# Case Teaching Notes

*for*

## "Gas Cylinders and Safety: A Case Study in Chemistry"

*by*

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## Introduction / Background

This case was used in a one-semester "Introduction to General, Organic, and Biochemistry" course offered as part of a two-year dental hygiene curriculum. It was incorporated into the course following the introduction of concepts related to gas behavior such as Boyle's Law, Dalton's Law, Charles' Law, and the Combined Gas Law. Students may familiarize themselves with the Ideal Gas Equation through advance reading in order to respond to the case study dilemma.

### *Objective*

- Apply gas properties and gas storage identification systems to identify a mishandled or mislabeled gas cylinder.

## Major Issues

The following topics are explored in class to help connect the information presented in the case to information on gas behavior previously discussed in class:

- What is the role of a gas cylinder coupling? Which part is it on the diagram of an installed gas cylinder?
- What is the purpose of each part of a cylinder regulator? In particular what is the difference between flow pressure and internal pressure?
- What do the gas cylinder specification values mean in terms of gas quantities

The reason for exploring the purpose of the parts of a regulator is that students then have the means to answer how they would verify gas cylinder specifications on a delivered tank.

## Classroom Management

To introduce the case study, students are first provided the case scenario to read. They are required to work in pairs or groups of three (assigned if necessary) and to brainstorm questions they may have about the situation after reading about it. They are encouraged to write down any questions, including things they could easily look up. During this time, the instructor circulates among the groups. As s/he learns what the students' questions are, s/he writes them up on the board. Resources for addressing these questions and their answers are incorporated in the following discussion, below.

Likely student questions include: "How are gases in cylinders identified?" and "What is a coupling?"

In response to the second question, students are given Handout I, "Gas Cylinder Regulator Fittings." The handout discusses the way that tank connectors vary with the gas in the cylinder connected. Although the word "coupling" is not used, students may deduce that a coupling refers to the threaded connection between a tank and a gas line based on the warning about unsafely "making" a regulator fit a tank. (A summary of a widely reported fatal accident that was caused by overriding this safeguard is included as part of the handout.) To test their comprehension of that, students are given Handout II, which depicts two gas regulators, and asked in their pairs to come to agreement about which part in the labeled illustration is the "coupling." Although this illustration is labeled, it does not use the word "coupling."

Using Handout II, students work in pairs to guess what each part of the regulator does. If students are collectively stuck, they can be reminded of what "pressure" is, i.e. force per unit area. In other words, the gas pushes on the cylinder *and* the gas is pushing on the air as it is flowing out. Both pressures are monitored. Only one is controlled.

The instructor ties the gas regulator illustrations to the case study by distributing Handout III, which contains a table with information on gas cylinder specifications. Handout III also includes illustrations of relative gas cylinder sizes. Students working in pairs must figure out how to verify that a delivered tank meets each of these specifications. In this process students should recognize that each gas has two volume values listed. The concept of gas storage conditions versus standard temperature and pressure conditions can be incorporated in explaining why two volume values are listed and what each means.

Students are asked to follow up the classroom discussion by responding in writing to the following questions:

1. What proof might convince the distributor that the tank definitely contains the wrong gas and not that the right gas had the wrong coupling?
2. Why would the technician be certain of the gas's identity when the coupling didn't match to begin with?

Students are also provided with the grading guidelines. They must explain how gas cylinders are identified, state what forms of proof one might use to distinguish between each of the medical gases listed in the handout, and show calculations to support their method(s) of proof where applicable.

To aid them in their problem-solving, students may be told that they may assume a scale is available to weigh the tanks and that they either know or can find the mass of an empty tank or perhaps can compare the mass of the questionable tank to another full tank of less ambiguous identity.

## Answer Key

Answers to the questions posed in the case study are provided in a separate answer key to the case. Those answers are password-protected. To access the answers for this case, go to the key. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our password policy and then apply online or write to answerkey@sciencecases.org.

## References

Bruan, Julie A. 2006. "Take a look before you hook." *Nursing Homes: Long Term Care Management* 55(6):69–71.

The Glassware Gallery.
http://www.ilpi.com/inorganic/glassware/regulators.html

Oxygen tank mix-up blamed in deaths of Ohio nursing home residents.
http://archives.cnn.com/2000/US/12/14/nursinghome.deaths.ap/index.html

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## Handout I—Proper Regulator Connection

### *Selecting the Proper Regulator*

Most commercially distributed gases are colorless and odorless. In other words, the gases, when outside the tank, cannot readily be identified. Users and distributors, thus, depend on accurate labeling of tanks to identify the contents. However, because the small risk of a labeling error could result in dramatically harmful consequences, an additional safeguard is utilized.

The threads of the tank fittings are designed to match the threads for a particular regulator. This measure is intended to prevent a user from connecting the wrong kind of gas to an existing gas outlet. In 1999, the Compressed Gas Association (CGA) designated codes to identify threads in a fitting. These codes are stamped, generally, on the regulator just above the threads of the cylinder connection and also on the cylinder valve. Without these stamped codes, the identity of threads would be lost once the threads are forced in a mismatching connection. The CGA recognized the need for these stamped numbers as a result of incidents of valve ejection from cylinders with mismatched threads to these valves.

**Table 1.** Connection Codes for Some Typical Medical Gases

| Gases | CGA # |
|---|---|
| Air | 346 |
| Carbon Dioxide | 320 |
| Cyclopropane | 510 |
| Helium | 580 |
| Nitrogen | 580 |
| Nitrous Oxide | 326 |
| Oxygen | 540 |

One example of a thread variation is the reverse threading used for flammable gases. This acts as an additional safeguard. Flammable gas fittings cannot be connected to non-flammable regulators because they require counterclockwise turning for connection, rather than the conventional clockwise turning.

### *Example of a Regulator Fitting Accident*

"On December 7, 2000, four residents of a nursing home in Bellbrook, Ohio, died and six were injured after being administered industrial nitrogen instead of oxygen. The 84-bed nursing home received a shipment of four portable cryogenic medical gas containers labeled as medical oxygen, but one container also bore an industrial nitrogen label that partially obscured the medical oxygen label. That vessel was filled with industrial nitrogen.

The nursing home was running low on oxygen and sent an employee to connect a new oxygen vessel to the oxygen supply system. The employee mistakenly selected the nitrogen container. Despite recommendations by the Compressed Gas Association, a safety and standards organization for medical and industrial gases, many of the large cryogenic vessels that contain medical gases do not have permanently brazed, or welded, connections or fittings that cannot be removed. The container's nitrogen-specific gas-use-outlet connection was incompatible with the connector on the facility's oxygen supply system.

Although the employee initially was unable to connect the container to the oxygen supply system, the fatal connection ultimately was made when an oxygen-specific gas-use-outlet connection from an empty portable cryogenic medical oxygen container was removed and substituted for the nitrogen-specific connection on the industrial nitrogen container. The employee then connected the deadly product to the oxygen supply system. The employee was not properly trained and did not examine the drug label to verify that the product was, indeed, medical oxygen before installing the vessel. Furthermore, the employee did not know that connection incompatibility is a built-in safeguard."

Credits: Table 1 created on the basis of information from Linde Gas LLC, MSDS and Safety, CGA Valve Fittings (http://www.us.lindegas.com/International/Web/LG/US/likelgus30.nsf/DocByAlias/nav_safe_cga) and *Compressed Gas Association Technical Bulletin*, TB-16, 2004. The report of the regulator accident is from Bruan, Julie A. Take a Look Before You Hook, *Nursing Homes: Long Term Care Management* (2006) 55(6):69–71.

# Handout II—Gas Cylinder Regulators

Figure 1. Gas Cylinder Regulator

Figure 1 provided by MESA Specialty Gas & Equipment (http://www.mesagas.com).
Used with permission.

Figure 2. Connected to Gas Cylinder

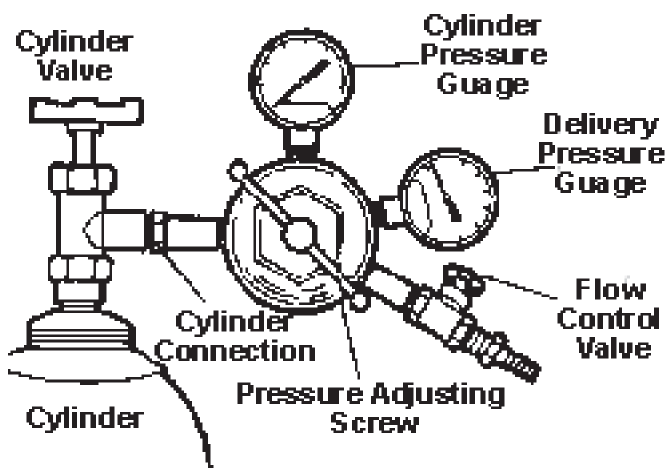


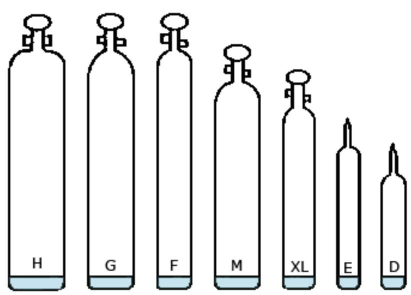

Figure 2 provided by the Safety Office of University of Waterloo.
Used with permission.

# Handout III

Table 2. Typical Medical Gas Cylinders Volume and Weight of Available Contents at 70F
(Based on a table created by Ismael Cordero, Clinical Engineer. Used with permission.)

| Cylinder Style & Dimensions | Nominal Volume Cu In/Liter | Contents | Air | Carbon Dioxide | Cyclo- Propane | Helium | Nitrogen | Nitrous Oxide | Oxygen |
|---|---|---|---|---|---|---|---|---|---|
| | | Cylinder Color | yellow | gray | orange | brown | black | blue | green |
| B | | psig | | 838 | 75 | | | | 1900 |
| 3 1/2 od x 13" | 87/ 1.43 | Liters | | 370 | 375 | | | | 200 |
| 8.89 x 33cm | | Lbs.-Oz. | | 1-8 | 1- 7 1/4 | | | | - |
| | | Kilograms | | .68 | .66 | | | | - |
| D | | psig | 1900 | 838 | 75 | 1600 | 1900 | 745 | 1900 |
| 4 1/4" od x 17" | 176/ 2.88 | Liters | 375 | 940 | 870 | 300 | 370 | 940 | 400 |
| 10.8 x 43 cm | | Lbs.-Oz. | - | 3-13 | 3- 5 1/2 | - | - | 3-13 | - |
| | | Kilograms | - | 1.73 | 1.51 | - | - | 1.73 | - |
| E | | psig | 1900 | 838 | | 1600 | 1900 | 745 | 1900 |
| 4 1/4" od x 26" | 293/ 4.80 | Liters | 625 | 1590 | | 500 | 610 | 1590 | 660 |
| 10.8 x 66 cm | | Lbs.-Oz. | - | 6-7 | | - | - | 6-7 | - |
| | | Kilograms | - | 2.92 | | - | - | 2.92 | - |
| M | | psig | 1900 | 838 | | 1600 | 2200 | 745 | 2200 |
| 7" od x 43" | 1337/ 21.9 | Liters | 2850 | 7570 | | 2260 | 3200 | 7570 | 3450 |
| 17.8 x 109 cm | | Lbs.-Oz. | - | 30-10 | | - | - | 30-10 | 122 cu ft |
| | | Kilograms | - | 13.9 | | - | - | 13.9 | - |
| G | | psig | 1900 | 838 | | 1600 | | 745 | |
| 8 1/2" od x 51" | 2370/ 38.8 | Liters | 5050 | 12,300 | | 4000 | | 13,800 | |
| 21.6 x 130 cm | | Lbs.-Oz. | - | 50-0 | | - | | 56-0 | |
| | | Kilograms | - | 22.7 | | - | | 25.4 | |
| H or K | | psig | 2200 | | | 2200 | 2200 | 745 | 2200 |
| 9 1/4" od x 51" | 2660/ 43.6 | Liters | 6550 | | | 6000 | 6400 | 15,800 | 6900 |
| 23.5 x 130 cm | | Lbs.-Oz. | - | | | - | - | 64 | 244 cu ft |
| | | Kilograms | - | | | - | - | 29.1 | - |

Figure 3. Comparison of Gas Cylinder Sizes

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