Phone: +61 2 8987 1922 | www.elastotec.com.au

Pulley Lagging Analysis Tool

laggingselect
PERFORMANCE OPTIMISATION TOOL

Elastotec Australia, in collaboration with Conveyor Dynamics Inc. (CDI), has developed a new Lagging Analysis Tool, called **Laggingselect** to quantify the complex interaction between the belt and the pulley lagging for both driven and non-driven applications.

Laggingselect allows a detailed examination of:

- Traction utilization, including the determination of if and where localized slip will occur.
- Evaluation of the lagging and belt wear power, which causes wear when localized slip occurs.
- Defines the maximum level of shear stress applied to the belt and belt splices which can affect fatigue life.
- Evaluates the optimal selection of lagging type for a conveyor design to avoid inducing shear stress caused by incompatible belt and lagging stiffness.
- Evaluate the shear stress developed in the lagging at key locations to identify if the rubber and/or rubber adhesion bonds (ceramic tile and pulley steel) may fail prematurely.
- Evaluate the effects of uneven lagging wear, belt cover wear and material buildup on both driven and non-driven pulleys, which results in differential shear and accelerated wear.

Usage and benefits

Typical usage and benefits of **Laggingselect** are for:

- Selecting the optimal lagging type and design for a new or refurbished conveyor pulley evaluated for the specific conveyor design.
- Evaluating the cause(s) and/or contributing factors of premature lagging failure in an existing application.
- Evaluating an existing pulley lagging selection and quantifying the benefits of changing to an alternate lagging selection to improve belt and lagging wear life.

It is noted that the **Laggingselect** does not consider additional factors that are required to be considered during lagging selection, namely:

- Water and material shedding capabilities.
- Wear resistance.

These are evaluated along with the **Laggingselect** results to select the best lagging for the required application.

Analysis methods

Pulley lagging selection has traditionally been based upon experience or industry standards without a detailed engineering-based understanding of the system. **Laggingselect** uses a numerical algorithm to solve the simultaneous equations which describe how the shear stress and strain are developed between the belt and pulley lagging around the full pulley wrap as a function of the belt and lagging shear stiffness and the available friction that is developed. The available friction used in the analysis is based upon the variant friction model in lieu of the conventional Euler friction method. The variant friction model reflects how an elastomeric material's friction is highly dependent upon the applied contact pressure. At low contact pressures, the available friction is generally higher than that in traditional Euler theory because the contact surfaces can increase their micro-surface interaction as relative movement increases towards a maximum saturation. Conversely, at higher contact pressures, the micro surface interaction is already approaching maximum saturation resulting in an apparent friction approaching the Euler theory traditional values. The pulley lagging internal shear stress is evaluated within the tool in the form of a 'Lagging Performance Envelope'. The envelope is developed using Finite Element Analysis (FEA) methods to define the acceptable operating envelope (shear stress versus normal pressure) for a specific lagging design to achieve an acceptable serviceable life based upon defined rubber and rubber bond shear fatigue characteristics at key locations including:

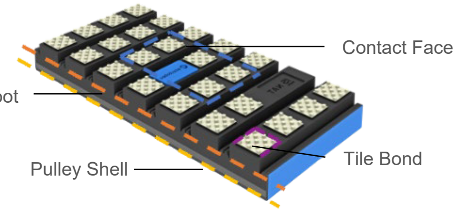
- Lagging/belt contact interface
- Lagging tread root
- Pulley shell bond interface

Phone: +61 2 8987 1922 | www.elastotec.com.au

PULLEY LAGGING ANALYSIS TOOL

- Ceramic tile bond interface

The specific lagging design shear modulus is also derived from the FEA output for use in the analysis. Differential induced shear caused by uneven lagging wear, belt wear and material buildup is also analyzed for both driven and non-driven pulleys by deriving the resultant differential tensions developed across the belt width in contact with the pulley due to the differential path lengths. The differential tensions across the belt width cause areas that are not worn to resist the change in peripheral speed and belt tension in areas that are worn or built-up resulting in an induced differential shear stress between the lagging and the belt. This can be additive to the shear stress developed on driven pulleys and cause a non-driven bend pulley to be subject to shear stress similar to that of a drive pulley. It can be demonstrated that uneven wear and/or material buildup on a pulley can result in a high rate of lagging wear and a positively reinforcing damage mechanism leading to a rapid wear failure.



Contact Face: The surface of the lagging in contact with the belt cover

Tread Root: The base of the lagging profile, level with the grooves/sipes of the lagging

Pulley Shell: Where the lagging is adhered to the pulley shell

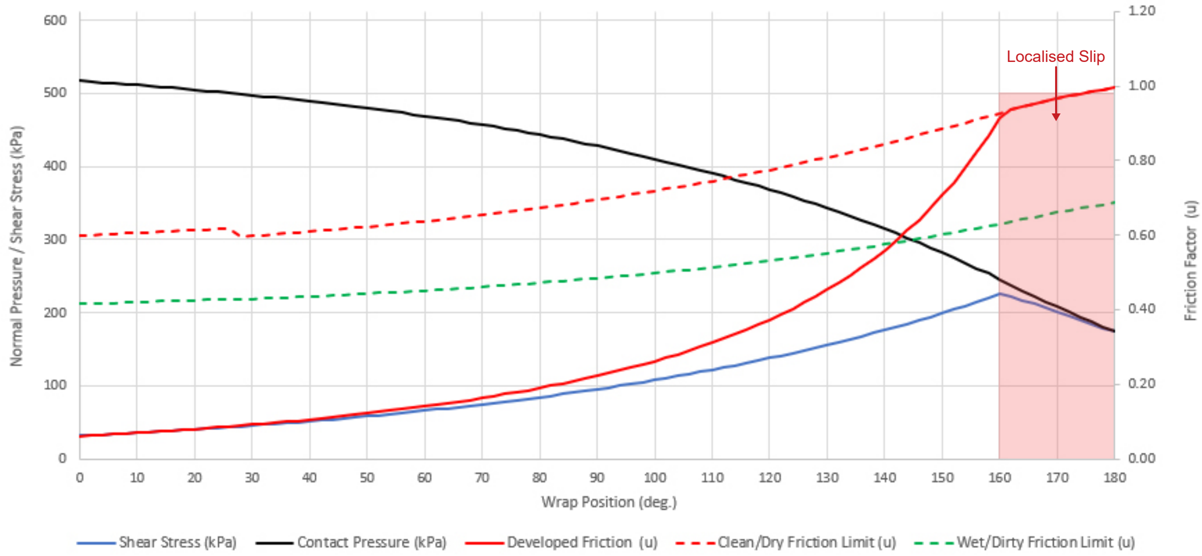
Tile Bond: The bond/adhesion of the ceramic tile into the rubber section of the lagging

Note: None of these factors should exceed 100% of their available utilization. It the limits are exceeded, it is predicted that lagging could fail in this area.

Analysis Results - Example

The Lagging select output is presented in a graphical format for review and interpretation by the designer, along with numerical results quantifying the utilization and magnitude of key selection factors:

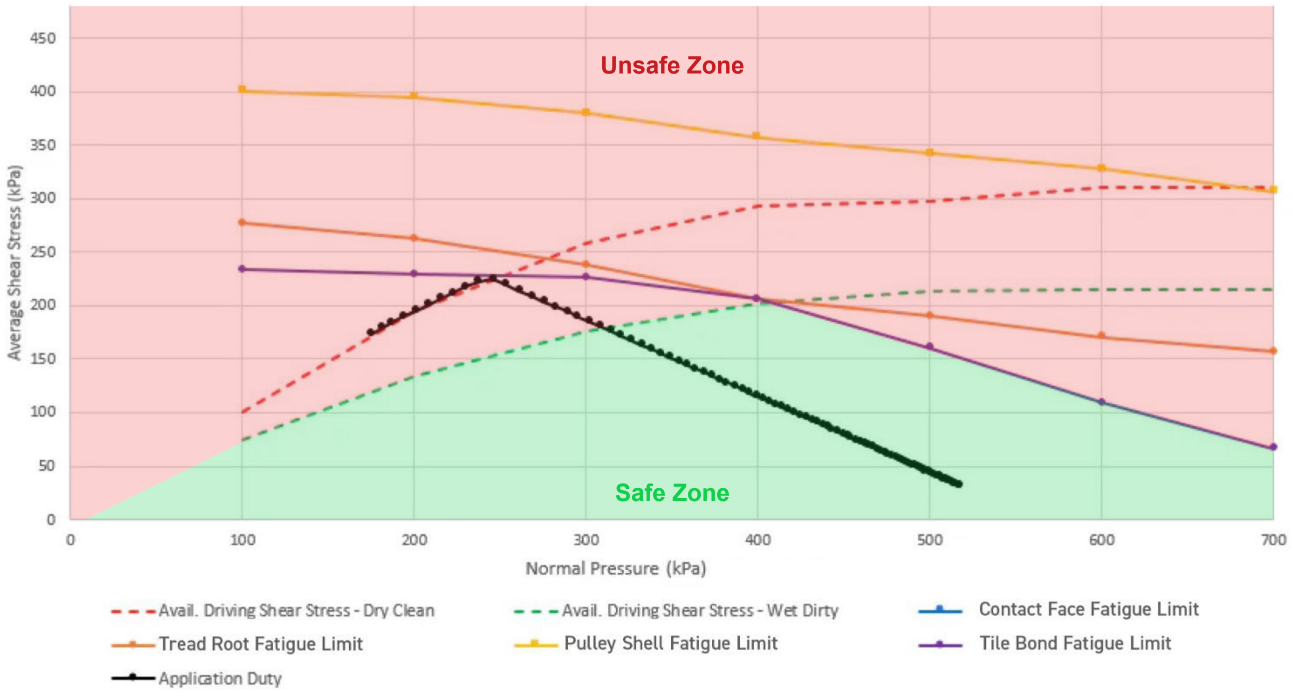
Pulley Lagging Analyss: High Power, Drive Pulley, Dry Clean
Elastotec 38% Ceramic Dimpled, 12mm, 65 Duro



Traction	100%	of available traction util.	382	kN	min. T2 tension to avoid localized slip	0.27	Euler equivalent running friction factor	
Results:	20	degrees of local slip = 11%	225	kPa	Maximum shear stress	3.08	mm	Belt contracture
						0.61	mm	of localized slip movement
						0.529	mm/s	localized slip speed
						0.04	W/mm	of width - slip wear power

PULLEY LAGGING ANALYSIS TOOL

Lagging Envelope: Elastotec 38% Ceramic Dimpled, 12mm, 65 Duro



Lagging Results:				
	0%	Contact Face Shear Stress util.	36%	Pulley Shell Shear Stress util.
	57%	Tread Root Shear Stress util.	62%	Tile Bond Shear Stress util.

Analysis Results – Interpretation

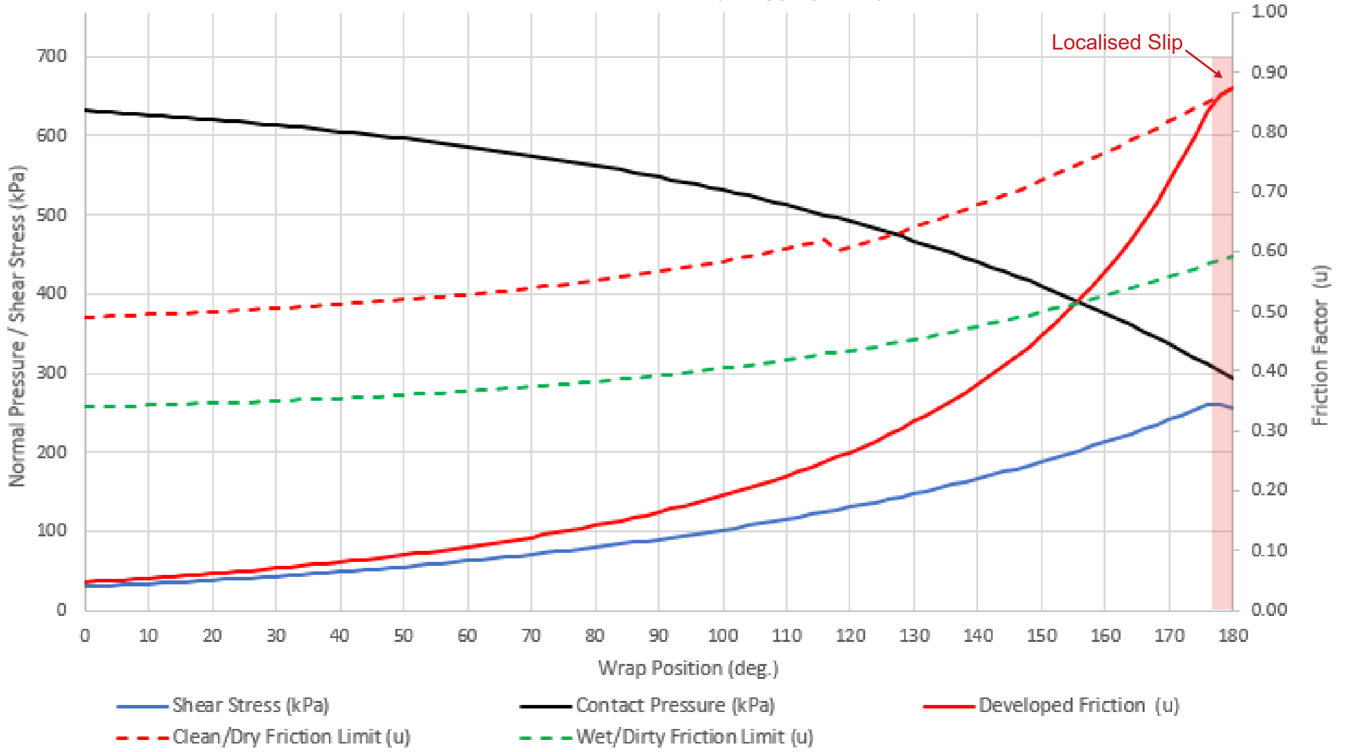
The results of the Pulley Lagging Analysis are summarized on a plot representing the average normal pressure, shear stress and the developed friction between the lagging and the belt around the wrap angle between the belt entry and exit.

To assist in interpreting the analysis results, please refer to the following key points and example interpretation:

- The primary Y-Axis represents the Average Shear Stress and Normal pressure developed between the lagging and the belt.
- The secondary Y-Axis represents the effective friction factor developed as a function of Normal Pressure and Shear stress.
- The X-Axis represents the wrap position from the entry point T1 to the exit point T2 over the full wrap.
- The Available Driving Shear Stress (dry and wet) represent the upper limits as defined by the Variant Friction model and is a characteristic of the lagging material and geometry.

PULLEY LAGGING ANALYSIS TOOL

Example interpretation of a Pulley Lagging Analysis plot



From the example plot above, the Shear Stress developed gradually increases around the pulley wrap with a corresponding decrease in Contact Pressure as the tension in the belt decreases towards the T2 exit. Localized belt slip will occur when the Shear Stress builds to a level where the Developed Friction intersects the Friction Limit lines. Both clean/dry and wet/dirty friction limits are represented.

An efficient lagging selection will show a progressive increase in Shear Stress around the full wrap with lower peak Shear Stress levels and friction requirements. A mismatch in the belt and lagging selection, primarily a mismatch in shear stiffness, can be caused by a lagging that is too stiff and resist the belts tendency to contract as the tension decreases around a drive pulley. This induces a shear stress which can exceed the friction available resulting in a greater localized slip.

Analysis Results – Interpretation of Lagging Performance Envelope

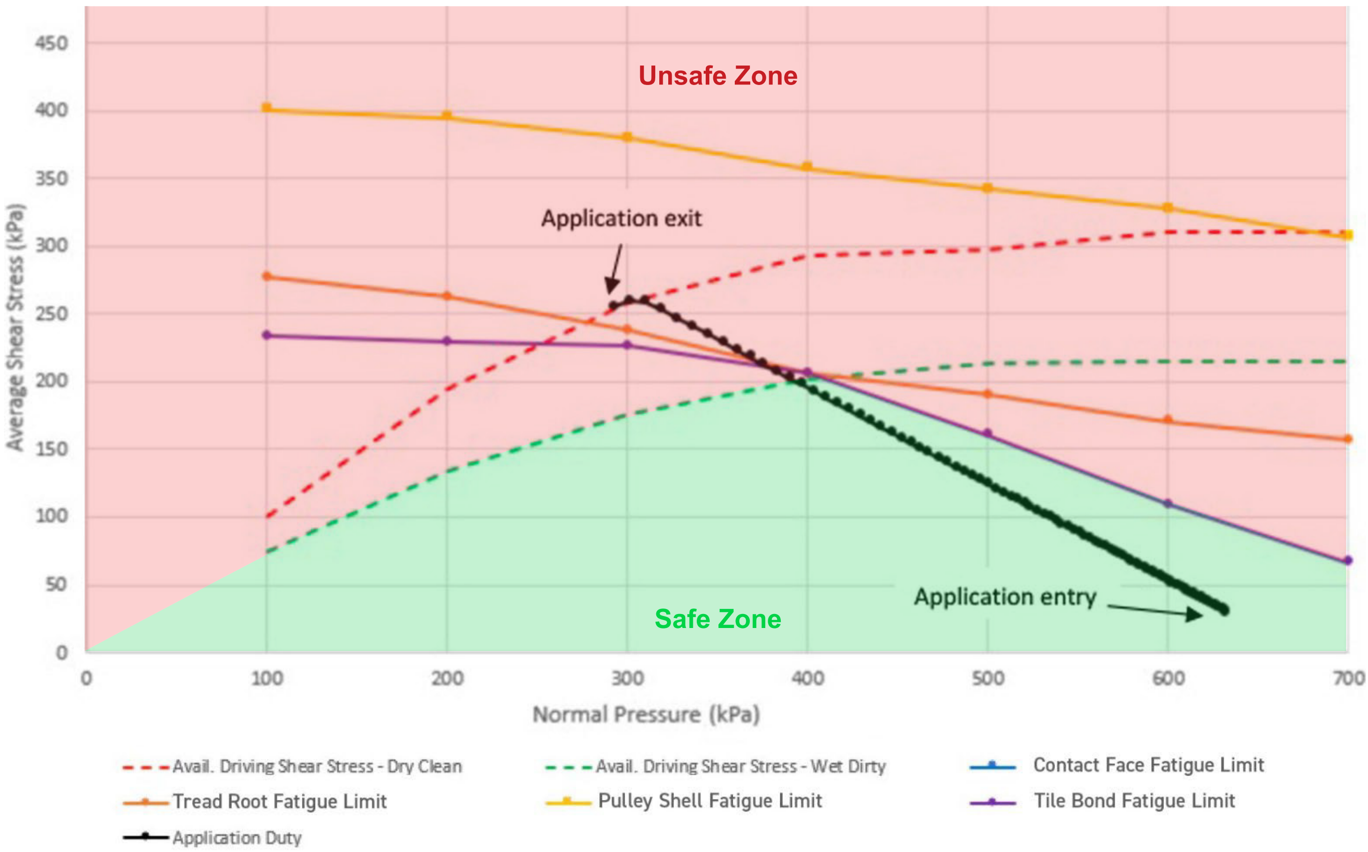
The Lagging Performance Envelope plot is a complex representation of the traction and shear stress fatigue limits of the lagging design evaluated. To assist in interpreting the envelopes developed please refer to the following key points and example interpretation:

- The Y-Axis represents the Average Shear Stress between the lagging and the belt.
- The X-Axis represents the Average Normal Contract Pressure between the lagging and the belt.
- The Available Driving Shear Stress (dry and wet) represent the upper limits as defined by the Variant Friction model and is a characteristic of the lagging material and geometry.
- The lines representing the fatigue stress limit at each of the key points represent the envelope., above which is indicative of excessive shear stress being developed in the lagging rubber at that key point.
- The Application line represents the nominal range of normal pressure and shear stress along the arc of contact between the belt entry point to the exit point, i.e. T1 and T2 conditions from the Pulley Lagging Analysis plot.

The percentage of utilization at each key point is also presented in the results.

PULLEY LAGGING ANALYSIS TOOL

Example interpretation of a Lagging Performance Envelope



From the example plot above, it can be interpreted that the application line is just within the performance envelope for the lagging example evaluated. However, the last approximate 20 degrees of contact arc before the belt exits the pulley @ T2 does indicate that the fatigue shear stress in the lagging rubber at both the tread root and tile bond locations is marginally exceeded.

This would indicate a fatigue life in these locations of slightly less than 5 years. It also indicates that under less than ideal (clean dry) conditions, the last 20 degrees of contact will have localized slip which can result in an increased rate of abrasion wear of both the lagging and belt.

ENGINEERED TO PERFORM

PULLEY LAGGING ANALYSIS TOOL

Information required

To perform a comprehensive conveyor analysis using laggingselect requires the following information for each pulley to be provided in either metric or us imperial units:

PARAMETER	VALUE	UNITS
Conveyor Design		
Belt Tension – T1 (incoming)		kN / kips
Belt Tension – T2 (outgoing)		kN / kips
Belt Speed		m/s / fpm
Motor Power		kW / hp
Belt Details		
Belt carcass type (Steel or Fabric)		
Belt Strength		kN/m / piw
Belt Width		mm / in
Pulley Details		
Pulley Diameter (over shell)		mm / in
Wrap Angle		Degrees
Belt Cover in Contact Details		
Cover Thickness		mm / in
Cover Durometer (Shore A)		duro (A)
Pulley Lagging Details		
Lagging Type		
Lagging Thickness		mm / in
Lagging Durometer (Shore A)		duro (A)

This information is typically contained within a conveyor design report and/or within conveyor and conveyor component equipment datasheets.

In cases where the existing belt or pulley contact covers are worn unevenly or exposed to material build-up then then additional information is required for a comprehensive analysis:

PARAMETER	VALUE	UNITS
Material Buildup		Height mm / in
		Width mm / in
Belt Cover Wear		Height mm / in
		Width mm / in
Pulley Lagging Wear		Height mm / in
		Width mm / in

For more information contact:

David Molesworth
Elastotec Pty Ltd
Email: david@elastotec.com.au
Mobile: +61 0423 200 178