MARYLAND STATE GUIDELINES:

Management of the Needs of the Oxygen Dependent Student

Maryland State Department of Education
Maryland Department of Health and Mental Hygiene
Maryland State School Health Council

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Disclaimer

This publication, *Maryland State Guidelines: Management of the Needs of the Oxygen Dependent Student*, is designed to provide accurate and current information about the subject matter. It is published with the understanding that the Maryland State Department of Education, the Maryland Department of Health and Mental Hygiene, and the Maryland State School Health Council are not engaged in rendering legal, accounting, or other professional services. If legal advice or other expert assistance is required, the services of a competent professional person should be sought.

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TABLE OF CONTENTS

Introduction

These guidelines are provided to assist local school systems (LSS) and school personnel in planning for the safety of students when oxygen is stored or in use in or around the school building or on a school bus. The use of oxygen in any of the aforementioned places requires considerable planning to ensure safety. School staff, to include qualified transportation and related-services personnel, must work together to make decisions to ensure compliance with the Individuals with Disabilities Education Act (IDEA), Section 504 of the Rehabilitation Act of 1973 (Section 504), the Americans With Disabilities Act (ADA), and State law. This document is an initial step in tackling the challenge of managing oxygen in schools and on school buses. On-going studies and research will likely result in additional recommendations.

Legal Basis

The rights of students with disabilities to attend school are firmly established in three federal statutes: IDEA, Section 504, and the ADA. Section 504 prohibits school districts from denying access to students with disabilities by reason of their disability. The major objective of Section 504 is the removal of barriers that limit services to students with disabilities. IDEA requires that all public school systems provide a free appropriate public education to all students who are eligible for special education and related services. Transportation is a related service that is defined under both Section 504 and IDEA.

CHAPTER 1

Planning For the Oxygen Dependent Student

Because of the complex needs of most oxygen dependent students, it is recommended that planning for the needs of these students be done by the pupil/student services team or the Individualized Education Program (IEP) team if the student is disabled according to the IDEA. The use of oxygen should be appropriately documented on the IEP document. This information should be made available to both school and transportation personnel. The team should, as a minimum, consist of the parent/guardian, a school administrator, the school nurse, a teacher, a counselor, and a representative from the transportation office, if the student requires transportation by school bus. The parent/guardian may also request that other personnel (a nurse case manager, private duty nurse, respiratory therapist, physical therapist, etc.) attend the team meeting to better explain the needs of the student during the school day.

The plan developed by the team should address the following:

Student's Need for Assistance

- The student's need for nursing services to include the requirement of a private duty nurse and/or a school nurse on the school bus [(1)];
- The need for trained personnel in the school building or assigned to the student;
- Any assistance the student may need in managing the oxygen equipment in order to move freely about the classroom;
- Involvement of the student, to the maximum extent possible, in his/her own care;
- The student's ability to request oxygen or assistance as needed;
- The student's ability to assist with the administration and maintenance of the oxygen equipment;
- The type of assistance the student may need to get on and off the school bus, secure oxygen on the school bus, and attend to his or her own health needs;
- Emergency plans, to include who is responsible, in the event the student experiences respiratory distress and/or the equipment malfunctions;
- Plans for field trips and other special school-sponsored activities; and
- A schedule for providing needed treatments to reduce disruptions and time out of class.

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[1] The United States Supreme Court ruled in 1999 (Cedar Rapids v. Garret F.) on the requirements associated with serving medically fragile students in public school systems or students placed in private placements by a public school. The Court ruled that there is an affirmative requirement to provide all medical procedures that can be delivered by an individual other than a physician. This requirement includes related service provisions such as transportation. It is essential that qualified personnel make decisions regarding safe transportation for students who are medically fragile including the use of oxygen.

Safe Environment

- Strategies to maintain the equipment in an upright position to prevent spillage;
- Impact of the equipment on safe movement in the classroom to include emergency evacuation of the students and the equipment;
- Identification of activities that may be hazardous to the oxygen dependent student and/or cause respiratory compromise (e.g., activities which create strong chemical odors, an increase of airborne particulate matter, or require open flames);
- Procedures for ensuring that oxygen is safely stored (e.g., venting for liquid oxygen) in the classroom and/or health suite;
- The need for a modified school day/schedule and/or home and hospital services;
- Plans for delivery and removal of oxygen to and from school;
- The location of signs to alert school staff and students, public safety personnel, and visitors to the use and storage of oxygen;
- Special equipment and/or supplies the student may require (e.g., additional oxygen tubing, tank carrier, etc.) and the provider of the equipment;
- Daily plans to check equipment; and
- Back up plans for oxygen in case of equipment failure.

Training

- Nature and type of training required for school staff (i.e., school nurse, school bus driver, school bus attendant, classroom teachers, etc.), and
- Plan for educating the student's classmates about the student's needs, the equipment, and any safety precautions;

The school nurse should develop an individualized nursing care plan or emergency protocol for all oxygen dependent students. A sample plan format is provided in Appendix A of this document.

CHAPTER 2

Assessing the Needs of the Oxygen Dependent Student

When a student who is oxygen dependent enters a school, the school nurse is the lead team member in assessing the needs of the student, performing a nursing appraisal/assessment and developing a care plan that meets the needs of the student in school. The school nurse is responsible for making all other school personnel involved with the student aware of the student's needs.

The Maryland Nurse Practice Act (COMAR, Title 10, Subtitle 27) allows certain nursing functions to be delegated. However, the nursing assessment for an oxygen dependent student cannot be delegated.

Data Collection and the Nursing Assessment

The school nurse is responsible for obtaining the student's medical/health history from the parent/guardians and health care providers. The school nurse is also responsible for obtaining any physician's orders regarding health services required by the student during the school day (oxygen, medications, suctioning, etc.). The assessment and plans developed by the school nurse for the oxygen dependent student should address the following:

- The student's health status, anticipated absences, and the need for a shortened school day due to decreased stamina;
- Whether the student requires oxygen continuously or p.r.n. (pro re nata - as needed);
- The type of oxygen the student will use (liquid or gas) and the student's medical supplier *(Note: Concentrators are not recommended for classroom usage because they are not portable, require an electrical outlet, and emit a constant motor noise that may be distracting in a classroom setting)*;
- Whether the student requires other related interventions such as air-conditioned rooms, pulse oximetry readings, etc;
- The ability of the student to determine and communicate his/her need for oxygen, as well as the student's ability to assist in administering and maintaining the oxygen;
- Signs of respiratory distress and steps to take should this occur (an emergency plan); and
- The need for a spare or back-up oxygen source.

The school nurse must also collect the following additional information about the oxygen dependent student's day:

- How the student will get to and from school (school bus or personal car) and the duration of the ride;

- The location of the student's classrooms, and whether there is space for the oxygen container in each classroom;
- The presence/absence of air conditioning in the classrooms;
- The characteristics (e.g. age, maturity) of the student's classmates and potential safety concerns they may present; and
- The times and locations of physical education classes, recess, and other scheduled activities that may require special consideration.

Note: When oxygen is administered on a p.r.n. basis, the nurse should determine if a nursing assessment must be completed before administering oxygen.

Emergency Protocols/Plans

All students with special needs, including the use of oxygen, should have up-to-date emergency information available in the school and on the school bus.

It is important that this information be filled out by qualified personnel, updated annually or more often as needed, and kept in a convenient and safe location.

All emergency information should be handled as confidential in accordance with the Family Education Rights Privacy Act (FERPA). It is recommended that the school nurse, in consultation with the family and primary health care provider, develop the child's individual emergency plan. Transportation should be fully informed of this information for emergency evacuation purposes.

It is recommended that both the parent/guardian and the primary health care provider sign this form and share it with all school staff that has a need to know.

CHAPTER 3

Managing the Needs of the Oxygen Dependent Student in the School Building

In planning for the school day of the oxygen dependent student, consideration must be given to the health and developmental status of the child, training of personnel, safe usage and storage of equipment, and emergency procedures. Additionally, school personnel must be concerned with the impact the presence of oxygen equipment may have on movement in the classroom, limitations it may pose on instructional activities, and the need for information sharing with the other students and staff. **Through thorough assessment, planning, communication and training procedures, these children with special health care needs can successfully enjoy full and safe access to all educational programs.**

Developmental Status of the Child and His/Her Peers

Prior to the oxygen dependent student's entry into school, the school nurse should conduct a complete assessment of the student's needs as outlined in Chapter 2 of this document. Classroom personnel should receive direct training regarding the student's health care needs, the use of the equipment, and the impact on classroom management and instructional activities. With parental/guardian consent, school personnel may also consider providing information regarding the oxygen to the peers of the oxygen dependent student. Depending on the developmental level of the students, it may be appropriate to share information regarding the need for supplemental oxygen and the extra care they must take when moving around the equipment. Such information may reduce the fears and concerns of some students as well as provide an opportunity for them to ask questions. The oxygen dependent student and parent/guardian should be involved in planning and presenting these learning opportunities. In general, school personnel should follow the same safety and risk management parameters outlined in Chapter 5 of this document.

Training of Personnel

The duties and responsibilities of various personnel in the school building - nurse, teacher, administrators, custodians, risk managers, etc. are outlined in Appendix C. The actual training of personnel in order to successfully fulfill their duties is covered in Chapter 5.

Safe Usage and Storage

School personnel must be trained and knowledgeable regarding the proper usage and storage of the equipment for the oxygen delivery system (ODS) while in the school building. The ODS must be secured properly when in use by the student or in a storage area of the school. Areas where oxygen is in use should be labeled as such and care must be taken to keep the ODS away from sources of heat. In-depth coverage given to the handling of the equipment may be found in Chapter 5.

Emergency Evacuation Procedures

It is essential to have a written emergency evacuation plan which takes into consideration the individual needs of students who use oxygen equipment or other special equipment. Evacuation procedures should be well known and rehearsed by teachers and school staff. The daily seating plan in school should always consider evacuation procedures (e.g. egress from the building). Oxygen dependent students should practice evacuation procedures to the same extent as their non-disabled peers. The manufacturer's guidelines should be followed for the use of oxygen in the school building. Additionally, school administrators should alert their school system's risk managers to the presence of oxygen in the building. In the event of fire or a fire drill, alert the responding fire department as to where oxygen is stored in the building.

CHAPTER 4

Transporting the Oxygen Dependent Student and Related Equipment

Transporting children with special needs has become increasingly challenging. The number of students in Maryland who require specialized transportation services has increased significantly and has placed increased demands on school districts, large and small, to meet the unique needs of these students.

Transporting oxygen dependent students requires that transportation staff, school bus drivers and school bus attendants be thoroughly informed about the specific needs of each oxygen dependent student. Local school systems and local health departments should collaborate to develop programs to train school bus drivers and attendants. Such training should ensure that transportation personnel are knowledgeable about the mandates that guarantee the right to related service transportation for children with disabilities. They must also understand the characteristics of students with disabilities, and be aware of special considerations that influence services such as the use of oxygen. As is the case with all students, safety must be the first priority when transporting oxygen dependent students.

Transportation and Federal and State Law

IDEA requires schools to provide transportation for eligible special education students in order to enable them to benefit from special education and related services. Transportation is defined by IDEA as:

> (i) Travel to and from school and between schools;
> (ii) Travel in and around school buildings; and
> (iii) Specialized equipment (such as special or adapted buses, lifts, and ramps), if required to provide special transportation for a child with a disability.
> §300.24 (b)(15).

Transportation is defined in COMAR 13A.05.01.03B (73) as

> (a)Travel to and from school and between schools;
> (b) Travel in and around school buildings; and
> (c) Specialized equipment, such as special or adapted buses, lifts, and ramps, if required to provide special transportation for a student with a disability.

The process for deciding whether a student with a disability requires oxygen is determined by the student's physician. The decision as to whether an oxygen dependent student is transported on a school bus is determined on an individual basis by the IEP team. In reviewing the needs of the student, the IEP team, at a minimum, should answer the following question: *If a student requires specialized services (accommodations) such as oxygen, can this service be provided on the "regular" school bus or does the student require service delivery on a separate bus with specialized equipment including trained personnel?*

Each decision regarding the use of oxygen on a school bus should be made on a case-by-case basis. An IEP team composed of personnel qualified to determine the specialized needs of the student makes this decision. The decision to assign a nurse to ride on a bus with an oxygen dependent student should be done in accordance with the school district's written policy to provide this service. If this service is provided under the requirements of IDEA, then it should be addressed on the student's IEP.

If the parents/guardian do not agree with the transportation service provided by the IEP, they are encouraged to discuss their concerns with the IEP team in order to work out an agreement with the team. Parents/guardians or the school district may ask for mediation (if agreeable to both parties) or a due process hearing to resolve differences. They may also file a complaint with the state education agency (SEA) over an issue related to transportation. Parents/guardians are afforded procedural safeguards in the area of transportation under IDEA, Section 504 and the ADA.

Documentation and Confidentiality

The IEP is the required special education form on which the related service transportation is addressed. In addition to the IEP, additional forms may be required to address such matters as the use of special equipment, oxygen, or a nurse provided through private insurance or Medical Assistance. Copies of all forms should be kept with the student's special education records. If there is a difference of opinion regarding the content, under FERPA, a parent/guardian may file a complaint. Under FERPA, parents/guardians are assured of who can and cannot see student records without the consent of the parent/guardian. Parent/guardian consent is the guiding principle regarding the right to release or exchange information. It is recommended that all persons involved understand how problems, questions and concerns can be addressed.

Safe Transport of Oxygen

The following information should be provided to the school bus driver and attendant before the student starts riding the bus:

- Why the student is using oxygen (included in emergency plan);
- Whether the oxygen is continuous or on an as needed basis (included in emergency plan for emergency medical system- EMS);

- On what level the oxygen is set (included in emergency plan for EMS);
- How to secure the oxygen and how to handle the oxygen in case of a bus evacuation;
- What constitutes an emergency for this student;
- Appropriate emergency phone numbers to be called (usually 911);
- How and what to report in an emergency;
- Basic safety procedures to follow until emergency personnel arrive; and
- Training in the safe use of oxygen (see the Chapter 5)

The school bus should be equipped with two-way communications and a sign (or magnetic sticker) conspicuously posted on or near each door that states:

NO SMOKING
NO OPEN FLAMES
CAUTION - OXYGEN ON BOARD

- Seats should be assigned considering the student's proximity to heaters and other types of motors.
- The school bus attendant should be able to continuously observe the student.
- All storage, transportation and usage requirements specified by equipment manufacturers must be met.

Oxygen cylinders/containers must be secured as follows:

- All respiratory related equipment must be securely mounted or fastened to a wheel chair, bus seat, or bus floor during transit;
- Compressed gas oxygen cylinders should be secured to prevent movement. Specific procedures should be developed by each school district with assistance from the oxygen supplier and manufacturer;
- Liquid oxygen containers should be secured in an upright position to prevent leakage;
- Liquid oxygen containers should be secured to prevent contact with cryogenic material;
- Liquid oxygen containers must be stored in a well-ventilated area; and
- All oxygen containers should be secured in a location that would allow all passengers free access to or egress from emergency exits.

Need For Assistance on the Bus

If the student requires oxygen on an as needed basis (p.r.n.), it is the responsibility of the school nurse to determine if a nursing assessment is needed (see Chapter 2) in order to administer the oxygen. **If a nursing assessment is not needed for the administration of oxygen, the nurse must assess and document that the student's health care needs are chronic, stable, uncomplicated, routine and predictable**. Only in this situation may the administration of the oxygen be delegated to unlicensed personnel. Other factors to be considered in delegating the administration of oxygen are:

- If the student is able to provide his/her own care with supervision;
- If the environment is conducive to delegation; and
- If an unlicensed person is able to perform the delegated nursing task in a safe and competent manner.

The school nurse, in conjunction with the school team, will determine whether a nurse, parent, or other trained caretaker must accompany the student on the bus. In some situations, it may be determined that the student is stable and can safely ride the bus while using the oxygen. The decision as to whether a licensed nurse is needed in school and during transport to and from school is made using the criteria for delegation outlined in the Maryland Nurse Practice Act (COMAR, Title 10, Subtitle 27) and the nurse's professional judgment. If a nurse is not required, the school nurse will determine the appropriate personnel/staff to whom responsibility for monitoring the oxygen may be delegated.

The school bus driver and attendant should not be responsible for administering oxygen or monitoring oxygen therapy in any case, which requires a nursing assessment of the child's need for oxygen or change in oxygen administration. The school bus driver and attendant must be trained to recognize oxygen equipment malfunctions and the steps to take to remedy the malfunction.

Special Equipment Handling

Personnel with special expertise (e.g. a respiratory therapist or oxygen supplier) should be used to plan for the type of oxygen and equipment to be used on the school bus. Oxygen is provided by prescription. Rules governing oxygen equipment should be incorporated into the student's IEP. Necessary precautions as prescribed by the manufacturer should be followed. Several kinds of equipment may be required during the period a child is receiving transportation services. Each piece of equipment should be used in accordance with the manufacturers' guidelines. Safety is the primary objective.

Emergency Bus Procedures

All personnel who transport oxygen should receive training as outlined in Chapter 5 of this document. The individual bus drivers and substitutes should be familiar with the emergency plan developed by the school nurse for each oxygen dependent student.

Evacuation Procedures

It is essential to have a written emergency evacuation plan, which takes into consideration the individual needs of students who use oxygen equipment or other special equipment. Evacuation procedures should be well known and rehearsed by teachers, school staff, school bus drivers and attendants. The daily seating plan in school and on the bus should always consider evacuation procedures**.** Oxygen dependent students should practice evacuation procedures to the same extent as their non-disabled peers. The manufacturer's guidelines should be followed for the use and evacuation of oxygen on the school bus and the school building.

Education of Other Students on the Bus

Consideration should be given to educating the other students on the bus where oxygen is being transported. The education should include the necessary precautions that should be used when traveling with oxygen on board.

Special Considerations

There are a number of special considerations faced by transporters of students with disabilities. It is important, when special circumstances are encountered that the IEP process be the mechanism for making decisions. Care must be taken to ensure that all decisions regarding care and services involve the entire IEP team and the parents/guardians. A unilateral decision regarding the use of oxygen on a school bus should never be made.

CHAPTER 5

Staff Training And Risk Management Guidelines

Schools are charged with teaching students and providing a range of legally required services in the safest manner possible. As employers, school systems must provide a safe and healthy workplace for their employees. Therefore, it is critical that school employees working with oxygen dependent students and their equipment be capable of safely operating these technologies. They must also be knowledgeable of the potential hazards associated with these devices. This Chapter will provide the necessary background and guidelines for training personnel and minimizing the risks associated with oxygen and oxygen delivery systems used in school systems.

This chapter can be used as a study guide for employees who are required to work with oxygen dependent students or near oxygen delivery systems. It contains:

- Characteristics of oxygen and oxygen delivery systems;
- Recommendations for the safe use and handling of oxygen and oxygen delivery systems;
- Descriptions of the types of accidents that might occur with oxygen use;
- Recommendations for responding to accidents; and
- A glossary of important terminology.

Note: The recommendations contained in this chapter are based on suppliers' literature, expert opinions, and consensus documents believed to be reliable. However, the Maryland State Department of Education and its consultants make no guarantee of the results and assume no liability or responsibility in connection with the information or recommendations contained herein. Moreover, it should not be assumed that every acceptable description, safety recommendation, or accident response is contained within this document, or that abnormal or unusual circumstances may not warrant or suggest further recommendations or additional procedures.

Characteristics of oxygen

Oxygen composes about a fifth (20.8%) of the air we breathe. As part of air, oxygen supports life and can cause things to burn and rust. During illness, extra oxygen can be therapeutic and is often prescribed for management of diseases such as asthma, cardiac insufficiency, and cystic fibrosis. Because some children who attend school use extra oxygen from one of several types of supplies, it is important for school staff to know about oxygen, oxygen delivery systems, and the risks they present.

A good source of general information on oxygen is the Material Safety Data Sheet (MSDS) for oxygen, available from the oxygen supplier. Information regarding MSDS can be found at http://www.ilpi.com/msds/. Information for specific information on oxygen can be found at http://hazard.com/msds/mf/cards/file/0138.html. Each facility where oxygen is present must have a MSDS for oxygen ready for use or inspection in accordance with OSHA's Hazard Communication Standard, 29 CFR 1910.1200 and COMAR Title 9, Subtitle 12 Chapter 33. The MSDS has useful information in its text.

Oxygen for therapy is a prescribed drug and must be +99% pure and medical grade as defined by the United States Pharmacopoeia. Oxygen this pure is produced by compressing air into a liquid and then separating the component gases by distillation. Therapeutic oxygen is delivered to a patient as a gas, but is stored as a gas or a liquid. As a gas, it is colorless, odorless, and a bit heavier than air, so it will generally sink away from a source and collect in low areas. As a liquid, oxygen is a light blue, water-like substance that is very cold, boiling at -183°C (-297°F) at room temperature. As it boils, the liquid oxygen, or LOX, produces about 860 liters of gaseous oxygen, or GOX, for every liter of liquid. The very cold, or cryogenic, liquid or gas can rapidly freeze skin and materials, causing frostbite in tissue and most materials to become brittle enough to shatter.

The biggest hazard of extra oxygen is the increased risk of fire. Oxygen itself does not burn. Rather, it supports and accelerates combustion. In air many things will burn but need to be ignited by considerable heat. In oxygen-enriched atmospheres, most everything will burn, even some things that will not burn in air, and the amount of heat needed to ignite these materials is considerably less than the amount needed in air. The more oxygen present, the easier it is for a fire to ignite, and the bigger, faster, and hotter the fire will be. There are ways, however, to minimize the fire and other risks involving oxygen and its use and are detailed later in this section under the subtitle *Recommendations for safe use and handling of oxygen and oxygen delivery systems.*

Characteristics of oxygen delivery systems

Oxygen delivery systems (ODS) use a regulated supply of either gaseous (GOX) or liquid (LOX) oxygen to deliver a flow of oxygen to a user. Each system is comprised of:

- a source
- a regulator, and
- a user connection.

The user connection is common to most supply systems and is attached to an outlet on the supply system.

GOX systems: Gaseous oxygen is supplied under pressure of about 2000 psia (13,800 kPa [abs]) in standardized cylinders (regulated by the Department of Transportation) made of steel or aluminum or, very rarely, woven fiberglass. Cylinders are sometimes called bottles, tanks, and cartridges. In GOX systems, the cylinder is the source, a separate gas regulator is usually required, and the common delivery tubing, connectors, and dispensers form the user connection.

The cylinders used for portability are a few inches in diameter and up to 3 feet (90 cm) in length, weigh up to 16 pounds (7.3 kg) and hold up to 25 cubic feet (700 L) of gas. Each cylinder has a supply valve and a relief valve that will melt or break under heat or high pressure. The supply valve opens and closes by using a cylinder wrench or wheel. One type of cylinder has an integral regulator. The smaller portable cylinders can be carried in a shoulder pack, while the larger portable cylinders are carried in a small cart or attached to the user's conveyance, e.g., wheelchair, scooter. (See Figure 2.)

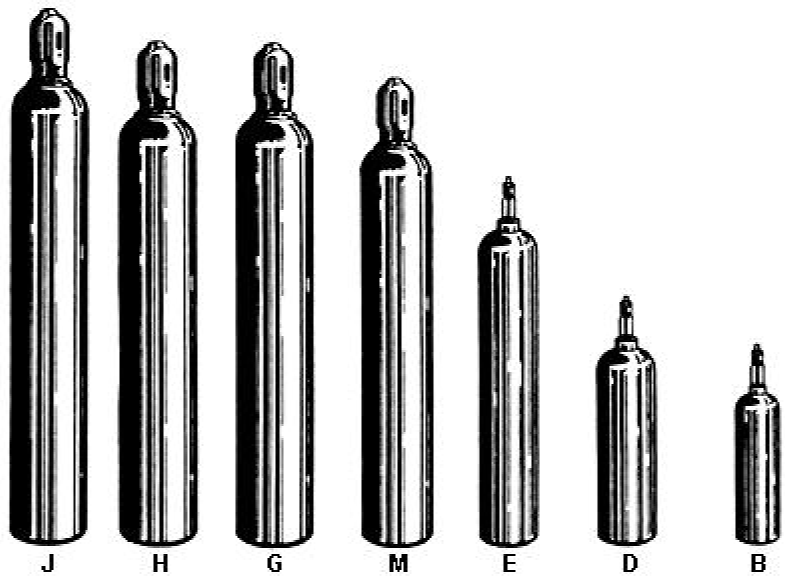

Figure 1. Relative sizes of standard cylinders


Figure 2. Sample portable systems.

Most cylinders are painted green or have a section painted green. While color suggests what gas might be in a cylinder, the cylinder label is the only positive indicator of its contents. Medical grade oxygen is labeled "Oxygen, U.S.P." and "Oxygen, Compressed UN 1072".

Devices using medical gases may have gas-specific connectors to prevent the use of the wrong gas with a device.

A regulator must be attached to a cylinder to convert the high-pressure gas to a gas at atmospheric (or room) pressure with a controlled flow. (See Figure 3 a, b, & c.) Most regulators for portable systems attach to the cylinder's supply valve with a screw clamp that can be hand tightened, and require a gasket to seal the regulator to the supply valve's outlet port. Regulators for stationary systems attach to the cylinder valve with a connector that must be wrench tightened, and do not require a gasket.

Figure 3 a, b & c. regulators. Note reusable gasket inside yoke in right-most figure.

A pressure gauge on the regulator indicates the cylinder's available gas. A full cylinder has about 2000 psia (13,800 kPa [abs]). As the pressure falls, the amount of gas in the cylinder is directly proportional to the pressure. Cylinders should not be allowed to fall below 25 psia (172 Kpa [abs]) to prevent contaminants from entering the cylinder.

Most portable regulators have a flow control valve that limits gas flow from no flow to 15 liters per minute in discrete steps. Stationary regulators used for oxygen therapy have a similar flow control. The flow is prescribed by the user's physician and ranges from 2 to 15 liters per minute.

Regulators have a patient delivery tubing connector for gas at room pressure. Some regulators have an additional connector for pressurized gas. The two connectors are not interchangeable.

LOX systems: LOX is stored under low pressure (i.e., less than 40 psia [276 kPa (abs)]) in a thermally insulated container made of stainless steel and covered by a plastic housing. In LOX systems, the container is the source, while a flow regulator is incorporated into the container, and the user connection is the same as for GOX systems.

LOX containers for medical use are labeled “Oxygen, U.S.P.” and “Oxygen, Refrigerated Liquid, UN 1073.” The container looks like a thermos but has additional piping to maintain pressure on the LOX, to allow filling and withdrawing, and to protect the container and piping from excess pressure. Unlike cylinders, LOX oxygen delivery systems are not standardized and differ in details among suppliers. Because the LOX is constantly warmed in spite of the container’s insulation, containers intermittently vent gas through a pressure relief valve, and therefore must be stored and used in well-ventilated areas to prevent elevation of oxygen concentration in the space around the container. The containers have a gauge mechanism (similar to a car’s fuel gauge) to indicate (by weight or liquid level) the amount of LOX in the container. A LOX container also has piping within its housing to warm the gas to near room temperature, vent excess gas, and regulate the flow of gas to the user. Because the piping is connected to the container at its top, the container must be kept upright to prevent *harmfully cold* LOX from entering the piping and possibly being delivered to the user or vented onto the user. Contact with leaked or spilled liquid oxygen can cause frostbite and serious tissue damage.

Portable containers hold up to a half-gallon (2 L) of LOX or 29 to 58 cu. ft. (800 to 1600 L) of GOX. (See Figure 4.) Portable containers are carried with shoulder straps, in backpacks, or in handbags, allowing the user to be mobile. The carrying packs are vented. Most portable containers have a connector to allow the portable to be filled from a base station. This connector must be kept free of dirt and lint. A portable container from one supplier usually cannot be used with a base station from another supplier.

Figure 4. Portable LOX units.

Base station containers hold up to 12 gal (50 L) of LOX and are similar to, but larger than, the portables. (See Figure 5.) The portables plug into or onto the base station and are automatically filled. The system's supplier usually refills the base station. During filling, moisture from the air will condense and freeze on the piping and connectors. Occasionally, this freezing will glue the portable to the base station. Allowing the system to thaw will free the portable. Most base stations can also provide oxygen to the user independent of the portable unit.

Figure 5. LOX base stations.

<u>Oxygen concentrators</u>: A few patients needing oxygen use oxygen concentrators that compress room air, remove the oxygen from the air, concentrate the oxygen, and deliver about 93% oxygen to the patient through a flow regulator. Oxygen concentrators require electricity to run the compressor and valve switching and are stationary units.

<u>The user connection</u> of the ODS consists of delivery tubing, connectors, and disposable or single use breathing devices. Oxygen is administered to the user by a long, thin, clear or green plastic tube that connects the supply to a breathing device worn by the user. Breathing devices include nasal cannula, facemasks, and tracheotomy tubes. Most users wear a nasal cannula, a small tube worn over the ears and under the nose with openings at each nostril. Some users wear a facemask, a vented clear plastic cone that fits over the mouth and nose with a strap around the head. Masks and cannula have integral delivery tubes. A few users are fitted with a tracheotomy tube, a tube inserted through a surgical incision in the neck to which the delivery tubing is connected. Most of the tubing connectors are force fitted together. A few have screw connectors.

Supply duration: How long an oxygen supply will last depends on what flow the user requires and how much gaseous oxygen the supply can provide. By dividing the amount of gas in the supply by the flow rate to the user, the duration of the supply is figured. However, when figuring the supply duration allow for a residual of oxygen that would necessarily remain in the supply and be unavailable to the user. This residual is established by the ODS supplier. For example, an E cylinder holds about 705 L of gas and at a flow of 2 L per minute would last 705 divided by 2 or 353 minutes or 5.8 hours. Then, allowing for a 10 % residual, a full E cylinder would last for 5.2 hours (5.8 minus 10% of 5.8). Or a LOX portable holds 1.2 L of liquid, which converts to 1,032 L (860 expansion ratio of LOX to GOX multiplied by 1.2 L) of gaseous oxygen. At 2 liters per minute, the LOX portable would provide gas for 516 minutes or 8.6 hours. As before, allowing for a 5% residual, a LOX portable holding 1.2 L of LOX would last for about 8.2 hours (8.6 minus 5% of 8.6).

Oxygen-conserving devices: While most ODS provide a continuous flow of oxygen to the user, some oxygen users have a device connected into the system that delivers oxygen intermittently as required by the user. These oxygen-conserving devices sense the user's breathing and allow oxygen flow during inhalation and stop flow during exhalation, thus delivering oxygen to the user only when it is needed and prolonging the supply duration. Most of these devices are battery operated. Therefore, it is imperative that fresh batteries are readily accessible to the user.

Need for ODS inspection: The ODS are mechanical devices and wear out. Periodic inspection helps prevent the risks of leaks, and ensures proper and continuous therapy for the user. Normally the user, home caregiver, and supplier should be checking the ODS, but the school-based caregiver should be alert to the condition of the ODS. Leaks, a worn or dirty appearance, ill-fitting parts, and other possible signs of wear should signal that the ODS should be inspected for proper operation and safety by the supplier.

Recommendations for safe use and handling of oxygen and oxygen delivery systems

Several national standards and many pamphlets describe safe handling practices for LOX and GOX (see references). In general, these simple practices help minimize the risk of fire and chemical or mechanical explosion. Despite their simplicity, disregard of these practices can place the user, caregiver, and bystanders at risk of serious injury or death. The following is a summary of recommended safe handling practices for LOX and GOX that can prevent oxygen-related accidents.

In General: Whenever dealing with oxygen and any ODS, follow these basic practices:

- Only persons familiar with oxygen safety and the specific ODS use and safety should handle an ODS;
- Read the labels. They are the only sure indicator of contents. Only supplies labeled "Oxygen, U.S.P." should be used;

- Do not use unmarked cylinders or containers;
- Use only labeled devices. Devices not labeled for oxygen could be contaminated or otherwise incompatible with oxygen;
- Protect containers, cylinders, and devices from impact and excessive heat. Both can cause explosions or the release of gas;
- Keep container or cylinder upright at all times. Tipped containers present a risk of frostbite and rapid oxygen release. Tipped cylinders present a risk of fire during use;
- Do not drop cylinders or allow them to fall over. Such actions present a risk of fires during use and explosive release of gas;
- Have clean hands and tools when working with oxygen devices;
- Read and understand the system's instructions for use;
- Do not use or repair damaged devices. Have supplier repair or replace them;
- Do not apply oil or lubricants to any oxygen device;
- Clear the cylinder supply valve by briefly opening and closing the valve before attaching devices. Clearing the flow path removes particles and debris and reduces fire risk;
- Use only liquid leak detectors. Never use a flame to check for leaks;
- Attach devices when the flow control is set to zero;
- When assembled, open the cylinder valve slowly and fully. Slow opening allows pressure and temperature to equalize. Full opening ensures proper gas flow;
- Do not allow the system to become part of an electrical circuit. Electric current flow through an ODS could cause fire or explosion;
- Do not use flammable aerosol sprays near an ODS or users. They can cause an explosive combustion; and
- Do not allow use of open flames, sparks, or heat sources within 5 ft (1.5 m) of an ODS or users.

During ODS setup: Setup involves preparing the ODS for use and should be done at home or by the supplier. **Portable containers are not to be filled in schools.** School personnel should be aware of the following protocol:

- Do not touch frosted components, skin may freeze to them. Use gloves. Use face protection;
- Understand the system's warnings;
- Read the labels. They are the only sure indicator of contents. Only supplies labeled "Oxygen, U.S.P." should be used;
- Clearly mark or tag empty containers or cylinders so they are not reused;
- Note the condition of the ODS. Do not use leaking or damaged ODS. Have the supplier repair or replace the system;
- Ensure that the connections are tight and leak free. Do not use a flame to check for leaks;
- When assembled, open cylinder valve slowly and fully. Slow opening allows pressure and temperature to equalize. Full opening ensures proper gas flow; and
- Set the flow control to the required flow number. Do not set between numbers, as flow will be restricted.

During use: Accidents that occur during oxygen use are due mainly to exposure to heat sources, impacts, or movement. Reduce the possibility of accidents during use by adhering to the following guidelines:

- Ensure good ventilation in spaces where an ODS is used;
- Keep containers and cylinders upright so they cannot be tipped or knocked over. Use stands or clamps designed to stabilize containers or cylinders;
- Ensure that delivery tubing is free of kinks, pinch points, or easily snagged loops;
- Do not use combustible aerosol sprays near an ODS or its user;
- Do not smoke near an ODS or its user, or allow the user to smoke.
- Keep the ODS and users 5 ft (1.5 m) away from heat sources, electrical appliances, open flames, or sparks (Note: electrical appliance refers to electrically powered devices with spark gaps or high heat producing elements);

- Replace supply as indicated by the system's instructions for use; and
- Never cover or place anything over an ODS or oxygen supply.

In storage**:** Few accidents occur in storage provided the storage space is properly designed and used. Reduce the risk of these rare incidents by adhering to the following guidelines while storing oxygen systems and supplies:

- Ensure that local building and occupancy codes (e.g., NFPA 101, 30 minute rated firewall) regarding oxygen and the use of an ODS are followed;
- Make the name of the oxygen supplier and the supplier's contact information available to school staff and post this information in the storage location;
- Protect the containers or cylinders from tampering, impacts, flammable materials, and heat sources in the storage space;
- Locate the storage space away from trafficked areas and building exits;
- Label the storage space "Oxygen Storage Only. No Smoking. No Open Flame."
- Keep the storage space temperature below 125ºF (52 ºC);
- Ensure that the storage space is well ventilated;
- Store only oxygen containers or cylinders in the storage space;
- Ensure that the containers and cylinders are stored upright and cannot tip; and
- Store empty containers and cylinders separately from full ones. Use supplies on a first-in, first-out basis.

In school**:** Accidents during ODS use in school can be caused by exposure to heat sources, impacts, movement, or tampering. Reduce the occurrence of these accidents by adhering to the following guidelines:

- Have immediately available a spare or backup ODS, based on the student's needs;
- Position or locate the ODS so they are protected from tampering, tipping, heat sources, and impacts;
- If needed, secure the container or cylinder in an upright position. Use stands or clamps designed to stabilize containers or cylinders;

- Keep the ODS and users 5 ft (1.5 m) away from heat sources, electrical appliances, open flames, or sparks. (Note: electrical appliance refers to electrically powered devices with spark gaps or high heat producing elements.); and

- Ensure that delivery tubing is free of kinks, pinch points, or easily snagged loops.

During transport: Oxygen accidents during transport can be caused by exposure to heat sources, impacts, or movement. Traffic accidents involving vehicles with oxygen supplies can lead to fires. The following guidelines are designed to minimize the occurrence of such incidents:

- Do not place containers or cylinders in a car trunk on in unoccupied vehicles;

- Do not allow smoking, open flames, or sparks in vehicles with an ODS;

- Ensure that the vehicle is well ventilated;

- Locate the ODS and user away from exits and heat sources;

- Secure the container or cylinder in an upright position so it cannot be knocked over or bumped; and

- Ensure that delivery tubing is free of kinks, pinch points, or easily snagged loops.

Types of Accidents

Accidents with oxygen use are rare but do occur and can cause significant injury and damage. Strictly following the above guidelines will minimize the risks associated with use of oxygen and the ODS. However, there have been many reported problems with ODS (mainly to the U.S. Food and Drug Administration), and most are related to misuse on the part of the user, the caregiver, or the supplier. For example, cases of bad-smelling gas are usually related to ignition events during filling or assembly. Fires are often the result of not following safety practices. Reported incidents can be categorized by frequency as fires, cryogenic incidents, pressure incidents, loss of gas incidents, and miscellaneous incidents.

Fires: Fires involving ODS occur in only a few ways; adiabatic compression ignition, particle impact ignition, and external ignition. Cylinders are subject to all of these, while containers, because of their low pressure, are mostly subject to the last.

Adiabatic compression ignition is the result of high-pressure gas rapidly expanding and recompressing into a space, such as the high-pressure side of a regulator. This recompression can raise the gas temperature to a high temperature that can cause some materials to auto-ignite.

Should combustible materials be present or introduced into the space, they can burn. This small fire can provide enough heat to cause other nearby materials to burn, including gaskets, aluminum, brasses, and steels. The resulting fire is explosive, and usually self-extinguishes because the pressure is rapidly released through a breach in the device. However, this jet of fire can ignite nearby combustible materials and cause severe injury to bystanders.
Preventative action: Preventing this type of fire requires that the ODS be kept clean and free of combustible materials such as oil, grease, metal filings, lubricant tapes, and gasket fragments, and slowly allowing pressurized oxygen into a device.

Particle impact ignition is the result of a small fragment of material hitting another object at high speed under high-pressure oxygen. The energy of the impact causes the ignition of the particle, the target material, or both, which in turn causes a fire like the one described above.
Preventative action: Preventing this type of fire involves keeping particles out of the high-pressure gas stream. Good maintenance by the student's caregiver and the oxygen supplier will help in preventing this type of ignition.

External Ignition Sources: Regardless of the source of oxygen, cylinder or container, many fires occur because some heat source got into the oxygen-enriched atmosphere surrounding the oxygen outlet. If the user, caregiver, or bystander is unaware of the fire risk associated with the use of oxygen, he or she may unknowingly do something that would result in a catastrophic fire. Oxygen risks are outside of most people's experience. For example, many people smoke without immediate problem, but smoking with oxygen in use can set delivery devices and clothing on fire. While grinding sparks from metalwork ordinarily does not cause fires, sparks hitting an oxygen user's clothing can cause them to burn. Even if the ODS has been removed from the user, his clothing will be oxygen-saturated and very easy to ignite for up to an hour afterwards. Similarly, oxygen use in a confined space or a poorly ventilated area can enrich the exposed materials and cause them to be easily ignited.
Preventative action: Keeping oxygen in a well-ventilated area and away from heat sources can minimize the risk of these incidents.

<u>Cryogenic Incidents</u>: These incidents occur when liquid oxygen or cryogenic gas leak from a container. The leaks lead to risks of frozen connections, frostbite, and percussive ignition in addition to the fire risk of an oxygen-enriched atmosphere. In addition, skin can freeze to cold surfaces and splashes of cryogenic fluids can freeze eyes. As with oxygen risks, cryogenic risks are outside of most people's experience.

Frozen connections occur when moisture condenses from the air onto or into the ODS. For example, when the portable unit is being filled from the base station at home, the connection joining the two devices can become frozen in ice and inseparable until the ice thaws. Dirty connectors, ice in the system, or a piping or seal leak can cause this problem. Ice inside the system can prevent valves from working.
Preventative action: Good filling practices by the supplier minimize this risk.

Frostbite is a risk from any exposed parts of the ODS whenever the device emits cryogenic fluids (i.e., when a relief valve opens or when the unit is tipped). If a container is exposed to high temperatures, loses its insulation, or simply sits unused, its relief valve will open and vent very cold gas to reduce the pressure inside the container. Normally this venting is inside the container's housing, and the user and bystanders are not exposed to the cold. If the device is near the user or under his clothing or a covering, the user may become frostbitten. Most containers, if tipped, will have LOX enter the delivery tubing and jet onto the user, causing frostbite if the delivery tubing is not quickly removed from the user and the unit set upright.
Preventative Action: Following the ODS instructions and keeping containers upright can minimize the risk of frostbite.

Percussive ignition is a rare_phenomenon that occurs when organic materials (e.g., asphalt, synthetic carpets, plastic floor coverings) are saturated with LOX and exposed to an impact. In some cases the energy contained in a footstep is sufficient to cause an explosive ignition of the organic material. **Preventative action:** Should LOX leak onto a floor, the area should be ventilated and people excluded from the area until the cloud or fog and frost surrounding the container have dissipated.

<u>Pressure Incidents</u>: These incidents occur when the pressure contained in an ODS is rapidly released, often propelling some object with great speed and force. Most pressure incidents are caused by problems with the device such as wear, abuse, and improper assembly. For example, if a worn gasket is used to seal a regulator to a cylinder, and the cylinder valve is opened, the pressure might blow the gasket out of the assembly. The gasket might then hit the caregiver. When pressurized, a poorly assembled regulator can blow apart and injure the caregiver. Worn or damaged hoses can blow open. Upon impact, a valve stem can eject from a cylinder causing the cylinder to shoot across the room. **Preventative action:** Proper maintenance and handling of the ODS can minimize these risks.

<u>Loss of Gas Incidents</u>: These events are usually caused by mistakes and tampering that disable the ODS from performing as expected.

Mistakes involve the caregiver or user doing something wrong so oxygen does not get to the user. Mistakes are also described as operator error, user error, or use error. For example, an improperly tightened regulator may allow the oxygen to leak at the seal and the user to not have the expected duration of gas. A cylinder thought to be full might only be partially full, and not last for the expected duration. A regulator might be mounted incorrectly. Improper maintenance can cause loose connections on a LOX container to leak, resulting in shorter than expected duration of use of the ODS.
Preventative action: Knowledge of the devices and their proper use can minimize these types of mistakes.

Tampering incidents occur when someone not authorized to use the ODS, misuses the device. Many tampering incidents involve changes in gas flow or inadequate supply. For example,

vandals can gain access to a locked gas storage facility and empty all the cylinders. A malicious person can easily change the setting on an ODS or disconnect the delivery tubing while the user isn't looking, causing the user to receive inadequate oxygen flow or to run out of gas faster than expected.
Preventative action: Security and awareness of such events can protect against these incidents.

Miscellaneous Incidents: These incidents do not clearly fall into the previous categories. For example, some fires occur in high-pressure oxygen systems and do not cause a large fire or explosion. However, the combustion gases mix with the oxygen and cause it to smell. Foul or acrid-smelling gas is contaminated and should not be used. Another possibility is that the delivery device becomes disconnected from the user or the supply due to poor assembly, movement of the user or supply, or something pulling the delivery device. Or, the ODS does not function as expected because of breakage, clogging, loss of insulation, or dead batteries.
Preventative action: Knowledge of the ODS and its assembly, and awareness of the user and his surroundings can minimize these risks.

Recommendations for dealing with accidents

As discussed above, oxygen accidents, while rare, happen very quickly, and can cause severe injury or death. Quick reaction by the user or caregiver, as described below, can minimize an adverse outcome.

Fires

- Rescue student and all others directly involved. Remove them from the vicinity of the ODS and fire.
- Activate alarm or notify 911.
- Contain fire in area (shut doors).
- Evacuate other students and personnel from the fire area per fire emergency protocol.
- Shut off oxygen supply or remove tubing from supply, if possible and if safe to do so.
- Extinguish fire with water, if possible and if safe to do so.

Cryogenic Incidents

- Remove student or involved personnel from area of the leak.
- Warm the affected body parts (e.g., warm water, blankets).
- Use gloves and clothing to prevent frostbite of exposed skin.
- Attempt to upright the container and shut off supply.
- Ensure that the area is well ventilated or remove leaking container to well ventilated area, if possible and if safe to do so.
- Do not attempt to disengage frozen connectors. Allow them to thaw.
- Do not enter or walk in any vapor cloud near the leak.
- Get a backup ODS and apply it to the user.

- Notify 911 if a backup ODS is unavailable.

<u>Oxygen Leaks</u>
Depending of the type of oxygen leak, different responses are needed.

Poor gasket seals usually cause Regulator/Cylinder leaks.
- Get a backup ODS and apply it to the user.
- Notify 911 if a backup ODS is unavailable.
- Shutoff cylinder valve.
- Contact supplier/parent.

LOX container can leak from the delivery port, relief valve, connector, or loose fittings.
- Remove student or involved personnel from area of the leak.
- Get a backup ODS and apply it to the user.
- Warm the affected body parts (e.g., warm water, blankets).
- Use gloves to prevent frostbite.
- Attempt to upright the container and shut off supply, if possible and if safe to do so.
- Ensure that the area is well ventilated or remove the leaking container to a well-ventilated area and allow the container to empty, if possible and if safe to do so.
- Do not attempt to disengage frozen connectors. Allow them to thaw.
- Do not enter or walk in any vapor cloud near the leak.
- Notify 911 if a backup ODS is unavailable.

Cylinder can leak from the relief valve or the valve stem.
- Remove cylinder to outdoors if possible, or ventilate the area, and allow the cylinder to empty, if possible and if safe to do so.
- Get a backup ODS and apply it to the user.
- Notify 911, if a backup ODS is unavailable.

<u>Loss of gas</u>
- Keep user calm.
- Get a backup ODS and apply it to the user.
- Notify 911, if a backup ODS is unavailable.

Glossary

Adiabatic compression ignition: The increase in temperature, associated with compressing oxygen in a space to the point at which materials in the space will start to burn.
Caregiver: The person responsible for providing therapy to another.
Combustion: The process of burning.
Container: A device designed to hold and dispense liquid and gaseous oxygen at very low temperatures under low pressure.
Cryogenic: Temperatures below -184ºF (-120ºC).
Cylinder: A device designed to hold and dispense gaseous oxygen under high pressure.
Frostbite: The freezing injury or destruction of skin and underlying tissue, most often that of the nose, ears, fingers, or toes, resulting from exposure to very low temperatures. Eyes are particularly vulnerable to very low temperatures.
GOX: gaseous oxygen
High-pressure: Pressures above 500 pounds per square inch absolute (3450 kilopascals absolute).
Ignition: The raising of the temperature of a substance to the point at which it starts and continues to burn.
(kPa [Abs]): measures of pressure in pounds per kilopascals absolute. The absolute refers to the reference point of the measurement, in this case, zero pressure.
LOX: liquid oxygen
Oxygen delivery system (ODS): A supply, flow regulator, and delivery device used to provide a user with therapeutic oxygen.
Particle impact ignition: An ignition caused by the energy present in a moving particle as it hits a target material. The particle, the target material, or both ignite.
Percussive ignition: The detonation of organic materials saturated by liquid oxygen.
psia: measures of pressure in pounds per square inch absolute.
Regulator: A device that decreases gas pressure and controls gas flow from a supply.
User: A person requiring therapeutic oxygen to perform normal daily tasks or to maintain adequate systemic oxygenation.

References/Resources

Federal and State law:

Individuals with Disabilities Education Act, 20 U.S.C. § 1400 (1997).

Section 504 of the Rehabilitation Act , 29 U.S.C. § 794 (1973).

Americans With Disabilities Act, 42 U.S.C. § 12101 (1990).

Maryland Nurse Practice Act: Annotated Code of Maryland, Health Occupations Article, Title 8, Code of Maryland Regulations (COMAR), Title 10, Subtitle 27.

Special Instructional Programs, Provision of a Free Appropriate Public Education, Title 13A, Code of Maryland Regulations (COMAR), Subtitle 05, Chapter 01.

Indiana Administrative Code, Title 575 State School Bus Committee, Article I, Rule 5.5

Books & Articles

Porter S., Haynie M., Bierle T., Caldwell, Terry H, and Palfrey, J. (1997). Children and Youth, Assisted by Medical Technology in Educational Settings, Paul H. Brookes Publishing Co., Post Office Box 10624, Baltimore, MD.

Transporting Children with Special Health Care Needs (RE9852). American Academy of Pediatrics, Committee on Injury and Poison Prevention. Pediatrics, Volume 104, Number 4, October 1999, pp. 988-992.

Other Resources:

Oxygen users and suppliers developed these references over many decades through experiences and committee actions. Most of these references on safe use of oxygen are periodically updated. Be sure to examine the latest edition.

Compressed Gas Association pamphlets, Arlington, VA

- G-4 Oxygen
- P-1 Safe Handling of Compressed Gases
- P-2 Characteristics and Safe Handling of Medical Gases
- P-2.7 Guide for the Safe Storage, Handling, and Use of Portable Oxygen Systems in Healthcare Facilities
- P-12 Safe Handling of Cryogenic Liquids
- P-14 Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres

Compressed Gas Association (CGA) CGA P-2.7-2000

SB-9 --"Recommended Practice For the Outfitting and Operation of Vehicles Used in the Transportation and Transfilling of Liquid Oxygen to be used for Respiration"

U.S. Food and Drug Administration, Rockville, MD. Hidden Danger: Oxygen regulator fires. [video]

National Fire Protection Association publications, Quincy, MA

50 Standard for Bulk Oxygen Systems at Consumer Sites

53 Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres

99 The Standard for Health Care Facilities

101 Life Safety Code

APPENDIX

Appendix A: Sample Nursing Assessment/Emergency Protocol

Appendix B: AAP -"Emergency Information Forms for Children with Special Needs"

Appendix C: School Team Responsibilities in Managing the Oxygen Dependent