

Focus on Protective Breathing Equipment



Protective Breathing Equipment (PBE) protects the user's face and respiratory system from heat, smoke and noxious gases. In-service events were reported to Airbus where the PBE did not work as expected or where cabin crew had difficulties using their equipment or inappropriately used it, which impaired their safety.

This article explains the concept and specificities of PBE. It recalls the essential maintenance, operational, and training considerations that must be followed in order to ensure PBE integrity and safe use in the case of an emergency.

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CASE STUDY

Event Description

An A330 aircraft was taxiing to its departure runway when the flight crew noticed a smell of heated asphalt in the cockpit. The outside air temperature was 38 °C. The flight crew reportedly suspected that the smell was coming from the heated airport ground. There were 2 flight crew members, 10 cabin crew members, and 223 passengers onboard.

Strong unusual smell during initial climb

The flight crew performed a takeoff with both air conditioning packs set to OFF, and then switched pack 2 back to ON during the initial climb. Soon after, they detected a smell of "dirty socks". The flight crew switched pack 2 OFF again. This stopped the smell. They waited for 5 minutes and switched pack 2 ON again. The smell did not reappear. Pack 1 was set to ON soon after.

Temporary unusual smell also confirmed in the cabin

The cabin crew members confirmed the presence of the smell in the cabin during the initial climb but also that the smell quickly disappeared.

In-flight turnback due to abnormal symptoms felt in the cabin

When the aircraft reached FL 340, several cabin crew members reported that they felt burning sensation and irritation of the eyes, as well as headaches. The flight crew decided to perform an in-flight turnback. They put on their oxygen masks and initiated the descent.

Use of PBE in the cabin

Several cabin crew members decided to put on their PBE **(fig.1)**. Seven of them faced difficulties using their PBE:

- Several of them found it difficult to open the vacuum bag in which the PBE was packaged. Two of them had to use scissors or a knife to open the bag
- One of the two straps used to initiate the oxygen supply and secure the mask broke off when a cabin crew pulled on it
- One cabin crew member needed three minutes to don their PBE and felt very uncomfortable due to the high temperature and the tightness of the neck seal
- Several cabin crew members felt that inhalation was difficult when using the PBE
- Communication between crew members wearing PBE was challenging.

Safe landing

The aircraft landed safely after two hours of flight with no reported injuries among passengers or crew.



(fig.1) Type of PBE used during the event (photo from the PBE manufacturer)

Event Analysis

The root cause of the smell was not formally identified

Troubleshooting performed by the maintenance crew did not formally identify the root cause of the smell.

Use of PBE

The CCOM mentions that Protective Breathing Equipment (PBE) protects the user's face and respiratory system from heat, smoke and noxious gases.

Two damaged PBE

Post-flight inspection of the PBE used during the event revealed that, in addition to the broken strap on a PBE, a second PBE showed damage on the visor that could not be a result of incorrect removal from the vacuum bag.

Cabin crew were not comfortable with the use of PBE

Despite having regular training on the use of PBE, the cabin crew found it difficult to use the PBE in this situation, which highlights the potential need for training improvement.

Extended use of the PBE exposed some cabin crew members to risk of hypoxia

Two cabin crew members kept their PBE on until after landing, which resulted in the PBE being used for longer than the certified duration of 15 minutes.

Although no health issues were reported by PBE users, this incident underscored the importance of increasing cabin crew awareness regarding the limitations of PBE and the potential for hypoxia with prolonged use. ■



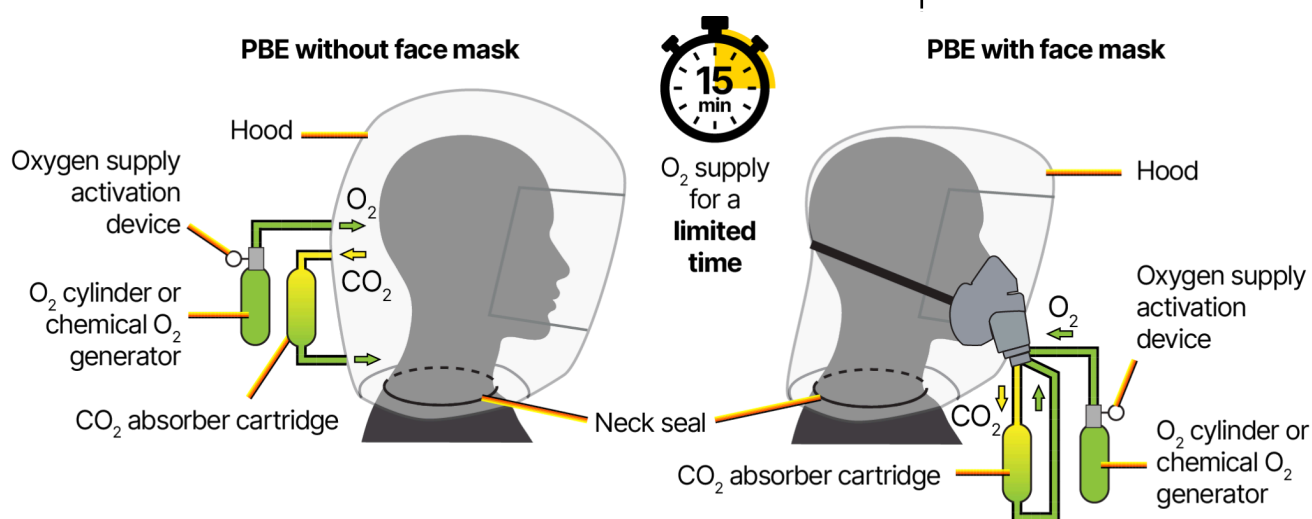
PBE DESIGN

PBE, also called smoke hood, is designed to protect the crew members from smoke, carbon dioxide, and other harmful gases while they are on flight deck duty or while combating fires. PBE is available in several locations in the aircraft cabin, in the cockpit, and crew rest areas.

A Common Principle

Several models of PBE are available. Each one has its specificities that are detailed in the PBE manufacturer's documentation. However, regardless of the PBE type, they are based on a similar concept of a closed-circuit breathing system **(fig.2)**.

(fig.2) Principle of PBE



Each PBE includes a **hood** to cover the head of the user, providing a protected environment. A **neck seal** ensures the airtightness of the hood to prevent smoke, gas, or fumes from entering the hood.

The CO₂ exhaled by the user is removed by a **CO₂ absorber cartridge**. Additional oxygen supply is obtained via either a **gaseous oxygen cylinder** or a **chemical oxygen generator**. Oxygen can be provided directly into the hood or through a facemask depending on the PBE type **(fig.3)**. The user generally activates the oxygen supply by pulling on an activation ring or a lanyard. The activation device may differ depending on the PBE model.



KEYPOINT

PBE can only be used for a limited time. Certification criteria requires that PBE provide oxygen for **15 minutes**.

(fig.3) Various types of PBE can be used in Airbus aircraft (photos from the PBE manufacturers)



PBE Stowage

Each PBE is packed in a **vacuum/moisture resistance bag** to protect it from humidity and contamination **(fig.4)**. Each vacuum bag is stored in a **container**. Integrity of both the container and the vacuum bag is essential to ensure operational PBE.



(fig.4) Examples of PBE container and vacuum/moisture resistance bag (photos from the PBE manufacturers)

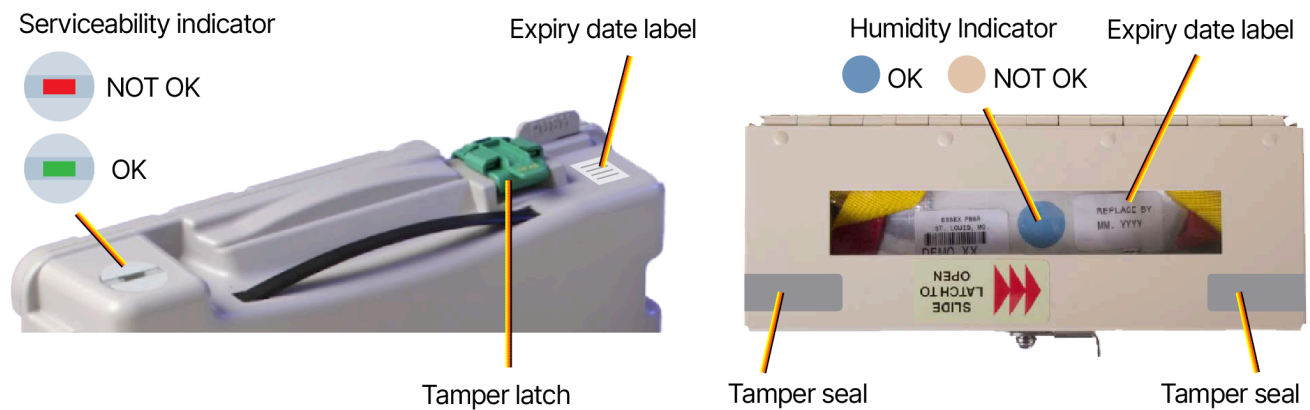
A **serviceability or condition indicator** is available on the container of some PBE models. On other PBE models, a **humidity indicator** is available **(fig.5)**.

A **tamper seal** or a **tamper latch** is available on some containers to indicate if the container was opened.

Limited service life

PBE usually has a 10-year service life (after date of manufacturing). An expiry date is displayed on the container or on the vacuum bag. ■

(fig.5) Examples of containers equipped with a serviceability and humidity indicator as well as tamper seal or tamper latch



MAINTENANCE CONSIDERATIONS

PBE must be replaced as specified in the Maintenance Planning Document (MPD), before reaching its expiry date.

Regular maintenance checks

PBE must be inspected at the interval defined in the MPD. The associated Aircraft Maintenance Manual (AMM) procedure must be followed.

Typical checks that must be performed include:

- Check of the **PBE expiry date**
- Check the **vacuum/moisture resistance bag condition** (if visible): The bag must not be inflated
- Check the **container's tamper seal or tamper latch condition** (if installed): If damaged, the AMM may request that the container be opened to verify the integrity of the vacuum bag and replace the damaged tamper seal or tamper latch
- Check that the **PBE serviceability/condition indicator** (if installed on the container) is green (if red, the vacuum is compromised. The PBE must be replaced)
- Check that the **humidity indicator** (if installed) is blue (if pink, the PBE must be replaced)
- Check of the **general condition of the container.** ■

OPERATIONAL CONSIDERATIONS

Preflight Check

Cabin crew and flight crew members should check the condition of the PBE devices available in the aircraft before each flight or before the first flight of the day depending on the airline's policy and local regulations. This includes checking the PBE in the cabin and in the cockpit.

Typical checks that should be performed include:

- Check of the **PBE expiry date**: If expired, maintenance personnel should be informed
- Check the **vacuum bag condition** (if visible): The bag must not be inflated
- Check the **container's tamper seal or tamper latch condition** (if installed): If damaged, maintenance personnel should be informed
- Check that the PBE **serviceability/condition indicator** (if installed on the container) is green. If red, the vacuum bag is compromised. Maintenance personnel should be informed: the PBE must be discarded
- Check that the **humidity indicator** (if installed) is blue (if pink, Maintenance should be informed: the PBE must be discarded)
- Check the **general condition of the container.**



KEYPOINT

Cabin crew and flight crew members must be **familiar with the characteristics of the PBE** available in the aircraft they are flying in, so that they know which item needs to be verified during the preflight check.

Use of PBE

Adherence to the PBE manufacturer procedure is essential to ensure the safe use of PBE. Here is a recall of some key information to be considered when using the PBE:



KEYPOINT

All crew members, including flight crew and cabin crew, must be **familiar with the use of the PBE available in the aircraft they are flying in.**

Choosing a safe area to don the PBE

As for any oxygen supply, fire risk must be considered for the donning of PBE.



KEYPOINT



The user must **don the PBE away from a fire area** since oxygen leak outside of the device during the donning sequence.

Unfolding the PBE

PBE remains tightly folded in the vacuum/moisture resistant bag for months and may need some effort to be unpacked. It is recommended to have dry hands to open the PBE container and vacuum/moisture resistance bag as it may require some force to do it.

Tear pads also referred to as **tear off strips** (generally red) must be pulled to open the vacuum bag (**fig.6**). Arrows may indicate the direction of the pull to ease opening.

Specific unfolding actions may be needed depending on the PBE type.



(fig.6) Example of a PBE vacuum bag with tear pads to ease opening



KEYPOINT

PBE users must be **familiar with the unpacking and unfolding of the PBE** available in the aircraft they are flying in, to enable **timely donning and prevent damage** to the device.

Adjustment of the PBE

The neck seal requires widening to don the PBE. This may require some force.

It is essential to correctly don the PBE and adjust the neck seal so that the airtightness of the device is ensured. Any hair passing through the neck seal can impair the airtightness and create an oxygen leak or allow smoke to enter the hood. Therefore, the user must ensure that all their hair is inside the hood.

It is also essential to correctly adjust the face mask on PBE equipped with this technology so that oxygen supply and CO₂ removal is done correctly.



KEYPOINT

Correct adjustment of the PBE is essential to ensure safe protection.

Activation of the oxygen supply

Depending on the type of PBE, the oxygen supply is activated either before, during, or after donning. Oxygen supply activation is done manually (**fig.7**) or automatically depending on the PBE type. When activated, the oxygen supply produces noise due to the oxygen flowing inside the hood, especially shortly after activation. This indicates that the oxygen supply is activated. The noise may disappear after this initial phase depending on the type of oxygen generation. The user should be aware of the time when the oxygen is activated and check the duration of usage.



(fig.7) Example of an oxygen supply activation (photo from a PBE manufacturer)

Comfort of the PBE

Chemical oxygen generators and CO₂ absorber cartridges may emit heat due to the chemical reactions that occur. The moisture level of the mask may also increase due to the humidity from the user's exhalation. Therefore, **the user should be prepared for this experience of a closed, relatively hot, and humid environment**. However, excessive heat and humidity can be a sign of the device dysfunctioning and requires immediate PBE removal.

When to remove PBE

The duration of use is limited to 15 minutes. The PBE must be removed as soon as the oxygen supply stops or a dysfunction of the PBE occurs.



KEYPOINT

Flight crew and cabin crew members **must be aware of the signs that it is time to remove the PBE** to prevent hypoxia. Typical signs of oxygen supply stoppage are:



- A rapid increase of temperature inside the hood
- An excessive humidity inside the hood
- Difficulty to take a full inhalation
- The PBE hood collapses around the head of the user
- The end-of-service indicator flashes red (if installed)

The signs showing that the oxygen supply stops may differ depending on the PBE model. They are listed in the user guide from the PBE manufacturer and should be known by all crewmembers.



KEYPOINT

At any time, the user must immediately remove the PBE if they feel any sign of hypoxia (low oxygen level in the blood) **or hypercapnia** (high CO2 level in the blood) like:



- Rapid breathing
- Difficult breathing
- Increased heart rate
- Confusion
- Headache
- Restlessness

Choosing a safe area to remove and stow the used PBE

The PBE must be removed away from the source of smoke.

The user must be aware that oxygen may remain in their hair and clothes after the removal of the PBE and that used PBE may still generate oxygen for a period of time.



KEYPOINT



PBE must be removed and stowed away from a fire area to prevent remaining or leaking oxygen from feeding the fire.

The PBE may remain hot after removal

Depending on the PBE model, the oxygen generator and CO2 absorber cartridge may remain hot after use. The crew members should avoid touching them until they are cooled down.

Used PBE must not be reused

When removed, PBE must be considered as unserviceable. It must not be used again. ■

TRAINING CONSIDERATIONS

PBE is used during emergency events and must be donned quickly. The context of an emergency event may create additional stress for the crew when trying to don the PBE. Therefore, it is essential that appropriate training is provided for the crew in order to mitigate such stress and improve overall performance and decision-making.

Detection of Hypoxia and Hypercapnia

During training, crews should be reminded about the physiological signs of hypoxia and hypercapnia. This will enable them to react appropriately by immediately removing their PBE at the first signs of hypoxia or hypercapnia.

Training on the Right PBE Models

Crews must be trained on the specific PBE model(s) installed in the aircraft they are assigned to fly.

Flight and cabin crews should have access to the user guide from the PBE manufacturer. This will enable them to familiarize themselves with the PBE's characteristics, limitations, and signs of oxygen supply stoppage.

Representativity of Training PBE

As per regulations, cabin crews and flight crews must be regularly trained on the use of PBE. Dummy PBE devices are usually used for training. They may have a similar shape and weight and simulate some features, however, they are not fully representative of the real PBE that the crews may use onboard the aircraft.



Real PBE



Training PBE

(fig.8) Training PBE may not be fully representative of the real device (photos from the PBE manufacturers)

Training PBE is usually already unfolded

Training PBE is usually already removed from the vacuum/moisture resistance bag and container and unfolded. As a result, the trainees do not experience the actual opening of the PBE container and vacuum bag. Real PBE remains tightly folded in the vacuum bag for months and may need some effort to be unpacked and unfolded.

Training PBE can have a loose neck seal

Training PBE is reused many times. Despite having the possibility to replace the neck seal, it may not be as tight as a new unit.

Training PBE does not emit noise or heat

Training devices do not have an oxygen supply or a CO2 absorber. Therefore, the use of the training PBE does not provide a realistic experience of the sound of the oxygen supply and of the heat that may be generated by the chemical reaction(s) that occur in real PBE. This may create a startle effect and stress when the crew members use the PBE in a real situation, where they experience the sounds, heat, and relative discomfort for the first time.

Training PBE does not reproduce signs of the oxygen flow stoppage

A training device cannot reproduce the specific signs that would indicate the need to remove the PBE. ■



NOTE

To enhance the training aspects of PBE, units reaching the end of their shelf life and removed from aircraft may be used to complement the training and provide some experience with real units.

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Protective Breathing Equipment (PBE) is needed in emergency situations, such as during fire or smoke events. PBE consists of a closed-circuit breathing system that removes the carbon dioxide from the user's exhaled air and provides oxygen for 15 minutes.

PBE devices are located in the cabin, cockpit, and crew rest areas. They are protected in a vacuum bag and stowed in a container. PBE usually has a 10-year service life from their manufacturing date, and must be replaced before their expiry date.

Regular checks must be done by maintenance personnel to check the integrity of PBE. In addition, the cabin crew and flight crew members should check the integrity of their PBE before the first flight of the day or before each flight depending on the operator's policy and local regulations. Checks include the verification of the expiry date of the device, the condition of the PBE container and of its vacuum bag, either visually, or with the help of a serviceability or humidity indicator, tamper seal or tamper latch, where applicable.

When using PBE, specific attention must be paid to key steps, including:

- Always put on, remove, or discard PBE away from a fire source
- Make sure that the PBE is correctly adjusted as specified in the manufacturer's instructions to ensure correct activation of the oxygen supply and correct operation
- The user must remove the PBE as soon as the oxygen supply stops or a dysfunction of the PBE occurs
- The user must remove the PBE immediately if they feel any sign of hypoxia (low oxygen level) or hypercapnia (high carbon dioxide level)
- Never reuse a used PBE

During training, crews should be reminded about the physiological signs of hypoxia or hypercapnia. They must be trained on the specific PBE model(s) installed in the aircraft they are assigned to fly, and should have access to the user guide from the PBE manufacturer to familiarize themselves with the PBE's characteristics, limitations, and signs of oxygen supply stoppage.

Dummy PBE used during regular crew training may not be fully representative of the real device that crew will use in the case of an emergency. The use of real PBE removed from an aircraft due to its close-to-expiry date may enable the trainees to observe the use of a real device. As a result, they would be better familiarized with PBE, if they need to use it in an emergency situation.

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