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INTRODUCTION TO

AUTOMATED AMPLITUDE ADJUSTMENT

John Gravatt



INTRODUCTION



John

Gravatt

**PRODUCT MARKETING MANAGER,
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- Recovering Engineer
- Ingersoll-Rand / Volvo 2003-2020, focused primarily on paver design
- Semi Retirement (2020-2023)
- BOMAG Americas 2023 - present

AGENDA

Introduction to Automated Amplitude Adjustment

- 01 Existing Vibration Systems
- 02 2 Amplitude / 2 Frequency Vibration Systems
- 03 Multiple Amplitude Vibration Systems
- 04 Oscillation Systems
- 05 Directed / Vectoring Vibration Systems
- 06 Summary

VIBRATION SYSTEMS

OVERVIEW



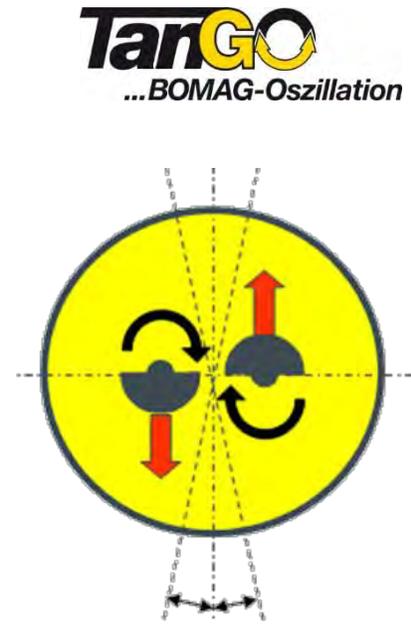
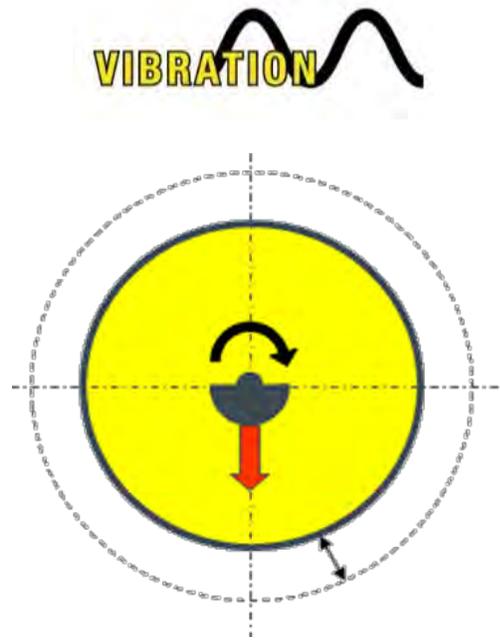
VIBRATION SYSTEMS

Overview

Conventional Vibration: A vibration system that uses a single eccentric mass to create vibration, often with adjustable frequency and/or amplitude.

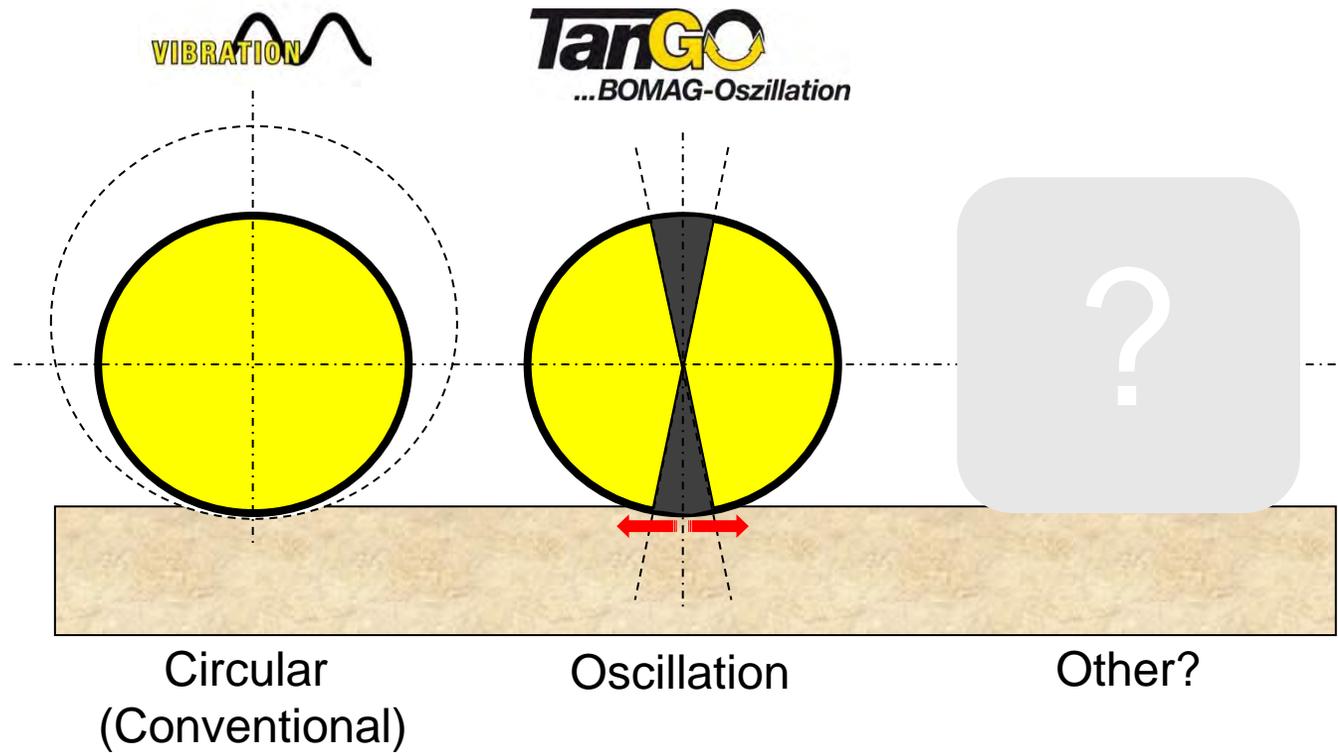
Oscillation Vibration: A vibration system that uses two or more eccentric masses which are typically 180° out of phase and rotating in the same direction, thus creating a torque and corresponding rotational vibration of the drum.

Other Systems?



VIBRATION TYPES

Overview



VIBRATION SYSTEMS

2 AMPLITUDE / 2 FREQUENCY

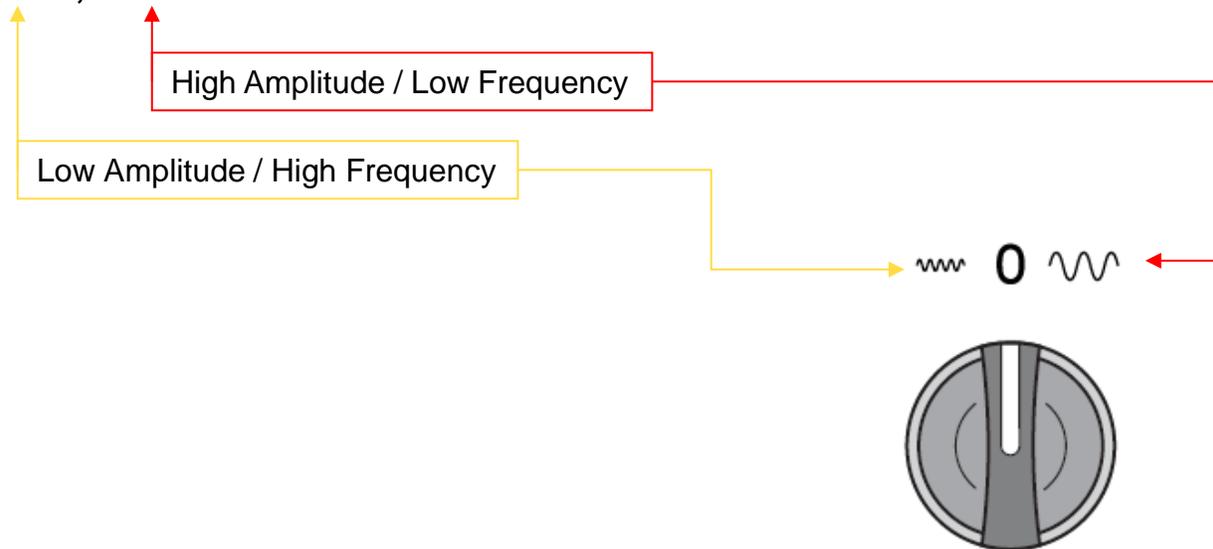
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VIBRATION SYSTEMS

2 Amplitude / 2 Frequency

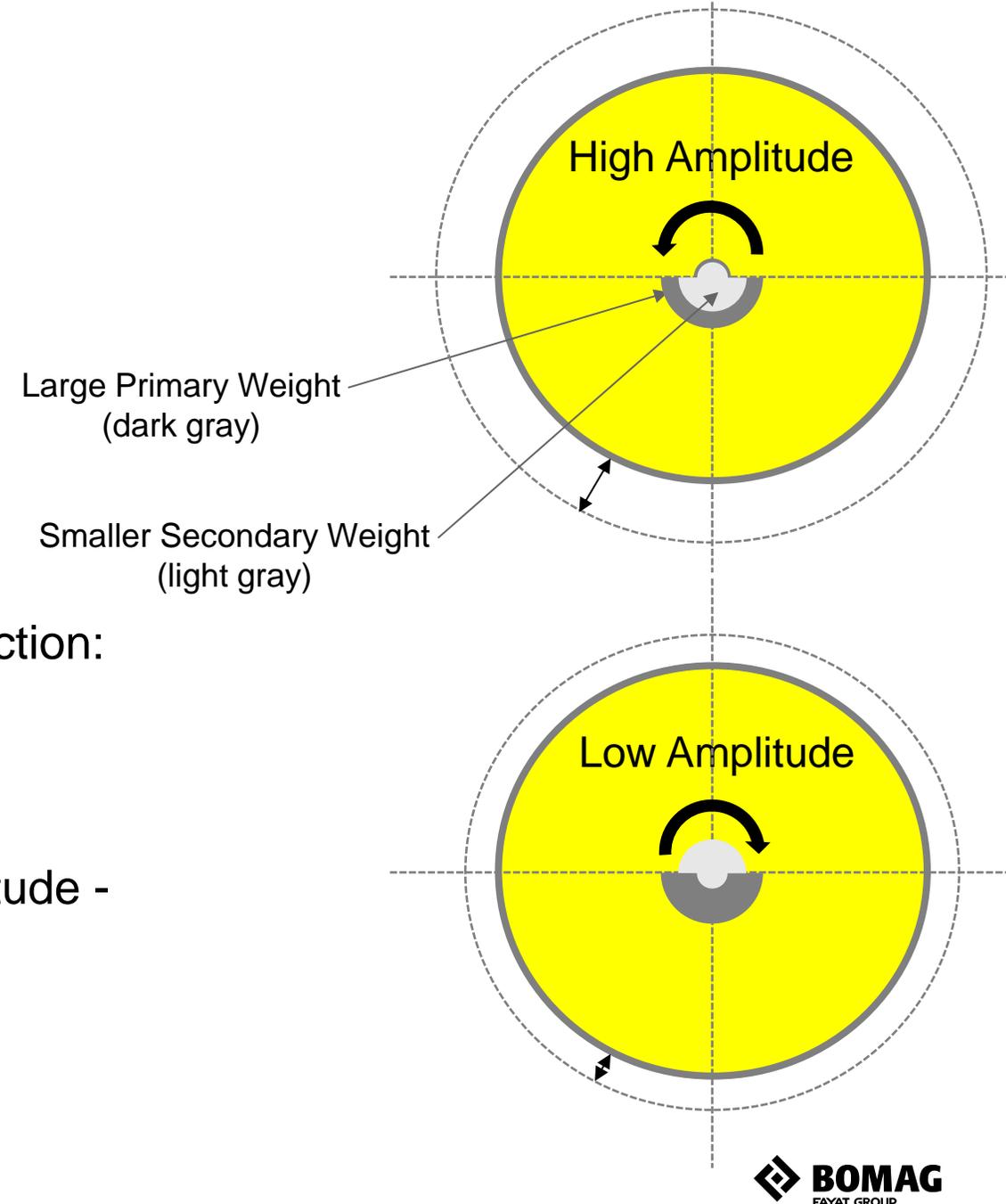
- Early systems were a single weight turning at a set speed (single frequency / single amplitude)
- Modern systems are often dual amplitude and dual frequency
 - Lo/Hi, Hi/Lo



VIBRATION SYSTEMS

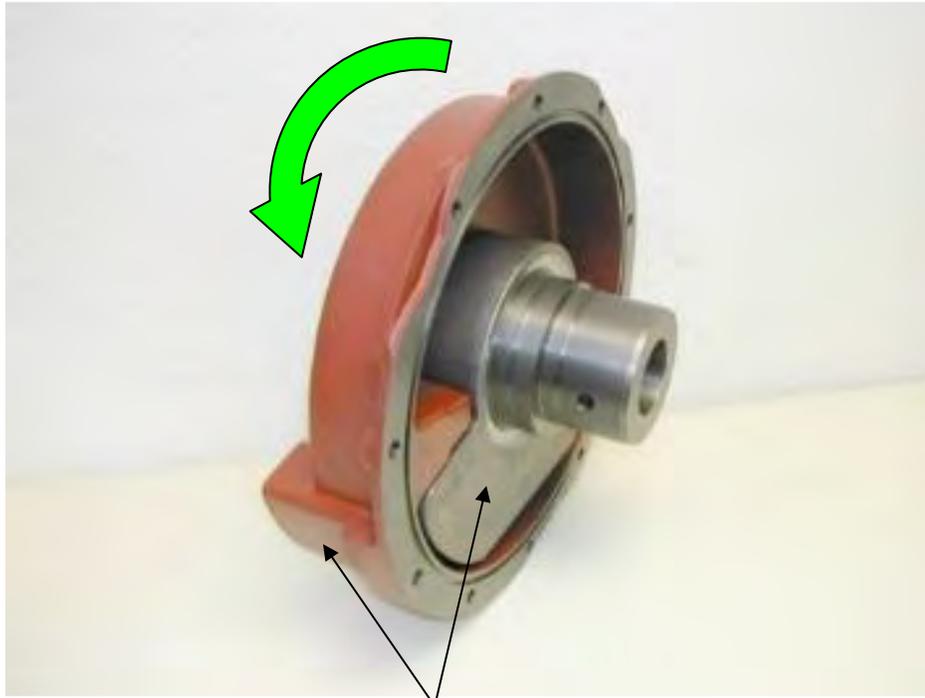
2 Amplitude / 2 Frequency

- Uses a 2 coaxial eccentric weights
 - Large Primary
 - Smaller Secondary (Offset weight)
- Provides 2 settings, based on eccentric turning direction:
 - Weights aligned = High Amplitude (CCW in example)
 - Weights opposed = Low Amplitude (CW in example)
- Vibration frequency is inversely related to the amplitude -
As amplitude increases, frequency decreases
 - Weights aligned = High Amplitude + *Low Frequency*
 - Weights opposed = Low Amplitude + *High Frequency*

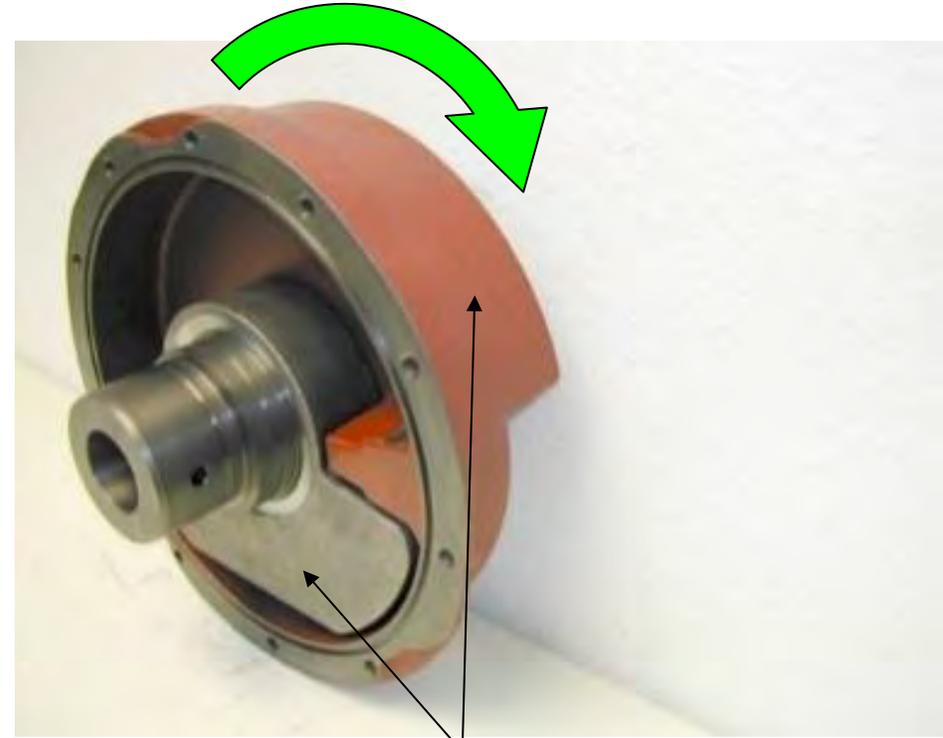


VIBRATION SYSTEMS

2 Amplitude / 2 Frequency



Weights aligned
High Amplitude



Weights opposed
Low Amplitude

VIBRATION SYSTEMS

2 Amplitude / 2 Frequency

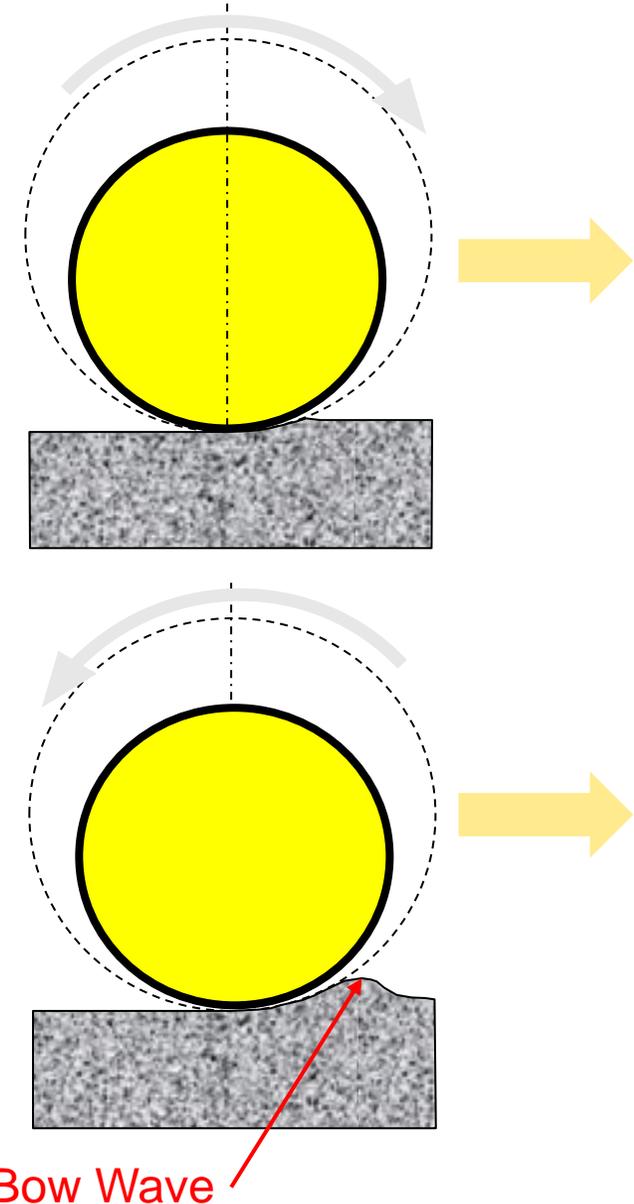
■ Advantages

- Can handle thin lifts (low amplitude)
- Can handle thick lifts (high amplitude)

■ Disadvantages

- Operator must understand amplitude and how / when to adjust it - Can damage aggregate when not used correctly
- Can amplify bow-wave effect

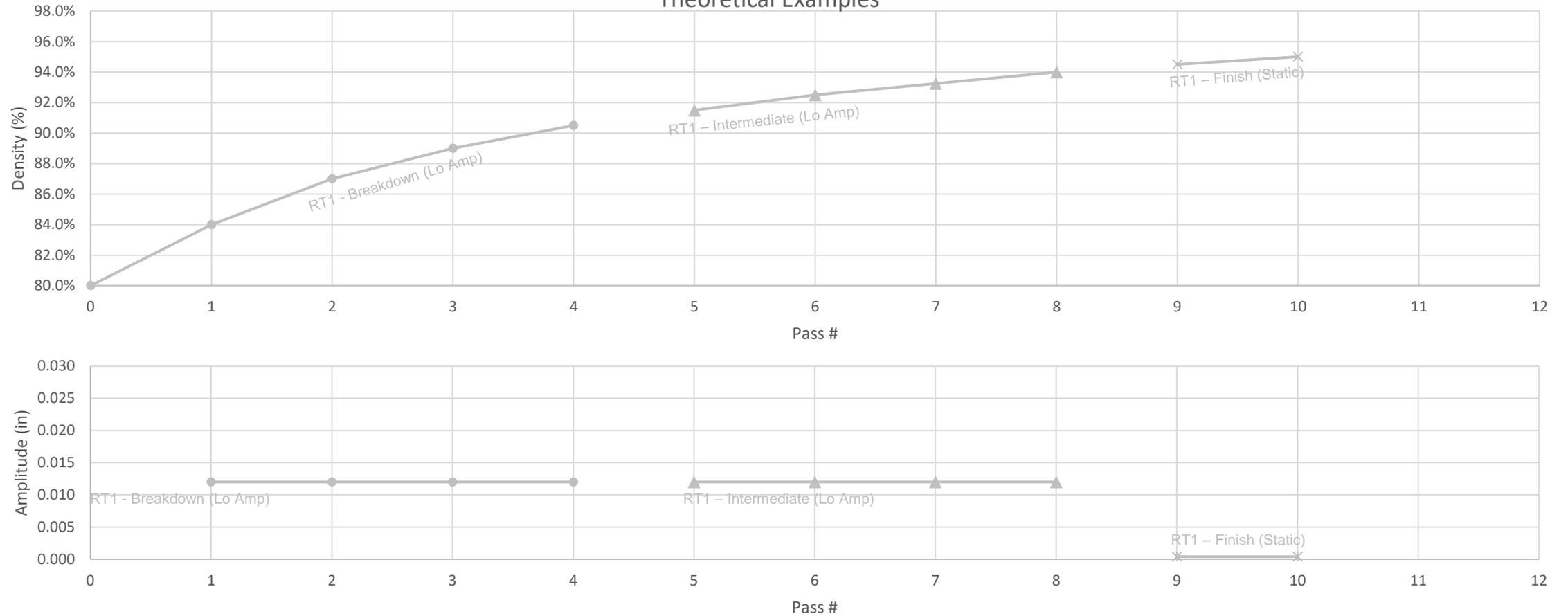
- **Tip:** On a sensitive mix, mitigate bow-wave effects by vibrating in the low-bow-wave direction only



VIBRATION SYSTEMS

2 Amplitude / 2 Frequency

Density and Amplitude per Pass
Theoretical Examples



VIBRATION SYSTEMS

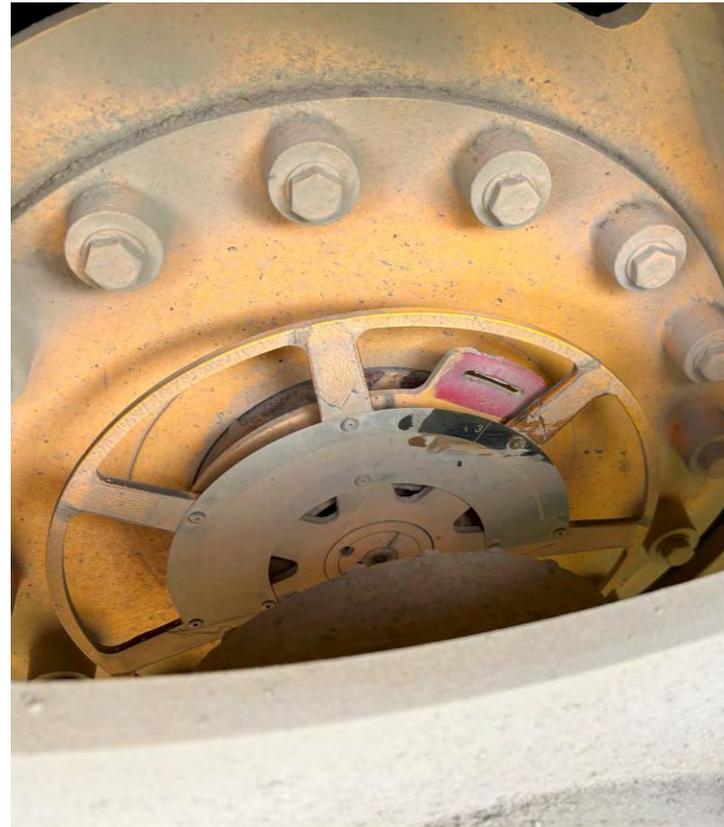
MULTIPLE AMPLITUDE (>2)



VIBRATION SYSTEMS

Multiple Amplitude Systems

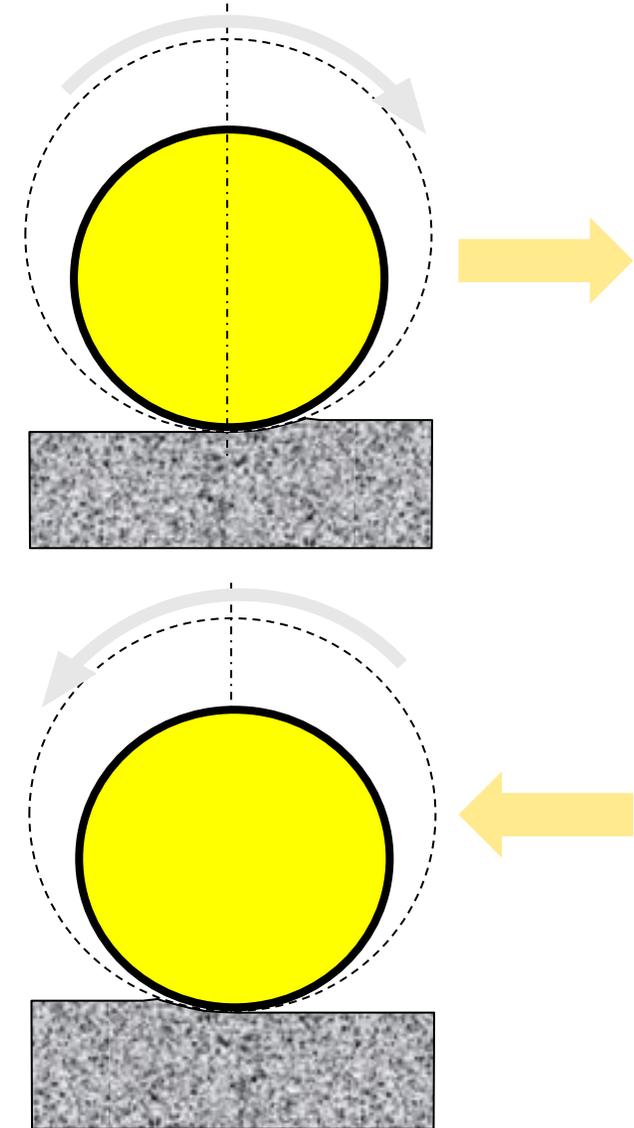
- Similar to 2A/2F systems – use multiple weights that can be manually positioned relative to one another
- Multiple systems available: 4-, 5-, and 8- amplitude
- Amplitude is adjusted using an amplitude wheel in each drum



VIBRATION SYSTEMS

Multiple Amplitude Systems

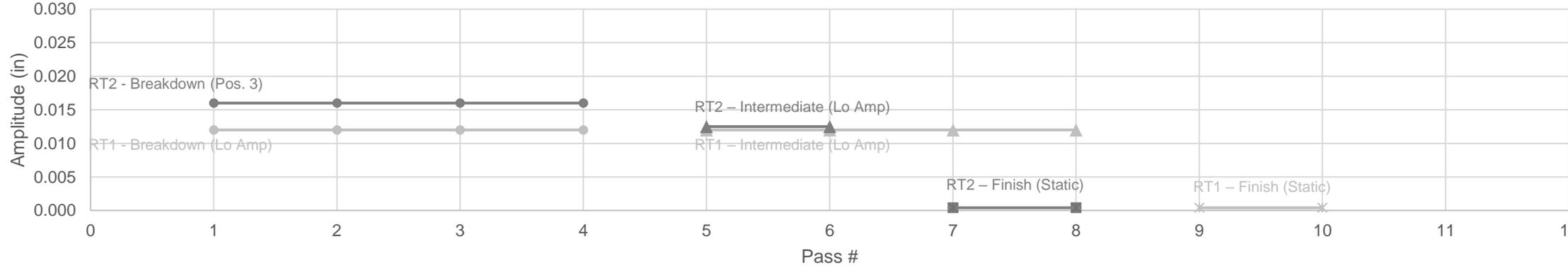
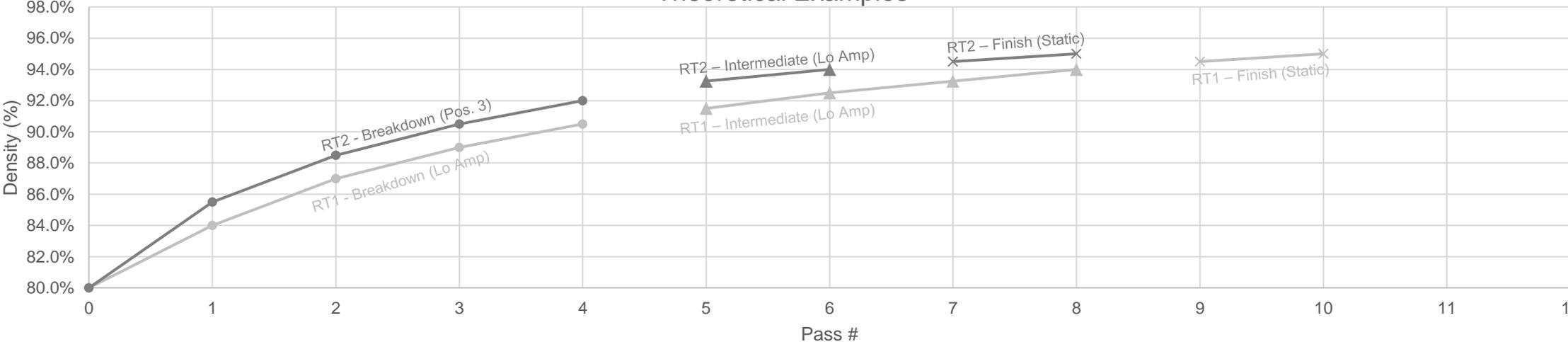
- Advantages
 - Provide great flexibility for various lift thicknesses and mix designs
 - Bow wave mitigation by reversing vibration direction (select machines)
- Disadvantages
 - Require a skilled operator or QC technician to set up the machine
 - If not properly adjusted, can damage the aggregate or mat
- **Tip:** Pay attention to the amplitude adjustment decal on the side of the machine for setup guidance



VIBRATION SYSTEMS

Multiple Amplitude Systems

Density and Amplitude per Pass
Theoretical Examples



VIBRATION SYSTEMS

OSCILLATION



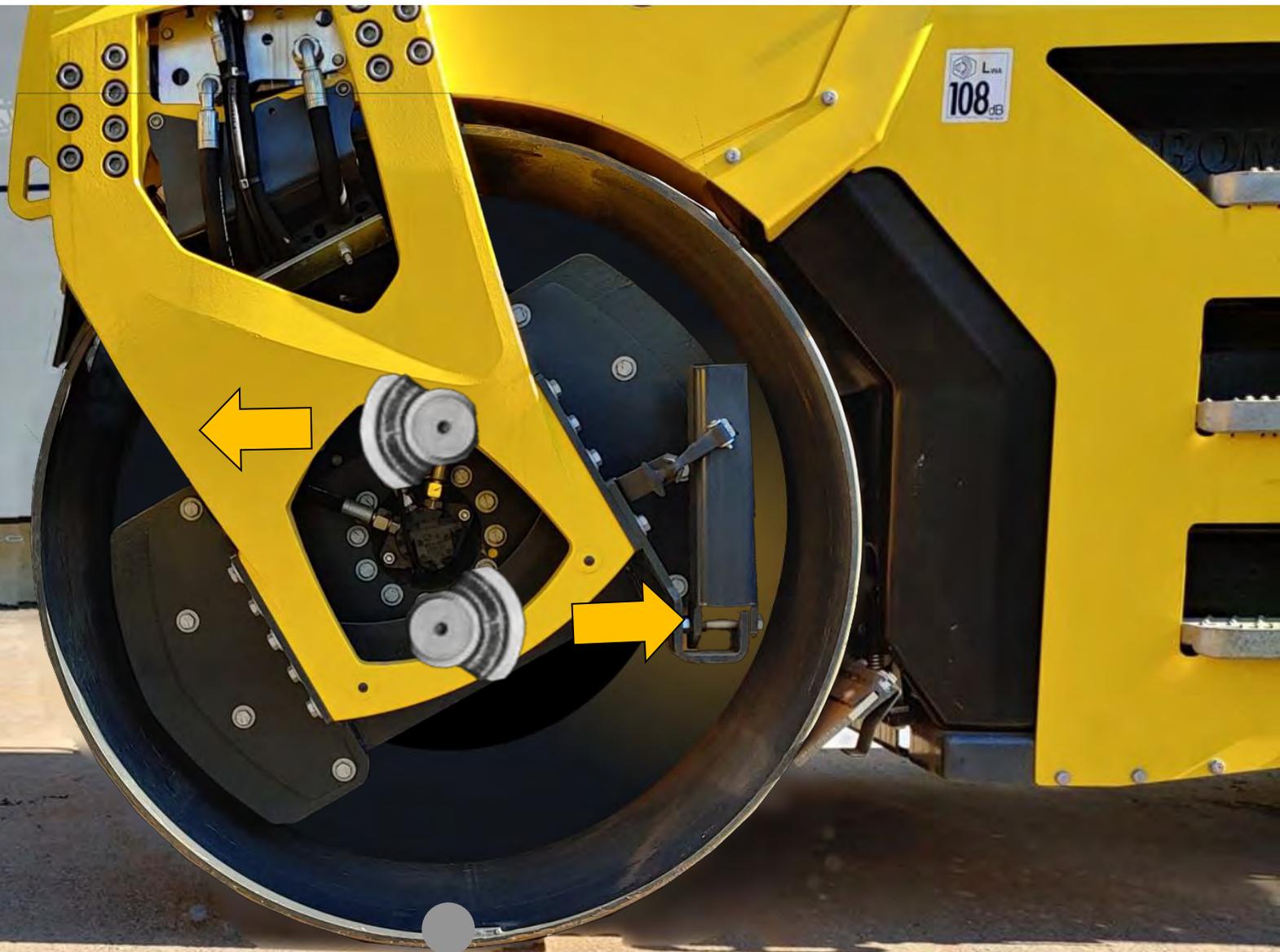
VIBRATION SYSTEMS

Oscillation

- Oscillation was pioneered by Hamm, as a solution to overcompaction¹.
- Field trials of oscillation technology began in 1983, commercial availability 1989
- In an oscillation system, the drum is sliding across the asphalt, introducing tangential shear force to the mix.
 - There is no vertical amplitude, thus no impact spacing
 - Drum is always in contact with the surface
 - Oscillation can be used to “iron out” impact marks on the mat
 - Energy going into the base / substructure is minimized

VIBRATION SYSTEMS

Oscillation



VIBRATION SYSTEMS

Oscillation

What is an oscillation system good for?

- Near sensitive structures (old buildings, etc.)
- Over aging or fragile utilities infrastructure (clay or cast iron pipes, fiber optic lines, etc)
- On bridge decks
- In tunnels
- Hot-on-cold joints
- Thin lifts
- Sensitive / Delicate mixes
- Finish rolling

Where is oscillation not the best choice?

- Thick Lifts
- Stiff mixes

VIBRATION SYSTEMS

Oscillation

- Advantages
 - Limits vibration energy into sub structure, can be used in areas where conventional vibration cannot
 - No impact spacing
 - Lower noise levels
- Disadvantages
 - Low depth effect for compaction
 - Often limited in use to specific application

VIBRATION SYSTEMS

DIRECTED / VECTORING

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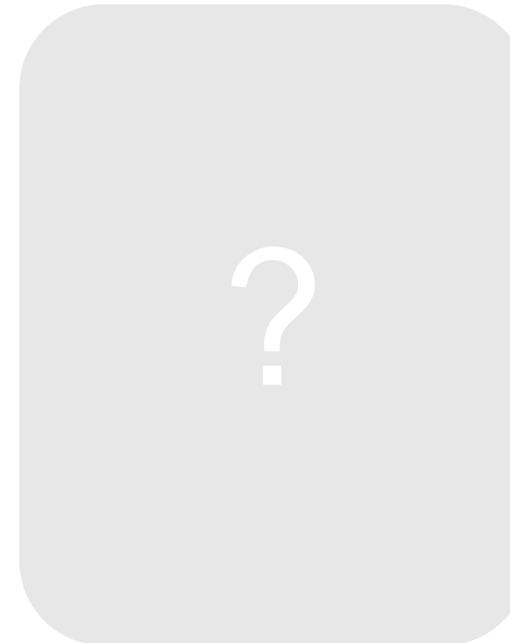
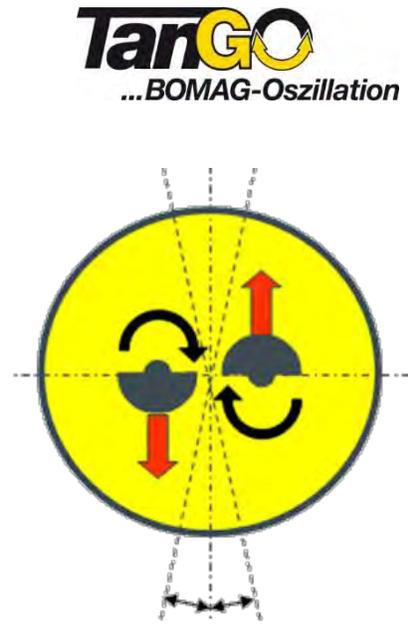
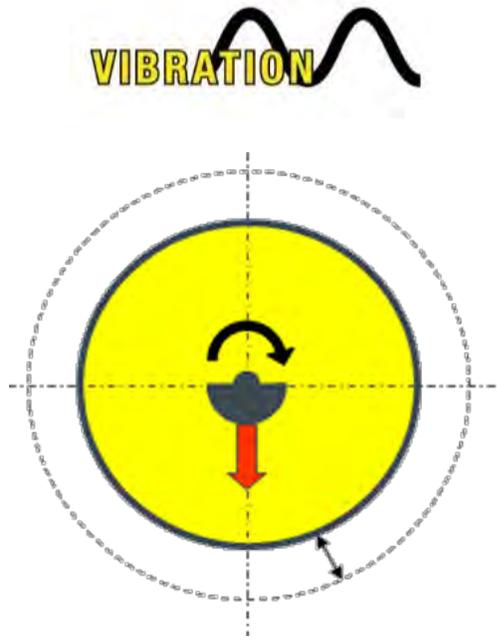
VIBRATION SYSTEMS

Overview

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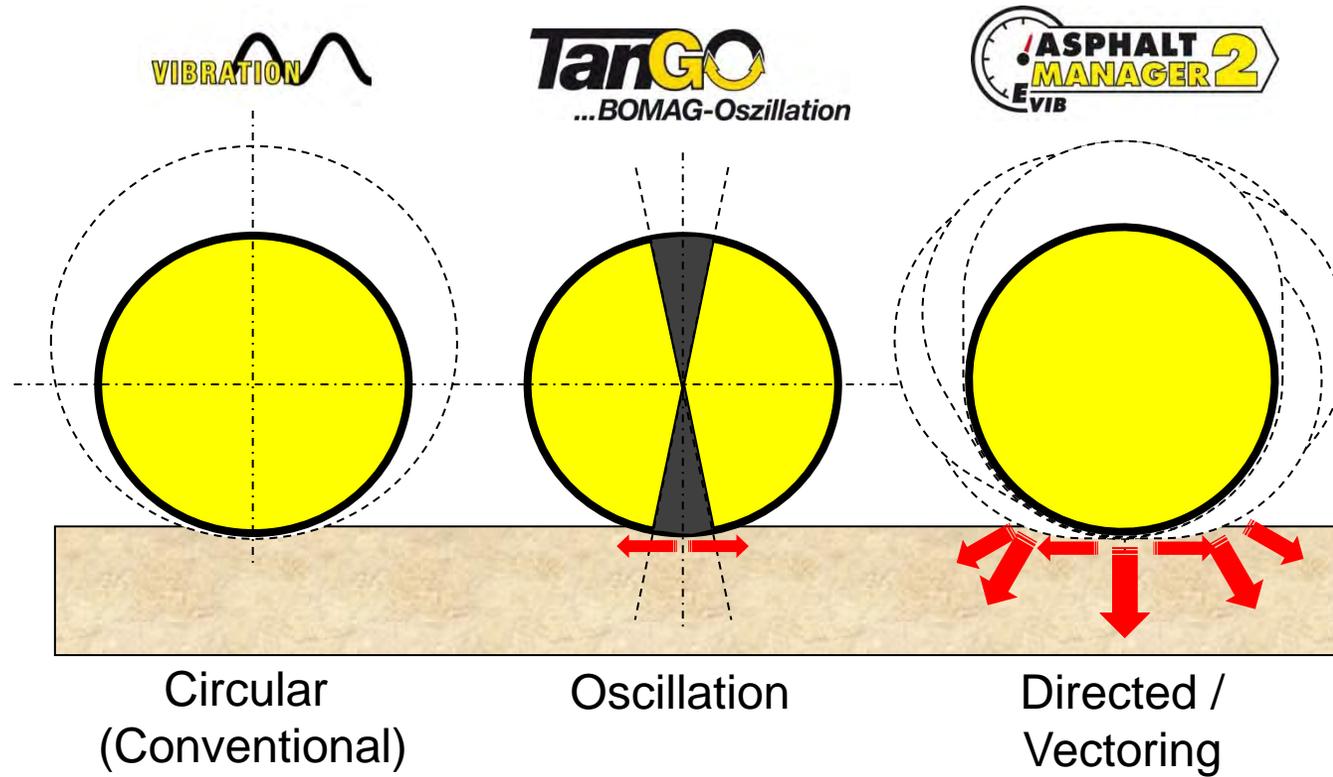
Oscillation Vibration: A vibration system that uses two or more eccentric masses which are typically 180° out of phase and rotating in the same direction, thus creating a torque and corresponding rotational vibration of the drum.

Directed / Vectoring Vibration: A BOMAG proprietary vibration system that uses 2 eccentric masses in phase but counter-rotating, thus creating a purely linear force and movement of the drum.



VIBRATION TYPES

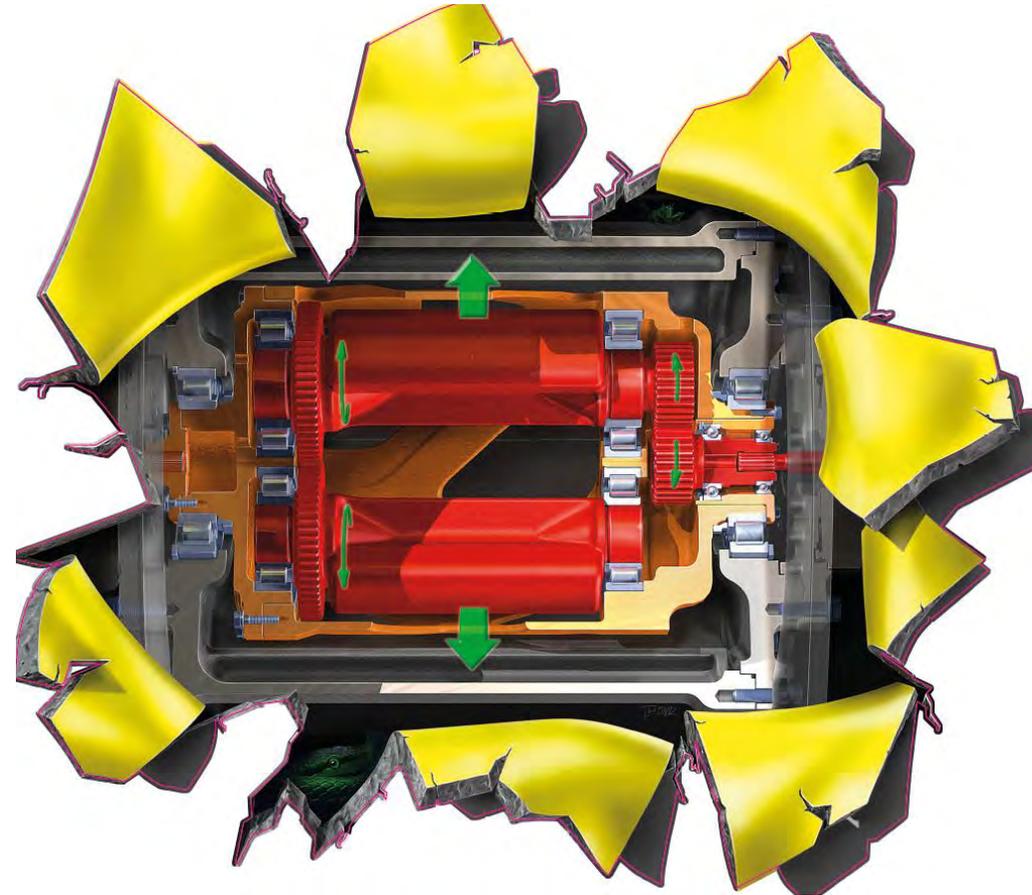
Overview



VIBRATION SYSTEMS

Directed / Vectoring Vibration - History

- Directed / Vectoring Vibration rollers was pioneered by BOMAG in the late 90s:
 - Vario 1995 (Bauma)
 - Variomatic 1996
 - Variomatic 2 1998
 - Asphalt Manager 2000 (Intermat)
2001 (Bauma)
- Goal was to automate the compaction amplitude adjustments to optimize compaction and avoid over-compaction.

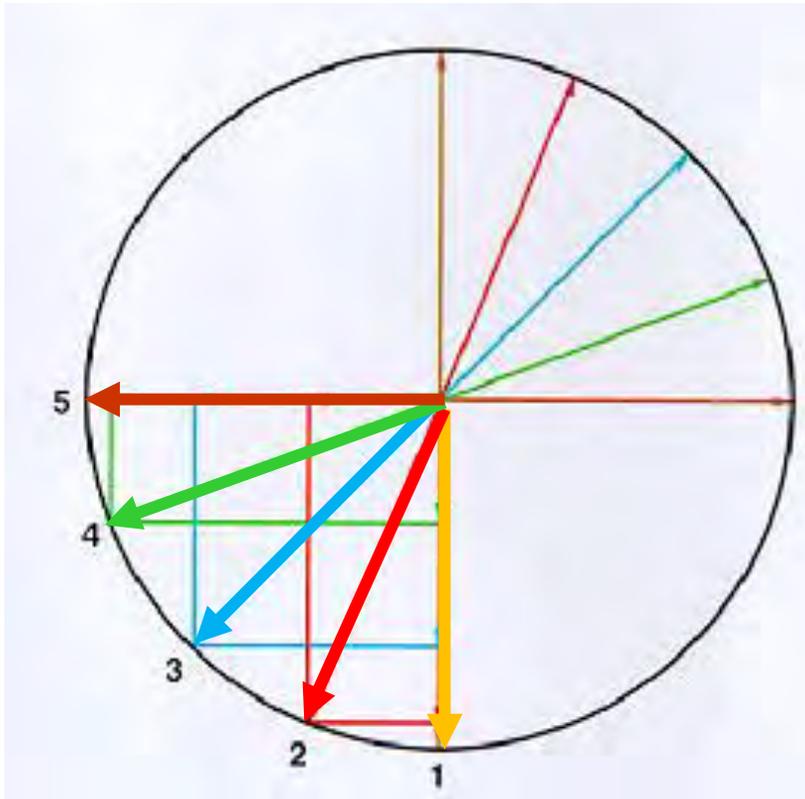


VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works: Vectoring

The amplitude is always the same – only the direction (or vector) changes

Example: BW 206 AD-5 AM



Pos.	Angle	Amplitude	Vertical Amplitude Component
1	90°	0.85mm 0.033"	0.85mm 0.033"
2	67.5°	0.85mm 0.033"	0.77mm 0.030"
3	45°	0.85mm 0.033"	0.60mm 0.024"
4	22.5°	0.85mm 0.033"	0.32mm 0.013"
5	0°	0.85mm 0.033"	0.00mm 0.000"

This changes the “effective amplitude” seen by the asphalt

VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works: Measuring

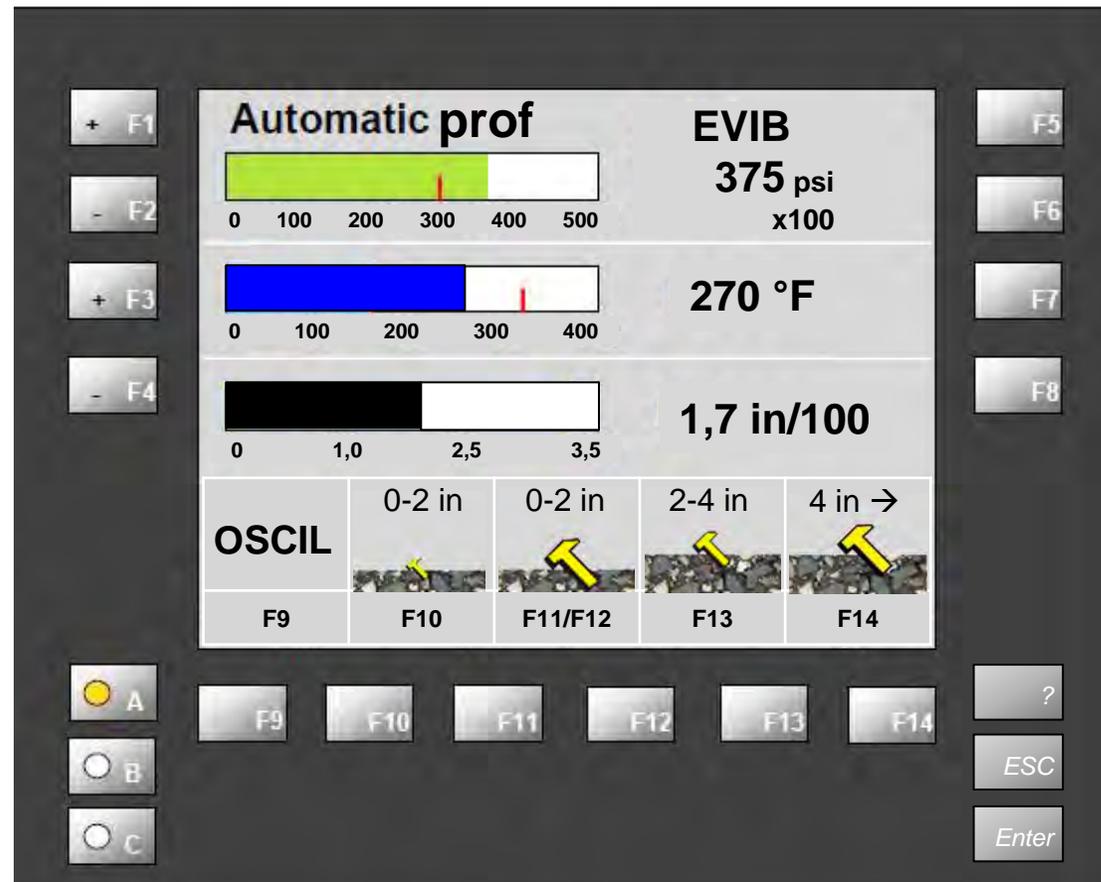
- 2 sensors – one on each side of the front drum
- Sensors are measuring vibration feedback



VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works: Controls (AD-5)

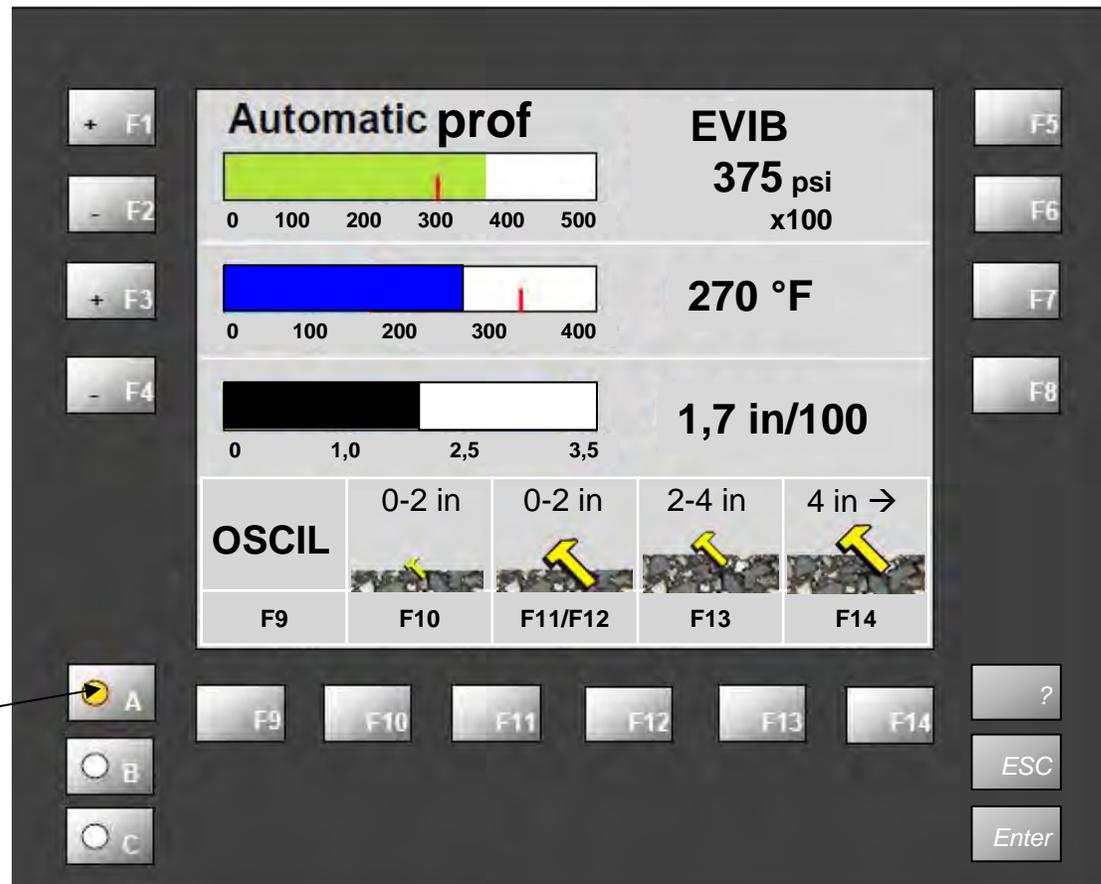
- Control system measures feedback and other parameters, then adjusts vibration vector to optimize compaction



VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works: Controls (AD-5)

- Easy Operation: In auto mode, just pick a thickness



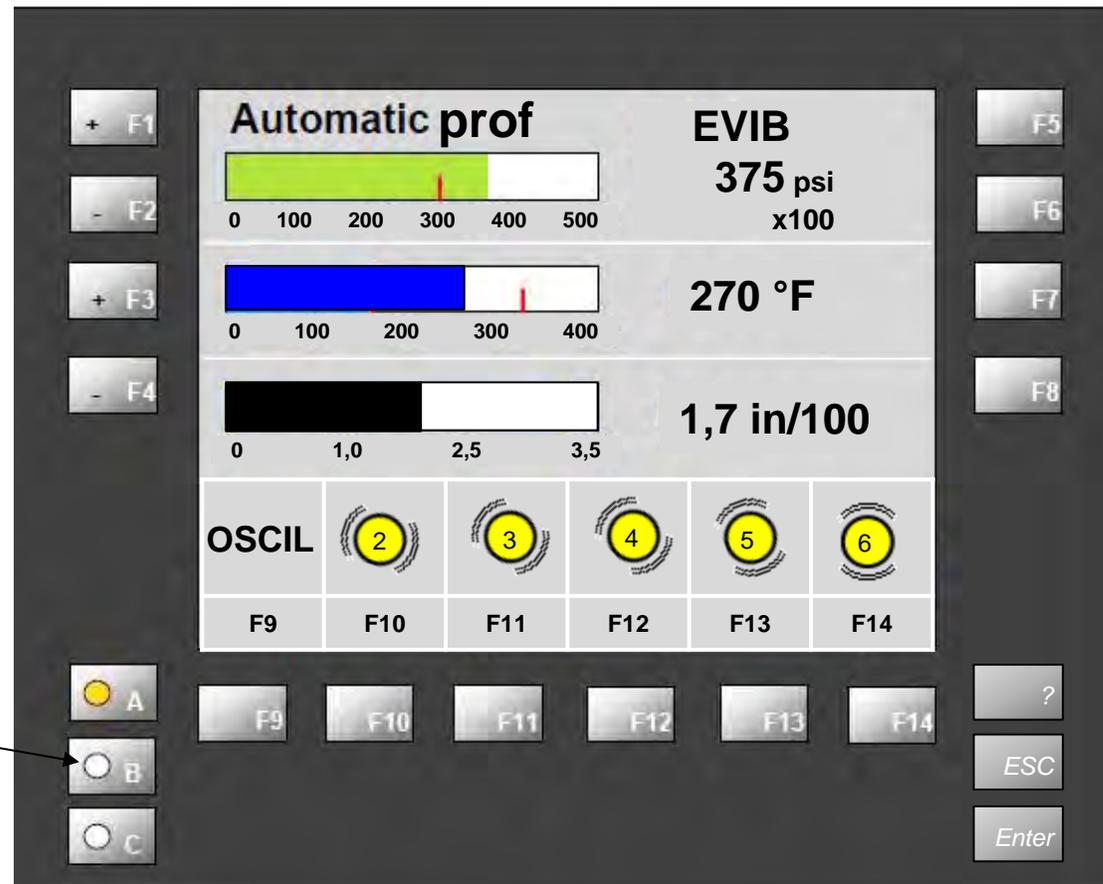
Auto (1x)

Auto prof (2x)

VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works: Controls (AD-5)

Easy Operation: In manual mode, just pick an amplitude from oscillation (1) to vertical (6)



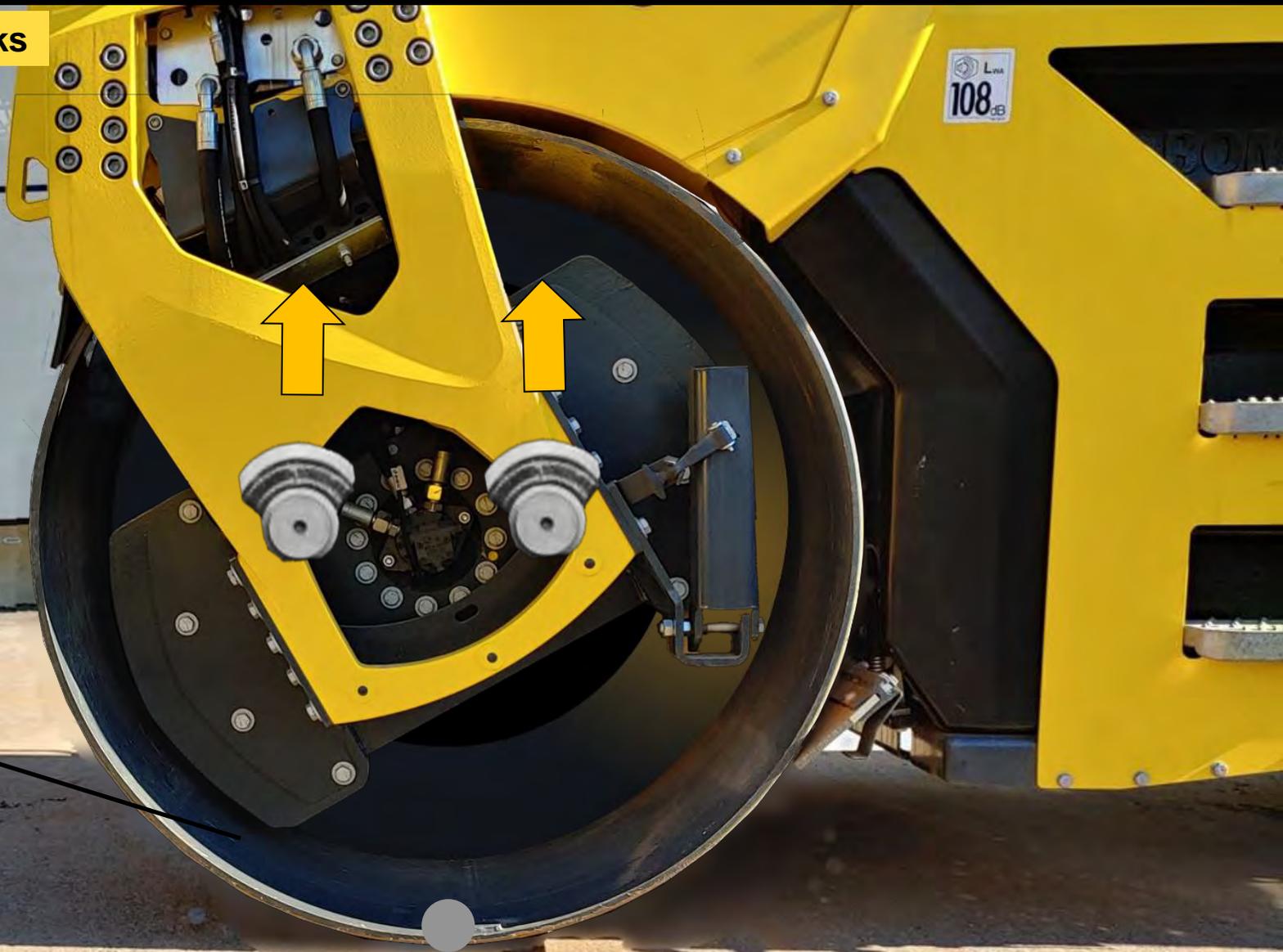
Manual

VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works



From vertical

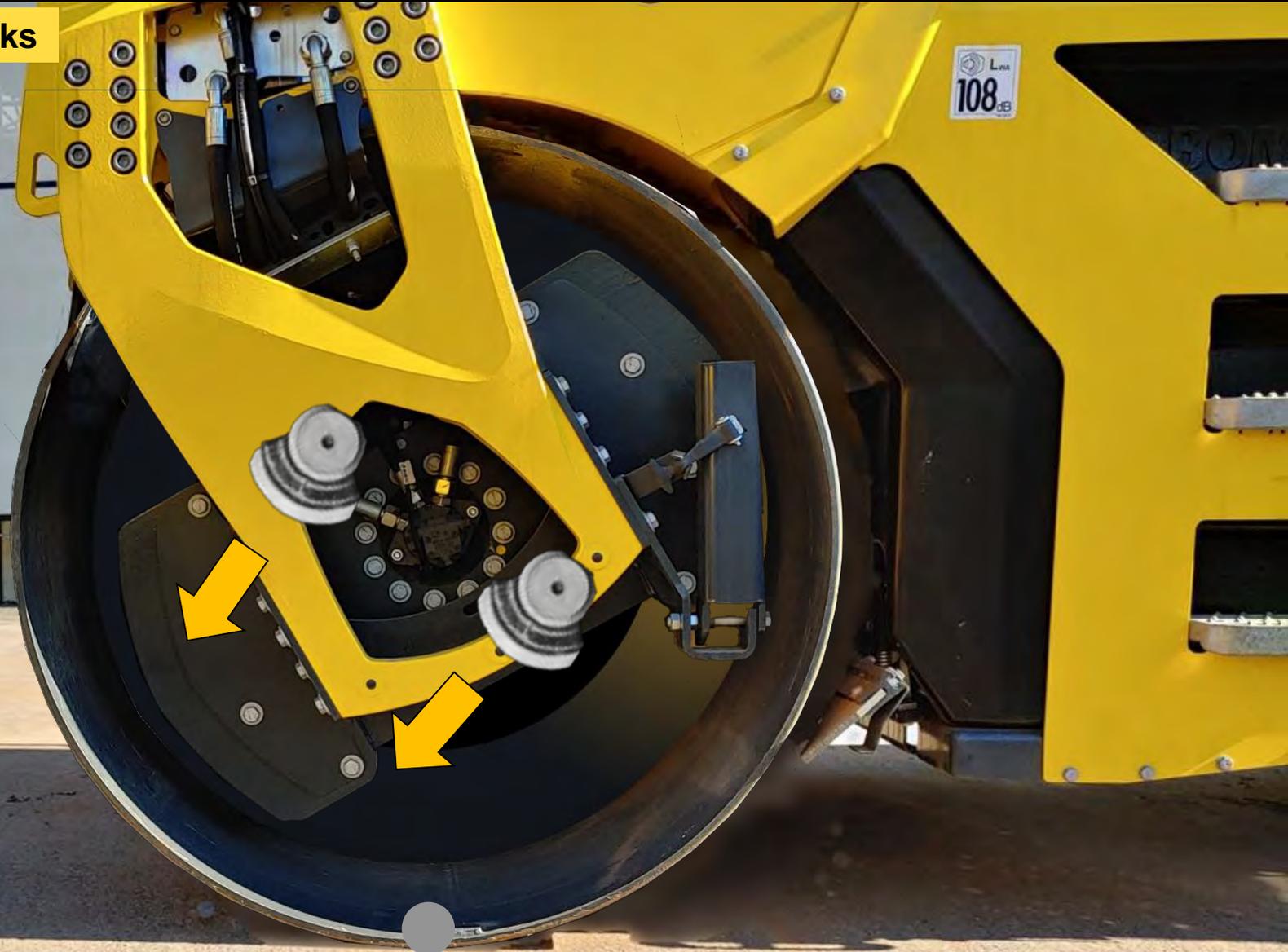


VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works



any angle up to...

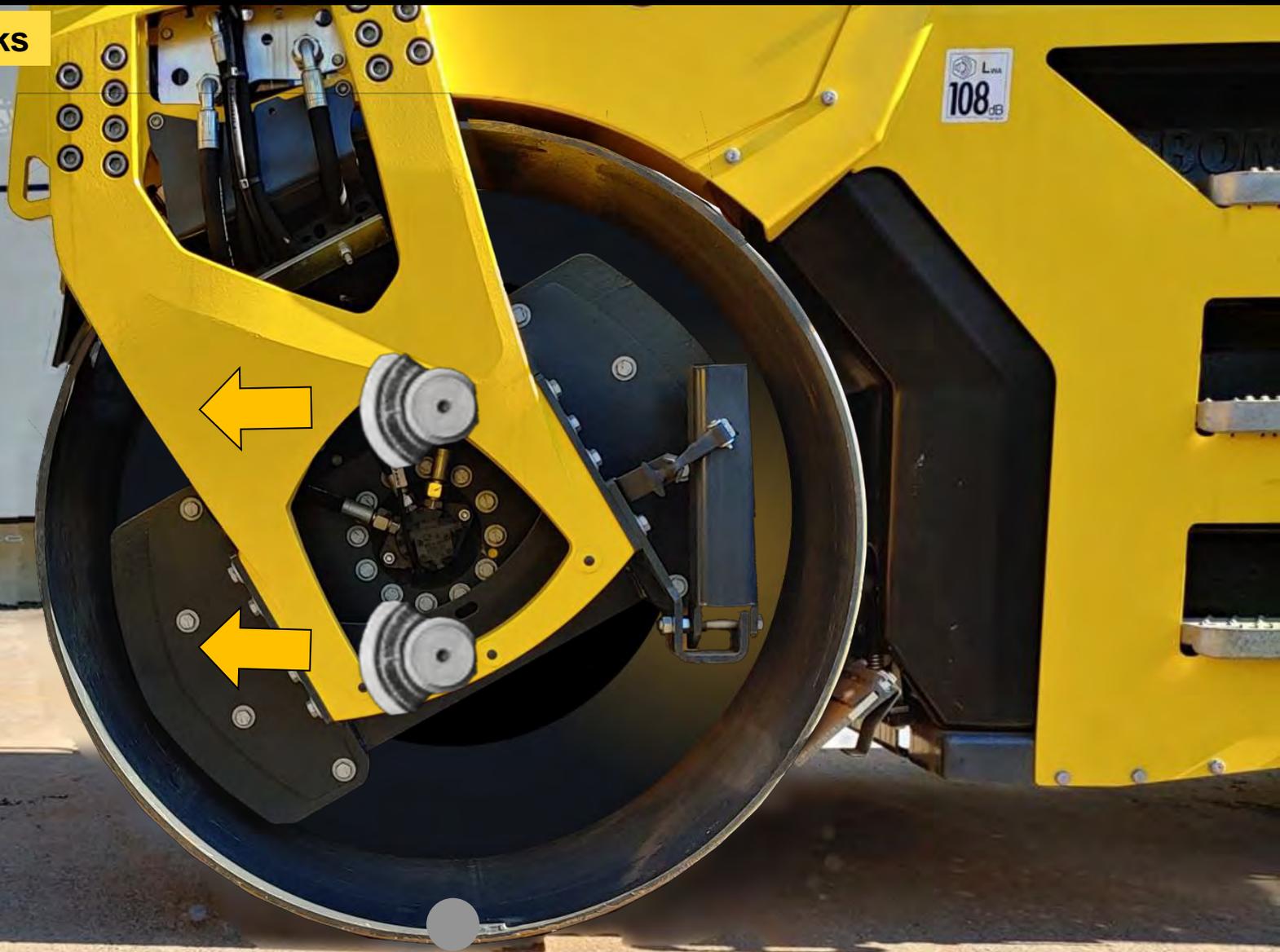


VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works



horizontal...



VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works



Rolling Direction

Adjusts vector direction based on
machine travel direction



VIBRATION SYSTEMS

Directed / Vectoring Vibration - How It Works



Adjusts vector direction based on
machine travel direction

VIBRATION SYSTEMS

Directed / Vectoring Vibration - What It Does

- Adjusts amplitude automatically, between 0 and maximum
 - Applies the maximum vibration energy to compact when necessary
 - Avoids over-compaction / crushing aggregate
 - Prevents drum jumping
- Actively eliminates bow wave in both automatic and manual mode
 - Reduced pushing / shoving of material
 - Aids in improving IRI and density consistency by compacting material in place
- Can be used manually: 4-5 manual amplitude settings (model dependent)
- Oscillation mode: Front drum can be set to oscillation-only.

VIBRATION SYSTEMS

Directed / Vectoring Vibration - What It Does

- Conventional Rear Drum: Standard dual amplitude / dual frequency vibration
- Stiffness (EVib) / Mat Temperature: Can be mapped in BOMAP, helpful for proof rolling
- All adjustments made from the operator platform: No getting off the machine to adjust the drum itself
- Performs the job of several different machines in one
 - Heavy breakdown roller (High vertical amplitude)^{***}
 - Intermediate roller (medium amplitude)
 - Finish roller (low amplitude / oscillation)

VIBRATION SYSTEMS

Directed / Vectoring Vibration - What It Does

High amplitude (conventional)

- Good depth effect
- Can over-compact and damage the top surface

Low amplitude (conventional)

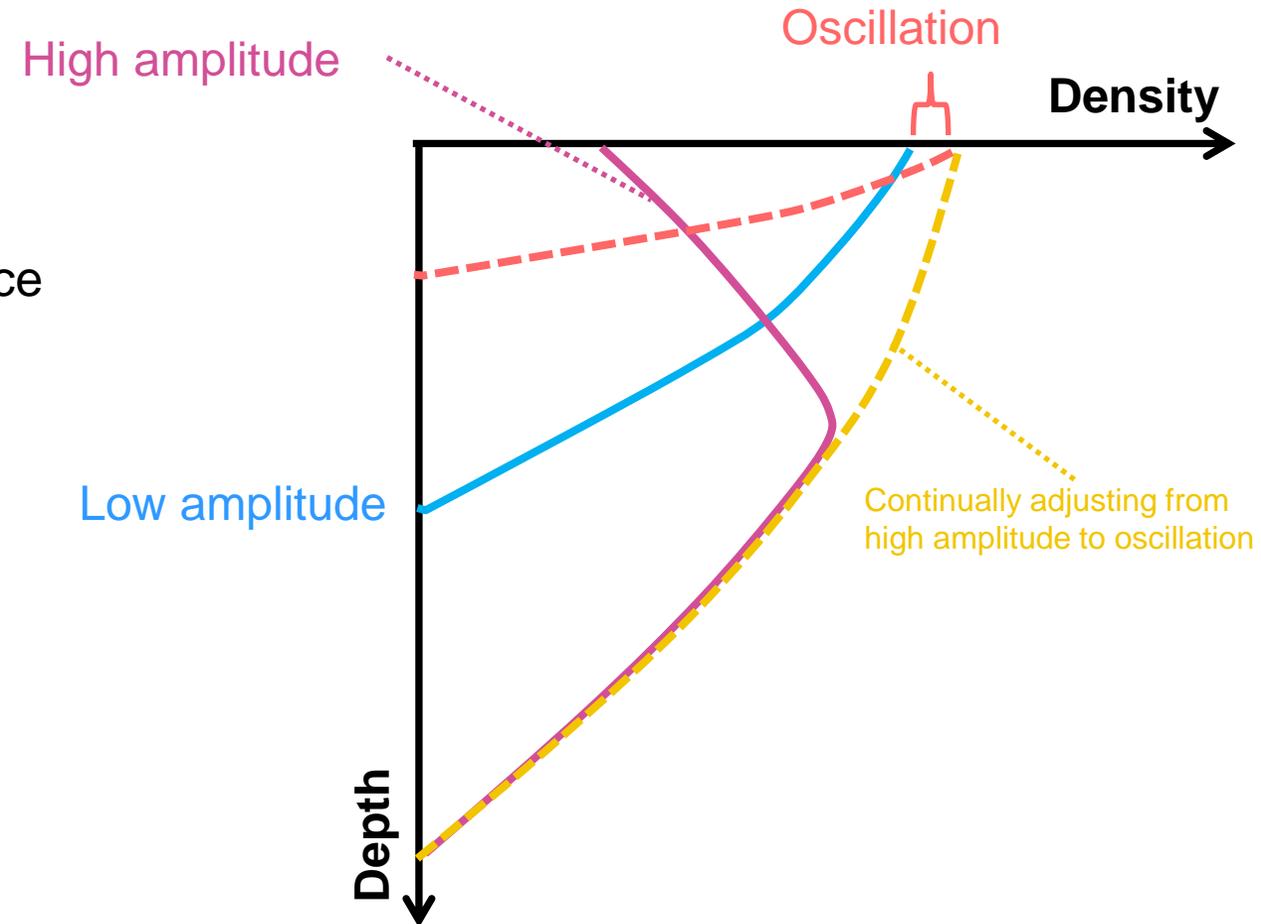
- Shallower depth effect
- Good surface density

Oscillation

- Good at surface finishing
- Depth depends more on static linear load

Asphalt Manager 2

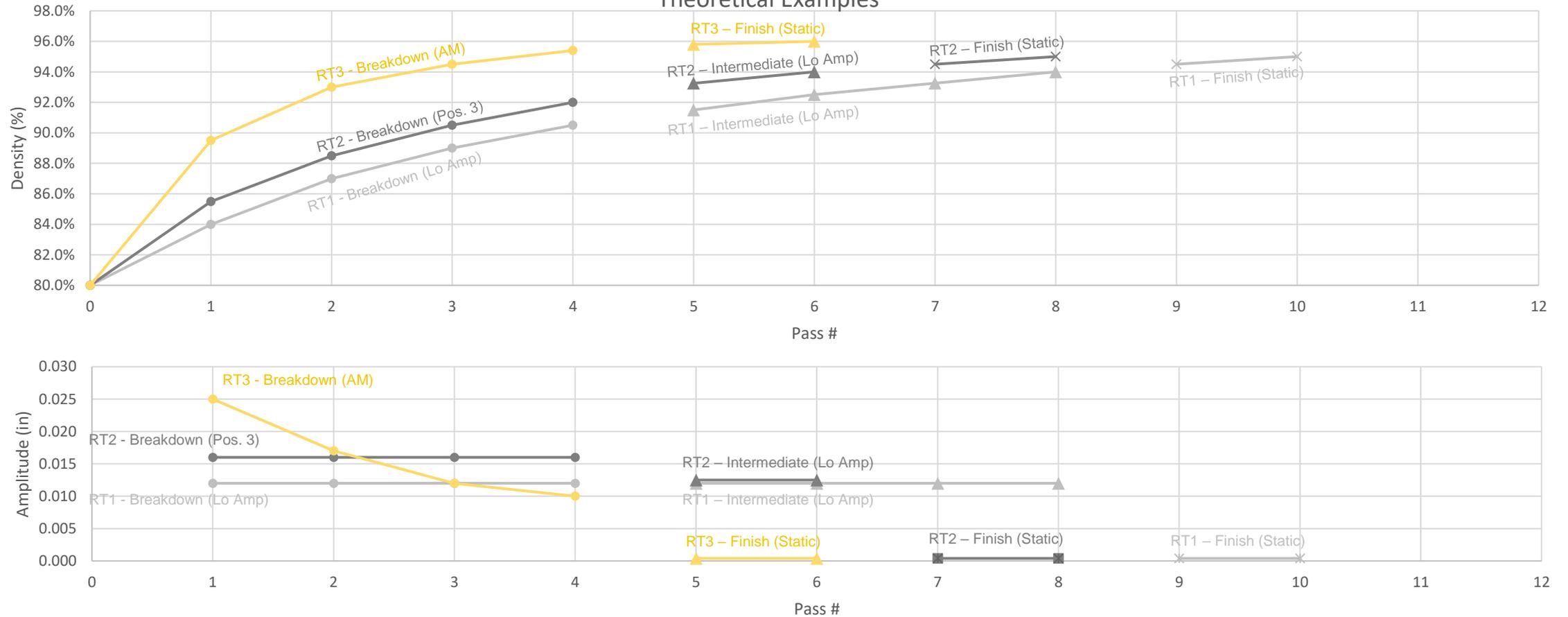
- Does it all



VIBRATION SYSTEMS

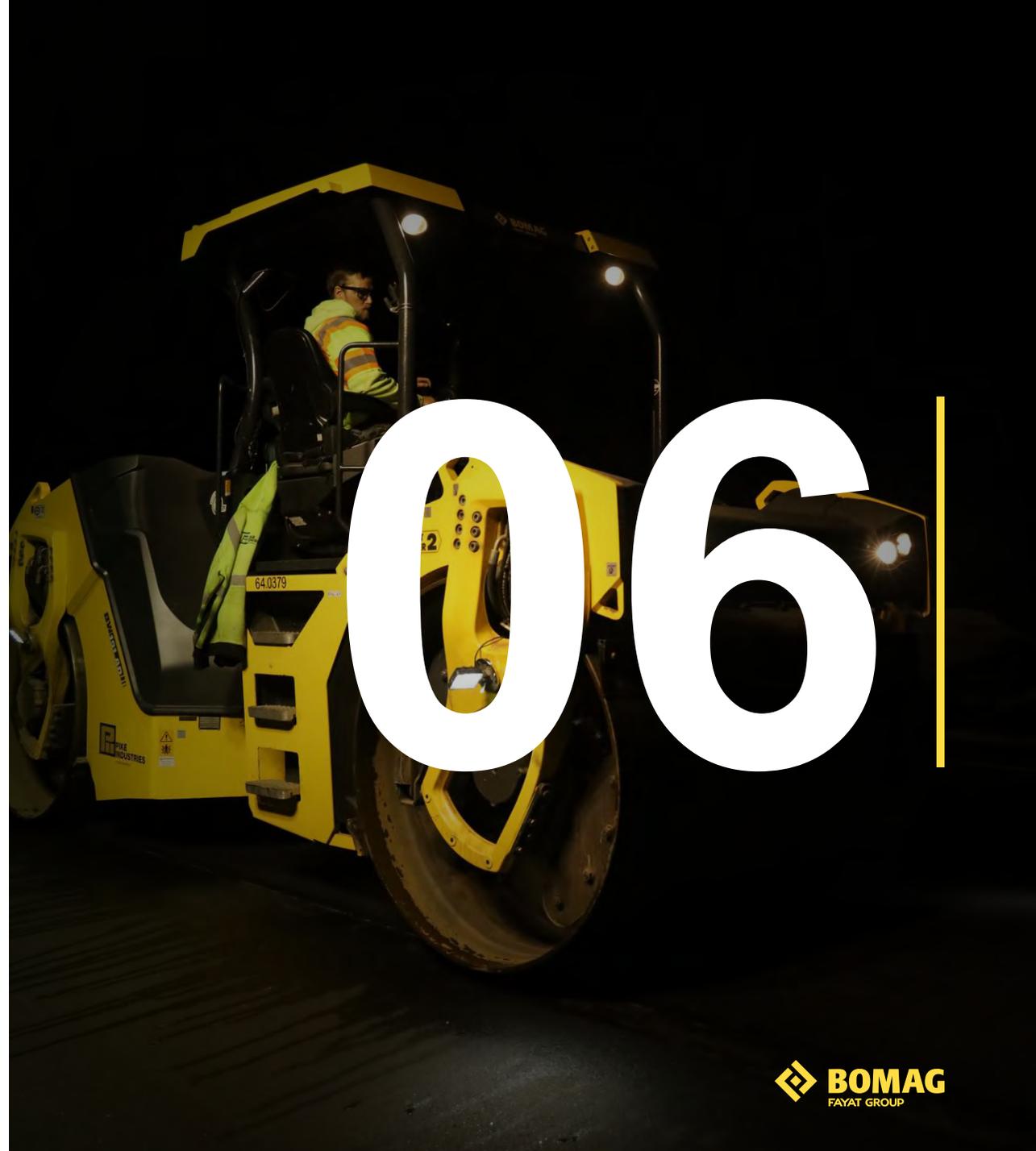
Directed / Vectoring Vibration

Density and Amplitude per Pass
Theoretical Examples



VIBRATION SYSTEMS

SUMMARY



VIBRATION SYSTEMS

Summary

- All of these systems can achieve good, when combined with proper expertise and application
 - 2A/2F systems: check the amplitude switch, beware of the bow wave
 - Multi-amplitude systems: Check and adjust the amplitude wheel for each different job, set it accordingly.
 - Oscillation: Ensure the application aligns with the strengths of the oscillation system
 - Directed / Vectoring: Combines the advantages of the other systems and adds automation to drive for more improved results.
 - Automatically monitors vibration feedback, adjusts amplitude to optimize compaction
 - Knows when to adjust itself – operator does not need to change amplitude or frequency
 - Prevents drum bounce / breaking aggregate
 - Turns a standard operator into a pro



