FLIGHT SAFETY FOUNDATION
CABIN CREW SAFETY

Vol. 36 No. 4 | For Everyone Concerned With the Safety of Flight | July–August 2001

Current Procedures Maintain Safety During Medical Use of Oxygen

With few exceptions, air carriers prohibit the use of oxygen equipment furnished by the passenger. To assume responsibility for providing safely and effectively oxygen for medical use, cabin crewmembers must receive periodic training on normal operating procedures and on emergency procedures.

FSF Editorial Staff

Many of the world's air carriers provide physician-prescribed oxygen to passengers throughout a flight, typically based on advance arrangements, medical assessment and a medical clearance process. The medical community and some air carriers call this type of oxygen "supplemental oxygen"; the U.S. Federal Aviation Regulations (FARs) refer to oxygen provided as directed by a physician's statement as "oxygen for medical use" (the term used in this article).[1]

Oxygen for medical use helps passengers who have health problems to breathe while flying in the aircraft cabin. Passengers most commonly receive the prescribed flow of oxygen from portable compressed-gas cylinders (commonly called "bottles") or from an aircraft system that distributes oxygen from a stationary source to outlets in the cabin (ring-main system).[2]

With few exceptions, air carriers that provide oxygen for medical use prohibit the use of oxygen equipment furnished by the passenger.[3] Oxygen is considered a hazardous material in aviation and is considered a prescription drug in medicine. As a result, the air carriers, their passenger service agents and their cabin crewmembers accept responsibility for providing this type of oxygen safely and effectively.[4]

No accidents or incidents involving medical use of oxygen in the cabins of airplanes operating under FARs Part 121 were found in searches of a U.S. accident/incident database and a database of safety reports submitted by U.S. crewmembers.[5]

A 1999 report by the American Medical Association (AMA) said that, although industrywide data on passengers receiving oxygen for medical use were not available, data obtained from individual air carriers in the mid-1990s indicated that each carrier transported annually from 100 oxygen-using passengers to 4,000 oxygen-using passengers.[6]

British Airways, which normally permits no more than one oxygen-using passenger per flight, transported 2,500 oxygen-using passengers in 2000.[7]

Recent studies have found variation in the availability and service aspects of oxygen for medical use.[8] Cabin crew training and standard operating procedures also vary among air carriers because of differences in areas such as individual air carrier policies, labor agreements, equipment, services and regulations.[9]

For example, British Airways trains cabin crews in the use of all oxygen equipment aboard the aircraft during safety-equipment training and medical training, said Dr. Nigel Dowdall, senior consultant occupational physician, British Airways Health Services.[10]

"Training needs are annually reviewed, and introduction of new equipment will always include an assessment of the training need; for example, in introduction of automated external defibrillators (AEDs), the procedure for administering shock includes a requirement to check that any oxygen is removed from the immediate vicinity of the casualty," Dowdall said.

To document passenger requests for medical use of oxygen and the passengers' fitness for commercial air travel, many member air carriers of the International Air Transport Association (IATA) use the organization's medical information form (MEDIF) and include in their medical guidelines information published by the Aerospace Medical Association (AsMA).[11] The passenger typically completes one part of the MEDIF and the passenger's medical representative completes another part of the MEDIF, allowing time for medical assessment and medical clearance. For medical use of oxygen, the process typically requires 48 hours to 72 hours but varies among air carriers and may require up to 30 days.

Canadian Airline Considers Medical Clearance Vital

Claude Thibeault, M.D., medical director of Air Canada, president of the International Academy of Aviation and Space Medicine and president-elect of AsMA, said that the medical clearance process for passengers who request medical use of oxygen helps to prevent in-flight health problems.[12]

"Flight attendants can assume that passengers using oxygen on the flight have been medically cleared," said Thibeault. "The airline medical department or an outside medical agency will look at [the MEDIF] to establish what is required, such as whether the oxygen flow rate will be two [liters], four [liters] or six liters per minute, for example. Sometimes the treating physician requests a service that is not approved; the airline physicians will consult with the treating physician to make sure that oxygen is provided appropriately. Sometimes we require passengers to accept oxygen, or we will not let them fly. We may accept a passenger, for example, who has a recent cardiac problem or pulmonary problem, but the person would have to use oxygen even if he or she did not ask for oxygen."

The process also determines whether the passenger can fly alone or requires either a nonmedical escort (such as a family member) or a medical escort (such as a nurse), he said. At Air Canada, medical clearance prior to medical use of oxygen has contributed to an incidence of in-flight medical emergencies that is lower among oxygen-using passengers than other passengers, said Thibeault.

"There is less chance of a problem among these passengers than for someone whose medical problem we do not know about," he said. "We have yet to have an in-flight medical problem with those we have cleared."

Nevertheless, cabin crewmembers should resolve with a passenger service agent — before departure — any question about the medical clearance or the treating physician's prescription for a passenger who will be using oxygen on the flight, he said.

Thibeault said that programs for medical use of oxygen vary among air carriers because of differences in national regulations, union rules for cabin crew duties and related agreements.

For example, the role of cabin crewmembers in providing oxygen for medical use varies between Canadian airlines and U.S. airlines, he said.

"Flight attendants in Canada will help the passenger, but they do not accept responsibility for providing [oxygen for medical use]," Thibeault said.

The assumption is that the passenger or the passenger's escort will be able to operate the oxygen equipment properly and independently, he said.

"The passenger and/or escort will be shown the airline's oxygen equipment," Thibeault said. "People turn the valve until the needle indicates the required flow rate, and the equipment works. Flight attendants are trained to operate all oxygen equipment on board if there is a problem, however."

A possible concern is that a passenger could increase the flow rate and use more oxygen than required, he said.

"The amount of oxygen carried [for medical use] is calculated in our technical department based on the flow rate specified in the medical clearance," he said. "If a lower flow rate was specified, but the flow rate then is increased, the passenger may run out of oxygen."

Medical criteria for the medical use of oxygen during flight are not standardized, he said.

"The question of medical need is more complex if passengers do not use supplemental oxygen on the ground," said Thibeault. "Physicians then discuss the patient's blood gases and decide if the passenger will require in-flight oxygen or not. Flight attendants will assume that if a passenger [requires oxygen for medical use], the passenger would need more help than others in an emergency. Someone who is short of breath to begin with will be in trouble more quickly, especially if there is smoke [in the cabin]."

Thibeault said that Air Canada has experienced an increase in demand for medical use of oxygen but that opinions differ as to the reason. Some have cited the demographic characteristics of an aging population, but cultural changes also have occurred, he said.

"Twenty years ago, if people were sick, they stayed home," said Thibeault. "Now, people with significant illness want to travel. This change in attitude about illness and travel has made the difference."

Incidence of Lung Diseases Increases Number of Oxygen-using Passengers

The AMA report said that more than 30 million Americans have chronic lung disease and that the most common type, chronic obstructive pulmonary disease (COPD), was diagnosed in 16.4 million Americans, including 14.5 million with chronic bronchitis and 1.9 million with emphysema.[13] The AMA report said that the prevalence of COPD in the United States had increased by 60 percent since 1982 and had affected 3 percent to 5 percent of the U.S. population.

An estimated 800,000 to 1 million Americans require home oxygen therapy, said the report. Such therapy typically involves breathing physician-prescribed medical oxygen from a mask, a nasal cannula (tubes positioned under the nose) or a connection to the patient's trachea (windpipe) through tubing from sources such as compressed-gas cylinders, containers of liquid oxygen or concentrators that provide oxygen from air.

Advances in technology enable many oxygen users to breathe medical oxygen at home, at work and while conducting normal activities away from these settings, including while traveling.

The AMA report said that without continuous oxygen — for example, during trips to and from the airport, before boarding a flight, after completing a flight, and during delays in airports — some travelers may experience problems ranging from discomfort to the worsening of an existing illness.

Pressurization systems for aircraft operating at 30,000 feet to 40,000 feet above sea level typically maintain the aircraft cabin at a pressure equivalent to that found at 5,000 feet to 8,000 feet above sea level.

The AMA report said, "Whereas most healthy travelers tolerate the decrease in [partial oxygen pressure in arterial blood] during flight, significant hypoxemia [less than normal oxygen in arterial blood] and oxyhemoglobin desaturation [less than normal combination of oxygen and hemoglobin to transport oxygen in blood from the lungs to the tissues] can develop in passengers with cardiac [disease] and respiratory disease. This includes passengers with severe respiratory disease who are hypoxemic at ground level, as well as those with milder disease who only become hypoxemic when exposed to the lower [partial pressure of oxygen in arterial blood] that occurs in air travel."[14]

The heart rate and breathing rate of healthy aircraft occupants at cruise altitude will compensate for the changes in available oxygen and will restore adequate oxygen levels in the blood and throughout the body, said the report.

"A passenger with a cardiopulmonary condition who is unable to manifest a compensatory response may become seriously desaturated, causing tissue hypoxia [less than normal oxygen in tissue], ischemia [insufficient blood supply] or infarction [sudden insufficiency of blood supply]," said the report. "The situation may be worsened by physical exertion; hypoventilation [reduced breathing] during sleep; drying of respiratory secretions (due to low cabin humidity); hypoxemia-induced pulmonary hypertension [high blood pressure] (which can result in decreased cardiac output); and the effects of alcohol, sedatives and other medications."[15]

The report said that the following subtle signs may occur in a person experiencing mild in-flight hypoxia:

- Mental confusion;
- Euphoria;
- Impaired judgment;
- Impaired vision;
- Increased susceptibility to fatigue; and,
- Drowsiness.

The report said that the following signs may occur in a person experiencing more severe in-flight hypoxia:

- Headache;
- Nausea;
- Listlessness;

- Insomnia;
- Altered personality;
- Altered breathing pattern;
- Seizures; and,
- Coma.

"Few data are available on the incidence and clinical significance of hypoxemia and hypoxemia-induced symptoms and complications in cardiopulmonary patients traveling on commercial airlines," said the report. "Limited data suggest that acute hypobaric exposure [reduced air pressure] has minimal effect on in-flight morbidity [illness/injury] and mortality. With appropriate medical screening and preparation, most patients with cardiopulmonary problems can safely tolerate the effects of flight-related hypoxia."[16]

Cabin crew training about the flight environment and its effects on human physiology — as well as their training in the use of oxygen for responding to in-flight medical emergencies, cabin decompression, fumes, smoke or fire — provides background for the medical use of oxygen.

General emergency training prepares cabin crews to respond knowledgeably to situations that involve oxygen-using passengers, said Thibeault. For example, the practice of assigning another passenger as a "buddy" to assist an oxygen-using passenger during an emergency may be applicable. Similarly, in fighting a cabin fire, the cabin crew may remove oxygen bottles from the area.

Nevertheless, specific procedures for oxygen-using passengers are provided in some air carrier training, which varies according to specific equipment and policies. British Airways includes such training for cabin decompression, for example.

"In a decompression, crew check that all passengers have put on the drop-down [oxygen] mask, which will deliver a higher concentration of oxygen [than in medical use of oxygen]," Dowdall said. "There is no facility to further increase the oxygen supply to passengers who had been on supplemental [medical use of] oxygen; however, this should not create a problem, as the aircraft will descend rapidly to a safe altitude."

In the United States, a required number of hours of crewmember training to provide medical use of oxygen is not specified. Nevertheless, U.S. Federal Aviation Administration (FAA) Order 8400.10, *Air Transportation Operations Inspector's Handbook*, includes medical use of oxygen under topics that must be covered in crewmember emergency training under FARs Part 121.417.[17] The regulation requires that each type of emergency oxygen system must be taught in initial training and in recurrent training at least every 24 months, and that each crewmember must perform specified drills and operate specified equipment. Part 121.417 also requires that crewmembers who serve in operations above 25,000 feet receive instruction in the following topics relevant to the medical use of oxygen (paragraph numbers omitted): "respiration, hypoxia, duration of consciousness without supplemental oxygen at altitude, gas expansion, gas bubble formation, and physical phenomena and incidents of decompression."

Improved Assessment of Oxygen Requirement Protects Passengers

Physicians can estimate by several methods the ability of a patient with chronic lung disease to tolerate reduced pressure without the medical use of oxygen.

The AMA report said, "A simple test is to determine whether the patient can walk 50 yards [a 50-meter test also is used] or climb one flight of stairs without becoming severely dyspneic [short of breath]. Persons who perform poorly on this test should be evaluated further."

British Airways Health Services, using guidelines derived from IATA recommendations, said, "Individuals who are markedly breathless at rest should be advised not to fly."[18]

Methods used to assess a person's ability to breathe adequately during flight include:

- Use of tables and equations to estimate what the patient's arterial partial pressure of oxygen would be at various cabin pressure altitudes based on measurements in the physician's office;
- Tests in a hypobaric chamber in which air pressure is reduced to levels that the patient would experience in flight; and,
- Tests in the physician's office in which the patient's arterial partial pressure of oxygen is measured as the patient breathes a mixture of gases containing 15 percent oxygen to simulate a cabin pressure altitude of approximately 8,000 feet.[19]

The physician typically will make one of the following determinations:

- The passenger can fly safely without medical use of oxygen;
- A prescription for medical use of oxygen is required to fly safely; or,
- The risk of in-flight medical problems is too great to fly safely.

The report said, "For patients who do not ordinarily require supplemental oxygen at ground level, [a flow rate of two liters per minute] should adequately correct hypoxemia. For those on supplemental oxygen at ground level, flow rates should be increased by one [liter per minute] to two liters [per minute]."[20]

Providing Oxygen Helps to Prevent Medical Diversions

Joan Sullivan Garrett, president and CEO of MedAire and chairwoman of the Flight Safety Foundation Corporate Advisory Committee Oxygen Working Group, said that flying comfortably on air carriers has become routine for passengers who use medical oxygen at home. Assessing passengers before flight and providing the prescribed oxygen during flight help prevent medical diversions, she said.[21]

When a person at sea level breathes oxygen delivered by nasal cannula at two liters per minute, the fraction of inspired oxygen (percentage of oxygen in the air breathed) increases from 21 percent (without supplemental oxygen) to a range of 24 percent to 28 percent, Garrett said. At sea level, increasing the flow rate with this delivery method has the effect of increasing the fraction of inspired oxygen as follows: three liters per minute, 28 percent to 30 percent; four liters per minute, 32 percent to 36 percent; five liters per minute, 40 percent; and six liters per minute, a maximum of 44 percent.

"When the body is deprived of an adequate oxygen supply, even for a short period, various organs and processes in the body begin to suffer impairment from hypoxia," Garrett said. "The objective of providing oxygen in flight is to prevent hypoxia and its complications. Hypoxia affects every cell in the body, especially the brain and central nervous system. Heart rate and respirations may increase."

Symptoms of hypoxia may include feelings of shortness of breath, confusion, impaired judgment, headache, dizziness, euphoria, decreased coordination, restlessness, hyperactivity, sleepiness, numbness, tingling of skin, blurred vision or double vision, lethargy, delirium and finally death, she said.

Medical conditions typically requiring oxygen for air carrier passengers include pre-existing respiratory disease, sickle cell disease, pre-existing cardiac conditions, resolving pneumonia (involving improvement in the patient's symptoms) and COPD, she said. (British Airways medical guidelines said that in-flight oxygen also may be recommended for cerebral artery insufficiency.[22])

Passengers at risk for different types of in-flight hypoxia include those who have histories of anemia (less than normal number of red blood cells or less than normal hemoglobin), recent surgery and pneumonia, Garrett said.

"Certain cases of in-flight hypemic hypoxia [inability of the blood to accept oxygen in adequate amounts] could be induced by smoking before the flight," Garrett said. "Passengers with acute anemias whose hemoglobin level is less than 10 grams per 100 milliliters or who have hereditary hemoglobin disease, such as sickle cell or sickle thalassemia, also are at risk for in-flight hypoxia [because anemia reduces tolerance to hypoxia]."

A passenger who requires medical oxygen on the ground but does not arrange for medical use of oxygen for air travel — perhaps not realizing the implications — could have a significant problem, said Garrett.

"Many physicians are not aware that the cabin is pressurized to 8,000 feet and believe the cabin is pressurized to sea level," she said. "Consequently, they may approve a patient to fly when a condition (such as having one lung) could preclude flying safely at 8,000 feet cabin altitude."

Patients receiving home oxygen therapy would be at a very high risk for in-flight complications without medical use of oxygen, she said.

"Medical oxygen is considered a drug, and can be harmful if not properly used," said Garrett. "Regulation at the prescribed flow rate especially is critical with end-stage COPD patients. They do require oxygen, but it is a fine balance. Not all patients respond the same way to like conditions on the ground or in flight.[23] Given too much oxygen, they can retain carbon dioxide; when the carbon dioxide builds up, the result is excessive sleepiness, lethargy, coma and eventually respiratory failure."

In people who have healthy lungs, decreased oxygen in the body will cause the breathing rate to increase, but the most powerful stimulant of respiration is the accumulation of carbon dioxide, she said. In contrast, in a person who has end-stage COPD, the drive to breathe is the lack of oxygen; if too much oxygen is given, the drive to breathe is decreased and could affect their ability to continue breathing; in this situation, artificial respiration would be required.

"In either case, a hypoxic patient must be given oxygen regardless of whether the respiratory drive is compromised or not," said Garrett. "That is why training of the cabin crew in life support is so essential."

As at Air Canada, MedAire's data show that passengers who require medical use of oxygen rarely are involved in in-flight medical emergencies, Garrett said. In a medical emergency involving one of these passengers, cabin crews typically are trained to respond in the same manner they respond to other passengers, she said. The following differences would be present, however:

- "If the oxygen-using passenger were to have any hypoxia or respiratory distress, one drug used for treatment — oxygen — already has been implemented," she said. "The oxygen flow rate might be increased under physician direction to help the passenger if the oxygen equipment available can be adjusted for other than fixed flows, or other treatments might be indicated such as bronchodilators, steroids and other medications from the onboard emergency medical kit"; and,

- With readily available data about the oxygen-using passenger, physicians on the ground would respond to the in-flight medical emergency as any other, but with the benefit of knowing the passenger's physician, previous diagnoses, medical record, medications and the people to be advised of the situation.

MedAire recommends that physicians advise patients to carry medications in the aircraft cabin for ready accessibility if needed during the flight.

"The passenger's initial request for the oxygen involves an understanding that the air carrier will need medical information," Garrett said. "Air carrier personnel must maintain in strictest confidence the information received about the patient's condition." In most cases, the airline will delegate the medical information gathering to their medical department or a medical service, she said.

One method of meeting the duration criteria in the FARs for medical use of oxygen is calculating the required number of bottles so that each bottle will provide one extra hour of flight time, said Garrett.

"The longer the flight, the more reserve oxygen is allotted," she said. "The aircraft emergency oxygen (portable bottles) could be utilized if the reserve supply was depleted due to excessive delays." Nevertheless, the air carrier's procedures must be followed regarding the amount of reserve emergency oxygen required for emergency use during the remainder of the flight, she said.

Some passengers who require medical use of oxygen may have increased risk of respiratory distress due to overexertion or stress, she said.[24] To reduce this risk, air carriers can provide mobility assistance (such as a wheelchair) in the airport and/or aircraft, preboarding and an aircraft seat near a lavatory to minimize exertion.

The current policy of most air carriers — prohibiting the use of oxygen equipment furnished by the passenger — also has been effective, in part because of the required periodic maintenance and safety checks, Garrett said. Cabin crews also are trained about the hazards of mishandling oxygen bottles and the possibility of extremely rapid and intense fire if oxygen gas contacts a flame or some substances, she said.

"Otherwise, the operator would have no control over the maintenance of the passenger's equipment," she said. "The airline would have no mechanism to verify that these pressurized cylinders are certified by the FAA and routinely checked hydrostatically. If passengers dropped a cylinder while exiting a car, for example, they could damage the regulator, putting themselves and others at risk of regulator disengagement in flight and creating a high-pressure-powered missile."

In recent years, changing demographics of air carrier passengers, data about in-flight medical emergencies and changes in medical care have prompted debate about alternative methods of providing both medical use of oxygen and oxygen for in-flight medical emergencies, Garrett said.

"There have been little if any changes since oxygen equipment originally was placed on U.S. aircraft for supplemental purposes in the 1950s and 1960s," she said. "It is time to recognize that the profile of the average traveler is markedly different today. We need to change the emergency oxygen availability and delivery tools. In-flight medical emergencies are on the rise — for example, MedAire through its MedLink service currently is handling more than 1,200 in-flight emergency calls per month and 500 passenger-prescreening cases per month."

Discrepancy, Misunderstanding Create Anxiety for Oxygen-using Passengers

Gail Livingstone, vice president of the National Home Oxygen Patients Association (NHOPA), a U.S. patient advocacy and educational organization, said that, since 1984, she has used most U.S. air carriers and some non-U.S. air carriers that provide for medical use of oxygen.[25] She said that she has advocated medical use of oxygen at more air carriers and industry standardization of services for medical use of oxygen.

Her expectation is that all air carrier personnel will be trained in the procedures for medical use of oxygen, but not for the health care aspects, she said.

"I am on medical oxygen at home and very familiar with the management of my therapy," she said. "Oxygen-using patients typically are trained by their oxygen-providing company, respiratory therapist, nurse or physician."

Her personal experiences may help cabin crews understand how some aspects of medical use of oxygen can generate concerns for oxygen-using passengers, she said.

"Sometimes the service goes very smoothly — it all depends on how comfortable the [passenger service agents and] flight attendants are with [the equipment and duties]," she said. "I have no problem with the airlines' equipment and understanding how it operates. Typically, I can look at dials to see that the oxygen flow is on, the liter flow and the quantity remaining."

Livingstone said that she has experienced the following types of problems:

- “Some flight attendants seem to be uncomfortable with a passenger checking the liter flow set by the cabin crew and bringing liter flow to their attention if incorrect,” she said. Many passengers, who take responsibility for their medical oxygen at all other times, believe that this responsibility continues while flying, she said;

- A discrepancy between the approved flow rate in the written directions to the cabin crew and the flow rate specified in her physician’s written statement was not resolved on one night flight, she said. She said that she elected to take the flight with a lower flow rate than she believed necessary because she had no arrangements for medical oxygen in the airport;

- Livingstone said that when using a bottle positioned under the seat in front of her, she often has reminded cabin crewmembers to change bottles when the pressure dropped below 500 pounds per square inch — even though the cabin crewmembers were checking the bottle periodically;

- She said that on other flights, she experienced an air carrier policy in which cabin crewmembers initiated the flow of oxygen after reaching cruise altitude, but she needed to use oxygen as soon as possible after preboarding the aircraft. “Flight attendants should not wait until all passengers are seated to initiate oxygen flow,” she said; and,

- Sometimes preboarding has not been part of the air carrier’s procedures for the medical use of oxygen, although the practice has been helpful when using other air carriers.

NHOPA has been among organizations seeking a review by the U.S. Department of Transportation (DOT) of the regulations for air carrier medical use of oxygen, she said.

“The ultimate position NHOPA would like to achieve is to allow individuals to bring their own oxygen on board,” Livingstone said. “Airlines simply have not stayed up with the state of the art, such as portable low-pressure systems using liquid oxygen and portable concentrators. We believe that responsibility could be given to the individual passenger who needs oxygen and that this would allow passengers to have their own oxygen on the ground when they arrive at the destination or have connecting flights.

“There are certainly lesser steps that could be taken to make a significant change in the ability of people on oxygen to travel. For example, providing fully adjustable flow meters instead of only high/low flow rates increases the number of airlines that people could use.”

Thomas Petty, M.D., a pulmonologist, professor of medicine at the University of Colorado, Denver, U.S., and at Rush University School of Medicine, Chicago, Illinois, U.S., and member of the board of directors of NHOPA, said that physicians can play a larger role in enabling passengers to travel safely on air carriers that offer medical use of oxygen.[26]

“The physician needs to be in a position to advise the oxygen-using patient about details of traveling by air; there are a lot of medical shades and nuances,” Petty said. “The physician should assess not only the need for oxygen but also the practical issues and logistical issues, such as recommending nonstop flights instead of connecting flights. Most patients are very knowledgeable about oxygen therapy and know they will need oxygen to fly if they use oxygen at home. The provider cannot possibly go wrong with low-flow oxygen.”

Bill Mosley, public affairs specialist for the DOT Office of the Secretary, said that DOT representatives and representatives of disability organizations participated in meetings in early 2001 about many aspects of U.S. air carrier compliance with 1990 DOT regulations implementing the Air Carrier Access Act of 1986.[27]

“One issue was [medical use of] oxygen,” Mosley said. “We have agreed to continue discussing the request to allow use of a passenger’s oxygen equipment. We are working with the disabled community to see if this could be done, but there is no formal proposal yet. Ultimately, FAA would make any change in regulations that prohibit this.” Studies of the feasibility of changing the current system as requested have not been conducted by DOT, he said.

U.S. Air Carrier’s Procedures Accommodate Oxygen Users

Leslie Spahn, manager of cabin safety and regulatory compliance for Continental Airlines, a U.S. air carrier, said that the company’s initial training program for cabin crewmembers and passenger service agents includes a video presentation that covers all aspects of its medical use of oxygen from the passenger’s initial request for oxygen through the postflight return of empty bottles to an oxygen contractor. Training also includes policies; procedures; hands-on experience with equipment for medical use of oxygen; and methods of communication with passengers.[28] Annual recurrent training includes a hands-on equipment review and testing on policies and procedures involved in medical use of oxygen.

As an example of current practices, Spahn said that the company’s medical use of oxygen includes the following elements:

- When passengers first request medical use of oxygen, they are advised that a physician’s written statement is required. Then they receive assistance from a reservations agent who has special training to respond to requests for medical use of oxygen;

- Information is sent to MedAire, which provides preflight medical consultation and in-flight medical consultation from its MedLink Emergency Telemedicine Center, for medical follow-up with the passenger and physician (with steps to ensure documentation of the prescribed flow rate, oxygen quantity, relevant medical information and preference for mask or nasal cannula);

- All information about the passenger's flight, special needs and details for medical use of oxygen are recorded in the reservation system, from which oxygen equipment logistics are controlled;

- Passenger service agents verify that oxygen units (padded cases containing a bottle, regulator, tubing and mask or nasal cannula) have been delivered to the gate. They connect the mask or nasal cannula to all the oxygen units scheduled for use on the flight segment before carrying this equipment onto the aircraft. The agents are responsible for ensuring that the correct number of oxygen bottles is placed at the assigned seat, with one bottle secured typically under the seat in front of the passenger. (If empty seats are available, the oxygen bottle in use may be strapped into an adjacent seat.) Additional bottles are secured in the overhead compartment above the passenger;

- The passenger service agent determines that the bottles are filled, selects the correct flow rate and verifies the passenger-specific documentation that accompanies the bottles. The flow rates available on this oxygen equipment range from 0.25 liters per minute to eight liters per minute, but company policy sets a maximum approved flow rate of six liters per minute. Copies of the documentation supplied with the bottles are distributed to the lead flight attendant, the captain and load control personnel;

- The passenger service agent typically preboards the passenger (if the passenger wants to preboard), assists the passenger in being seated, rechecks the correct flow rate, initiates the flow of oxygen and provides any needed assistance in adjusting the tubing, mask or cannula;

- Responsibility for the oxygen service and cabin safety aspects of oxygen is coordinated between the boarding agent and the cabin crew. The lead flight attendant ensures that all duties during the passenger's medical use of oxygen have been assigned;

- Cabin crewmembers responsible for the oxygen-using passenger ensure compliance with cabin safety regulations (such as criteria for passengers who may occupy exit seats), recheck that oxygen flow has been initiated at the correct flow rate, check that the passenger is comfortable and verify that the equipment is positioned safely for flight;

- A cabin crewmember then provides a "special needs" safety briefing tailored to the oxygen-using passenger, supplementing the general preflight safety briefing and safety information cards. The cabin crewmember typically advises the passenger to keep the oxygen bottle stowed securely like carry-on baggage, to leave the oxygen bottle behind in the event of an emergency evacuation, to continue using the oxygen bottle if a decompression occurs, to summon a cabin crewmember using the call button if assistance is needed, and to expect the cabin crew to change oxygen bottles before the bottle pressure drops below 500 pounds per square inch;

- During flights for which the passenger will use more than one bottle of oxygen, cabin crewmembers consult a chart that shows the approximate duration of oxygen at the prescribed flow rate and then schedule a time to change the bottle;

- Normal cabin surveillance includes observation of passengers using oxygen. The cabin crew normally will not disturb the passenger except when necessary to check periodically a bottle's remaining oxygen quantity and approved flow rate and to change oxygen bottles. In the event of a diversion or a ground delay, the cabin crew also is responsible for reminding the captain about the medical use of oxygen by the passenger;

- To change bottles, the cabin crewmember first removes the new bottle from its storage location, verifies that the flow rate has been set correctly and starts the flow of oxygen. The cabin crewmember then assists the passenger in removing the mask or cannula, exchanges the tanks under the seat in front of the passenger, assists the passenger in accommodating the new mask or cannula, and securely stows the used bottle in the overhead compartment; and,

- When the aircraft reaches its destination gate, an arrival passenger service agent will have determined from the flight manifest that the flight has a passenger receiving medical use of oxygen. A cabin crewmember will remind the passenger to remain seated until the passenger service agent comes aboard to provide deplaning assistance and coordination with any waiting oxygen service provider arranged by the passenger. Finally, the passenger service agent takes responsibility for removing the oxygen equipment from the aircraft and following procedures for the equipment to be retrieved by the oxygen contractor.

Spahn said that the process has been designed to be efficient and nondisruptive for the passenger. Only the air carrier's trained personnel may operate the oxygen equipment provided by the company, however. This practice may be unfamiliar to passengers who are knowledgeable about their oxygen requirements and know how to operate safely other oxygen equipment. Spahn said that cabin crews — after a brief explanation of how they will provide oxygen service — rarely encounter a passenger who misunderstands the procedures or objects to the procedures.

Although infrequent, passengers have told passenger service agents or cabin crewmembers that the flow rate set on the oxygen equipment is different from what the passenger expected, Spahn said. Most often, the passenger said that a higher flow rate was needed, she said.

"If the customer says that there needs to be a different flow rate — for example, four liters per minute instead of two liters per minute — flight attendants are not allowed to change the flow rate specified in the company's documentation," said Spahn. "The flow rate must not be changed until MedLink has been contacted by the passenger service agent, if on the ground, or by the captain, if in the air — and authorizes a change. The cabin crew does not want to run out of oxygen half way through the flight by increasing the flow rate."

Spahn said that the company's training also includes the following guidelines about travel contingencies that might affect the safety or health of a passenger who requires medical use of oxygen:

- Passenger service agents and cabin crews are expected to update oxygen-using passengers about travel delays because delays may disrupt the passenger's plans for continuity of oxygen services; and,

- Cabin crews must be familiar with backup sources of oxygen for the passenger, including walk-around bottles (oxygen equipment required aboard the aircraft for use by cabin crews for decompression, firefighting and first aid purposes).

"We try to keep these passengers informed about any irregular operation or delay affecting their travel plans, as we would inform anyone else," Spahn said.

Oxygen-using Passengers Expect Safety, Sensitivity

Some physicians recommended to oxygen-using air carrier passengers that they take direct flights whenever possible; consider traveling with a companion; and "avoid overeating, maintain adequate hydration, avoid alcohol and ensure [that they] are well rested."[29]

In summary, cabin crewmembers involved in the medical use of oxygen should remember the following safety factors:

- Oxygen is a hazardous material and oxygen equipment must be stowed carefully at all times to prevent damage and to keep all exterior surfaces free of flammable contaminants;

- Applicable regulations and air carrier procedures must be followed as to where passengers using oxygen can be seated in the cabin;

- Oxygen equipment should not be left unrestrained at any time. If strapped into a seat beside the passenger, for example, the restraints should be checked periodically to ensure that the equipment cannot come loose and cause injury during an encounter with turbulence;

- The cabin crew should know if the passenger's physician statement requires the flow of oxygen to be initiated before departure;

- The oxygen-using passenger, an oxygen bottle and/or oxygen tubing should not obstruct another passenger's access to the aisle, an emergency exit or a regular exit;

- If oxygen is supplied from an overhead compartment, the tubing should not be compressed when the compartment door is closed and latched;

- Any source of sparks or flame should be kept at a safe distance from oxygen equipment. Although smoking aboard aircraft no longer is permitted by U.S. air carriers, the FARs still require that a passenger using oxygen be seated at least 10 feet (three meters) from anyone smoking;

- Air carrier procedures should be reviewed regarding how emergency oxygen bottles could be used — including expected duration and policy on depleting emergency reserves — if an oxygen-using passenger's supply were depleted for any reason; and,

- Procedures and training for medical use of oxygen should be reviewed periodically, including whenever cabin equipment changes or cabin procedures change.♦

Notes and References

1. U.S. Federal Aviation Regulations (FARs) Part 121.574, "Oxygen for Medical Use by Passengers," contains the following requirements that affect air carrier cabin crews using compressed oxygen cylinders (paragraph numbering omitted): "A certificate holder may allow a passenger to carry and operate equipment for the storage, generation or dispensing of oxygen when the … equipment is furnished by the certificate holder; [is] of an approved type or is in conformity with the manufacturing, packaging, marking, labeling and maintenance requirements of [U.S. Department of Transportation (DOT)] Parts 171, 172 and 173, except Section 173.24(a)(1); [is] maintained by the certificate holder in accordance with an approved maintenance program; [is] free of flammable contaminants on all exterior surfaces;

[is] capable of providing a minimum mass flow of oxygen to the user of four liters per minute; [is] constructed so that all valves, fittings and gauges are protected from damage; and [is] appropriately secured; [and when] the oxygen is stored in the form of a compressed gas … the equipment has been under the certificate holder's approved maintenance program since its purchase new or since the last hydrostatic test of the storage cylinder and the pressure in any oxygen cylinder does not exceed the rated cylinder pressure. Each person using the equipment has a medical need to use it evidenced by a written statement to be kept in that person's possession, signed by a licensed physician, which specifies the maximum quantity of oxygen needed each hour and the maximum flow rate needed for the pressure altitude corresponding to the pressure in the cabin of the airplane under normal operating conditions. This paragraph does not apply to the carriage of oxygen in an airplane in which the only passengers carried are persons who may have a medical need for oxygen during flight, no more than one relative or other interested person for each of those persons, and medical attendants. When a physician's statement is required by … this section, the total quantity of oxygen carried is equal to the maximum quantity of oxygen needed each hour, as specified in the physician's statement, multiplied by the number of hours used to compute the amount of airplane fuel required by [Part 121]. The pilot-in-command is advised when the equipment is on board, and when it is intended to be used. The equipment is stowed, and each person using the equipment is seated, so as not to restrict access to or use of any required emergency [exit], or regular exit or of the aisle in the passenger compartment. No person may, and no certificate holder may allow any person to, smoke within 10 feet [three meters] of oxygen storage and dispensing equipment carried in accordance with … this section. No certificate holder may allow any person to connect or disconnect oxygen-dispensing equipment to or from a gaseous oxygen cylinder while any passenger is aboard the airplane. The requirements of this section do not apply to the carriage of supplemental [oxygen] or first-aid oxygen and related equipment required by [the FARs]."

2. Typically the compressed-gas cylinders provided to passengers for medical use of oxygen contain medical oxygen, but regulations and air carrier practices vary in the use of medical oxygen or aviators breathing oxygen for this purpose. U.S. Food and Drug Administration (FDA). "Fresh Air 2000: A Look at FDA's Medical Gas Requirements." www.fda.gov/cder/dmpq/freshair.htm. January 22, 2001. FDA, which regulates the use of medical gases as drugs, defines aviators breathing oxygen (ABO) as "oxygen in fixed [oxygen containers or systems] or portable oxygen containers or systems intended for commercial [aircraft use] or private aircraft use, meeting the [United States Pharmacopeia (USP)] specifications and having the special moisture[-limiting characteristics] and/or other limiting characteristics required for aviators breathing oxygen. ABO may not be used for recreational inhalation or medical therapeutic treatment of man or animal."

3. Lyznicki, James M.; Williams, Michael A.; Deitchman, Scott D.; Howe, John P., III (for the Council on Scientific Affairs, American Medical Association [AMA]). "Report of the AMA Council on Scientific Affairs: Medical Oxygen and Air Travel." *Aviation, Space and Environmental Medicine.* Volume 71 (August 2000): 827. The report includes a review of medical literature from several countries on in-flight use of oxygen prescribed by physicians and prearranged with commercial air carriers.

4. For example, the DOT Research and Special Programs Administration defines compressed oxygen or liquid oxygen as hazardous material under DOT Part 172.191. Lyznicki et al. 827–829. The report said that primary safety concerns include "inability to assess the integrity of oxygen cylinders and regulators, potential fire hazards, and inability to assure uniform quality of the equipment … [and] the ability of passengers to appropriately calculate oxygen needs and supplies throughout the trip, including ground time and unexpected delays." The report said that security concerns include "chain of custody and the inability to adequately inspect equipment and verify contents [for concealed weapons or gases other than oxygen]." Joint Aviation Authorities (JAA) Joint Aviation Requirements–Operations (JAR–OPS) 1.1160 (b)(4) said that an operator shall comply with technical instructions when dangerous goods (paragraph numbering omitted) "are carried for use in flight for medical aid for a patient, provided that gas cylinders have been manufactured specifically for the purpose of containing and transporting that particular gas; drugs, medicines and other medical matter are under the control of trained personnel during the time when they are in use in the airplane; … proper provision is made to stow and secure all the equipment during takeoff and landing and at all other times when deemed necessary by the commander in the interest of safety; or they are carried by passengers or crewmembers." JAA Interpretive and Explanatory Material (IEM) OPS 1.1160, "Medical Aid for a Patient," said, "Gas cylinders … are the dangerous goods which are normally provided for use in flight as medical aid for a patient. However, what is carried may depend on the needs of the patient. These dangerous goods are not those which are part of the normal equipment of the airplane. [They] may also be carried on a flight made by the same airplane to collect a patient or after that patient has been delivered when it is impracticable to load or unload the goods at the time of the flight on which the patient is carried." JAA IEM–OPS 3.1160(b)(5), "Scope – Dangerous Goods Carried by Passengers or Crew," said that among dangerous goods excluded from requirements normally applicable are "small gaseous oxygen [cylinders] or air cylinders for medical use."

5. The U.S. National Transportation Safety Board Aviation Accident/Incident Database and the U.S. National Aeronautics and Space Administration Aviation Safety Reporting System were searched with several oxygen-related terms. Lyznicki et al. 829. The AMA report said, "As of 1999, there are no reported incidents of morbidity [injury/illness] or mortality associated with passenger use of portable oxygen systems on U.S. commercial aircraft."

6. Lyznicki et al. 828.

7. Dowdall, Nigel. British Airways. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 30, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

8. Lyznicki et al. 829–830. Stoller, James K.; Hoisington, Edward; Auger, Glen. "A Comparative Analysis of Arranging In-flight Oxygen Aboard Commercial Air Carriers." *Chest.* Volume 155 (1999). 991–995. Data for this study — obtained from 33 commercial air carriers (11 U.S.-based air carriers and 22 non-U.S. based air carriers) — showed that 25 air carriers (76 percent) provided oxygen for medical use. The report said, "There was a great variation in oxygen device and liter flow availability. Liter-flow options ranged from only two flow rates (36 percent of carriers) to a range of one [liter per minute] to 15 liters per minute (one carrier). All carriers offered [a] nasal cannula, which was the only device available for 21 carriers (84 percent)."

9. Lyznicki et al. 829. British Airways Health Services. "Your Patient and Air Travel: A Guide to Physicians." www.britishairways.com. May 22, 2001. One variation in equipment for in-flight medical use of oxygen, for example, is the use of molecular-sieve oxygen concentrators (which provide oxygen from air).

10. Dowdall.

11. British Airways Health Services. 4.

12. Thibeault, Claude. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 27, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

13. Lyznicki et al. 827.

14. Lyznicki et al. 828.

15. Lyznicki et al. 828.

16. Lyznicki et al. 828–829.

17. Kalt, Bruce. U.S. Federal Aviation Administration. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. August 3, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

18. Lyznicki et al. 828. British Airways Health Services. 8.

19. Lyznicki et al. 828–829.

20. Lyznicki et al. 829.

21. Sullivan Garrett, Joan. Telephone interviews and e-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

22. British Airways Health Services. 9.

23. Garrett cited Christensen, C.C.; Ryg, M.; Refvem, O.K.; Skjønsberg, O.H. "Development of Severe Hypoxemia in Chronic Obstructive Pulmonary Disease Patients at 2,438 meters (8,000 feet) Altitude." *European Respiratory Journal.* Volume 15 (April 2000): 635–639. The report said that in an experimental study in Norway of 15 male patients — who had moderate chronic obstructive pulmonary disease (COPD) to severe COPD (according to criteria of the American Thoracic Society) and no preflight hypoxemia [less than normal oxygen in arterial blood] or mild preflight hypoxemia at sea level — participants developed marked hypoxemia at a simulated altitude of 8,000 feet. Each patient's stable sea-level partial pressure of oxygen in arterial blood was considered adequate under current aeromedical guidelines for avoiding severe hypoxemia during air travel. The report also said, "During minor exercise [equivalent to slow walking along the aircraft aisle], which is recommended during longer flights, the majority of the COPD patients became severely hypoxemic."

24. Christensen et al.

25. Livingstone, Gail. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 24, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

26. Petty, Thomas. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 30, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

27. Mosley, Bill. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. August 1, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S. DOT Part 382, *Nondiscrimination on the Basis of Disability in Air Travel.* March 1990.

28. Spahn, Leslie. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. August 1, 2001. Flight Safety Foundation, Alexandria, Virginia, U.S.

29. Lyznicki et al. 830.

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