CO_2 MANAGEMENT IN PRESSURISED OPERATOR CABINS

Why CO_2 management is important

Carbon dioxide (CO_2) is naturally produced when an operator breathes. In an enclosed machine cabin, CO_2 can gradually increase if there is not enough fresh outside air entering the cabin.

A pressurised cabin therefore needs to achieve two things:

1. **Provide sufficient filtered fresh air to the cabin.**
2. **Maintain positive cabin pressure to minimise the entry of contaminated outside air through gaps and leakage points.**

The Cleancab pressuriser continuously introduces filtered outside air into the cabin and automatically adjusts fan speed to maintain the selected cabin-pressure target.

CO_2 monitoring provides an additional indication that sufficient fresh air is being supplied to the cabin.

ISO 23875 CO_2 REQUIREMENTS

ISO 23875 specifies requirements for air-quality control systems used in operator enclosures. The standard specifies that the maximum sustained CO_2 concentration should be no more than:

Ambient CO_2 + 400 ppm

For example:

Ambient CO_2	ISO 23875 maximum sustained level
350 ppm	750 ppm
400 ppm	800 ppm
500 ppm	900 ppm
600 ppm	1,000 ppm

Ambient CO_2 can vary depending on location and conditions. Consequently, the ISO 23875 limit can vary with the ambient CO_2 concentration.

Cleancab alarm settings

Cleancab systems are configured with a **1,000 ppm first alarm**.

ISO 23875 also specifies a **2,500 ppm second alarm**. The monitoring system requirements include audible and visual notification, with the second alarm recurring at intervals of no more than 10 minutes if the alarm condition remains.

The 1,000 ppm Cleancab setting provides a practical fixed alarm point across different operating environments. However, the ISO 23875 performance requirement of **ambient + 400 ppm** remains a separate requirement and should be considered when assessing system performance.

WHAT DOES A CONTINUOUS CO_2 ALARM MEAN?

If the CO_2 alarm continues to operate after completing the **15-minute CO_2 gain test**, the system should be investigated.

A continuously elevated CO_2 level generally indicates that the cabin is not receiving enough effective fresh-air exchange for the particular cabin leakage and operating conditions.

Fan speed is an important indicator

The Cleancab pressuriser controls cabin pressure by automatically adjusting the pressuriser fan speed.

The system continually adjusts the fan speed to achieve the programmed cabin-pressure target.

Therefore, **fan speed provides a useful indication of how hard the pressuriser is working to maintain the required cabin pressure.**

CHECKING PRESSURISER FAN SPEED

When investigating a high CO_2 level, check the pressuriser with the machine's HVAC system **switched off**.

Allow sufficient time for the cabin pressure to stabilise.

This is important because the machine's HVAC system can contribute to the movement of air within the cabin.

If the HVAC system is operating, the HVAC fan can assist the Cleancab system. Depending on the HVAC fan speed, this can result in the Cleancab pressuriser operating at a lower fan speed than it would with the HVAC system switched off.

Therefore:

For troubleshooting the Cleancab pressuriser, assess the pressuriser fan speed with the machine HVAC switched off.

CO_2 GAIN TEST

When conducting the CO_2 gain test, the machine HVAC should normally be operated at **medium fan speed** where required by the test procedure.

The HVAC fan helps circulate and mix the air within the cabin, allowing the CO_2 measurement to better represent the cabin atmosphere.

The pressuriser itself should be assessed separately with the HVAC switched off when determining the pressuriser's actual operating fan speed and pressure performance.

WHAT IF CO_2 IS HIGH AND PRESSURISER FAN SPEED IS LOW?

Cleancab testing has shown that, for the specified test configuration, a cabin pressure target of approximately **35 Pa** with a pressuriser fan speed of approximately **17% or greater** provides sufficient airflow for CO_2 management.

This figure should be treated as a **Cleancab system/test reference**, rather than a universal airflow requirement for every machine. Cabin volume, leakage, operator occupancy, HVAC configuration and installation conditions can all affect CO_2 behaviour.

If a cabin has elevated CO_2 and the pressuriser fan speed is below the expected operating range, investigate the following options.

Option 1 — Increase the pressure target

Increase the cabin-pressure target and repeat the test.

For example, the pressure target can be progressively increased, where appropriate for the installation, up to the permitted system/design limit.

Increasing the pressure target causes the pressuriser to increase fan speed, which increases the amount of filtered outside air being delivered into the cabin and increases the air leaving through the cabin leakage paths.

Important: ISO 23875 specifies a minimum sustained pressurisation of 20 Pa and a maximum sustained pressurisation of 200 Pa.

Option 2 — Increase controlled cabin air leakage

If the cabin is exceptionally well sealed, there may not be sufficient airflow passing through the cabin even though the pressuriser is maintaining the required pressure.

A controlled increase in cabin leakage can allow more fresh air to pass through the cabin and assist CO_2 removal.

Any modification to cabin sealing should be assessed carefully because excessive leakage can reduce the cabin's ability to prevent contaminated outside air entering the enclosure.

WHY CABIN LEAKAGE MATTERS

A pressurised cabin works by supplying more filtered air than the cabin naturally loses through leakage.

This creates positive pressure.

However, **some air must leave the cabin** for fresh air to continuously pass through the enclosure.

If the cabin is sealed extremely tightly, the pressuriser can reach the required pressure with relatively little airflow.

This can result in:

- low pressuriser fan speed;
- insufficient fresh-air exchange;

- increasing CO_2 concentration.

Conversely, excessive cabin leakage can require the pressuriser to operate at a higher fan speed and can reduce the effectiveness of cabin pressurisation.

The objective is therefore not to make the cabin completely airtight. The objective is to achieve the correct balance between **cabin sealing, filtered fresh-air supply, airflow and positive pressure**.

CO_2 EXPOSURE LIMITS — DO NOT CONFUSE THESE WITH ISO 23875

ISO 23875's CO_2 requirement is a **cabin air-quality performance requirement**. It should not be confused with workplace exposure limits.

Under the Australian WES framework, the general CO_2 exposure standard is:

- **8-hour TWA: 5,000 ppm**
- **15-minute STEL: 30,000 ppm**

Safe Work Australia currently lists these values for CO_2.

From **1 December 2026**, Australia is scheduled to transition from WES to WEL terminology.

These exposure limits are **not the target operating levels for an ISO 23875 cabin**.

For an ISO 23875 cabin, the much lower **ambient + 400 ppm** requirement is the relevant cabin-performance criterion.

CO_2 IN UNDERGROUND COAL MINING

Coal mining has a specific CO_2 exposure value.

Safe Work Australia's exposure-standard database identifies a separate value for **carbon dioxide in coal mines**:

- **TWA: 12,500 ppm**
- **STEL: 30,000 ppm**

This special value applies to underground coal mining where CO_2 emissions from the coal strata are a natural phenomenon.

Queensland's Coal Mining Safety and Health Regulation also specifically addresses underground mine CO_2. It limits general-body CO_2 concentration to **12,500 ppm**, with a provision allowing exposure up to **30,000 ppm** where continuous personal monitoring is used and the applicable TWA does not exceed 12,500 ppm.

These mining exposure limits should **not be used as the desired CO_2 concentration inside an operator cabin**.

For a pressurised operator cabin, the ISO 23875 requirement remains considerably more stringent:

Ambient CO_2 + 400 ppm maximum sustained CO_2.

KEY POINTS FOR TECHNICIANS

When investigating CO_2 in a pressurised cabin:

1. CO_2 is produced by the operator.

2. Fresh filtered outside air is required to remove CO_2 from the cabin.

3. Positive pressure helps prevent contaminated outside air entering through cabin leakage points.

4. Cabin pressure alone does not guarantee sufficient fresh-air exchange.

5. A very well-sealed cabin can achieve high pressure with relatively low airflow.

6. Fan speed is therefore an important indicator when investigating CO_2 performance.

7. Assess Cleancab pressuriser fan speed with the machine HVAC switched off when determining the pressuriser's actual operating condition.

8. Use the HVAC at the specified test setting during the CO_2 gain test to assist air mixing within the cabin.

9. If CO_2 remains high, investigate cabin airflow, fan speed, pressure target, cabin leakage and installation conditions.

10. Do not confuse the Australian workplace exposure limits with the ISO 23875 cabin-performance requirement.

The objective

The objective of the Cleancab system is not simply to maintain a positive pressure inside the cabin.

The system must provide an appropriate combination of:

Filtered fresh air + positive pressure + controlled cabin leakage + effective air circulation + CO_2 monitoring

Important Information – CO_2 Alarm Settings

The CO_2 alarm settings within the Cleancab system are provided as an operational monitoring and warning function and should not be interpreted as establishing or confirming compliance with any applicable Workplace Health and Safety (WHS), mining, occupational hygiene, exposure limit or other regulatory requirements.

At the time of publication, ISO 23875 provides recommended CO_2 alarm levels, including a first warning level based on an increase of approximately **400 ppm above ambient CO_2 concentration** and a second warning level of approximately **2,500 ppm**. These levels are recommendations associated with the standard and should not be regarded as a substitute for the specific requirements applicable to the workplace, site, plant or jurisdiction.

The site operator, PCBU, mine operator or other responsible person must determine the CO_2 monitoring and alarm requirements applicable to the workplace, considering relevant legislation, regulatory requirements, site conditions, risk assessments and occupational hygiene requirements. Where required, independent advice from a suitably qualified occupational hygienist or another competent person should be obtained.

Where a CO_2 alarm is **not required by the applicable site requirements**, the CO_2 alarm threshold in the Cleancab application may be configured to **10,000 ppm**. At this setting, the alarm function will effectively be disabled for normal cabin CO_2 concentrations. This setting should only be used where the responsible site authority has determined that a CO_2 alarm is not required.

Important: Changing or disabling the CO_2 alarm setting does not remove or alter any legal duty or regulatory requirement applicable to the workplace. Cleancab does not determine whether a particular CO_2 alarm setting is appropriate or sufficient for a specific workplace, plant item, mine or operating environment.

ISO 23875 is currently subject to review. Requirements and/or recommendations relating to cabin air quality and CO_2 levels may therefore change in future. Users should refer to the current edition of the applicable standard and the requirements of the relevant WHS or mining regulator.

Cleancab is also developing a future software update that will provide the ability to configure CO_2 alarm thresholds up to **40,000 ppm**. This functionality is intended to provide greater flexibility for site-specific monitoring requirements, including applications where higher alarm thresholds may be specified by the relevant site or mining requirements. The availability of an adjustable alarm threshold does not, in itself, constitute confirmation of regulatory compliance.

The responsible site operator remains responsible for determining and maintaining the CO_2 alarm levels and other control measures required for the specific workplace and operating conditions.

Documentation of Site-Specific CO_2 Settings

Where the CO_2 alarm levels are changed from the standard Cleancab settings to suit specific site requirements, the reason for the change and the authorised setting should be documented and retained for future reference.

It is recommended that confirmation of any site-specific CO_2 alarm settings be provided in writing by the responsible site representative. Email correspondence is the preferred method of documenting and retaining this information. Documentation should identify the applicable site, equipment, agreed CO_2 alarm settings, reason for the change, and the person or organisation authorising the change.

This documentation should be retained by the relevant parties as part of the site's equipment, commissioning, maintenance or compliance records and made available for future reference where required.