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MDEC Presentation Agenda

Agenda

- 1.1 M424.0 Team
- 1.2 Context on the architecture
- 1.3 Overview of Previous M424 and New M424 Architecture (how will the M424 will look)
- 1.4 ISO 19296 compared to M424.0 – Details on Clauses accepted “as is” and Canadian Deviations

CSA GROUP

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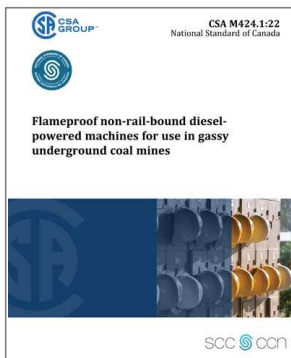
CSA Subcommittee on Underground Mining Mobile Equipment — General Requirements

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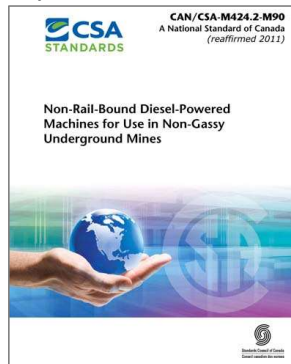
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CSA M424 FAMILY UNDERGROUND MINING VEHICLE/EQUIPMENT SCOPE REVIEW / DEVELOPMENT (Current State)



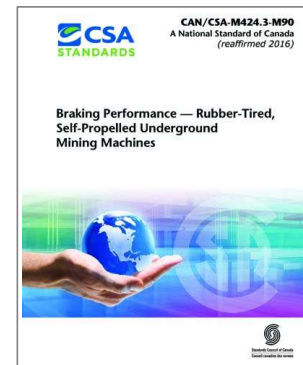
CSA M424.1-16 Flameproof non-rail-bound diesel powered machines for use in gassy underground coal mines.

1.1 This Standard describes the technical requirements and procedures necessary for the design, performance, and testing of new or unused flameproof, non-rail-bound diesel-powered, self-propelled machines for use in gassy underground mines. Note: The working environment of gassy mines is characterized by the presence of methane gas and combustible dust.



CSA M424.2-16 Non-rail-bound diesel-powered machines for use in non-gassy underground mines

1.1 This Standard describes the technical requirements and procedures necessary for the design, performance, and testing of new or unused non-rail-bound, diesel-powered, self-propelled machines for use in non-gassy underground mines.



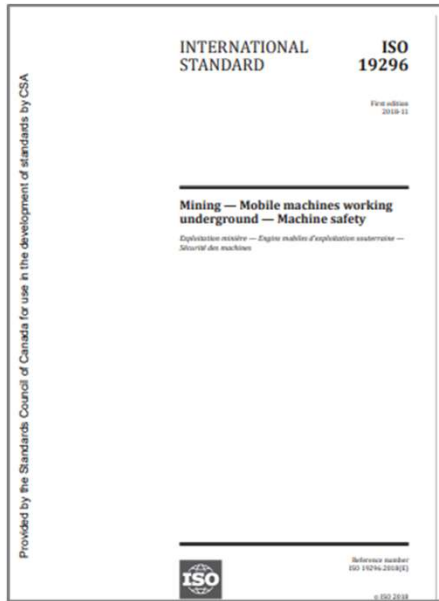
CSA M424.3 Braking performance - rubber-tired, self-propelled underground mining machines

1.1 This Standard describes minimum performance criteria for the service braking system, secondary braking system, and parking system for rubber-tired, self-propelled underground mining machines with maximum rated speeds of 32 kph or less and having a rated gross mass of 45 000 kg or less.



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CSA M424 FAMILY UNDERGROUND MINING VEHICLE/EQUIPMENT SCOPE REVIEW / DEVELOPMENT (Current Equivalent)



ISO 19296:2018 Mining — Mobile machines working underground — Machine safety

This document specifies the safety requirements for self-propelled mobile machines used in underground mining, as defined in 3.1.

This document deals with hazards, hazardous situations and hazardous events (see Annex B) relevant to these machines when they are used as intended or under conditions of misuse reasonably foreseeable by the manufacturer.

For utility/service/support machines, this document only includes provisions to address the risks associated with the mobility (movement of the whole machine from one location to another). Risks for the additional functions (e.g. scaling, concrete spraying, bolting, charging, drilling, attachments) are not covered in this document.

This document specifies the appropriate technical measures for eliminating or sufficiently reducing risks arising from hazards, hazardous situations or hazardous events during commissioning, operation and maintenance.

This document does not address:

- the additional risks for machines operating in potentially explosive atmospheres;
- air quality and engine emissions.

This document is not applicable to:

- machines constrained to operate by rails;
- continuous miners, roadheaders, drill rigs, conveyors, long wall production equipment, tunnel boring machines (TBM), and mobile crushers.



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New Architecture – ISO 19296 as Basis for M424.0

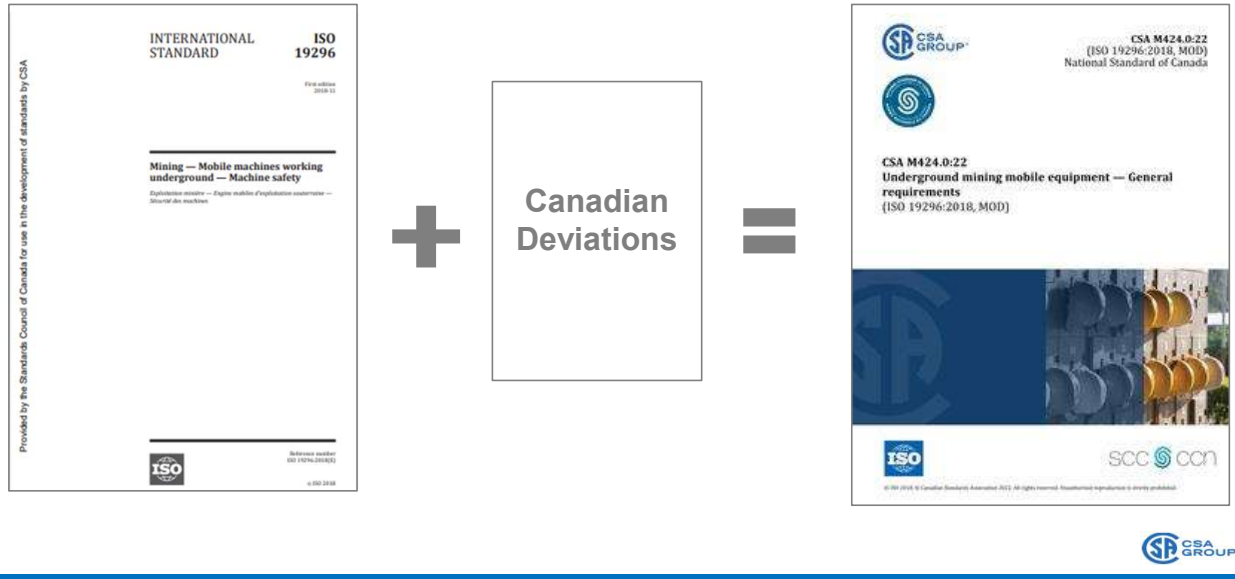
Why start with ISO 19296?

- In a comparison between M424.1 and .2 there were clauses that were identical between the two
- This was a trigger to use 19296 – because overlapping clauses in .1 and .2 were covered in 19296
- ISO 19296 was a direction that the CSA group was looking at (integrating as part of all of our standards).
- M424.3 existing – Didn't want to drop because there was a lot of excellent content in there and there was consideration for adding some Canadian content to the ISO standards



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New Architecture – ISO 19296 as Basis for M424.0



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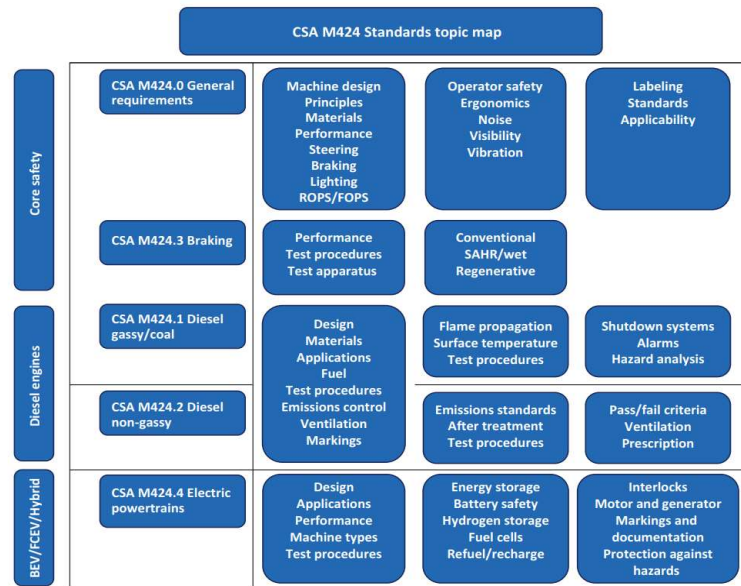
New Architecture - New M424 Suite of Standards



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New Architecture New M424 Suite of Standards

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



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M424.0 Content Summary identifying Canadian deviations from ISO19296

1	Scope (*Canadian deviation)	4.14	Noise (Accept as is)
2	Normative references (*Canadian deviation)	4.15	Vibrations (Accept as is)
3	Terms and definitions (*Canadian deviation)	4.16	Radiation health risks (Accept as is)
4.1	General requirements (*Canadian deviation)	4.17	Tyres and rims (Accept as is)
4.2	Lifting and transportation (Accept as is)	4.18	Stability (Accept as is)
4.3	Towing and Retrieval (*Canadian deviation)	4.19	Load haul dump capacity (Accept as is)
4.4	Fluid power systems (*Canadian deviation)	4.20	Maintenance (*Canadian deviation)
4.5	Electrical equipment (*Canadian deviation)	4.21	Quick coupler systems (Accept as is)
4.6	Machines powered by diesel engine (*Canadian deviation)	5	Verification of safety requirements and/or protective/risk reduction measures (Accept as is)
4.7	Fuel systems (*Canadian deviation)	6.1	Operator's manual (*Canadian deviation)
4.8	Light intensity and quantity (*Canadian deviation)	6.2	Marking (*Canadian deviation)
4.9	Warning devices and safety signs (Accept as is)	6.3	Training manuals (*Canadian deviation)
4.10	Braking (*Canadian deviation)	Annex A:	Brake requirements for rubber tyred underground mining machines (*Canadian deviation)
4.11	Control systems and devices (*Canadian deviation)	Annex B:	List of significant hazards, hazardous situations and hazardous events (Accept as is)
4.12	Operator and passenger's position (*Canadian deviation)	Annex C:	Verification Table (*Canadian deviation)
4.13	Fire protection (Accept as is)	Annex D:	Examples of performance levels for safety-related functions (*Canadian Deviations)

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ISO19626 Clauses That Were Accepted As Is

ISO19626 clauses that were accepted as is have no Canadian Deviations and are left unchanged in the new M424.0 standard.

Selection Methodology:

- Is the clause within the scope of M424 General equipment requirements?
- Does an equivalent clause exist within the M424.1, .2, or .3 standards
- Does the equivalent cause in ISO 19296 align with M424.1,.2, .3, and the common core Safety elements foundational to M424
- Does the committee accept the ISO19626 in its current state?
- Does the ISO19626 clause require modifications/additions based on Canadian regulations relating to the existing M424 standards?



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3 - Terms and definitions

ISO19296 – Clauses accepted as is

3.3.1 lead haul dump LHD
machine whose primary purpose is for the loading, hauling and dumping material but can be extended to other applications by utilizing attachments in place of the bucket
Note 1 to entry: See Figure 1.

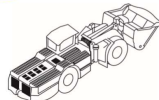


Figure 1 — Lead haul dump

3.3.2 underground dumper hauler
rigid frame or articulated machine with an open body for hauling and dumping materials, without the capability for self-loading
Note 1 to entry: See Figure 2.



Figure 2 — Dumper hauler

3.3.3 underground dumper
self-propelled crawler or wheeled machine designed or modified to be used underground with equipment having either a digging attachment which cuts, moves and grades material through forward motion of the machine or a mounted attachment used to exert a push or a pull force

3.3.4 underground utility/service/support machine
mobile machine that supports the primary production of the underground process, e.g. concrete spraying, charging, lifting and installation, servicing, scaling, transporting material
Note 1 to entry: See Figure 3 through Figure 6.

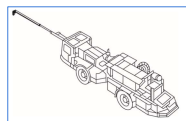


Figure 3 — Concrete spraying machine

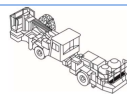


Figure 4 — Charging machine



Figure 5 — Utility and service machine

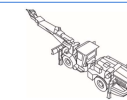


Figure 6 — Trailing machine

3.3.5 underground personnel transporter
machine whose primary function is to transport people at the mine site
Note 1 to entry: See Figure 7.



Figure 7 — Personnel transporter

3.3.6 continuous hauler
machine equipped with digging arms or buckets that feed a conveyor transporting the material to the back of the machine for loading dumpers, conveyors, etc.
Note 1 to entry: See Figure 8.

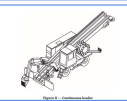


Figure 8 — Continuous hauler

3.3.7 shuttle car
self-propelled enclosed haulage vehicle for transporting mineral material between a mining machine and a rock crusher
Note 1 to entry: See Figure 9.

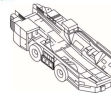


Figure 9 — Shuttle car

3.2 operator
designated, competent person, suitably trained and qualified by knowledge and practical experience and provided with the necessary instructions to ensure safe use of the machine for all operations it is designed for and within the limits of safe operation of the machine

3.3 brake system
all components which combine together to stop or hold the machine, including the brake control, brake actuation system, the brakes themselves and, if the machine is so equipped, the retarder

3.3.1 service brake system
primary system used for stopping and holding the machine

3.3.2 secondary brake system
system used to stop the machine in the event of any single failure in the service brake system (3.3.1)

3.3.3 parking brake system
system used to hold a stopped machine in a stationary position

3.4 maximum speed
speed the machine has been designed by the manufacturer to achieve on level ground per ISO 6014

3.5 gross machine mass
maximum machine mass as approved by the manufacturer which combines the operating mass of the machine with the heaviest combination of equipment and attachments, the heaviest combination of optional equipment, the rated payload (mass that can be carried by the machine, as specified by the manufacturer), and the rated ballast mass (maximum mass of ballast that can be added to the machine, as specified by the manufacturer)

3.6 routine maintenance
maintenance that is specified in the periodic maintenance schedule of the operator's manual for performing scheduled daily/weekly/monthly maintenance on the machine
[SOURCE: ISO 2867:2011, 3.1.3 Modified]



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4.1 - General Requirements**ISO19296 – Clauses accepted as is****4.1.1 General**

Machines shall comply with the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed according to the principles of ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document. The manufacturer shall undertake a process of risk assessment for the design and functions of the machine. The manufacturer shall include a process of risk assessment for typical operations over the machine life cycle. Risk assessment processes shall be in accordance with ISO 12100.

4.1.2 Moving parts

All moving parts that create a hazard of crushing, shearing or cutting shall be designed, constructed, positioned or provided with guards or protective devices that minimize the risk. Guards shall comply with ISO 3457. Fixed guards that are to be removed as a part of routine maintenance, described in the operator's manual, shall be fixed by systems that can be opened or removed only with tools. Fixed guards that are removable for routine maintenance shall have a means of fastening that shall remain attached to the guards or to the machinery when the guards are removed.

4.1.3 Equipment carrier restraints

Machines intended to carry equipment other than bulk materials shall be provided with facilities for the attachment of load restraint devices to secure loose equipment. The load restraint system shall as a minimum be able to withstand the following:

- a) 0.8 times the force of gravity in each direction of travel;
- b) 0.5 times the force of gravity in lateral directions;
- c) 0.2 times the force of gravity in a vertical direction where the load is not contained by adequate height sides.

This requirement does not apply when the machine has a forklift attachment fitted.

4.1.4 Starting system

The starting system of machines shall be provided with a starting device (e.g. a key) and shall comply with ISO 10264 or have similar protection.

If anti-theft systems are provided, they shall comply with ISO 22448.

4.1.5 Unintended movement

Mobile machinery shall be so designed that unintended movement of the machine or its working equipment or attachment shall not occur by starting the engine or energizing the machine under normal operating condition.



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4.2 – Lifting and transportation**ISO19296 – Clauses accepted as is****4.2 Lifting and transportation**

Lifting and tie down points shall be in accordance with ISO 15818 and shall be clearly identified on the machine.

Articulated steered machines shall be fitted with an articulated frame lock conforming to ISO 10570.



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4.4 – Fluid power systems

ISO19296 – Clauses accepted as is

4.4 Fluid power systems

4.4.1 Hydraulic systems

4.4.1.1 General

Hydraulic systems shall be designed and installed to conform to ISO 4413.

Hydraulic systems shall be designed to enable the use of fluids that minimize risks to health.

The systems shall be designed to enable fire-resistant fluids to minimise fire hazards (see ISO 7745 for guidance).

As an alternative to fire-resistant fluids the following precautions shall be taken for all systems:

- a) all hydraulic lines shall be separated from any electrical cable and equipment and prevent rubbing of moving parts;
- b) all hydraulic lines shall be separated from any part of the machine which can reach 80 % of the flashpoint temperature of the hydraulic fluid for which the system has been designed;
- c) hydraulic lines shall be covered or protected to prevent flammable fluid under pressure from being ejected during a leak or a burst onto a hot surface as defined in paragraph a) and b) above;
- d) hydraulic hose temperature capability shall be compatible with the operating temperature environment.

4.4.1.2 Fluid tanks

Hydraulic fluid tanks shall be protected against corrosion and be secured to the machine and incorporated in such a way (e.g. inside the rigid structure of the machine) that they are protected against mechanical damage. Alternatively, the tank shall be sufficiently robust to withstand damage from normal operation without leakage of fluid.

4.4.1.3 Tank filling

The filling apertures of hydraulic fluid tanks shall be easily accessible. If the aperture is not reachable when standing on the ground, then facilities or equipment shall be provided to allow easy access. The filling aperture shall be designed and positioned in such a way that any overflow or escape of hydraulic fluid is prevented on any gradient for which the machine is designed.

Any cap fitted shall be secured to prevent unintended loosening in service and shall require an intentional action to release it. The cap shall remain permanently attached to the machine in open position.

The location and marking of the filling point of any hydraulic system shall be so designed to avoid inadvertent introduction of other substances (e.g. fuel, water, sand).

4.4.1.4 Tank drainage

Hydraulic tanks shall be provided with a drainage device at their lowest point. Provision shall be made for free flow and safe catchment of fluid without coming into the proximity of hot parts or electrical equipment. The design intent shall be to prevent any fluid residues collecting in parts of the machine outside the hydraulic system.

Pressure in the tanks exceeding the specified pressure shall be automatically compensated by a suitable device (vent, safety valve, etc.).

4.4.1.5 Relief valves

Hydraulic pressure relief valves shall discharge the fluid back into the system only.

4.4.1.6 Pressure lines

Hydraulic pressure lines shall be designed as rigid metal lines or as flexible hoses. Hydraulic lines and hoses shall meet the following requirements:

- a) materials for hydraulic hoses and their components shall be fire resistant so that the materials self-extinguish within 30 s of removal of the flame in accordance with ISO 8030;
- b) safety factor of the hose assembly (complete with end fittings) shall be a minimum of 4 times operating pressure before failure. If hoses of different pressure rating are used, provisions to reduce the risk of using the wrong hose pressure capability, e.g. different diameters, hose markings, shall be incorporated;
- c) hydraulic lines shall be designed to take into account the twisting or movement of the machine and attachments or equipment. Hydraulic lines shall be supported along their length to prevent damage due to vibration, abrasion, and chafing;
- d) hydraulic hoses containing fluid with a pressure exceeding 5 MPa (50 bar) or a temperature exceeding 60 °C and which are located within 1 m of the operator shall be guarded in accordance with ISO 3457. Parts or components may be considered as guards;
- e) for coal applications, materials for hydraulic hoses and their components shall be in accordance with ISO 6805.

4.4.1.7 Tank level indicator

Hydraulic fluid tanks shall be fitted with a mechanically protected fluid level indicator showing at least the maximum and minimum operating levels.

4.4.1.8 Fluid temperature

Means shall be provided to monitor hydraulic fluid temperature and to warn the operator when the fluid temperature approaches the maximum temperature specified by the manufacturer.

4.4.1.9 Manufacturer's instructions

The hydraulic system, under intended operating conditions and when maintained according to the manufacturer's instructions, shall be designed such that overheating of the fluid beyond the fluid and component rated temperature specified by the manufacturer does not occur.



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4.5 – Electrical equipment

ISO19296 – Clauses accepted as is

4.5.3 Batteries

Where batteries are fitted for starting purposes or for feeding other power circuits, the following shall apply:

- a) batteries shall be positioned and secured to prevent mechanical damage. Spillage of liquid shall not be possible on components of the machine;
- b) non-sealed batteries shall be housed in a ventilated space and contain a drain path for fluids to escape;
- c) the finish of internal surfaces of battery containers shall be resistant to the chemical effects of the electrolyte;
- d) the individual battery terminals shall be protected against contact, e.g. by insulating covers or shrouds;
- e) a switch disconnect shall be fitted close to the battery. A starter isolator shall be provided when live testing or system diagnostics are required;
- f) the battery housing shall be designed and constructed in such a way as to prevent the electrolyte being ejected on to the operator in the event of rollover or tip over and to avoid the accumulation of vapours in places occupied by operators.



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4.6 – Machines powered by diesel engines

ISO19296 – Clauses accepted as is

4.6.2 Exhaust pipes

In addition, exhaust pipes shall be so directed that the risk of personnel in the close proximity during operation is minimized.



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4.8 – Light intensity and quantity

ISO19296 – Clauses accepted as is

4.8 Light intensity and quantity**4.8.1 General**

Lighting systems within and on the machine should be designed and installed using ISO 12509 as a guide.

4.8.2 Head lights

Machines shall be equipped at the front with a minimum of two head lights, for travelling. They shall have provision for both low and high beam operation, if the maximum speed of the machine does not allow illumination of the stopping distance, or if the maximum speed of the machine is more than 10 km/h.

4.8.3 Tail lights

Machines shall be equipped at the rear with two red tail lights. In addition, the rear of machines shall be fitted with one of the following:

- a) two red reflectors, each of at least 20 cm² area;
- b) two red triangular reflectors of 0,15 m side length;
- c) reflecting film of at least equivalent area and of the same form and colour.

4.8.5 Stop lamps

Machines shall be equipped with two stop lamps at the rear for machines that travel faster than 12 km/h. Machines that comply with [4.8.6](#) do not need stop lamps.

4.8.6 Both direction lights

Machines normally operating in both directions (e.g. load haul dump or similar machines) shall have head lights for travelling in both directions.

4.8.7 Protective systems

Protective systems for the lenses of lights and reflectors shall allow easy cleaning.

NOTE Machines can be equipped with additional independent working lamps, illuminating specific parts of the machine or the working area during operation.



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4.10 - Braking**ISO19296 – Clauses accepted as is****4.10.1.1 Retarder**

Underground dumper haulers shall have provisions to be equipped with a retarder system, which meets the requirements of ISO 10268.

4.10.1.2 Wheel chocks

A storage location shall be provided on the machine in an accessible location for wheel chocks.



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4.11 – Control systems and devices**ISO19296 – Clauses accepted as is****4.11 Control systems and devices****4.11.1 General**

For safety-related functions of control system(s), the principles outlined in ISO 13849-1:2015 shall be used or methods giving similar protection. Examples of performance levels (PL_r) for safety-related functions are detailed in [Annex D](#).

4.11.2 Control devices

Control devices shall be arranged and located based on ISO 6682 and ISO 10968 so that the control devices can be operated easily and safely. The location of the control zones may be moved to accommodate different seat cushion angles. Emergency controls (e.g. horn manually operated audible warning signal) should be located in the zone of comfort.

- a) Controls which can cause a hazard due to inadvertent activation shall be so arranged or deactivated or guarded as to minimize the risk, e.g. when the operator gets into or out of the operator's station and also when the operator is seated at the controls. The deactivation device shall either be self-acting or by compulsory actuation of the relevant device.
- b) On machines with more than one operating position, the layout of the control devices shall be similar at each position. This does not apply to auxiliary work stations, e.g. working platforms, remote control.
- c) The control devices shall only be controlled from one operating position at a time. Means shall be provided to ensure that the use of other control positions is prevented. This shall not apply to the secondary or parking brake control devices and to the fire extinguishing systems.
- d) Remote controls for mining machines working underground shall be in accordance with ISO 15817.

4.11.3 Steering systems

Steering systems on wheeled machines shall comply with ISO 5010.

Steering systems on crawler machines with a forward/reverse travel speed greater than 20 km/h shall be gradual.

4.11.4 Displays

Displays shall follow the general guidance of ISO 6011.

4.11.4.1 Display information

The following display information shall be provided at each driving position, where appropriate to the particular type of machine:

- a) speed;
- b) pressure of pneumatic or hydraulic brake systems;
- c) parking brake applied.

4.11.4.2 Additional information

In addition, for example, the following can be provided:

- a) fuel level or battery charge;
- b) hydraulic reservoir level;
- c) engine oil pressure;
- d) temperature of oil-immersed brakes;
- e) pressure in hydrostatic drives if service braking is hydrostatic;
- f) cooling water temperature;
- g) hydraulic transmission temperature;
- h) running time or distance travelled meter;
- i) service hour meter;
- j) fire suppression system operating pressures;
- k) hydraulic oil temperature;
- l) transmission oil pressure;
- m) system voltage;
- n) engine oil temperature;

4.11.4.3 Multiple positions

On machines with more than one driving position, the arrangement of display equipment required for operation shall be similar at each driving position.



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4.12 – Operator and passenger's position

ISO19296 – Clauses accepted as is

4.12 Operator and passenger's position

4.12.1 Protection

- a) The seats shall be so located to minimise the likelihood of injuries, e.g. from accidental contact with the roof or sides of the roadway and moving parts of the machine (e.g. wheels). For applications where there is a risk of injury due to objects entering the cab, protection shall be provided. The impact of visibility shall be evaluated when installing such protection.
- b) A risk assessment shall be used to evaluate the need for FOPS (falling objects protective structure). The risk assessment shall take into account, but shall not be limited to, the risk of falling objects due to the intended use of the machine in the mine as well as the functional requirements to the entire machine especially when working in narrow envelopes. If FOPS is required, it shall comply with ISO 3449. For operator FOPS shall comply with ISO 10262.
- c) A risk assessment shall be used to evaluate the need for ROPS (roll over protective structure). If ROPS is required, it shall comply with ISO 3471.
- d) Where possible, pipes and hoses shall be routed outside the operator's and/or passenger's position.
- e) Where this is not possible, pipes and hoses shall be guarded in accordance with ISO 3457.

4.12.2 Access systems

- a) Access systems that comply with ISO 2867 shall be provided to the operator station and to areas where routine maintenance is performed by the operator as described in the operator's manual except for machines with restrictions. Machines with restrictions that cannot comply with ISO 2867 require risk assessments (see 4.1.1) and instructions to be provided in the operator's manual.
- b) An emergency exit shall be provided on a different side from the normal exit according to ISO 2867. Machines with restrictions that cannot comply with ISO 2867 require risk assessments (see 4.1.1) and instructions to be provided in the operator's manual. The emergency exit shall be able to be opened from both the inside and outside of the machine.
- c) When the window panel is used as an emergency exit, it shall bear an appropriate marking (see, for example, ISO 7010-2011, Figure E001).
- d) Door latches shall be operable from inside and outside the operator station. A means shall be provided to prevent inadvertent opening.

4.12.3 Visibility

- a) Machines shall be designed so that the operator has sufficient visibility from the operator's station in relation to the travel and work areas of the machine. The operator's visibility shall be measured according to ISO 2606. If the direct view is restricted and where hazards due to restricted visibility exist, the risks shall be addressed with visibility aids, e.g. mirrors, closed circuit TV (CCTV), reverse camera or detection systems.
NOTE The CCTV does not need to have a recording function.
- b) Glazing shall be made of safety glass, or of other material which provides at least equal safety.
- c) Windscreen wipers, washers, demisters, etc., shall be provided if the conditions under which the machine is to be used make these necessary.

4.13 Fire protection

- a) An evaluation of fire hazards shall be performed. Components such as fuel tanks, fuel lines, cables, battery container, the hydraulic system including associated lines, and other similar items that can ignite due to operating heat of the machine shall be arranged and guarded to avoid fire.
- b) A means shall be provided to prevent the spray from ruptured hydraulic or lubricating oil lines from being ignited by contact with engine exhaust system components.
- c) If an enclosed operator station is installed on the machine, its interior, upholstery and insulation and other parts of the machine where insulation materials are used shall be made of flame retardant materials. The burn rate shall not exceed 200 mm/min, tested in accordance with ISO 3795.
NOTE Insulation or water jacketing of hot components, conduit over lines to block sprays, separate compartments for hot engine components and lines, fire-resistant fluid, etc. can be effective.
- d) Exhaust systems shall be so designed or located so that they minimize the risk of damage or ignition of the fuel system, hydraulic system or machine tyres.
- e) Brake systems shall be so designed to prevent sparks and installed that the emitted heat cannot ignite the fuel system, hydraulic system or tyres. Hot engine and brake system components shall be designed to minimize the accumulation of combustible material.
- f) Machine suspension systems shall be so designed, that in the event of failure, the tyres do not abrade on the machine body.
- g) Provision shall be made for fitting portable fire extinguishers suitable in type and size for the fire type and load, protected against heat and mechanical shock and vibration.
- h) Space provisions should be provided for fire suppression systems on all machines. If all surface temperatures are below 150 °C, then provision for fire suppression systems might not be required subject to local requirements.
NOTE The above requirement does not mean that the machine is already prepared to accept certain fire suppression systems.
- i) A fire risk assessment shall be conducted to determine the need for a fire suppression system. If needed, a suppression system shall cover the high risk areas identified and be possible to initiate the system from the cab.
- j) The engine and all power sources shall be shut down automatically in the event of actuation of any on-board fire suppression system, possibly subject to a time delay according to the agreement with the manufacturer of the fire suppression system.
- k) Where single conductor cables are used, they shall be designed and installed so as to avoid any hazard arising from induced current from magnetising fields, for example by causing dangerous levels of eddy currents to flow in adjacent metalwork, resulting in dangerous heating in the metallic frame of the machine.
- l) In the case of machines operating in coal mines, the pneumatic systems should incorporate a device to give the operator warning if the temperature of the air being discharged from the air compressor exceeds 150 °C.



21

4.14 - Noise

ISO19296 – Clauses accepted as is

4.14 Noise

4.14.1 Noise reduction at source at the design stage

- a) Machinery shall be so designed and constructed that risks resulting from noise emission are reduced to a reasonable level taking account of technical progress, machine constraints and the availability of means of reducing noise.

NOTE Guidelines for the design of cabs and enclosures can be found in ISO 15667.

- b) When designing machinery, the available information and technical measures to control noise at source shall be taken into account. Guidelines for the design of low-noise machinery are given in ISO/TR 11688-1.

4.14.2 Information on noise emission

Information on noise emission shall be given by the manufacturer in the operator's manual (see 6.1).

4.14.2.1 A-weighted sound power level

Measurement to determine the A-weighted sound power level shall be made according to ISO 6395, using the loader cycle for LHDs and the dumper cycle for hauling trucks. For utility/service/support machines the test cycle shall be weighted 30% forward, 30% reverse, 40% high idle for machines that travel in both directions and 60% forward and 40% high idle for machines that normally travel forward. The test cycle used shall be indicated with the A-weighted sound power level reported, see [Clause 6](#).

4.14.2.2 A-weighted emission sound pressure level at the operator's position

The A-weighted emission sound pressure level at the operator's position shall be measured according to ISO 6396, using the cycles defined in 4.14.2.1. The test cycle used shall be indicated with the A-weighted emission sound pressure level reported, see [Clause 6](#).



22

4.15 - Vibrations

ISO19296 – Clauses accepted as is

4.15 Vibrations

- a) Machinery should be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to reasonable levels, taking account of technical progress in the mining industry and the availability of means of reducing vibrations. ISO 2631-1 provides techniques for measuring whole-body vibrations.
- b) The driver's hand-arm vibration measurements shall be evaluated according to ISO 5349-1. ISO/TR 25398 provides information for evaluating whole-body vibrations.
- c) Whole-body vibrations are dependent upon the application, the terrain conditions and operator techniques. Whole-body vibration levels can be minimized by recommending the following:
 - 1) train operators to run machines smoothly;
 - 2) maintain the surface where machines operate to minimize bumps, holes, ditches;
 - 3) operate machines at the appropriate speed for the terrain conditions.



23

4.16 – Radiation health risks

ISO19296 – Clauses accepted as is

4.16 Radiation health risks

Where laser equipment is used, the following shall be taken into account:

- a) laser equipment on machinery shall be designed and constructed in such a way as to prevent any accidental radiation;
- b) laser equipment on machinery shall be protected in such a way that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health;
- c) optical equipment for the observation or adjustment of laser equipment on machinery shall be such that no health risk is created by laser radiation.



24

4.17 – Tyres and rims**ISO19296 – Clauses accepted as is****4.17 Tyres and rims**

- a) Rubber tyred mobile machinery working underground shall have tyre and rim load performance adapted to the machine's purpose and application.
- b) Rims shall have clear identification in accordance with ISO 4250-3.
- c) To ensure safety of machines working underground follow use and maintenance instructions recommended by the tyre and rim manufacturers.
- d) The machine manufacturer should provide maintenance and safety information on tires and rims as recommended by the tire and rim manufacturers.



25

4.18 - Stability**ISO19296 – Clauses accepted as is****4.18 Stability**

- a) Mobile machines with working equipment or attachments and optional equipment shall be designed and constructed so that stability is provided under all intended operating conditions including maintenance, assembling, dismantling, and transportation, as specified by the manufacturer in the instruction manuals.
- b) Devices intended to increase the stability of machines in working mode (e.g. outriggers, oscillating axle locking) shall be fitted with locking devices, e.g. check valve which keeps the device in position in case of hose failure or oil leakage.
- c) Stabilizer or similar devices shall be retained in their retracted positions for travelling and the operator should be able to verify the travelling position.
- d) Means, e.g. inclinometer, should be provided at the operator's station to indicate the slope of the machine.



26

4.19 – Load haul dump capacity**ISO19296 – Clauses accepted as is****4.19 Load haul dump capacity**

The rated operating capacity shall be determined according to ISO 14397-1.

The volumetric rating of bucket shall be determined according to ISO 7546.

NOTE The mass, volumetric rating of bucket and density of the material are factors to take into account when the bucket capacity is selected for a specific application.

The volumetric capacity of the dumper body shall be determined according to ISO 6483.



27

4.20 – Maintenance**ISO19296 – Clauses accepted as is****4.20.4 Tilttable cab support device**

If the operator's cab has an integral tilt system for maintenance, servicing or other non-operational purpose, the cab or system shall be equipped with a support device to hold the cab in the fully raised or tilted position.

This system shall meet the requirements of ISO 13333.

When a cab is tilted, a locking system of the controls shall be available to avoid unintended movement of the machine and equipment/attachment actuated by the controls located in the cab.



28

4.21 – Quick coupler systems

ISO19296 – Clauses accepted as is

4.21 Quick coupler systems

Quick coupler systems and quick coupler control systems to allow the quick interchange of attachments shall meet the requirements of ISO 13031.



29

5 - Verification of safety requirements and/or protective/risk reduction measures

ISO19296 – Clauses accepted as is

5 Verification of safety requirements and/or protective/risk reduction measures

Safety requirements and/or protective measures of [Clauses 4](#) and [6](#) of this document shall be verified according to [Annex C](#).

**Annex C
(normative)****Verification table**

Safety requirements and/or protective measures of [Clauses 4](#) and [6](#) of this document shall be verified according to Table C.1. Table C.1 includes the following verification methods:

- design check: to establish that the machine as designed complies with the requirements of this document;
- calculation: to establish that the requirements of this document have been met;
- visual verification: to establish that something is present (e.g. a guard, a marking, a document);
- measurement: to show that the required numerical values have been met (e.g. geometric dimensions, safety distances, resistance of insulation of the electric circuits, results of physical tests);
- functional tests: to show that the adequate signals intended to be forwarded to the main control system of the complete machine are available and comply with the requirements and with the technical documentation.

Table C.1 – Verification table

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
4.1.1	X				
4.1.2	X		X	X	
4.1.3	X	X			
4.1.4, para 1	X		X		
4.1.4, para 2	X				
4.1.5	X				X
4.2, para 1	X	X	X	X	
4.2, para 2	X		X		
4.3, para 1	X		X		
4.3, para 2	X		X		
4.3, para 3	X				
4.3, para 4	X	X			
4.3, para 5	X		X		
4.3, para 6	X		X		
4.4.1.1, paras 1 to 3	X				
4.4.1.1, para 4	X		X		
4.4.1.2	X		X		
4.4.1.3	X		X		
4.4.1.4, para 1	X		X		
4.4.1.4, para 2	X				
4.4.1.5	X				
4.4.1.6	X		X (b, c and d only)	X (d)	



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[illegible]

- a) design check: to establish that the machine as designed complies with the requirements of this document;
- b) calculation: to establish that the requirements of this document have been met;
- c) visual verification: to establish that something is present (e.g. a guard, a marking, a document);
- d) measurement: to show that the required numerical values have been met (e.g. geometric dimensions, safety distances, resistance of insulation of the electric circuits, results of physical tests);
- e) functional tests: to show that the adequate signals intended to be forwarded to the main control system of the complete machine are available and comply with the requirements and with the technical documentation.

Class name	Design check	Calculation	Visual verification	Measurement	Functional tests
1.0.0					
1.0.2					
1.0.3		X	X		
1.0.6, para 1	X				
1.0.6, para 2	X				
1.0.8					X
1.0.9, para 1	X	X	X		
1.0.9, para 2	X		X		
1.3, para 1	X		X		
1.3, para 2	X				
1.3, para 3	X				
1.3, para 4	X	X			
1.3, para 5	X				
1.3, para 6	X		X		
1.3.0.1, para 1 to 3					
1.3.0.1, para 4	X		X		
1.3.0.2					
1.3.0.3					
1.3.0.4, para 1	X		X		
1.3.0.5					
1.3.0.6, para 1	X				
1.3.0.6, para 2	X				
1.3.0.7					
1.3.0.8	X	X (3), and d		X (1)	

ISO19626 Canadian Deviation Review

The following deviations are intended to align with local occupational health and safety practices and to meet the requirements of Canadian workplace regulations.

Selection Methodology:

- Does an equivalent clause exist within the M424.1, .2, or .3 standards?
- Is the clause within the scope of M424 General equipment requirements?
- Does the committee accept the ISO19626 in its current state? If not;
- Does the ISO19626 clause require modifications/additions based on Canadian regulations relating to the existing M424 standards?



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1.0 – Scope

Canadian Deviation Review

ISO19296 Content Summary:

1 Scope

This document specifies the safety requirements for self-propelled mobile machines used in underground mining, as defined in 3.1.

This document deals with hazards, hazardous situations and hazardous events (see Annex B) relevant to these machines when they are used as intended or under conditions of misuse reasonably foreseeable by the manufacturer.

For utility/service/support machines, this document only includes provisions to address the risks associated with the mobility (movement of the whole machine from one location to another). Risks for the additional functions (e.g. scaling, concrete spraying, bolting, charging, drilling, attachments) are not covered in this document.

This document specifies the appropriate technical measures for eliminating or sufficiently reducing risks arising from hazards, hazardous situations or hazardous events during commissioning, operation and maintenance.

This document does not address:

- the additional risks for machines operating in potentially explosive atmospheres;
- air quality and engine emissions.

This document is not applicable to:

- machines constrained to operate by rails;
- continuous miners, roadheaders, drill rigs, conveyors, long wall production equipment, tunnel boring machines (TBM), and mobile crushers.

M424.0 Content Summary:

1 Scope (*Canadian deviation)

[Replace this Clause with the following]

This Standard applies to new or unused wheeled or tyred, self-propelled, non-rail-bound, mobile machines for use in underground mines.

This Standard describes the technical aspects and procedures necessary for the design, performance, and testing of core design and safety requirements.

This Standard covers general requirements only. Requirements common to a variety of underground mining mobile equipment are grouped in this Standard.

The remaining Standards in the series state requirements for braking and specific types of power trains. See Annex DA for additional information on how to apply the CSA M424 series of Standards.

For utility / service / support machines, this Standard only includes provisions to address the risks associated with the mobility (movement of the whole machine from one location to another). Risks for the additional functions (e.g., scaling, concrete spraying, bolting, charging drilling attachment) are not covered in this Standard.



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2 – Normative References

ISO19296 Content Summary:

2 Normative references

The following documents are referred to in the text in such a way that some or all of their contents constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2867:2011, *Earth-moving machinery — Access systems*
 ISO 3411:2007, *Earth-moving machinery — Physical dimensions of operators and minimum operator space envelope*
 ISO 3449:2005, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements*
 ISO 3450:2011, *Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems*
 ISO 3457:2003, *Earth-moving machinery — Guards — Definitions and requirements*
 ISO 3471:2008, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements*
 ISO 3795:1989, *Road vehicles, and tractors and machinery for agriculture and forestry — Determination of burning behaviour of interior materials*
 ISO 3864-3:2012, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols for use in safety signs*
 ISO 4250-3:2011, *Earth-mover tyres and rims — Part 3: Rims*
 ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*
 ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*
 ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*
 ISO 5006:2017, *Earth-moving machinery — Operator's field of view — Test method and performance criteria*
 ISO 5010:—, *Earth-moving machinery — Rubber-tyred machines — Steering requirements*
 ISO 5349-1:2001, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements*
 ISO 6011:2003, *Earth-moving machinery — Visual display of machine operation*
 ISO 6014:1986, *Earth-moving machinery — Determination of ground speed*
 ISO 6016:2008, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*
 ISO 6395:2008, *Earth-moving machinery — Determination of sound power level — Dynamic test conditions*
 ISO 6396:2008, *Earth-moving machinery — Determination of emission sound pressure level at operator's position — Dynamic test conditions*
 ISO 6405-1:2017, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*
 ISO 6405-2:2017, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Symbols for specific machines, equipment and accessories*
 ISO 6482:1980, *Earth-moving machinery — Dumper bodies — Volumetric rating*
 ISO 6682:1986, *Earth-moving machinery — Zones of comfort and reach for controls*

ISO 6682:1986, *Earth-moving machinery — Zones of comfort and reach for controls*
 ISO 6683:2005, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests*
 ISO 6750:2005, *Earth-moving machinery — Operator's manual — Content and format*
 ISO 6805:1994, *Rubber hoses and hose assemblies for underground mining — Wire-reinforced hydraulic types for coal mining — Specification*
 ISO 7130:2013, *Earth-moving machinery — Operator training — Content and methods*
 ISO 7546:1983, *Earth-moving machinery — Loader and front loading excavator buckets — Volumetric ratings*
 ISO 8030:2014, *Rubber and plastics hoses — Method of test for flammability*
 ISO 8084:2003, *Machinery for forestry — Operator protective structures — Laboratory tests and performance requirements*
 ISO 8152:1984, *Earth-moving machinery — Operation and maintenance — Training of mechanics*
 ISO 9244:2008, *Earth-moving machinery — Machine safety labels — General principles*
 ISO 9533:2010, *Earth-moving machinery — Machine-mounted audible travel alarms and forward horns — Test methods and performance criteria*
 ISO 10262:1998, *Earth-moving machinery — Hydraulic excavators — Laboratory tests and performance requirements for operator protective guards*
 ISO 10263-2:2009, *Earth-moving machinery — Operator enclosure environment — Part 2: Air filter element test method*
 ISO 10263-3:2009, *Earth-moving machinery — Operator enclosure environment — Part 3: Pressurization test method*
 ISO 10264:1990, *Earth-moving machinery — Key-locked starting systems*
 ISO 10265:2008, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*
 ISO 10268:1993, *Earth-moving machinery — Retarders for dumpers and tractor-scrappers — Performance tests*
 ISO 10532:1995, *Earth-moving machinery — Machine-mounted retrieval device — Performance requirements*
 ISO 10533:1995, *Earth-moving machinery — Lift-arm support devices*
 ISO 10570:2004, *Earth-moving machinery — Articulated frame lock — Performance requirements*
 ISO 10968:2004, *Earth-moving machinery — Operator's controls*
 ISO 12180:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*
 ISO 12508:1994, *Earth-moving machinery — Operator station and maintenance areas — Bluntness of edges*
 ISO 13031:2016, *Earth-moving machinery — Quick couplers — Safety*
 ISO 13333:1994, *Earth-moving machinery — Dumper body support and operator's cab tilt support devices*
 ISO 13766-1:2018, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 1: General EMC requirements under typical electromagnetic environmental conditions*
 ISO 13766-2:2018, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 2: Additional EMC requirements for functional safety*
 ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

Canadian Deviation Review

M424.0 Content Summary:

2 Normative references

[Replace the entry for ISO 6750:2005 with the following]

ISO 6750-1:2019, *Earth-moving machinery — Operator's manual — Part 1: Contents and format*

[Add the following]

In this Standard, any reference to International Standards shall be replaced by the relevant National Standard of Canada.

Where reference is made to CSA Group publications, such reference shall be considered to refer to the latest edition and all amendments published to that edition. This Standard refers to the following publications, and the years shown indicate the latest editions available at the time of publication:

CSA Group B51:19 Boiler, Pressure Vessel, and Pressure Piping Code

CSA/8 M423:M87 (R2021) Fire resistant hydraulic fluids

M424.1:22 Flameproof non-rail-bound diesel-powered machines for use in gassy underground coal mines

M424.2:22 Diesel-powered machines for use in non-gassy underground mines

M424.3:22 Braking performance — Rubber-tired, self-propelled underground mining machines

M424.4:22 Self-propelled, electrically driven, non-rail-bound mobile machines for use in non-gassy underground mines

ASME (The American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, 2021 Section VIII, Division 1, Rules for Construction of Pressure Vessels

CENELEC (European Committee for Electrotechnical Standardization) TR 14489:2005 Fire-resistant hydraulic fluids. Classification and specification. Guidelines on selection for the protection of safety, health and the environment

IATA (International Air Transport Association) Dangerous Goods Regulations — 2021 UN 3480, Lithium ion cells and batteries UN 3471, Battery-powered vehicle or Battery-powered equipment

ISO (International Organization for Standardization) ISO 12922:2020 Lubricants, industrial oils and related products (class L) — Family H (hydraulic systems) — Specifications for hydraulic fluids in categories HFAE, HFAS, HFB, HFC, HFDR and HFDU

SAE International J10-2018 Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements — Truck and Bus



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3 - Terms and definitions

Canadian Deviation Review

ISO19296 Content Summary:

3.6

routine maintenance

maintenance that is specified in the periodic maintenance schedule of the operator's manual for performing scheduled daily/weekly/monthly maintenance on the machine

[SOURCE: ISO 2867:2011, 3.1.3 - Modified.]

M424.0 Content Summary:



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4 – General requirements

Canadian Deviation Review

ISO19296 Content Summary:

4.1.1 General

Machines shall comply with the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed according to the principles of ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document. The manufacturer shall undertake a process of risk assessment for the design and functions of the machine. The manufacturer shall include a process of risk assessment for typical operations over the machine life cycle. Risk assessment processes shall be in accordance with ISO 12100.

M424.0 Content Summary:

4.1.1 General

[Add the following sentence]

Battery handling, replacement, and fire-suppression recommendations are described in Annex DB.



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4.3 – Towing and retrieval

Canadian Deviation Review

ISO19296 Content Summary:

4.3 Towing and retrieval

All machinery designed to tow or to be towed by other machines shall be fitted with towing or coupling devices designed, constructed and arranged in such a way as to ensure easy and secure connection and disconnection and to prevent accidental disconnection during use.

If the machine is equipped with towing devices (hooks, ears, etc.), the manufacturer shall provide information regarding the maximum permitted gross trailer mass which can be towed for braked and unbraked trailers and the relevant roadway conditions.

The gross trailer mass shall be based on the static friction characteristics for the intended roadway conditions with the machine unloaded. The manufacturer shall specify any ballast requirements where necessary.

The towing devices on the machine shall have a breaking strength not less than 2,5 times the gross trailer mass.

Retrieval devices shall be provided and they shall comply with ISO 10532.

Operator and other personnel stations shall be equipped with guards that comply with ISO 8084 if the machine is equipped with a winch that has wire rope cable.

M424.0 Content Summary:

4.3 Towing and retrieval

[Replace the fifth paragraph with the following]

Retrieval devices shall be designed to the applicable sections of ISO 10532, except the capacity of the machine-mounted retrieval device shall be increased from 1.5 to 3 times the gross vehicle weight (GVW) with a safety factor of 2.5 for underground applications. Retrieval devices shall be located at the non-working end of the equipment and shall be an open-ended hook designed to easily accept a retrieval sling or shackle of appropriate capacity.



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4.4 – Fluid power systems		Canadian Deviation Review
ISO19296 Content Summary:	M424.0 Content Summary:	
<p>4.4.1.1 General</p> <p>Hydraulic systems shall be designed and installed to conform to ISO 4413.</p> <p>Hydraulic systems shall be designed to enable the use of fluids that minimize risks to health.</p> <p>The systems shall be designed to enable fire-resistant fluids to minimise fire hazards (see ISO 7745 for guidance).</p> <p>As an alternative to fire-resistant fluids the following precautions shall be taken for all systems:</p> <ol style="list-style-type: none"> all hydraulic lines shall be separated from any electrical cable and equipment and prevent rubbing of moving parts; all hydraulic lines shall be separated from any part of the machine which can reach 80 % of the flashpoint temperature of the hydraulic fluid for which the system has been designed; hydraulic lines shall be covered or protected to prevent flammable fluid under pressure from being ejected during a leak or a burst onto a hot surface as defined in paragraph a) and b) above; hydraulic hose temperature capability shall be compatible with the operating temperature environment. 	<p>4.4.1.1 General</p> <p>[Replace the third paragraph with the following]</p> <p>The systems shall be designed to enable fire-resistant fluids to minimise fire hazards (see ISO 7745 for guidance). If fire-resistant fluids are used, they shall meet the requirements of CSA M423, ISO 12922, or CEN/TR 14489.</p> <p>[Add the following paragraph]</p> <p>Hydraulic systems and components presently excluded from the fire-resistant hydraulic fluid requirements are listed as follows:</p> <ul style="list-style-type: none"> - engine-related hydraulic systems such as hydraulic valve lifters, hydraulic cooling fan drives, lubricating systems, and fuel injection systems; - torque converters; - transmissions; - axles; - braking systems employing totally enclosed friction elements immersed in a liquid coolant; - braking systems whose hydraulics are independent of any other hydraulic system; and - hydraulic systems having liquid capacities containing less than 2 L. 	



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4.5 Electrical equipment		Canadian Deviation Review
ISO19296 Content Summary:	M424.0 Content Summary:	
<p>4.5.2 Electromagnetic compatibility (EMC)</p> <p>Underground mobile machines shall comply with the requirements of electromagnetic compatibility as specified in ISO 13766-1 and ISO 13766-2.</p>	<p>4.5.2 Electromagnetic compatibility (EMC)</p> <p>[Replace this Clause with the following]</p> <p>Underground mobile machines should comply with the requirements of electromagnetic compatibility as specified in ISO 13766-1 and ISO 13766-2.</p>	
<p>4.6 Machines powered by diesel engine</p> <p>4.6.1 Fuel and exhaust</p> <p>Diesel engines shall use a fuel which has a flash point exceeding 55 °C.</p> <p>The engine exhaust system shall release the exhaust gas away from the operator and the air inlet of the cab and other personnel stations on the machine. The exhaust gas shall not be discharged directly upwards to avoid thermal stresses on the roof.</p> <p>Exhaust systems which can be reached and touched during operation, access or maintenance shall be guarded in accordance with ISO 3457 considering touchable surface temperatures defined in ISO 13732-1.</p>	<p>4.6 Machines powered by diesel engine</p> <p>4.6.1 Fuel and exhaust</p> <p>[Replace the first paragraph with the following]</p> <p>Refer to CSA M424.1 and CSA M424.2 for additional requirements.</p> <p>[Replace "Exhaust systems" in the third paragraph with "Hot parts"]</p>	



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4.6 – Machines powered by diesel engines

Canadian Deviation Review

ISO19296 Content Summary:

4.6.3 Engine cooling system

A means to release the engine cooling system pressure shall be provided, that address the risk of human exposure to hot water or steam.

M424.0 Content Summary:

4.6.3 Engine cooling system

[Replace the title of this Clause with the following]

Cooling system

[Delete "engine" from the first paragraph]



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4.7 – Fuel systems

Canadian Deviation Review

ISO19296 Content Summary:

4.7.1 Fuel tanks

Fuel tanks shall be protected against corrosion, be fixed to the machine and be incorporated in such a way that they are protected against mechanical damage (e.g. by placing the fuel tank within the rigid structure of the machine). Non-metallic fuel tanks shall comply with ISO 21507. Metallic fuel tanks shall comply with the pressurization and spill requirements of ISO 21507.

4.7.3 Fuel tank vent system

Fuel tanks shall have a vent system to control pressure within the tank during filling. Fuel tanks shall be vented to maintain atmospheric pressure within the tank by use of a breather filter rated not greater than 125 µm during operation. Fuel tanks shall prevent the ingress of foreign material by use of a tank filler filter rated not greater than 250 µm.

4.7.5 Fuel shut-off system

The purpose of this system is to provide the means of removing the fuel from a fuel fire and another means of stopping an engine if all other methods fail.

Fuel tanks shall have provisions to stop fuel flow from the tank.

Manual fuel shut-off valves:

- a) shall be connected into the fuel system after all supply (lift) pumps and filters, to minimize the time required to shut down the engine system after operation of the valve;
- b) shall be accessible from the outside of the machine;
- c) shall be clearly identified and labelled including operating instructions. The label shall be as close as practical to the valve;
- d) for mechanical fuel injection pumps, the valve shall close both the supply and return lines from the injection pump.

Electrically controlled valves shall be automatically closed when the machine is shut down.

M424.0 Content Summary:

4.7.1 Fuel tanks

[Delete the second and third sentences]

4.7.3 Fuel tank vent system

[Replace this Clause with the following]

Refer to CSA M424.1, CSA M424.2, and CSA M424.4 for requirements.

4.7.5 Fuel shut-off system

[Replace the third and fourth paragraphs with the following]

Refer to CSA M424.1, CSA M424.2, and CSA M424.4 for additional requirements.



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4.7 – Fuel systems		Canadian Deviation Review
ISO19296 Content Summary:		M424.0 Content Summary:
<p>4.7.6 Fuel lines</p> <p>Fuel lines on the machine shall be:</p> <ol style="list-style-type: none"> made of metal piping or fire and wear resistant hoses. Hoses that comply with ISO 7840 fulfil this requirement; installed taking into account the effects of mechanical vibration, corrosion and heat, chafing, and abrasion; in addition: <ol style="list-style-type: none"> line joints shall remain visible; line connections shall be minimised in number and be designed to provide reliable protection against leaks during operation; routed to avoid potential for fuel to contact surface temperatures above the ignition point of the fuel as far as practical. 		<p>4.7.6 Fuel lines</p> <p><i>[Replace this Clause with the following]</i></p> <p>Fuel lines on the machine shall be</p> <ol style="list-style-type: none"> installed taking into account the effects of mechanical vibration, corrosion and heat, chafing, and abrasion. In addition, <ol style="list-style-type: none"> line joints shall remain visible; and line connections shall be minimized in number and be designed to provide reliable protection against leaks during operation; and segregated to avoid contact with electrical and hydraulic lines to decrease the potential of fire hazards. <p>Refer to CSA M424.1, CSA M424.2, and CSA M424.4 for additional requirements.</p>



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4.8 – Light intensity and quantity		Canadian Deviation Review
ISO19296 Content Summary:		M424.0 Content Summary:
<p>4.8.4 Reversing lights</p> <p>Machines shall be equipped with a minimum of two reversing lights except for machines normally operating in both directions.</p>		<p>4.8 Light intensity and quantity</p> <p>4.8.4 Reversing lights</p> <p><i>[Replace this Clause with the following]</i></p> <p>Machines shall be equipped with a minimum of two automatic reversing lights except for machines normally operating in both directions. The automatic reversing lights shall activate when the machine is put into reverse gear and remain on until the machine is put into a neutral or forward gear.</p>



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4.10 – Braking

4.10 Braking

4.10.1 General requirements

Machines shall be fitted with service, secondary and parking brakes. The brakes on rubber-tired wheeled machines shall fulfil the requirements in Annex A of this document (modified from ISO 3450:2011, Annex A). Crawler machines shall fulfil the requirements of ISO 10265.

Canadian Deviation Review

4.10 Braking


4.10.1 General requirements

[Replace the second sentence with the following]

The brakes on rubber-tired wheeled machines shall fulfil the requirements of CSA M424.3.

[Add the following paragraph]

The parking brake shall be released only by activating a manual control. Where operation of the parking brake control also activates another braking system, provision shall be made to allow the operator to test the holding capacity of the parking brake. The parking brake control shall be designed so that the possibility of accidental release of the parking brake is minimized.



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4.11 – Control systems and devices

ISO19296 Content Summary:

4.11.1 General

For safety-related functions of control system(s), the principles outlined in ISO 13849-1:2015 shall be used or methods giving similar protection. Examples of performance levels (PL_r) for safety-related functions are detailed in Annex D.

Canadian Deviation Review

M424.0 Content Summary:

4.11 Control systems and devices

4.11.1 General

[Add the following]

Machine accelerator and brake controls shall be of automobile orientation (i.e., when an operator is facing the controls, the brake is on their left and the accelerator is on their right). For machines with steering wheels, clockwise rotation shall turn the machine to the right, and counter-clockwise rotation shall turn the machine to the left with respect to the direction of machine travel. Machine accelerator control devices shall be designed to provide automatic return to the low idle position when released.


Note: ISO 6682 and ISO 3411 may be used for guidance regarding the minimum dimensions for the location of system controls.

Instruments, and audible and visible warning alarms shall be provided to indicate to the driver unsafe conditions including, as a minimum, but not necessarily limited to, those in Table 1A.

Table 1A
Instrument, warning, and shutdown requirements

Item	Instrument	Visible warning	Audible warning
a) Service brake system	*	†	†
b) Application of parking brake	Not required	Required‡	Not required
c) Engine coolant temp	§	§	Not required
d) Transmission operating pressure	Required	Not required	Not required
e) Torque converter outlet fluid temperature	§	§	Not required
f) Independently-cooled retarder system temperature	§	§, **	**
g) Automatically applied secondary braking system as required under Clause 4.3.2.2 of CSA M424.3	Not required	**	**

* An instrument is required for pneumatic systems.
† A visual or audible warning is required for each braking circuit on vehicles using air, air over hydraulic, or full hydraulic brakes.
‡ When actuation is produced exclusively by mechanical linkage, a visible warning is not required.
§ An instrument or visible warning is required.
** A visual or audible warning is required.



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4.12 – Operator and passenger's position

Canadian Deviation Review

ISO19296 Content Summary:

4.12.4 Interior space, dimensions, and seats

- a) The operator's position shall be based on the requirements specified in ISO 3411. The horizontal seating surface height (see ISO 3411:2007, Table 1) and the dimension R1 may be reduced following the guidance in ISO 3411 where the available height is restricted. For low-profile machines, the operator's space envelope shall be based on a risk assessment.
- b) The interior shall be free from sharp edges and corners, which might cause personal injuries, and shall comply with ISO 12508.
- c) The dimensions of operator seats should comply with the requirements of ISO 11112. Seats should accommodate the wearing of essential personal protective equipment. Every seat shall offer a stable position. ISO 11112 does not apply to low-profile and narrow vein underground mining machines. A risk assessment should be performed for low-profile underground mining machines to determine acceptable seating.
- d) Settings for adjusting seats to the size of the operator should comply with the requirements of ISO 11112. Settings should be changeable without the use of tools.
- e) All machines equipped with ROPS shall have a suitable restraining system according to ISO 6683. All seats shall have provisions to add seat belts, even without ROPS.
- f) A space intended for the safekeeping of the operator's manual and other instructions shall be provided near the operator's station.
- g) Machines should have facilities that are easily accessible for secure storage of personal protection equipment (e.g. cap lamp, filter self-rescuer). Provision shall be provided to secure any equipment in the operator station so it cannot cause a hazard due to movement of the machine.
- h) The ventilation system for machines with enclosed operator cabs should be capable of providing the cab with filtered fresh air at the minimum of 43 m³/h. The filter shall be tested according to ISO 10263-2.
- i) When a cab is provided with a pressurization system, it shall be tested according to ISO 10263-3 and shall provide an interior relative pressure of at least 50 Pa.

M424.0 Content Summary:

4.12 Operator and passenger's position

4.12.4 Interior space, dimensions, and seats

[Add the following paragraph to item h)]

- Good engineering design of a ventilation system in the operator's enclosure is designed to
- 1) supply clean air across the breathing zone (e.g., supply air from the top of the compartment and exhaust near the floor to avoid re-entrainment of dust); and
 - 2) install system for optimal filtration performance (e.g., include pre-filters or cyclones to allow the use of high efficiency filters).



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4.20 – Maintenance

Canadian Deviation Review

ISO19296 Content Summary:

4.20.3 Support devices

On machines where routine maintenance can only be performed with equipment (e.g. bucket or truck body), in a raised position, such equipment shall be mechanically secured with a device according to ISO 10533 or ISO 13333.

If a support device is required for routine maintenance, it should be permanently fixed to the machine or be stored on a safe place on the machine. Support device instructions shall be provided in the operator's manual.

Engine access panels shall be provided with a support device to secure the panel in the open position.

Instructions for raising and supporting of the machine off the ground in order to perform maintenance shall be provided.

M424.0 Content Summary:

4.20 Maintenance

4.20.3 Support devices

[Replace "engine access panels" with "hinged access panels" in the third paragraph]



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6.1 – Operators manual

Canadian Deviation Review

ISO19296 Content Summary:

6.1 Operator's manual

6.1.1 General

The manufacturer of the machine shall provide, at the time of delivery, one or more operator's manuals containing information for the safe operation and maintenance of the machine.

The operator's manual shall be in an official language of the country for which the machine is placed on the market, and if relevant, in a language specified by the customer.

The operator's manual shall be in accordance with **ISO 6750** with the following additional information:

- a) the cleaning requirements in order to avoid hazardous accumulation of material;
- b) instructions on the capacity and type of fire extinguisher to be used;
- c) instructions for operation of fire extinguishing and fire suppression equipment;
- d) information identifying risks from specific fire hazards and specific information to reduce the hazards;
- e) a checklist for the operator to use before starting the machine;
- f) advice about the possible hazards that can occur by leaning out of the machine;
- g) information on operator's visibility and instructions for safe operation shall be provided;
- h) jacking points;
- i) instructions for maintenance and replenishment of fire extinguishing and suppression equipment in accordance with manufacturers recommendations;
- j) safety precautions information for charging, changing, and maintenance of traction batteries where appropriate;
- k) machine disposal instructions;
- l) data for verification of the brake systems, methods of testing and adjustment;
- m) inspection and instructions for replacement of machine safety messages and instructions if damaged or illegible;
- n) instructions for energy isolation and achieving zero energy including the bleeding of pressurized lines and components without the loosening of fittings;
- o) instructions for installing and removing wheel chocks;
- p) instructions for machine maintenance, inspection and replacement of parts that wear;
- q) information on the machine capability, (e.g. loads, slopes, speed);
- r) instructions for the use of radiation equipment;
- s) information on the use of equipment carrier restraints;
- t) information for inspecting and replacing pressure containing components such as hoses and tyres that have internal structural wires, yarns, etc. that become exposed due to abrasion, ageing, etc.

M424.0 Content Summary:

6 Information for use

6.1 Operator's manual

6.1.1 General

[Replace "ISO 6750" with "ISO 6750-1" in the third paragraph]



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6.2 – Marking

Canadian Deviation Review

ISO19296 Content Summary:

6.2 Marking

6.2.1 General

The machine shall be permanently fitted with a legible, easily visible plate marked (e.g. etched, engraved or stamped) with the following minimum information:

- a) business name and address of the manufacturer and, where applicable, the authorised representative;
- b) designation of the machine;
- c) certification marking, as applicable;
- d) designation of series or type;
- e) product identification number, e.g. PIN according to ISO 10261;
- f) the following additional information can be provided:
 - 1) year of construction, that is the year in which the manufacturing process is completed;
 - 2) nominal power, expressed in kilowatts (kW);
 - 3) operating voltage and frequency for electrically powered machines;
 - 4) mass of the most usual configuration, in kilograms (kg), per ISO 6016 operating mass;
 - 5) and, where appropriate:
 - i) maximum drawbar pull provided for at the coupling hook, in newtons (N);
 - ii) maximum vertical load provided for on the coupling hook, in newtons (N).

M424.0 Content Summary:

6.2 Marking


6.2.1 General

[Add the following item to the list]


fA) maximum rated speed.



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6.2 – Marking		Canadian Deviation Review
ISO19296 Content Summary:	M424.0 Content Summary:	
<p>6.2.2 Attachment points</p> <p>Attachment points for lifting, handling, transport, assembly and dismantling shall be marked.</p>	<p>6.2.2 Attachment points [Replace this Clause with the following]</p> <p>Attachment points for lifting, handling, and transport shall be marked. The markings shall be visible while the machine is in use.</p>	
<p>6.2.3 Section or sub-assemblies</p> <p>Where the machine is constructed in separate sections or sub-assemblies to facilitate handling and transport, the weight of each such section or sub-assembly and the position of lifting points shall be permanently and unambiguously marked on it.</p>	<p>6.2.3 Section or sub-assemblies [Replace this Clause with the following]</p> <p>Where the machine is constructed in separate sections or sub-assemblies to facilitate handling and transport, the weight of each such section or sub-assembly and the position of the lifting points should be permanently marked on the machine. The weight of each section or sub-assembly and the position of the lifting points shall be included in the service and maintenance manual.</p>	
		

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6.3 – Training manuals		Canadian Deviation Review
ISO19296 Content Summary:	M424.0 Content Summary:	
<p>6.3 Training manuals</p> <p>The operator training manual shall be based on ISO 7130.</p> <p>The manual for training of mechanics shall be based on ISO 8152.</p>	<p>6.3 Training manuals [Replace "shall" with "should" in both sentences]</p> <p>The operator training manual should be based on ISO 7130.</p> <p>The manual for training of mechanics should be based on ISO 8152.</p>	
		

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Annex A: Brake requirements for rubber tyred underground mining machines

Canadian Deviation Review

ISO19296 Content Summary:

Annex A
(normative)

Brake requirements for rubber tyred underground mining machines

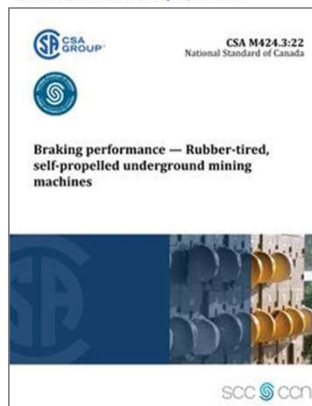
M424.0 Content Summary:

Annex A (normative)

Brake requirements for rubber tyred underground mining machines

[Replace this Annex with the following]

Refer to CSA M424.3 for braking requirements.



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Annex DA (Normative) Organization of the CSA M424 Series of Standards

Canadian Deviation Review

ISO19296 Content Summary:

M424.0 Content Summary:

[Add the following Annexes]

Annex DA (normative)

Organization of the CSA M424 series of Standards

DA.1 Overview

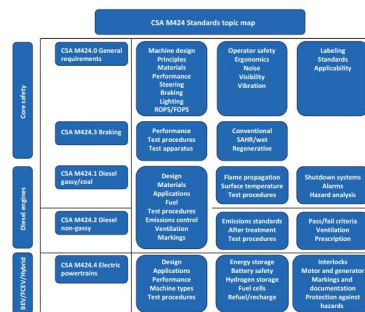
This Annex describes the intended use of the CSA M424 series of Standards.

The CSA Technical Committee on Underground Mining Mobile Equipment decided to restructure the whole set of stand-alone Standards in the CSA M424 series and transform it into a new set of Standards composed of general requirements documents and specific requirements documents.

This Standard contains the basic safety and essential performance requirements that are generally applicable to a variety of underground mining mobile equipment. This Standard shall be read and applied in conjunction with the relevant specific requirements standards for braking (CSA M424.3) and the specific type of power train concerned (CSA M424.1, CSA M424.2, and CSA M424.4).

Figure DA.1 shows the specific topics covered by the different Standards in the CSA M424 series of Standards.

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



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Annex DB (Informative): Battery handling, replacement, and fire suppression

Canadian Deviation Review

ISO19296 Content Summary:

M424.0 Content Summary:

*Annex DB (informative)***Battery handling, replacement, and fire suppression**Note: This Annex is not a mandatory part of this Standard.**DB.1 General**

The end user (mine operator/mine contractor), in conjunction with the equipment supplier (manufacturer), should complete a joint task-based technical risk assessment to include, but not be limited to, the following:

- a) transportation and storage of new, used, and damaged batteries;
- b) requirements for fire suppression/mitigation for the safe operation of the mobile equipment through its life cycle; and
- c) emergency protocol(s) in the event of imminent or complete battery failure.

In addition to completing a task-based technical risk assessment on the topics above, the equipment supplier (manufacturer) should provide documentation/training related to those topics limited to the operation and maintenance of the intended use of the machine.



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Annex DB (Informative): Battery handling, replacement, and fire suppression

Canadian Deviation Review

ISO19296 Content Summary:

M424.0 Content Summary:

DB.2 Example of key elements to consider in the execution of the joint task-based risk assessment

Table DB.1 provides an example of a risk register and key elements to consider in the execution of a joint task-based risk assessment(s).

Table DB.1 is provided for guidance purposes only. The example provided is battery electric vehicle (BEV)-oriented.

Table DB.1
Example of a risk register for a joint task-based risk assessment

Legend: The following abbreviations are used in this Table:

ALARP	– as low as reasonably possible
BEV	– battery electric vehicle
ER	– emergency response
H&S	– health and safety
HDEM	– heavy duty equipment mechanic
JSA	– job safety analysis
MOC	– management of change
MGF	– maintenance general foreman
OEM	– original equipment manufacturer
PM	– prescribed maintenance
PTAC	– pre-task assessment card
R&D	– research and development
SME	– subject matter expert
S/OEM	– supplier/original equipment manufacturer
SOP	– standard operating procedure
TDG	– transportation of dangerous goods



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Annex DB.1 (Informative): Example of key elements to consider in the execution of the joint task-based risk assessment

ISO19296 Content Summary:

M424.0 Content Summary:

March 2022

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CSA/19

Table DB.1 (Continued)

Key element	Risk event description	Event cause	Consequence	Existing controls	Health and safety management of risk				Substantial or major consequences occurring (with likelihood)		Adaptivity of controls		Additional risk treatment actions to reduce risk to ALARP			
					Current	Residual	Current	Residual	In spite of existing controls	In spite of proposed controls	Current	Proposed	Risk treatment actions	Current	Target	Capital cost
1. BEV-1000 M424.0 M424.1 M424.2 M424.3 M424.4 M424.5 M424.6 M424.7 M424.8 M424.9 M424.10 M424.11 M424.12 M424.13 M424.14 M424.15 M424.16 M424.17 M424.18 M424.19 M424.20 M424.21 M424.22 M424.23 M424.24 M424.25 M424.26 M424.27 M424.28 M424.29 M424.30 M424.31 M424.32 M424.33 M424.34 M424.35 M424.36 M424.37 M424.38 M424.39 M424.40 M424.41 M424.42 M424.43 M424.44 M424.45 M424.46 M424.47 M424.48 M424.49 M424.50 M424.51 M424.52 M424.53 M424.54 M424.55 M424.56 M424.57 M424.58 M424.59 M424.60 M424.61 M424.62 M424.63 M424.64 M424.65 M424.66 M424.67 M424.68 M424.69 M424.70 M424.71 M424.72 M424.73 M424.74 M424.75 M424.76 M424.77 M424.78 M424.79 M424.80 M424.81 M424.82 M424.83 M424.84 M424.85 M424.86 M424.87 M424.88 M424.89 M424.90 M424.91 M424.92 M424.93 M424.94 M424.95 M424.96 M424.97 M424.98 M424.99 M424.100	Loss of control of a battery pack during transport, handling or storage, leading to thermal runaway, fire, explosion, and maintenance effects.	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	Current	Residual	Current	Residual	In spite of existing controls	In spite of proposed controls	Current	Proposed	Risk treatment actions	Current	Target	Capital cost
1. BEV-1000 M424.0 M424.1 M424.2 M424.3 M424.4 M424.5 M424.6 M424.7 M424.8 M424.9 M424.10 M424.11 M424.12 M424.13 M424.14 M424.15 M424.16 M424.17 M424.18 M424.19 M424.20 M424.21 M424.22 M424.23 M424.24 M424.25 M424.26 M424.27 M424.28 M424.29 M424.30 M424.31 M424.32 M424.33 M424.34 M424.35 M424.36 M424.37 M424.38 M424.39 M424.40 M424.41 M424.42 M424.43 M424.44 M424.45 M424.46 M424.47 M424.48 M424.49 M424.50 M424.51 M424.52 M424.53 M424.54 M424.55 M424.56 M424.57 M424.58 M424.59 M424.60 M424.61 M424.62 M424.63 M424.64 M424.65 M424.66 M424.67 M424.68 M424.69 M424.70 M424.71 M424.72 M424.73 M424.74 M424.75 M424.76 M424.77 M424.78 M424.79 M424.80 M424.81 M424.82 M424.83 M424.84 M424.85 M424.86 M424.87 M424.88 M424.89 M424.90 M424.91 M424.92 M424.93 M424.94 M424.95 M424.96 M424.97 M424.98 M424.99 M424.100	Loss of control of a battery pack during transport, handling or storage, leading to thermal runaway, fire, explosion, and maintenance effects.	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	BEV design, BEV R&D maintenance, operation, management plans, Access & handling batteries on site (including disposal), Transporting batteries to/within/from site, Storage maintenance/by area for stability control, Commissioning prescribed verifications, Inspection – trades/OEM, Routing servicing/OEM prescribed maintenance, Troubleshooting/diagnostics – trades/OEM, Repairing/OEM prescribed bed shop repairs (SOP's), Repairing/OEM prescribed bed field repairs, Authorized personnel – maintenance knowledge, training, experience, Authorized personnel – operation knowledge, training, experience, Operating – pre-op/servicing, Operating – break-downs, BEV – emergency response	Current	Residual	Current	Residual	In spite of existing controls	In spite of proposed controls	Current	Proposed	Risk treatment actions	Current	Target	Capital cost
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Etc. Risk assessment example is very comprehensive and is a good guide on how to conduct one



Annex DB.1 (Informative): Example of key elements to consider in the execution of the joint task-based risk assessment

Key elements:

- BEV engineered specifications/standards
- BEV R&D maintenance, operation, management plans
- Access & handling batteries on site (including disposal)
- Transporting batteries to/within/from site
- Storage maintenance/by area for stability control
- Commissioning prescribed verifications
- Inspection – trades/OEM
- Routing servicing/OEM prescribed maintenance
- Troubleshooting/diagnostics – trades/OEM
- Repairing/OEM prescribed bed shop repairs (SOP's)
- Repairing/OEM prescribed bed field repairs
- Authorized personnel – maintenance knowledge, training, experience
- Authorized personnel – operation knowledge, training, experience
- Operating – pre-op/servicing
- Operating – break-downs
- BEV – emergency response

