Medical Gas Therapy

• ____________ is the most commonly used medical gas in respiratory care
• adding supplemental oxygen can increase $F_O_2$ which can increase $P_aO_2$
• accomplished with oxygen administration devices
• where do we get this “supplemental” oxygen?

Fractional Distillation of Liquid Air

• most common method of commercially producing $O_2$
• based on the different boiling points for gases

• $\rightarrow$ __________________________
  or __________________________
Fractional Distillation of Liquid Air

• before air is liquefied, water vapor and carbon dioxide are removed, (the CO₂ is saved) because these substances solidify when cooled and would _______ of the air liquefaction plant

• the dry, CO₂-free air is compressed to about _______ atmospheres - compression causes the air to become warm, and the heat is removed by passing the compressed air through radiators

• cooled, compressed air is then allowed to expand rapidly - causes the air to become cold, so cold that some of it _______

• by the alternate compressing and expanding of air, most of it can be liquefied

Fractional Distillation of Liquid Air

• once liquid air is obtained (~200°C), the temperature is increased

• as liquid warms, the elements reach their respective boiling points and come off as
  – nitrogen boils at -195°C
  – oxygen at -183°C, so N₂ leaves as a gas before O₂

• this procedure is also repeated, with the gas becoming increasingly higher in N₂ and the liquid becoming increasingly higher in O₂

• other gases, such as N₂ can also be captured from this process

Fractional Distillation of Liquid Air

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Fractional Distillation of Liquid Air

- this process can provide both liquefied and non-liquefied medical gases
- non-liquefied gases are transported and stored under high pressure in ______________
- liquefied gases are transported and stored in specially designed bulk liquid storage units
- the design and construction of all types of these transportation and storage units must conform to

Gas Cylinders

- metal cylinders have been used to store compressed gases since 1888
- Department of Transportation (DOT) contain well-defined specifications for cylinders
- these plus ___________ from NFPA and the CGA provide industry standards (Cairo, p.53-57)

The policies of regulating agencies, usually federal or state, have the effect of law. These regulations must be followed.

Recommending agencies write guidelines, standards and/or codes that enhance the safety and usability of medical devices. While these do not have the effect of law, most manufactures follow them and they can be adopted locally as regulations.
Regulating Agencies

Environmental Protection Agency (EPA)
Department of Health and Human Services (HHS)
Department of Transportation (DOT)
Food and Drug Administration (FDA)
Occupational Safety and Health Administration (OSHA)

Recommendating Agencies

American National Standards Institute (ANSI)
Compressed Gas Association (CGA)
International Standards Organization (ISO)
National Fire Protection Association (NFPA)
United States Pharmacopeia/National Formulary (USP/NF)
Z-79 Committee

Gas Cylinder Construction

- compressed gas cylinders are constructed of seamless, high quality steel, chrome-molybdenum, or aluminum
- cylinders are either __________________ into shape with a punch-press die or ______________ into shape by wrapping heated steel bands around a mold – the bottom is welded closed and the top is threaded for a valve stem
Gas Cylinder Construction

• type ________ cylinders are produced from heat-treated, high-strength steel
• type ________ cylinders are made of non-heat-treated carbon steel
• type ________ cylinders are constructed of specially prescribed seamless aluminum alloys
• the steel and aluminum used must meet the chemical and physical standards set by the

Gas Cylinder Construction

• because of changes in ambient conditions, cylinders should be capable of holding up to ________% more than the listed maximum filling pressure
• all cylinders must contain a

Gas Cylinder Maintenance

• types 3AA and 3A cylinders must be hydrostatically tested every ________ years (some are allowed a 10 year cycle – indicated by an __________ following the test date stamped on the cylinder)
• hydrostatic testing measures a cylinder’s ________ characteristics when filled to 5/3 its working pressure
Gas Cylinder Maintenance

• cylinder is filled with ___________ and placed in a vessel also filled with ___________

• pressure is applied to the ___________ of the cylinder, causing it to expand and displace water from the jacket around the cylinder

• the amount of water displaced when pressure is applied is known as ___________

• the amount of water displaced when pressure is removed is known as the ___________

Gas Cylinder Maintenance

• this information is then used to calculate the ___________ (EE) of the cylinder

• EE is directly related to cylinder wall thickness – an increase in EE usually reflects a ___________ in wall thickness (corrosion)

Gas Cylinder Testing
• most commonly used cylinder sizes in respiratory care – _____, _____ / _____, _____

• E cylinder uses
  – patient transport
  – emergencies (CPR carts)
  – ambulatory patients
  – anesthetic gases
  – calibration gases for portable diagnostic equipment
  – home care
Gas Cylinder Sizes & Capacities

- G, H & K cylinder uses
  - hospital cylinder banks
  - specialty gases (heliox)
  - home care
  - calibration gases for diagnostic equipment (PF, ABG)

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Gas Cylinder Color Codes

<table>
<thead>
<tr>
<th>Gas</th>
<th>Color Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>yellow or black &amp; white</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>gray</td>
</tr>
<tr>
<td>Carbon Dioxide/Oxygen</td>
<td>gray &amp; green</td>
</tr>
<tr>
<td>Cyclopropane</td>
<td>orange</td>
</tr>
<tr>
<td>Ethylene</td>
<td>red</td>
</tr>
<tr>
<td>Helium</td>
<td>brown</td>
</tr>
<tr>
<td>Helium/Oxygen</td>
<td>brown &amp; green</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>black</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>light blue</td>
</tr>
<tr>
<td>Oxygen</td>
<td>green</td>
</tr>
</tbody>
</table>

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Gas Cylinder Labeling

- color codes are to be used as guides only
- the only sure way to know the contents of a cylinder is to ________________
- the label should include the name of the gas and its USP purity, or simply Oxygen USP
- recently, members of the USP Convention started a movement to require the use standard cylinder colors and to include on each label the word Medical (e.g. Medical Oxygen USP)

USP is an acronym for United States Pharmacopeia

NF is an acronym for National Formulary

At one time, these were separate entities, but have now joined forces to produce a single publication, USP-NF

The United States Pharmacopeia (USP) is a non-government organization that promotes the public health by establishing state-of-the-art standards to ensure the quality of medicines and other health care technologies. These standards are developed by a unique process of public involvement and are accepted worldwide. In addition to standards development, USP’s other public health programs focus on promoting optimal health care delivery and are listed below. USP is a not-for-profit organization that achieves its goals through the contributions of volunteers representing pharmacy, medicine, and other health care professions, as well as science, academia, the U.S. government, the pharmaceutical industry, and consumer organizations.
Gas Cylinder USP Purity Standards

<table>
<thead>
<tr>
<th>Gas</th>
<th>Purity</th>
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<tbody>
<tr>
<td>Air</td>
<td>99%</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
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<td>Oxygen</td>
<td>99%</td>
</tr>
</tbody>
</table>

Gas Cylinder Valves

- the control devices that ________________________ the contents of compressed gas
- components
  - brass body
  - threaded inlet for attachment to the cylinder
  - a stem that opens and closes the cylinder
  - an outlet connection for attachment of regulators
  - a pressure-relief valve

Gas Cylinder Valves

- two types
  - _______________________ valves – generally used when pressures are greater than 1500 psi
  - _______________________ valves – generally used when pressures are less than 1500 psi
Gas Cylinder Pressure-Relief Valves

• three types
  – rupture (______________) disks – a thin metal disk that ruptures or buckles when pressure inside the cylinder exceeds a predetermined limit

• fusible (______________) – metal alloy plug that melts when the temperature of the gas in the cylinder exceeds a predetermined limit

• (______________) devices – metal seal held in place by an adjustable spring
Gas Cylinder Safety Systems

• Outlet connections of cylinder valves are __________________ according to standards designed by the CGA

• American Standard connections are non-interchangeable to prevent the interchange of regulating equipment between gases that are not __________________

Gas Cylinder Safety Systems

• ASSS (Thread Index Safety System) for ______________ cylinders (G, H, K)
  – indexed by thread type, thread size, right- or left-handed threading, internal or external threading and nipple seat design

Gas Cylinder Safety Systems

• PISS (Pin Index Safety System) for __________ cylinders
  (AA – E)
  – indexed by the exact placement of ____ pins into holes on the post valve
  – Hole positions are numbered 1 – 6; each medical gas uses a specific pairing e.g. 2 & 5 for oxygen
Gas Cylinder Safety Systems

- DISS (Diameter-Index Safety System)
  - threaded fittings to connect gas-powered devices to station outlets
  - differ in _________ of threads per inch

Gas Cylinder Safety Systems

- Quick Connect
  - used to connect flowmeters to _____________
  - quick access
  - differ in configuration and sizes
Gas Cylinder Duration

- to determine the ____________ of a medical gas cylinder, you must know
  - cylinder size
  - cylinder pressure
  - cylinder factor (volume/pressure conversion)

Ex. - E cylinder volume = 622 L; pressure = 2200 psi
622/2200 = 0.28

Gas Cylinder Duration

- volume-pressure conversion factors (O₂)

<table>
<thead>
<tr>
<th>Gas</th>
<th>Cylinder Size E</th>
<th>Cylinder Size H &amp; K</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂, O₂/N₂, air</td>
<td>0.28</td>
<td>3.14</td>
</tr>
<tr>
<td>O₂/CO₂</td>
<td>0.35</td>
<td>3.84</td>
</tr>
<tr>
<td>He/O₂</td>
<td>0.23</td>
<td>2.50</td>
</tr>
</tbody>
</table>

Gas Cylinder Duration

Duration of flow (minutes) =

cylinder pressure (psi) x cylinder fac
flow rate of gas (L/min)
Gas Cylinder Duration

Example:
You set up a full K cylinder of O₂ for a croup tent running at 12 L/min. How long will the cylinder provide the appropriate flow?

\[
\frac{\text{cylinder pressure (psi) x cylinder fac}}{\text{flow rate of gas (L/min)}} \]

\[
\frac{2200 \text{ psi} \times 3.1}{12}
\]

575 minutes or 9 hrs. 36 min.