Basics of Gage Face (GF) Lubrication & Top-of-Rail Friction Control (TORFC)

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"If I have seen farther than Descartes, it is because I have stood on the shoulders of Giants" - Isaac Newton

Outline

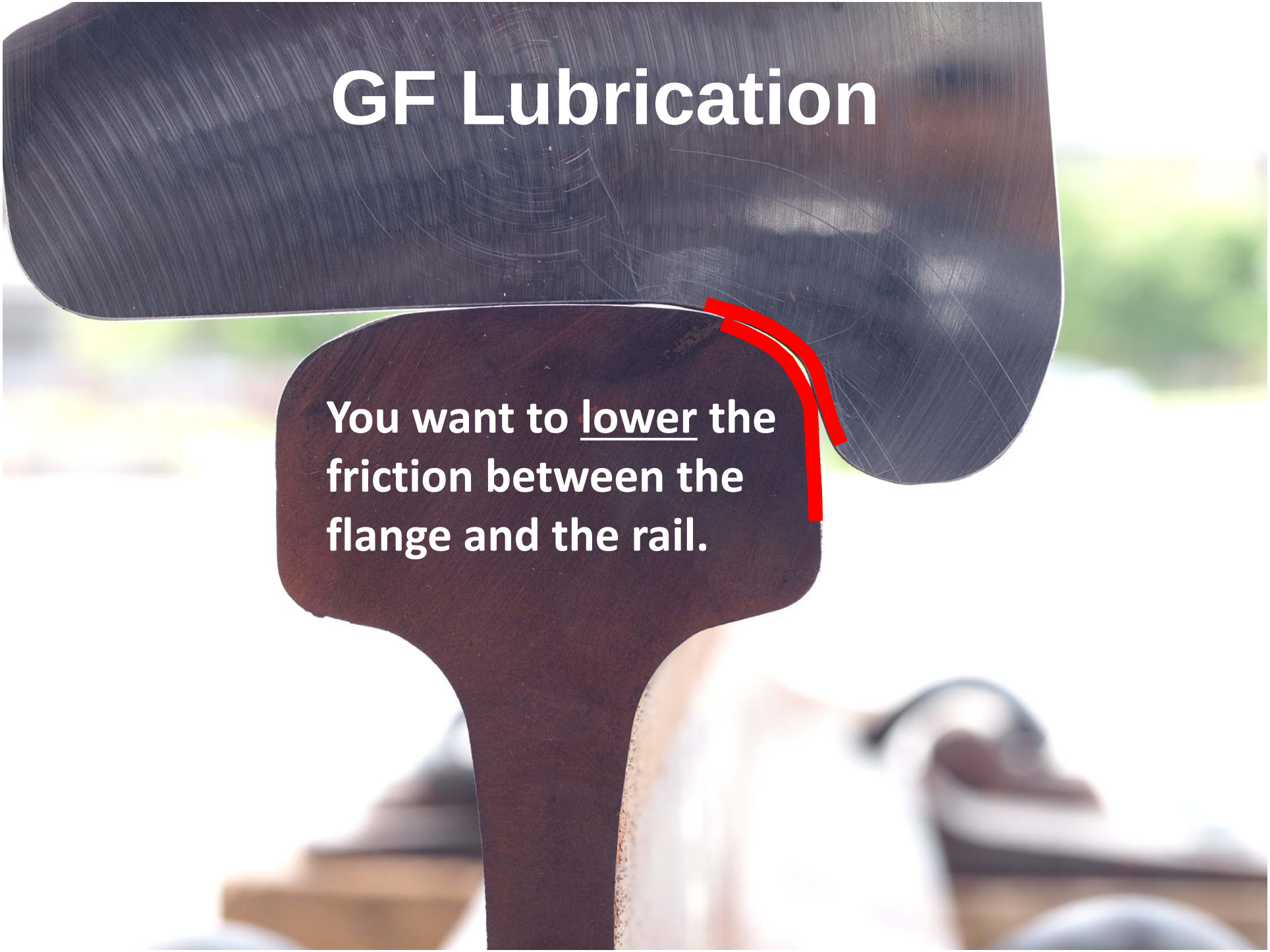
1. What is gage face lubrication (GF) and top-of-rail friction control (TORFC)?
2. Why do we use it?
3. How does it work and what type of systems and materials are used?
4. How do evaluate the performance?

Definitions

gage face (GF) lubrication – a methodology used to deposit a material to lower the friction between the wheel flange and the gage corner of the high rail in a curve, to reduce wear.

top-of-rail friction control (TORFC) – a methodology used to deposit a material to control the friction between the wheel tread and the top of the rail head, to reduce curving forces.

GF Lubrication



You want to lower the friction between the flange and the rail.


TORFC
You want to control the friction between the tread and the rail.

Why GF Lubrication?

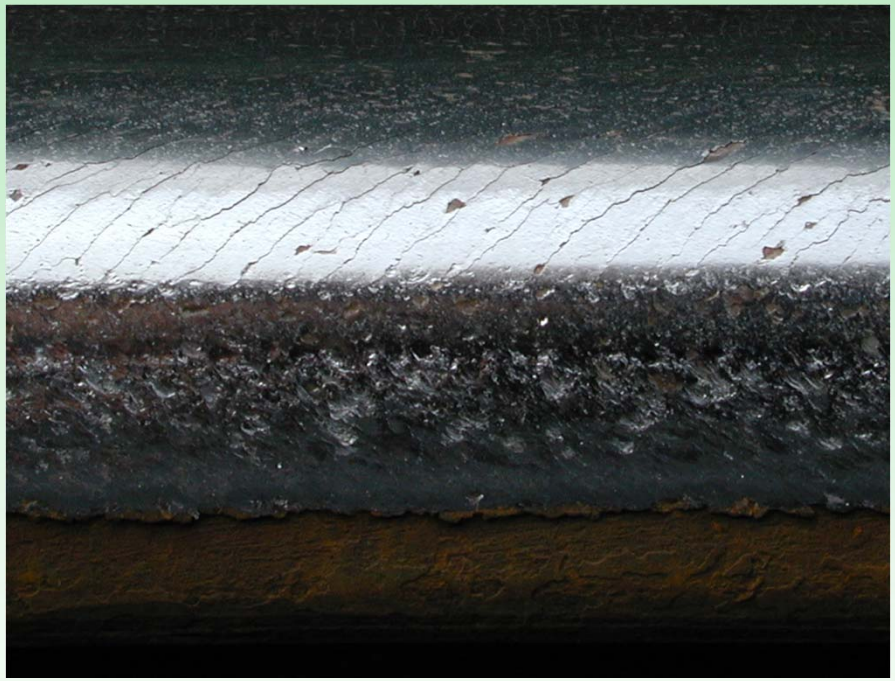
Reduce curving resistance, saving fuel.

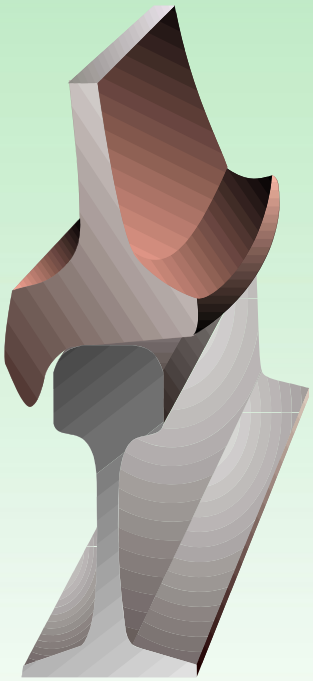
Reduce flange and gage face wear, prolonging life.

Fuel Savings

- Resistance $_{train}$ = R $_{grade}$ + R $_{curve}$ + R $_{rolling}$ + …
- Fuel can only be saved when a train is <u>not coasting</u> or is <u>not using dynamic or air-tread braking</u>.

Why GF Lubrication?

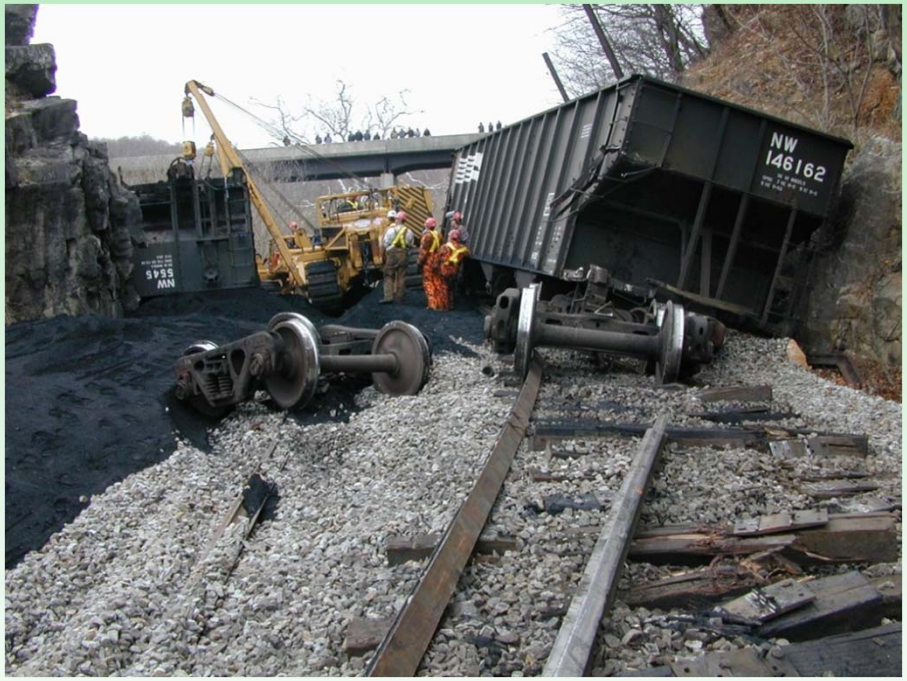




Reduce flange and gage corner rolling contact fatigue (RCF), requiring less trueing/grinding.

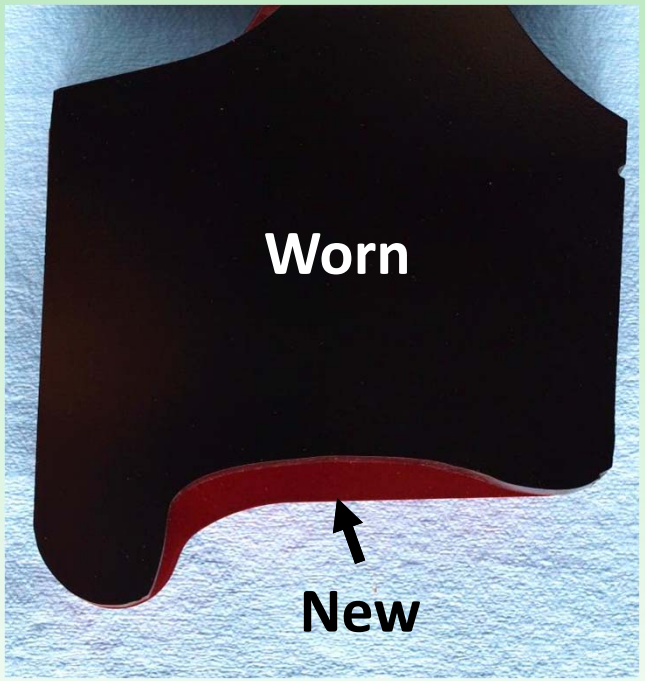
Reduce curve flanging noise.

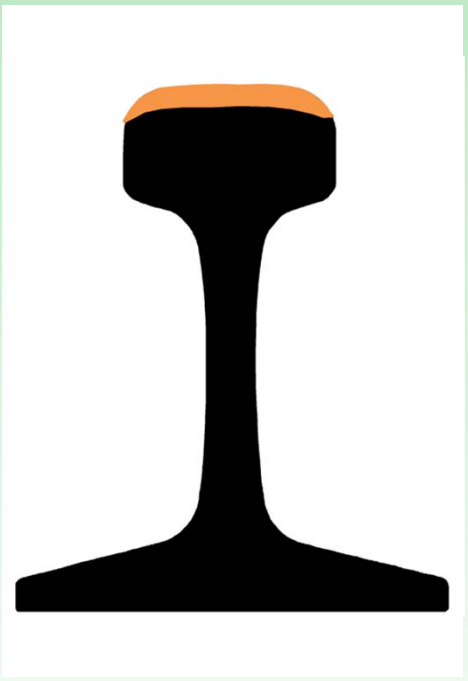
Why GF Lubrication?



Reduce high rail wheel climb <u>derailments</u>, reducing service interruptions.

Why TORFC?





Reduce <u>curving and rolling resistance</u>, saving fuel.

Reduce tread and head wear, prolonging life.

Why TORFC?

Reduce rail <u>head checks and spalls</u>, prolonging life.

Reduce <u>wheel shells</u>, prolonging life.

Why TORFC?

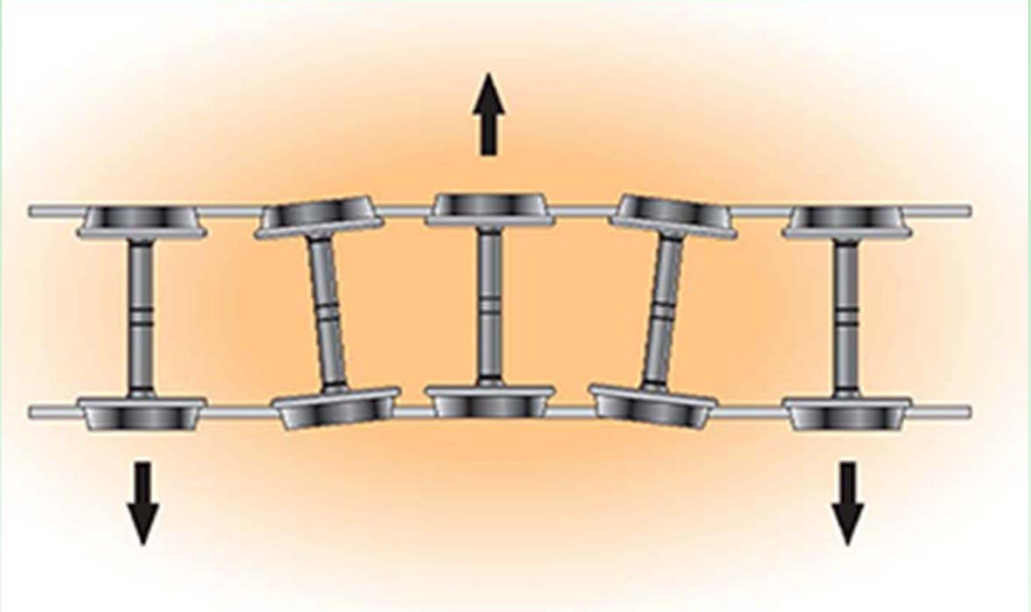
Reduce curve squeal noise (stick/slip & negative friction).

Reduces rail rollover derailments, reducing service interruptions.

Why TORFC?

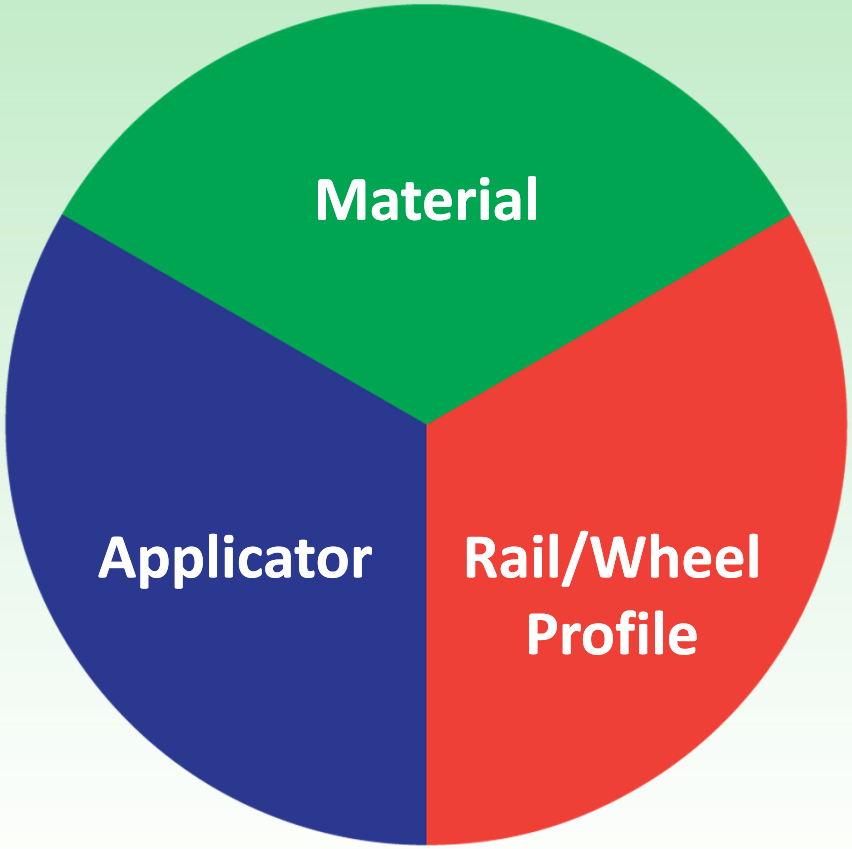
Reduce lateral curving forces, prolonging track component life (fasteners, ties, plates).

Why TORFC?



Reduce <u>hunting in tangent track</u>, reducing derailments and service interruptions.

GF & TORFC Are Systems



How Does it Work? - GF

Material (e.g. grease) creates an interface between the wheel flange and gage corner/face of the high rail in a curve, preventing wear.

How Does it Work? - GF

The geometry of the contact is impacted by the angle of attack (AoA) between the wheel and the rail.

Therefore, the greater the degree of curvature, the greater the angle of attack and the greater the force at the contact point.

How Does it Work? - GF

Analogy of an Internal Combustion Engine – If no oil is used in a crankcase, the components will wear away quickly and more energy is consumed by the friction between the internal engine components.

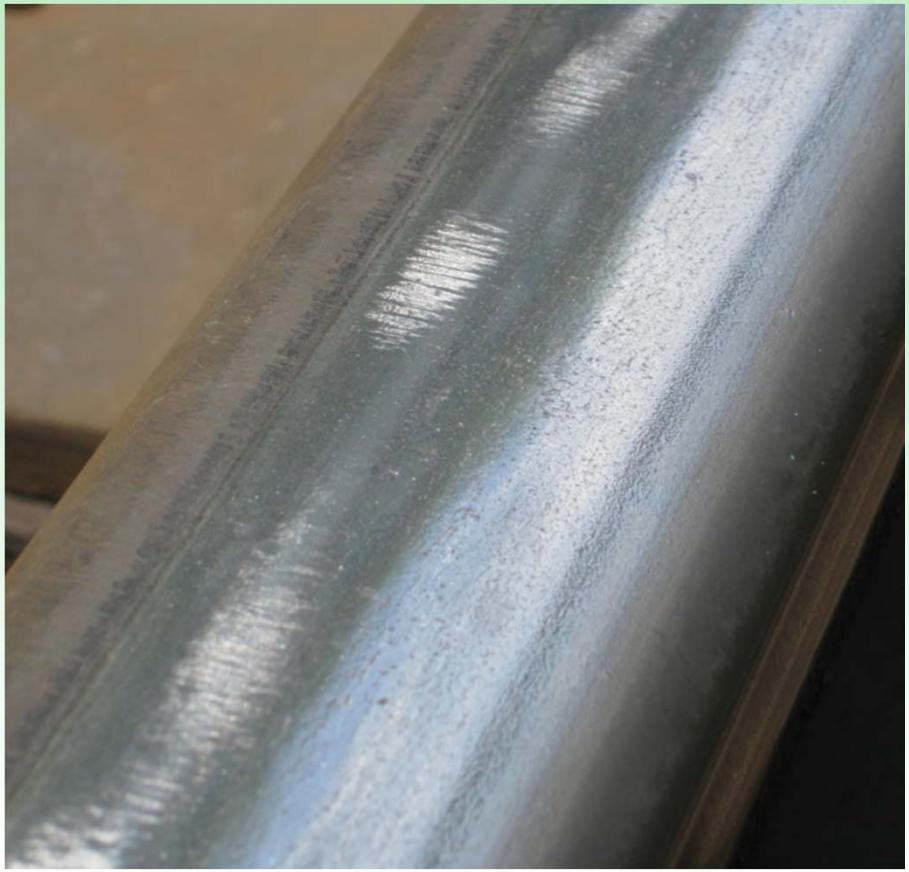
If oil is used in the crankcase, the components will not wear away as quickly and less energy is consumed by the friction between the internal engine components

How Does it Work? - TORFC

Slip-stick occurs in curves because high-side wheels must travel a longer distance than low-side wheels.

To compensate, one wheel must slip to stay on rotation with the other.

How Does it Work? - TORFC



This slip occurs when the longitudinal, lateral and spin creep forces applied by the wheel exceed the friction force holding the wheel.

By reducing the friction, the creep forces that hold the wheel are reduced, resulting in less energy to make the wheel slip.

How Does it Work? - TORFC

4WD Analogy - On dry pavement, vehicle wants to push itself outward when turning. On wet pavement (i.e. rain & snow), vehicle turns normally. This is due to lower friction which causes the wheels to slip easier.

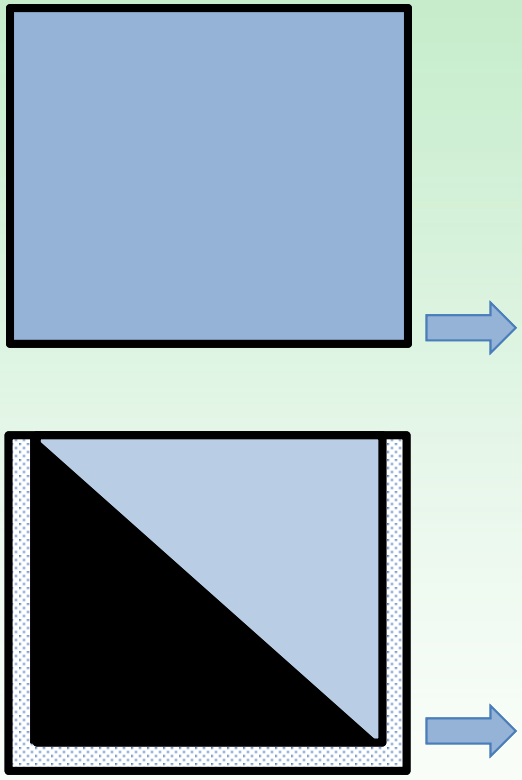
Types of GF Systems

- **Wayside**
- **Hi-rail**
- **Locomotive/Car**

Wayside GF Systems

- Material Reservoir
- Power & Motor
- Pump
- Control Electronics
- Applicator Bar(s)

GF Material Reservoir

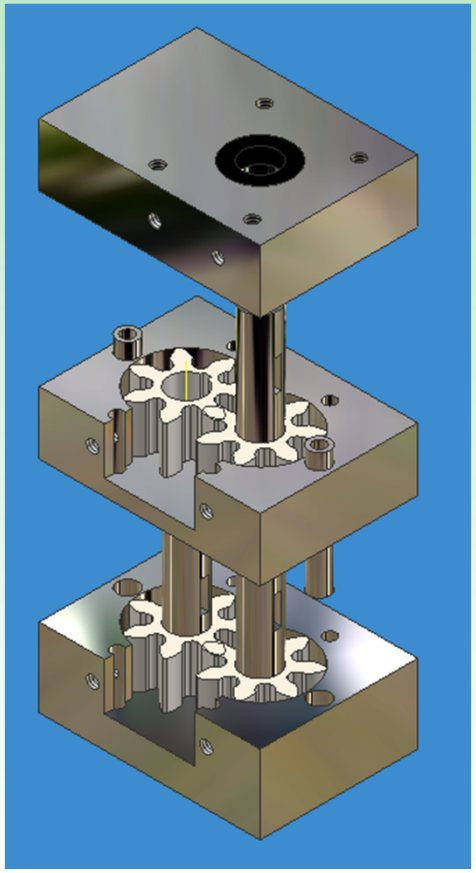


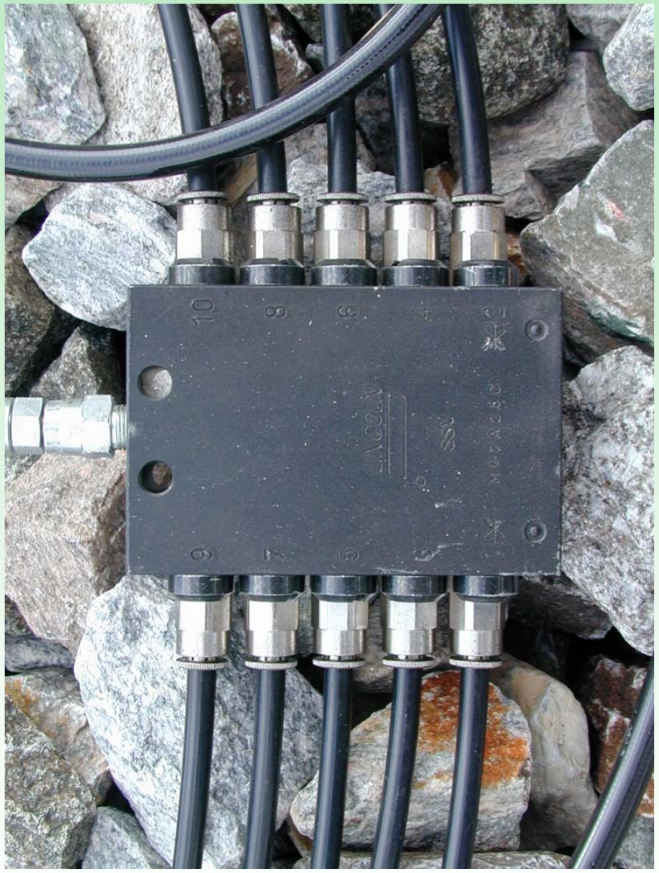
- Capacity
- Slope sheet design
- Insulated walls
- Corrosion protection

GF Power & Motor

- Electric (AC or DC solar)
  - Shaft rotation/voltage
  - Encoders & viscosity
  - Inertia & braking
  - Stepper
- Hydraulic
  - Speed dependent
- Mechanical

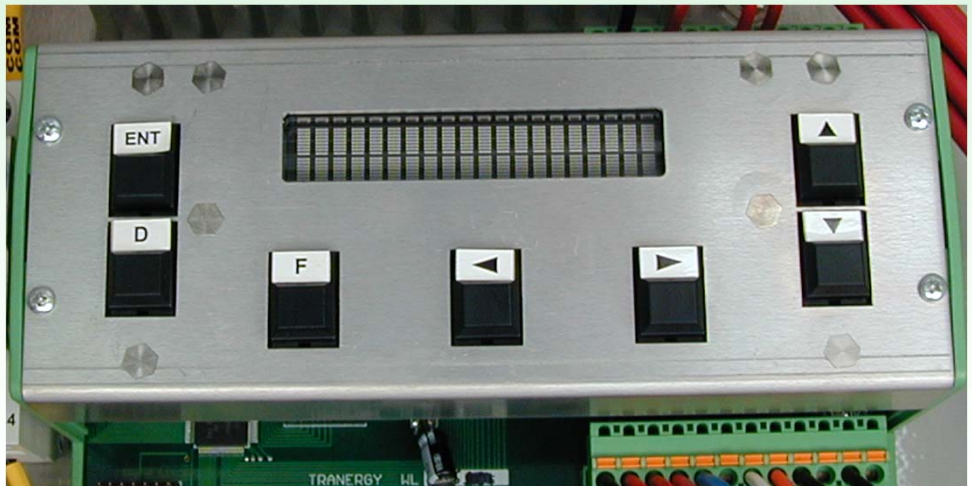
GF Pumps





- Gear-type
- Low pressure, high volume
- High pressure, low volume
- Divider valves
- Displacement, response time & train speed

GF Control Electronics



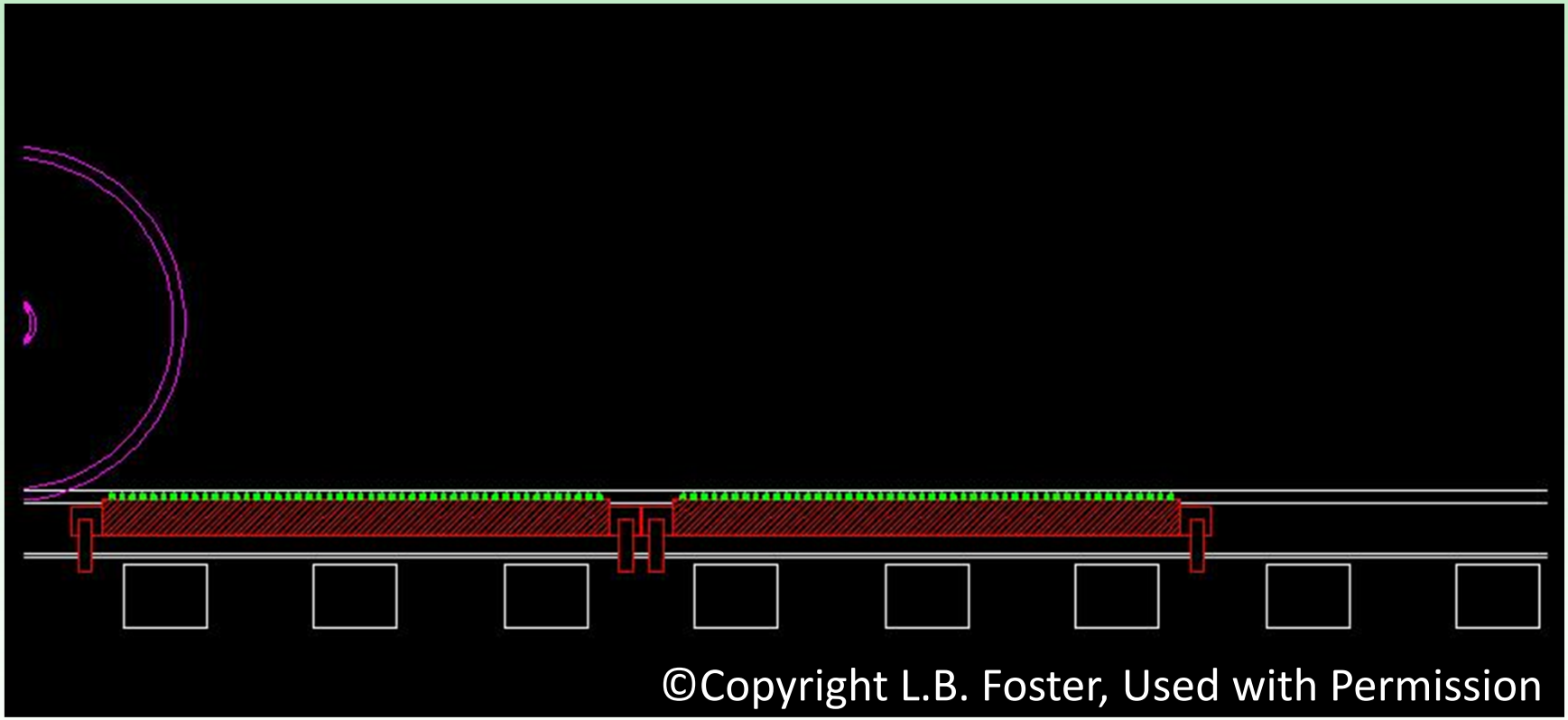
- Application rate controlled by
  - Pump ON time
  - # of gear teeth
  - Pump activation per axles passed (wheel sensor)

GF Applicator Bars

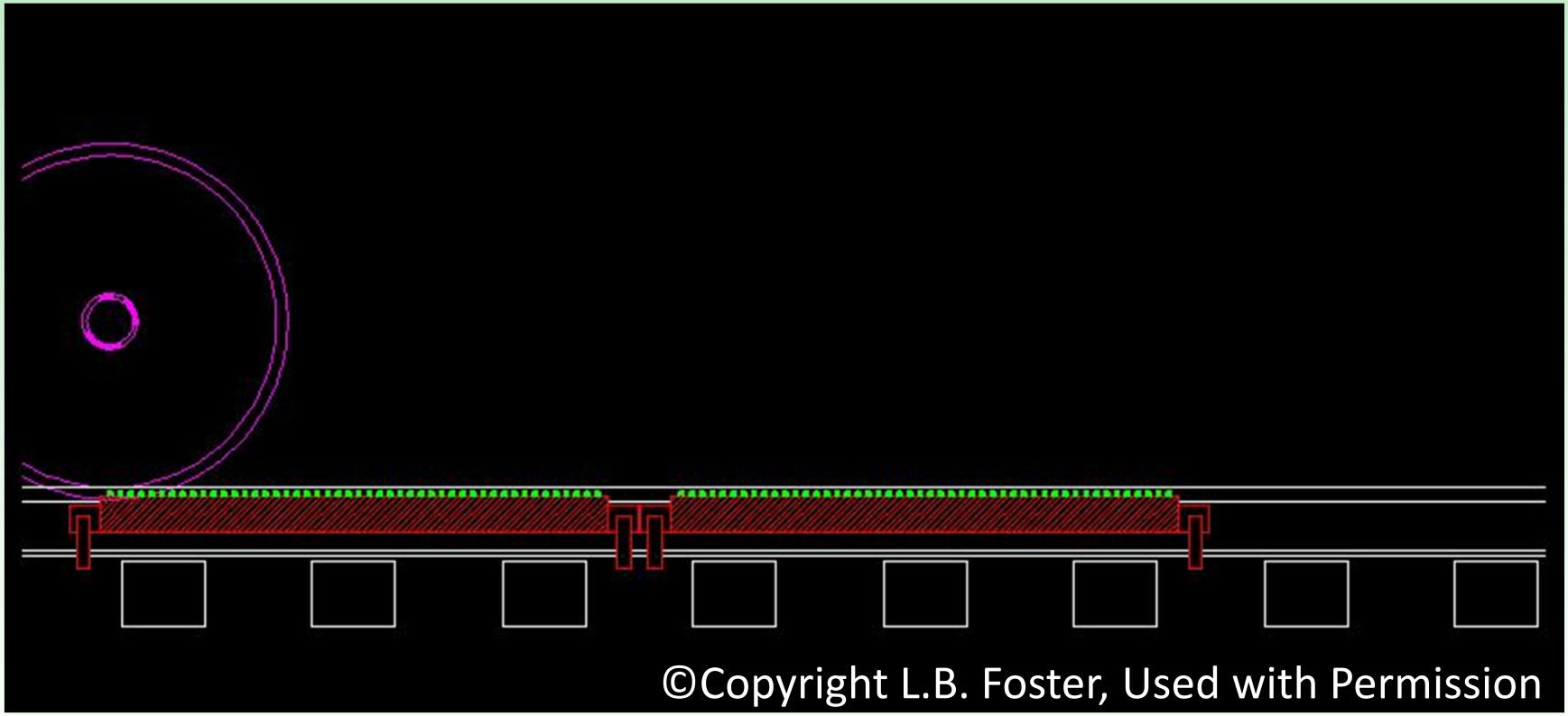
- Small ports & length of full wheel circumference.
- ⅞ to 1⅛” below top of rail.
- Installed in tangents, 100 ft. min. from spiral.

Full Wheel Circumference

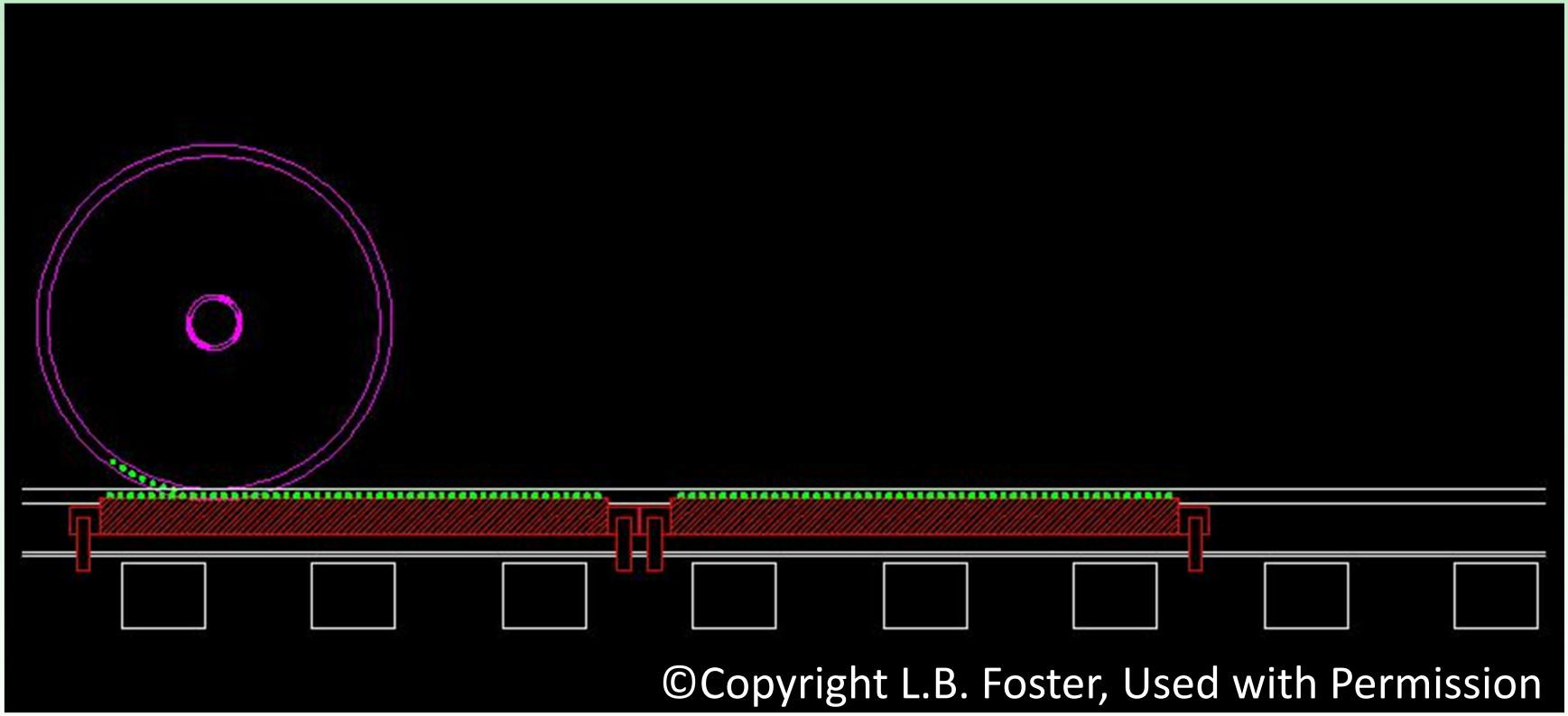
Grease Pickup & Transfer



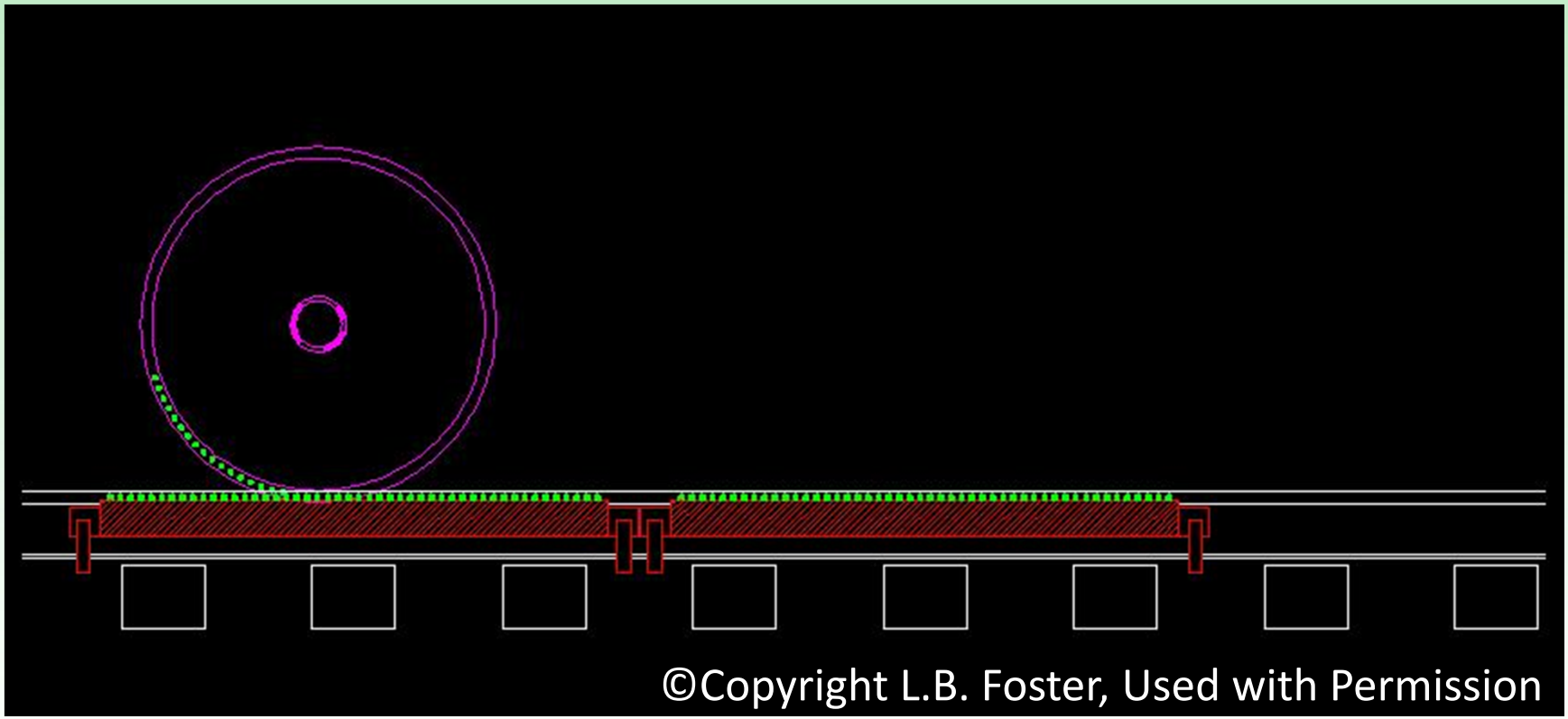
Grease Pickup & Transfer



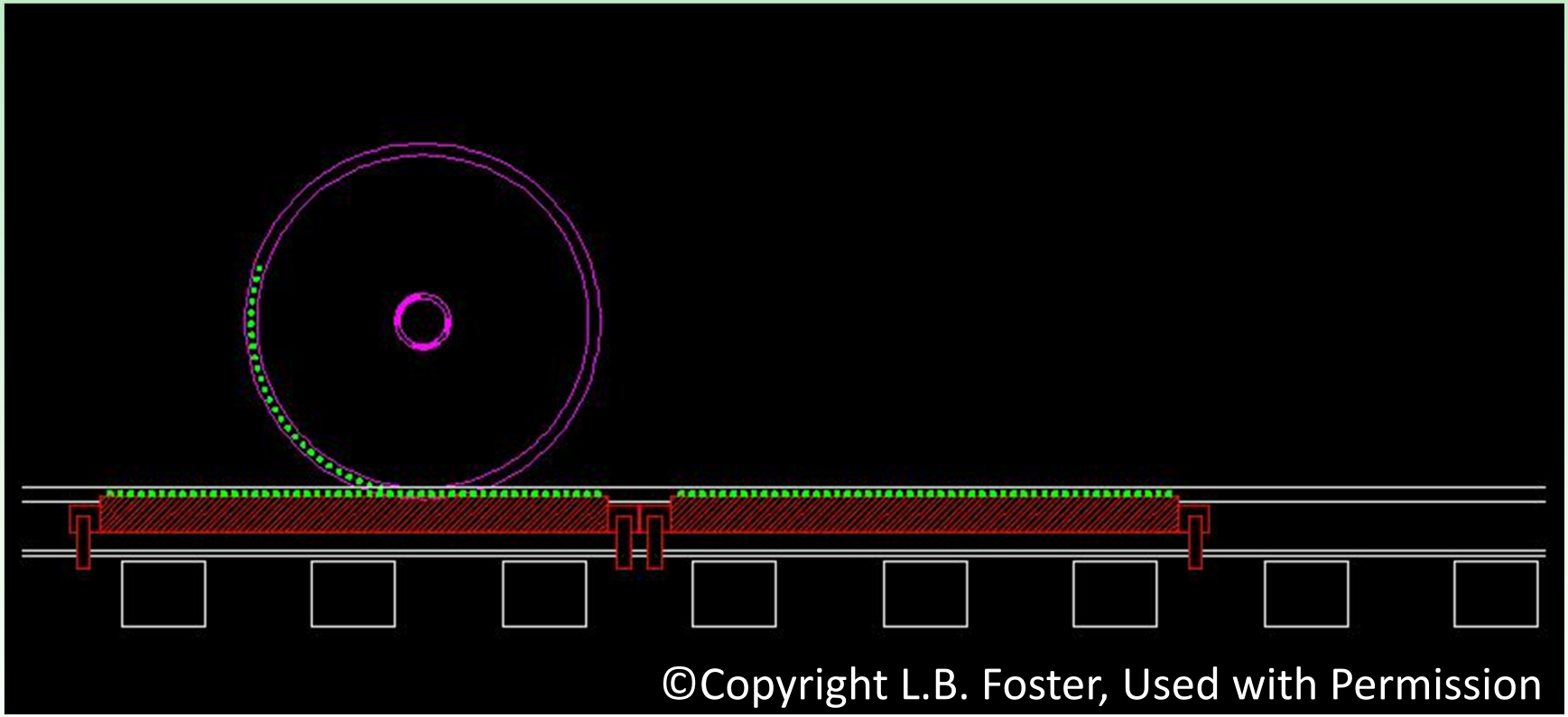
Grease Pickup & Transfer



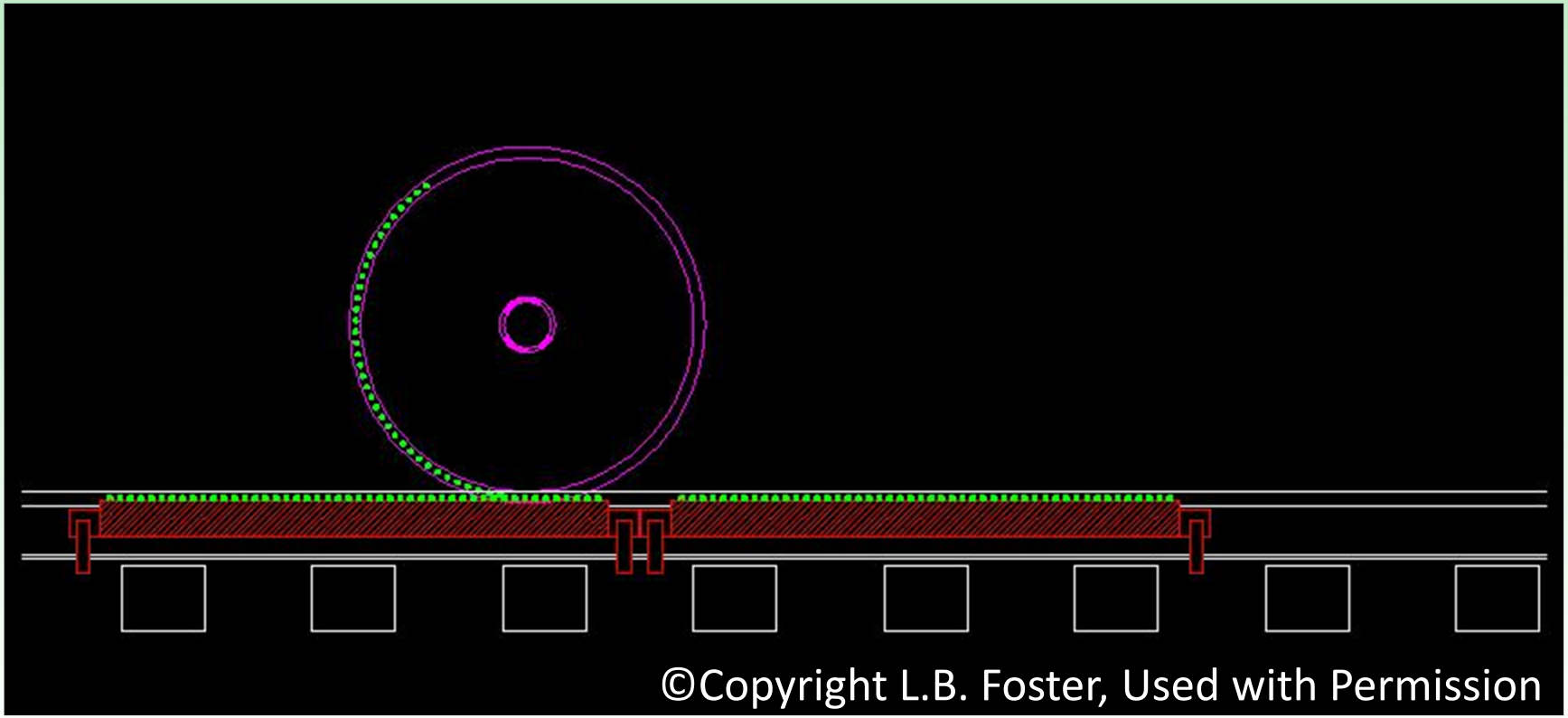
Grease Pickup & Transfer



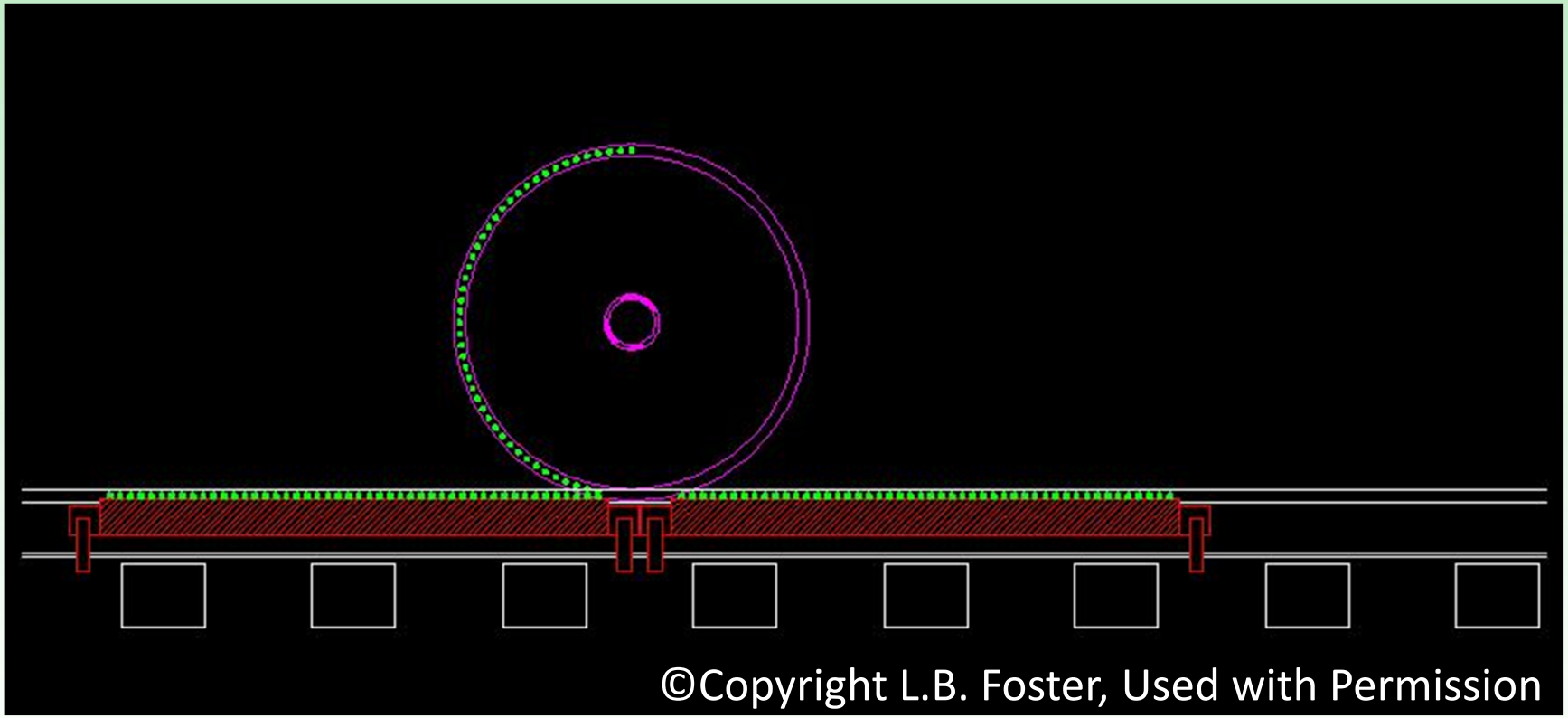
Grease Pickup & Transfer



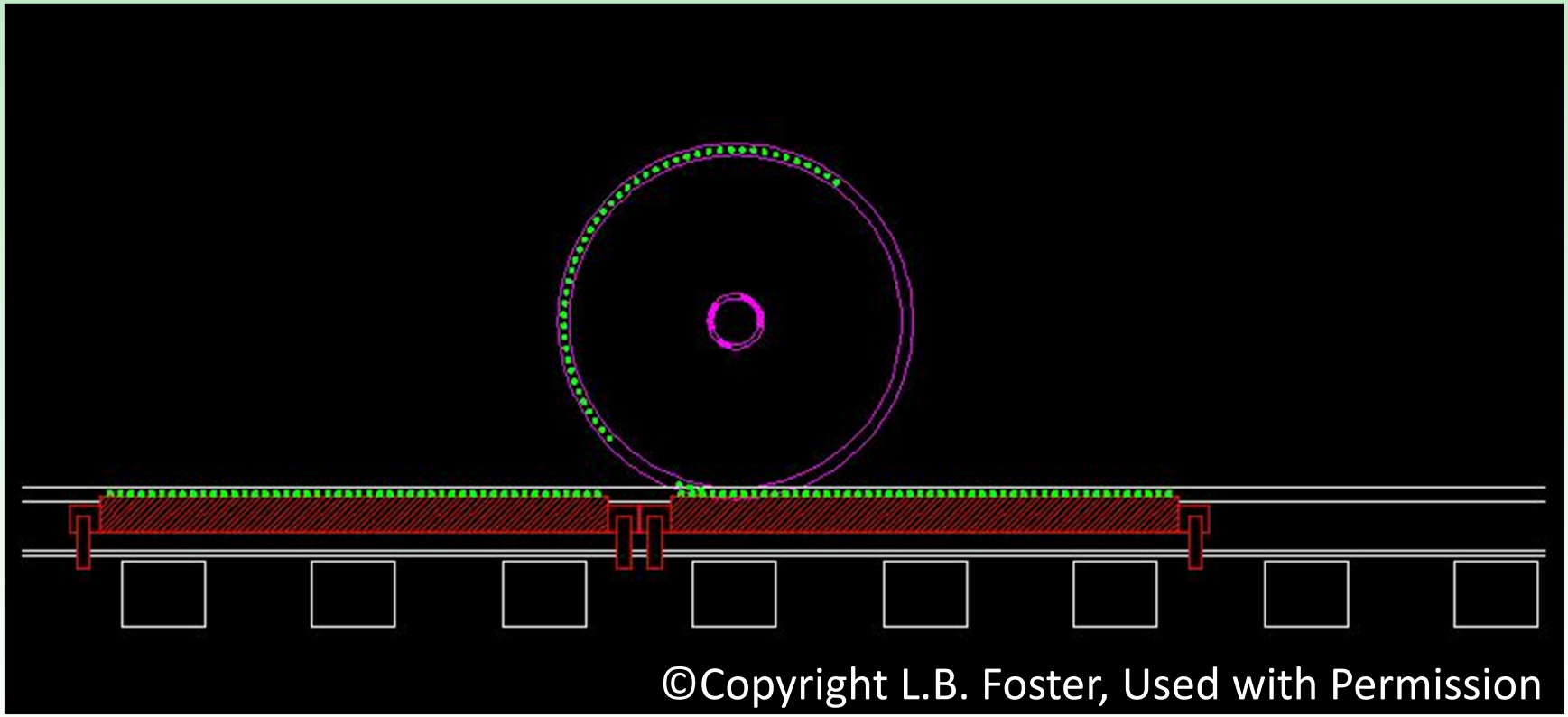
Grease Pickup & Transfer



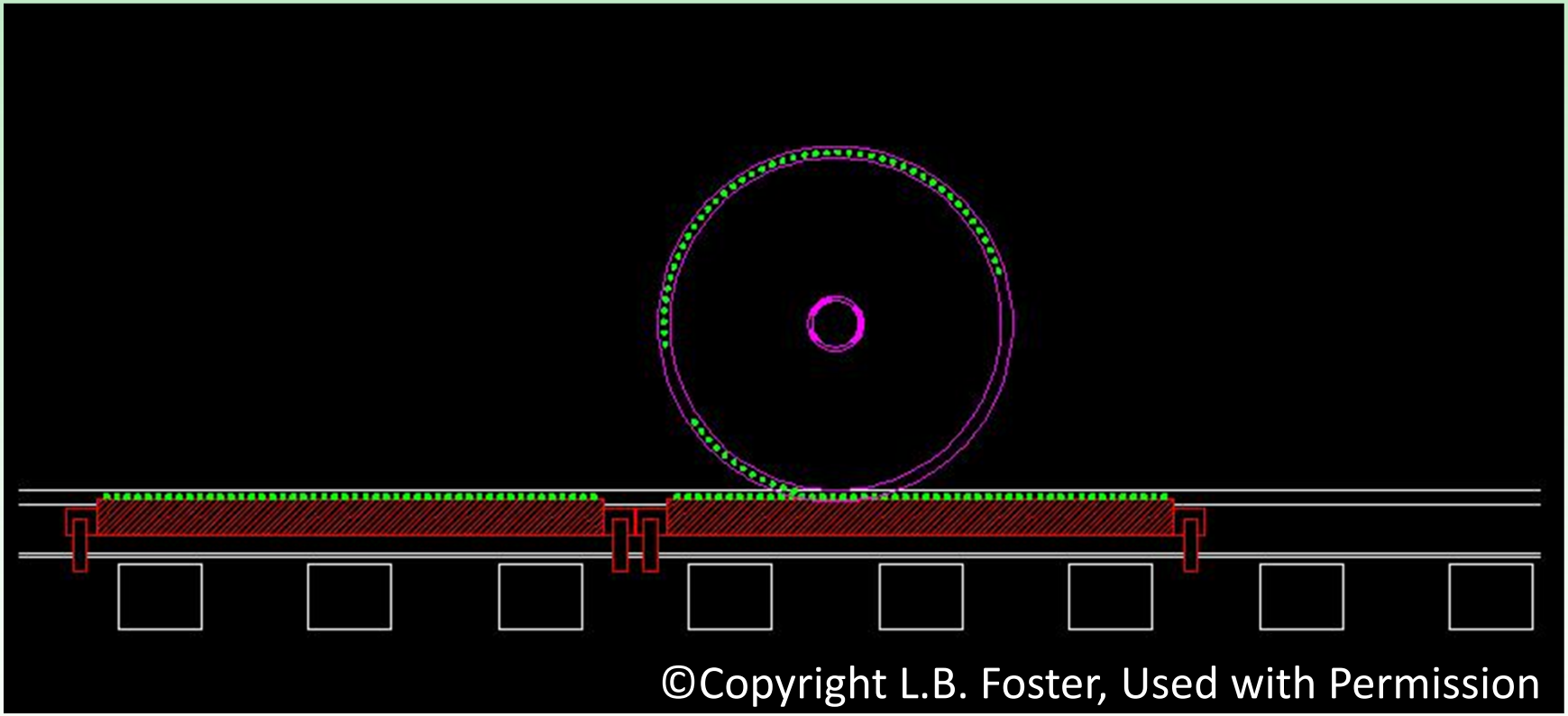
Grease Pickup & Transfer



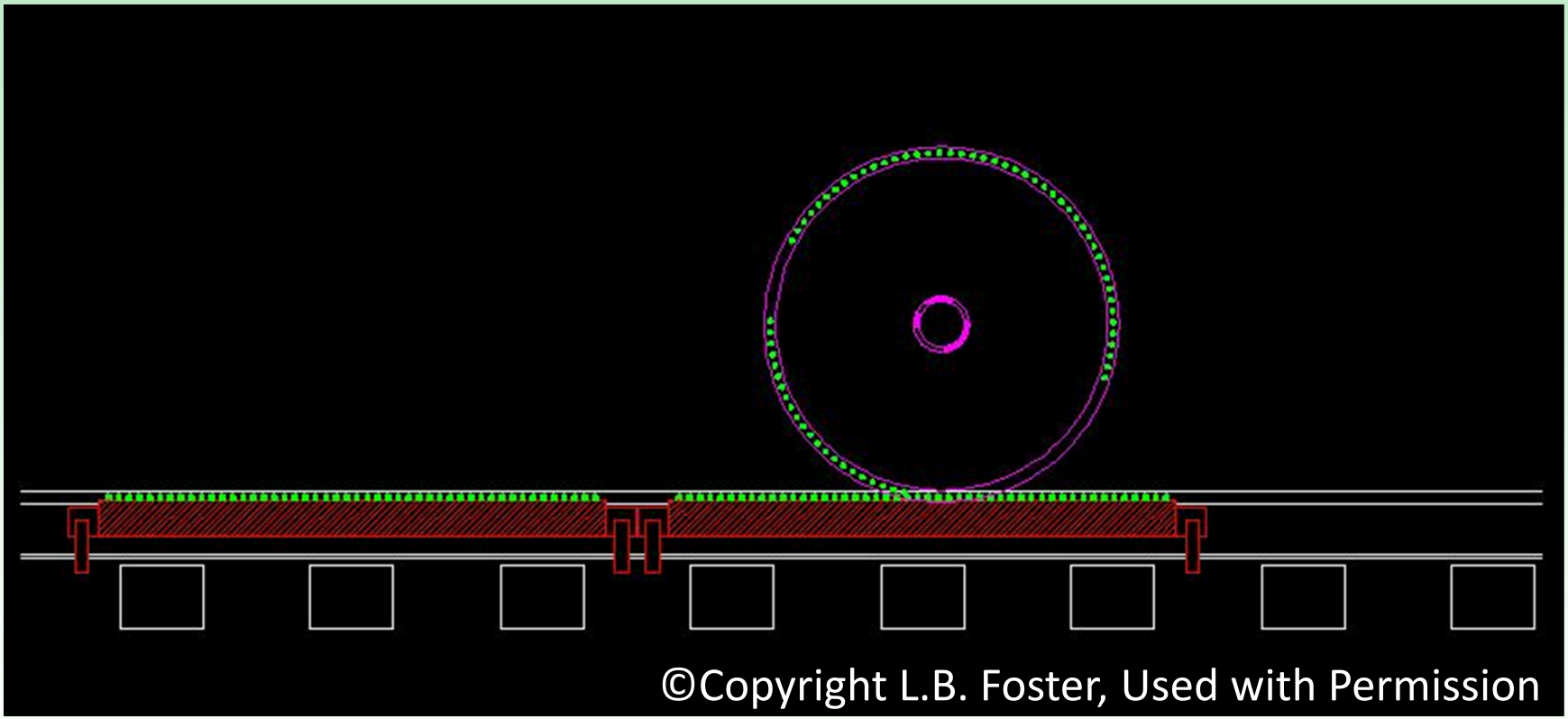
Grease Pickup & Transfer



Grease Pickup & Transfer



Grease Pickup & Transfer



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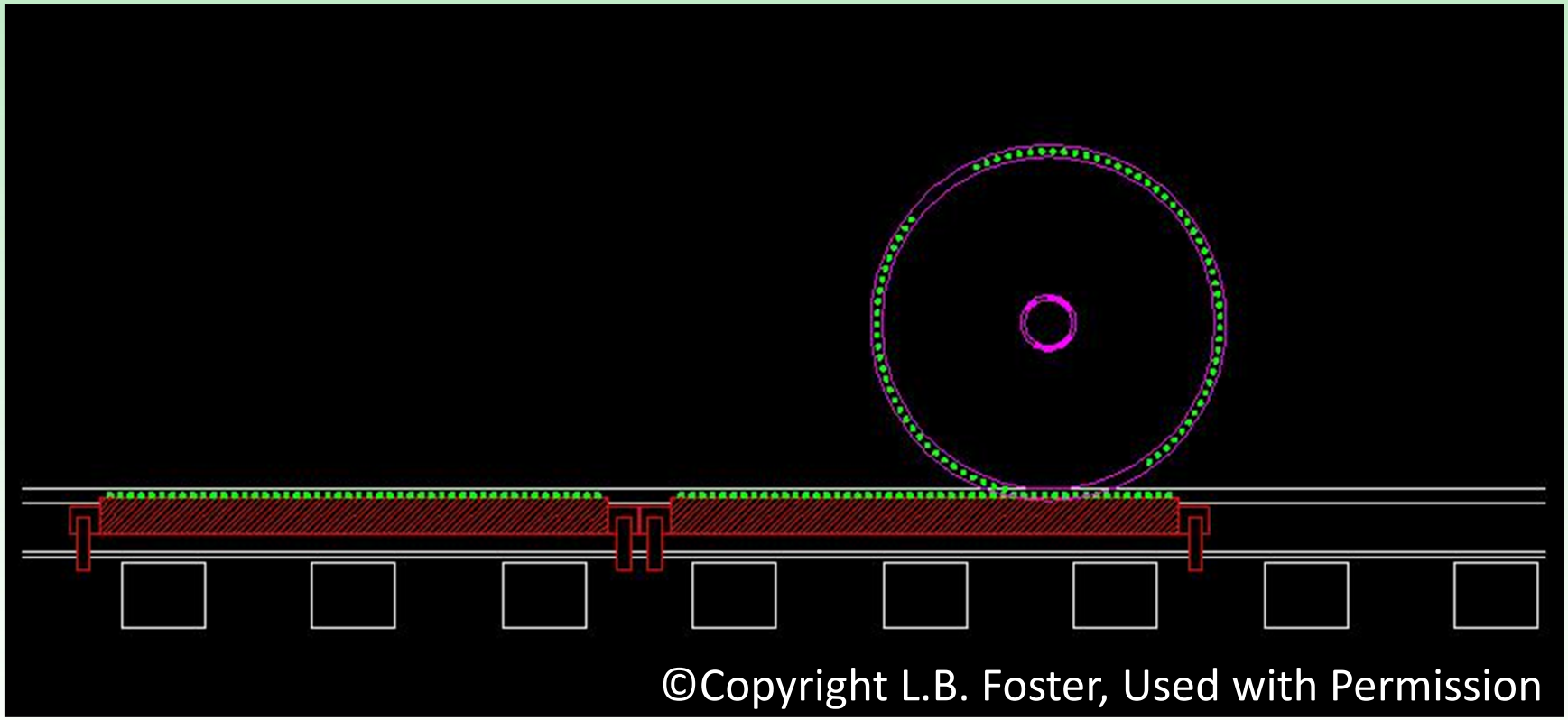

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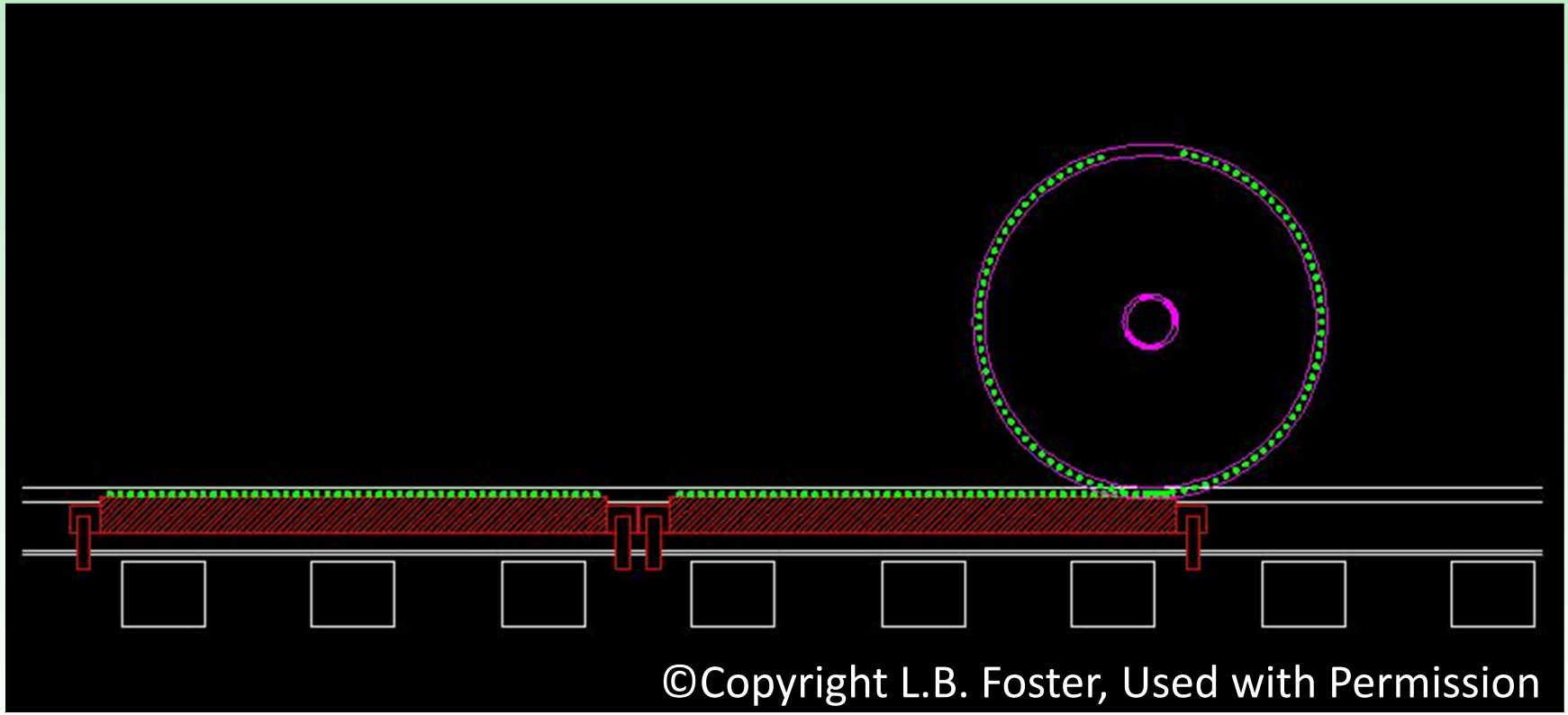

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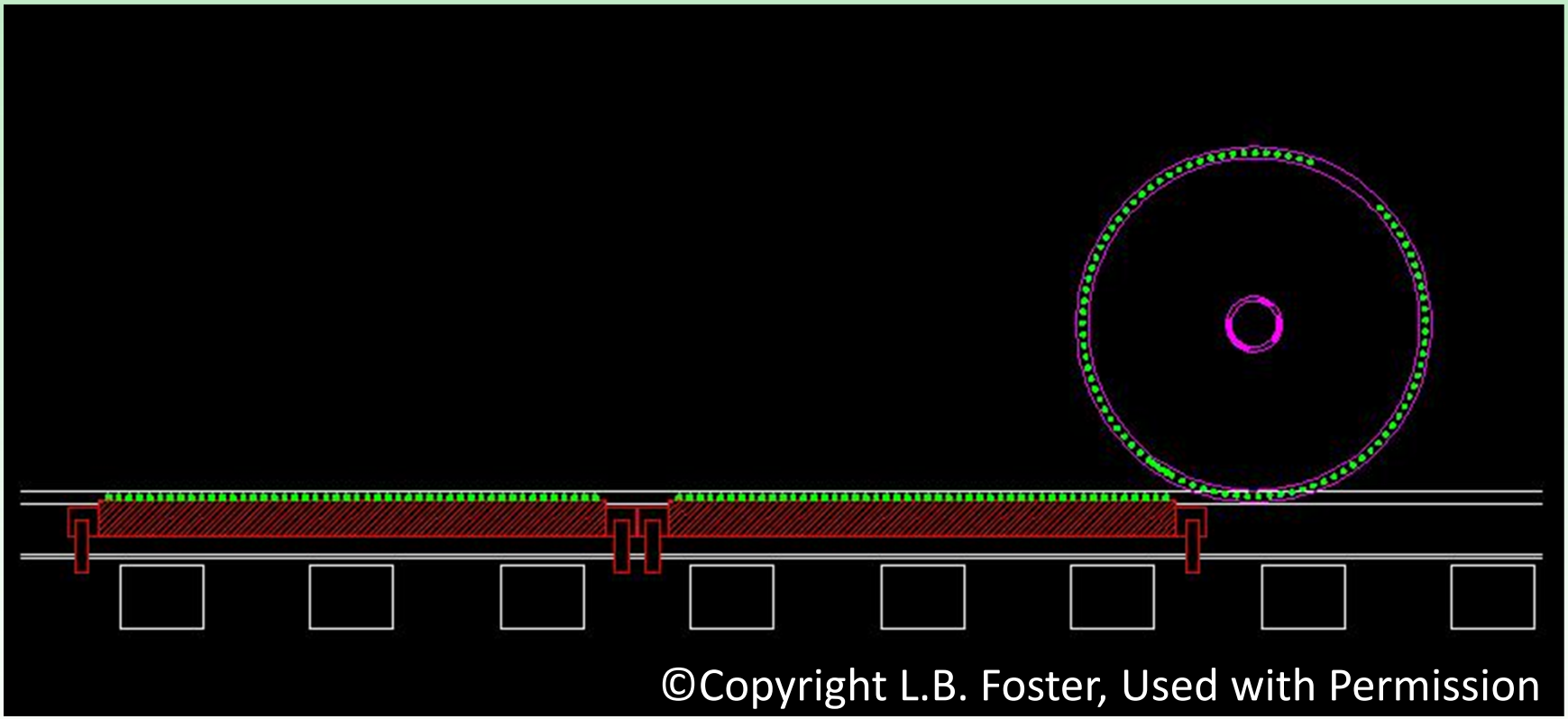
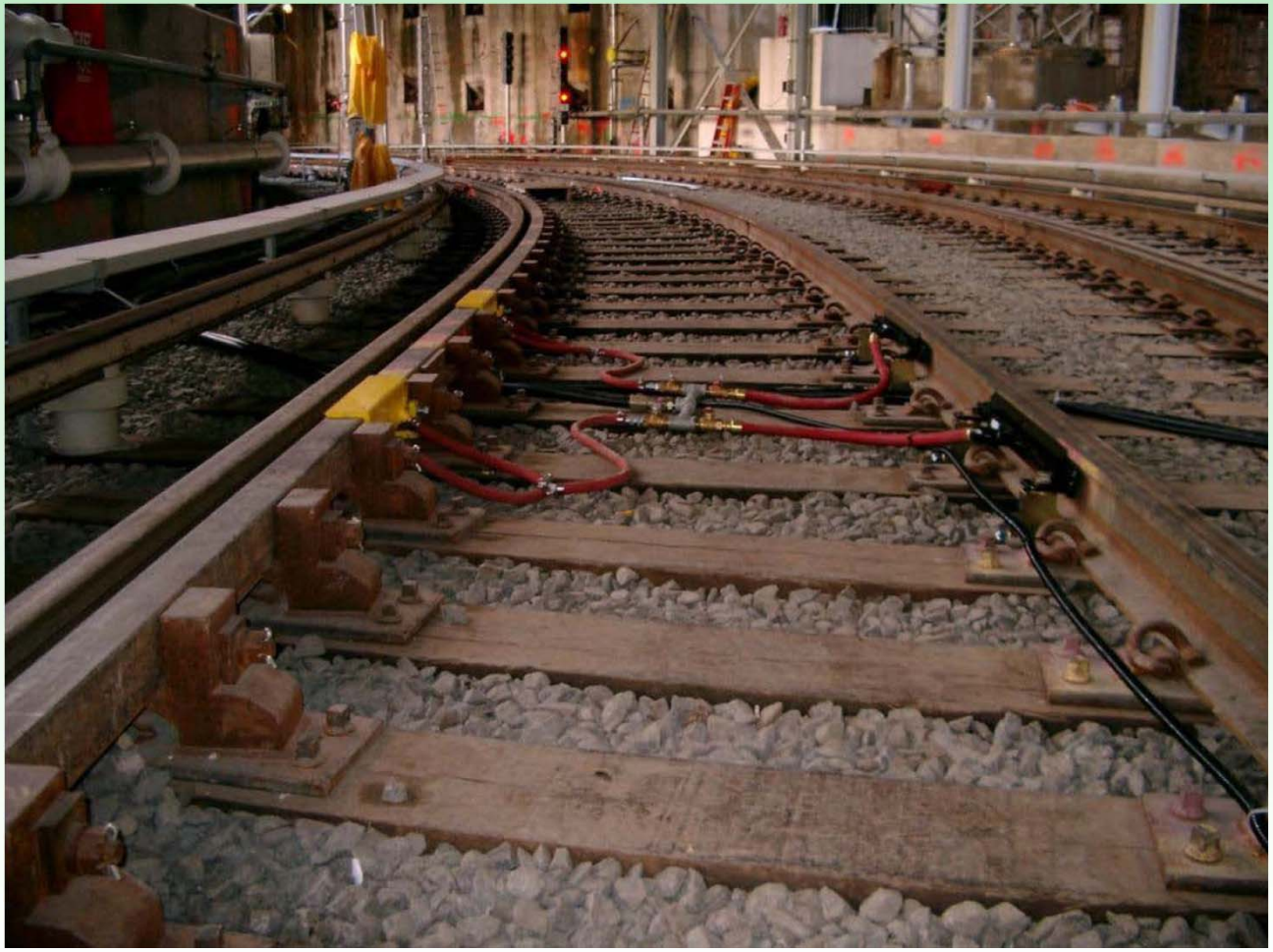
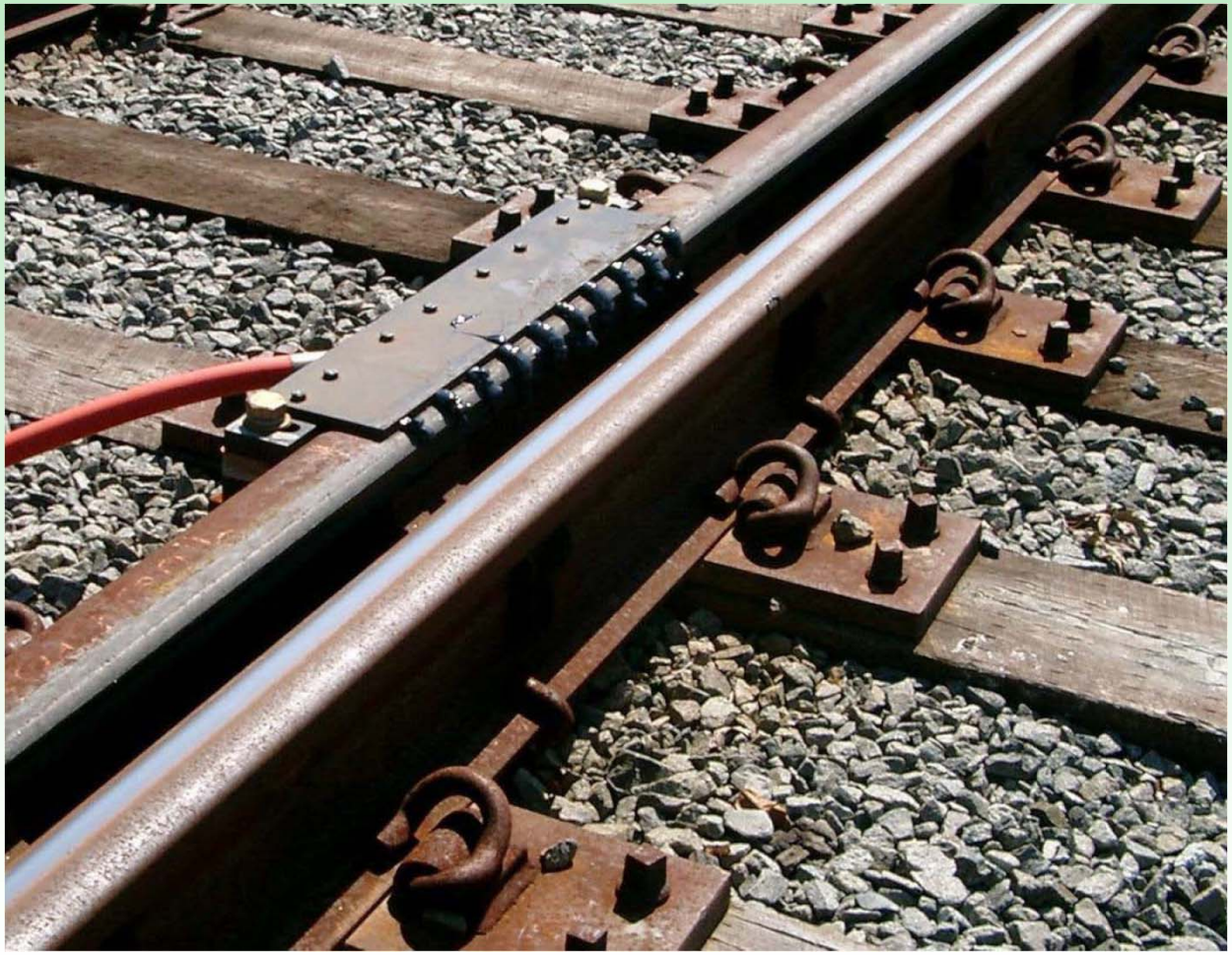


GF Grease Guides

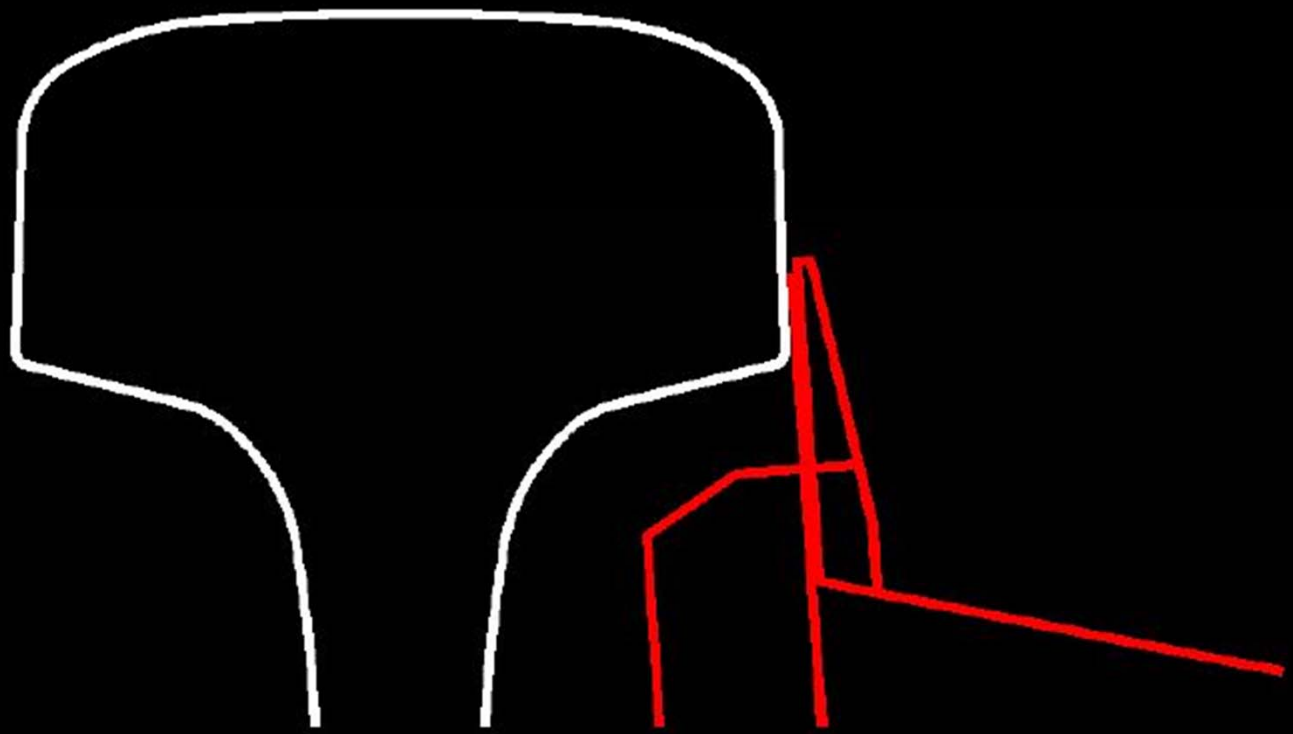
GF Applicator in Curve



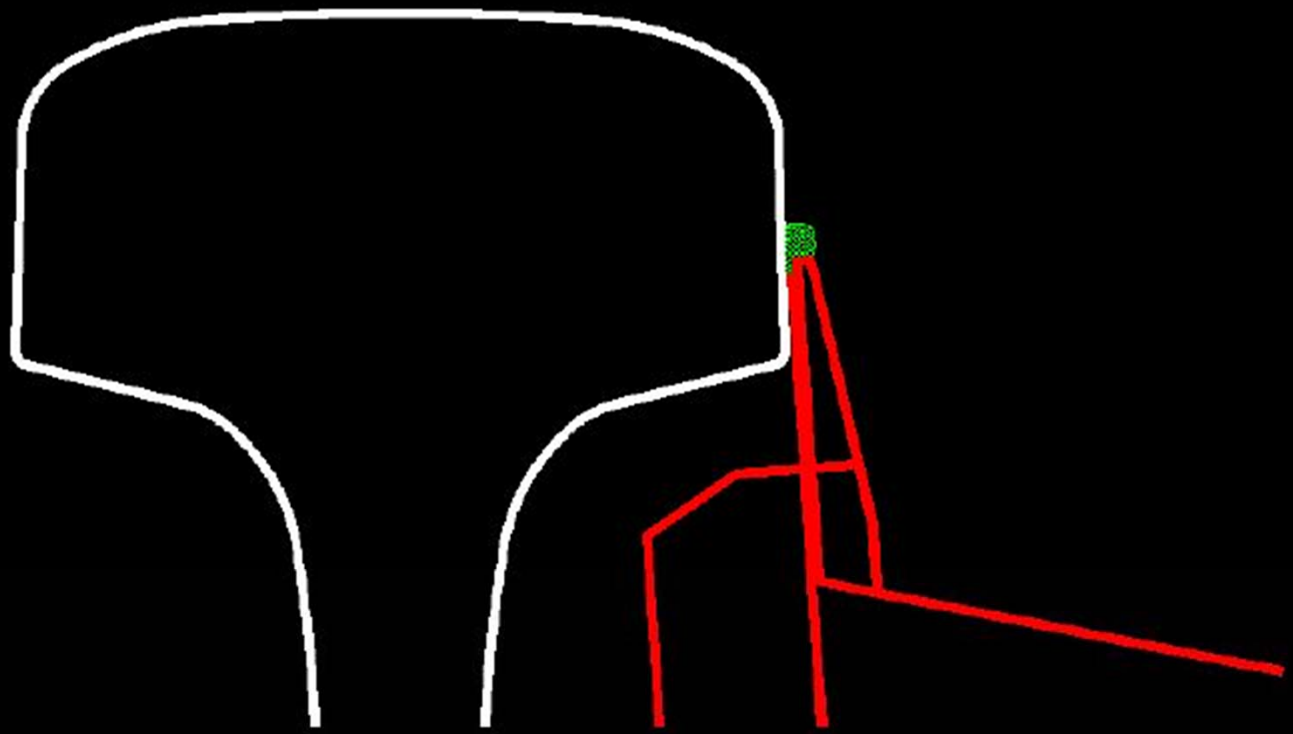
GF Applicator & Restraining Rail



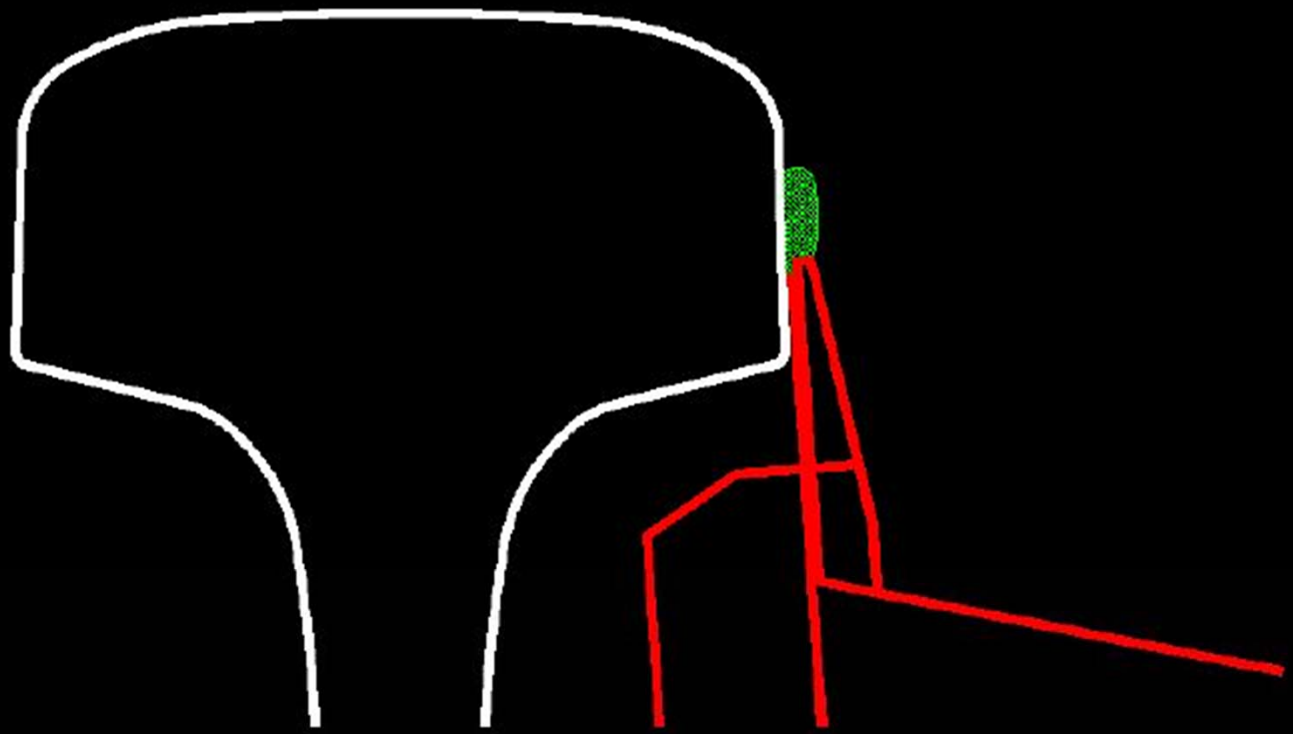
Grease Applicator Mounted to Rail



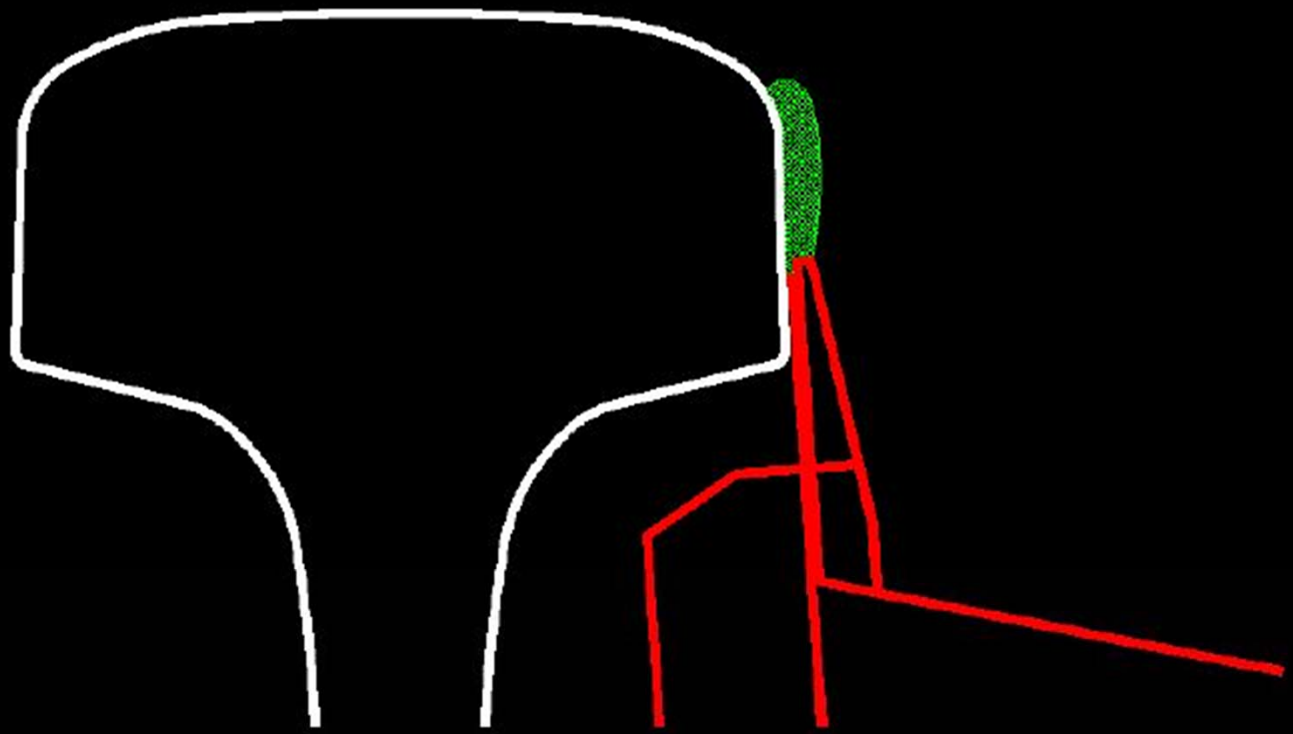
Grease Emerges from Ports



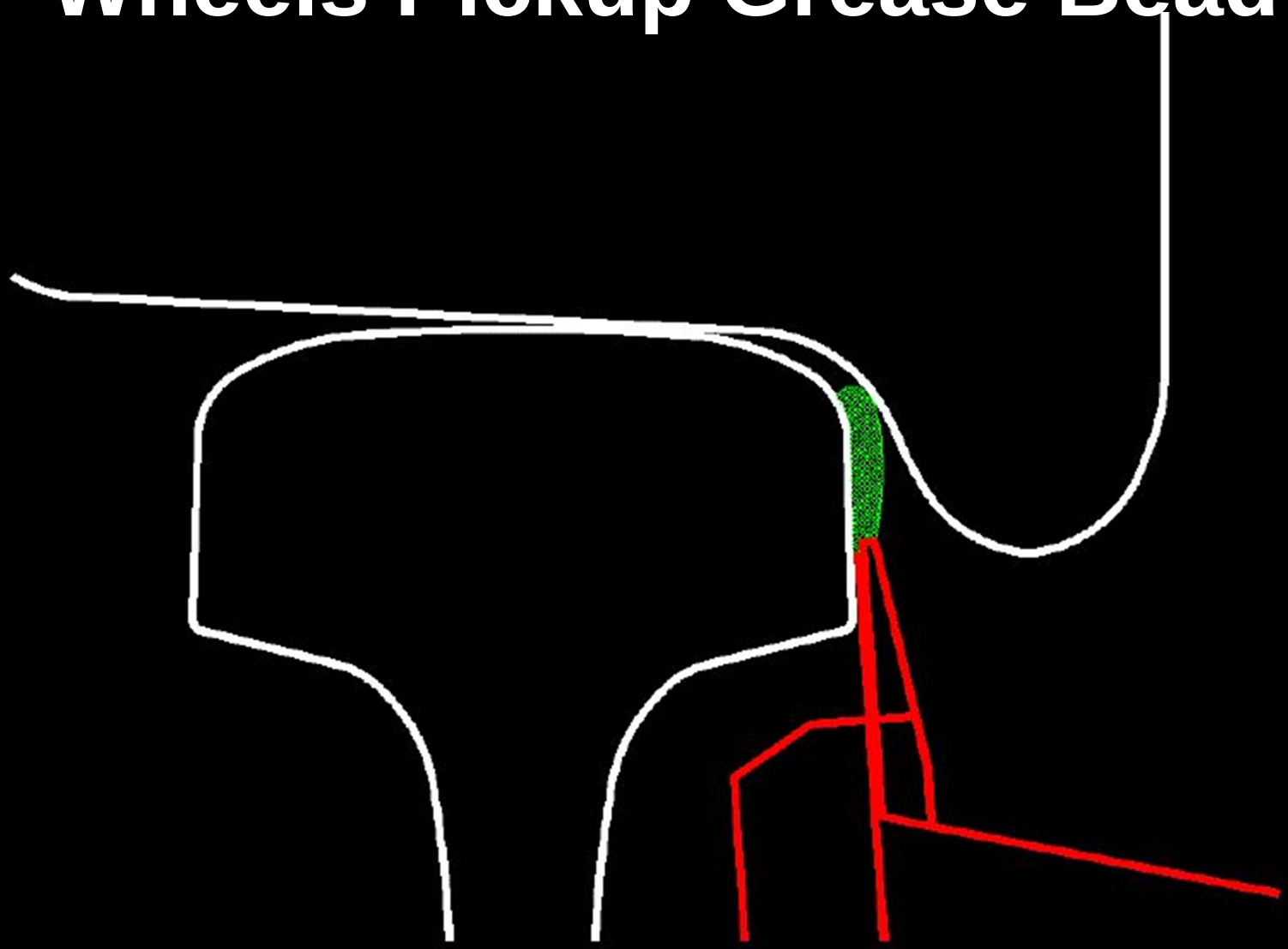
Grease Climbs Gage Face



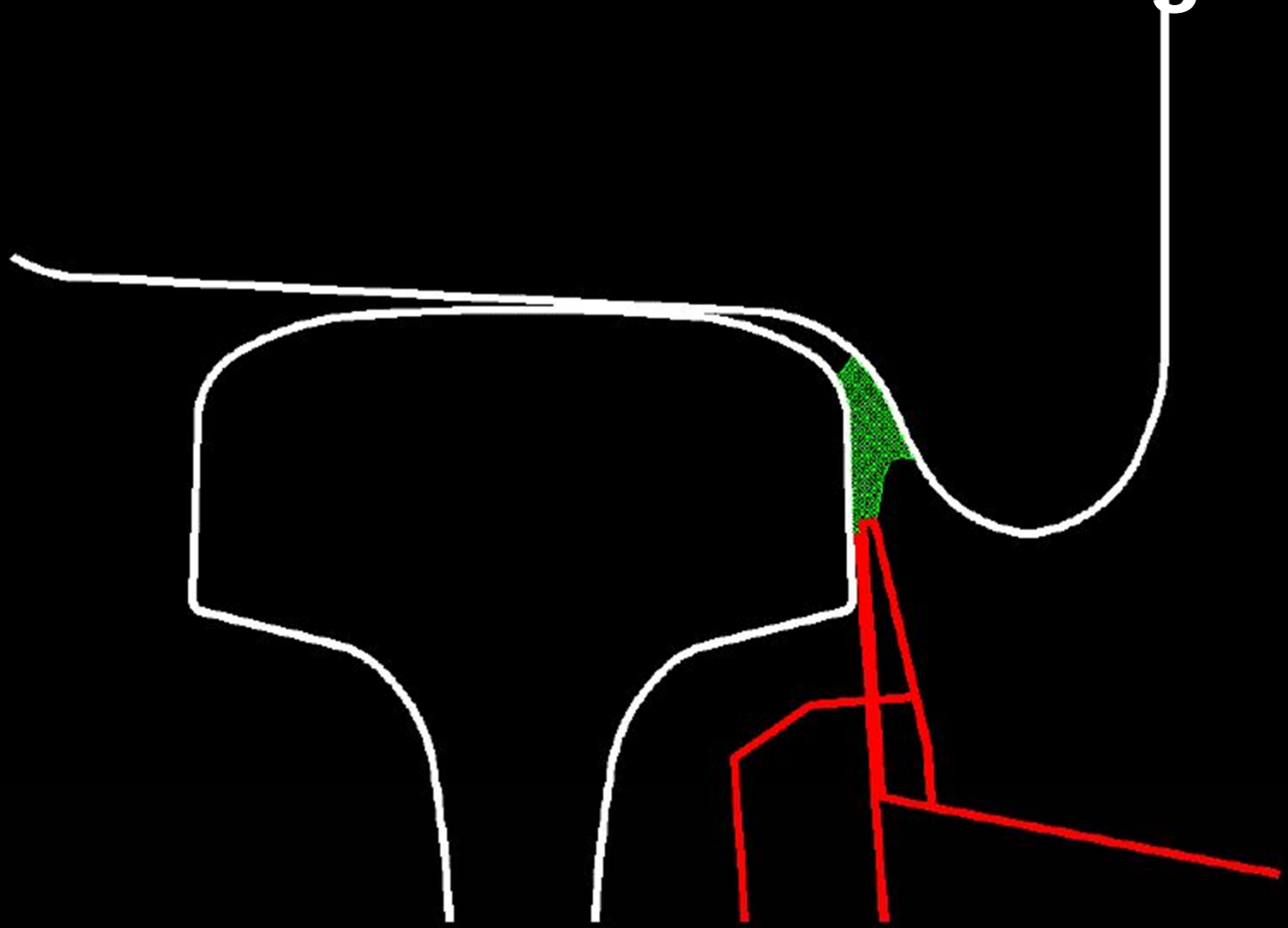
Grease Bead Grows Larger



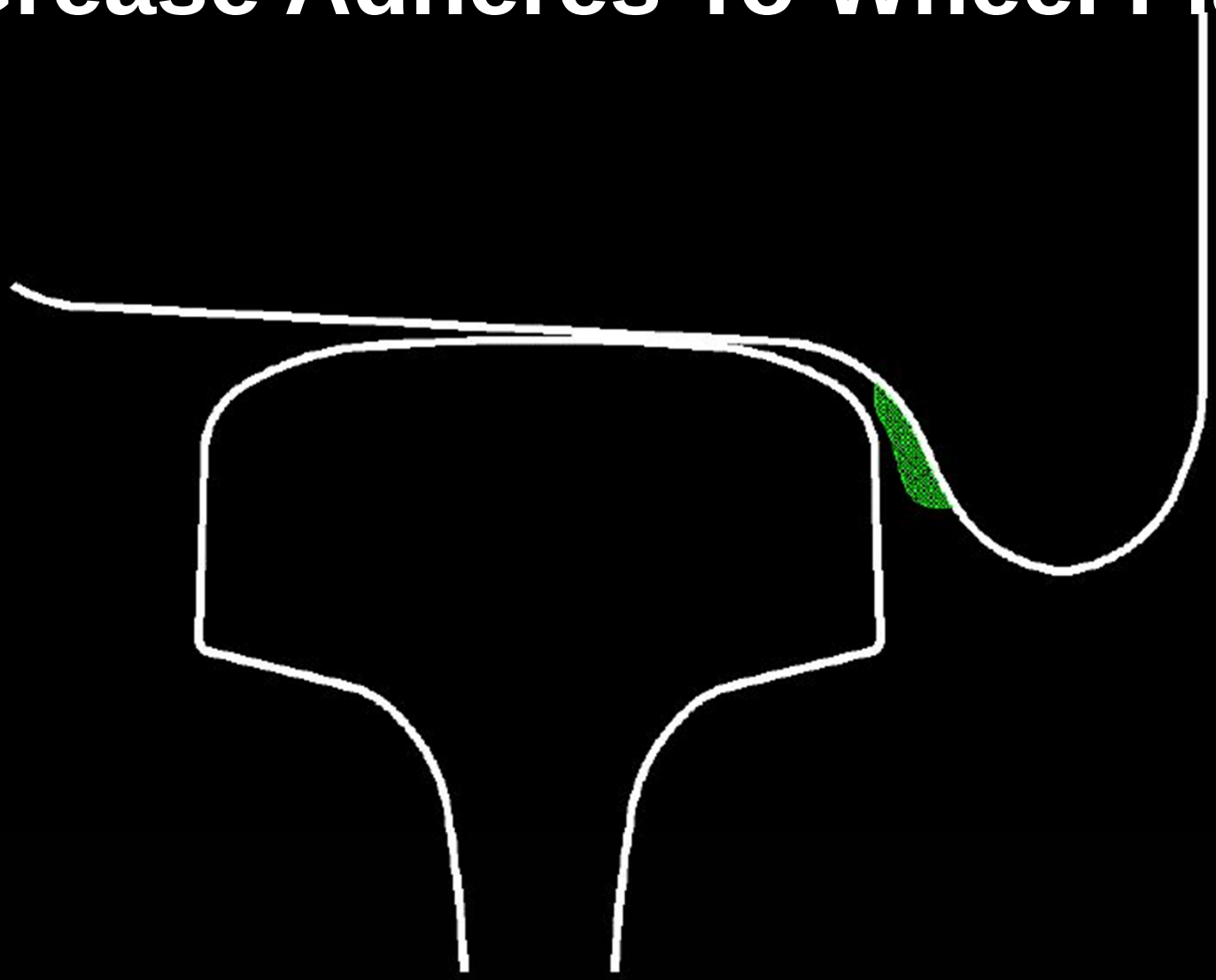
Wheels Pickup Grease Bead



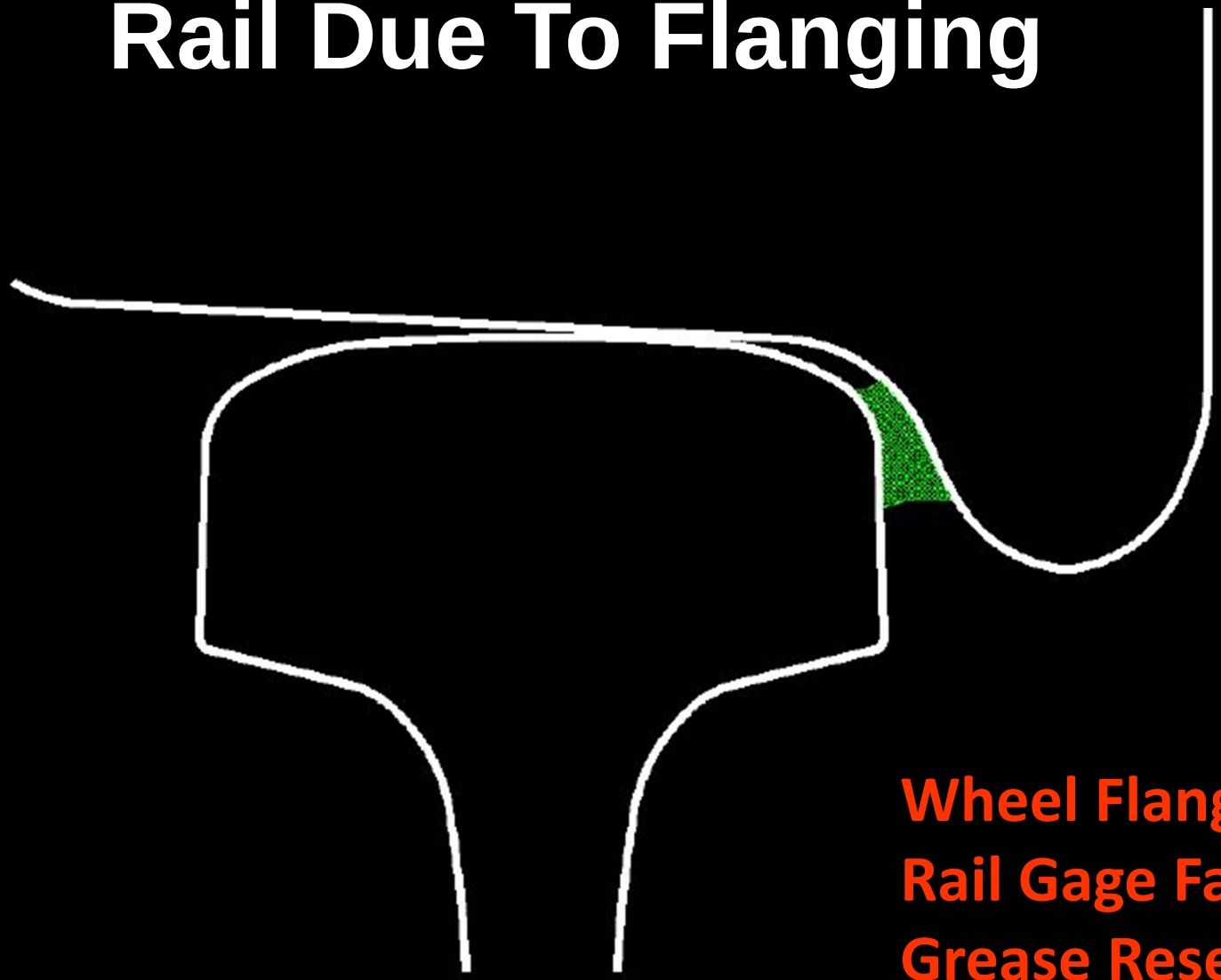
Grease Transfers to Flange



Grease Adheres To Wheel Flange

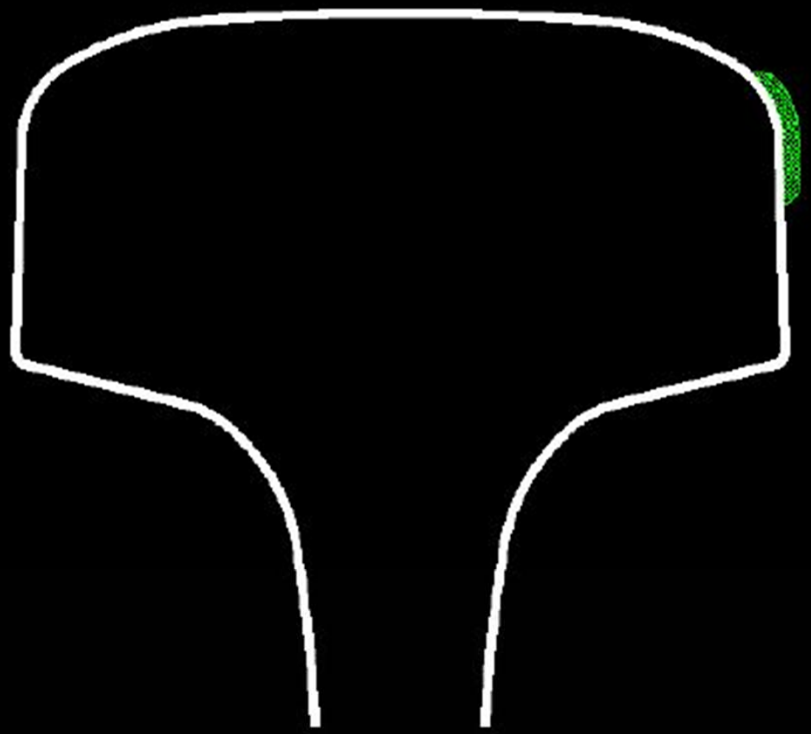


Grease Transfers Back To Rail Due To Flanging



Wheel Flanges and Rail Gage Face act as Grease Reservoirs

Grease Remains On Rail



Hi-Rail GF Systems

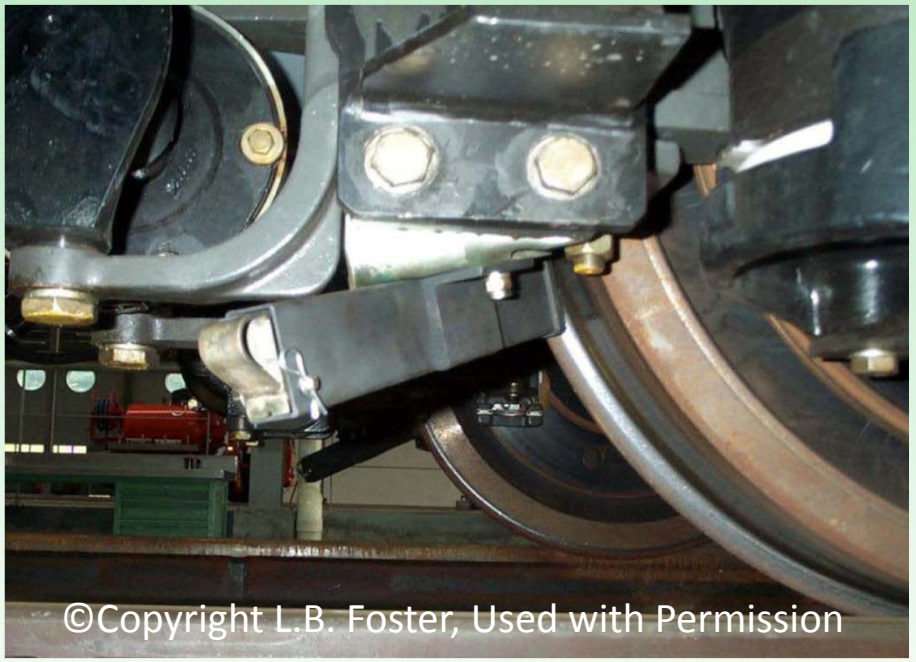
- Material Reservoir
- 12VDC Pump
- Control Electronics
- Applicator Nozzles

Hi-Rail GF Systems

Applied to high rail gage face, amount determined by vehicle speed. Frequency depends on train traffic.

Locomotive GF Systems

Pressurized Spray System



Stick System

Locomotive GF Systems

- Spray systems
  - Nozzle alignment critical (railhead/wheel tread contamination).
  - Spraying of oils preferred due to solids clogging.
  - Sensing used to apply in curves and/or tangents.

- Stick systems
  - Spring-loaded, requires no power
  - Applies solid film to wheel
  - No migration (railhead/wheel tread contamination).

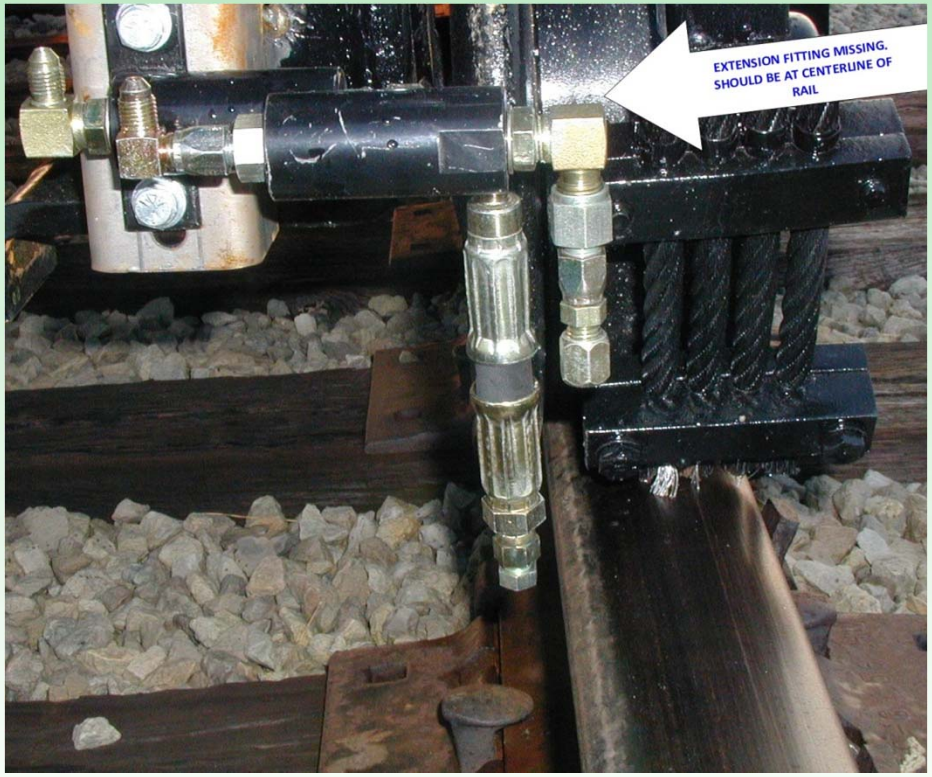
Wayside TORFC Bars

Applies material from the field side to the top of the running surface.

Wayside TORFC Bars

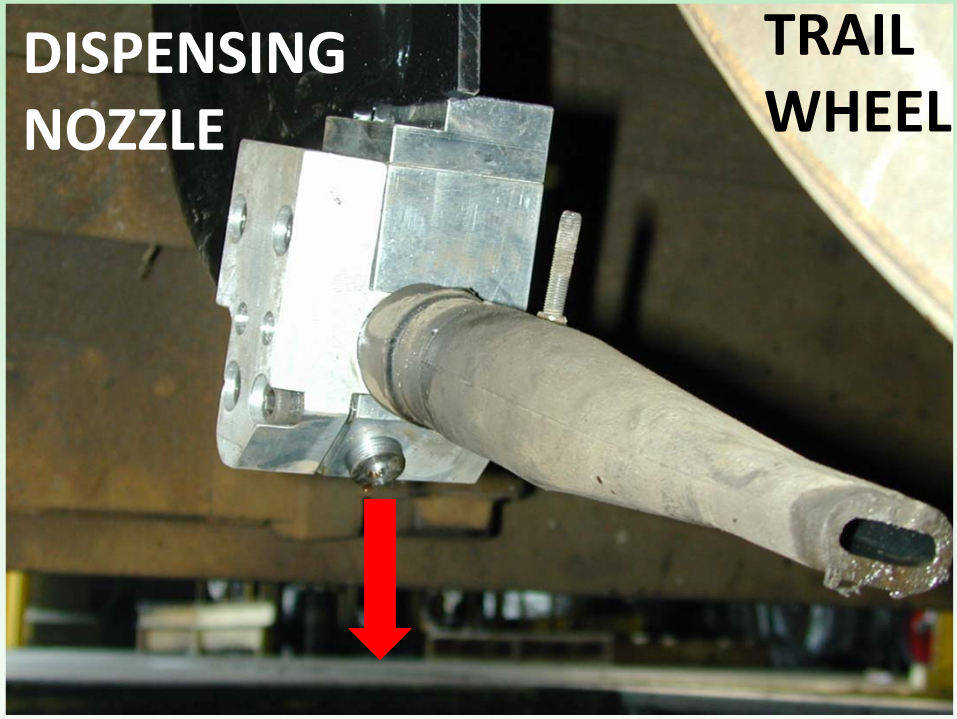
Passing wheels try to push material back to the field side.

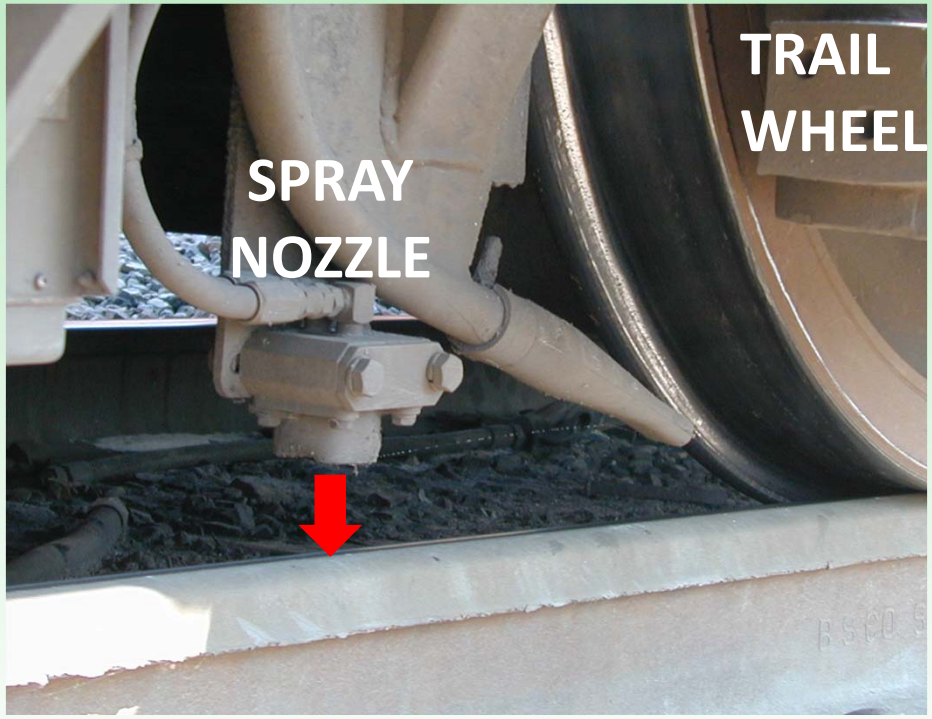
TORFC - Hi-rail



Material is sprayed or pressure-applied to the top of the railhead.

Locomotive TORFC





Material is applied behind the last wheel of the last locomotive. Curve sensing and/or trailing tonnage used to determine rate.

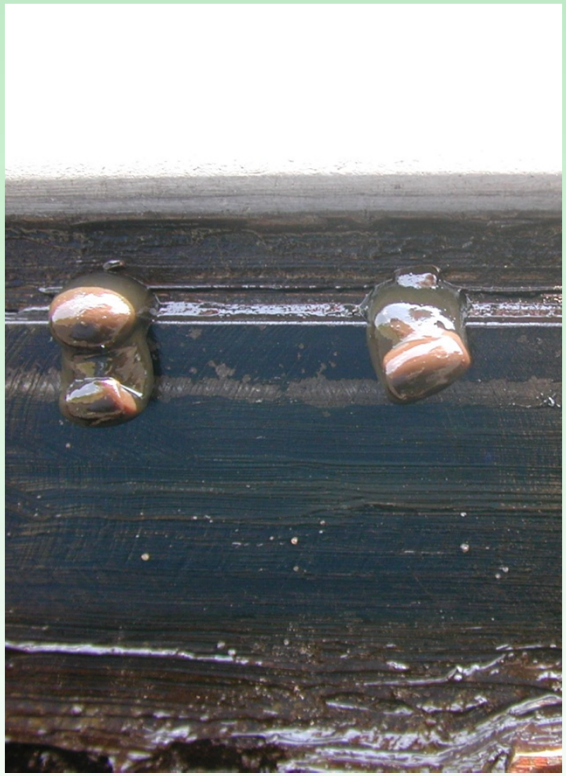
Car TORFC

Requires locomotive power/air, no operator involvement and can be placed anywhere in train. Application area programmable by GPS and possible to access remotely.

GF Material Properties

- Must form grease bead in hot temperatures.
- Must stick to the wheel and not fling off.
- Must adhere to the rail and transfer back and forth.
- Must protect against wear.
- Must not wash off in the rain.
- Must not “string” when applied.
- Must not have “oil” bleed.
- Must slump to the pump in cold weather.
- Multiple types (e.g. winter & summer) with overlapping temperature range between.

GF Material Properties



- **Must form grease bead in hot temperatures.**
- **Must stick to the wheel and not fling off.**

GF Material Properties

- **Must not wash off in the rain.**
- **Must not have “oil” bleed.**
- **Must not “string” when applied.**

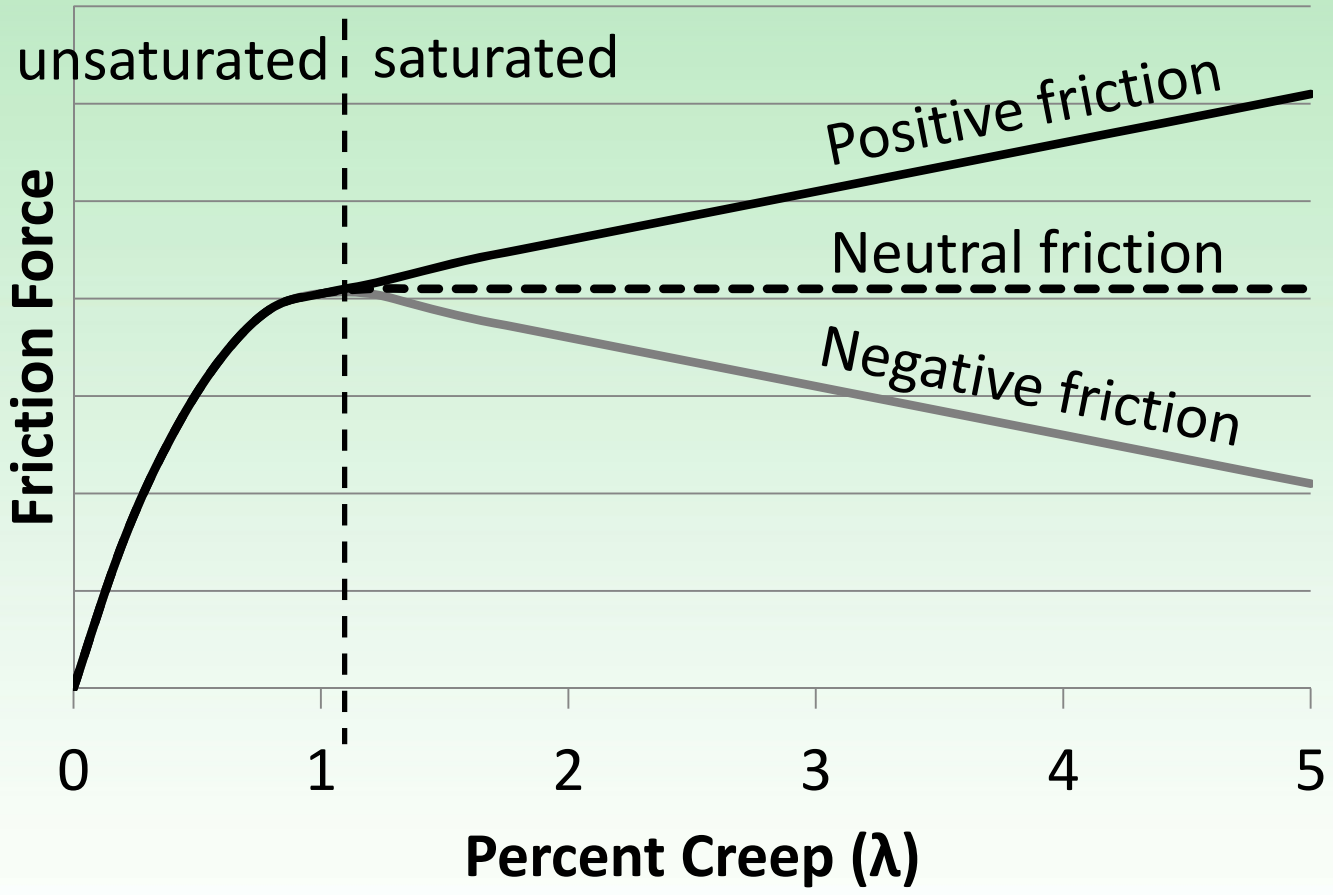
GF Material Properties

- **Must move or “slump” to the pump in cold weather.**

TORFC Material Properties

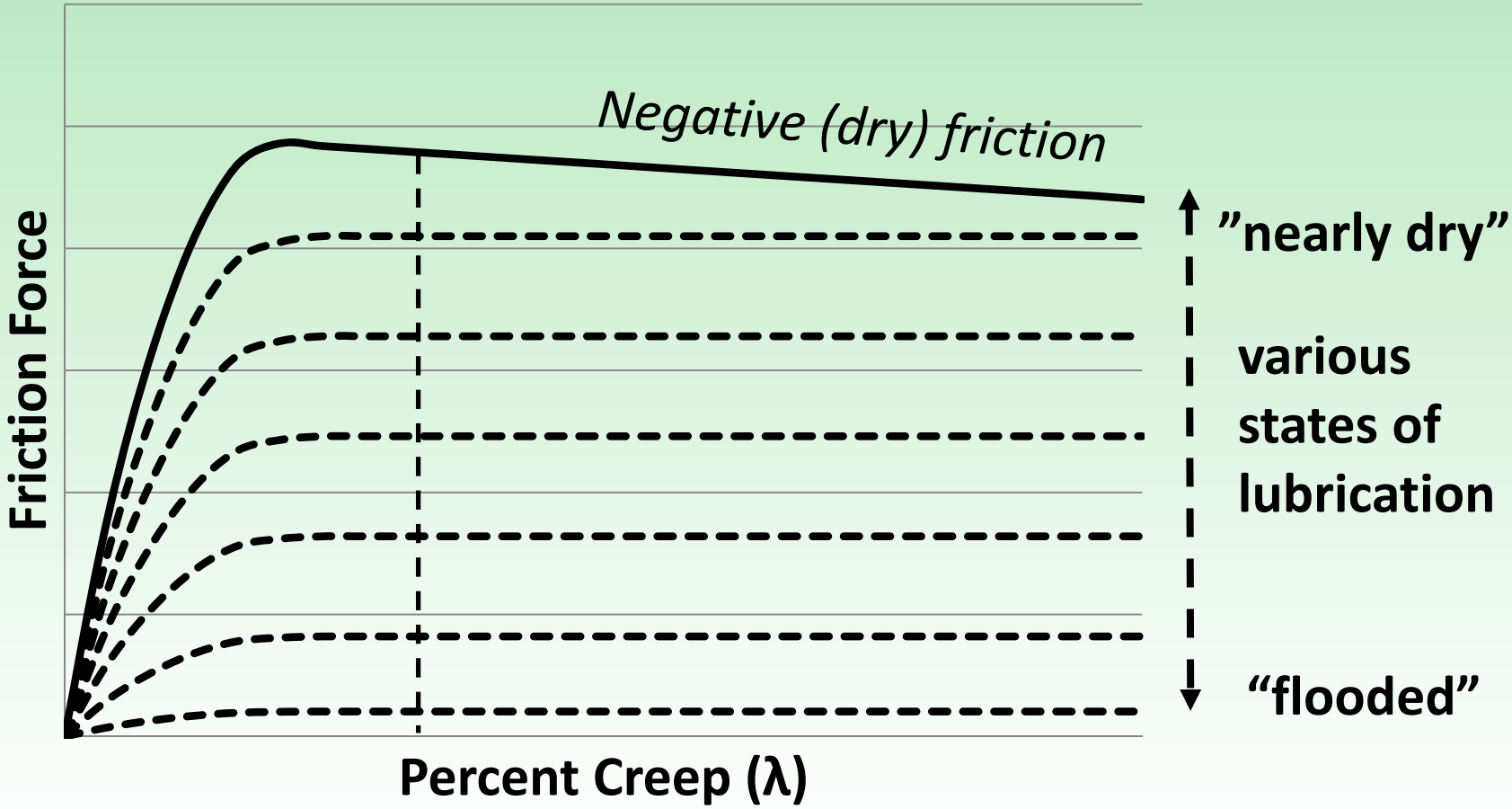
- Must adhere to rail/wheel.
- Reduce lateral curving forces.
- Control/manage the friction level
  - Low enough to reduce curving forces.
  - High enough not to impact locomotive adhesion and vehicle steering.
- Friction force/creepage relationship.
- Not increase RCF development (incompressibility).
- Not affect train signaling/rail testing systems.
- Compatible with equipment (e.g. corrosion).
- Usable temperature range.

TORFC Friction Behavior



*Friction force of positive friction materials are amount independent.

Lubricant Friction Behavior



*Friction force of lubricant materials are amount dependent.

Evaluating Performance - GF

Visual Observation of Grease Pattern (rail-HAL)

Evaluating Performance - GF

Visual Observation of Grease Pattern (flange)

Evaluating Performance - GF

Visual Observation of Metal Shavings after HAL

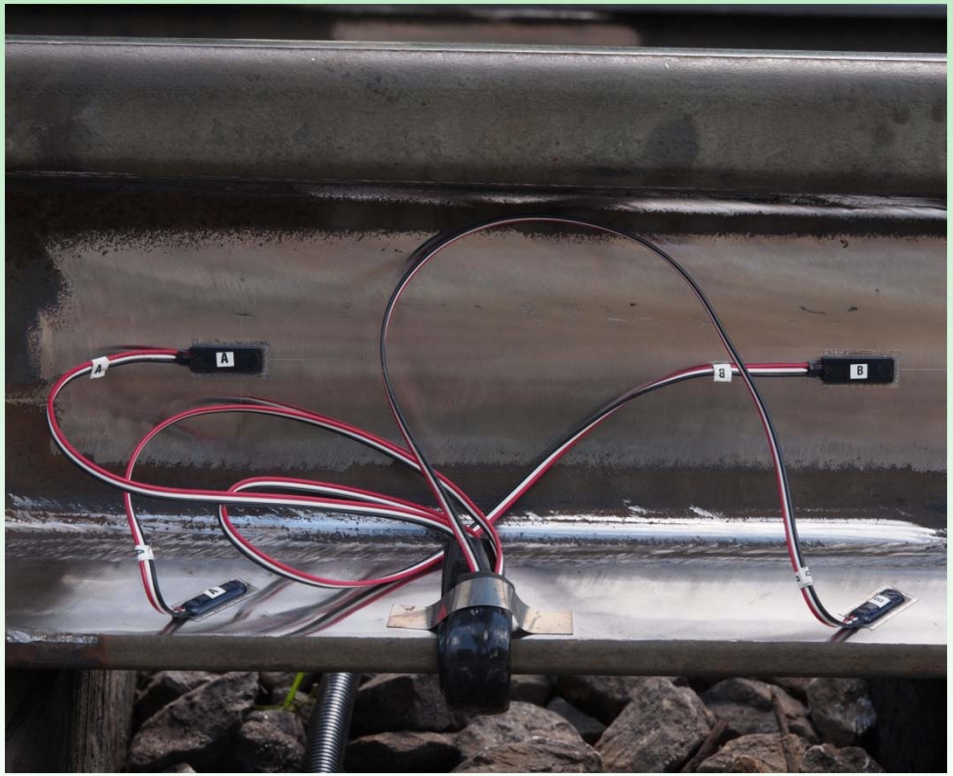
Evaluating Performance - GF

Hand-Push & High Speed Tribometer

GF Tribometer Measurements

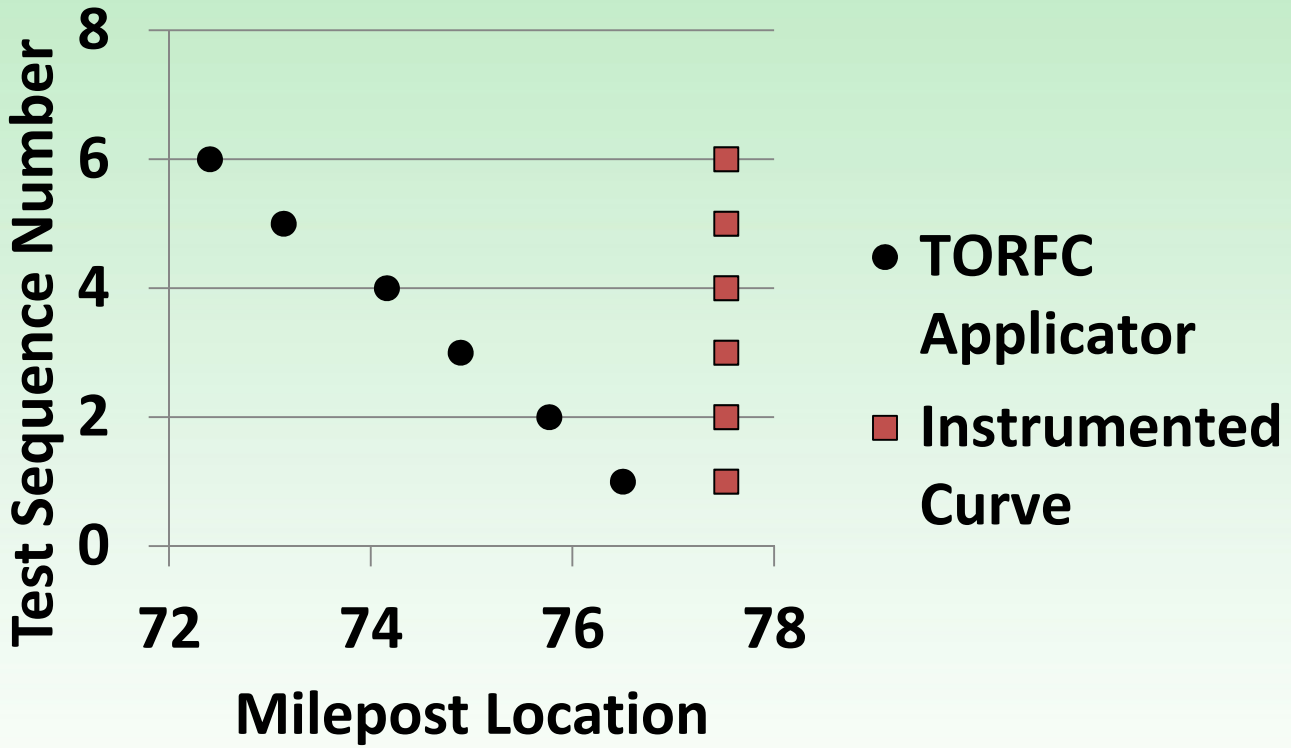
- **Only measures the friction on the rail, not the wheel.**
- **Only measures one point on the railhead, gage corner or gage face.**
- **Hand-push tribometer very dependent on operator experience.**
- **Measurements should never be made following a hi-rail vehicle (head contamination).**

Evaluating Performance - TORFC

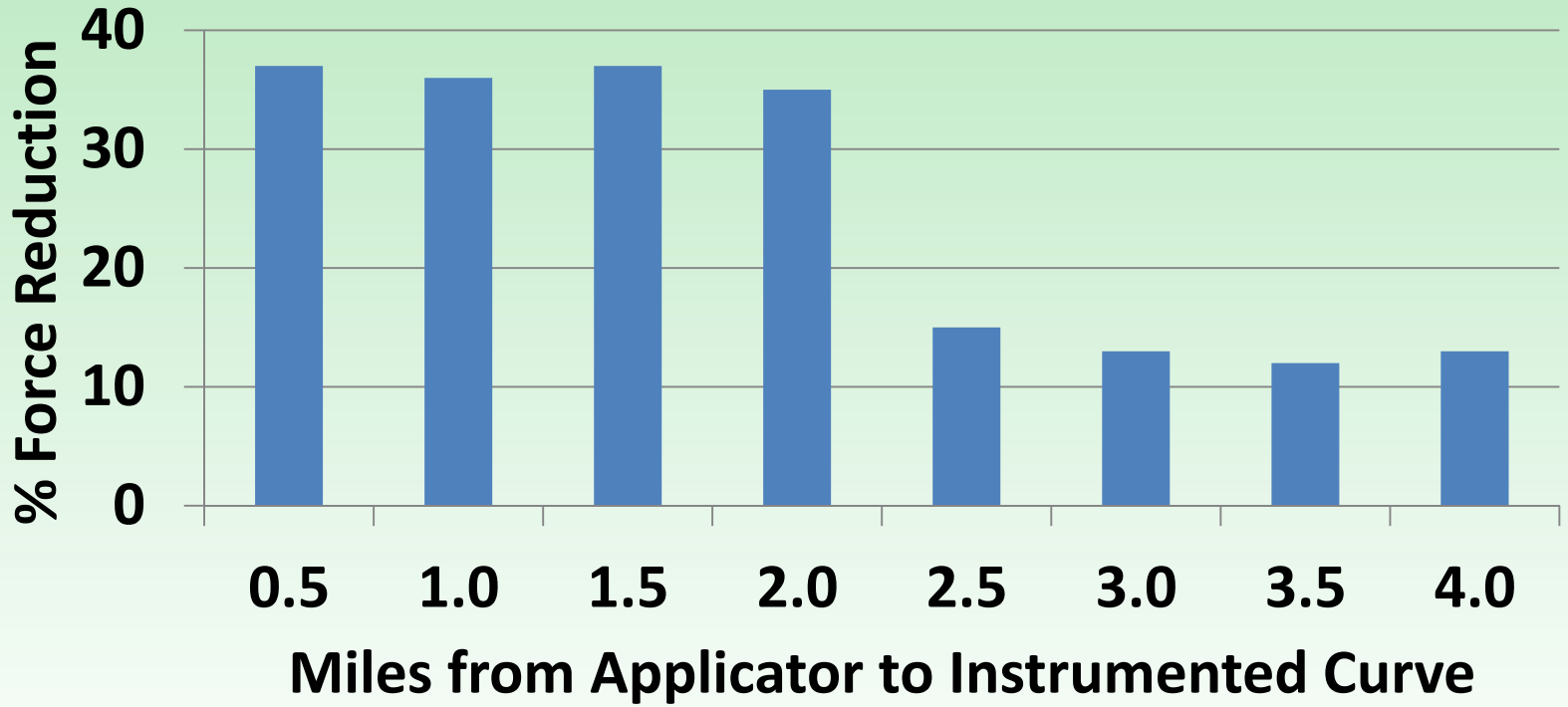


Strain gage-based lateral force monitoring site(s).

Evaluating Performance - TORFC



Evaluating Performance - TORFC



Metric is Lead Axles L/V Car Forces

Factors That Affect GF/TORFC

Air Brake Application

Locomotive Sanding

Distributive Power (Pushers)

Thank You!

Questions?