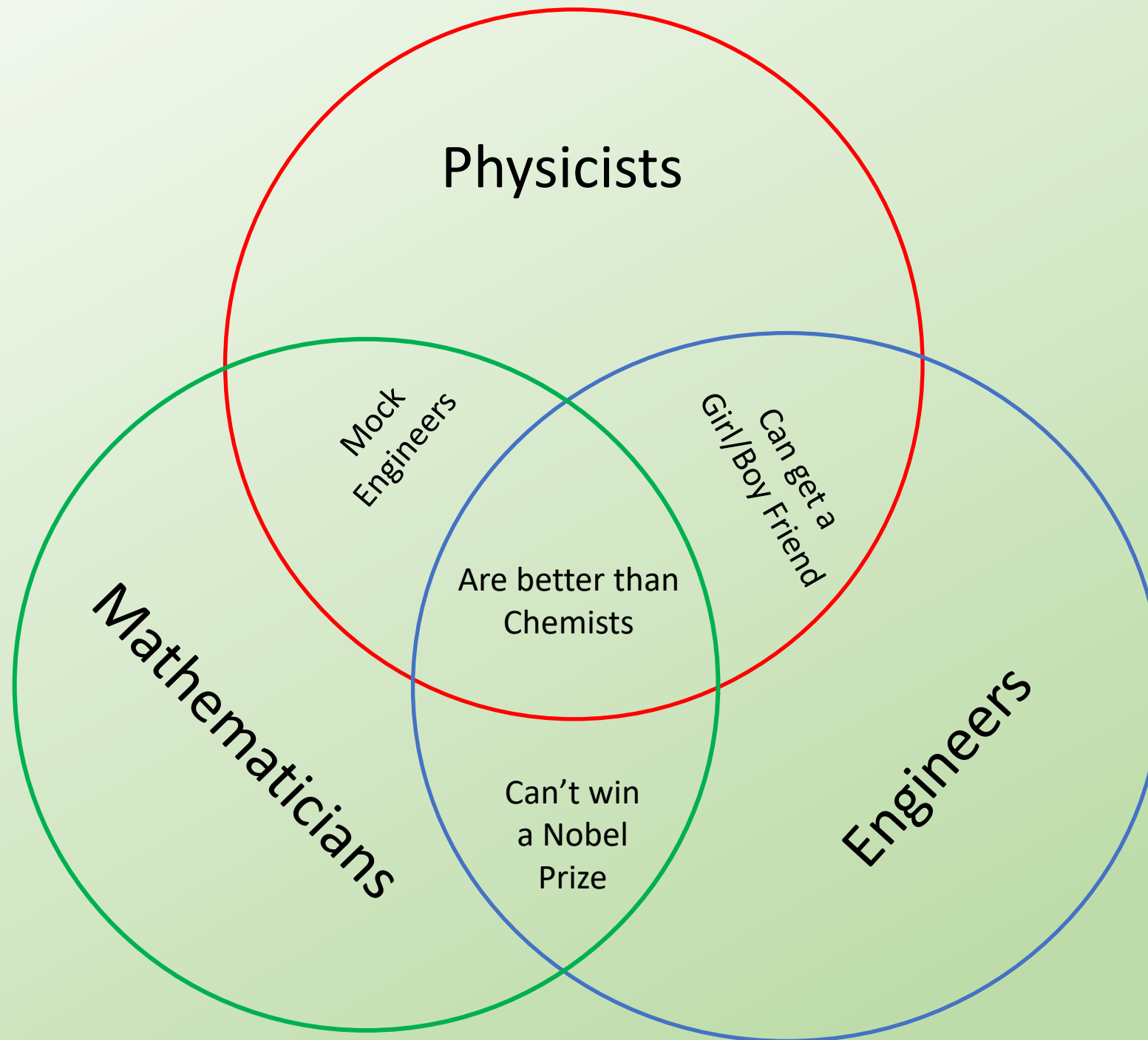
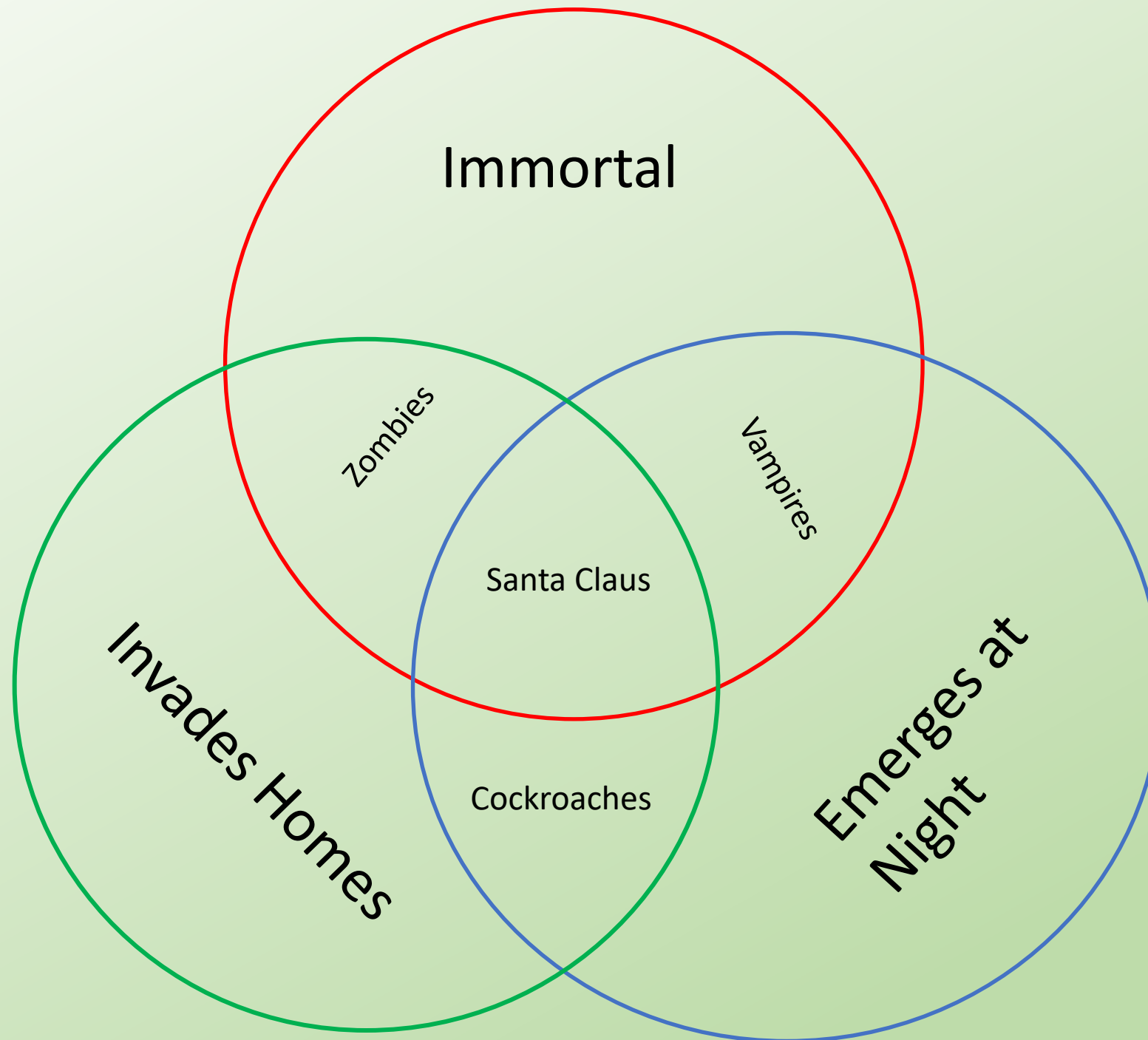








CSA M424.3:27 – MVPC Update October 2026

Braking performance — Rubber-tired, self-propelled underground mining machines

TSC Chairs: Cynthia Matikainen, Jason Flanagan

M424.0 and M424.3 Final Draft

- M424.0:27 revisions
- M424.3:27 revisions



M424.3 :27 changes

Highlights:

- Moved common (for all mobile machines) clauses for braking to M424.0
- Developed Stability Index (SI) criterion to determine when brake test can be performed according to ISO 19296 Annex A (level ground test course).
- Revised M424.3 to clarify wording, for mobile machines with $SI \geq 1.0$



CSA M424.3:22
National Standard of Canada



**Braking performance — Rubber-tired,
self-propelled underground mining
machines**



scc  ccn

M424.0 :27 Changes

- Adopt ISO 19296 Annex A within M424.0, with Canadian deviations which includes the following:

4.10 Braking

4.10.1 General requirements

[Replace the second sentence with the following]

If the stability index is less than 1.0 (see M424.0 annex C), the test may be performed according to ISO 19296 Annex A with Canadian deviations.

If the stability index is greater or equal to 1.0 the brakes on rubber-tyred wheeled machines shall fulfil the requirements of CSA M424.3.

M424.0 Word Draft Oct 2025 with annex C.PDF



M424.0 :27 Changes

- Include the following definition, to ensure consistent terminology through the M424 series:

Mobile Machine — Self propelled machine used in mining operations.

Notes:

Common types of mobile machines include: load-haul-dump, haulage truck, service vehicles, mobile drills.

The term “Mobile Machine” is often referred, in other regulations and standards, as motor vehicle, self-propelled machinery, earth-moving machinery, mining and earth-moving machinery, machine, mobile machinery, vehicle powered by any energy source such as electricity, battery, diesel, hydrogen, pneumatic, etc.



M424.3 :27 Changes

Revisions to CSA M424.3:

4.1 General

The general requirements for braking, test conditions and performance tests of M424.0 apply except as specified in this standard.

The following applies to machines that have a Stability Index of greater or equal to 1.0, see M424.0 Annex C.



M424.0 :27 Addition

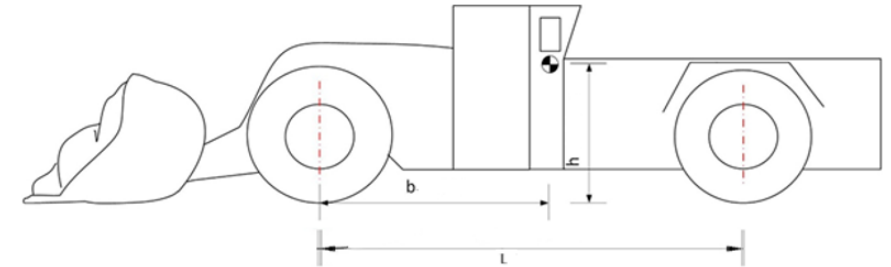
Annex C Stability Index calculation

Stability Index is derived from the critical center of gravity (CG) calculation and the deceleration rate during braking of the vehicle.

Critical CG height (h') is the Height of the Centre of Gravity of the vehicle when the Rear tires' reaction is zero due to dynamic weight shift when braking on a slope.

Deceleration rate can be determined by measurement or calculated by the manufacturer.

Figure DD.1
Visual depiction of mining machine with stability index parameters
(See Clause DD.1)



Legend:

 = Center of Gravity (CG)

$b = 3.00 \text{ m}$

$h = 1.84 \text{ m}$

$L = 5.6 \text{ m}$

Table DC.1 Information required from the manufacturer or obtained by testing

Parameter	Symbol	Description	Units
CG distance from front axle centre line	b	Horizontal distance from front axle to CG	m
CG height	h	Actual height of CG fully loaded	m
Braking deceleration	d	Measured or design deceleration during braking on level ground	m/s^2
Slope angle	θ	Incline angle of the test surface	degrees ($^\circ$)
Gravitational acceleration	g	Standard gravitational constant	9.81 m/s^2

M424.0 :27 Addition

Stability Index calculation

$$\text{Stability Index} = \frac{\text{Actual CG Height (h)}}{\text{Critical CG Height (h')}}$$

SI $\geq$ 1.0 Rear tires' reaction equal to or less than zero during braking

SI $<$ 1.0 Rear tires' reaction greater than zero during braking

DC.2.1 Calculation of stability index

The stability index is determined by comparing the actual centre of gravity (CG) height (h) of the machine to the critical CG height (h'), which represents the height at which the reaction force on the rear wheels becomes zero during braking on a slope while fully loaded. The critical CG height (h') is calculated using Equation DC.1:

$$h' = b \times \frac{\cos \theta}{\sin \theta + \frac{d}{g}} \quad (\text{DC.1})$$

where:

h' = critical CG height (m)

b = CG distance from front axle centre line (m). The calculation for b is shown in Clause DD.3.

θ = slope angle (11.3° for this standard, representing a 20% grade)

d = braking deceleration (m/s²)

g = gravitational acceleration (9.81 m/s²)

DC.2.2 Interpretation of stability index results

Table DC.2 provides guidance on selecting the appropriate brake test procedure based on the calculated stability index.

Table DC.2 Results interpretation

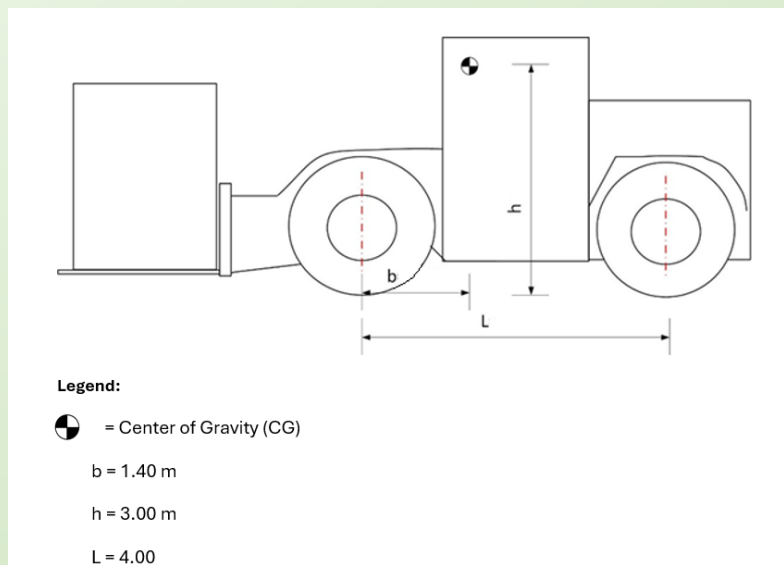
Stability index (SI)	Condition	Interpretation
SI $<$ 1.0	Rear tires' reaction greater than zero during braking on 20% grade	Brake test may be performed according to Annex A on level ground.
SI $\geq$ 1.0	Rear tires' reaction equal to or less than zero on 20% grade	Brake test shall be performed according to CSA M424.3 on a 20% grade.

M424.0 :27 Addition

Guidance on stability index calculation

DD.2 Example Calculation for machine with SI>1.0

Figure DD.3 Visual depiction of mining machine with stability index parameter



DD.3 Calculation of variable b in Equation DC.1

DD.3 Calculation of variable b in Equation DC.1

The parameter “b” from the machine’s weight distribution can be determined using the front and rear axle weights measured on level ground, along with the wheelbase, as illustrated in Table DD.3 and calculated using Equations DD.1 to DD.3.

$W = W_f + W_r$ Example: $80000 = 56000 + 24000$ **(DD.1)**

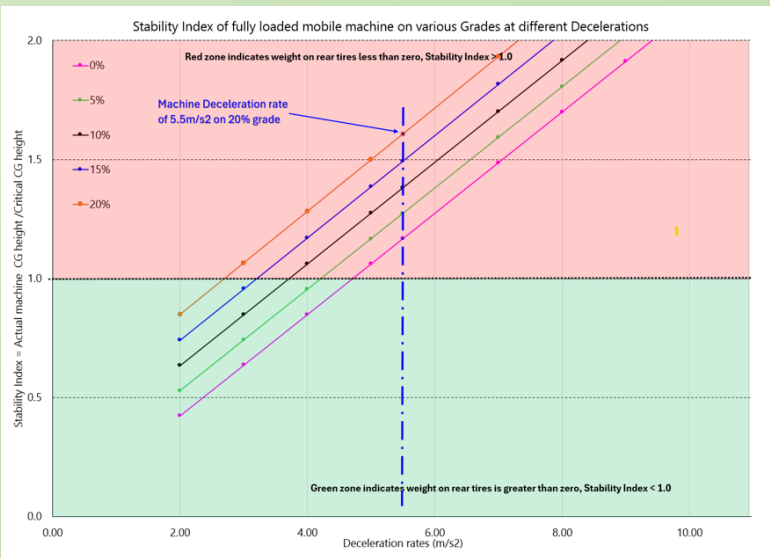
$b = W_r \times \frac{L}{W}$ Example: $b = 24000 \times \frac{4}{80000}$ $b = 1.2 \text{ m}$ **(DD.2)**

$c = W_f \times \frac{L}{W}$ Example: $c = 56000 \times \frac{4}{80000}$ $c = 2.8 \text{ m}$ **(DD.3)**

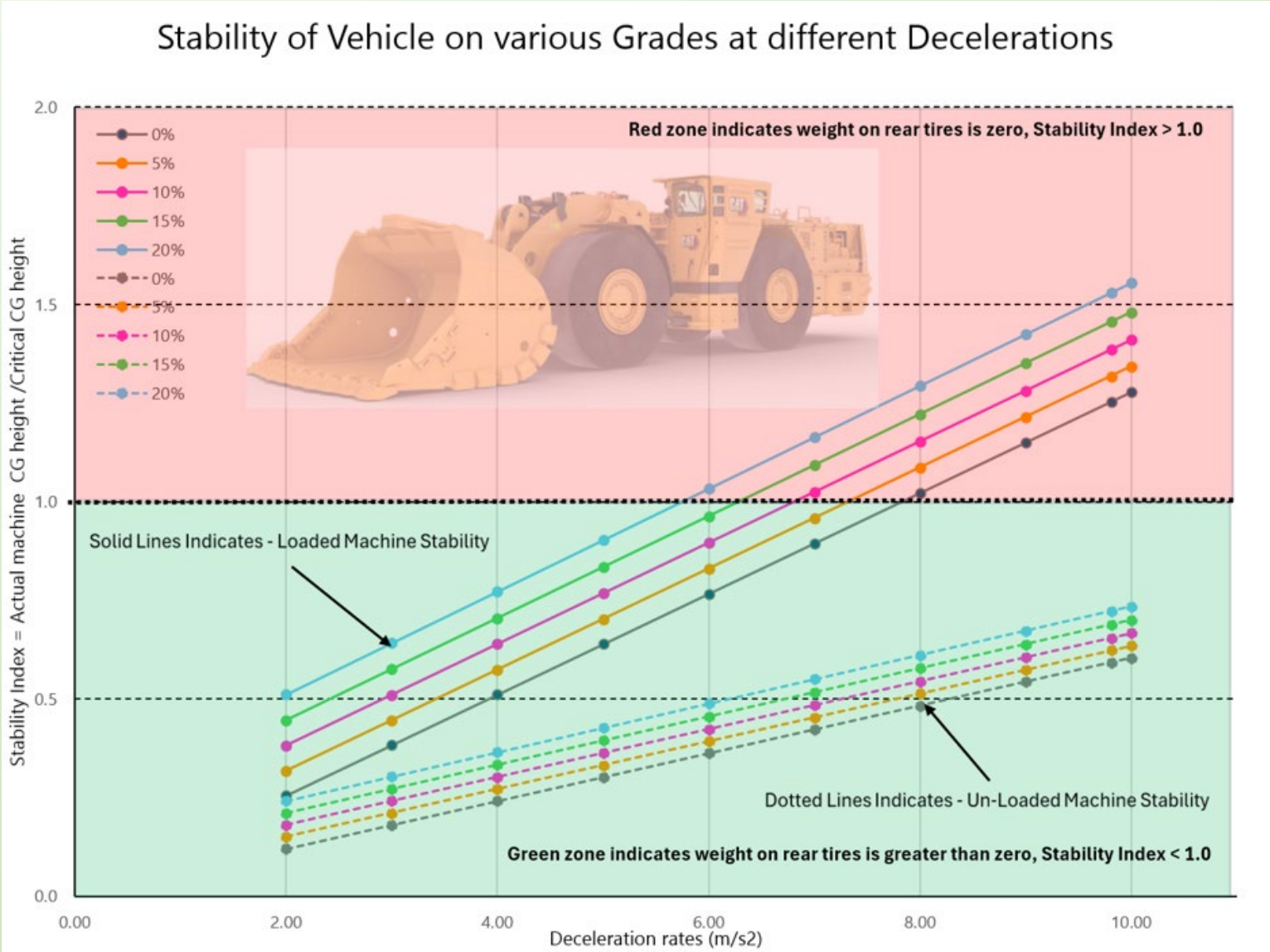
where:

- b = CG distance from front axle centre line
- W = weight of mobile machine (can be obtained from machine brochure)
- W_f = front axle normal reaction (can be obtained from machine brochure)
- W_r = rear axle normal reaction (can be obtained from machine brochure)
- L = wheelbase (can be obtained from machine brochure)

Figure DD.4 Loaded machine decelerating at 5.5m/s² on slopes from 0-20%



M424.0 :27 Additions – SI Example



CSA M424.0 Changes reflective of public comments

Remove Safety Factor value requirement, allow for design according to risk assessment

Clause 4.3 Towing and Retrieval

[Add to the fifth paragraph, the following]

Retrieval devices shall be located at the non-working end of the machine and shall be an open-ended hook designed to easily accept a retrieval sling or shackle of appropriate capacity.

If the machine has become mired or inundated, a field risk assessment shall be performed to determine proper recovery procedure.

Note: An example of a risk assessment procedure is in ISO 12100

CSA M424.0 Changes reflective of public comments

Clarify conditions for Stability Index calculation – Annex DC

Table DC.1 Information required from the manufacturer or obtained by testing

Parameter	Symbol	Description	Units
Distance from front axle to CG	b	Horizontal distance from front axle to centre of gravity (CG)	m
CG height	h	Actual height of the centre of gravity fully loaded	m
Braking deceleration	d	Measured or design deceleration during braking on level ground	m/s ²
Slope angle	θ	Incline angle of the test surface	degrees (°)
Gravitational acceleration	g	Standard gravitational constant	9.81 m/s ²

CSA M424.0 Changes reflective of public comments

Add a note to clarify speed during test

Add a note after each of the Clauses 5.3.1 and 5.3.2:

Note: The intent is to ensure that machines are tested at their **maximum achievable speed**, as designed by the manufacturer. To clarify:

- If a machine is capable of reaching a maximum speed X (where $X > 20$ km/h), it should be tested at that speed.
- If the machine is designed to operate at a reduced speed Y (where $Y < X$ but still > 20 km/h), it must include a built-in mechanism to limit its speed to Y . In such cases, testing should be conducted at speed Y , in accordance with the machine's intended design and application.
- If either X or Y is less than 20 km/h, then the machine can be tested at that lower value.

Vehicles with a Maximum speed greater than 20 km/hr

Vehicles with a Maximum speed less than 20 km/hr

Vehicles whose speed is governed by a device to limit its speed less to than 20 km/hr

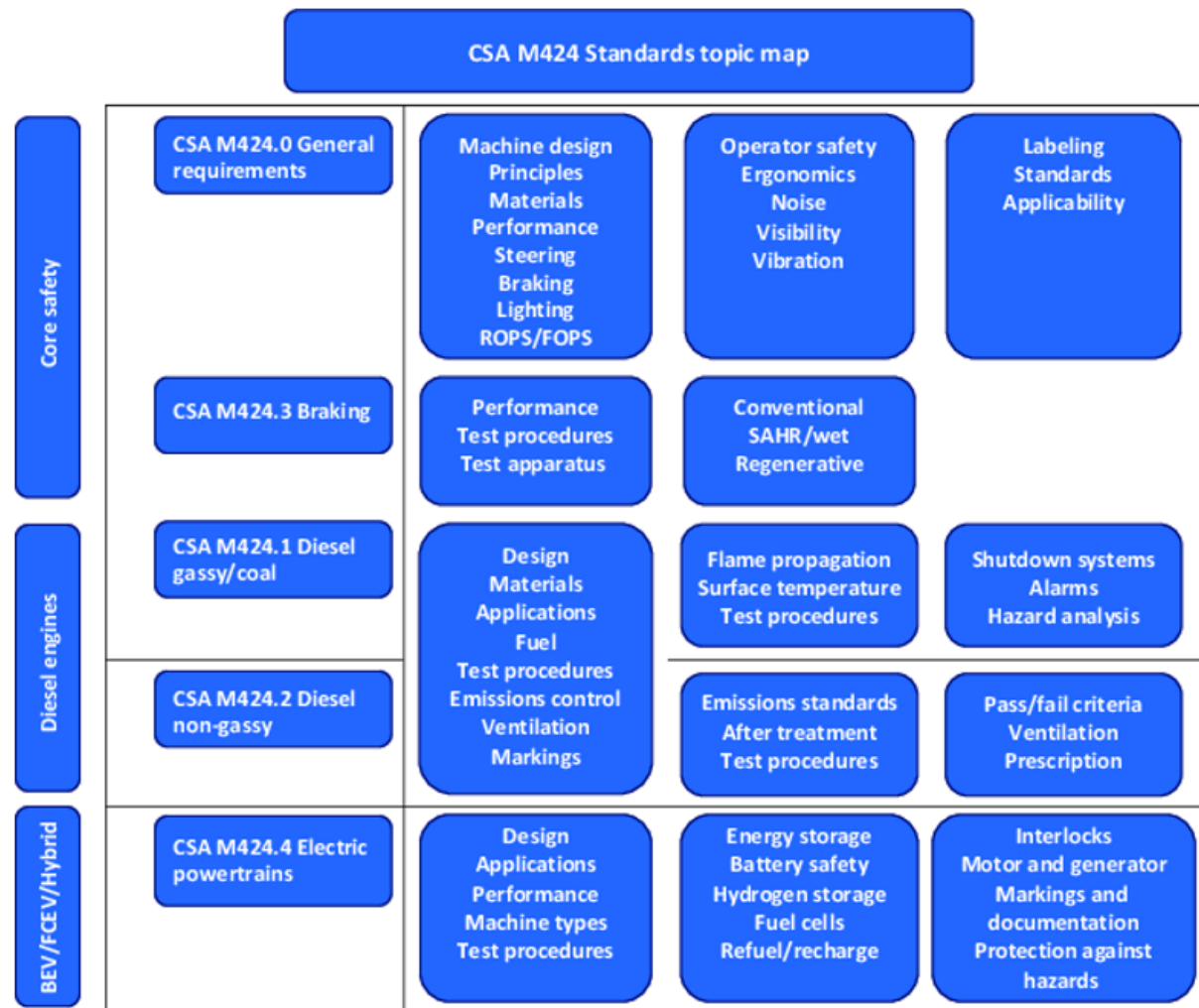
Vehicles whose speed is governed by a device to limit its speed, but whose governed speed is greater than 20 km/hr

Test at maximum Speed

Test at maximum governed Speed

CSA M424.0 – Guidance on organization of this series of standards

Figure DA.1
Topic map of the CSA M424 series of Standards
(See Clause DA.1.)



CSA M424.0 or M424.3 Considerations for next revision

1. Brake design and test requirements for autonomous machines.
2. Requirement for maximum jerk (rate of deceleration) when brakes are applied, to improve operator safety.
3. Machines shall be equipped with a seat that reduces the vibration transmitted to the operator in accordance with ISO 7096.

M424.0:27 and M424.3:27



Questions?