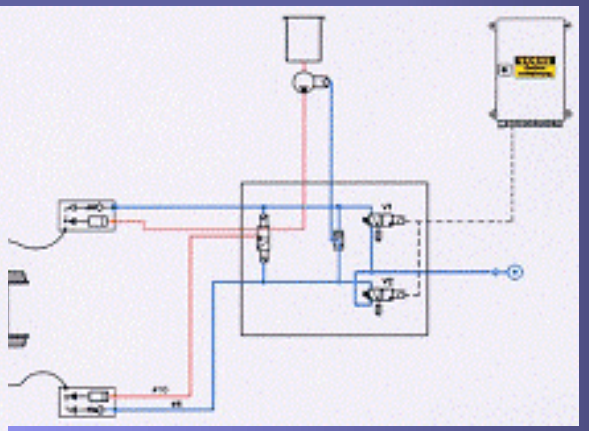


- High Pressure system (max120 bar) for long pipes between pump and nozzle
- Pneum. Grease pump (5/25kg ratio 1:13
- Grease control valve for forward and reverse or left and right hand lubrication
- Lubrication module (pump, SF10 solenoids)
- Distance /time depending lubrication with IG 666(24, 110VDC
- For oils and semisolid greases NLGI 000…1

Spray Nozzle SP 8-4/S3: Dimensions and Adjustments







Grease output -	30mm ^{3}/shot
Air Pressure -	6-10 bars
Air Consumption per spray cycle (1.5 sec.) -	1.5L
Grease Pressure max -	120 bars
Lubricant -	fluid grease NLGI-KI. 000 or 00
Shot frequency -	max 0.7Hz

There Are Basically Two Types of Systems

- Lubricant is dispensed into a single feed line with the air, the lubricant is atomized and carried to the spray nozzle then out to the wheel flange

Problem

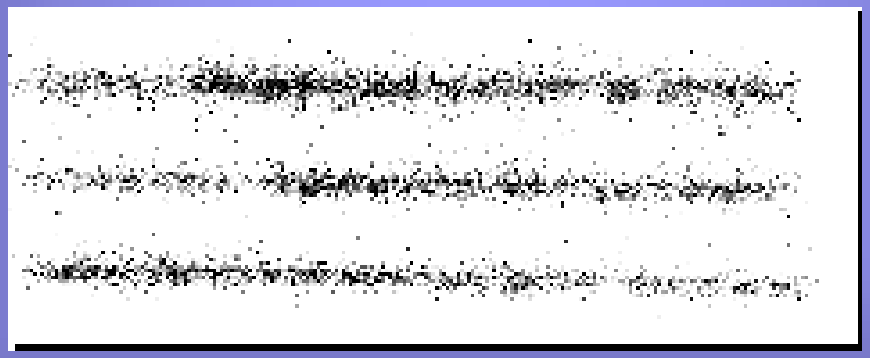
- Changes in temperature will affect the apparent viscosity of the grease which will change the amount of lubricant dispensed. A further complication is with long and difficult routed tube runs the amount of lubricant dispensed is compromised.

The Vogel Way is:-

- A positively dispensed shot of grease with an independent air supply mixing the lubricant at the spray nozzle, ensuring precise lubrication at all times unaffected by temperature change or installation routing

Wheel flange lubrication, calculation example:

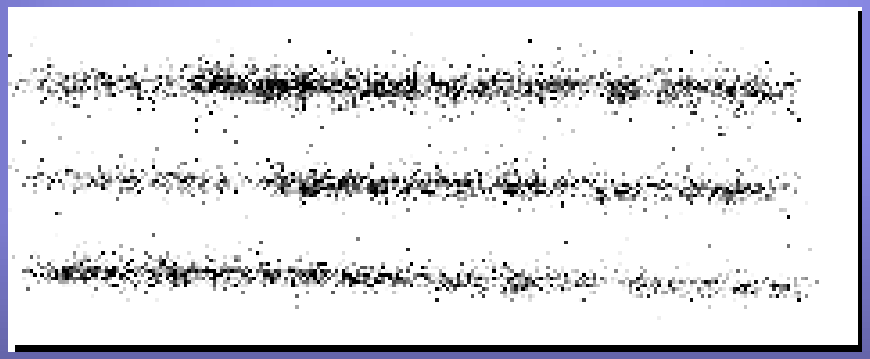
Width of the spray jet on the wheel flange:	20 mm
Wheel diameter:	900 mm
Lubricant quantity per spray cycle:	30 mg
Thickness of lube film on the first wheel set:	ca. 0.5 µm



Spray Pattern from Test Rig Trial

Wheel flange lubrication, calculation example

Lubricant quantity per cycle:	30 mg
Travelling distance per cycle:	500 m
Total distance:	1000 km
Lubricant consumption at each side:	60 g



Spray Pattern from Test Rig Trial

Conrails Eyeball Chart

Visual Determination of the Coefficient of Friction

OBSERVED CONDITION	APPROXIMATE μ
Chewed up rough gauge face.	> 0.45
Smooth gauge face with a shiny un-lubricated surface.	0.35 to 0.45
Smooth gauge face with lubricant covering 10 to 40% of the surface.	0.30 to 0.35
Smooth gauge face with lubricant covering 40 to 60 % of the surface metal still visible through the lubricating film	0.25 to 0.30
Smooth gauge face with lubricant covering 60 to 90 % of the surface	0.20 to 0.25
Gauge face 100% covered with a thin film of lubricant, polished surface of the rail may be seen through the lubricant	0.15 to 0.20
Gauge face 100% covered by a black lubricating film of graphite	< 0.15

Field Test Results

Locolube Biodegradable, High-Performance Lubricant

Conventional Lubricant

80% reduction in wear over mineral oil

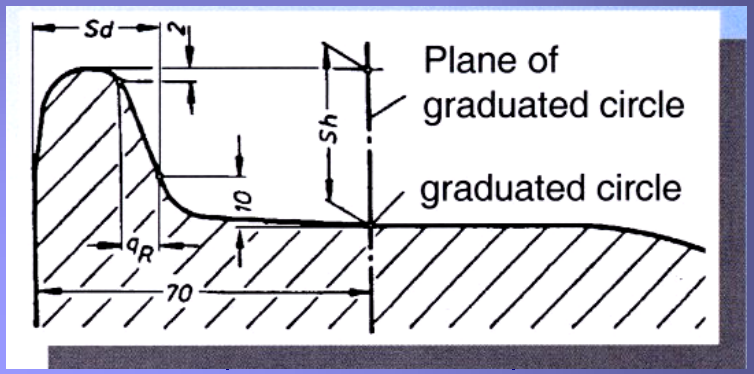
sd: -0.22 / -1.11

sh: -1.82 / -1.32

qr: 0.25 / 0.91

a: 2.20 / 1.71

73% reduction in wear over mineral oil



Used E-Lok :-BR 111,D
Total test distance: 1.9 million kilometers

-3 -2 -1 0 1 2 3

Please note: wheel flange height and tyre thickness cannot be influenced by the lubricant

Wear in mm / 100,000 kilometers (62,140 miles)

Source: Deutsche Bahn AG, Nov. '94

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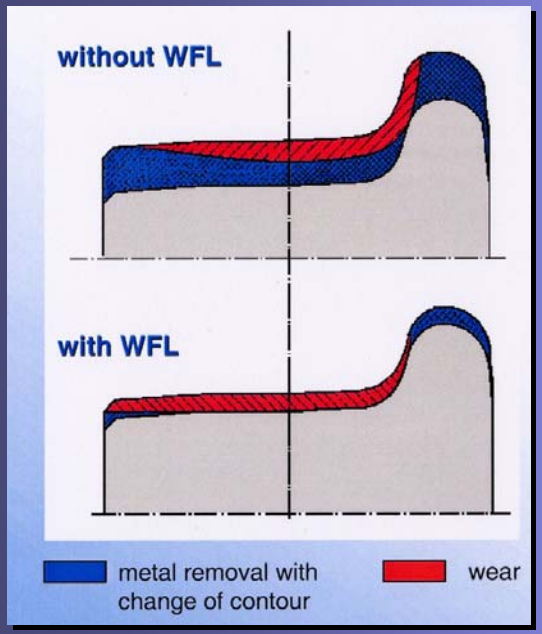
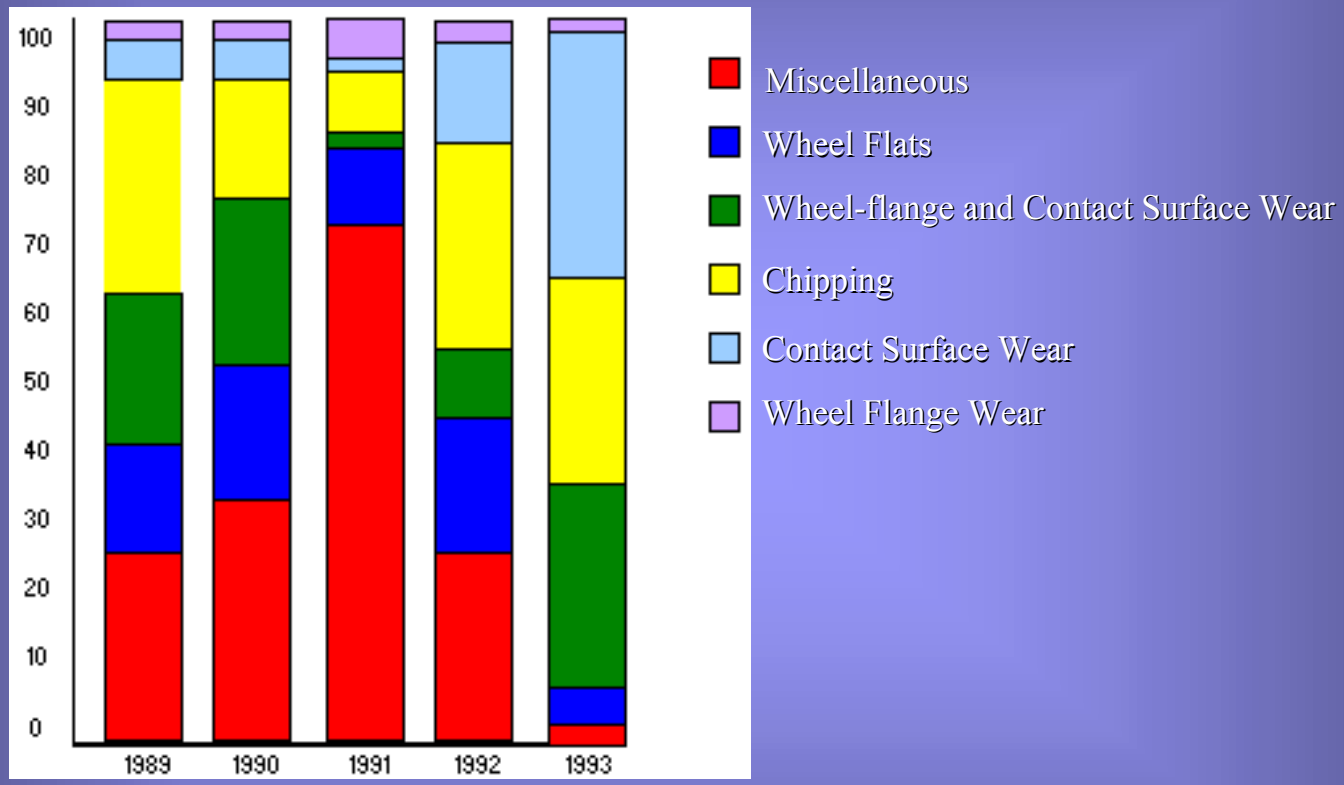
Reduction of wheel flange wear



Published Results	Operator	Without W F L	With W F L
Re-profiling period	D.B. AG	480,000 km	960,000 km
Wheel Flange repair	D.B. AG		50% Reduction
	OBB		50% Reduction
	Conrail		70% Reduction
Re-profiling costs	D.B. AG		50% Reduction
	OBB		60% Reduction
	Conrail		20% Reduction

Benefits of a Locolube VOGEL® System

Cause – Related Treatment of Wheel Sets



Benefits of a Locolube VOGEL® System

	Conrail	CSX	AAR
Fuel/Energy savings	25… 35%	8…10%	35%
Maintence cost cuts for wheel sets	DB AG 50%	BN 80%	ÖBB 30%
Lubricant savings ref: to wayside lubricator	20%	50%	50%
Labour costs cuts ref: To wayside lubricator	30…40%	-	50%

Key Factors

- *Quality of bogies and tracks*
- *Reliable lubrication systens*
- *Vehicles with WFL*

Potential Annual Savings From Rail Lubrication ($ Millions)

Potential Annual Savings From Rail Lubrication ($ Millions)

	All Main Track	Curves only
Energy	300-400	90-150
Rail	245	245
Wheels	-70	-15
Net savings	530-670	370-430

Benefits of a Locolube VOGEL® System

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VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Fiat Ferroviaria
Number of Vehicles – 35
Number of SP8 Systems – 70

High Speed Train ETR 500 For FS

References

VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Breda
Number of Vehicles – 145
Number of SP8 Systems – 145

E-Loco E633 For FS

References

VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Siemens SGP
Number of Vehicles – 50
Number of SP8 Systems – 50

Shunting Loco Type 1063 For ÖBB

References

VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Breda
Number of Vehicles – 410
Number of SP8 Systems – 410

E-Loco E656 For FS

References

VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Ansaldo
Number of Vehicles – 230
Number of SP8 Systems – 230

E-Loco E402 for FS

References

VOGEL – Wheel Flange Lubrication Systems SP 8

Manufacturer – Adtranz
Number of Vehicles – 120
Number of SP8 Systems – 120

Diesel Loco DG1200 for Private Railways

References

Future Requirements

- *Further development of existing products and systems*
- *Search for higher performance raw materials*
- *Take account of new trends in environmental legislation*
- *Be aware of development of new materials for wheels and rails*
- *Be aware of new designs covering carriages and bogies*
- *Be aware of future requirements for higher wheel loads*

Benefits of a Locolube VOGEL® System

- *Track resistance drops by some 30 to 35%, and motive-power reserves are increased. Traction and braking performance are not affected.*
- *Fuel savings up to 15% create fast R.O.I. in less than six months, improvement in shareholder value.*
- *Wear reduction by 30 to 80%. Time between wheel truing and rail life is extended.*
- *Greater safety due to the decreased possibility of derailment, it is harder for the wheel flange to climb the track.*