Kindergarten through Grade 12

A planning guide for designing indoor facilities and outdoor learning areas for Texas schools

Science Facilities Standards

a publication of the
Charles A. Dana Center

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Texas Education Agency

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Felipe T. Alanis
Commissioner of Education

September 2002

TO ADMINISTRATORS and SCIENCE TEACHERS:

Using critical-thinking skills to apply science concepts in laboratory and field-based settings is a primary goal of science education. As we approach the challenges and opportunities of the implementation of the No Child Left Behind Act, these skills are crucial for student success. School districts must provide adequate facilities so that all students have access to science instruction that reflects these expectations.

The Texas Essential Knowledge and Skills (TEKS) outline what students should know and be able to do in science. At the heart of the science TEKS is the expectation that students will perform the activities of science. High school science courses shall include at least 40% hands-on laboratory investigations and field work using appropriate scientific inquiry.

Instructional personnel can provide important contributions to the design of their teaching facilities when upgrades to existing facilities or new facilities are to be constructed. When planning is under way, certain standards should be consulted. This document provides a handy, concise reference for science-friendly school facilities.

This Science Facilities Standards handbook consists of information that has been compiled to provide assistance in designing, improving, and maintaining the finest indoor facilities and outdoor learning areas for Texas schools.

Science Facilities Standards is a guide for providing the best environment for the teaching and learning of science for all Texas students. This guide is a resource that educators and contractors will find invaluable.

Sincerely,

Ann Smisko

Ann Smisko
Associate Commissioner
Curriculum, Assessment, and Technology

SCIENCE FACILITIES STANDARDS

Kindergarten
through
Grade 12

A Guide for Designing Indoor Facilities and Outdoor Learning Areas for Texas Schools

January 2002

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Introduction

The Texas Essential Knowledge and Skills require students in kindergarten–grade 8 and in every high school science course to use scientific inquiry methods to conduct field and laboratory investigations following safe procedures. Our schools must provide well-equipped classrooms and laboratories, as well as access to outdoor space, so that students can do investigations using scientific inquiry.

> "Inquiry is a multifaceted activity that involves observations; posing questions; examining books and other resources of information to see what is already known; planning and conducting investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions, and communicating the results."
>
> National Research Council, *National Science Education Standards*, 1996

Why It Is Important to Have Good Science Facilities

Good science facilities are necessary in order for teachers to provide the quality of instruction that is expected in today's education system. As more demands are placed on our teachers to improve student performance and schools are held accountable for the level of student performance, the need for modern, well-equipped science facilities becomes increasingly important. Research has proven that students learn and understand science concepts better when all of their senses are stimulated during the learning process. Nowhere can they acquire this level of understanding better than during laboratory and field investigations.

Small laboratory rooms with overcrowded student workstations, a lack of safety equipment, and inadequate supplies and materials can no longer be tolerated in our schools. In order for teachers to be able to guide students to the expected levels of achievement, school districts must build safe, modern science facilities and renovate old, inadequate facilities. School designs should be sustainable in order to maximize the efficient use of natural resources and minimize potential damage to the environment.

The purpose of this manual is to provide teachers, school administrators, and architects contractors with standards for designing facilities that will help students achieve their full potential.

Thirteen Considerations for a Sustainable School Design

1. Ecology Education

Design your sustainable school to be a teaching tool by incorporating the environment into the education program.

2. Site Planning and Landscape Design

Evaluate the regional impacts of the school on the environment, and protect and retain existing landscaping and natural features. Incorporate environmentally friendly design solutions—sound erosion control, storm water retention, and xeriscape landscaping principles

3. Environmentally Sensitive Building

Maximize the use of recycled and enviro-friendly products that reduce the polluting effects of construction on the environment.

4. Energy-Efficient Building Shell

Maximize energy efficiency by using light colors for roofing and wall finish materials; high R-valve wall and ceiling insulation; minimal glass on east and west exposures; and more glass on north and south exposures.

5. Solar Energy Systems

Consider the use of solar energy systems as a means to reduce peak electrical demand. Incorporate the technology in the school's ecology education program.

6. Indoor Air Quality

Eliminate sources of harmful contaminants and discomfort by minimizing building materials and furnishings that contain toxins. Use natural ventilation wherever possible.

7. Energy-Efficient Mechanical and Ventilation Systems

Consider low-energy mechanical systems such as solar heating and cooling, double-effect absorption cooling, or geothermal heat pumps.

8. Daylighting

Develop strategies to provide natural daylight for at least two-thirds of the day, minimizing the need for artificial light in the learning areas. Recognize the limitations associated with perimeter daylighting and the benefits associated with roof monitors (large skylights).

9. Water Conservation

Collect rainwater for site irrigation and toilet flushing using separate plumbing to channel this gray water. Minimize wastewater by installing waterless urinals, using low-flow and water conserving fixtures, and insulating piping to reduce hot water waste.

10. Energy-Efficient Lighting and Electrical Systems

Include motion sensors tied to dimmable lighting controls to reduce utility costs. Fiber-optic lighting maximizes efficiency, reduces overheating, and eases lamp replacement in areas that are difficult to reach.

11. Recycling Systems and Waste Management

Facilitate recycling by providing central locations for collection that are convenient to students and staff. Include recycling chutes for multistory schools.

12. Transportation

Discourage single-car travel by providing easy access to the school via public transportation, bicycle paths, and walkways. Consider alternatives such as electric service vehicles and buses.

13. Commissioning and Maintenance

Develop a commissioning process that helps ensure the proper operation of mechanical, electrical, and solar systems. Recognize the need to educate students and staff so they can make the most of their sustainable school.

A recent publication by the Charles A. Dana Center, *An Analysis of Laboratory Safety in Texas*, presented the results of a statewide survey on safety in science classrooms and laboratories. The report listed the following conclusions based on the data collected from the survey.

1. As class sizes increase, the occurrence of both major and minor accidents increases.
2. As student enrollments increase, so does the occurrence of minor accidents.
3. Low numbers of teachers are completing professional development activities focused on laboratory safety
4. Many schools are not conforming to laws and regulations regarding the availability and use of safety equipment, the proper storage of chemicals, laboratory size, and the existence of ventilation and communication systems.

As a result of the findings of this report, the Texas Education Agency (TEA) has made the following recommendations.

- Strengthen state safety regulations, and resume the systematic monitoring of science facilities and safety procedures in public schools by the Texas Education Agency.

> Evidence in the report shows that many science teachers and students lack access to required safety equipment. Strengthening regulations and regular monitoring can assist schools in identifying deficiencies and encourage prompt compliance with regulations.

- Texas school districts constructing or remodeling school buildings should provide safe science laboratories of the appropriate size and with appropriate storage space and ventilation.

> Further evidence suggests that accidents can be reduced or avoided by having appropriate physical facilities for science teaching and the handling of science materials. Facility planners should follow TEA recommendations regarding science laboratory floor space and storage facilities.

- Reduce the teacher-student ratio in middle and high school science classes.

> Teacher reports of accidents in science classes indicate a positive and direct relationship between the number of students in a science class and the number of accidents that occur. Research suggests that an appropriate limit to the student-teacher ratio for science instruction is 25 to 1.

The information and standards presented in this manual reflect the findings of the Dana Center's safety survey report. It is important that construction and renovation in Texas public schools progress toward providing safe and effective learning environments for our students.

The Texas Education Agency reported that during the 1999–2000 school year, 7,395 school campuses in 1,041 school districts and 142 charter schools employed 267,922 full-time teachers. These teachers had the responsibility of educating approximately 4 million students required to learn science concepts and do science investigations. Each year approximately 1,638 high school campuses, 1,420 middle and junior high school campuses, and 4,337 elementary school campuses are required to provide adequate science facilities for their teachers and students.

Who Should Be Included in the Planning Process?

The planning of a science facility should involve representatives from the school district's administration, including—but not limited to—the director of school facilities, the kindergarten–grade 12 curriculum coordinator, the science supervisor, the technology coordinator, the principal, the science teacher, a maintenance personnel, and a representative from a science equipment and furniture manufacturer. In addition, the architect will bring his or her knowledge of engineering and building codes (local, state, and federal) and the construction team for the project.

One of the most valuable members of the committee (but often not included) is the science teacher, who has the responsibility of teaching in the new facility. The science teacher must be able to function effectively in the science classroom and laboratory and can provide valuable insights to the committee about what should be taught and how it should be taught. Architects sometimes fail to recognize the importance of including teachers, who may spend up to twenty years of their lives working in these facilities.

What Should Be Included in Science Facilities?

Determining what should be included in a science classroom, laboratory room, storage room, preparatory room, or field site is a complex process that should not be rushed. Too often, after the construction is complete a teacher will realize that certain things should have been included or are in the wrong place in the room—too late. Checklists are often helpful when deciding what to include in a room. It is sometimes easier to cross items off a list than to try to remember what should be included on the list. The following chapters are designed to assist with the following:

- floor space requirements
- types and styles of fixtures
- laboratory furniture
- classroom designs
- technology requirements
- laboratory room designs
- lecture/laboratory room designs
- preparation room designs
- equipment storage room designs
- chemical storage room designs
- science department designs
- outdoor learning area designs

A convenient facilities and equipment checklist for elementary, middle, and high schools is included in Appendix C and may be helpful when you are planning for your facilities. However, it is not intended as a final list of what should be included in a science room.

Be flexible in your designs. The state's mandated science standards will change in the future, and your facilities must be able to change to meet the new needs of our students.

Chapter 1
Laws, Rules, and Regulations

According to the National Science Education Standards, students at all grade levels should engage in scientific inquiry to gain an understanding of scientific concepts and acquire science process skills. They can not acquire these skills merely by reading a textbook; in addition, they must experience meaningful investigations in laboratory and field settings.

Well-designed science facilities provide students with a safe learning environment for laboratory and field investigations. This chapter presents requirements and recommendations for constructing science facilities in Texas school districts. Chapter 2 presents regulations and recommendations regarding classroom and laboratory space and accessibility for all students.

> *"Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and technology to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments."*
>
> National Research Council, *National Science Education Standards*, 1996

Curriculum-Based Designs

Designs for science facilities should be based on the requirements listed in a school district's educational program and on the student population that the facilities serve. Chapter 112 of the Texas Administrative Code provides teachers with standards for science. These standards, the Texas Essential Knowledge and Skills (TEKS) for Science, specify what all students should know and be able to do in kindergarten through grade 12 science. The TEKS are part of a district's educational program and provide local school districts with the foundation for their science curriculum.

The TEKS were intentionally written with active verbs—such as *demonstrate*, *conduct*, *investigate*, *manipulate*, and *observe*—that make it difficult, if not impossible, for students to learn science without doing hands-on laboratory and field investigations. Architects and engineers can use the activities described in this chapter as a guide for designing the kinds of facilities districts require.

Elementary School Science Curriculum

The science standards for elementary school provide students with ways to explore the natural world through curricula based on integrated relationships that exist among the science disciplines. It is important for students to relate what they learn in science classes to what they experience outside the school setting. School districts must provide well-designed science facilities that support students' work in laboratory investigations involving life, earth/space, and the physical sciences.

> The National Science Teachers Association (NSTA) recommends that a minimum of 60 percent of the instructional time be devoted to laboratory investigations. However, the Texas Education Agency gives each school district the authority to establish the percentage of time elementary students will spend doing hands-on laboratory and field investigations.

The following information represents a summary of the content requirements for elementary school science and can serve as a guide to the types of facilities that are necessary in order for students to meet the state standards for science. The complete TEKS for science are included as Appendix A.

Kindergarten

Students participate in simple classroom and field investigations safely to develop skills to do scientific inquiry, and to use critical thinking to make decisions. They use their own senses, common tools, and models to make observations and collect information. In addition, they use computers and other technology to support their investigations.

They identify components of the natural world, including rocks, soil, and water. Students observe changes in the seasons and in the growth of plants and animals, and they explore the basic needs of living organisms. They actively participate to identify organisms and objects; manipulate parts of objects; group living organisms and nonliving objects; and observe life cycles in plants and animals.

First Grade

Students in first grade conduct classroom and field investigations safely to develop skills to do scientific inquiry, and to use critical thinking to make decisions. They use tools, including computers and models to observe, describe, and measure objects and organisms.

Students measure, manipulate, and sort objects and organisms. They distinguish, group, and compare living organisms and nonliving objects, identify the basic needs of living organisms, and compare the ways in which living organisms depend on each other.

They engage in activities to identify components of the natural world including streams, lakes, and oceans. They observe rocks and soil samples; they measure changes that result from the application of heat, that occur during different weather and seasons, and that occur during the life cycles of organisms.

Table 1.1
Kindergarten Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Eye/face washes
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles
- Safety goggle disinfecting equipment or materials: soap and water, bleach solution, hot water

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment
- Balances
- Bowls, plastic
- Computers
- Cups (paper or plastic)
- Hand lenses

Recommended[2]

Materials and equipment
- Aquarium and accessories
- Clocks
- Egg incubators
- Scissors, primary
- Terrarium and accessories

Consumables
- Aluminum foil
- Bags, plastic with zipper seals
- Construction paper
- Crayons, wax
- Nails, small
- Paste
- Potting soil
- Soil samples
- Spoons, plastic
- Strings for measurement
- Textured materials, such as sand paper, silk

Audiovisuals
- Personal growth graph

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Table 1.2
First Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Eye/face washes
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment, including soap and water, bleach solution, hot water
- Safety goggles, splash-proof

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances
- Clocks with second hand
- Computers
- Hand lenses
- Thermometers; non-rolling, non-mercury

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Beakers, plastic, 250 mL
- Bodkin needles and thread
- Bowls, plastic
- Construction blocks
- Egg incubators
- Eyedroppers, plastic
- Geometric shapes sets, colored
- Lamps or light sources
- Magnet sets
- Metal samples, including iron
- Metric rulers
- Noise-making devices
- Terrarium and accessories

Living/preserved specimens

- Animals and plants
- Seeds such as peas, corn and beans

Consumables

- Aluminum foil
- Bags, plastic with zipper seals
- Bowls, plastic
- Construction paper
- Crayons, wax
- Cups (paper and plastic)
- Ice source
- Nails, small
- Measuring objects (string, paper clips, washers)
- Paste
- Potting soil
- Rock samples
- Scissors, primary
- Spoons, plastic
- Soil samples: sand, silt, clay, loam
- Textured objects, such as sand paper, silk, wax paper

Audiovisuals

- Pictorial graph
- Video, *Sources of Water*

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Second Grade

Students in second grade conduct classroom and field investigations safely to develop skills to do scientific inquiry, and they use critical thinking to make decisions. They use tools and models to observe, describe, and measure objects and organisms. In addition, they use computers and other technology to support their investigations.

They identify and illustrate components and processes of the natural world, including the water cycle and use of the earth's resources. Students engage in activities to observe and measure change that occurs during melting and evaporation, weathering, and the pushing and pulling of objects.

Students distinguish between the characteristics of living organisms and nonliving objects, compare needs of plants and animals, and identify parts and characteristics of plants and animals to gain an understanding of how living organisms depend on their environments.

Third Grade

Third-grade students conduct field and laboratory investigations safely using environmentally appropriate and ethical practices. Students develop skills to do scientific inquiry, and they use information, critical thinking, and scientific problem-solving skills to make decisions. In addition, they use computers and other technology to support their investigations and repeat investigations to increase the reliability of their results.

They identify components of the natural world, including rocks, soil, water, and atmospheric gases. Students participate in activities to observe the direction and position of objects as they are pushed and pulled, and the movement of the Earth's surface, as examples of changes caused by a force. They investigate magnetism and gravity and use models to represent the natural world.

Students conduct activities to explore organisms' needs, habitats, and competition with other organisms within the same ecosystem. In addition, they observe characteristics among species that allow each species to survive and reproduce, and they investigate how species adapt to change. They identify inherited traits in plants and animals.

Table 1.3
Second Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Eye/face washes
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment, including soap and water, bleach solution, hot water
- Safety goggles (splash-proof)

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment
- Hand lenses
- Clocks
- Computers
- Balances
- Thermometers; non-rolling, non-mercury

Recommended[2]

Materials and equipment
- Aquarium with accessories
- Beakers, plastic, 250 mL
- Bodkin needles and thread
- Bowls, plastic
- Construction blocks
- Egg incubators
- Eyedroppers, plastic
- Geometric shapes set, colored
- Lamps or light sources
- Magnet sets
- Metal samples including iron
- Metric rulers
- Terrarium and accessories
- Noise-making devices

Living/preserved specimens
- Animals and plants
- Seeds, such as peas, corn and beans

Consumables
- Aluminum foil
- Bags, plastic with zipper seals
- Bowls, plastic
- Construction paper
- Crayons, wax
- Cups (paper and plastic)
- Ice
- Nails, small
- Measuring objects (string, paper clips, washers)
- Paste
- Potting soil
- Rock samples
- Scissors, primary
- Spoons, plastic
- Soil samples: sand, silt, clay, loam
- Textured objects, such as sand paper, silk, wax paper

Audiovisuals
- Graph, pictorial
- Video, *Sources of Water*

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Table 1.4
Third Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Eye/face washes
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment, including soap and water, bleach solution, hot water
- Safety goggles (splash-proof)

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances
- Clocks
- Computers
- Hand lenses
- Measuring cups
- Meter sticks
- Rulers, metric
- Thermometers, non-mercury

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Beakers, 250 mL
- Cars, toy
- Egg incubators
- Eyedroppers
- Fans, small
- Flashlights
- Light sources
- Magnet sets
- Musical instruments, rhythm band
- Nails and hammers
- Rock sample sets: sedimentary, igneous, and metamorphic
- Terrarium and accessories
- Thermometers, outdoor

Consumables

- Aluminum foil
- Bags, plastic with zipper seals
- Construction paper
- Crayons, wax
- Cups (paper)
- Measuring objects (paper clips, string, washers, bolts)
- Nails, small
- Paste
- Scissors, primary
- Potting soil
- Spoons, plastic
- Soil samples: clay, loam, silt, sand

Living/preserved specimens

- Animals and plants
- Seeds such as peas, corn and beans

Audiovisuals

Charts

- Constellation
- Growth
- Water cycle
- Wind speed

[1]Required tools are specified in the TEKS.

[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Fourth Grade

Students conduct laboratory and field investigations safely using environmentally appropriate and ethical practices to do scientific inquiry. They use critical thinking and scientific problem-solving skills to make informed decisions. In addition, students use computers and other technology to collect and analyze information and repeat investigations to increase the reliability of their results.

They identify components and processes in the natural world, including properties of soils, effects of the oceans on land, and the role of the Sun as the major source of energy. In addition, students identify the physical properties of matter and observe that the addition or reduction of heat can cause changes in states of matter.

Students learn the roles of living and nonliving components in a simple system and investigate the differences between learned characteristics and inherited traits. They identify species of organisms that lived in the past and compare them to existing species.

Fifth Grade

Students conduct field and laboratory investigations safely according to environmentally appropriate and ethical practices and using tools and methods to do science inquiry. They use scientific methods and critical thinking and scientific problem-solving skills to make informed decisions. In addition, they use computers and other technology to support their investigations and repeat investigations to increase the reliability of their results.

They conduct activities to identify structures and functions of Earth systems including the crust, mantle, and core; and they investigate the effects of weathering on landforms.

Students learn how some past events have affected present events by exploring growth, erosion, and dissolution. They conduct activities to investigate magnetism, physical states of matter, and conductivity as ways of classifying matter. In addition, they learn about forms of energy, such as light, heat, and electricity.

Other activities include learning about adaptations that can improve the survival of members of a species, exploring an organism's niche within an ecosystem, and discovering a variety of traits that are inherited by offspring, as well as other characteristics that are learned.

[1]Required tools (materials and equipment) are specified in the TEKS.
[2]Recommended lists of tools (materials and equipment) were generated by analyzing the concept TEKS.

Table 1.5
Fourth Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment
- Safety goggles (splash-proof)

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances
- Calculators
- Cameras, disposable
- Clocks with second hand
- Compasses, magnetic
- Computers
- Meter sticks
- Microscopes, stereoscopic
- Rulers, metric
- Sound recorders
- Thermometers, non-mercury

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Electric circuit kits
- Beakers, plastic, graduated
  - 250 mL and 1000 mL
- Graphing mats
- Hot plates
- Incubators, egg
- Lamps, aluminum reflector
- Magnet sets
- Mirrors, plastic
- Scissors
- Spinning tops with pump action
- Rocks, limestone samples
- Terrarium with accessories
- Thermometers, outdoor
- Weather vanes

Living/preserved specimens

- Animals and plants
- Seeds, such as peas, corn and beans

Consumables

- Aluminum foil
- Bags, plastic, with zipper seal
- Clay, modeling
- Construction paper
- Crayons, wax
- Cups (paper)
- Glue, school
- Nails, small
- Paste
- Pencils, colored
- Potting soil
- Salt and water for concentrations
- Soil samples: clay, loam, sand, silt
- Spoons, plastic
- Straws
- Sugar cubes

Audiovisuals

Charts

- Water cycle
- Clouds
- Wind speed
- Vinegar
- Constellations
- Butterfly life cycle
- Dinosaurs
- Geologic time table

Videos

- Streams and rivers
- Volcanoes
- Tides and hurricanes

Table 1.6
Fifth Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment
- Safety goggles (splash-proof)

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances, triple beam
- Calculators
- Cameras, disposable
- Clocks
- Collecting nets
- Compasses, magnetic
- Computers
- Hand lenses
- Hot plates
- Magnets
- Meter sticks
- Microscopes, stereoscopic
- Rulers, metric
- Sound recorders
- Thermometers, non-mercury

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Egg incubators
- Electric kits: knife-blade switch, lamp and base, electric bell, copper wire, nail
- Beakers, plastic, graduated, 400 mL
- Beakers, Pyrex, graduated
  - 250 mL
  - 600 mL
- Burners, propane, or Bunsen burners
- Conductometers
- Cylinders, graduated, 100 mL
- Eyedroppers
- Iron filings
- Lamps with aluminum reflector
- Lenses, 2, convex
- Mineral sets
- Mirrors
- Prisms
- Rock sets: sedimentary, igneous, and metamorphic
- Rubber hammers
- Scissors
- Terrarium
- Thermometers, outdoor
- Tuning forks

(*table continues*)

Table 1.6—*Continued*

Materials and Equipment

Recommended[2]

Consumables
- Aluminum foil
- Bags, plastic, with zipper seal
- Baking soda
- Batteries, dry cell, 6 volt
- Beef bouillon cubes
- Coal
- Coffee cans with lids
- Construction paper
- Fertilizers
- Glue, school
- Ice
- Paper, simple graphing
- Pencils, colored
- pH paper (vials)
- Pots, plants
- Potting soil
- Salt
- Solar tinting sheets for windows
- Spoons, plastic
- Sugar
- Vinegar

Living/preserved specimens
- Animals and plants
- Seeds, such as peas, corn and beans
- Tree ring samples

Audiovisuals

Models
- Geologic cross-cut diagram
- Globe, Earth
- Globe, lunar
- Planetarium, hand-held

Charts
- Water cycle
- Carbon cycle
- Coal and oil formation
- Life cycle of tree
- Lunar phases
- Nitrogen cycle
- Tidal schedule

Videos
- Adaptive characteristics of organisms
- Rain forest
- Serengeti

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Middle School Science Curriculum

Middle school students continue to learn and experience science through an integrated curriculum at each grade level. Science facilities must be flexible to support a curriculum that, within a single school year, requires students to conduct investigations in life science, earth/space science, and the physical sciences. As with elementary students, it is important for middle school students to be able to see the connection between what they learn in science classes and the science they experience outside the school setting.

> The Texas Education Agency gives each school district the authority to establish the percentage of instructional time that middle school students spend doing hands-on laboratory and field investigations. NSTA recommends that middle school students spend 80 percent of their time in the science classroom doing these kinds of activities.

The following information represents a summary of the content requirements for middle school science and can serve as a guide to the types of facilities that are necessary in order for students to meet the state standards for science. The complete science TEKS are included in Appendix A.

Sixth Grade

Students use environmentally appropriate, ethical, and safe practices to conduct field and laboratory investigations. They use a variety of scientific methods and tools to collect and analyze data, record information, and make informed decisions using critical thinking and scientific problem-solving skills. They use computers and information technology to support their scientific investigations.

Students identify components of the solar system, including the Sun, planets, moon, and asteroids, and learn how seasons and the length of day are caused by the tilt and rotation of the Earth as it orbits the Sun. They investigate the rock cycle and identify sources of water in a watershed. In addition, students engage in activities to identify changes in objects—including their position, direction, and speed—when acted upon by a force.

Students classify substances according to their chemical properties and identify the water cycle and decay of a biomass as examples of the interactions that can occur between matter and energy. They identify life processes and the relationships between the structure and function of organisms.

Table 1.7
Sixth Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles (splash-proof)
- Safety goggle disinfecting materials or equipment

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances, triple beam
- Beakers, plastic, graduated
  - 100 mL
  - 250 mL
  - 400 mL
- Calculators
- Compasses, magnetic
- Computer probes
- Computers
- Field equipment
- Graduated cylinders, graduated
  - 10 mL
  - 100 mL
- Hot plates
- Magnets
- Meter sticks
- Microscopes
- Petri dishes
- Safety goggles
- Spring scales
- Telescopes
- Test tubes
- Thermometers, non-mercury
- Timing devices
- Weather instruments
  - outdoor
  - thermometer
  - barometer
  - sling psychrometer

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Electric generators
- Electric fans
- Eye droppers
- Inclined planes with force mechanism
- Insect collecting nets
- Insect anesthetizing jars
- Insect pins
- Lamps with aluminum reflectors
- Metric rulers
- Microscope slides, blank
- Microscope slides, depression
- Microscope cover slips
- Plant presses
- Rock samples: sedimentary, igneous, and metamorphic
- Scissors
- Steam engines
- Stirring rods
- Terrarium with accessories
- Test tube holders
- Test tube racks
- Thermometers, outdoor
- Water filtering kits

(*table continues*)

Table 1.7—*Continued*

Materials and Equipment

Recommended[2]

Consumables

- Aluminum foil
- Bags, plastic, with zipper seal
- Brush, artist
- Clay, modeling
- Compost pile
- Construction paper
- Glue, school
- Herbarium paper
- Herbarium paste
- Kitchen chemicals
    - lemon juice
    - vinegar
    - baking soda
    - ammonia
    - liquid detergent
    - carbonated drink
    - tea
    - coffee
- pH paper or litmus paper
- Pans, aluminum pie
- Paper, simple graphing
- Pencils, colored
- Plant pots
- Potting soil
- Spoons (plastic)

Living/preserved specimens

- Mealworms, aquatic snails, or earthworms
- Plant seeds
- Microscope slides, prepared
    - muscle cells
    - blood cells
    - nerve cells
    - plant and animal
    - chromosomes, stained

Audiovisuals

Videos and CD-ROMs

- Mountain Building
- Volcanic activity
- Solar system: meteorites, comets, and asteroids
- Space travel

Game

- Food webs

Charts and transparencies

- Energy pyramid
- Rock cycle
- Atmospheric composition
- Clouds
- Composing
- Food pyramid
- Human organ systems
- Production of energy for human use
- Solar system

Models

- Animal cell
- Globe, Earth
- Human torso
- Lung
- Plant cell
- Planetarium showing tilt of Earth
- Planetarium, illuminated, hand-held

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Seventh Grade

Students use environmentally appropriate, ethical, and safe practices to conduct field and laboratory investigations. They use a variety of scientific methods and tools to collect and analyze data, record information, and make informed decisions using critical thinking and scientific problem-solving skills. They use computers and information technology to support their scientific investigations.

Students identify gravity and phases of the moon as components of the solar system and explore the effects on the Earth of events such as hurricanes. Students conduct activities using pulleys and levers to understand the relationship between force and motion and then relate that concept to processes found in the human organism. In addition, they investigate the chemical and physical properties of substances, and identify the physical properties of elements in order to understand their placement on the periodic table.

Students learn about kinetic and potential energy and identify photosynthesis as an example of the transformation of radiant energy to chemical energy. They investigate systems in humans to identify their structure and functions, and compare asexual and sexual reproduction to illustrate that genetic materials are responsible for dominant and recessive traits in organisms.

Eighth Grade

Students use environmentally appropriate, ethical, and safe practices to conduct field and laboratory investigations. They use scientific methods and tools to collect and analyze data, record information, and make informed decisions using critical thinking and scientific problem-solving skills. They use computers and information technology to support their scientific investigations.

Students investigate the ways in which the Earth's systems have been altered by human activities and natural events; learn about cycles within the Earth's systems by exploring lunar and rock cycles; and explore interactions in matter and energy found in solar, weather, and ocean systems.

Students learn that stars and galaxies are part of the universe, describe distance in terms of light years, and research scientific theories of the origin of the universe.

They examine information on the periodic table to learn how elements are grouped into families. In addition, students demonstrate exothermic and endothermic reactions.

Students participate in activities in which they predict results from different genetic combinations and explore the extinction of some species of organisms.

Table 1.8
Seventh Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggle disinfecting materials or equipment
- Safety goggles, splash-proof

Recommended[2]

- Sinks
- Transport cart

Materials and Equipment

Required[1]

Materials and equipment

- Balances, triple beam
- Beakers, plastic
  - 100 mL
  - 250 mL
  - 400 mL
- Calculators
- Compasses, magnetic
- Computer probes
- Computers
- Dissecting kits
- Field equipment
- Graduated cylinders
  - 10 mL
  - 100 mL
- Hot plates
- Magnets
- Meter sticks
- Microscopes, compound
- Plant presses
- Petri dishes
- Spring scales, 10 N
- Telescopes
- Test tubes
- Thermometers, non-mercury
- Timing devices
- Weather instruments
  - outdoor thermometer
  - barometer,
  - sling psychrometer
  - wind vane
  - rain gauge

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Anemometers
- Bottles, thermos
- Brushes, beaker
- Carts, mechanical or dynamic
- Dropping Bottles
- Eyedroppers
- Flasks, Erlenmeyer, 1000 mL
- Herbarium paper
- Herbarium paste
- Insect nets
- Insect anesthetizing jars
- Insect pins
- Lamps with aluminum reflector
- Lever system kits (using meter sticks)
- Metric rulers

(*table continues*)

Table 1.8—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment
- Microscope cover slips, plastic
- Microscope slides
- Microscope slides, depression
- Pulley kits with suspension system
- Respirometers
- Stirring rods, glass
- Stethoscopes
- Stream table kits
- Terrarium with accessories
- Test tube holders
- Test tube racks
- Thermometers, oral, disposable sleeves
- Tracks, potential and kinetic

Living/preserved specimens
- Fish and other animals
- Paramecia and other protists
- Seeds, bulbs, plant cuttings, rhizomes
- Microscope slides, prepared
  - blood cells
  - sperm cells
  - cheek cells

Consumables

Materials
- Bags, plastic, with zipper seal
- Pots
- Soil samples
- Steel wool bundles
- Wood splints

Chemicals
- Iron filings
- Sulfur

Audiovisuals

Books
- Field guides: wildflowers, insects, etc.

CD-ROM or Video
- Emergence of seeds
- Flow of blood

Charts
- Asexual and sexual reproduction
- Ecological succession
- Human body system (digestive, circulatory)
- Periodic Table of Elements
- Photosynthesis
- Renewable/non-renewable/ inexhaustible energy
- Solar system

Models
- Cell
- Human skeleton
- Human torso
- Lung demonstration
- Planetarium, hand-held

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Table 1.9
Eighth Grade Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles, splash-proof
- Safety goggle disinfecting materials or equipment

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Required[1]

Materials and equipment

- Balances, triple beam
- Beakers
  - 100 mL
  - 250 mL
  - 400 mL
- Calculators
- Computer probes
- Computers
- Dissecting kits
- Field equipment
- Graduated cylinders
  - 10 mL
  - 100 mL
- Hot plates
- Meter sticks
- Microscopes, compound
- Petri dishes
- Spring scales, 10 N
- Telescopes
- Test tubes, 20 mL
- Thermometers, non-mercury
- Timing devices
- Water test kits
- Weather instruments

Recommended[2]

Materials and equipment

- Anemometers
- Aquarium and accessories
- Astrolabes
- Collision ball demonstrator
- Eyedroppers
- Flasks, 1000 mL
- Herbarium paper
- Herbarium paste
- Inclined planes, Hall's carriage, weight hangers and slotted weights
- Insect anesthetizing jars
- Insect nets
- Insect pins
- Lamps with aluminum reflector
- Metric rulers
- Microscope cover slips
- Microscope slides
- Microscope slides, depression
- Plant presses
- Rain gauge
- Rock types sets
- Sling psychrometers
- Slinky and wave demonstration ropes
- Static electricity kits
- Stirring rods

(*table continues*)

Table 1.9—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment
- Stream table and accessories
- Terrarium with accessories
- Test tube holders
- Test tube racks
- Thermometers, oral, disposable sleeves
- Thermometers, outdoor
- Wind vanes

Living/preserved specimens
- Invertebrates, such as brine shrimp
- Plants, various
- Seeds with known genetic ratios

Consumables

Materials
- Bags, plastic, with zipper seal
- Potting soil

Chemicals
- Baking soda
- Calcium chloride
- Nitric acid, dilute
- Phenol red
- Sulfuric acid, dilute
- Vinegar

Audiovisuals

Books
- Field guides

Charts
- Earth's climatic zones
- Earth's prevailing winds
- Lunar cycle
- Nitrogen, carbon, and water cycles
- Ocean currents
- Periodic table of elements
- Tides

Globe
- Earth

Map
- Northern Hemisphere

[1]Required tools are specified in the TEKS.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

High School Science Curriculum

High school science courses beyond Integrated Physics and Chemistry concentrate less on integrated relationships among the science disciplines and more on a single discipline of science, although some integration is present. For example, Biology focuses on life science, but some of the essential knowledge and skills in the course require students to use chemistry, physics, and earth science.

School districts must support this discipline-focused curriculum by providing well-equipped laboratories where student-centered activities in biology, chemistry, physics, and the earth/space sciences can occur.

> The Texas Administrative Code *requires* that at least 40 percent of the instructional time in all secondary science courses consist of laboratory and field work during which students apply appropriate scientific inquiry techniques.

The following information represents a summary of the content requirements for high school science courses and can serve as a guide to the types of facilities that are necessary in order for students to do the work required by the state curricular standards for science. The complete Science TEKS are included as Appendix A.

Integrated Physics and Chemistry

Students use safe, environmentally appropriate, and ethical practices to conduct field and laboratory investigations. They use a variety of scientific methods and make informed decisions using critical thinking and scientific problem-solving skills.

They investigate concepts of force and motion by exploring systems, Newton's laws, changes in force, and mechanical advantage and efficiency in simple machines. In addition, they demonstrate the effects of waves by investigating wave types and characteristics, wave interactions, uses of electromagnetic waves, and applications of acoustic principles.

Students explore the impact of energy transformations by investigating the movement of heat through solids, liquids, and gases, analyzing the efficiency of energy conversions, comparing the economic and environmental impacts of using energy, measuring conductivity in materials, comparing parallel and series circuits, analyzing electric current and magnetic field in electromagnets, and analyzing effects of heating and cooling processes.

They understand the effects of changes in matter when engaged in activities that allow them to distinguish between physical and chemical changes, analyze energy changes in chemical reactions, analyze the economic and environmental impact of the end products of chemical reactions, investigate the law of conservation of mass, and describe types of nuclear reactions.

In addition, students investigate solution chemistry by exploring water as a universal solvent, relating the concentration of ions to a chemical's physical and chemical properties, simulating effects of acid rain, and demonstrating how various factors influence solubility and the rate at which substances dissolve.

Table 1.10
Integrated Physics and Chemistry Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles, splash-proof
- Safety goggle disinfecting materials or equipment

Recommended[2]

- Sinks
- Transport cart

Materials and Equipment

Recommended[2]

Materials and equipment

- Alligator clips for electric circuits
- Ammeters
- Beakers
  - 100 mL
  - 250 mL
  - 600 mL
  - 1000 mL
  - 2000 mL
- Balances, triple beam
- Balls and rings
- Bimetallic strips
- Bunsen burners with wing tips
- Copper-insulated wire
- Calculators, graphing
- Clocks
- Computers
- Computer probes (light and sound, temperature, magnetic, and photogate)
- Conductivity testers
- Conductometers
- Cork borer set and sharpener
- Cylinders, graduated
  - 10 mL
  - 100 mL
  - 1000 mL
- Density block sets
- Dropping bottles
- Dynamic carts
- Eyedroppers
- Flasks, Erlenmeyer
  - 250 mL
  - 1000 mL
  - 2000 mL
- Friction blocks
- Friction pads, fur
- Friction pads, silk
- Friction pads, wool
- Funnels, short-stem
- Hall's Carriages
- Hammers, rubber
- Hot plates
- Inclined planes with pulley attachment
- Interference tubes
- Knife blade switches
- Lamps with aluminum reflectors
- Lamps base and bulbs for circuits
- Lever system kits (using meter sticks)
- Magnets, pair of bar
- Mass sets, hooked

(*table continues*)

Table 1.10—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment
- Meter sticks
- Metric rulers
- Mortars and pestles
- Optics kits
- Optics bench kits
- Overflow cans
- Pith balls, pair, coated in graphite and metal
- Polarized lens sets
- Power supplies (or dry cell battery)
- Prisms
- Protractors
- Pulley kits with suspension system
- Resonance apparatuses
- Ring stands with 4" ring
- Ripple tank generators for overhead projector
- Rods, glass
- Rods, rubber
- Scales, spring, 2.5 N capacity
- Scales, spring, 10 N capacity
- Samples: elements, compounds, and mixtures
- Sets of substances of varying densities
- Slinky springs
- Solar cells
- Spatulas
- Spectroscopes, quantitative analysis
- Steel spheres
- Stirring rods
- Stopwatches
- Stoppers, rubber and cork (assorted)
- Test tube holders
- Test tube racks
- Test tubes, 15 x 125 mm
- Test tubes, 20 x 150 mm
- Thermometers, metal back, alcohol
- Tongs, beaker
- Triangular files
- Tuning fork sets, various frequencies
- Tuning forks, same frequency
- Wash bottles, plastic
- Watch glasses
- Wave demonstration springs
- Voltmeters
- Wire screens, ceramic centered

Living/preserved specimens
- Microorganisms for acid rain investigation

Consumables
- Iron filings
- Litmus paper, vials
- pH paper, vials
- Salt for density solutions

Audiovisuals
- Periodic Table of Elements chart

[1]Required and recommended safety equipment are specified in the law.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Biology

Students use safe, environmentally appropriate, and ethical practices to conduct field and laboratory investigations. They use a variety of scientific methods and make informed decisions using critical thinking and scientific problem-solving skills.

They investigate cells as the basic structures of all living things and learn that cells have specialized parts that perform specific functions. They engage in activities to identify cell parts and cellular processes, understand the differences in structure and function between living cells and viruses, and explore the role of bacteria in maintaining health.

Students conduct investigations to discover how organisms grow and how specialized cells, tissues, and organs develop. They compare cells from plants and animals, identify cell differentiation, and sequence levels of organization in multicellular organisms.

In addition, they learn about the structures and functions of nucleic acids in the mechanisms of genetics. They also learn about the theory of biological evolution by identifying changes in species' DNA and examining other evidence.

Students practice taxonomy by collecting and classifying organisms, analyzing relationships among organisms, and identifying characteristics of a hierarchical classification system.

Investigations conducted by students further their understanding of metabolic processes and energy transfers that occur in living organisms, as they explore the structures and functions of biomolecules, compare photosynthesis to respiration, identify the effects of enzymes on food, and analyze matter and energy at different trophic levels.

Further investigations engage students with an understanding that living systems are found within other living systems, organisms maintain homeostasis, and interdependence and interactions occur within an ecosystem.

Chemistry

Students use safe, environmentally appropriate, and ethical practices to conduct field and laboratory investigations. They use a variety of scientific methods and make informed decisions using critical thinking and scientific problem-solving skills.

They investigate physical and chemical properties and determine compressibility, structure, motion of particles, shape, and volume of solids, liquids, and gases. Students investigate mixtures and pure substances and use the periodic table to describe an element's physical and chemical characteristics.

Students conduct investigations to observe energy transformations that occur during physical and chemical changes in matter. They engage in activities to identify changes in matter, and measure energy transformations and the influence of heat energy on the properties of liquids, solids, and gases.

In addition, they explore atomic structure as determined by nuclear composition, allowable electron cloud, and subatomic particles, as well as variables that influence the behavior of gases. Students participate in activities that help them understand how atoms form bonds to acquire a stable arrangement of electrons.

They actively engage in activities to demonstrate common oxidation reactions, use balanced chemical equations to interpret and describe interactions of matter, and investigate factors that influence the solubility of solutes in a solvent.

Students conduct investigations to understand the relationships among the concentration, electrical conductivity, and colligative properties of solutions, as well as the properties of acids and bases; and they discover the factors involved in chemical reactions.

Table 1.11
Biology Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles, splash-proof
- Safety goggle disinfecting materials or equipment

Recommended[2]

- Transport carts
- Sinks

Materials and Equipment

Recommended[2]

Materials and equipment

- Aquarium with accessories
- Autoclaves
- Balances, triple beam
- Beakers, Pyrex
    - 100 mL
    - 250 mL
    - 400 mL
    - 600 mL
    - 1000 mL
    - 2000 mL
- Bird feeders
- Bunsen burners
- Brushes, flask
- Brushes, beaker
- Calculators, graphing
- Clamps, pinch
- Clocks with second hand
- Computer probes
- Computers, resident
- Cork borer sets and sharpeners
- Cylinders, graduated
    - 10 mL
    - 100 mL
    - 500 mL
- Dichotomous keys
- Dishes, culture
- Dissecting kits
- Dissecting pans
- Dropping bottles, 10 mL
- Eyedroppers
- Files, triangular
- Flasks, Erlenmeyer
    - 125 mL
    - 250 mL
    - 500 mL
    - 1000 mL
    - 2000 mL
- Funnels, short-stem
- Herbarium labels
- Herbarium paper
- Herbarium paste
- Hot plates
- Incubators for eggs
- Incubator ovens
- Inoculating loops
- Insect anesthetizing jars
- Insect nets
- Insect pins
- Lenses, hand
- Meter sticks
- Metric rulers
- Microscopes, compound and stereo
- Microscope cover slips, plastic
- Microscope slides
- Microscope slides, depression
- Mortars and pestles

(table continues)

Table 1.11—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment
- Pens, wax, marking
- Petri dishes
- Pipets, graduated
  - 1 mL
  - 5 mL
  - 10 mL
- Plant presses
- Pots, planting, plastic
- Ring stands
- Ring stand clamps
- Spatulas, 4", stainless steel
- Sphygmomanometers
- Stethoscopes
- Stirrers, magnetic
- Stirring rods, glass
- Stoppers, rubber, assorted
- Survey collections, animals
- Survey collections, plants
- Terrarium with accessories
- Test tube baskets
- Test tube brushes, regular
- Test tube brushes, small
- Test tube holders
- Test tubes, Pyrex, 20 x 150 mm
- Test tubes, Pyrex, 10 x 75 mm
- Test tube racks
- Thermometers, oral, disposable sleeves
- Thermometers, alcohol 10° –110° C
- Tongs, beaker
- Trays, dissecting
- Tubing, dialysis

Living/preserved specimens
- Aquatic plants, *Elodea*
- Brine shrimp
- Cultures
  - *Bacillus cereus*
  - *Bacillus subtilis*
  - *Escherichia coli*
- Protist cultures
- Seeds for DNA studies
- Slides, prepared
  - animal cells and tissues
  - plant cells and tissues
- Yeast suspension

Consumables
- Agar plates, starch
- Cotton swabs
- Food coloring
- Food products
- Kidney, fresh
- Lamp with reflector
- Milk
- Nitrogen fertilizer
- Scissors
- Starch

Audiovisuals

CD-ROMs and videos
- Cell structure and function
- Classification
- Evolution processes
- Body systems
- Meiosis
- Mitosis
- Plant anatomy and physiology
- Photosynthesis
- Planting flats, plastic

Charts
- Bacteria
- Human body systems
- Prokaryotic and eukaryotic cells
- Viruses
- Cycles (carbon, oxygen, nitrogen, and water)

Models
- DNA structure and protein synthesis activity kits
- Human torso
- Meiosis
- Mitosis
- Variation and evolution kits

[1]Required and recommended safety equipment are specified in the law.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Table 1.12
Chemistry Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles, splash-proof
- Safety goggle disinfecting materials or equipment

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Recommended[2]

Materials and equipment

- Balances, electronic
- Barometers
- Beakers, graduated
    - 100 mL
    - 250 mL
    - 400 mL
    - 600 mL
    - 1000 mL
- Bottles, dropper, 10 mL
- Bottles, dropper, 30 mL
- Burets, 50 mL
- Burners, Bunsen or Tirrill
- Calculators, graphing
- Calorimeters
- Centrifuges
- Ceramic squares
- Clamps
    - test tube
    - 3-prong jaw
    - buret, double
    - pinch
    - utility
- Clocks
- Cobalt-blue glass
- Computers
- Computer probes
    - temperature
    - pH
    - barometric pressure
    - Geiger Miller tube
- Condensers
- Conductivity apparatuses
- Condensers
- Cork borers
- Crucibles
- Crucible covers
- Cups, plastic foam, 16 oz.
- Cylinders, graduated
    - 10 mL
    - 50 mL
    - 100 mL
    - 1000 mL
- Cutters, metal
- DC sources, 0–12 v., 5 amp with leads
- Desiccators
- Droppers, medicine
- Droppers, pipet
- Drying ovens
- Electrolysis apparatuses
- Evaporating dishes

(*table continues*)

Table 1.12—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment
- Files, triangular
- Flasks, distilling, 250 mL
- Flasks, filter, 500 mL
- Flasks, volumetric
  - 100 mL
  - 1000 mL
  - 250 mL
  - 500 mL
- Flasks, Erlenmeyer
  - 100 mL
  - 1000 mL
  - 250 mL
  - 500 mL
- Funnels, long-stem
- Funnels, short-stem
- Geiger counters
- Hot plates
- Lighters, burner
- Magnetic stirrers
- Meter sticks
- Molecular model sets
- Mortars and pestles
- pH meters, handheld
- Pencils, glass marking
- Pipets, graduated, glass
  - 1 mL
  - 5 mL
  - 10 mL
- Ring supports with clamps: 2" and 4"
- Ring stands, 20"
- Ring stand screens
- Rubber bands, small
- Rubber policemen
- Rubber suction bulbs
- Rulers, metric
- Spatulas/scopulas
- Spectrophotometers
- Spectroscopes
- Spectrum tubes
- Spectrum tube power supplies
- Spot plates
- Stirring rods, glass
- Stoppers, cork, assorted
- Stoppers, rubber, 1-hole and 2-hole, assorted
- Stoppers, rubber, solid, assorted
- Test tube holders
- Test tube racks
- Test tubes, large
- Test tubes, medium
- Test tubes, small
- Thermometers, -20 to 150° C
- Thermometers, electronic
- Tongs, crucible
- Tongs, beaker
- Triangles, 1 1/2", clay-covered
- Tubing, plastic, connecting
- Tubing, rubber, connecting
- Tubing, capillary, glass, melting point
- Tubing, glass, assorted
- Tubing, rubber, 1/4" ID
- Tweezers or forceps
- Wash bottles, plastic
- Watch glasses
- Weighing bottles
- Wire gauze, ceramic centers, 5" x 5"
- Wire, nichrome or platinum

Consumables
- Litmus, red & blue vials
- Paper, chromatography
- Paper, filter, assorted sizes
- Paper, pH, vials
- Parafilm, roll

Audiovisuals

Charts
- Common ions
- Oxidation-reduction potential
- Periodic table of elements
- Spectrum

[1]Required and recommended safety equipment are specified in the law.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

Physics

Students use safe, environmentally appropriate, and ethical practices to conduct field and laboratory investigations. They use scientific methods and make informed decisions using critical thinking and scientific problem-solving skills.

They investigate the laws governing motion by analyzing uniform and accelerated motion, exploring the effects of forces on motion, and developing free-body diagrams for force analysis.

Students conduct investigations in which they explore changes that occur within a physical system, observe kinetic and potential energy, and learn the influence of mass and distance on gravitational forces.

They actively engage in activities in which they learn about the laws of thermodynamics; they examine the characteristics and behavior of waves by propagating waves in various types of media; and they describe simple examples of quantum physics by explaining the line spectra from gas-discharging tubes.

Advanced High School Courses

Chapter 112 of the Texas Administrative Code identifies additional courses for school districts to consider when developing a well-balanced science program. These include Environmental Systems, Aquatic Science, Astronomy, and Geology, Meteorology, and Oceanography.

In addition, Advanced Placement® (AP) and the International Baccalaureate® (IB) courses should be available to challenge students. In both AP and IB courses, specific laboratory investigations are strongly recommended for students prior to their taking end-of-course examinations.

AP Courses	IB Courses
• Biology	• Biology
• Chemistry	• Chemistry
• Physics	• Physics
• Environmental Science	• Environmental Systems

Other High Schools Courses for Science Credit

The Texas Administrative Code, Chapter 121 (Health Science Technology Education) and Chapter 123 (Technology Education/Industrial Technology Education) identify additional courses for which students may receive high school science credits. These courses require that at least 40 percent of the instructional time consist of laboratory and field investigations during which students apply appropriate scientific inquiry methods. Therefore, school districts must provide well-designed and well-equipped facilities in order for students to meet the requirements of these courses.

Health Science Technology Education	Technology Education and Industrial Technology Education
Scientific Research and Design	Principles of Technology I
Anatomy and Physiology of Human Systems	Principles of Technology II
Medical Microbiology	
Pathophysiology	

Table 1.13
Physics Laboratory Materials and Safety Equipment

Safety Equipment

Required[1]

- Aprons
- Eye/face washes
- Fire blankets
- Fire extinguishers
- First-aid kits
- Material Safety Data Sheets
- Safety goggles, splash-proof
- Safetygoggle disinfecting materials or equipment

Recommended[2]

- Sinks
- Transport carts

Materials and Equipment

Recommended[2]

Materials and equipment

- Ammeters, triple range
- Balances, triple beam
- Balls and rings
- Beakers, Pyrex, 400 mL
- Beakers, Pyrex, 600 mL
- Bimetallic strips
- Bunsen Burners
- Calculators, graphing
- Calipers, micrometer
- Calipers, vernier
- Calorimeters
- Carts, dynamics set
- Cathode ray tubes, sealed, with screen
- Clamps (4")
- Clocks
- Cloud chambers
- Collision apparatuses, two dimensions
- Compasses, magnetic
- Computer probes tube
    - sound
    - light
    - temperature
    - Geiger Miller
    - magnetic
    - photogate
    - pendulum
- Computers
- Conservation of momentum apparatus
- Coulomb's Law apparatus
- Cylinders, graduated
    - 10 mL
    - 50 mL
    - 500 mL
    - 1000 mL
- Discharge tubes, vacuum
- Eyedroppers
- Friction blocks with hooks
- Friction pads, fur
- Friction pads, silk
- Friction pads, wool
- Electroscopes, measuring
- Galvanometers, center zero
- Hall's Carriages
- Hammers, rubber
- Hot plates
- Inclined planes
- Induction coils
- Lab masses, set, brass
- Lab masses, set, hooked
- Lamps with aluminum reflectors
- Light sources, intense, for ripple tank
- Magnets, bar
- Magnets, strong, bar, pair
- Magnets, strong, horseshoe
- Masses, small, known specific heat, metal,

(*table continues*)

Table 1.13—*Continued*

Materials and Equipment

Recommended[2]

Materials and equipment

- Masses, unknown specific heat, metal, small
- Meter sticks
- Nails, large iron
- Nylon thread
- Optical bench sets
- Optics kits
- Pendulum bobs
- Pendulum supports
- Pith balls pair, graphite or metal coated
- Polarized lenses
- Power supplies: AC, DC
- Prisms
- Protractors
- Pulleys with clamp for table edge
- Recorder timers
- Resistors, 5–10 watts
    - 5 ohms power rating
    - 10 ohms power rating
    - 15 ohms power rating
    - 30 ohms power rating
- Resonance tubes, 50 cm
- Ring clamps
- Ring stands
- Ring stand screens
- Rings, 4"
- Ripple tank assemblies, complete
- Ripple tank wave generators
- Rods, rubber
- Rods, glass
- Rulers, metric
- Scales, spring
    - 2.5 N
    - 10 N
    - 20 N
- Screwdrivers
- Slinkies
- Slotted weight sets
- Stopwatches
- Stroboscopes
- Switches, knife-blade
- Tagboards
- Thermometers, -2°–110° C, alcohol
- Trajectory apparatuses
- Tuning for sets, 256 Hertz and above
- Voltmeters, triple range: 0–1.5, 3, 30A
- Wave motion rope
- Weight hangers
- Wire, copper, insulated, 18 gauge

Consumables

- Carbon paper
- Dry ice
- Iron filings
- Paper clips
- Paper, white, craft
- Recorder timer carbon discs
- Recorder timer tapes
- Sheets of cardboard
- Tracing paper
- Twine, heavy cotton
- Wax

Audiovisuals

CD-ROM

- Laws of thermodynamics
- Photoelectric effect
- Role of electromagnetic spectrum

Charts

- Electromagnetic spectrum
- Periodic table of elements

Books

- *Handbook of Physical Constants*

[1]Required and recommended safety equipment are specified in the law.
[2]Recommended lists of tools were generated by analyzing the concept TEKS.

School Facilities Standards

The state commissioner of education has established rules concerning the standards for school facilities in Chapter 61.1033 of the Texas Administrative Code, School Facilities Standards. These rules provide definitions and procedures, dates by which school facilities must be compliant, certification of design and construction, minimum square foot requirements, educational adequacy, and construction quality of facilities within school districts in Texas (Appendix A).

Renovations and New Construction

Renovations may vary from redesigning a single science laboratory room to remodeling furniture, cabinets, fixtures, electrical systems, plumbing, and mechanical systems in an entire science wing. Some extensive renovations are classified as *major space renovations*, in which case the school district must comply with the current rules and regulations for new construction.

Major Space Renovation

The School Facilities Standards define construction projects as major space renovations when at least 50 percent of the gross area of a facility's instructional space is within the limits of the work. For example, if the science area of a school consists of 10 classrooms and 5 laboratory rooms, and at least 50 percent of the total area containing the rooms is being renovated, the construction project is classified as a major space renovation.

Effective Date

New construction projects and major space renovations that were approved by a local school board of trustees after September 1, 1998 must comply with the regulations set forth in School Facilities Standards.

The Commissioner's Rules Concerning School Facilities, Chapter 6, Subchapter CC are being revised. These new rules, concerning new construction and renovations, will replace the current rules discussed in this chapter.

Certification of Design and Construction

New construction or major space renovations must be certified by the architect or engineer to assure the school district that

- the architect or engineer has reviewed the School Facilities Standards and used his/her best professional judgment and care consistent with the practice of architecture or engineering in the state of Texas in executing construction documents; and
- the certification documents conform to the provisions of the School Facilities Standards, except where indicated.

A copy of the Certification Compliance Form, required of the architect or engineer as specified under the Texas Administrative Code Chapter 61.1033(c)(3)(A)-(C), can be found in Appendix A.

Certification must include the following provisions:

- The school district must notify and obligate the architect or engineer to provide the required certification.
- The architect's or engineer's signature and seal must appear on the construction documents to certify compliance.
- The school district must provide the architect or engineer with the long-range school facility plan and/or the educational specifications and building code specifications for the facility.

- The architect or engineer must perform a building code search under applicable regulations and must certify that the design has been researched before finalizing it.

- The architect or engineer must certify that the facility has been designed according to the provisions in the School Facilities Standards, based on the long-range facility plan and/or educational specifications, building codes, and documented changes to the construction documents provided by the district.

- The building contractor or construction manager must certify that the facility has been constructed in accordance with the construction documents.

- When the construction is complete, the school district must certify that the facility conforms to the design requirements specified by the long-range plan and/or education specifications and building code specifications.

Educational Adequacy

A school district must provide instructional space for students that meets the district's educational specifications based on the requirements of educational adequacy. These requirements state that a proposed new school facility or a major space renovation of an existing school facility must be designed according to the requirements of the school district's educational program and the student population that it serves.

Space Requirements

A school district may satisfy educational adequacy requirements by using either the standard for minimum square feet per pupil or the standard for square feet per room. Room size requirements are based on rooms that will house 22 students at the elementary level and 25 students at the middle and high school levels.

Square feet per pupil is calculated by dividing the net interior space of a room by the maximum number of students to be housed in the room.

Square feet per room is the net square footage of the room that will house the students. The net square footage of a room may include exposed storage space (cabinets and shelves) but does not include hallway space or storage space, such as closets and preparation rooms, that may be connected to the room.

> The School Facilities Standards regulate space and minimum square foot requirements for science classrooms and lecture/laboratory combination rooms. There are no space or minimum square foot requirements for a standard science laboratory.

Science Classrooms

According to the definitions used to calculate the required space for students, science classrooms and lecture/laboratory rooms built after September 1, 1998 must meet the following requirements.

<u>General Classrooms</u>

- Prekindergarten–Grade 1 classrooms must provide a minimum of 36 square feet per pupil or 800 square feet per room.

- Elementary school rooms must provide a minimum of 30 square feet per pupil or 700 square feet per room.

- Secondary school rooms must provide a minimum of 28 square feet per pupil or 700 square feet per room.

According to these requirements, a school district may build new science classrooms for a middle school at 700 square feet per classroom, assuming that the average class load does not exceed 25 students.

25 students x 28 sq. ft. = 700 sq. ft.

If the average student load for a science classroom exceeds 25, the school district should increase the square footage of the room based on the increase above 25 for the average student per period. The minimum size of the room must not be less than 700 square feet.

If the average class load for a middle school science class is 32 students per period, the square footage should increase by 196 square feet to accommodate the increase in the number of students.

32 students x 28 sq. ft. = 896 sq. ft.

However, school districts may choose to use the square feet per room standard; although the room must accommodate 32 students, the district may choose to build to the minimum standard of 700 square feet.

The Texas Education Agency recommends that *no more than two science classrooms share a single laboratory*. The mandated time requirements for high school—40 percent laboratory and field investigations—cannot be met if more than two science teachers share laboratory facilities. Similarly, elementary and middle school teachers cannot adequately provide laboratory experiences when more than two teacher share a laboratory room.

Science Lecture/Laboratory Rooms

A lecture/laboratory room may be defined as a science room that is designed to support both standard classroom activities and laboratory investigations. It should be equipped with student stations and access to electricity, water, and natural gas.

In addition, features found in a standard science laboratory room should be present. A separate area used as a standard classroom must be contained in the same room. For examples of lecture/laboratory rooms and other science facility designs, please refer to Chapter Three.

Lecture/laboratory rooms must meet the following minimum space requirements.

- Elementary school lecture/laboratory rooms must provide a minimum of 41 square feet per pupil or 900 square feet per room.
- Middle school lecture/laboratory rooms must provide a minimum of 50 square feet per pupil or 1,000 square feet per room.
- High school lecture/laboratory rooms must provide a minimum of 50 square feet per pupil or 1,200 square feet per room.

Science Laboratory Rooms

The School Facilities Standards do not address a stand-alone science laboratory room. The National Science Teachers Association (NSTA) makes the following recommendations for science laboratory minimum size that schools involved in construction or renovation projects may use as guidelines (Table 1.14).

Table 1.14

NSTA's Science Laboratory Size Recommendations*

Grade Level	Number of Students	Square Feet/Room	Square Feet/Pupil
K–Grade 5	24	1,000	40
Grades 6–8	24	1,125	45
Grades 9–12	24	1,250	50

Overcrowding and Science Facilities

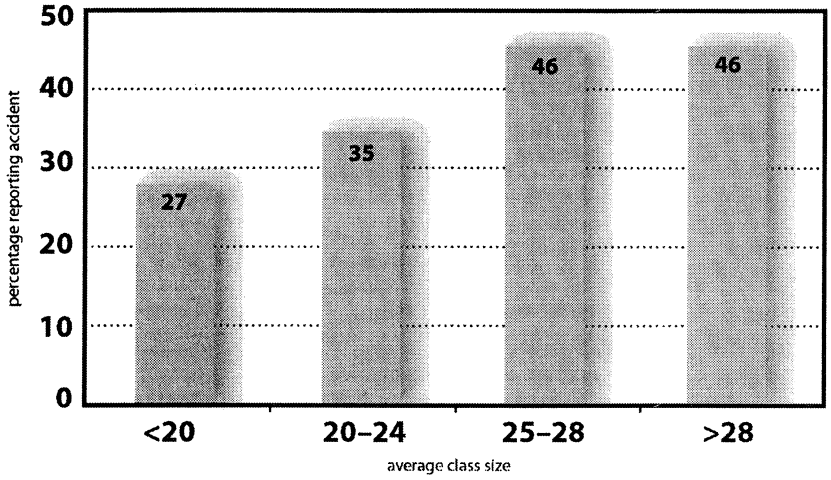
School districts in Texas are experiencing rapid increases in student enrollment that fill science classrooms and laboratories beyond the recommended capacities. School districts may only have building funds to accommodate existing student populations and may not include plans for future growth.

Schools should be aware of the dilemma that teachers confront when meeting the required Texas Essential Knowledge and Skills. Teachers are required by law to conduct laboratory and field experiences with their students while maintaining a safe learning environment in laboratories and classrooms. However, these two rooms may not provide enough workstations for the students they are assigned to teach.

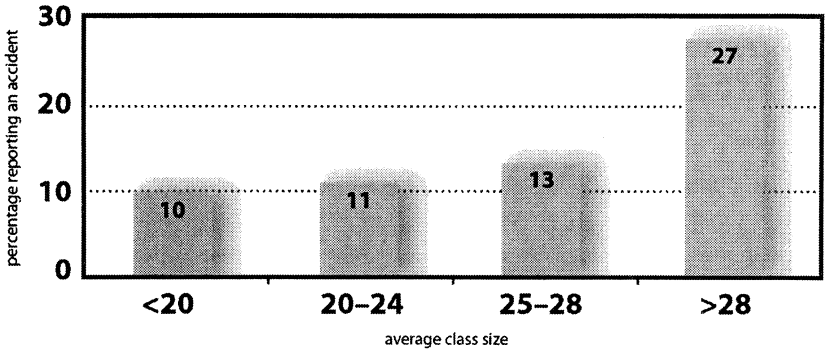
Research has confirmed that overcrowded conditions adversely affect the safety of students and teachers. Results reported in the Charles A. Dana Center's *Analysis of Laboratory Safety in Texas* confirm that minor accidents (Graph 1) and major accidents (Graph 2) are more likely to occur in schools with an average student/class ratio greater than 24. The report defined a major accident as one in which medical attention is required.

School administrators, therefore, should not be forced to decide whether to direct science teachers to ignore state requirements and not require laboratory instruction, follow the TEKS and permit their teachers to work in unsafe conditions, or reduce class loads for science teachers.

Graph 1: **Percentage of respondents reporting the occurrence of a minor accident by average class size**



Graph 2: **Percentage of respondents reporting the occurrence of a major accident by average class size**



A school district must comply with local building codes, including meeting fire and mechanical, electrical, and plumbing standards.

A district located in an area that has not adopted local building codes must adopt and use the latest edition of either the Uniform Building Code, the Standard (Southern) Building Code, or the International Building Code and related fire and mechanical, electrical, and plumbing codes, as well as the National Electric Code.

School districts must also comply with the provisions of the Americans with Disabilities Act of 1990 and other local, state (including the Texas Accessibility Standards), and federal requirements, where applicable.

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) prohibits discrimination on the basis of disability in employment, state and local government, public accommodations, commercial facilities, transportation, and telecommunications.

To be protected by the ADA, a person must have a disability or a relationship or association with an individual who has a disability. An individual with a disability is a person who has a physical or mental impairment that limits one or more major life activities; a person who has a history or record of impairment; or a person who is perceived by others as having such an impairment.

Architectural Barriers Act

The Architectural Barriers Act (ABA) requires that buildings and facilities designed, constructed, or altered with federal funds or leased by a federal agency comply with federal standards for physical accessibility. ABA requirements are limited to architectural standards in new and altered buildings and in newly leased facilities. They do not address the activities conducted in those buildings and facilities.

Individuals with Disabilities Education Act

The Individuals with Disabilities Education Act (IDEA) requires public schools to make available to all eligible children with disabilities a free and appropriate education in the least restrictive environment possible and appropriate to their individual needs.

Texas Accessibility Standards

The Texas Accessibility Standards establish regulations for accessibility by individuals with disabilities to public buildings and facilities; privately owned buildings or facilities leased or occupied by state agencies; places of public accommodation; and commercial facilities (Appendix A).

These standards should be considered the minimum requirements for all spaces and elements of building and facilities constructed after April 1, 1994. They further the equal treatment of people with disabilities to the maximum extent possible and reasonable.

Reference Guide to Safety and Science Facilities

The following reference guide summarizes laws, rules, regulations and recommendations that school districts should follow when designing science facilities and selecting safety equipment for their science programs. A complete version of the reference can be found in Appendix A.

Table 1.15

CONTEXT	REFERENCE	STATUS
Science must be taught in kindergarten–grade 12	19TAC§28. Subchapter A, Section 28.001	required
Science Essential Knowledge and Skills (TEKS), kindergarten–grade 12	19TAC§112. Subchapters (A–C)	required
Square foot per classroom and lecture/laboratory room	19TAC. Part II, §61. Subchapter CC, Section 61.1033	required
Square foot standards for science laboratories	Texas Education Agency, National Science Teachers Association	recommended
Certificate of Compliance for architects, engineers, and contractors	19TAC§61. Section 61.033(c)(3)(A–C)	required
Forty percent laboratory/field instruction in grades 9–12 science courses	19TAC. Part II, §74. Subchapter A, Section 74.3	required
Laboratory/field instruction required in science classes, grades 1–8	19TAC§112. Subchapters (A–C)	required
Inclusion of students with disabilities in science laboratory instruction	Public Law 105–17 Title I, Section 101, Part A	required
Access to science facilities for students and teachers with disabilities	Texas Accessibility Standards Architectural Barriers Act, Article 9102	required

(table continues)

Table 1.15—*Continued*

CONTEXT	REFERENCE	STATUS
Districts must provide free and appropriate education in the least restrictive environment possible.	Individuals with Disabilities Education Act (IDEA)	required
Districts must provide personal protective equipment, such as: • fume hoods • ventilation systems • eyewashes • safety showers • fire blankets	Texas Hazard Communications Act 5TAC. Subtitle D, Chapter 502 Subchapter A, Section 502.001	required
Standards for safety equipment safety showers eyewashes drench hoses	ANSI Z358.1 ANSI Z358.1 ANSI Z351.1	recommended
Standards for eye protection devices	25TAC. Part I, Chapter 195, Subchapter F	required
Protection of students from conditions detrimental to learning, physical health, mental health, and safety	19TAC. Part 7, Chapter 247	required
Districts provide eye safety goggles; students and teachers must wear them.	TEC. Chapter 38, Section 38.005	required
Fire extinguishers in laboratory rooms	28TAC. Chapter 34, Sections 34.501-34.523	required
Flammables and corrosives cabinets	National Fire Protection Agency (NFPA)	recommended
Two exits in rooms of 1000 square feet or larger	NFPA 45, Life Safety Code 101	required if adopted locally
Guidelines for maintaining the quality of air in public schools	Voluntary Indoor Air Quality Guidelines, 5TAC, Chapter 297	recommended

Chapter 2
SAFETY EQUIPMENT

Regulations regarding emergency safety equipment should specify what is meant by suitable facilities—for example, for drenching and flushing the eyes and body. The American National Standards Institute (ANSI) has developed voluntary standards concerning emergency equipment. Schools should use the standard ANSI Z358.1 as a guideline for establishing the correct design, installation, use, and performance of emergency safety equipment.

> The Council supports the premise that science should be taught in a space specifically dedicated to science classes with provisions for laboratory activities. A safe and well-equipped preparation area and workspace for students and teachers must be provided. Adequate storage space for equipment and supplies, including a separate storage area for potentially dangerous materials, must be provided. An adequate budget for facilities, equipment, supplies, and proper waste management must be provided to support the laboratory experiences.
>
> Council of State Science Supervisors, *Laboratory Safety*

Emergency Eye/Face Wash Stations

Purpose

Emergency eyewashes and eye/face washes deliver water to the user so that contaminants can be flushed from the eyes and face.

In Texas schools, eye/face washes are required in all science laboratories where students and teachers are exposed to chemicals or other hazardous substances that may splash into their eyes or onto their faces. Although safety goggles provide protection for the eyes when worn properly, they do not protect other areas of the face from harmful chemicals.

All emergency eyewashes and eye/face washes must be properly connected so that they will drain into the sewer lines.

Once the emergency eyewash or eye/face wash has been installed properly, teachers must receive professional development on the proper use and maintenance of the equipment. The school district should develop an emergency response plan in the event an accident should occur.

Types

Eyewashes are designed to deliver water to both eyes simultaneously. The type of emergency wash in Figure 2.1 supplies water from two spray heads to flush chemicals from the eyes.

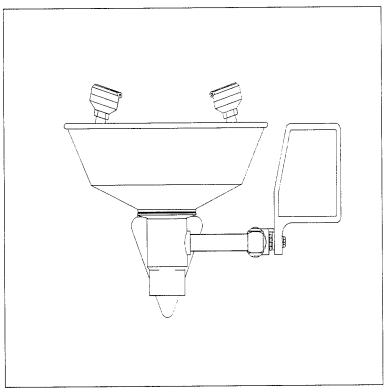


Figure 2.1
Eyewash (wall mounted)

Eye/face washes are designed to deliver water to both eyes and the face simultaneously. Some styles may contain four spray heads; however, manufacturers have designed models with two spray heads and a face ring spray (Figure 2.2) that delivers water to the entire face. This type of wash is especially useful in a chemistry laboratory, where students and teachers are exposed to more hazardous chemicals than in other science courses.

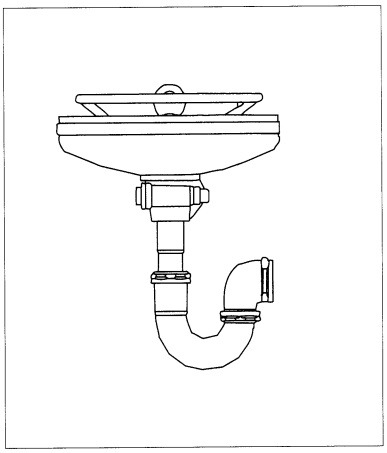


Figure 2.2
Eye/face wash (wall mounted)

Emergency shower/eyewashes (Figure 2.3) are generally found in science laboratories where an emergency shower and an eyewash are required. The eyewash must deliver water to both eyes simultaneously.

Figure 2.3 is a combination emergency shower and eyewash that has a foot pedal to activate the flow of water; however, this type of shower is not ADA compliant.

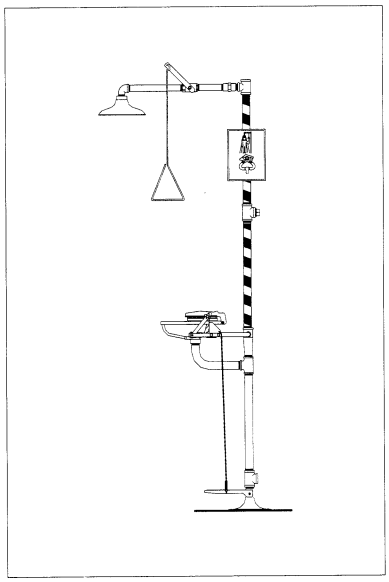


Figure 2.3
Emergency shower/eyewash

Faucet-mounted eyewashes connect to the existing water faucets in the laboratory. These do not meet ANSI standards because they require two movements by the user to activate the water flow. The user must turn on the water to the sink and then activate the valve that diverts the flow of water to the eyewash. Faucet-mounted eyewashes are not recommended for science laboratories and, therefore, are not shown here.

Faucet-mounted eyewashes are not recommended for science laboratories.

Countertop eyewashes mount onto the countertop and swivels over the sink with either a left-handed or right-handed movement (Figure 2.4). This allows the eyewash to remain out of the working area of the sink during laboratory investigations.

This style should have a stop and locking system so that once it is moved over the sink area, it remains in the correct position during its use.

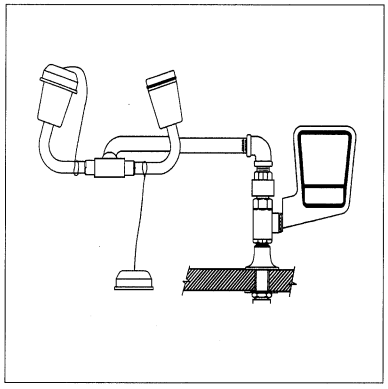


Figure 2.4
Countertop eyewash

Gravity-feed eyewashes (Figure 2.5) are not connected to a continuous water supply and must be recharged after each use. A bacteriostatic additive must be used to prevent the growth of bacteria or fungi in the water. Some manufacturers of this type of eyewash provide an insulated cover and heating element that will maintain a tepid water temperature (60–90^0 F).

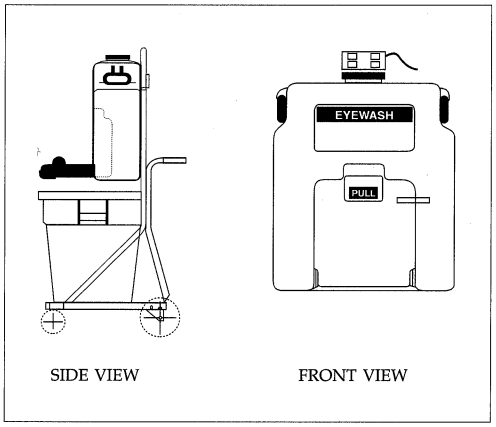


Figure 2.5
Gravity-feed eyewash

Portable emergency eyewash stations can provide a continuous flow of water for the required 15 minutes. Figure 2.6 is an example of a 10-gallon pressurized portable eyewash that can be used in laboratories where no permanent eyewash is installed or where plumbed potable water is not available. These must meet ANSI Z358.1 requirements.

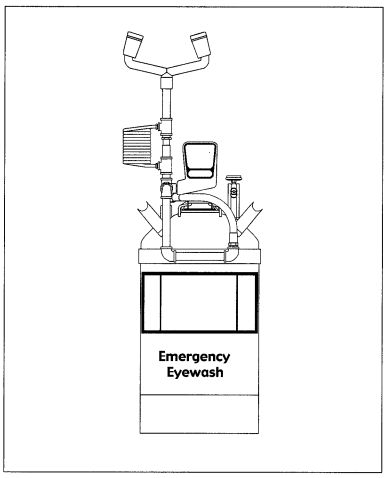


Figure 2.6
Ten-gallon portable eyewash

Standards

The following checklist was prepared using the ANSI Z358.1 standard for emergency eyewashes and eye/face washes.

1. Emergency eyewash or eye/face wash stations must be installed in science laboratories and preparation rooms where hazardous chemicals are used.

2. Each station must be no more than 10 seconds from any position in the laboratory or preparation room, and the path to the station must be unobstructed.

"The depth and severity of an injury corresponds inversely to the time it takes the victim to reach the water."

Andrew Munster, M.D.,
American Burn Association

3. The emergency eye/face wash must be capable of providing 3 gallons of water per minute for at least 15 minutes. Eyewashes should provide a continuous flow of water (0.4 gallons of water per minute) for at least 15 minutes. Protective covers should be provided to stop airborne contaminants from entering the spray heads.

4. Each outlet or spray head must be positioned between 33" and 45" from the floor and at least 6" from the wall or nearest obstruction.

5. The water temperature should be tepid or lukewarm (60–90° F).

6. The valve handle that starts the flow of water must be large enough for the user to locate and operate easily. Once activated, the water in an eye/face wash must flow at least at 30 PSI. Eyewashes must provide water at a low velocity that will not cause injury to the eyes.

7. There must be a "hands-free" valve on the eyewash that stays open and provides a continuous flow of water.

8. Safety signs identifying the emergency eye/face wash stations must be in a highly visible place so that students and teachers can locate them easily.

9. *Each eye/face wash should be inspected weekly and activated by allowing the water to flow for at least 5 minutes to remove mineral and biological contaminants that may be found in the water lines.*

10. It is recommended that each station be provided with an internal strainer and filter to reduce physical impurities from the water before it reaches the user's eyes.

11. Teachers and students must be instructed on the location and proper use of the eye/face wash.

Accessibility

There are many styles and designs of eye washes, ranging from those that are pedestal, deck, or countertop mounted, to those that are recessed into the wall. Some designs allow the water flow to begin when the user steps on a floor plate; others require the user to push a hand plate. But what about the student who is working in the laboratory from a wheelchair?

Texas Accessibility Standards

The Texas Accessibility Standards (TAS) do not address eyewash stations in a science laboratory. However, they do establish height and depth requirements for sinks.

According to TAS, the mounting heights for sinks in counter surfaces must be a maximum of 30" for students in prekindergarten though grade 5. In addition, the knee clearance must be a minimum of 26", and the distance to the faucets from the front edge of the counter or sink must be no more than 18".

Students in grades 6 through 9 must have sinks at a maximum height of 32", with knee clearance at 28". The distance to the faucet valve actuator from the front edge of the counter or sink must be no more than 20".

Students in grades 10 through 12 must have sinks at a maximum height of 34" with knee clearance at a minimum of 27". The distance to the faucet valve actuator from the front edge of the counter or sink must be no more than 20".

In kindergarten though grade 12, students must be able to move quickly to an emergency eyewash station. The countertop must allow the student in a wheelchair to be able to lean forward slightly, activate the water flow, and flush both eyes simultaneously without his or her knees coming into contact with the plumbing or other obstructions.

Exposed hot water and drain pipes under sinks must be insulated or otherwise configured so as to protect the student from contact. There must be no sharp or abrasive surfaces under sinks which could injure the person.

Americans with Disabilities Act

In addition to TAS regulations, the Americans with Disabilities Act (ADA) requires accessibility and usability procedures to be established for the physically impaired. The wheelchair accessibility guidelines for eyewash and eye/face wash stations are as follows:

1. The minimum clear floor space for a forward approach must be 48 inches in length and 30 inches in width (Figure 2.7).

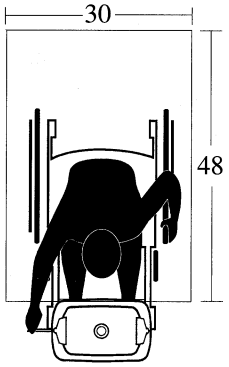


Figure 2.7
Clear floor space for forward approach

2. The minimum clear floor space for a parallel or side approach must be 30 inches in length and 48 inches in width (Figure 2.8).

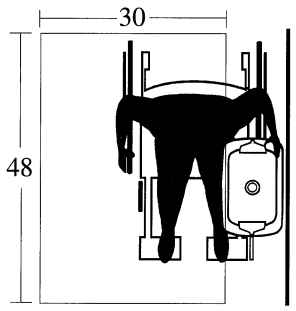


Figure 2.8
Clear floor space for parallel approach

3. Spray heads on emergency eyewashes and eye/face washes must not be higher than 36 inches from the floor to the spray outlet. The bottom of the bowl must be at least 27 inches from the floor and 17–19 inches from the wall or nearest obstruction (Figure 2.9).

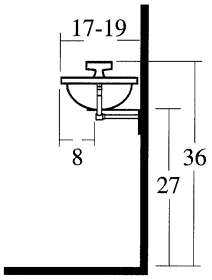


Figure 2.9
Spray head requirements

4. The activator should be on the front edge of the unit, if possible, or easily accessible on the side. If drench hoses are used, they should be within easy reach in front or on the side of the unit. Drench hoses may be used for minor decontamination to the eyes, face, and body and may supplement primary eyewash and eye/face wash units.

5. Wall-mounted or pedestal-mounted eyewash or eye/face wash units must have a minimum clear knee space between the bottom of the bowl and the floor of at least 27 inches high, 30 inches wide, and 17 inches deep (Figure 2.9).

6. Freestanding units with floor-length skirts or built-in wall units that do not have a clear space under them, such as a countertop-mounted unit, must have a parallel clear floor space of at least 48 inches in length and 30 inches in width (Figure 2.8).

7. If eyewash and eye/face wash bowls are mounted on a countertop, the rim of the counter should not be higher than 34 inches. The bowl should have a maximum depth of 7 inches.

8. The water supply and drain pipes under eyewash and eye/face wash units must be insulated to prevent injury to knees from hot pipes. In addition, all sharp or abrasive objects and surfaces must be eliminated from under the units where a person's knees could become injured.

9. Activators on eyewash and eye/face wash units should require only a one-quarter turn to operate the equipment. Self-closing valves are not permitted; only stay-open valves are allowed.

10. All emergency unit valves must provide the flow of water within one second of being activated.

11. Emergency eyewash and eye/face wash equipment must be in accessible locations that require no more than 10 seconds to reach. Extra consideration should be given to students limited to wheelchair access.

12. If only one eyewash is installed in a laboratory room or preparation room, it must be ADA compliant.

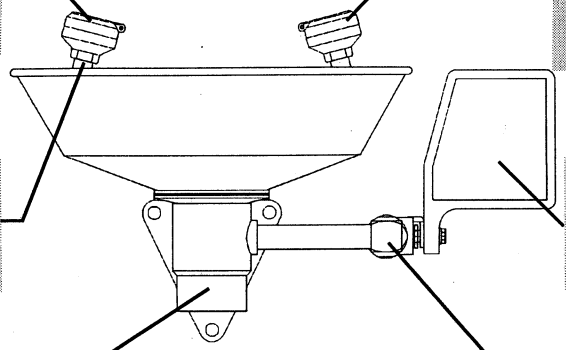
13. Teachers and students must receive training on the purpose and proper use of all safety equipment in the laboratory.

Paraphrased from *Best's Safety Directory*, Theodore J. Ziegler, 1994

As a general rule, at least one sink, eyewash station, and emergency shower in a laboratory room must be wheelchair accessible. However, if the laboratory contains several emergency stations, 5% of them should be compliant with the Texas Accessibility Standards.

Best's Safety Directory, Theodore J. Ziegler, 1994

Eyewash Station Specifications



Low-velocity flow rinses both eyes simultaneously.

Outlet heads between 33" and 45" from the floor and at least 6" from the wall.

Delivers 0.4 gallons of water per minute for 15 minutes.

Valve actuator is large enough to be located and operated easily.

Connect to minimum 1/2" water line to provide an uninterruptible water supply with at least 30 PSI flow pressure.

Hands-free, stay-open valve activates water in one second or less.

Install within 10 seconds from student stations.

Water temperature should be tepid (60–90°F).

Activate weekly to flush system of contaminants.

Note: The eyewash unit is not drawn to scale.

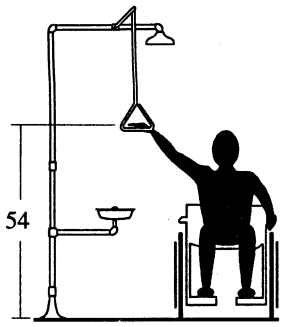


Figure 2.14
Side approach accessibility

- All emergency units must operate within one second or less when activated, according to ANSI Z358.1. Pull rods and chains with rings are acceptable activators for emergency showers, but each type should have a closed handle, such as a full triangle hand grasp (on a pull rod) or a full circle grasp (on a pull ring). Each should be easily identifiable.

- All emergency units must be in accessible locations that require no more than 10 seconds to reach. Time is critical in relieving the pain and suffering of a chemical burn victim.

- Activators should permit one-hand operation and must not require tight grasping, pinching, or twisting of the wrist. The force required to activate the controls of emergency equipment must not exceed five pounds.

- *Teachers and students must receive training on the purpose and proper use of safety showers. They must be aware that emergency equipment is in place for students' safety. Periodic drills with the students are recommended to reinforce their knowledge about and awareness of the equipment.*

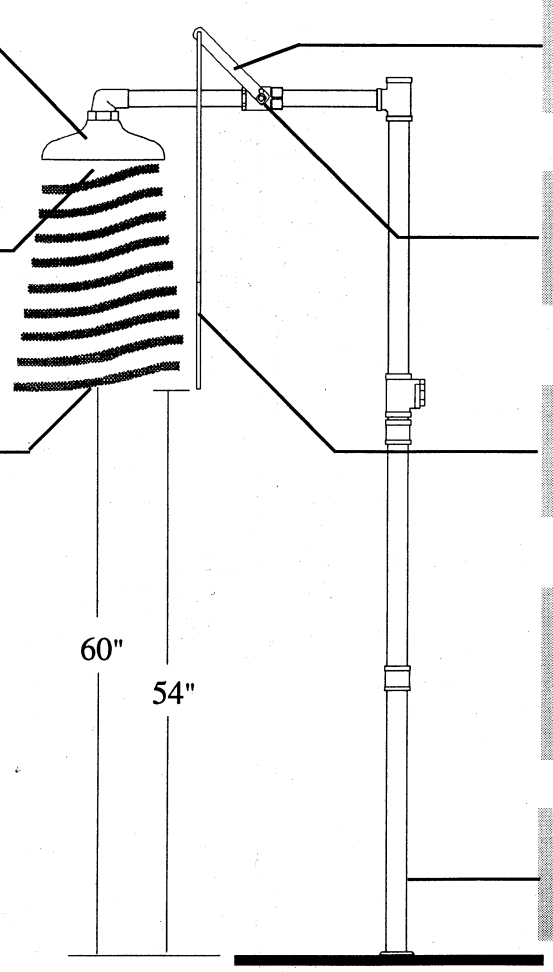
- New teachers and students, including those who are physically impaired, must be given special attention to make certain that they are included in a continuous safety program.

Paraphrased from *Best's Safety Directory*
Theodore J. Ziegler, 1994

"For people in wheelchairs, it is important for emergency equipment to be barrier free with no obstructions, so that the user can have the full benefit of the first-aid device."

Bob Spangler
Council of American Building Officials, 1994

Emergency Shower Specifications



Shower head should be located between 82" and 96" above the floor surface.

Shower must supply a flow of water at a rate sufficient to maintain the pattern for 15 minutes.

The center of the water pattern must be at least 16" from any obstructions.

At 60" above floor surface, the water pattern must be at least 20" in diameter.

Water temperature should be tepid (60–90° F).

Hands-free, stay-open valve activates shower in one second or less.

Hands-free, stay-open valve activates eyewash in one second or less.

Accessible actuator must be no higher than 69" above the floor.

Shower must provide at least 20 gallons of water per minute at 30 PSI.

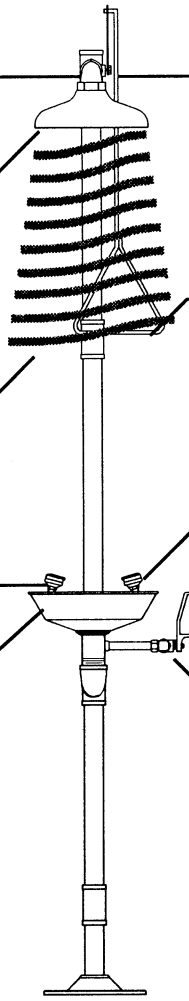
Water must be supplied to the shower through a minimum 1" water line.

Activate once monthly to flush contaminants from the system.

Install shower within 10 seconds of hazard with unobstructed travel path.

Note: The emergency shower is not drawn to scale.

Emergency Shower/Eyewash Specifications



Shower must provide at least 20 gallons of water per minute at 30 PSI.

Shower head should be located between 82" and 96" above floor surface.

At 60" above floor surface, the water pattern must be at least 20" in diameter.

Outlet heads are protected from airborne contaminates.

Eyewash delivers at least 0.4 gallons of water per minute at 30 PSI.

Install shower/eyewash within 10 seconds of hazard with unobstructed travel path.

Hands-free, stay-open valve activates shower in one second or less.

Accessible actuator must be no higher than 69" above the floor.

Outlet heads should be positioned between 33" and 45" from the floor.

Valve actuator is readily accessible and able to operated easily.

Hands-free, stay-open valve activates eyewash in one second or less.

Activate eyewash weekly and emergency shower monthly to flush contaminants from each system.

Water temperature should be tepid (60–90° F).

Water must be supplied to the shower through a minimum 1" water line.

Note: The emergency shower is not drawn to scale.

Hand-Held Drench Hoses

Purpose

Hand-held drench hoses can provide additional protection for students and teachers. However, they are not meant to replace emergency eyewash stations and safety showers, which are required in all chemistry laboratories. The drench hose line must be long enough to reach an injured person who is in a prone position, or to reach areas of the face and body inaccessible to the fixed stream of water from an eyewash or emergency shower.

School districts may choose to install hand-held drench hoses in chemistry, integrated physics and chemistry, and biology laboratories as an extra precaution.

Types

Several styles of hand-held drench hose are available to schools. A countertop-mounted type, shown in Figure 2.15, provides a single stream of water. This type can be installed on an existing emergency safety shower/eyewash unit or on sink/countertop areas.
A wall-mounted eye/face wash and drench hose provides the user with a dual stream of water for flushing the eyes or for spot body drenching.

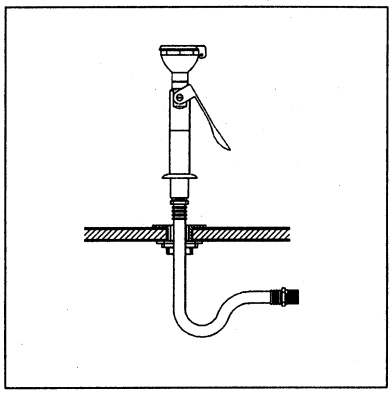


Figure 2.15
Countertop-mounted drench hose

This style, shown in Figure 2.16, is equipped with a stay-open valve that activates the flow of water when a push plate is moved by the user.

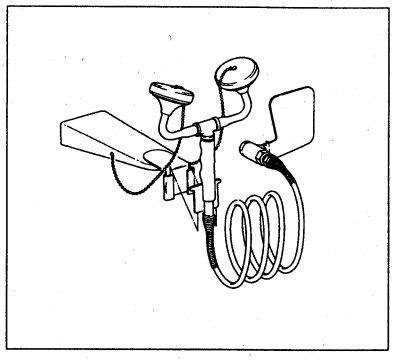


Figure 2.16
Wall-mounted eye/face wash and drench hose

The socket-mounted eyewash and drench hose, shown in Figure 2.17, also provides a dual stream of water for stationary flushing of the eyes or face, and it can be hand-held for spot body drenching. As with the other models mentioned, it has protective spray head covers that float off when the flow of water begins. This prevents some mineral and biological contaminants from entering the head of the unit.

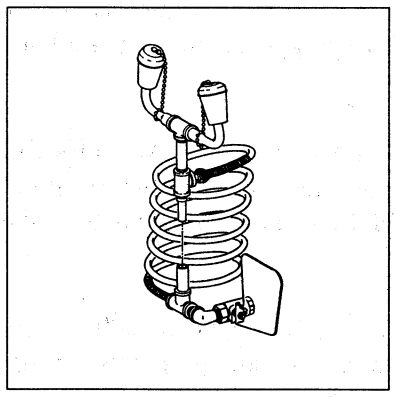


Figure 2.17
Socket-mounted eye/face wash and drench hose

Standards

1. Drench hoses must provide a controlled flow of water (3 gallons per minute) to flush hazardous materials from the user.

2. The unit must produce a continuous flow of water for at least 15 minutes.

3. The valve must go from the "off" position to the "on" position in one second or less. It should be resistant to corrosion.

4. The actuator valve must be easy to locate and operate.

5. The line connecting the drench hose to the water supply must be long enough to reach an injured person laying in a prone position on the floor.

6. The unit must be connected to a continuous source of water and protected from freezing.

7. Each drench hose location must be identified with a sign visible within the area served by the unit.

8. The area around the drench hose must be lighted and free of materials that could interfere with its immediate use.

9. The water temperature should be tepid (60–90°F).

10. Drench hoses must be inspected annually to ensure proper functioning of all their parts.

11. Each unit should be activated for five minutes once a week to remove mineral and biological contaminants from the system.

12. Teachers and students must be instructed on the location and proper use of the drench hose.

Accessibility

Wheelchair-bound students working in science laboratories must have access to the drench hose. The path from their work areas to the unit must be uncluttered and wide enough for a wheelchair to pass easily between laboratory tables, desks, and other items normally found in a science laboratory.

The handle for activating the flow of water, the actuator, must be within the reach of a student in a wheelchair. According to the Texas Accessibility Standards, the forward reach distance for the student must not exceed 48 inches, and the side reach must not exceed 54 inches. This is the standard requirement for access to a drench hose unit.

Hand-held drench hoses provide support for emergency shower and eyewash units but must not replace them.

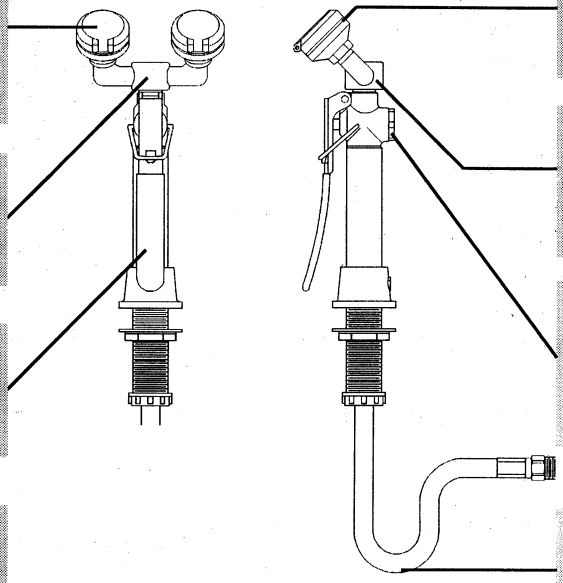
Eyewash and Drench Hose Specifications

Outlet heads must be positioned between 33" and 45"from the floor and at least 6" from the nearest obstruction.

Water flow must be controlled and at a low velocity for noninjurious rinse to both eyes.

Valve actuator must be readily accessible and able to be operated easily by the user.

Eyewash and drench hose unit must be identified with a highly visible sign.



Outlet heads must be protected from airborne contaminants.

Unit must deliver at least 3.0 gallons of water per minute through a 1/2" line for 15 minutes.

Valve must go from "off" to "on" in one second and remain activated until it is shut off intentionally.

Unit must be connected to an uninterruptible water source of at least 30 PSI flow pressure.

Must be installed within 10 seconds' reach of work stations and with unobstructed travel path.

Water temperature should be tepid (60–90°F).

Units must be tested and flushed at least weekly and inspected annually.

Note: The drench hose unit is not drawn to scale.

Fume Hoods

Purpose

A fume hood is defined as a ventilated enclosure where hazardous or toxic fumes can be worked with safely. The purpose of the fume hood is to contain and then eliminate hazardous contaminants before they escape into the science laboratory.

Fume hoods are required in chemistry laboratories and recommended for integrated physics and chemistry. Advanced Placement (AP)® Chemistry and International Baccalaureate (IB) Chemistry laboratories should provide two fume hoods for students.

Teachers and students should use a fume hood in each of the following situations:

- while handling chemicals that are hazardous when inhaled
- when conducting laboratory investigations with strong exothermic reactions
- when using chemicals with high vapor pressures
- while working with chemical vapors that are fire hazards
- when handling chemicals that produce an offensive odor

Airflow coming into the fume hood pulls air from the science laboratory or an auxiliary source and exits through the fume hood's exhaust system. The air from the laboratory dilutes the contaminated air in the fume hood so that it can be exhausted through the duct system to the outside, where it is dispersed at a lower concentration.

Fume hoods should be inspected periodically and maintained according to the manufacturer's recommendations.

Types

Fume hoods are generally classified in one of two categories according to the way the airflow is being pulled through the unit.

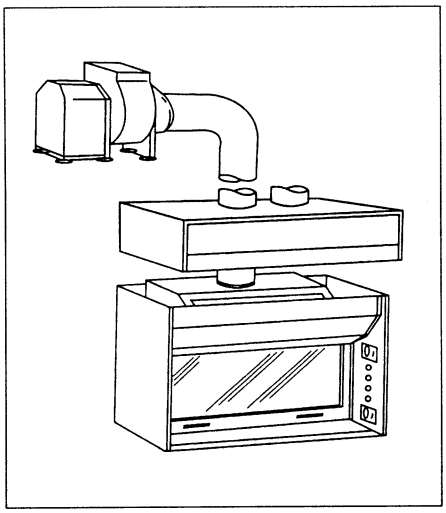


Figure 2.18
Conventional fume hood with vertical sash

Conventional Fume Hood

The conventional hood operates with a constant volume of air entering through the hood's door or sash opening (Figure 2.18). As the sash is closed, the velocity of the air at the sash opening increases. The wider the sash is opened, the more slowly air flows through the unit and the more slowly contaminants are removed from the hood.

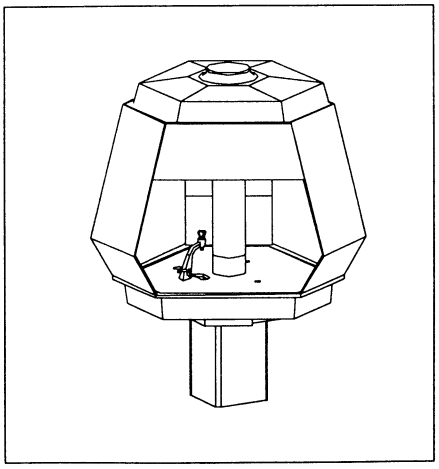


Figure 2.19
Trifacial conventional fume hood

Therefore, the performance of the hood depends largely on the sash position.

Many types of conventional hoods will accommodate more than one student at a time by providing two or more work areas (Figure 2.19). This type of fume hood is recommended for AP and IB Chemistry® laboratories.

Bypass Fume Hood

The bypass fume hood operates at a constant volume of air, as well. However, when the sash is closed, the air entering the hood is redistributed, thus eliminating the high-velocity air increases. Openings above and below the sash area reduce fluctuations in the velocity of the air when the sash is opened slightly or wide.

The temperature of the laboratory room may be affected by an operating fume hood. As the exhaust system eliminates hazardous fumes from the hood, it does so by bringing in the air from the laboratory room. To reduce the amount of conditioned air that is leaving the laboratory, a modified bypass hood may be used. This type is called an auxiliary-air fume hood (Figure 2.20).

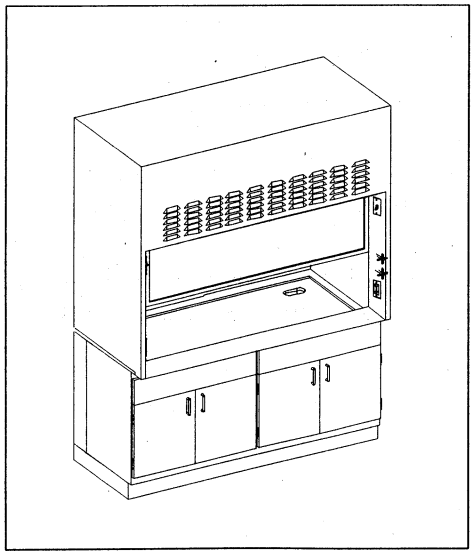


Figure 2.20
Auxilliary-air bypass fume hood

The auxiliary-air bypass fume hood provides 50–70 percent of the air going into the hood from outside the laboratory, therefore reducing the amount of conditioned air that leaves the laboratory by approximately half.

Standards

1. Fume hoods should have a constant average face velocity of 100 feet per minute. If the face velocity is too low, the fumes may not be contained within the hood.

2. The fume hood control system must be able to change the exhaust flow within three seconds in response to changes in the sash position. This is necessary to prevent the escape of fumes from the hood when the sash is moved from the closed position to the open position.

3. The sash should be left open, from two to six inches, when the hood is not being used by students or teachers.

4. Laboratory doors and windows should remain closed to prevent unplanned airflow patterns that might degrade the efficiency of the hood.

5. The fume hood should be located away from laboratory room traffic. Turbulence induced by pedestrian traffic can overcome the hood's ability to capture and remove chemical vapors. Schools should consider painting a zone two feet away from the hood to discourage traffic from getting too close to the unit.

6. The presence of objects in the hood lowers its efficiency. Do not use the hood as a permanent storage area for chemicals. Reduce clutter in the hoods.

7. The exhaust system must be able to remove fumes that are lighter or heavier than air and vented to the outside of the building and above the roof line.

8. Work should take place at least six inches inside the hood to maximize the capture of hazardous vapors. The user's face should not be in the same plane as the sash. Never work with your head inside the fume hood.

9. Run water in the fume hood drain once a week to prevent the drain trap from drying out and interfering with the airflow.

10. Consider mounting the exhaust blower on the floor or roof of the building, away from an air intake, to minimize noise produced by the blower.

11. Incandescent or fluorescent light bulbs must be sealed in vapor-proof fixtures to prevent chemical vapors from corroding the fixtures or causing explosions.

12. The interior work surface must be a watertight construction with a raised edge to contain spills and cleaning fluids.

Accessibility

Wheelchair accessibility guidelines for fume hood units follow below.

- The minimum clear floor space must be 48 inches in length by 30 inches in width with a forward approach to the emergency unit, and 30 inches in length by 48 inches in width with a parallel approach (Figure 2.21).

Figure 2.21
Fume Hood
(ADA compliant)

- Students must be able to reach into the hood unit and carry out laboratory procedures safely. The working surface or deck must be at height of 34 inches.

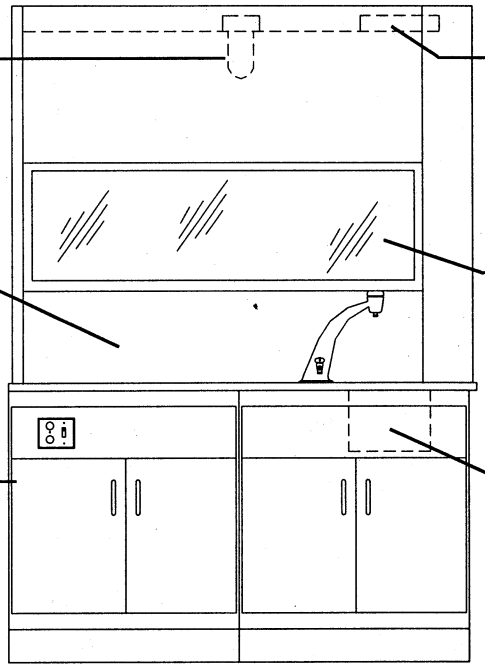
- If a forward approach is available, sharp obstacles and abrasive surfaces must be eliminated.

Fume Hood Specifications

Light fixture must be a sealed, vapor-proof incandescent or fluorescent light.

The speed of air moving into the hood, or the hood's face velocity, must be 100 feet per minute.

Exterior finish should be a chemical-resistant epoxy finish.



Exhaust system should remove fumes that are lighter than air as well as those that are heavier than air.

Shatterproof safety glass must be used in the sash to protect users in the event of an explosion.

Fill drain with water once a week to prevent gases from entering through the drain pipe.

Interior work surface should be watertight and constructed with a raised edge to contain spills.

Interior must be non-asbestos, Minerit, stainless steel, or Wesliner.

Exhaust system must be vented to the outside and above the roof line.

Note: The fume hood is not drawn to scale.

Corrosives and Flammables Cabinets

Purpose

Corrosives cabinets are designed to store chemicals that are classified as acids or caustics. The cabinets should be ventilated to the outside and above the roof line of the building to prevent the vapors from entering another part of the building.

Flammables cabinets must be available for the proper storage of flammable liquids such as alcohol. The National Fire Protection Association (NFPA) does not require nor recommend venting to the outside the vapors that develop inside the cabinet. According to the NFPA, it has not been proven that venting vapors from a flammables cabinet is necessary for fire protection (Figure 2.22).

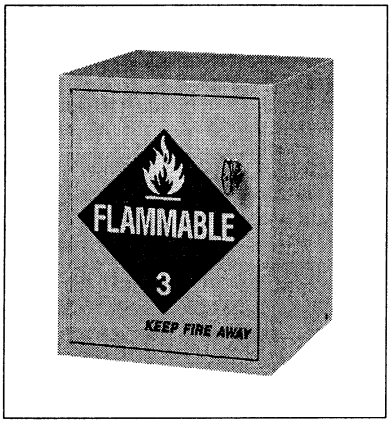


Figure 2.22
Flammables cabinet

Open vents may even compromise protection of the cabinet's contents from a fire. However, local codes may require flammable cabinets to be vented.

If venting the cabinet is required, remember that the top vent is for air intake, and the bottom vent pipes the vapors to the outside. The maximum length of pipe from the cabinet to the spark-free exhaust blower is 25 feet.

A spark-free exhaust blower must be used to vent the vapors and prevent air movement on the outside of the building from pushing the vapors back into the room.

Remember:

- Never vent a flammables cabinet through a fume hood.
- Do not use PVC pipe as the vent pipe. PVC pipe will probably melt, thereby releasing flammable vapors into the room and feeding the fire.
- Ground the cabinets to prevent an accidental spark from igniting flammable liquids in the cabinet.
- All cabinets must be clearly labeled with the type of hazardous materials stored inside.
- Cabinet doors should be kept locked.

Corrosives storage cabinets and flammables storage cabinets must be available in science storerooms and preparation rooms if a separate, properly ventilated chemical storage room is not provided.

Corrosives and flammables cabinets should only be used to store a small quantity of chemicals and should not be used to replace a chemical storage room.

Types

Corrosives cabinets may be constructed from metal, wood, or plastic. Well-constructed plastic or wooden cabinets are recommended for storing corrosive materials (Figure 2.23). Solid hardwood plywood cabinets coated with corrosive-resistant material should provide a safe, durable cabinet for the storage of caustic chemicals. However, some particleboard glues may deteriorate in the presence of certain chemical vapors.

Metal corrosive cabinets, though coated with special paints and corrosive-resistant materials, may deteriorate should a scratch or chip in the coating occur. Shelves supported with metal brackets or shelf support clips can corrode, weakening the stability of the shelf. Acids, especially nitric acid, can oxidize and react with any exposed metal surfaces and rapidly corrode the cabinet.

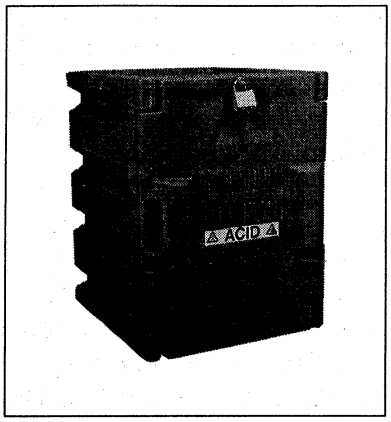


Figure 2.23
Acid cabinet

Flammables cabinets constructed of metal or wood are capable of storing less-corrosive flammable materials, such as alcohols and acetone. These materials are less likely to corrode metal and damage the cabinet than are stronger corrosives, such as acids and bases.

There is some debate about the extent to which a metal cabinet conducts heat during a fire. If the temperature inside the cabinet becomes too high, the flammable materials may explode and add fuel to the fire. Wood cabinets, although they may burn, do not conduct heat to the extent that metal cabinets do.

Styles

Manufacturers offer many cabinet styles with different storage capacities. They may accommodate only a few liters of corrosives or flammables, or they may be able to store large quantities.

Some cabinets are constructed so that they can be stacked one on the other. (Figure 2.24). However, it is recommended that cabinets not be stacked more than two high.

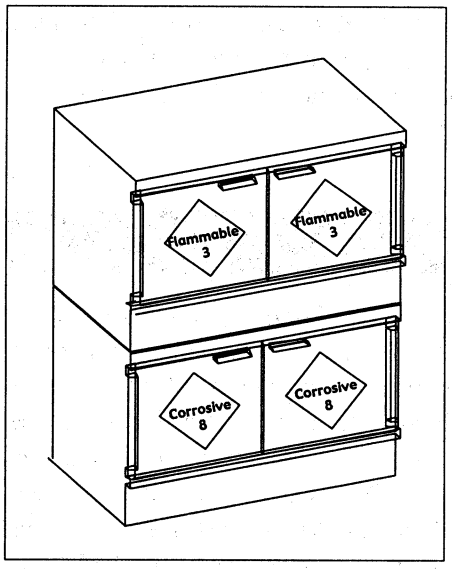


Figure 2.24
Stacking cabinets

Corrosives cabinets should never be placed on top of other stacking cabinets. If corrosive liquids seep out of the cabinet, they may cause damage to the cabinets beneath and create a dangerous condition.

Standards

When selecting corrosives and flammables cabinets for your school, consider the following:

- Corrosives and flammables cabinets should meet OSHA and NFPA standards.
- Corrosives cabinets should be composed of corrosive-resistant materials and should *never* have exposed metal surfaces, including shelf supports.
- All types of cabinets must have doors that can be locked securely.
- Store the acid and corrosives cabinets on the bottom shelf. Never store chemicals above eye level.
- A minimal amount of hazardous chemicals should be stored in the science departments. Where possible, use microscale chemistry techniques to reduce the inventory of, exposure to, and disposal of hazardous chemicals.

Accessibility

No unauthorized person, including students, should have access to either the corrosives cabinet or the flammables cabinet. Teachers must be trained in the proper handling, use, and disposal of all hazardous chemicals in the workplace. Material Safety Data Sheets on each chemical used are required to be kept in the workplace—for example, in the laboratory, preparation room, library, or nurse's office.

Floor-to-Ceiling Ventilation

Purpose

A floor-to-ceiling ventilation system pulls air from the floor upward toward the ceiling and vents it to the outside of the building. This type of system is required in science laboratories, where hazardous chemicals are used and noxious fumes are produced.

Types

Two types of floor-to-ceiling ventilation are required in science laboratories and storage rooms: continuous and forced.

1. A **continuous ventilation system** moves air 24 hours a day until the system is stopped manually.
2. A **forced ventilation system** uses a positive pressure blower that forces air into the room. Vents in the door, windows, ceiling, and walls must be eliminated in order for the vapors to exit through the duct work to the outside and away from air intake ducts.

A continuous-forced ventilation system is required in all chemical storage rooms. Hazardous chemical vapors can build to dangerous levels when the storage room is not properly ventilated. A floor-to-ceiling forced-ventilation system gently pulls air and heavier vapors from the floor, moves them upward, picks up lighter vapors, and vents them to the outside of the building.

A total of six air changes per hour is required to remove hazardous vapors from the room properly. Air should enter the room approximately 12 inches above the floor and exit through an exhaust duct located in the ceiling at the opposite end of the room. Vapors must flow through duct work that prevents them from reentering the building through open windows, doors, or air intake vents. Science equipment storerooms, preparation

rooms, and laboratories must be equipped with a forced-air ventilation system. These are manually operated and must be activated when activities conducted in these rooms release toxic, flammable, or odoriferous vapors.

Fire Extinguishers

Purpose

A fire extinguisher is a portable device used to extinguish fires of a limited size. Science laboratories, storage rooms, and preparation rooms are required to have a fire extinguisher located near an exit. The extinguisher must be placed inside the laboratory or classroom by an exit or immediately outside the exit.

Minimum standards for the selection, placement, and testing of portable fire extinguishers have been developed by the National Fire Protection Association (NFPA). Any fire extinguisher placed in a science facility should meet the NFPA minimum standards.

Types

Class A Fire Extinguishers

- Class A fire extinguishers contain water, calcium chloride, or an alkali-metal-salt solution as the extinguishing agent. They should be used only on Class A fires, such as burning paper, wood products, cardboard, and plastics. Type A fire extinguishers should never be used on electrical or metal fires.

- Class A fire extinguishers have a numerical rating that is based on tests conducted by Underwriter's Laboratories. This number refers to the amount of water the fire extinguisher holds and the size of fire it will extinguish.

Class B Fire Extinguishers

- Class B fire extinguishers contain dry chemicals, such as sodium bicarbonate, potassium bicarbonate, or ammonium phosphate as the extinguishing agent. They produce a blanket of fire-retardant chemicals that extinguish the fire and reduce the likelihood that the fire will reignite.

- Class B fire extinguishers should be used on flammable or combustible liquids, such as gasoline, kerosene, or alcohol, and may also be used on electrical fires.

- The numerical rating for Class B extinguishers is the approximate number of square feet of a flammable liquid fire that a nonexpert can expect to extinguish.

Class C Fire Extinguishers

- Class C fire extinguishers discharge carbon dioxide, but they may not prevent reignition of the fires as well as the dry chemical extinguishers will. The "C" indicates that the extinguishing material is nonconductive and is suitable for use on electrical fires.

- Class C fire extinguishers normally do not have a numerical rating, nor are they given a multipurpose rating for use on other types of fires.

Class D Fire Extinguishers

- Class D fire extinguishers are for metals fires. They operate by simply smothering the flames. Science laboratories and storage rooms where metals such as potassium or sodium are kept must have a Type D fire extinguisher. These metals react violently in the presence of water.

- Class D fire extinguishers normally do not have a numerical rating, nor are they given a multipurpose rating for use on other types of fires.

Multipurpose Fire Extinguishers

- Some fire extinguishers can be used on different classes of fires and are labeled with more than one designation, such as AB, BC, or ABC.

- ABC fire extinguishers are appropriate for use in science classrooms and laboratories. They are suitable for extinguishing Class A fires (paper, wood, straw, and cloth), Class B fires (flammable liquids), and Class C fires (electrical).

Science students and teachers must be trained in the proper use of fire extinguishers.

Standards

1. Use only NFPA-approved fire extinguishers in science facilities.

2. A type ABC fire extinguisher is recommended for science laboratories. In addition, a Type D extinguisher or bucket of sand must be present if metals are used in the laboratory.

3. A type BC fire extinguisher is recommended in preparation rooms, along with a Type D extinguisher if metals are present.

4. Fire extinguishers must be located near or at the room's exit or immediately outside the door.

5. Clearly marked signs must be placed by the extinguisher so that it can be located easily.

6. Students and teachers must be trained in the proper use of fire extinguishers.

7. The travel distance to a fire extinguisher should be no more than 75 feet.

8. The employer should visually inspect all fire extinguishers monthly and conduct an annual maintenance check.

9. When using a fire extinguisher, observe the following procedures:

   - Pull the pin at the top of the cylinder that keeps the handle from accidentally being pressed.

   - Aim the nozzle at the base of the fire.

   - Approach the fire no closer than 10 feet, and squeeze the handle to discharge the contents of the extinguisher.

   - Sweep the nozzle from left to right, aiming at the base of the fire until the fire appears to be out. Watch carefully to see that the fire does not reignite.

10. Understand that most fire extinguishers produce a flow of material for only 8–30 seconds.

11. The teacher may extinguish small fires successfully. However, it is important for the teacher to know when the fire is too large to extinguish with the fire extinguisher and to call 911.

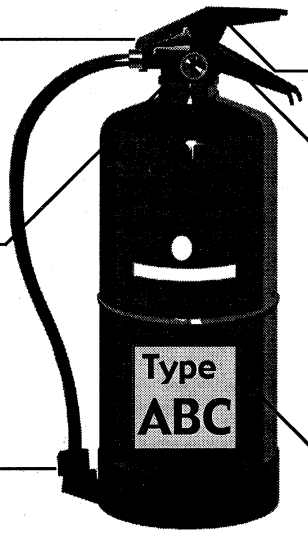
School personnel should consult with their local fire marshal to determine the correct types of fire extinguishers to use in their science facilities.

Fire Extinguisher Specifications

Class ABC (dry chemical) fire extinguisher is used on ordinary combustibles and flammable liquids.

Visual pressure gauge determines whether the extinguisher needs to be recharged.

Nozzle directs the flow of chemicals to the base of the fire.



Handle that must be squeezed to begin flow of extinguishing chemical.

Removable pin to prevent accidental discharge of the fire extinguisher.

Label that indicates which classes of fires can be extinguished with this unit.

Class A (water) fire extinguisher is used on burning paper, wood, and plastics.

Class BC (carbon dioxide) fire extinguisher is used on flammable liquid fires and electrical fires.

Class D (dry chemical) fire extinguisher is used on flammable metals.

Note: The fire extinguisher is not drawn to scale.

Emergency Shut-off Control

Purpose

An emergency shut-off control regulates utility services and devices such as water, natural gas, and electrical outlets within a classroom, laboratory room, preparation room, or storage room. The teacher can control when these utilities are available for use by the student and, in the event of an emergency, shut off the natural gas, water, and electricity before evacuating the room. This should be accomplished by using a single panel containing individual controls for each utility, or by engaging a single control switch to shut off all utilities.

Types

The Utility Controller is an example of a safety device that can regulate the control of various utility services and devices (Figure 2.25).

A keyed service switch integrated into the Utility Controller design restricts the ability to activate the services. This design permits any occupant of the classroom to deactivate the services while allowing only the teacher or supervisor to activate the service. For example, a student could turn off service to the gas jets in a laboratory room but would be prevented from turning them on again. Only the teacher would have that ability.

Some utility control units are equipped with a building alarm system. When the panic button is depressed, all utilities are shut off and an alarm is sounded to alert the administration that an emergency is occurring.

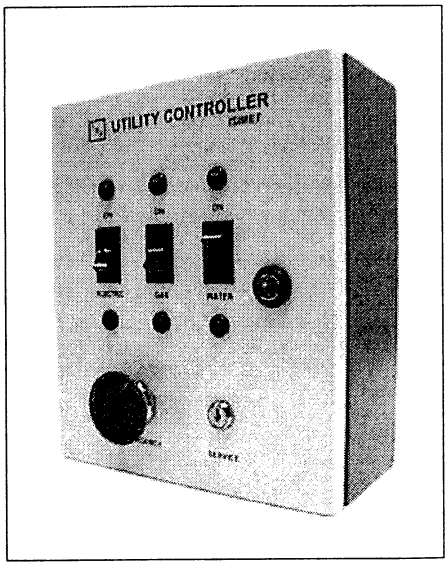


Figure 2.25
Utility Controller

CHAPTER 3

FURNITURE, FIXTURES, AND ACCESSORIES

Science classrooms and laboratories must be furnished with furniture and fixtures that provide a safe and effective learning environment for students. This chapter presents examples of laboratory tables, demonstration tables, upper and lower cabinets, gas jet assemblies, water faucet designs, and other fixtures. These examples represent only a few of many selections and options that teachers and administrators may consider when furnishing science classrooms and laboratories. A Laboratory Facilities and Equipment Checklist is provided in Appendix C and may be useful when determining the style of furniture and types of fixtures to select for a specific laboratory.

> The arrangement of available space and furnishings in the classroom and laboratory influences the nature of the learning that takes place. . . . Effective science teaching depends on the availability and organization of materials, equipment, media, and technology. . . . The school science program must extend beyond the walls of the school to include resources of the community.
>
> National Research Council, *National Science Education Standards*, 1996

Laboratory Tables

Purpose

Laboratory tables function as student workstations. School classrooms and science laboratories must provide each student with a workstation. Laboratory tables can accommodate 2–4 student workstations per table. The purchase of laboratory tables is a major expense for a school districts; therefore, tables should be well-constructed and maintained to support optimal student performance in the laboratory.

The Scientific Equipment and Furniture Association (SEFA) has developed a list of performance properties for laboratory tables work surfaces. These properties are shown in Table 3.1, along with their recommended use in different types of science laboratories.

Types

When deciding what style of table to purchase, give careful consideration to the composition of the table and tabletop, which can range from composite wood to solid wood (such as oak), to plastic and phenolic core laminates, to resin epoxy. If your school is located in a humid area, for example, the tables should be composed of material that does not absorb moisture easily.

The most appropriate choice of tabletop material depends on the kinds of classes being taught in the laboratory (Appendix A). For example, tables used in a chemistry laboratory should be composed of a chemical- and heat-resistant material such as epoxy resin. Physics laboratories require tables with a solid wood top to provide stability and durability during science investigations.

Laboratory table style is also important to consider. The examples presented below are available from several manufacturers; a list of manufacturers is included in Appendix D.

Freestanding Bench Tables

The style shown in Figure 3.1 can accommodate two, four, or more students. It comes with either a plain skirt or drawers under the skirt. Drawers can serve useful purposes in a laboratory; however, consider carefully whether they will actually be used or simply become reservoirs for trash.

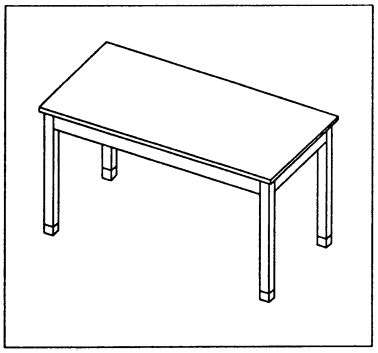


Figure 3.1
Freestanding 4-legged table

Figure 3.2 is a variation of the bench table, with the legs moved to a center position. This style of table is recommended for students in grades K–6 .

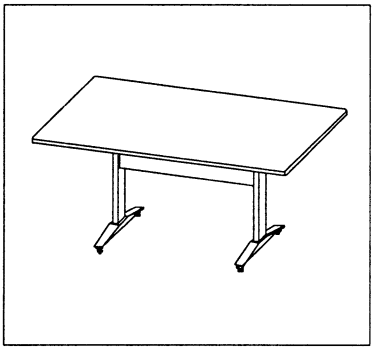


Figure 3.2
Two-to-four pedestal table

The TAS/ADA-compliant table shown in Figure 3.3 allows the teacher to adjust its height by turning a hand crank. It can be lowered for students in wheelchairs during one period and then returned to the original height for the next.

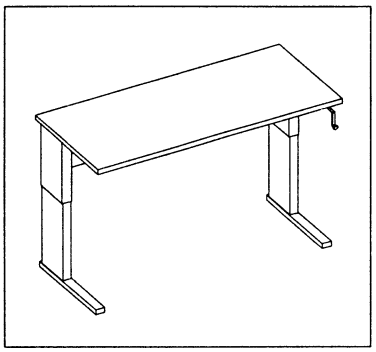


Figure 3.3
Two-student table
(TAS/ADA compliant)

Specialized tables and tabletops are available for the elementary grades, as shown in Figure 3.4. This style has an imprinted top for student activities using water-based markers. These can be arranged with a trifacial service island as shown in Figure 3.5.

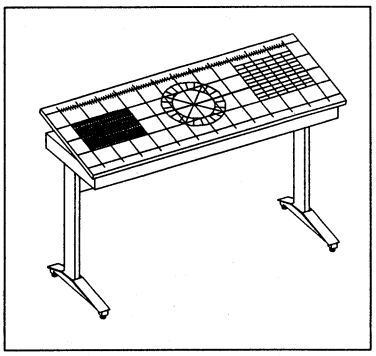


Figure 3.4
Two-student table
with imprinted top

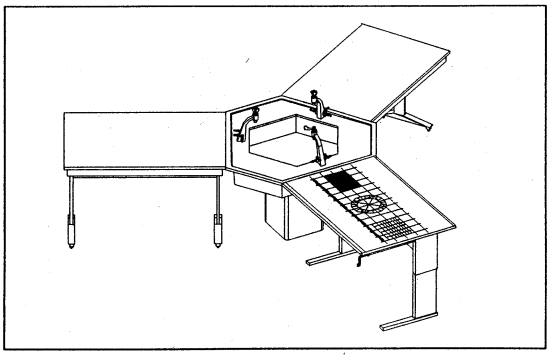


Figure 3.5
Trifacial lab center arrangement

The Axis 3™ (shown in Figure 3.6) will accommodate up to four students at a time.

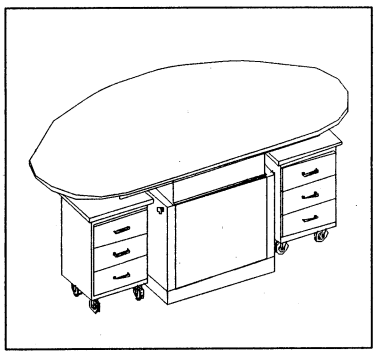


Figure 3.6
Axis 3™ student table

The student bench tables shown in Figures 3.7–3.8 provide services—data, water, gas, and electricity—to each student team, or may be purchased without services. This style of table can accommodate four students.

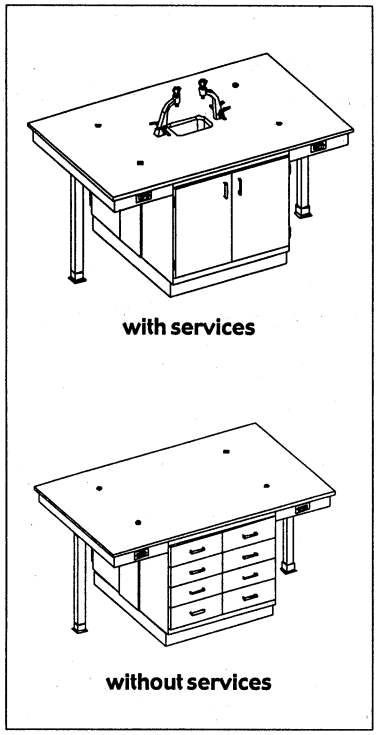


Figure 3.7
Four-student bench table

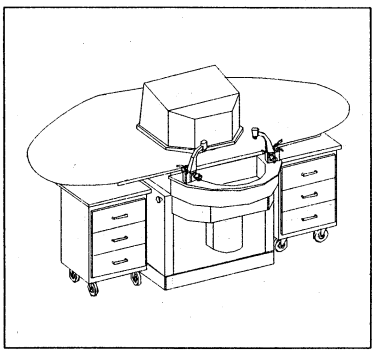


Figure 3.8
Axis 3™ student table with services

Freestanding Island, or Pedestal, Table

The island, or pedestal, table (Figures 3.9–3.10) is permanently mounted and provides access to services (data, electrical, gas, water) through the pedestal. It also includes a centrally located sink.

Some island assemblies are designed for tables to be used in conjunction with a central unit, as shown in Figure 3.9.

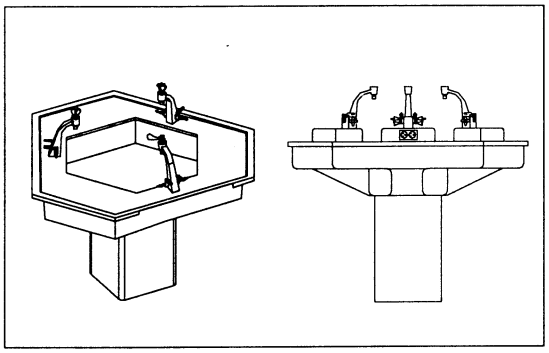


Figure 3.9
Trifacial lab center

The Texas Accessibility Standards and the Americans with Disabilities Act require that five percent, or at least one, of the student workstations meet their standards for wheelchair-bound students. Some manufacturers have responded by lowering one side of the laboratory table, as shown in Figure 3.10. Others meet the standard by offering an adjustable tabletop that can be raised or lowered manually by turning a crank or using a motor. Teachers can lower the tabletop for wheelchair-bound students and then raise it back to the standard height.

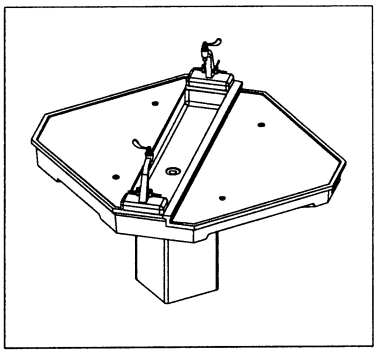


Figure 3.10
TE II table (TAS/ADA compliant)

Attached Perimeter Tables

Pedestal and bench tables can be attached around the permimeter of the laboratory room (Figure 3.11) as an alternative to freestanding tables. Services can be brought to the table along the wall of the room instead of from the floor, as a freestanding table would require.

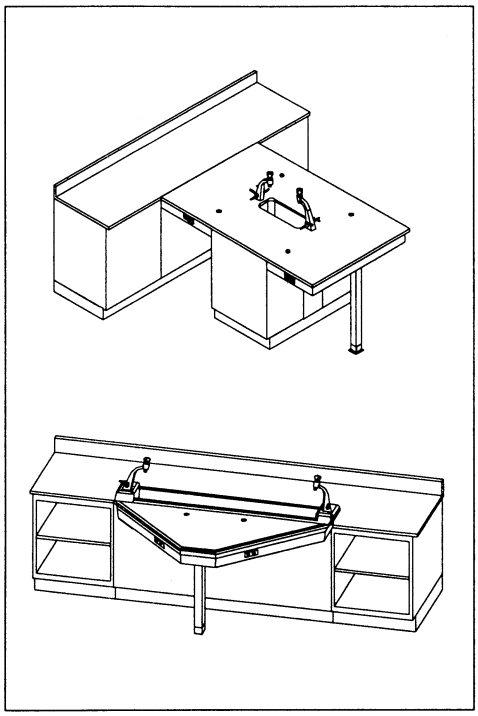


Figure 3.11
Pedestal and bench tables
(perimeter location)

Making a Choice

Before selecting student tables for your laboratory room, consider the following questions.

- What style of table will provide the best workspace for the student?
- What should be the composition of the table's top?
- Will the style of the table accommodate students with disabilities?
- What types of services should be available at the table?
- Should the table be one that can be moved to a different location or one that will remain stationary?
- How stable will the table be when students are working on activities?
- Will the table be used in a chemistry, physics, life science, or earth science class?

Demonstration Tables

Purpose

Demonstration tables provide easy access to water (hot and cold), gas, and electricity, and they may include an upright support rod assembly and a sink. Drawers of various sizes (some with locks) can also be part of the demonstration unit. The surface should be made of an acid- and scratch-resistant material.

Types

A standard item in science rooms is the demonstration table or desk. It can be a permanent fixture in the classroom and the laboratory (Figure 3.12) or a mobile unit that can be moved to different areas of the room depending on the type of demonstration that is being done (Figures 3.13–3.14).

The sizes vary from 5' to 8' in length and may include additional pieces that can be added to the table, such as a desk attachment.

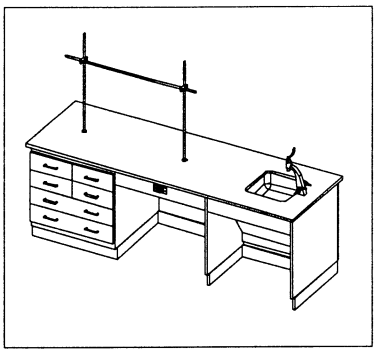


Figure 3.12
Demonstration table (attached to floor)

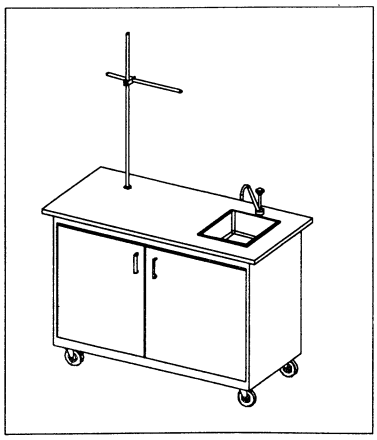


Figure 3.13
Demonstration table (mobile unit)

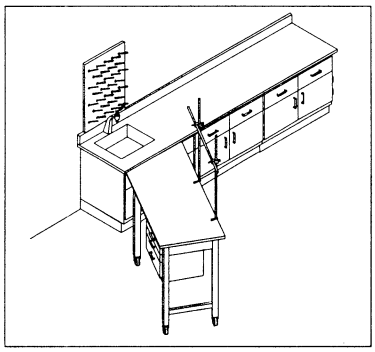


Figure 3.14
Angular demonstration table
(mobile unit)

A style that reduces the amount of floor space used is the Axis 3™ Focal Point Demonstration Desk, shown in Figure 3.15. This syle includes the standard features of water, gas, and electricity services, as well as a computer terminal and areas for a printer, VCR, and laser disk player.

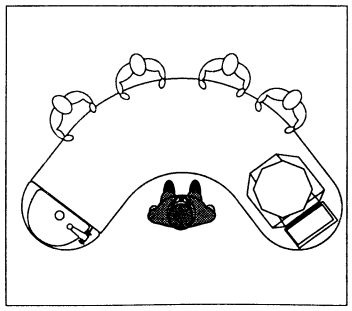


Figure 3.15
Axis 3™ demonstration table
(attached to floor)

The sink is TAS/ADA compliant, and the unit does not obstruct the teacher's view of the laboratory or classroom. It appears to be easier for individual teams of up to four students to work at this type of demonstration table than at the bench-style demonstration table.

Optional Features

Ity may be difficult for students to see all that is occurring on a demonstration table from different positions in the room. Therefore, some manufacturers provide a mirror system with the demonstration table or sell a separate mirror system for use with any table. The teacher can position the mirror so that all students are able to view the demonstration easily.

Two of the table/mirror systems that may be considered are the Rol-A-Lab™ and the Visual Aider Mirror. The Rol-A-Lab™ is a mobile demonstration table that comes with a mirror attached to the vertical support rods. It is adjustable in height and angle. The mirror can be removed at the end of the demonstration and stored in the preparation room.

The Visual Aider Mirror system is permanently fixed to the ceiling above the demonstration table (Figure 3.16). It is mechanically driven, which allows the mirror to be lowered over the demonstration area and the angle adjusted to provide an optimal view for all students. When the demonstration is complete, the mirror can be returned to the compartment on the ceiling and kept out of sight.

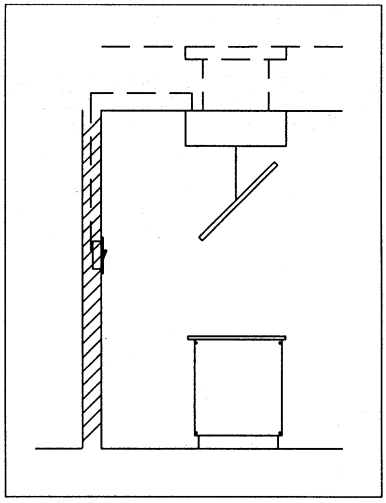


Figure 3.16
Retractable Mirror

Another optional feature is a teacher's desk unit (Figure 3.17), which can be added to the side of the demonstration desk. This eliminates the need for an additional piece of furniture in the science classroom.

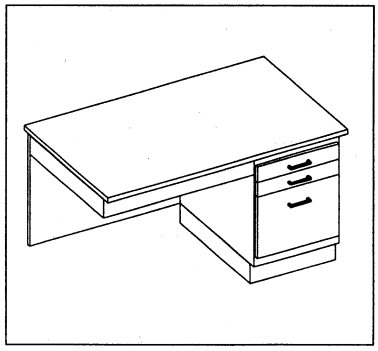


Figure 3.17
Teacher's desk unit

Making a Choice

Before selecting a demonstration desk for your classroom or laboratory, consider the following questions.

- Will a visual aid be needed with the demonstration table?
- Should the unit be mobile or permanently fixed in one place in the room?
- What services will be needed at the unit?
- Where should the unit be located in the room if it is permanently fixed to the floor?
- Will parts of the unit need to be TAS/ADA compliant, such as the sink?
- What type of material should the tabletop be made of?

Sinks and Sink Units

Purpose

Sinks that are used for cleaning equipment and for washing hands should provide hot and cold water. These sinks are usually located around the perimeter of the laboratory room; however, some styles of island sinks (Figure 3.21) may also have hot and cold water. Trough sinks, found in some laboratory tables (Figure 3.20), are designed for light cleanup and usually only provide cold water. This style should be used along with the larger, deeper sinks and not as a replacement for them.

There should be a least one sink for every four students in a laboratory room and at least one in science classrooms and the classroom portion of a lecture/laboratory room. Depending on the curriculum that is being taught, the sinks may be located at the student's workstation. In addition to the student's workstation, other sinks (one per four students) should be located around the perimeter of the room.

Sinks are usually composed of one of three materials: stainless steel, solid epoxy resin, or fiberglass. The curriculum taught in the laboratory should determine the sinks' composition. For example, an acid-resistant, solid epoxy sink should be selected for chemistry laboratories.

Types

Perimeter sinks vary in size and style. They range from very small sinks called cupsinks, which are approximately 3"x 6"x 8", to sinks with long sloping counters, known as rinse-away stations (Figure 3.18).

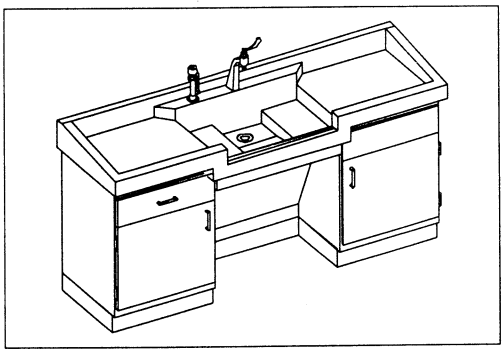


Figure 3.18
Perimeter sink

The rinse-away counter sinks (Figure 3.19) are very useful in life science laboratories for working with preserved specimens.

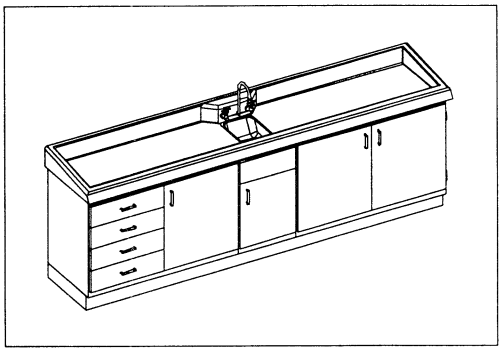


Figure 3.19
Rinse-away counter sink

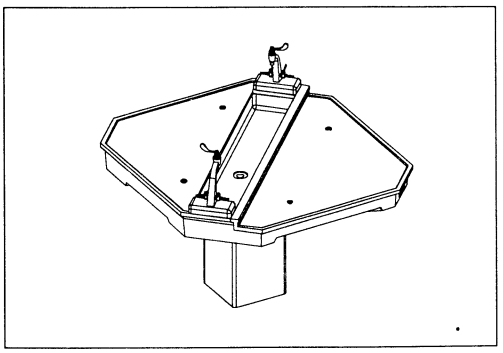


Figure 3.20
Trough sink

The island sink styles shown in Figure 3.21 may be placed along the perimeter of the room or used as islands that allow tables to be placed against the sides of the units.

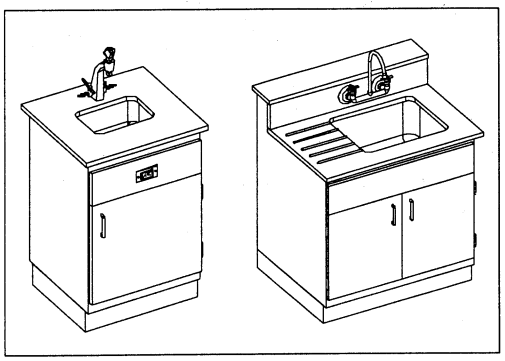


Figure 3.21
Island sinks

Federal regulations require that at least one sink in each laboratory room be TAS/ADA compliant. As a general rule, five percent of the sinks should be compliant with TAS/ADA regulations.

Glassware drying racks, or pegboards, are additional options that can be added behind the sinks to provide a place for freshly washed glassware to dry (Figure 3.22).

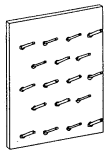


Figure 3.22
Glassware drying rack

Making a Choice

Before selecting sinks or sink units for your classroom or laboratory, consider the following questions.

- What will be the purpose and use of each type of sink?
- Where should the sinks be located in the room?
- Will the sinks also serve as locations for some eye/face wash stations?
- Should all of the sinks be composed of the same material?
- Where should the TAS/ADA-compliant sink be located?
- Should sinks be located at the student workstations and along the perimeter?

Faucets

Purpose

All science classrooms and laboratory rooms must have potable water available for the teachers and students. Faucets must deliver cold and hot water to every science room to comply with the U.S. Department of Health's Standard Precautions (Appendix A). At least one faucet must be TAS/ADA compliant.

Faucets can be manufactured from a variety of metals. Some faucets are made of aluminum, while others are made of brass tubing or cast brass. They may be chrome-plated or have an epoxy coating that resists corrosion from chemicals used in chemistry investigations.

Types

Several types of faucets are presented in this section. The style of faucet is very important to the function it will have in a science laboratory. The types shown in this section have an optional hose connection, aerator, or vacuum breaker at the end of the gooseneck (Figure 3.23). Hose connections are most often needed in a chemistry laboratory and are not recommended for use in other laboratories.

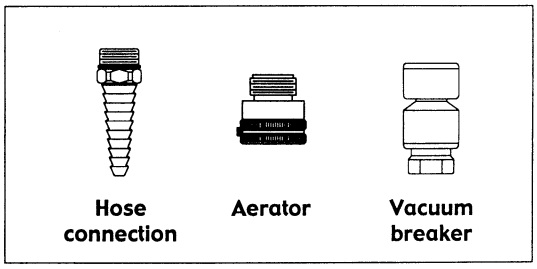


Figure 3.23
Faucet appliances

One of the most common faucets is the gooseneck faucet, which is usually connected to the cold water line only. This style, when mounted to the surface of the counter, is called deck mounted (Figure 3.24).

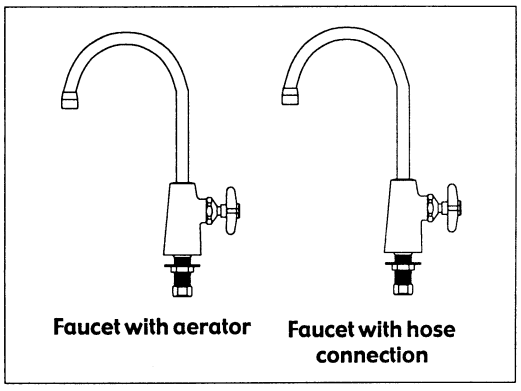


Figure 3.24
Gooseneck faucet
(deck mounted)

One style of gooseneck faucet has a neck that swivels from right to left (Figure 3.24). Teachers should be aware that this type of faucet is the easiest for students to damage.

Leaning on the gooseneck or twisting the neck portion around in a circle will cause damage to the faucet. The copper tubing that connects the water to the faucet will become so twisted that it breaks free from its mounting and floods the cabinet with water.

Some manufacturers have recognized this problem and have responded by developing a one-piece cast brass unit, as shown in Figure 3.25. This style does not allow the neck to be twisted or turned.

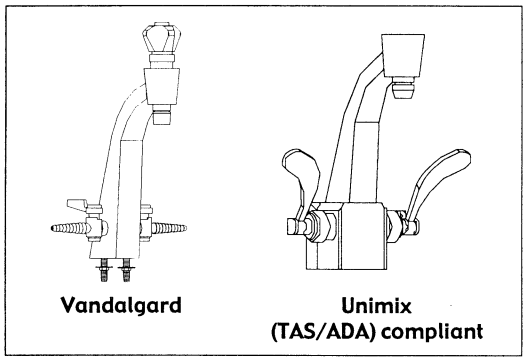


Figure 3.25
Unicast faucets

The vacuum breaker, shown in Figure 3.23, may be required by local code. This device, when attached to the faucet, will help prevent contaminated water from being sucked into the water line. The faucets shown in Figure 3.26 have the vacuum breaker built into the faucet's neck.

Vacuum breakers are recommended for chemistry laboratories where serrated hose connections are used.

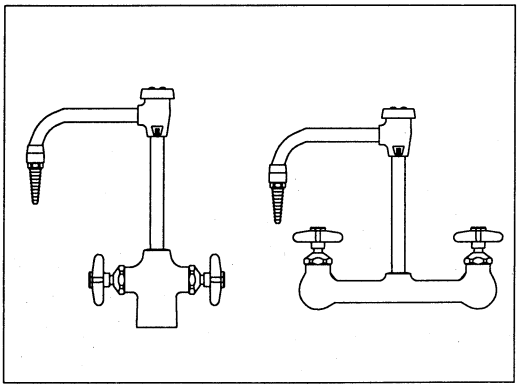


Figure 3.26
Faucets with vacuum breakers

The TAS/ADA requires that at least one sink be equipped with a faucet that is compliant with federal laws on access by wheelchair-bound students and teachers (Figure 3.27).

The faucet in Figure 3.27 provides TAS/ADA-compliant wrist handles. Instead of having to twist the valve handle to get the water to flow, the user only has to push against the wrist handles.

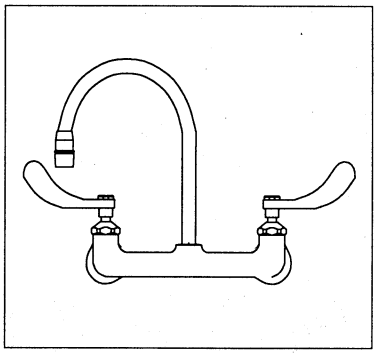


Figure 3.27
Faucets with TAS/ADA-compliant handles

Gooseneck faucets may be mounted to the panel behind the sink, as shown in Figure 3.28. The neck portion usually swivels; however, a stationary neck is also an option. In addition, panel-mounted faucets must meet TAS/ADA forward reach requirements.

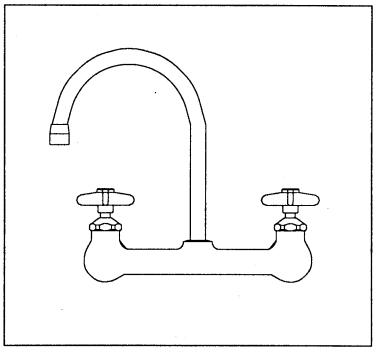


Figure 3.28
Gooseneck faucet (panel mounted)

Making a Choice

Before selecting faucets for your classroom or laboratory, consider the following questions.

- What style of faucet is needed for each type of laboratory and classroom?
- How many faucets should be equipped with TAS/ADA-compliant wrist handles?
- Which faucets should have protective coatings added to make them corrosion-resistant?
- How many faucets should provide both cold and hot water?

Gas Jets

Purpose

Access to natural gas should not be limited to high school science laboratories. Some school districts have eliminated natural gas lines in kindergarten–grade 8 classrooms and laboratories for safety reasons. A better solution would be to make natural gas available for the teacher's use—along the perimeter of the room or at the demonstration table—but not for student use at laboratory stations.

Teacher demonstrations should familiarize students with the uses of natural gas in laboratory investigations. Many investigations can be completed using hot plates rather than natural gas. *Under no circumstances should alcohol lamps be used as heat sources by any student.*

Types

Natural gas jets are manufactured in several configurations and can serve one to four Bunsen burners at one location (Figure 3.29).

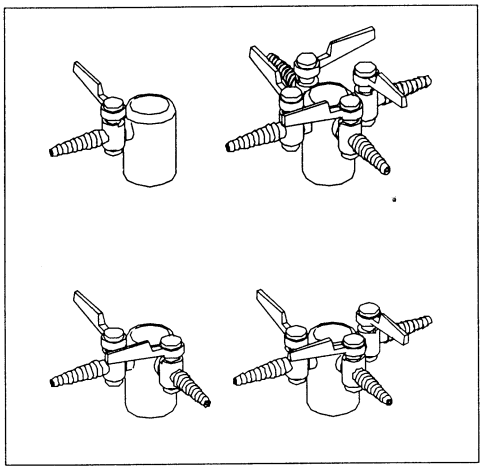


Figure 3.29
Natural gas jets

Some types of gas jets require annual cleaning and replacement of the grease that lubricates the valves. In addition, water may condense in the gas lines and prevent the flow of gas to the laboratory station. The water may need to be vacuumed from the gas line if the pressure in the gas line is not sufficient to force it out.

According to the Texas Accessibility Standards and the Americans with Disabilities Act, five foot-pounds of force or less are required to open a gas valve.

A problem common in science laboratories where gas jets are located is students inserting a pencil into the end of the gas jet and breaking off the pencil lead. The broken piece of pencil lead can block the flow of natural gas. It can be removed by disassembling the gas valve and inserting a piece of stiff wire into the jet to push the pencil lead free.

> The master utility gas valve must be turned to the off position before a gas jet valve is removed.

It is important to inspect all gas jets daily before leaving the laboratory. The teacher must confirm that all jet valves are in the closed position. *A room full of natural gas is very dangerous and needs only an ignition source to turn into a disaster.*

Storage and Display Cabinets

Purpose

Students require a variety of equipment and materials in order to do investigations and learn science concepts. Equipment and materials must be cared for properly and stored in well-designed cabinets.

Planners should use caution when deciding on the number and type of cabinets to install permanently in a laboratory room. The Texas Essential Knowledge and Skills can help planners determine what styles and quantities are needed. However, administrators and teachers must realize that the curriculum will not remain the same throughout the life of the room. Flexibility—in design as well as in considering what may be taught in the laboratory room—is an important factor that should be part of the planning process.

Types

Cabinets can be constructed from materials such as solid wood, pressed wood, plywood, metal, or polyethylene. They may be coated with protective paints or epoxy to further protect the construction materials. Inexpensive cabinets and shelves may cause problems if used in ways they were not intended. For example, it is not advisable to use a solid metal cabinet in the chemical storage room because of the corrosive nature of the chemicals.

Upper and Base Cabinets

Upper cabinets are useful for storing equipment and specimens and for displaying items that generate curiousity. Laboratory rooms should stimulate the mind as well as serve as place where students conduct investigations and science activities.

Selecting only tall cases may eliminate valuable countertop workspace. A better solution might be to use upper cabinets and base cabinets, thus providing ample storage for equipment and materials as well as needed workspace (Figure 3.30).

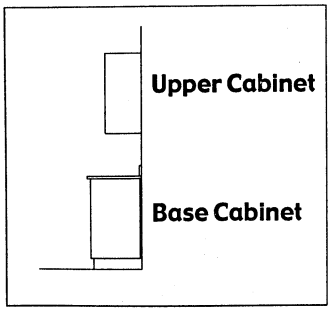


Figure 3.30
Upper and base cabinets

There are as many different configurations of base cabinets as the imagination can create. The types of cabinets that are installed should reflect the activities that are required in the curriculum and should be TAS/ADA compliant.

Integrated Physics and Chemistry, for example, requires the use of apparatus and chemicals for the physics and chemistry investigations. Base cabinet tops may be used as a student workspace where students can place the chemicals they are using during their laboratory time. The surface of the cabinets must be acid resistant.

The base cabinets in Figure 3.31 represent four of the configurations that are available. During the room design planning process, teachers should work with the architect to select the cabinets for their laboratory rooms.

Cabinets with same-size drawers or shelves may not serve a teacher's needs as well as cabinets with different-size drawers or shelves would (Figure 3.31).

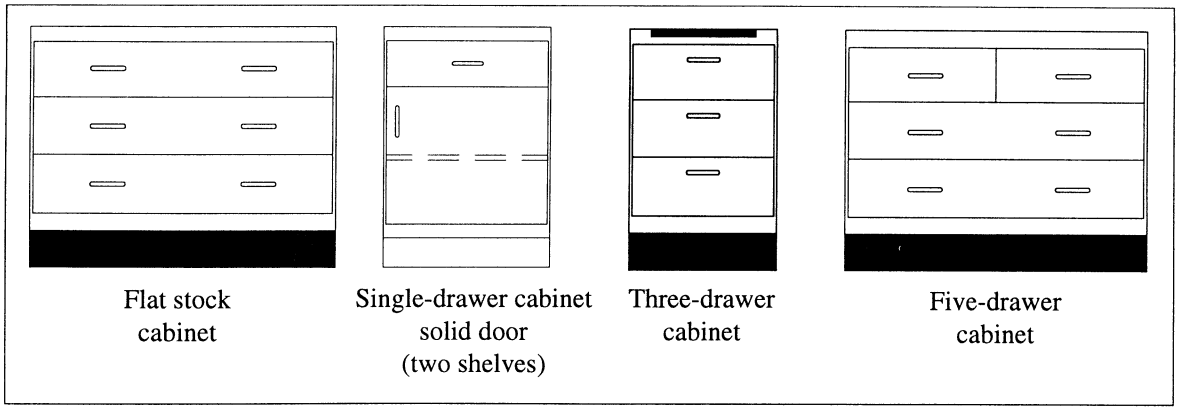


Figure 3.31
Base cabinets

Tall Cases

Tall cases are useful for storing and displaying larger items, such as human torso models and skeletons, long pieces of glass tubing, microscopes, models, charts, etc. Figures 3.32 and 3.33 show examples of the variety of tall cases that are available for teachers.

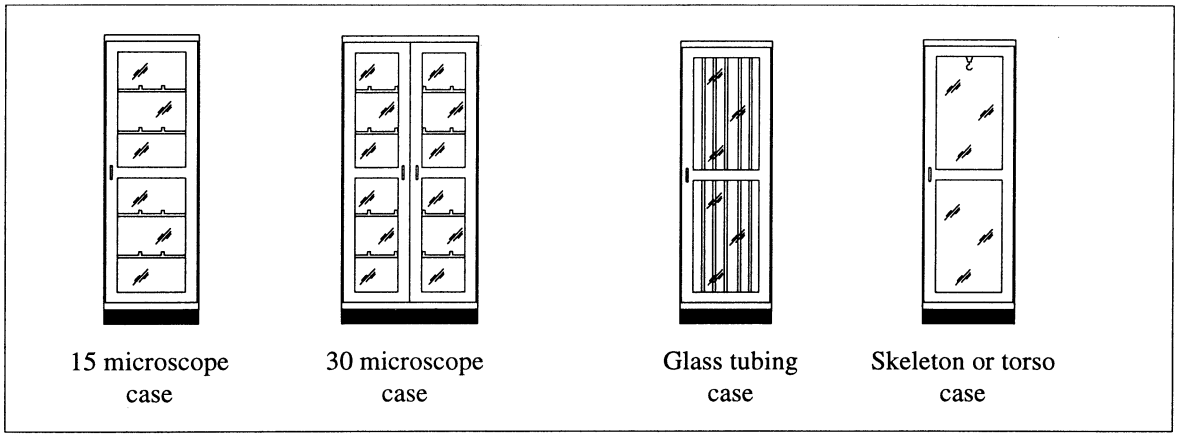


Figure 3.32
Tall display cases

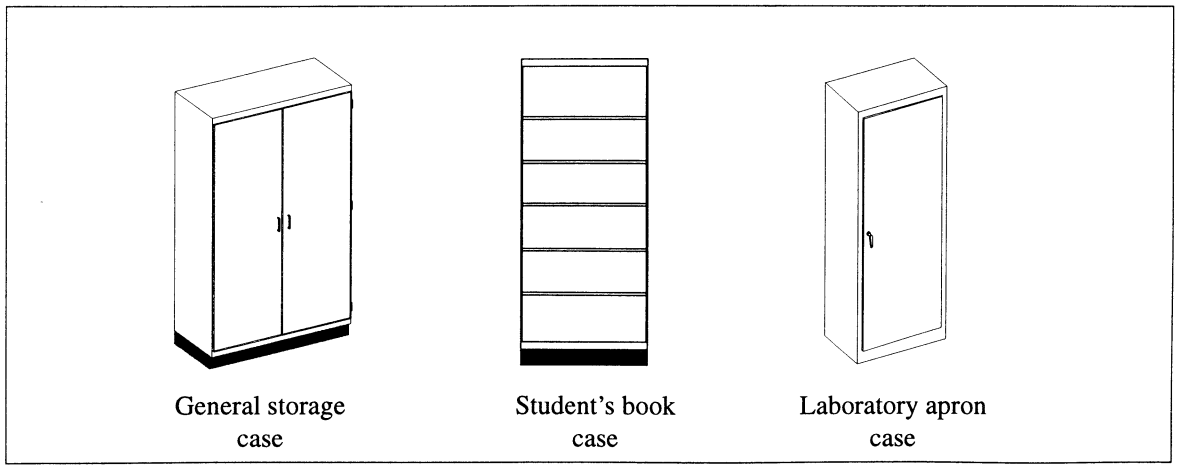


Figure 3.33
Tall storage cases

Specialty Cabinets and Shelves

In addition to the standard upper, base, and tall cabinets, there are many specialty shelves that can be used in the science laboratory. Plastic or fiberglass trays for holding loose items, sometimes called tote trays, can be stored conveniently in cabinets (Figure 3.34). If space becomes a problem in the preparation and storage rooms, select high-density storage shelves that are on tracks. These can be moved easily and stacked next to each other to take up less space in the room (Figure 3.35). If an assembly of shelves is more than 6' in length, a mechanical assisted carriage is recommended to help move the shelves more easily.

Chemical storage requires a much different type of shelving (Figure 3.36). These shelves should be shallow—approximately 8" to 12" deep—and protected with corrosive- and scratch-resistant paint. No metal shelving or metal brackets should be used in the chemical storage room.

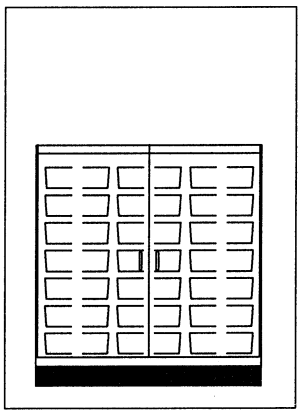


Figure 3.34
Tray storage cabinet

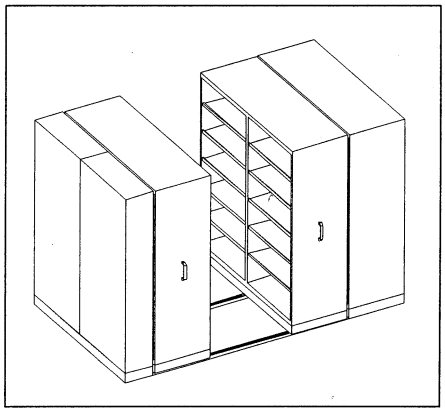


Figure 3.35
High-density shelving

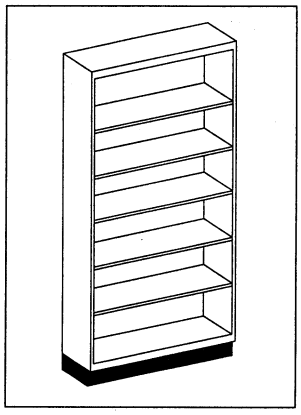


Figure 3.36
Chemical reagent storage shelves

Making a Choice

Before selecting cabinets or shelf units for your classroom or laboratory, consider the following questions.

- What types of activities do the Texas Essential Knowledge and Skills require to be conducted in the laboratories?
- What types of cabinets will meet students' needs?
- Of what type of material should the base cabinet tops be composed?
- Will upper and tall cabinets be used for display as well as for storage? If so, how many are needed?
- Will humidity cause problems with the material of which the cabinet is made?
- Does the height of at least one base cabinet top meet TAS/ADA regulations for side reach?
- Will locks be needed on the cabinets?
- Is there ample countertop workspace available?

Specialty Equipment

Each laboratory room is unique. The materials and equipment needed to teach life science differ from those needed to teach physics. They may not be standard items found in every laboratory room. There are as many different pieces of specialty equipment as there are different types of cabinets.

Sliding Marker Boards

Dry marker boards are replacing most of the chalkboards used in classrooms and laboratory rooms. The production of dust particles that interfered with electronic equipment caused alternatives to the chalkboard to be developed. The sliding dry marker board (Figure 3.37) uses panels that move into a stacking position, thus saving space while providing ample space for the teacher to write.

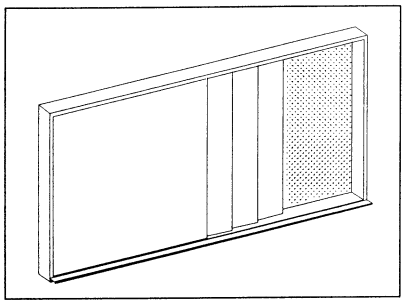


Figure 3.37
Sliding dry marker board

The dry marker board can also be found with storage space behind the board, as shown in Figure 3.38.

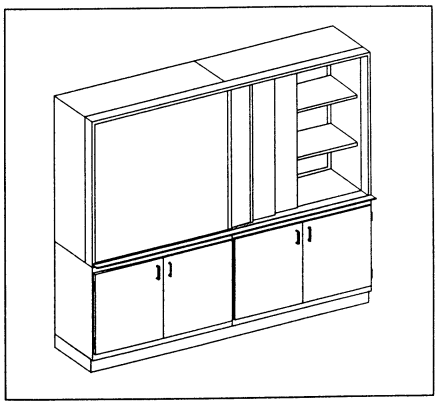


Figure 3.38
Sliding dry marker with storage space

Live Organism Study Centers

Aquarium and terrarium study centers allow students to study live organisms in a natural setting (Figure 3.39). This unit should be located near a window so that natural light can reach the plants.

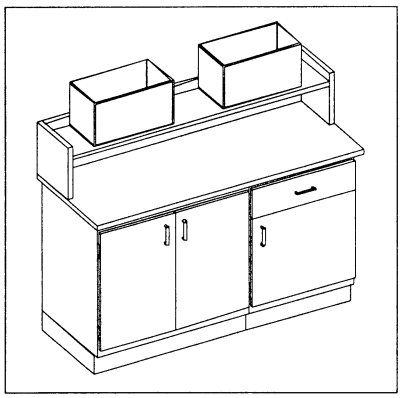


Figure 3.39
Live organism study center

A mobil marine study center (Figure 3.40) can be moved to different areas of the laboratory or classroom for student observations or for cleaning. This unit also allows access to live organisms by several science classes that may not be equipped to properly care for live organisms.

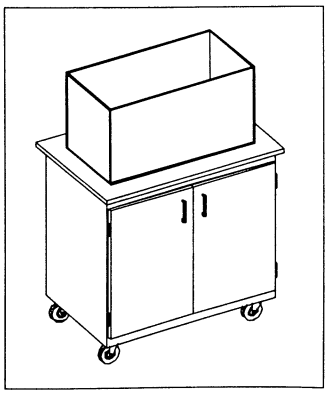


Figure 3.40
Mobile marine study center

The Texas Essential Knowledge and Skills require that students at certain grade levels study living plants and animals. These plants and animals must be kept in the laboratory or classroom in ways that are not dangerous or detrimental to their health (Figures 3.41–3.43).

Climate-controlled chambers are available that allow the students to work with living organisms and make observations without jeopardizing the safety or health of the plant or animal.

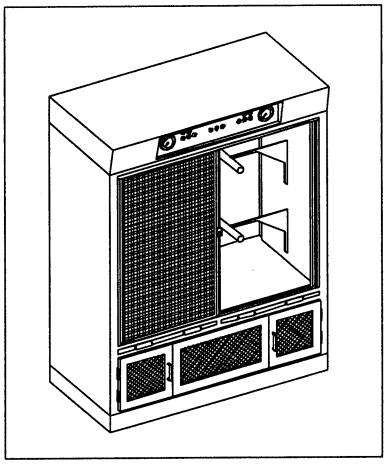


Figure 3.41
Animal study center

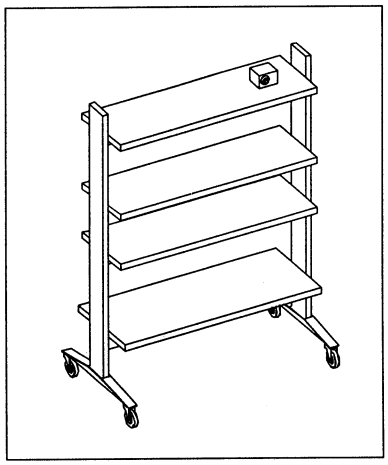


Figure 3.42
Plant study center

Emergency Shower/Eyewash Cabinet

Emergency showers and eye/face wash stations can be contained in a cabinet unit, as shown in Figure 3.43. This cabinet contains a TAS/ADA-compliant emergency shower and eyewash station with a fixed shelf for a fire blanket or first-aid kit.

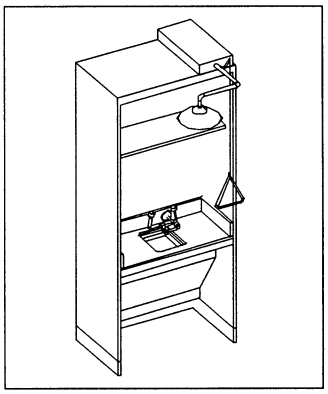


Figure 3.43
Safety center
(TAS/ADA compliant)

Chapter 4
ROOM DESIGN STANDARDS

This chapter presents the minimum standards for designing and building science facilities. These standards were developed, in part, from information provided by the Texas Education Agency, the National Science Teachers Association, and other professional organizations and manufacturers of laboratory facilities and equipment. They are also based on research conducted by the Charles A. Dana Center and published in the 2001 report, *An Analysis of Laboratory Safety in Texas*.

> "It is in science classrooms and laboratories that students work, learn, and experience real science, using the tools and practicing the skills and habits of mind that encourage science learning. Students form their first and most lasting impressions of the importance of science there."
>
> National Science Teachers Association,
> *NSTA Guide to School Science Facilities*, 1999

The floor plans, included in this manual, are meant to generate discussion among the design team. They are not intended to be used by school districts as drawn.The chapter also includes tables intended to clarify these standards; these should be used to determine the square footage per pupil for science classrooms, laboratory rooms, lecture/laboratory rooms, and preparation and storage rooms.

Classroom Standards

The Texas Education Agency (TEA) has established minimum-square-foot requirements for science classrooms. In addition, it limits the number of students in kindergarten–grade 4 classrooms to 22. However, TEA does not set limits on the number of students in grades 5–12 science classes.

According to TEA, prekindergarten–grade 1 classrooms are required to provide 36 square feet per pupil or a classroom of at least 800 square feet. At the elementary school level, grades 2–5 are required to provide 30 square feet per pupil or a classroom of at least 700 square feet. Middle school and high school classroom (grades 6–12) are required to provide 28 square feet per pupil or a room of at least 700 square feet.

Table 4.1 presents the *recommended minimum standards* for the square feet needed in a standard science classroom.

If the number of students in prekindergarten–grade 4 exceeds 22, an additional 36 square feet of space should be added per student. An additional 38 square feet per student should be added in grades 5–12 if the number of students exceeds 24.

Table 4.1

Science Classroom Standards		
Grade levels	Minimum square feet per room	Square feet per student
Prek–1	800 sq. ft.	36 sq. ft.
2–4	800 sq. ft.	36 sq. ft.
5–8	900 sq. ft.	38 sq. ft.
9–12	950 sq. ft.	38 sq. ft.

Laboratory Room Standards

The Texas Administrative Code, Commissioner's Rules Concerning School Facilities, Chapter 61 (Appendix A) does not establish a minimum standard for a science laboratory room. The following recommendations were developed from position statements of professional organizations and recommendations from the Texas Education Agency. Tables 4.2–4.4 establish the *recommended minimum standards* for a science laboratory.

The following floor plan (Figure 4.1) can be used as a guide to calculate the correct square feet for a standard laboratory room, storage/preparation room, and chemical storeroom for kindergarten–grade 12. (The chemical storeroom is not necessary in kindergarten–grade 5.)

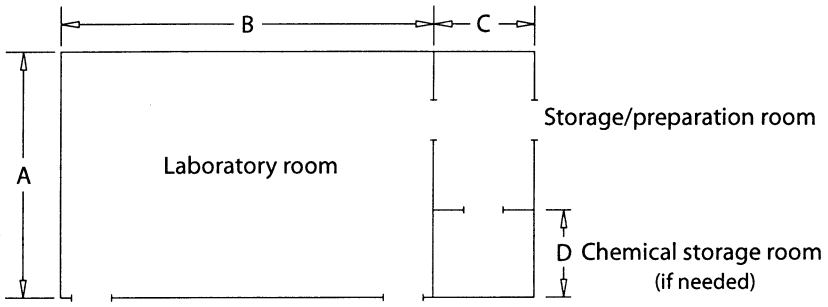


Figure 4.1
Laboratory room floor plan

If the total floor space required for an elementary laboratory room that will serve 22–24 students is 1000 square feet, then A x B must equal 1000 square feet. The storage/preparation room requires an additional 200 square feet, or 20 percent of the 1000 square feet of the laboratory room.

If a chemical storage room is needed—in grades 6–12, for example—, it should be no less than 8 feet of the total space required for the storage/preparation room. The measurements are inside dimensions.

Elementary School

Laboratory rooms for kindergarten–grade 5 should be designed using 40 square feet per student as the standard, with 1000 square feet as the minimum size. For example, an elementary laboratory room that accommodates 24 students or fewer should not be smaller than 1000 square feet.

The storage room, including a preparation area and equipment storage room, should be equal to 20 percent of the usable square feet of the laboratory room (Table 4.2).

Table 4.2 uses a range of 24 to 30 students; however, it is recommended that an elementary school science laboratory contain no more than 22 students in prekindergarten–grade 4 and no more than 24 in grade 5.

One laboratory workstation should be provided for each student

Table 4.2

Kindergarten–Grade 5		
Number of students	Square feet per room	Additional storage space
24	1000 sq. ft.	200 sq. ft.
26	1040 sq. ft.	208 sq. ft.
28	1120 sq. ft.	224 sq. ft.
30	1200 sq. ft.	240 sq. ft.

Middle School

Laboratory rooms designed for grades 6–8 should be 45 square feet per student, with 1100 square feet as the minimum size. For example, a middle school laboratory room that accommodates 24 students or fewer should not be smaller than 1100 square feet.

The storage room should be equal to 20 percent of the usable square feet of the laboratory room (Table 4.3).

Table 4.3 uses a range of 24 to 30 students; however, it is recommended that no middle school science laboratory room contain more than 26 students at one time.

One laboratory workstation should be provided for each student.

If the number of students in grades 6–8 exceeds 24, an additional 45 square feet of space per student should be added. In addition, storage space must increase proportionately.

Table 4.3

Grades 6–8		
Number of students	Square feet per room	Additional storage space
24	1100 sq. ft.	220 sq. ft.
26	1170 sq. ft.	234 sq. ft.
28	1260 sq. ft.	252 sq. ft.
30	1350 sq. ft.	270 sq. ft.

High School

Laboratory rooms designed for grades 9–12 should use 50 square feet per student as the standard, with 1200 square feet as the minimum size. For example, a high school laboratory room that accommodates 24 students or fewer should not be smaller than 1200 square feet.

The laboratory room should include an additional storage room that is equal to 20 percent of the usable square feet of the laboratory room (Table 4.4). Chemical storage rooms should be equal to one-fourth of the storage room space.

Table 4.4

Grades 9–12		
Number of students	Square feet per room	Additional storage space
24	1200 sq. ft.	240 sq. ft.
26	1300 sq. ft.	260 sq. ft.
28	1400 sq. ft.	280 sq. ft.
30	1500 sq. ft.	300 sq. ft.

Table 4.4 uses a range of 24 to 30 students; however, it is recommended that no high school science laboratory room contain more than 26 students at one time.

One laboratory workstation should be provided for each student.

If the number of students increases, the storage space must increase at a rate of 20 percent of the usable square feet contained in the laboratory room.

Lecture/Laboratory Room Standards

A lecture/laboratory room is one that is designed to support both classroom activities and laboratory investigations. It must provide student workstations that have access to electricity, water, and natural gas, as well as other features associated with a stand-alone science laboratory. A separate area within the room serves as a classroom, with student desks and other features found in a stand-alone science classroom.

In addition to establishing minimum standards for classrooms, Chapter 61 of the Texas Administrative Code provides minimum standards for science lecture/laboratory rooms (Appendix A). Chapter 1 details the contents of these minimum standards.

Tables 4.5–4.7 establish the *recommended minimum standards* for lecture/laboratory rooms.

The following floor plan can be used as a guide to calculate the correct square feet for a standard lecture/laboratory room with accompanying storage/preparation room and chemical storeroom for grades 6–12.

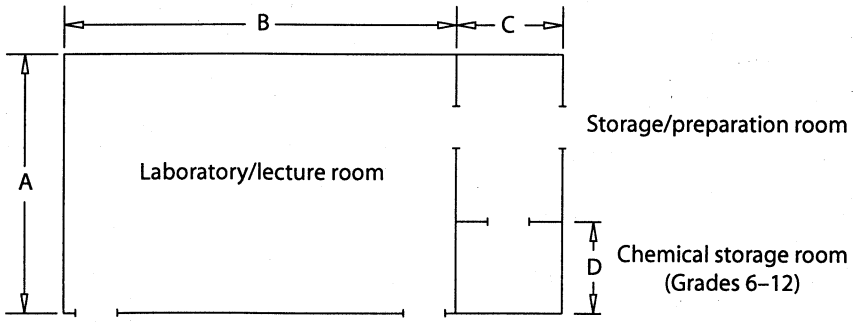


Figure 4.2
Laboratory/lecture room floor plan

Elementary School Level

Lecture/laboratory rooms for kindergarten–grade 5 should be designed using 45 square feet as the minimum standard, with 1100 square feet as the minimum size.

If the number of students in prekindergarten–grade 5 exceeds 24, an additional 45 square feet of space per student should be added.

All dedicated storage rooms should be equal to 20 percent of the usable square feet of the lecture/laboratory room (Table 4.5).

One laboratory workstation should be provided for each student.

Table 4.5

Kindergarten–Grade 5		
Number of students	Square feet per room	Additional storage space
24	1100 sq. ft.	220 sq. ft.
26	1170 sq. ft.	234 sq. ft.
28	1260 sq. ft.	252 sq. ft.
30	1350 sq. ft.	270 sq. ft.

Middle School

Lecture/laboratory rooms for grades 6–8 should be designed using 50 square feet as the minimum standard, with 1200 square feet being the minimum size. An additional 240 square feet of space, or 20 percent of the lecture/laboratory room, is required for storage (Table 4.6).

If the number of students in grades 6–8 exceeds 24, an additional 50 square feet of space per student should be added. In addition, storage space must increase proportionately.

One laboratory workstation should be provided for each student.

Table 4.6

Grades 6–8		
Number of students	Square feet per room	Additional storage space
24	1200 sq. ft.	240 sq. ft.
26	1300 sq. ft.	260 sq. ft.
28	1400 sq. ft.	280 sq. ft.
30	1350 sq. ft.	300 sq. ft.

High School

Lecture/laboratory rooms for grades 9–12 should be designed using 55 square feet as the minimum standard, with 1300 square feet as the minimum size. An additional 260 square feet of space, or 20 percent of the lecture/laboratory room, is required for storage (Table 4.7).

Chemical storage rooms should be equal to one-fourth of the space dedicated for storage.

If the number of students in grades 9–12 exceeds 24, an additional 55 square feet of space per student should be added. In addition, storage space must increase proportionately.

One laboratory workstation should be provided for each student.

Table 4.7

Grades 9–12		
Number of students	Square feet per room	Additional storage space
24	1300 sq. ft.	260 sq. ft.
26	1430 sq. ft.	286 sq. ft.
28	1540 sq. ft.	308 sq. ft.
30	1650 sq. ft.	330 sq. ft.

Comparing Minimum Standards

Tables 4.8–4.10 provide a quick comparison of the recommendations from the National Science Teachers Association, the rules established by the Texas Education Agency, and the recommended standards presented in this chapter. These represent minimum standards; school districts are encouraged to go beyond these standards when constructing new science facilities or renovating existing facilities.

Table 4.8

Minimum Square Feet for Science Classrooms			
Grade level	National Science Teachers Association recommendations[1]	Texas Education Agency Commissioner's Rules[2]	Recommended standards[3]
Prekindergarten–Grade 1	No recommendation	36 square feet/pupil (or) 800 square feet/room	36 square feet/pupil (or) 800 square feet/room
Grades 2–5	No recommendation	30 square feet/pupil (or) 700 square feet/room	36 square feet/pupil (or) 800 square feet/room
Grades 6–8	No recommendation	28 square feet/pupil (or) 700 square feet/room	38 square feet/pupil (or) 900 square feet/room
Grades 9–12	No recommendation	28 square feet/pupil (or) 700 square feet/room	38 square feet/pupil (or) 950 square feet/room

Table 4.9

Minimum Square Feet for Science Laboratory Rooms			
Grade level	National Science Teachers Association recommendations[1]	Texas Education Agency Commissioner's Rules[2]	Recommended standards[3]
Prekindergarten–Grade 1	40 square feet/pupil 1000 square feet/room	No rules	40 square feet/pupil (or) 1000 square feet/room
Grades 2–5	40 square feet/pupil 1000 square feet/room	No rules	40 square feet/pupil (or) 1000 square feet/room
Grades 6–8	45 square feet/pupil 1125 square feet/room	No rules	45 square feet/pupil (or) 1100 square feet/room
Grades 9–12	50 square feet/pupil 1250 square feet/room	No rules	50 square feet/pupil (or) 1200 square feet/room

Table 4.10

Minimum Square Feet for Lecture/Laboratory Rooms			
Grade level	National Science Teachers Association recommendations[1]	Texas Education Agency Commissioner's Rules[2]	Recommended standards[3]
Prekindergarten–Grade 1	45 square feet/pupil	41 square feet/pupil (or) 900 square feet/room	45 square feet/pupil (or) 1100 square feet/room
Grades 2–5	45 square feet/pupil	41 square feet/pupil (or) 900 square feet/room	45 square feet/pupil (or) 1100 square feet/room
Grades 6–8	60 square feet/pupil (or) 1440 square feet/ room	50 square feet/pupil (or) 1000 square feet/room	50 square feet/pupil (or) 1200 square feet/room
Grades 9–12	60 square feet/pupil (or) 1440 square feet/ room	50 square feet/pupil (or) 1200 square feet/room	55 square feet/pupil (or) 1300 square feet/room

[1]The National Science Teachers Association recommendations for square feet/pupil are based on 24 students at the elementary, middle, and high school levels.

[2]The Texas Education Agency Commissioner's Rules for square feet per pupil are based on 22 students at elementary school level and 25 at the middle and high school levels.

[3]The recommended standards for square feet per pupil are based on 22 students at the elementary school level and 24 at the middle and high school levels.

Science Room Designs

The following pages of classroom, laboratory room, and lecture/laboratory room **floor plans** represent only a few design examples. *These are intended to stimulate discussions among school district personnel who are responsible for designing science facilities.* Each page of floor plans contains a detailed drawing of different room arrangements using a variety of science furniture.

The items identified in the **legend** are some of the general features found in that design. Other items, such as fire extinguishers, fire blankets, etc., are not included in the drawings; however, these safety features are required by state law or local safety codes.

The **design rating scale** on each page indicates how well the design meets the state standards for laboratory designs. A circle icon to the left of the statement displays the degree to which the design satisfies that standards statement (Figure 4.3). For example, if the circle is filled, the design meets the best practice for that standard; if the circle is shaded, it is acceptable and meets most of the standard; if it is half full, the design partially meets the standard. If the circle is empty, the design does not meet the standard and is unacceptable.

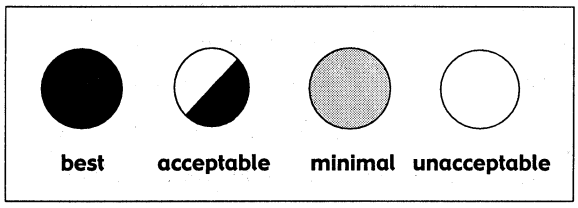
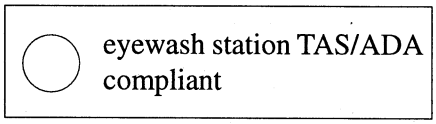
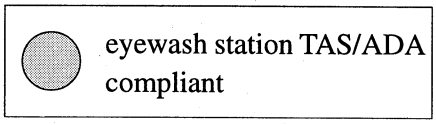


Figure 4.3
Design rating scale

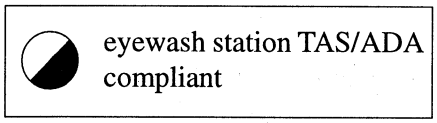
For example, if a laboratory room design does not have an eyewash station, the design rating will appear as follows:



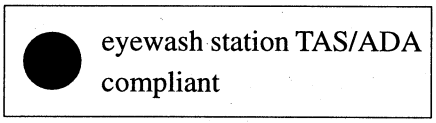
If a laboratory room design has one eyewash station, but it is not TAS/ADA compliant, the design rating will appear as follows:



If a laboratory design has one eyewash, and it is TAS/ADA compliant, the design rating will appear as follows:

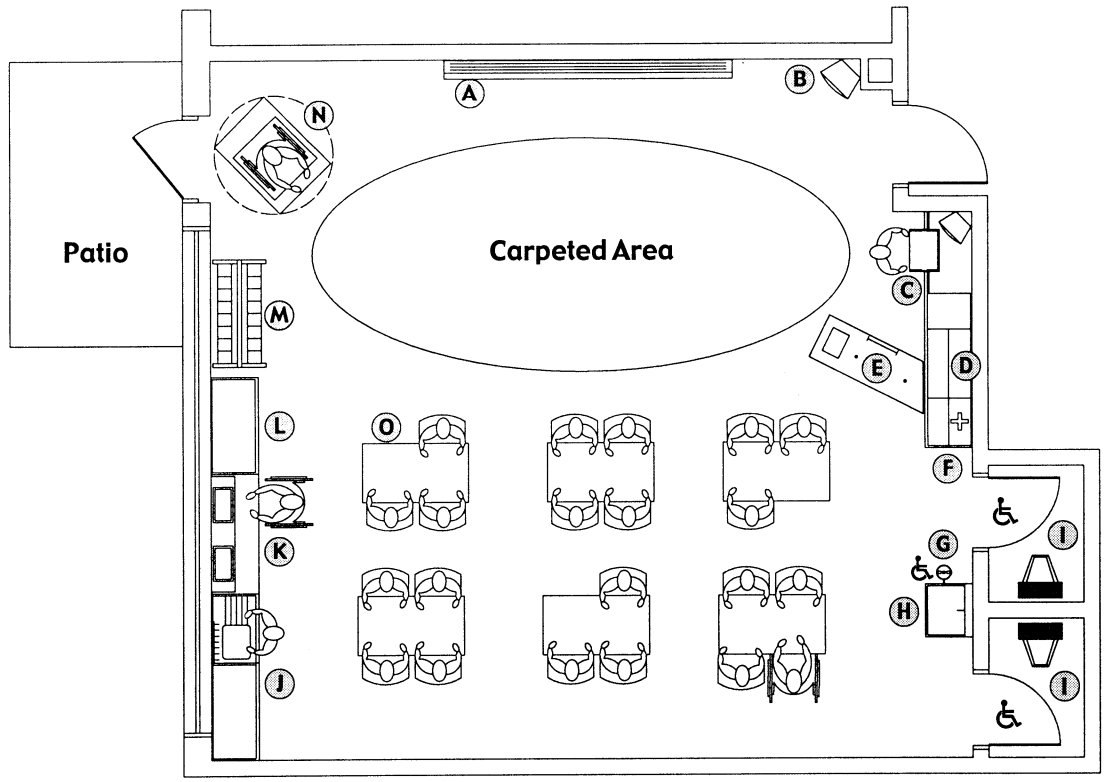


However, if the laboratory design has more than one eyewash and at least one of them is TAS/ADA compliant, the design rating will appear as follows:



Additional floor plans for classrooms, laboratory rooms, and lecture/laboratory rooms can be found in Appendix D.

Elementary School Science Classroom



ROOM DIMENSIONS: 29' x 30'

DRAWINGS MAY NOT BE TO SCALE.

Figure 4.4
Kindergarten–Grade 2

LEGEND

- (A) sliding marker board
- (B) TV monitor
- (C) computer workstation
- (D) safety goggles cabinet
- (E) mobile demonstration table
- (F) first-aid kit
- (G) eye/face wash
- (H) sink (hot and cold water)
- (I) restrooms
- (J) sink (TAS/ADA)
- (K) aquarium/terrarium
- (L) animal study center
- (M) plant study center
- (N) TAS/ADA turning area
- (O) movable student tables

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ◌ services available (electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students
- ● floor space per student
- ● eyewash station accessibility
- ◌ student access to computers
- ◌ sinks with hot and cold water
- ● student tables movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ◌ minimal ○ unacceptable

Elementary School Science Classroom

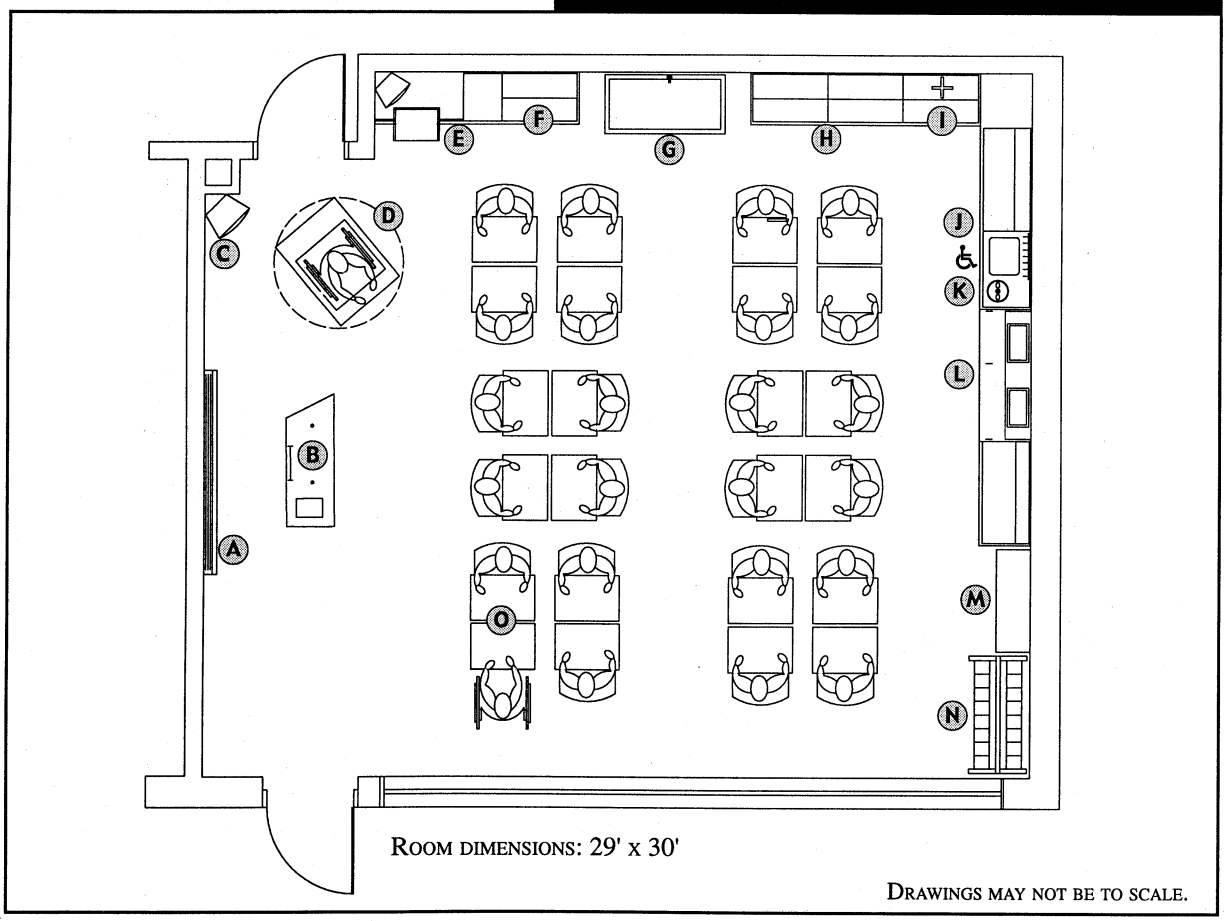


Figure 4.5
Grades 3–5

LEGEND

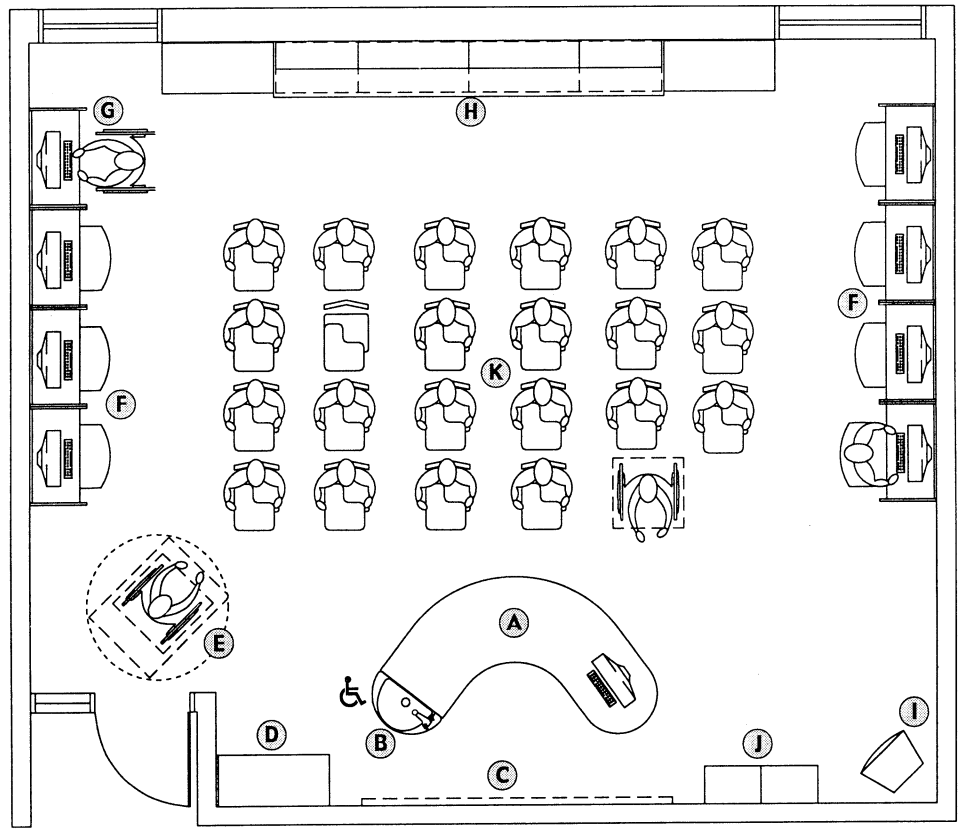
- (A) sliding marker board
- (B) mobile demonstration table
- (C) TV monitor
- (D) TAS/ADA turning radius
- (E) computer station
- (F) safety goggle cabinet
- (G) animal study center
- (H) tray storage cabinet
- (I) first-aid kit
- (J) sink (hot and cold water)
- (K) eye/fash wash
- (L) aquarium/terrarium
- (M) display/storage cabinet
- (N) plant study center
- (O) movable student tables

DESIGN RATING

- ● student workstations accessible
- ● students workstations TAS/ADA compliant
- ● traffic flow around the room
- ◍ services (electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash station accessible
- ◍ student access to computers
- ◍ sinks with hot and cold water
- ● student stations movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ◍ minimal ○ unacceptable

Secondary School Science Classroom



ROOM DIMENSIONS: 27' x 33'–9"

DRAWINGS MAY NOT BE TO SCALE.

Figure 4.6
Grades 6–12

LEGEND

- (A) fixed demonstration table
- (B) sink (TAS/ADA)
- (C) sliding marker board
- (D) teacher wardrobe
- (E) TAS/ADA turning area
- (F) computer workstations
- (G) computer workstation (TAS/ADA)
- (H) upper and base cabinets
- (I) TV monitor
- (J) models cabinet
- (K) student desks

DESIGN RATING

- student workstations accessible
- students workstations TAS/ADA compliant
- traffic flow around the room
- services (electric, water)
- services TAS/ADA compliant
- teacher's view of students clear
- floor space per student
- student access to computers
- sinks with hot and cold water
- student desks movable
- 5' turning radius for wheelchair

best · acceptable · minimal · unacceptable

Elementary School Science Laboratory

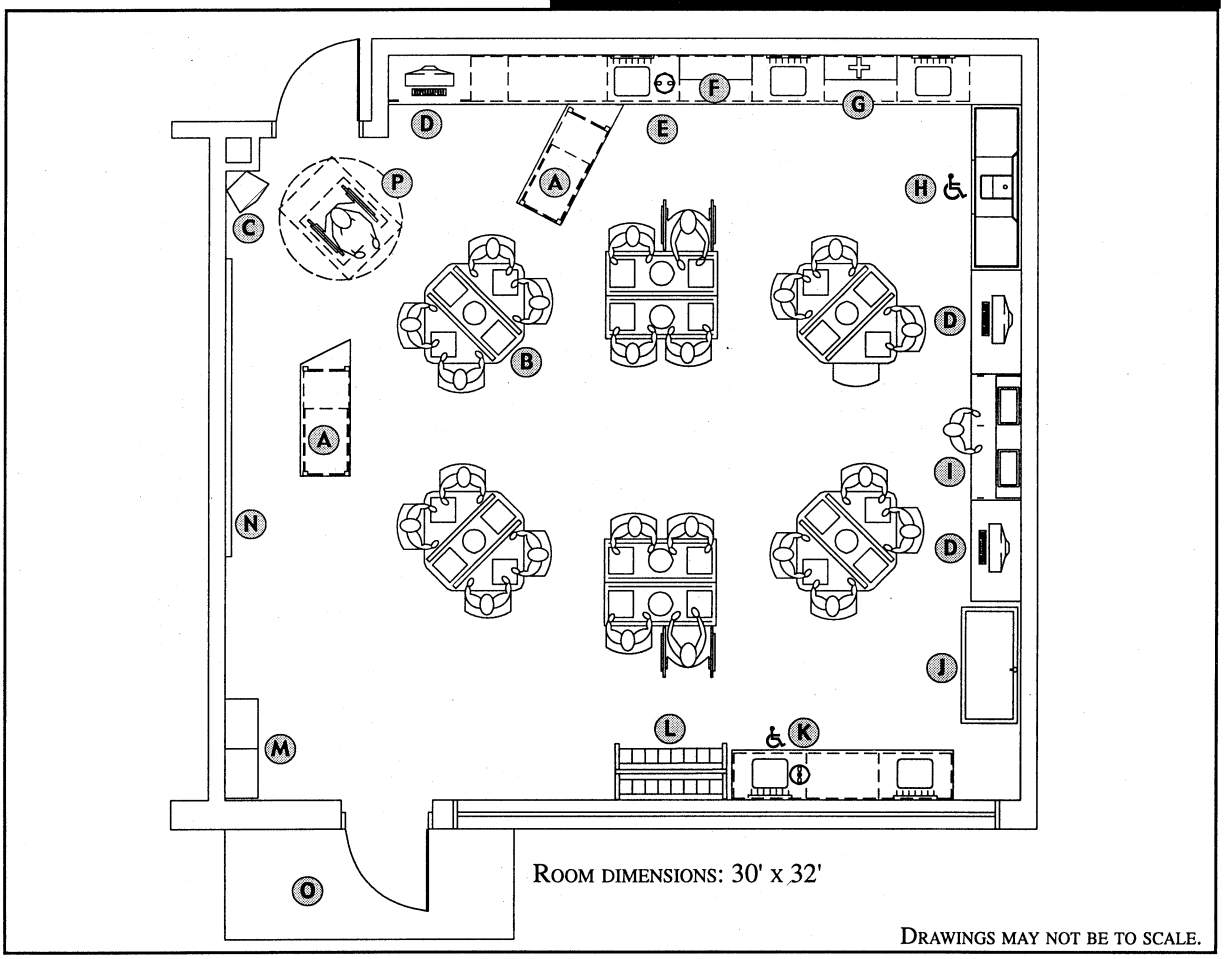


Figure 4.7
Kindergarten–Grade 2

LEGEND

- (A) mobile demonstration table
- (B) movable student workstation
- (C) TV monitor
- (D) computer workstation
- (E) sink (hot and cold water)
- (F) safety goggles cabinet
- (G) first-aid cabinet
- (H) sink (TAS/ADA)
- (I) aquarium/terrarium
- (J) animal study center
- (K) eye/face wash (TAS/ADA)
- (L) plant study center
- (M) microscope cabinet
- (N) sliding dry marker board
- (O) patio
- (P) TAS/ADA turning area

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash stations accessible
- ● student access to computers
- ● sinks with hot and cold water
- ● student stations movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ▨ minimal ○ unacceptable

Elementary School Science Laboratory

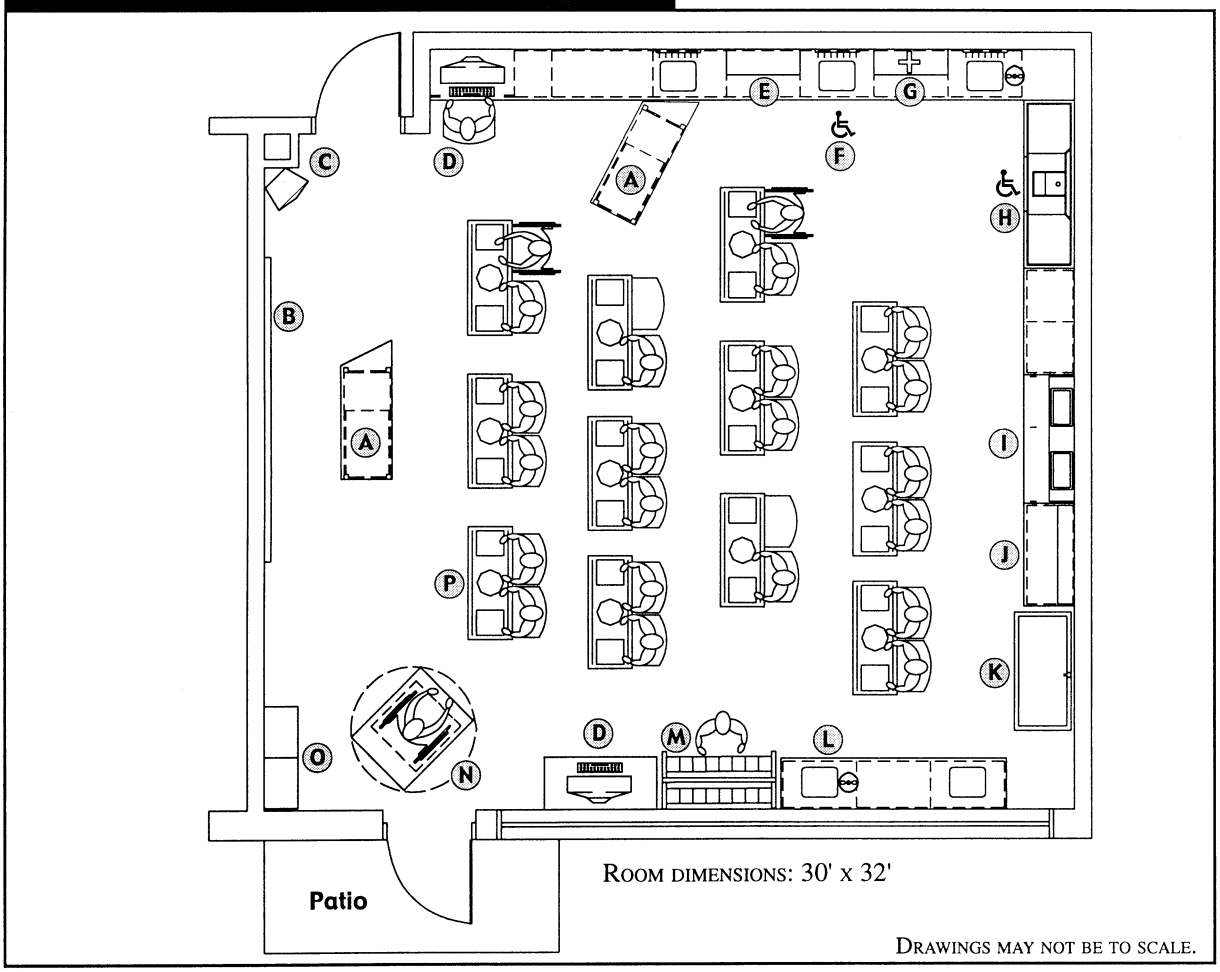


Figure 4.8
Grades 3–5

LEGEND

- Ⓐ mobile demonstration table
- Ⓑ sliding marker board
- Ⓒ TV monitor
- Ⓓ computer workstation
- Ⓔ safety goggles cabinet
- Ⓕ sink (TAS/ADA)
- Ⓖ first-aid cabinet
- Ⓗ eye/face wash (TAS/ADA)
- Ⓘ aquarium/terrarium
- Ⓙ tray storage
- Ⓚ animal study center
- Ⓛ sinks (hot and cold water)
- Ⓜ plant study center
- Ⓝ TAS/ADA turning area
- Ⓞ microscope cabinet
- Ⓟ student workstations

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash stations accessible
- ◪ student access to computers
- ● sinks with hot and cold water
- ● student stations movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ▒ minimal ○ unacceptable

Middle School Science Laboratory

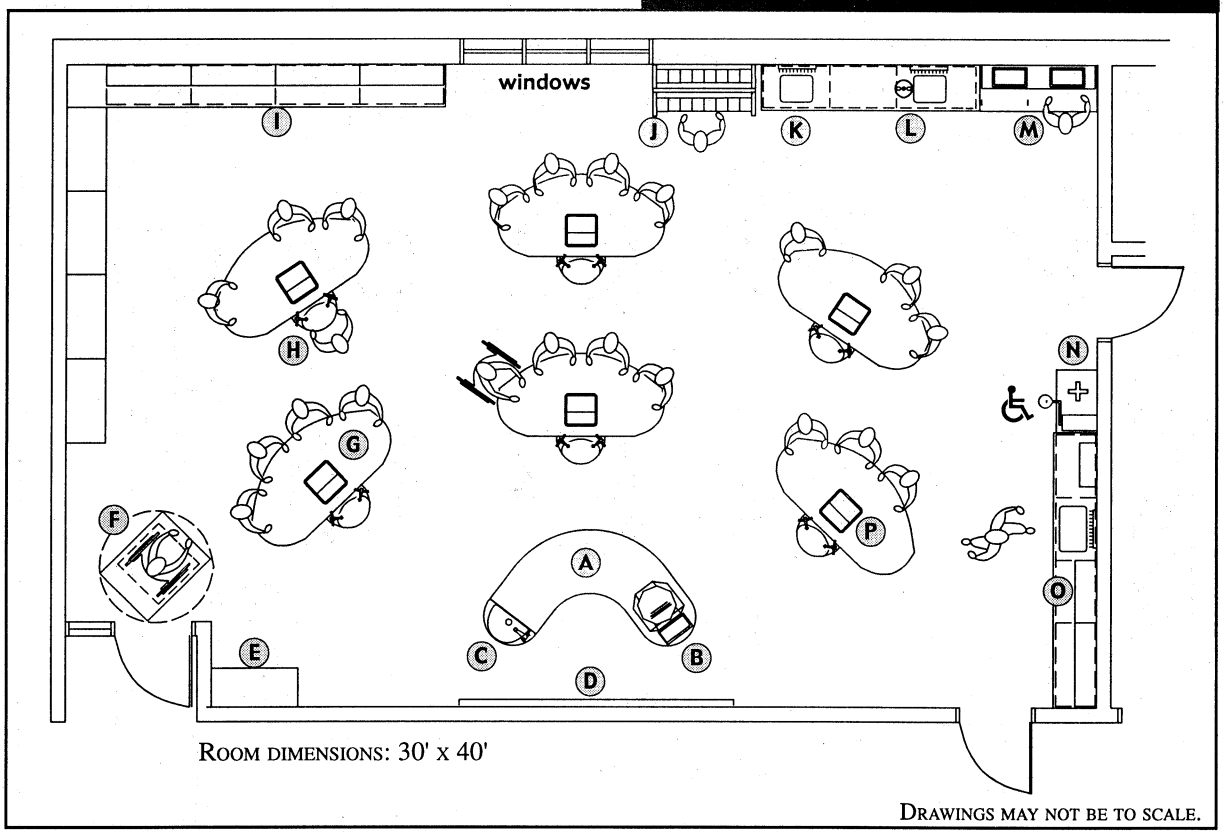


Figure 4.9
Grades 6–8

LEGEND

- (A) fixed demonstration table
- (B) computer console
- (C) sink (hot and cold water)
- (D) sliding marker board
- (E) teacher's wardrobe
- (F) TAS/ADA turning area
- (G) student workstation
- (H) TAS/ADA sink
- (I) countertop workspace
- (J) plant study center
- (K) sink (hot and cold water)
- (L) eyewash station
- (M) aquarium/terrarium
- (N) emergency shower
- (O) safety goggles cabinet
- (P) computer terminal

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash station accessible
- ● student access to computers
- ● sinks with hot and cold water
- ● student stations adjustable
- ● 5' turning radius for wheelchair

● best ◕ acceptable ◔ minimal ○ unacceptable

High School Science Laboratory

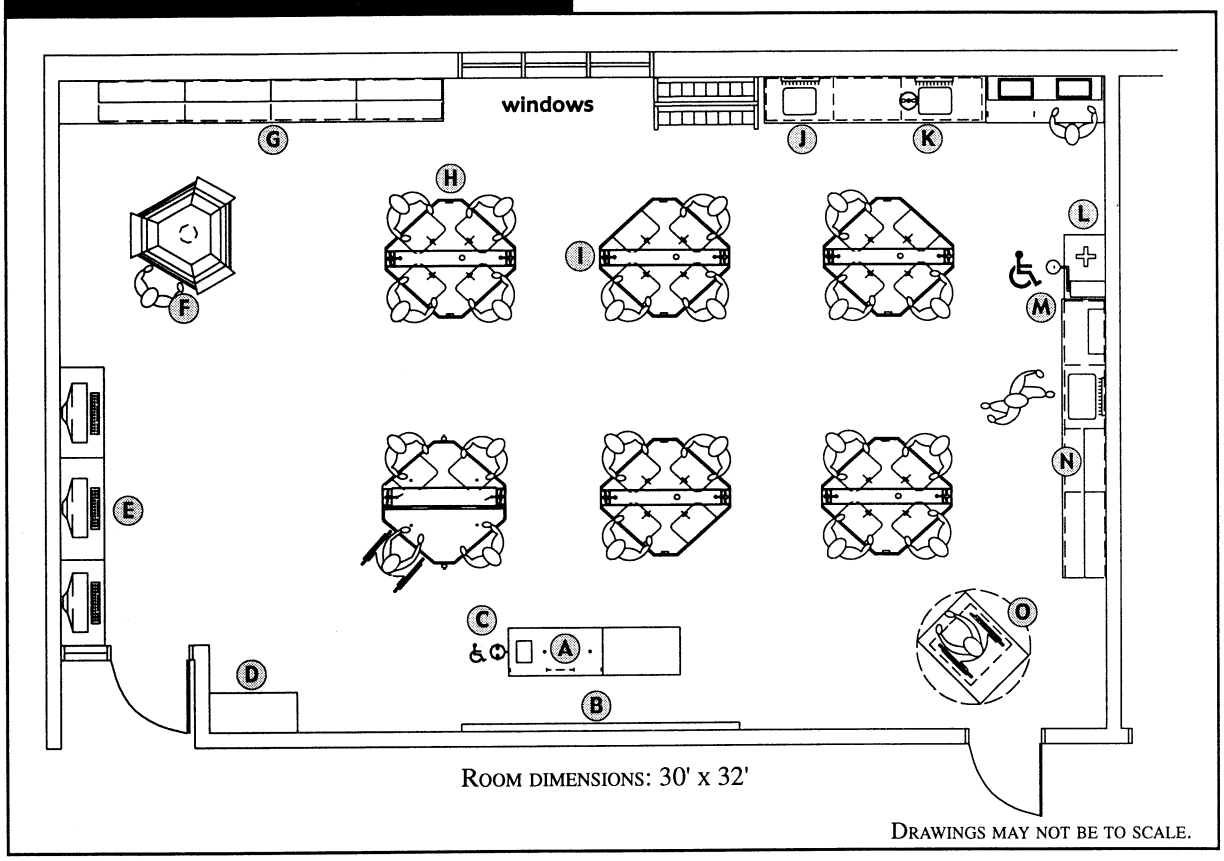


Figure 4.10
Grades 9–12

LEGEND

- (A) fixed demonstration table
- (B) sliding marker board
- (C) eyewash (TAS/ADA)
- (D) teacher wardrobe
- (E) computer stations
- (F) fume hood
- (G) storage cabinets
- (H) student workstation
- (I) trough
- (J) sink (hot and cold water)
- (K) eyewash station
- (L) first-aid kit
- (M) emergency shower
- (N) safety goggles cabinet
- (O) TAS/ADA turning area

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash/emergency shower accessible
- ◪ student access to computers
- ● sinks with hot and cold water
- ● 5' turning radius for wheelchair

● best ◪ acceptable ▒ minimal ○ unacceptable

Elementary School Lecture/Laboratory Room

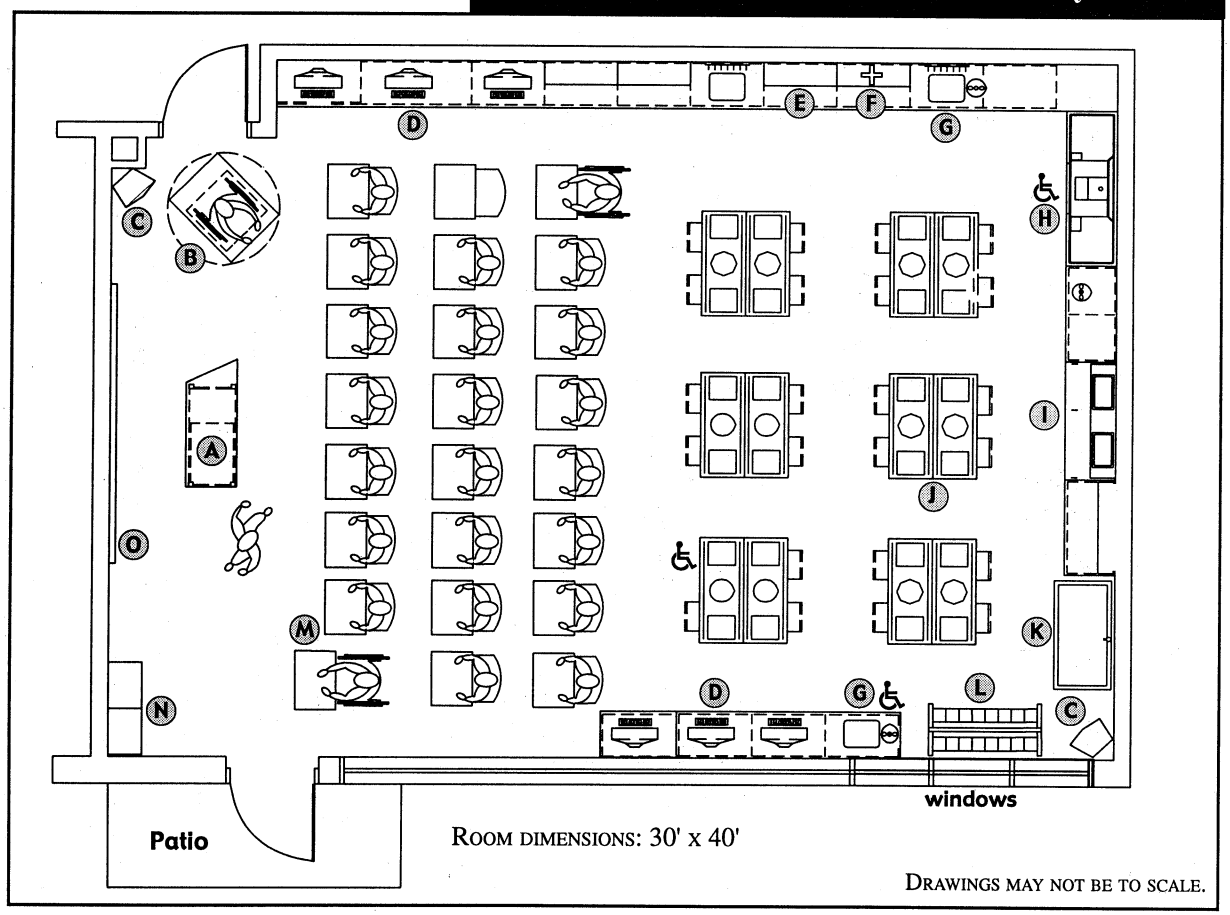


Figure 4.11
Grades 3–5

LEGEND

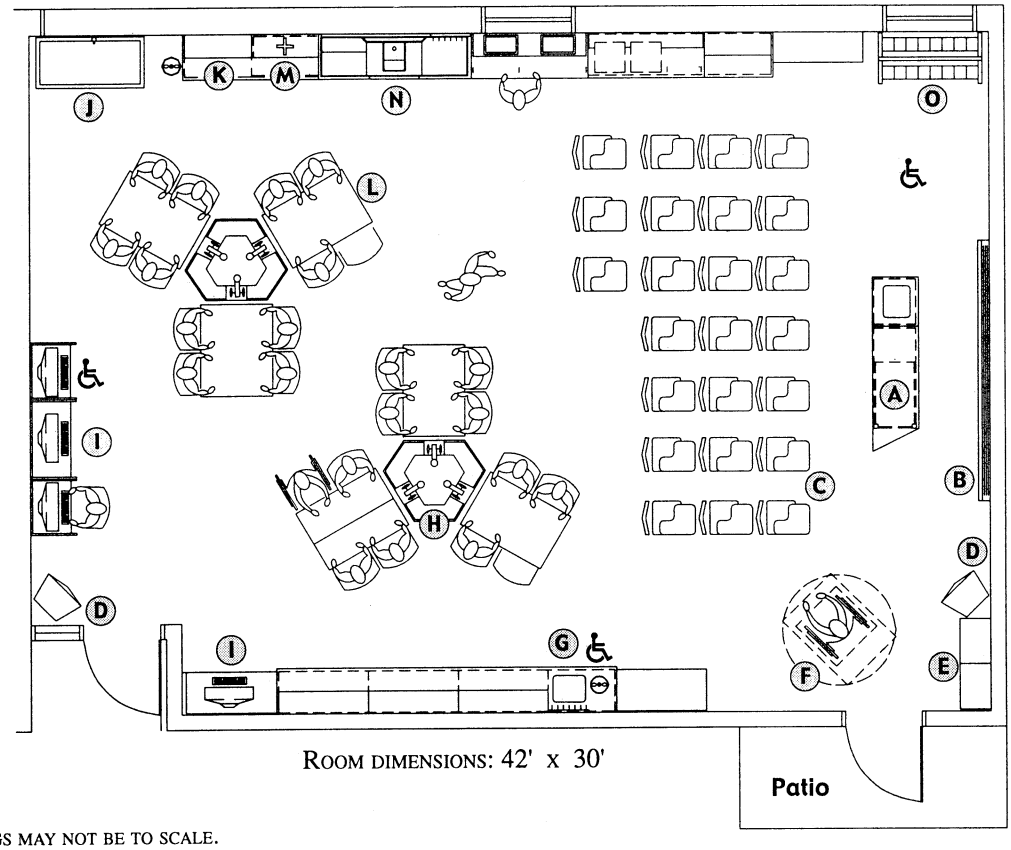
- Ⓐ mobile demonstration table
- Ⓑ TAS/ADA turning area
- Ⓒ TV monitor
- Ⓓ computer stations
- Ⓔ safety goggles cabinet
- Ⓕ first-aid cabinet
- Ⓖ sink (hot and cold water)
- Ⓗ sink (TAS/ADA)
- Ⓘ aquarium/terrarium
- Ⓙ movable laboratory tables
- Ⓚ animal study center
- Ⓛ plant study center
- Ⓜ student desks
- Ⓝ models/torso cabinet
- Ⓞ sliding marker board

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash station accessible
- ◪ student access to computers
- ● sinks with hot and cold water
- ● student workstations movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ▒ minimal ○ unacceptable

Middle School Lecture/Laboratory Room



DRAWINGS MAY NOT BE TO SCALE.

Figure 4.12
Grades 6–8

LEGEND

- (A) mobile demonstration table
- (B) sliding marker board
- (C) student desks
- (D) TV monitor
- (E) torso/skeleton cabinet
- (F) TAS/ADA turning area
- (G) sink (TAS/ADA)
- (H) sink (hot and cold water)
- (I) computer stations
- (J) animal study center
- (K) safety goggles cabinet
- (L) movable student workstation
- (M) first-aid cabinet
- (N) sink (hot and cold water)
- (O) plant study center

DESIGN RATING

- ● student workstations accessible
- ● student workstations TAS/ADA compliant
- ● traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash station accessible
- ◪ student access to computers
- ● sinks with hot and cold water
- ● student stations movable
- ● 5' turning radius for wheelchair

● best ◪ acceptable ◌ minimal ○ unacceptable

High School Lecture/Laboratory Room

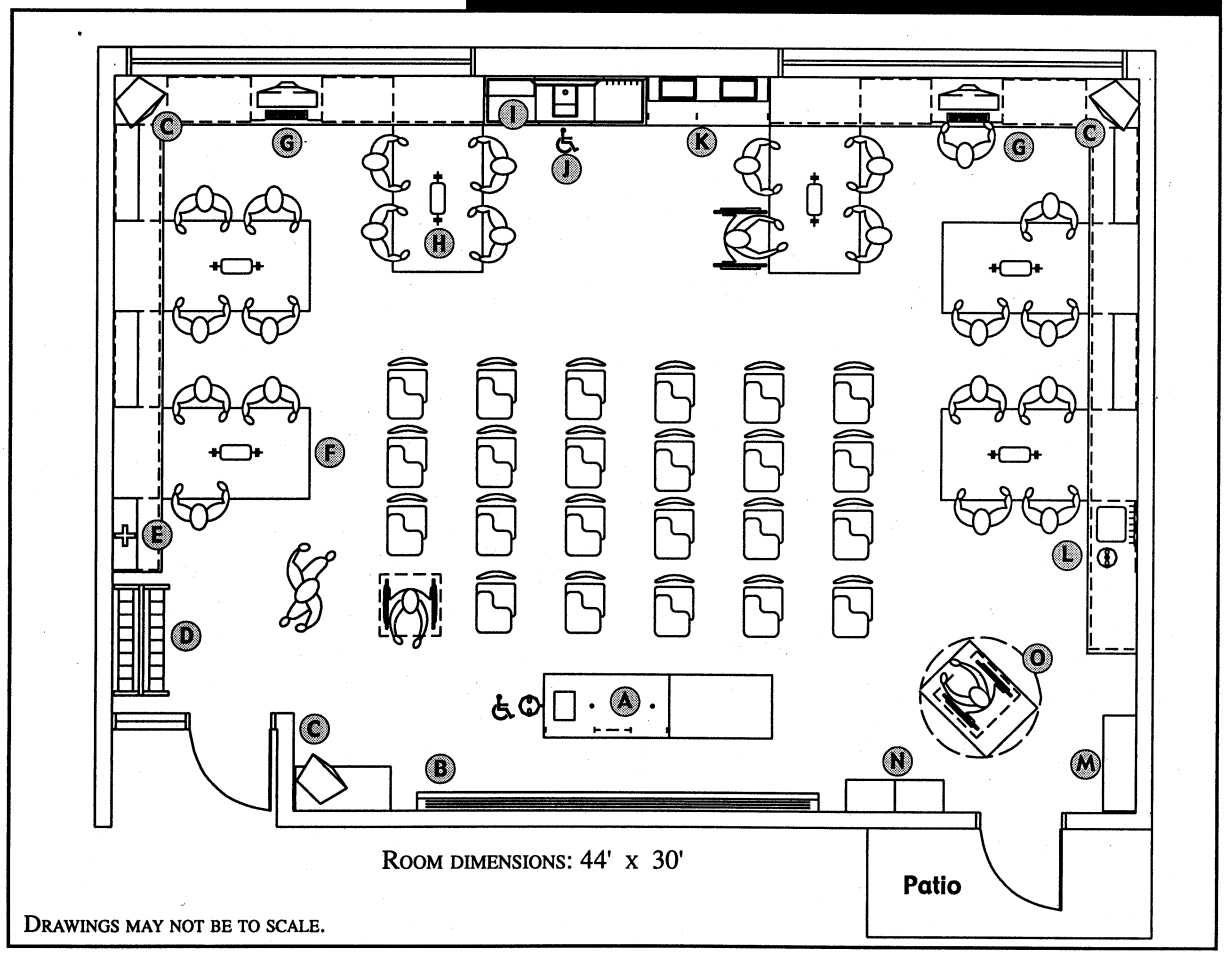


Figure 4.13
Grades 9–12

LEGEND

- (A) fixed demonstration table
- (B) sliding marker board
- (C) TV monitor
- (D) plant study center
- (E) first-aid cabinet
- (F) student workstations
- (G) computer stations
- (H) sink (hot and cold water)
- (I) safety goggles cabinet
- (J) sink (TAS/ADA)
- (K) aquarium/terrarium center
- (L) eyewash (TAS/ADA)
- (M) storage cabinet
- (N) balances cabinet
- (O) TAS/ADA turning area

DESIGN RATING

- ◪ student workstations accessible
- ● student workstations TAS/ADA compliant
- ◍ traffic flow around the room
- ● services (gas, electric, water)
- ● services TAS/ADA compliant
- ● teacher's view of students clear
- ● floor space per student
- ● eyewash station accessible
- ◍ student access to computers
- ● sinks with hot and cold water
- ● student tables movable
- ◍ 5' turning radius for wheelchair

● best ◪ acceptable ◍ minimal ○ unacceptable

Evacuating a Laboratory Room

The safety of students and teachers in any room is a priority. Examine each floor plan design for potential hazards. Consider, for example, whether students would be able to exit the room safely if a fire were to occur near a student workstation.

Below are four different designs that illustrate the ease or difficulty of evacuation that students might encounter if a fire were to occur in the laboratory room. These illustrations are intended to stimulate discussion among the contractor, school administrators, and science teachers before they finalize plans for a laboratory design and select the style of furniture for the room.

As you examine each arrangement, ask the question, How will the students evacuate the workstations and exit the laboratory room safely?

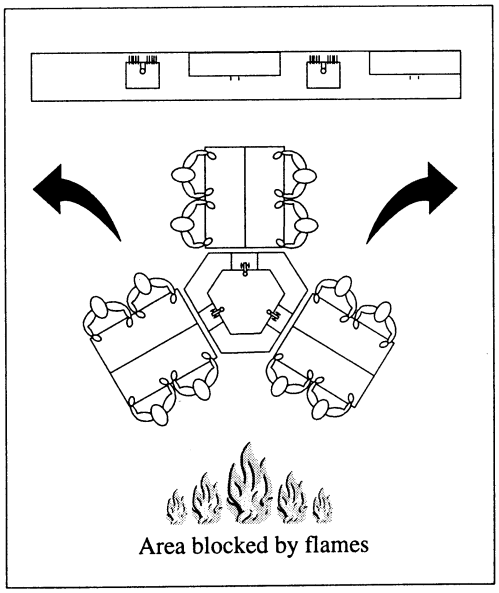


Figure 4.14
Island arrangement
(Trifacial-style tables)

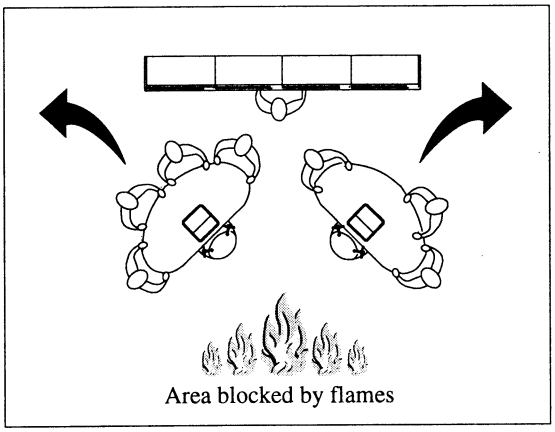


Figure 4.16
Island arrangement
(Axis 3™-style tables)

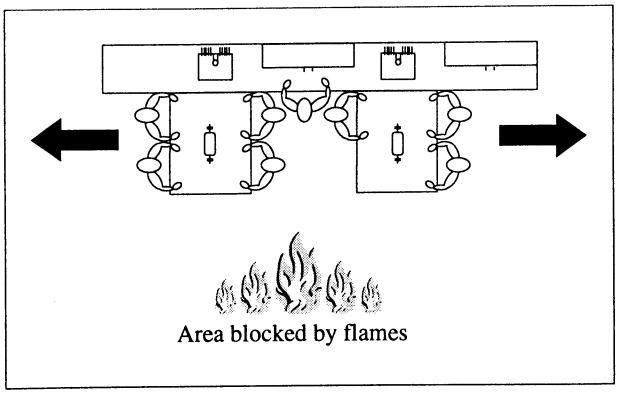


Figure 4.15
Perimeter arrangement
(Bench-style tables)

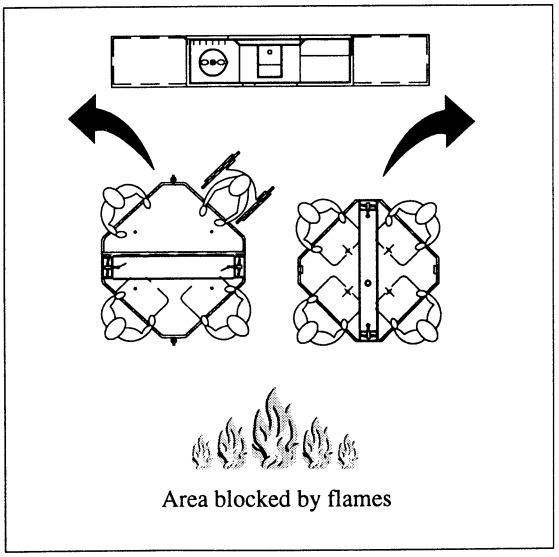


Figure 4.17
Island arrangement
(TE II-style tables)

Preparation/Storage Room

The preparation/storage room should be well-lighted and should provide teachers with open counter space for assembling materials, mixing chemicals, and collecting items that will be used for laboratory investigations. Ample space for moving in and around the preparation room is necessary so that equipment and utility carts can be brought into the room and loaded with materials for laboratory activities. Each preparation room should have two exits with locking doors.

Countertops should be made of a chemical-resistant and scratch-resistant material. Large sinks should provide hot and cold water and be equipped with a heavy-duty garbage disposal for eliminating biodegradable solid materials.

Each preparation room in middle school and high school should be equipped with an industrial laboratory-quality dishwasher. This would allow teachers and students who spend valuable laboratory time washing glassware to use that time, instead, to prepare for the laboratory experiences or work on their investigations.

Another reason to have dishwashers available is to be able to sanitize glassware and reduce the risk of contamination.

If a separate teacher office is not available, a designated area for teacher planning time should be part of the preparation room. This area should have a teacher's desk, locking file cabinets, and access to a computer with an internet connection. A phone should also be available for making calls to parents and conducting department business.

Every preparation room should have cabinets for storing equipment, but countertop workspace should not be sacrificed for storage areas. Special high-density shelving (Figure 4.18) is available that provides a large quantity of storage in a compact space. If the shelf assembly is more than six feet in length, a mechanical assisted carriage should be provided to move the shelf units more easily. Open wall space should be available for storing apparatus that are tall or too large for a cabinet.

Chemicals must be stored in a separate locked room so that teachers are not exposed to fumes and vapors from the chemicals. Spark-free refrigerators are especially needed for storing perishable materials properly.

In addition to the design features mentioned, safety must be considered. Safety features such as fire extinguishers, smoke detectors, chemical spill kits, first-aid kits, etc., should be included in any preparation room.

Safety showers and eye/face wash stations are not required in preparation rooms. If they are located in these rooms, *they must not replace the safety shower or eye/face wash* that is located in the laboratory room.

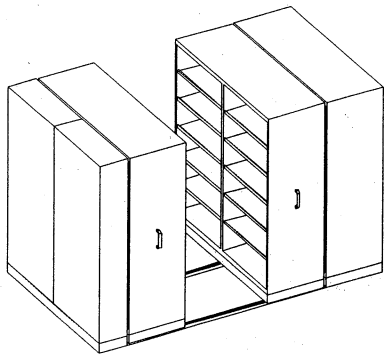


Figure 4.18
High-density shelving

Chemical Storage Room

A chemical storage room may be connected to a preparation/storage room or may be a stand-alone room. These specialized rooms must be equipped with a locking system to prevent students or other unauthorized persons from entering. Smoke detectors are recommended and may be required by local fire codes.

Each chemical storage room must be equipped with a continuous floor-to-ceiling ventilation system to remove all chemical vapors from the room. Non-vented flammables cabinets and separate, vented corrosive cabinets, both with locks, should be included in the room design.

The floor covering should be made of an acid- and corrosive-resistant material. Periodic inspection of the cabinets is necessary to check for deterioration of the cabinets.

Special shelving for storing chemicals in compatible families (Figure 4.19) should be used to prevent the corrosion of shelves and brackets. The depth of each shelf should not be more than 8"–12". Chemicals should not be stored more than two bottles deep on a shelf.

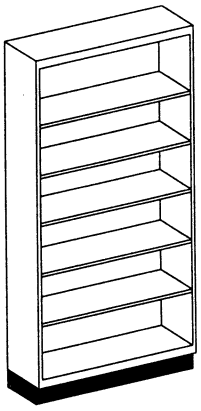


Figure 4.19
Open shelving for chemical storage

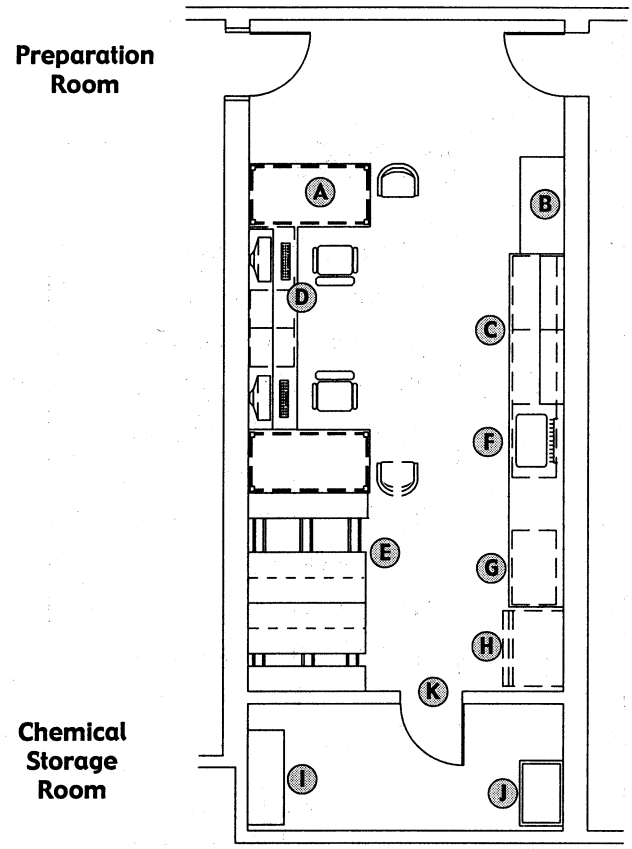
Shelving with a lip on the front of each shelf remains a controversial issue. Some argue that the lip may cause the bottle to tip when it is removed from the shelf, causing its contents to pour onto the person. However, the lip may prevent bottles from rolling off the shelf or chemicals from broken bottles from spilling onto other shelves. This remains an individual choice.

Schools should maintain no more than a two-year supply of chemicals. Periodic disposal of outdated or hazardous chemicals should be part of the school district's safety program.

Security should be considered a high priority. The entry door should be provided with a lock, and no windows should be located on any of the walls in a chemical storage room. Students should not be allowed to enter the chemical storage room or transport hazardous chemicals for the teacher.

Figures 4.20–4.22 represent three different floor plans for preparation/storage rooms and chemical storage rooms that middle and high school teachers could consider. Elementary schools require well-equipped preparation rooms but may not require a separate chemical storage room.

Chemicals should not be stored more than two bottles deep on a shelf.

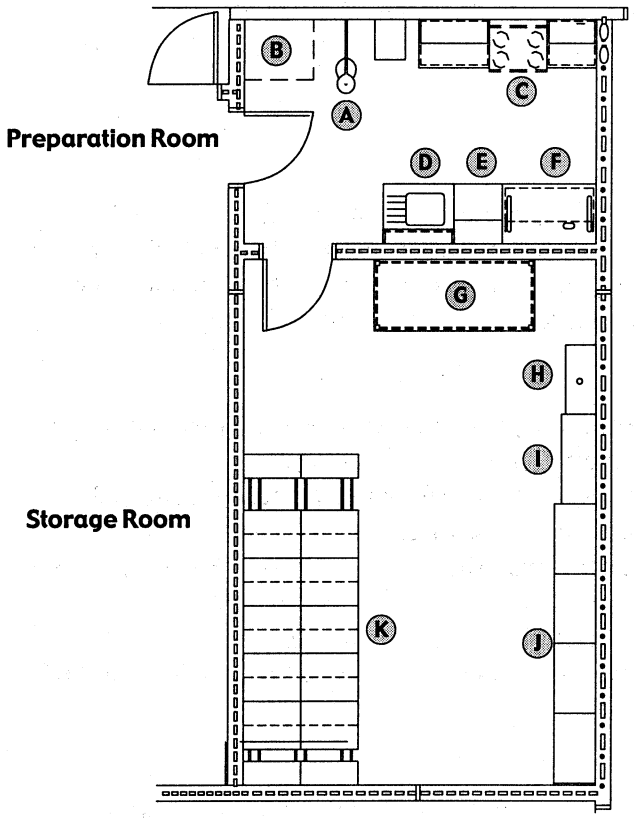


Room Dimensions: 32' x 14'–6"

LEGEND

- (A) large work table
- (B) laboratory cart
- (C) upper & base cabinets
- (D) computer workstation
- (E) high-density track shelving
- (F) sink with drying rack
- (G) dishwasher
- (H) spark-free refrigerator
- (I) flammables cabinet
- (J) corrosives cabinet
- (K) locking door

Figure 4.20
Preparation & chemical storage rooms



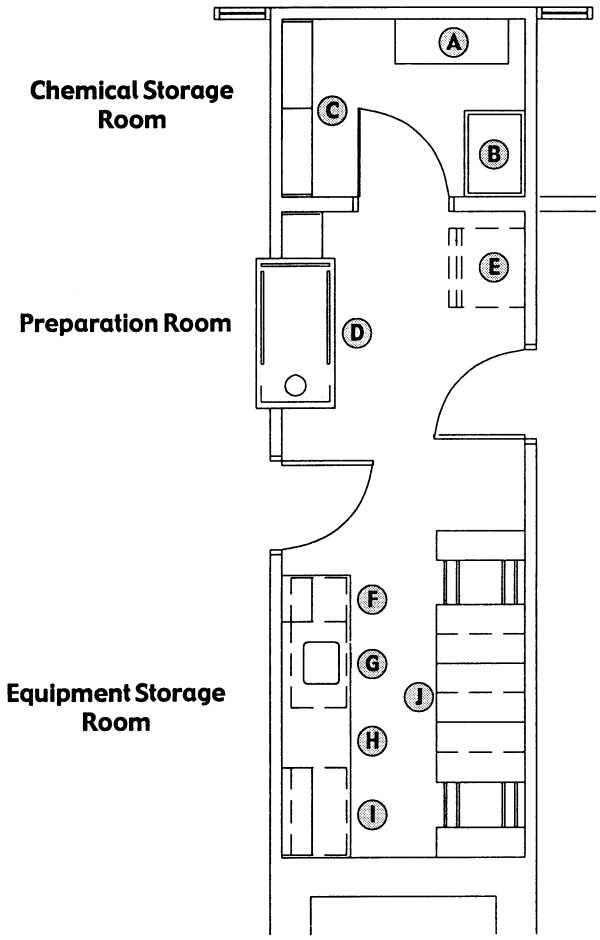
Room Dimensions: 32' x 14'–6"

LEGEND

- (A) safety shower/eyewash
- (B) spark-proof refrigerator
- (C) stove/oven
- (D) sink (hot & cold water)
- (E) dishwasher
- (F) fume hood
- (G) large work table
- (H) corrosives cabinet
- (I) flammables cabinet
- (J) tall cabinets
- (K) high-density track shelving

Figure 4.21
Preparation & equipment storage rooms

DRAWINGS MAY NOT BE TO SCALE.



LEGEND

- (A) flammables cabinet
- (B) corrosives cabinet
- (C) open storage shelves
- (D) double-sided fume hood
- (E) spark-proof refrigerator
- (F) upper & lower cabinets
- (G) sink (hot & cold water)
- (H) base cabinet
- (I) dishwasher
- (J) high-density track shelves

Figure 4.22
Preparation, chemical, and equipment storage rooms

DRAWINGS MAY NOT BE TO SCALE.

Science Department Designs

Before beginning new construction in the science area of a school, the planning team should determine how many of each type of science laboratory room will be needed; the type of science that will be taught in the rooms; and the location of the rooms in relation to each other and the science classrooms. The planning committee should consider questions such as the following:

- Should students in the same grade level be grouped together in the same area of the building?
- Which classrooms will share a common laboratory room?
- What style of laboratory or lecture/laboratory room will be best suited for each discipline?
- Should the laboratory reflect a multidisciplinary science setting?
- Should two science laboratories be arranged so that they share a common preparation/storage room?
- Is it necessary to build a separate chemical storage room for the department?
- How will the traffic flow in the corridor be affected by the arrangement of the laboratories and science classrooms?

The following floor plan designs (Figures 4.22–4.24) may guide you to decisions that work best for your students and teachers.

High School Science Wing

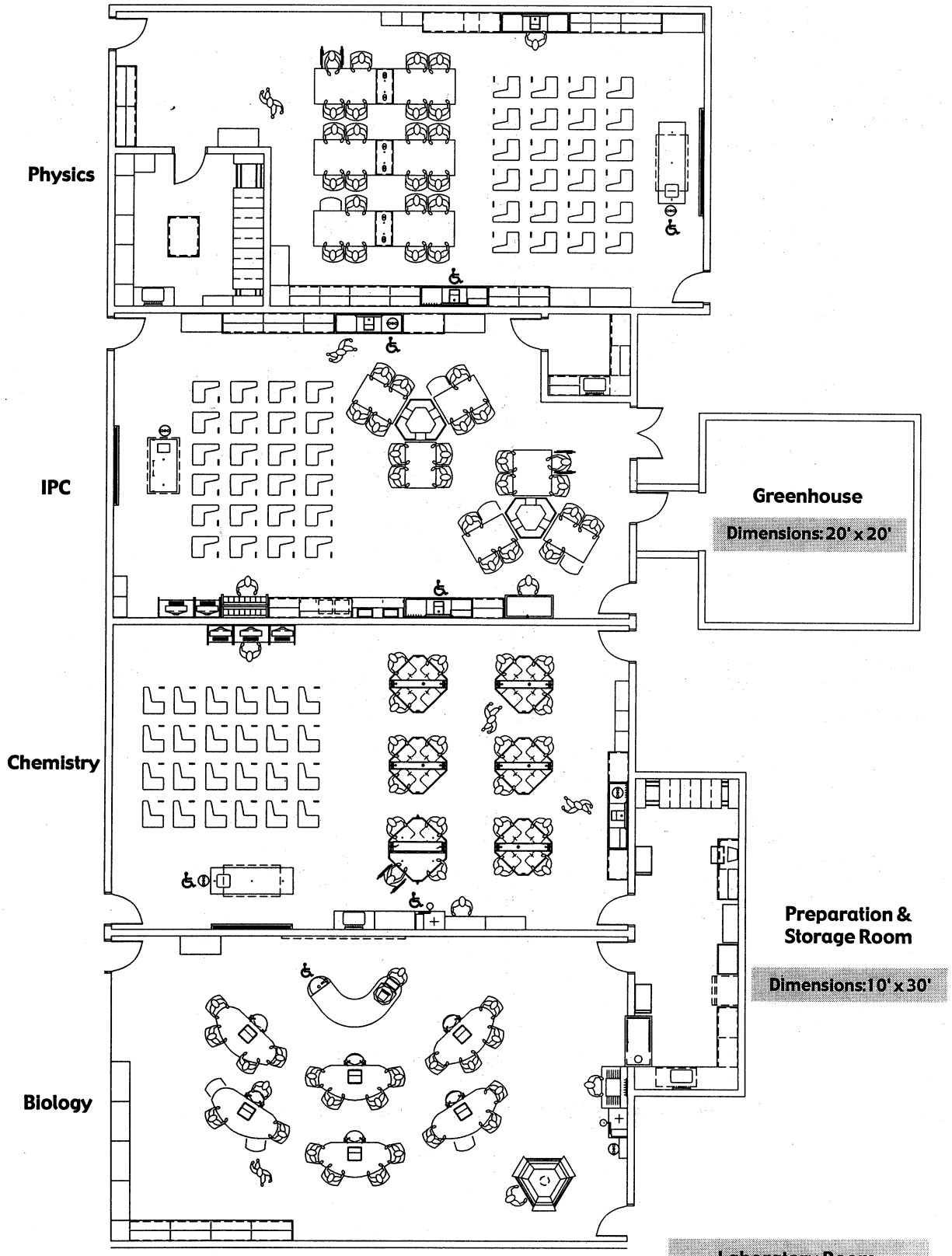


Figure 4.23
Grades 9–12

DRAWINGS MAY NOT BE TO SCALE.

Middle School Laboratory Area

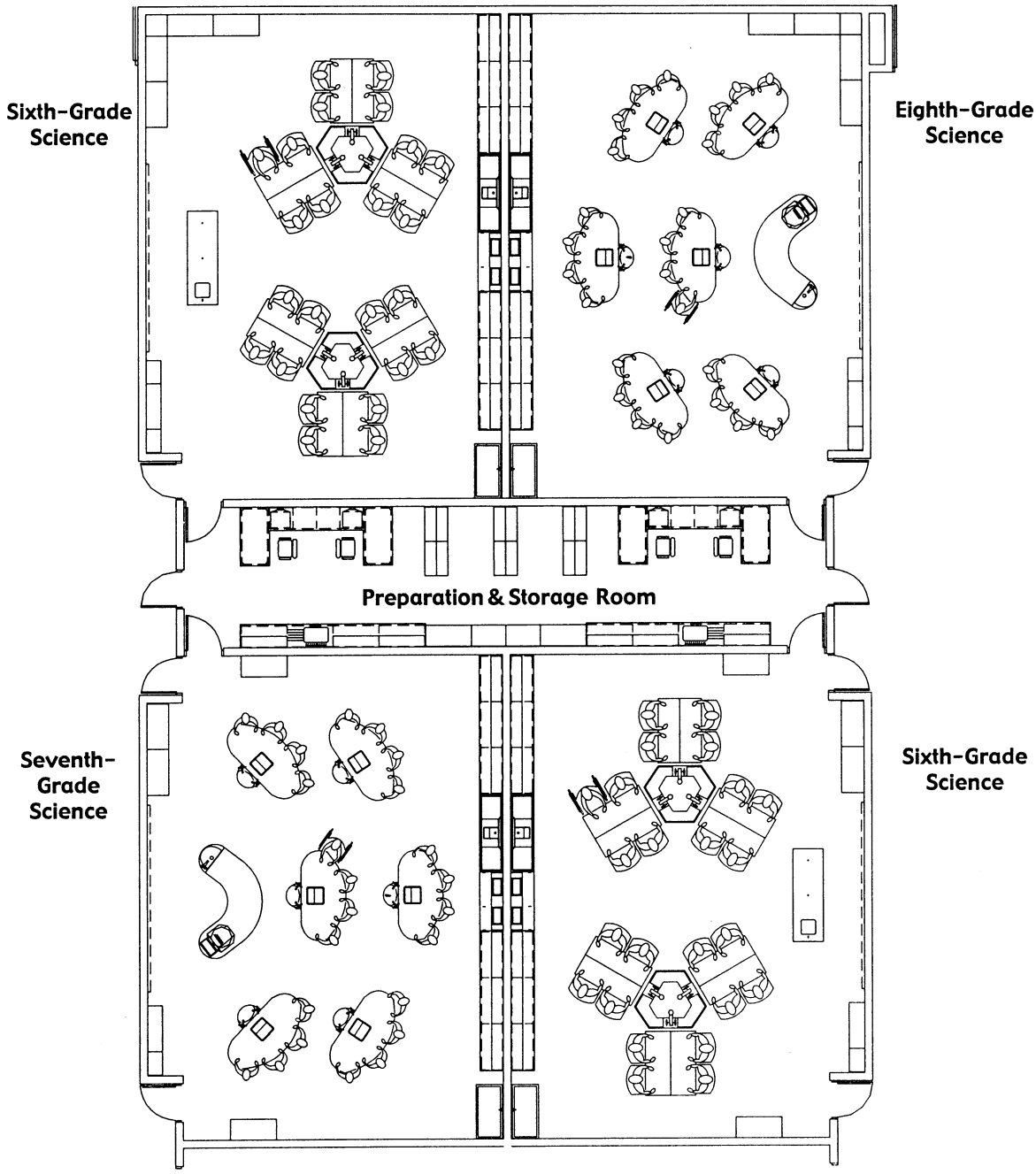
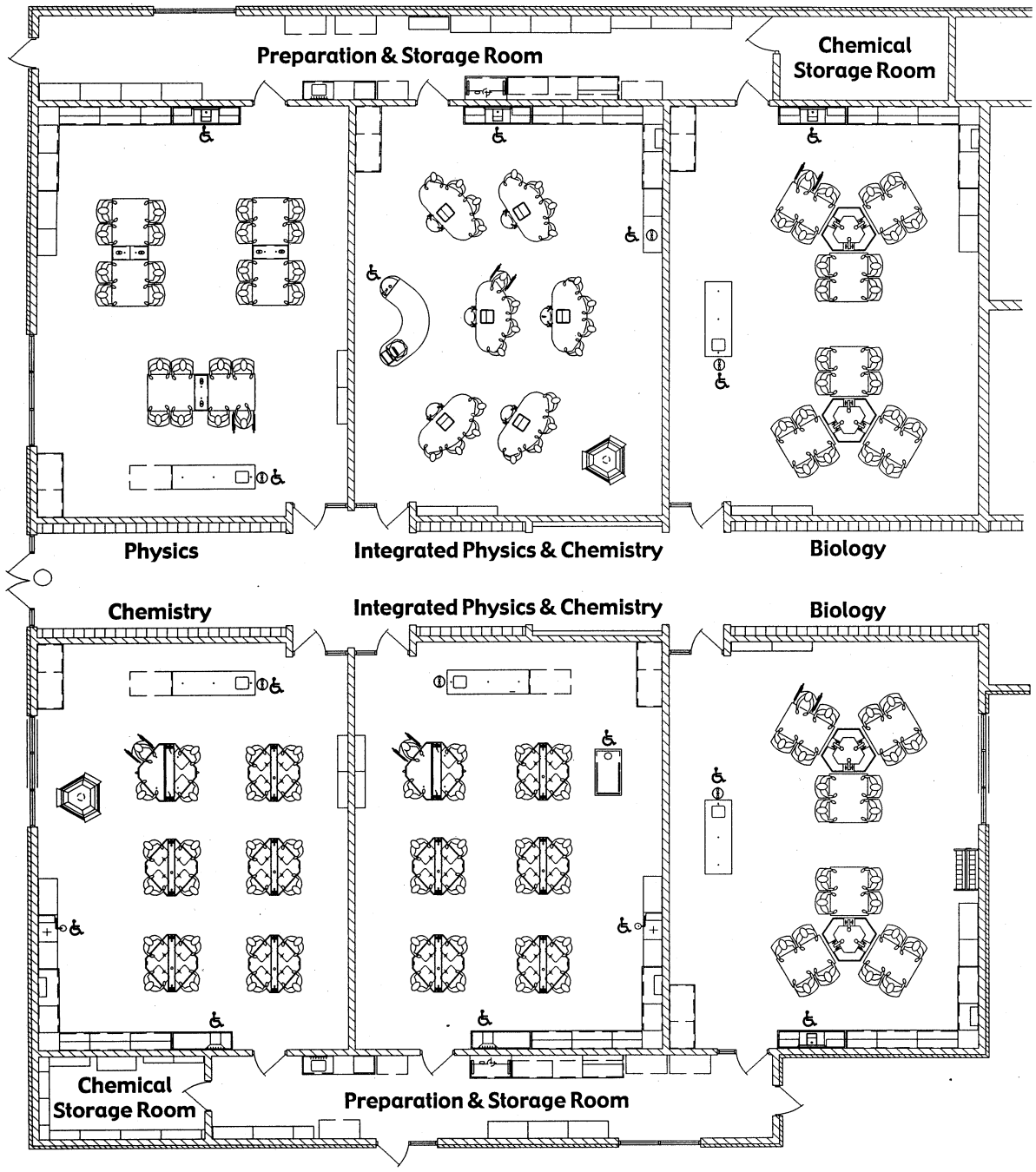


Figure 4.24
Grades 6–8

DRAWINGS MAY NOT BE TO SCALE.

High School Laboratory Area



Chemical Storage Room Dimensions: 10' x 13'

Preparation & Storage Rooms Dimensions: 10' x 55'

Laboratory Room Dimensions: 30' x 40'

Figure 4.25
Grades 9–12

DRAWINGS MAY NOT BE TO SCALE.

Chapter 5
OUTDOOR LEARNING AREAS

An outdoor learning area is a natural resource that is available to students for conducting field investigations outside the classroom setting. Although these sites are used primarily for field investigations, they provide learning opportunities all across the curriculum. The ideal site is located on the school grounds and is easily accessible for frequent visits. If space is a problem, consider seeking permission to use areas in nearby parks or other public facilities that are within walking distance from the school or are a short bus ride from the school. Most outdoor learning areas are associated with wildlife habitats and may include ponds, wetlands, wooded areas, native prairies, a butterfly garden, or a nearby field.

The process of establishing an outdoor learning area challenges the students' critical thinking and decision-making skills while incorporating reading, writing, mathematics, science, and social studies, as well as the visual arts. This chapter encourages school districts to establish an outdoor learning area with the help of students, faculty, parents, and the local community.

> A school's outdoor habitat is called by many names, including outdoor classroom, school sanctuary, nature study area, or outdoor learning area. No matter what name the area goes by, it is a piece of wildlife habitat that can be designed on a school's campus. The habitat becomes an exploratory classroom where students interact with the environment and observe living organisms in their natural settings. The excitement of learning is in the habitat itself.
>
> *Creating a School Habitat*

Creating an Outdoor Learning Area

A natural habitat provides the best type of area for student learning because the plant and animal relationships are already established in these areas. Preserve sections of the natural habitat prior to constructing new school buildings, renovating school grounds, or installing portable buildings. It is more difficult and costly to reconstruct the habitat later. When constructing new buildings, make every effort to identify and preserve a section of natural vegetation on the construction site. Select the best possible location for the future outdoor learning area, and protect that area with security fencing during the construction phase.

The Planning Committee

Having an organized planning committee is key to the success of an outdoor learning area. The committee may include students, teachers from all subject areas, maintenance personnel, school administrators, school board members, parents, business representatives, and natural resource professionals. Committee members should be encouraged to visit established outdoor learning areas so that they can gather ideas and learn about problems associated with creating an outdoor learning area. The committee may form subcommittees to use the member's expertise and share the work necessary for success. Some areas of responsibility include:

1. establishing goals and planning, designing, and developing the outdoor learning area
2. connecting the project to the school's curriculum
3. developing a budget and securing funds
4. implementing the project and ensuring its maintenance and sustainability
5. connecting the project to the community

Site Selection Criteria

The school curriculum should determine what type of outdoor learning area to create. A survey of the teachers can provide information about the types of activities they could conduct in the habitat. The next step is to select a site.

The outdoor learning area should serve as a site that

- provides excellent learning opportunities for the students and functions as an integral part of the curriculum,
- provides a quality habitat for wildlife, and
- becomes a permanent feature on the school's grounds.

The following are criteria for a selecting a good site:

1. The site should be located on school grounds whenever possible, or developed on property owned by the school district.
2. The property should not be slated for future development (such as a new playground or portable buildings).
3. Locate the site away from high-traffic areas, such as highways and areas heavily used by the students, to reduce disturbance of the wildlife.
4. Avoid areas that may need to be used as points of access for machinery and maintenance equipment.
5. The site should be easily accessible and located near the classrooms that will be using the site.
6. The site should provide good growing conditions for a variety of plant species.
7. The area should be open, providing easy access for wildlife.

Evaluating the Site

Once a site has been selected, committee members should create an inventory of existing features, including the native plants. These features may influence the plan for the outdoor learning area your committee will develop. The following items should be included in a detailed inventory.

Utilities

Check for items such as overhead utility lines, buried cables, water lines, water faucets, fences, and air conditioning units.

Soil Type(s)

Take soil samples to determine the soil type (clay, sand, loam, etc.). For more information on how to determine the soil type, refer to the *Creating a School Habitat* manual. Local offices of the Natural Resource Conservation Service may also be contacted for assistance.

Existing Vegetation

Make a list of all the plants growing on the site that you wish to keep. Evaluate existing plants for their benefits to wildlife. Consult reference books or local professionals for assistance. Keep the plants that will be of value to the wildlife. Consider removing the nonnative or invasive plants that might cause problems for the habitat.

Natural Light Patterns

Record the amount of natural light each section of the site receives during the day. Use this information to guide your planning and plant selection.

Drainage and Slope

Check the drainage patterns and the ground slope on a sketch of the site, noting the direction that water flows. Also, note any areas that retain water frequently or places where buildings or features drain onto the site.

Surrounding Properties

Survey features on surrounding properties that may affect your outdoor learning area, such as parking lots, noisy and aggressive pets, overhanging trees, tall buildings, or existing habitat. These features may be beneficial or detrimental to the habitat.

Security

Consider constructing a fence around the area to guard against potential problems, such as unsupervised children wandering into the site.

Wildlife Species

Research any wildlife species that may inhabit the area. Would wildlife still be able to access the site once it has been developed?

Creating a Habitat

The wildlife habitat is the heart of an outdoor learning area. A successful habitat provides the necessary components (food, water, shelter, and space) of a natural habitat, including beneficial plants, accessible water sources, and adequate space for wildlife. Secondary components may include supplemental feeders and nest boxes.

Students are provided with rich opportunities for outdoor studies once the habitat is established and the wildlife begin to appear. The following information will help attract wildlife to the site.

1. Mimic the kinds of habitats used by native wildlife in the area—for example, a wooded area, wetland, prairie, wildflower meadow, or desert. Remember, local wildlife require local habitats.

2. Research the types of plants that will be needed for each habitat, using native plant species.

3. Plan the locations for the habitat(s), and design the outdoor learning area(s) according to the growing conditions on the site.

Diversity

Using a variety of plant species will attract more types of wildlife. For example, if a habitat has two oak trees, grass, and nonnative shrubs, only a few squirrels may visit the site. However, if a variety of nectar and berry-producing plants are used, other wildlife, such as butterflies and birds, will be attracted to the site.

Layers of Vegetation

Research shows that two-thirds of the bird species studied used plants in the lowest two-thirds of a habitat. Yet, most people remove those parts of the habitat because they tend to like a "manicured" look. However, a successful habitat does not need to look messy; but it does need to include all of the necessary components of a successful habitat.

To make a habitat successful, replicate the layers of vegetation by including a variety of trees, shrubs, and other plants that produce seeds, nuts, berries, or nectar. This will provide important sources of food and may attract a variety of wildlife to the site.

Carrying Capacity and Limiting Factors

A habitat can properly support a limited number of animals. This "carrying capacity" is determined by the quantity and quality of the habitat components. Every population is controlled by "limiting factors." Limiting factors may include habitat components that are in short supply, such as water or food. Predators, automobiles, disease, and weather may influence a population's density.

For example, the natural vegetation growing in a pond maintains the natural balance of nutrients in the water. If the pond contains too many turtles, the pond's vegetation may be too rapidly consumed. Their waste products will contribute excess nutrients to the water, which are taken in by fewer existing aquatic plants. The result is a rapid growth of algae in the water. By relocating some of the turtles, the ponds' natural balance and carrying capacity can be restored.

Avoid releasing animals (domestic or rehabilitated wild species) into your habitat. There may be no limiting factors to control their population growth or their effects on the habitat.

Native Plant Species

Native plant species are attractive, interesting, and beneficial, but many people rarely take the time to discover them. A "native" plant is one that is indigenous to the area and grows without the intervention of people.

Benefits to Students

Through the study of native plants, students will gain an understanding of the role native plants play in an ecosystem and the relationships that exist between plants and animals.

Reduced Maintenance

Reduce the time, labor, materials, and costs involved in habitat maintenance by selecting native plant species. Plants that are native to a specific region are adapted to the growing conditions there. Each plant type exhibits specialized defenses against drought, floods, freezes, diseases, and insect damage. When working with the plants' individual growing preferences and natural defenses, the result is lower maintenance.

Plant Location

Just because a plant is native does not mean it can survive in undesirable conditions. For example, if a plant prefers to grow in full sunlight in well-drained soil, it may not survive in a wet, shaded part of the site. Place each plant species in its preferred location for the optimal growth and health of the plant.

Benefits to Wildlife

Wildlife species readily recognize native plant species as sources of food and shelter. If non-native plant species are planted, local wildlife may not use them for food or shelter at all.

Providing a Variety of Food

Many kinds of birds and other wildlife will be attracted to a variety of food, such as nuts, berries, fruits, seeds, nectar, and insects. The greater the variety of food, the more wildlife diversity will appear in the habitat. Plants represent sources of food and provide shelter, travel corridors, nesting and roosting sites for wildlife.

Multi-Benefit Plants

Many plants supply a food benefit to more than one species of wildlife. For example, sunflowers furnish nectar for butterflies and provide seeds for birds in the summer and fall. Decaying wood from dead trees, or snags, provide food for small insects. Woodpeckers and other insect-eating animals feed on the insects in the decaying wood. Evergreen shrubs, such as yaupon holly and cedar, supply berries and shelter, and native grasses become excellent sources of seeds and shelter during the fall and winter months.

Year-Round Sources

A school habitat will exist year round and through each season to benefit the wildlife. Select plants that provide food sources in spring, summer, fall, and winter to benefit wildlife.

Insect Food

A good habitat becomes home to a variety of insects. Leaves, nectar, fruit, and other food sources entice insects to inhabit the site. These insects become food for the other animals. Insects are a vital ingredient in the habitat, and using pesticides should be avoided; instead, organic gardening techniques and integrated pest management should be practiced.

Providing Shelter and Space

Animals need shelter from harsh weather conditions, concealment from predators, night roosting or resting areas, and nesting sites. Careful selection of plants for the site can provide animals with a variety of sheltered places.

Shelter

Some animals prefer thick evergreen shrubs as winter shelters. Clump shrubs to form sheltered thickets. Leaf litter, rock walls, wood or brush piles, rotting logs, and hollows under rocks can provide shelter for smaller animals such as lizards, snakes, skinks, and toads, as well as for insects and spiders.

Space

Space is defined as the area occupied by an individual or a family group. The size of an animal's living space depends on the animal's body size and its habits. An animal's home range is the space it requires to find the food, water, and shelter it needs to survive.

In your outdoor learning area, space will be limited to the area you plan to develop. The activities should focus on increasing the quality and availability of food, water, and shelter at the site.

Providing Water

Water is a vital ingredient in every habitat. Water can be provided in a variety of ways, such as in ponds, shallow pools, birdbaths, or shallow containers. It is important that the water supply be kept clean and constant.

Birdbaths

Make the water accessible to a variety of wildlife. An elevated water source is limited to birds and squirrels. Reduce hiding spots for predators by removing tall vegetation from around the edges or base of the birdbath.

If the bowl is deep or has steep sides, add rocks to the birdbath to give birds better access to the water.

Regular maintenance is required. To clean the birdbath, use a weak bleach and water solution, scrub with a strong brush, and rinse several times to eliminate any remaining bleach. Refill with fresh water.

Keep the water cool by placing the birdbath in partial shade. A branch hanging over the bowl allows birds a place to perch and survey the surrounding area for predators. However, leaves from the tree can make it difficult to keep the water clean.

Place the birdbath in view of the classroom to allow students the opportunity to observe birds in their natural surroundings.

Ponds

Every pond should have gently sloping sides, shallow ledges, or depressions where puddles can form around the edge. Wildlife will drink and bathe in these puddles. Most wildlife will use water that is at a depth of one to three inches.

Check with school district personnel to determine what the school's policy is regarding ponds on school grounds.

Constructing a Pond or Wetland Area

One of the purposes of a outdoor learning site is to bring wildlife into view for students to observe, study, and appreciate. No other component of a habitat does this as predictably as a water source does. A pond or wetland area has the potential of attracting the most wildlife diversity and also allows students to observe the life cycles of plants, invertebrates, and amphibians.

The process of establishing a pond or wetland area on a site can be divided into four phases:

- Site selection
- Design
- Installation
- Maintenance

Site Selection

Consider the topography, hydrology, available sunlight, soil type, and access to the site when selecting the location for a pond or wetland area.

Topography

Note those areas that appear to be in a low-lying spot where water tends to stand, or where the soil stays moist for an extended period of time. If no natural collection areas exist, then note the flat areas that might be suitable for an excavation.

Hydrology

Where will the water come from for the pond or wetland area, and how will it get there? Most ponds located on school campuses will not receive enough rainfall to sustain them during a typical summer. Determine what the potential watershed might be before constructing a large capacity pond.

School yards, athletic fields, parking lots, and building roofs may offer opportunities to collect and direct rainfall to the pond or wetland area. However, most sites will require additional water from the municipal water system. In parts of the state where municipal water is limited, you may have to rely entirely on rainwater. This may be a limiting factor when determining the size of the pond or wetland area.

Sunlight

Most wetland plants require at least five hours of sunlight daily to thrive. Trees and buildings may cast shadows on a pond and should be considered when selecting plants.

Soil Type

The best and least expensive pond is a natural one that results from digging a hole in suitable soil and filling it with water. The key to a soil's ability to hold water is its clay content.

Simple tests can be conducted to determine the soil's clay content.

Access

The chosen site must be accessible for construction, student investigations, wildlife recruitment, and maintenance. If the pond or wetland area becomes a regular part of the school curriculum, it must also be wheelchair accessible.

Design

The planning committee should consider the following when designing a pond or wetland area:

- Shape
- Size
- Depth and profile
- Liner options
- Preform designs
- Access

Shape

If the soil proves to be suitable for a natural pond, the shape can be as irregular as you prefer. Curves, dips, peninsulas, and coves provide more shoreline and better hiding places for animals.

If the soil is not suitable for a natural pond and, therefore, some type of liner material is necessary, then complex shapes may not be practical. The need to use clay or synthetic liners will likely require shapes that are more circular or rectangular.

Size

Pond size is limited only by site restrictions, needs, hydrology, and budget. Most ponds will require an additional water source to maintain the water level throughout the year.

A pond approximately 20 feet wide and 20 feet long, with an average depth of one foot, will hold approximately 3,000 gallons of water. Water cost can become a factor in deciding on pond size as well as excavation and disposal of the soil.

Depth and Profile

Pond sides with gradual slopes allow for the establishment of diverse plant communities and easy access for wildlife. If children are allowed at the edge of a pond, gentle slopes will limit their missteps to wet feet only and help prevent them from becoming completely submerged.

A ratio of 3 feet of horizontal length for every 1 foot of vertical depth is sufficient. Some sides of the pond may be steeper and others flatter, depending on the need. A maximum depth of 2 feet is sufficient for most ponds on a school campus.

In northern parts of Texas, a depth greater than 2 feet may be required to prevent the pond from freezing solid in the winter. Some municipalities may regulate ponds according to their depth. Check local codes before beginning construction.

Liner Options

If the soil will not hold water, then consider using lining materials to modify the excavation.

Bentonite, a processed clay product, can be mixed with existing soils to form a waterproof lining. However, the product can be expensive, and its application may be difficult.

Natural clay is another alternative and may be purchased in some areas of the state. The clay must be compacted once it has been spread onto the excavation area to create a waterproof liner.

Synthetic liners made of vinyl, polyethylene, or butyl rubber are available from many sources. These materials vary in cost depending on the thickness and width of the liner needed. Be sure to check the liner's temperature tolerances to ensure that it will withstand freezing temperatures in your area.

Preformed Ponds

Preformed, molded plastic and fiberglass ponds are available from manufacturers. However, most preformed designs are not suitable for wildlife since there are no shallow areas with gentle slopes included in the designs.

Access

School campus ponds and wetland areas may not be of sufficient size to withstand the impact of several students gathering around the vegetated areas at one time. A platform or deck that extends over the pond's edge or into the wetland area can protect delicate vegetation and limit the disturbance of wildlife. It can also help prevent students from returning to class with muddy shoes or wet feet.

The Americans with Disability Act requires that students with handicaps have access to these types of facilities. See *Texas Safety Standards for Kindergarten–Grade12* for additional information about these requirements.

Pond Maintenance

Pond maintenance consists of maintaining water levels and controlling excessive vegetation. In shallow ponds (3 feet deep or less), vegetation may eventually cover the entire water surface. Less desirable plants, such as cattails, can cover a pond in one or two growing seasons and will need to be controlled.

Ideally, half of the water surface should remain open and free from vegetation. This may require thinning plants from the pond on a regular basis.

Aquatic Plants

Carefully choose aquatic plants that are native to your area. Many aquatic plants can become established quickly and grow rapidly. Look for diversity in size, structure, and growth habits when selecting the plants.

Include emergent, submergent, and floating-leaf plants in the selection. Be aware that many nonnative species have become established locally and have caused problems in our natural waterways (Table 5.2).

Table 5.2
Aquatic Plants Prohibited in Texas

- Alligatorweed
- Eurasian water milfoil
- Giant duckweed
- Salvinia
- Hydrilla
- Water hyacinth
- Water lettuce
- Water spinach
- Rooted water hyacinth
- Torpedograss
- Lagarosiphon
- Paperbark (Melaleuca)

These plants are highly invasive and detrimental to a pond. It is against the law for you to possess these plant species. Check with a local resource professional for more information concerning these plants.

Filtering the Pond Water

Artificially filtering the water in the ponds should not be necessary because the plants act as a natural filter. A diverse mix of native aquatic plants will maintain proper water quality.

Mosquito Control

Mosquitoes are part of the natural environment and can be expected in the pond and wetlands area. If properly constructed and maintained, the pond will not be a source of mosquitoes but may actually help to control them.

A mosquito fish, such as *Gambusia* sp. or other such predatory fish species, will consume the eggs and larvae, thus controlling the mosquito population.

Another method for controlling mosquitoes is through the use of the bacteria, *Bacillus thuringiensis israelensis* (BT). Introducing this type of bacteria into the water will control the mosquitoes without harming any other life in the pond.

The Butterfly Garden

Planting a butterfly garden creates an outdoor laboratory for students to observe one of nature's beautiful insect groups while providing a source of food for adult butterflies and a place where they can continue their life cycles. A butterfly fluttering from one flower to the next drinking nectar is at the same time performing an important function in nature: pollination. Second only to bees, the butterfly plays a crucial role in the pollination of plants. Over 17,500 species of butterflies have been identified around the world, with approximately 700 species found on the North American continent.

The feeding habits and life cycles of a variety of butterflies can be directly observed in the field, or the butterfly larvae can be brought to the science laboratory and cared for until they emerge as adults. The use of insecticides and loss of habitat have affected butterfly populations and significantly reduced the number of species. Under no circumstances should insecticides be used in the outdoor learning area.

> By protecting, restoring, and managing natural habitats in our own backyards, we can help protect these beautiful creatures by creating conditions that promote their abundance and diversity, instead of destroying them. The reintroduction of natural landscape elements into neighborhoods may be one of the greatest contributions to ecosystem conservation that we can make.
>
> Texas Parks and Wildlife
> Nongame and Urban Program, 1998

Building a Butterfly Garden

A well-planned butterfly garden can serve as an outdoor laboratory for students. Wildflowers common to the area should be used as the foundation plants to lure butterflies to the site.

Location

A major part of the butterfly garden should be located in an area that will provide full sun for approximately 6–8 hours a day. The remainder of the garden should support plants that require less sun exposure.

Butterflies are cold-blooded organisms that require a warm area in order to raise their body temperatures on cool mornings. Rocks or logs are important as places where the butterflies can bask in the morning sun. If these features do not exist, they can be added easily to the site.

Attracting Butterflies to the Garden

Wildflowers and other flowering plants will attract butterflies to the site. However, butterflies require minerals and other nutrients as well as the sweet nectar they receive from the flowers.

Butterfly Food

The feeding habits of butterflies differ from those of the hummingbird. Butterflies prefer to visit flowers located in full sun. Butterflies are attracted to masses of flowers in shades of pink, purple, yellow, and orange.

Fragrant, small tubular flowers clustered in "bouquets," such as lantana, verbena, or viburnum—or composite flowers, such as sunflowers—entice butterflies to sample the rich nectar. Select a variety of plants so that flowers are blooming several months of the year to provide sources of nectar to the butterflies.

Plant tall nectar-producing trees, shrubs, and vines around the habitat's perimeter as windbreaks so the butterflies can avoid strong winds while feeding.

Larval Food

Butterflies choose specific plant species, called larval host plants, to deposit their eggs. Don't panic when a caterpillar appears munching on leaves in the habitat. The caterpillar may become one the butterflies or moths that are desired in the habitat.

For example, the monarch butterfly selects milkweed plants to lay its eggs. The gulf fritillary choose the tender leaves of the passionflower vine to lay her tiny yellow eggs. Several swallowtail species lay eggs on dill, fennel, or citrus plants.

Before selecting host plants for a butterfly garden, research the species of butterflies and moths that are common to the area. Use field guides and identification keys to help identify the various caterpillars in the habitat.

Don't spray the flowers with strong jets of water. This washes away the nectar and tiny caterpillars that are feeding on the plants. Instead, try watering the plants with a soaker hose or drip irrigation.

Butterfly Puddling

Butterflies require minerals and other nutrients as well as the sweet nectar they receive from flowers. Many butterflies are "puddlers," meaning that they gather at places rich in the kinds of nutrients butterflies need, such as moist soil, rotting fruit, oozing sap, and animal feces.

Providing a moist area with one or more of the ingredients mentioned may increase the frequency and abundance of butterflies at your site.

Planting Wildflowers

Correctly planting wildflowers native to the area is an important step in creating a successful garden that attracts a variety of butterflies and other insects.

Select an area that drains well for the garden. Eliminate existing vegetation that might compete with the seedlings. Prepare the garden bed by raking the surface with a sturdy rake. Level the soil by breaking apart large clumps of soil.

Evenly broadcast the seeds over the freshly raked soil. Some experts recommend combining the seeds with sand or other material before broadcasting them onto the soil. This will ensure a more uniform distribution of seeds.

After the seeds have been scattered, walk over the garden bed or use a commercial roller. This will press the seeds into the soil to the correct depth. Do not add additional soil or other material that might cover over the seeds. Planting wildflower seeds too deep will reduce the number that will germinate successfully in the garden.

Keep the garden moist for approximately 4–6 weeks so that the seedlings can become well established. It is important that the soil not dry out completely or receive too much water.

It should not be necessary to add additional fertilizer to the soil. Many wildflowers are well-equipped to survive in very poor soils.

Wildflower seeds can be ordered from speciality companies in several locations in the state (Appendix C).

Some species of plants may have characteristics that are undesirable for the habitat. For a listing of poisonous plants refer to *Texas Safety Standards: Kindergarten–Grade 12*.

Guide to Common Texas Wildflowers

A list of some common Texas wildflowers that can be planted in a prairie setting, butterfly garden, or flower garden at the school campus can be found in Appendix D. These are only a few of the 700 species that are found in the state.

An example of an outdoor learning area constructed between two wings of a school can be found on page 127. It incorporates several of the features that have been discussed in this chapter.

The information included in this chapter was taken from *Creating a School Habitat: A Planning Guide for Habitat Enhancement on School Grounds in Texas*, written by Diana M. Foss, Texas Parks and Wildlife, and Ronald K. Jones, U.S. Fish and Wildlife Service.

To obtain a copy of the *Creating a School Habitat,* please contact:

Texas Parks and Wildlife Department
Wildlife Diversity
4200 Smith School Road
Austin, Texas 78744
(512) 389-4974

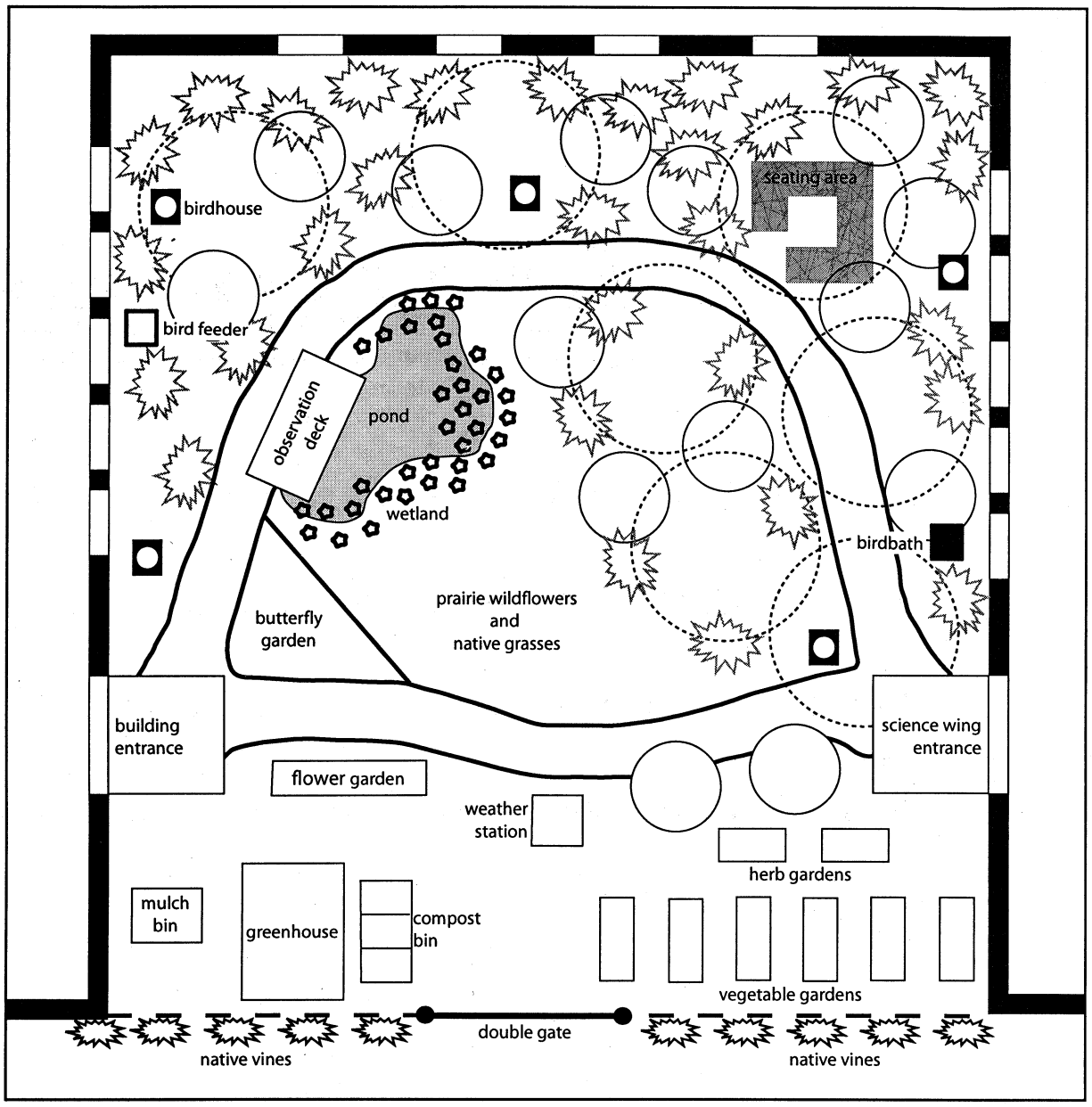
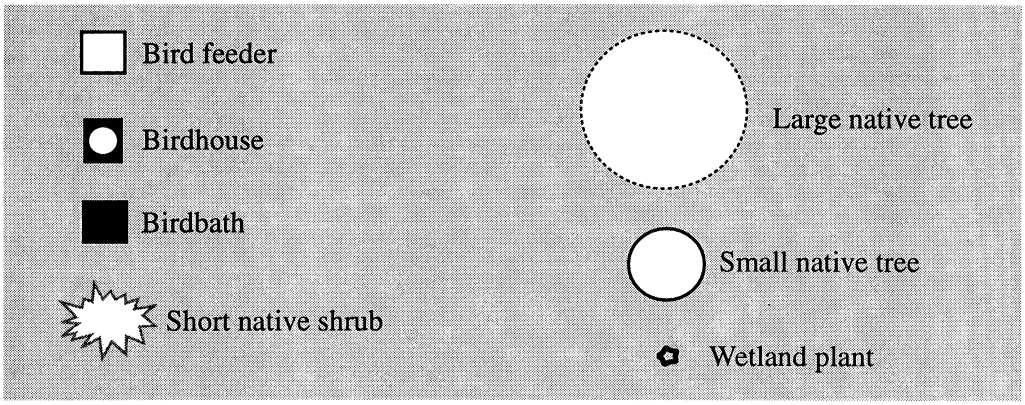


Figure 5.3
Outdoor Learning Area Design



APPENDICES

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APPENDIX A

LAWS, RULES, AND REGULATIONS

- 19 TAC Chapter 61, Subchapter CC. Commissioner's Rules Concerning School Facilities, §61.1033. School Facilities Standards

- 19 TAC Chapter 112,§§(A)–(C),Texas Essential Knowledge and Skills for Science

- Texas Accessibility Standards. Texas Department of Licensing and Regulation. Architectural Barriers Act. Article 9102, Texas Civil Statutes

- Texas Insurance Commission. 28 TAC Chapter 34, Sections 34.501–34.523 Fire Extinguishers/Fire Extinguisher Rules

Texas Administrative Code, Title 19, Part II
Chapter 61. School Districts
Subchapter CC. Commissioner's Rules Concerning School Facilities

Statutory Authority: The provisions of this Subchapter CC issued under the Texas Education Code, §42.004, unless otherwise noted.

§61.1033. School Facilities Standards.

(a) Definitions and procedures. The following words, terms, and procedures, when used in this section, shall have the following meanings, unless the context clearly indicates otherwise.

(1)–(4) Intentionally omitted.

(5) Major space renovations - At least 50% of the gross area of the facility's instructional space is within the limits of the work. Other renovations associated with repair or replacement of architectural interior or exterior finishes; fixtures; equipment; and electrical, plumbing, and mechanical systems are not subject to the requirements of subsections (d) and (e) of this section, but shall comply with applicable building codes as required by subsection (f) of this section.

(6) Square feet per pupil - The net interior space of a room divided by the maximum number of pupils to be housed in that room during a single class period.

(7) Square feet per room measurements - The net square footage of a room that will house 22 students at the elementary level and 25 students at the middle or high school level. The net square footage of a room includes exposed storage space, such as cabinets or shelving, but does not include hallway space or storage space, such as closets or preparation offices.

(b) Effective date. The requirements for school facility standards shall apply to projects for new construction or major space renovations approved by a school district board of trustees after September 1, 1998.

(c) Certification of design and construction.

(1) In this section, the word "certify" indicates that the architect or engineer has reviewed the standards contained in this chapter and used the best professional judgment and reasonable care consistent with the practice of architecture or engineering in the State of Texas in executing the construction documents. The architect or engineer also certifies that these documents conform to the provisions of this section, except as indicated on the certification.

(2) The school district shall notify and obligate the architect or engineer to provide the required certification. The architect's or engineer's signature and seal on the construction documents shall certify compliance.

(3) To ensure that facilities have been designed and constructed according to the provisions of this section, each of the involved parties shall execute responsibilities as follows.

(A) The school district shall provide the architect or engineer with the long-range school facility plan and/or educational specifications approved by the board of trustees as required by this subchapter, and building code specifications for the facility.

(B) The architect or engineer shall perform a building code search under applicable regulations that may influence the project, and shall certify that the design has been researched before it is final.

(C) The architect or engineer shall also certify that the facility has been designed according to the provisions of this section, based on the long-range school facility plan and/or educational specifications, building code specifications, and all documented changes to the construction documents provided by the district.

(D) The building contractor or construction manager shall certify that the facility has been constructed in general accordance with the construction documents specified in subparagraph (f) of this paragraph.

(E) When construction is completed, the school district shall certify that the facility conforms to the design requirements specified in subparagraph (A) of this paragraph.

(d) Space, minimum square foot requirements.

(1) A school district shall provide instructional space if required by the district educational specifications described in subsection (e) of this section.

(2) For each type of instructional space, a district may satisfy the requirements of this section by using, as appropriate, either the standard for the minimum square feet per pupil or for square feet per room specified in paragraphs (1)–(3) of this subsection. Room size requirements are based on rooms that will house 22 students at the elementary level and 25 students at the middle or high school level.

(A) General classrooms.

(i) Classrooms for prekindergarten-Grade 1 shall have a minimum of 36 square feet per pupil or 800 square feet per room.

(ii) Classrooms at the elementary school level shall have a minimum of 30 square feet per pupil or 700 square feet per room.

(iii) Classrooms at the secondary school level shall have a minimum of 28 square feet per pupil or 700 square feet per room.

(B) Specialized classrooms.

(i) Computer laboratories shall have a minimum of 41 square feet per pupil or 900 square feet per room at the elementary school level; and 36 square feet per pupil or 900 square feet per room at the secondary school level.

(ii) Science lecture/lab shall have a minimum of 41 square feet per pupil or 900 square feet per room at the elementary school level; 50 square feet per pupil or 1,000 square feet per room at the middle school level; and 50 square feet per pupil or 1,200 square feet per room at the high school level.

(e) Educational adequacy. A proposed new school facility or major space renovation of an existing school facility meets the conditions of educational adequacy if the design of the proposed project is based on the requirements of the school district's educational program and the student population that it serves.

(f) Construction quality.

(1) Districts with existing building codes. A school district located in an area that has adopted local building codes shall comply with those codes (including fire and mechanical, electrical, and plumbing codes). The school district is not required to seek additional plan review of school facilities projects other than what is required by the local building authority.

(2) Districts without existing building codes. A school district located in an area that has not adopted local building codes shall adopt and use the latest edition of either the Uniform Building Code or Standard (Southern) Building Code (and related fire, mechanical, and plumbing codes); and the National Electric Code. A qualified, independent third party, not employed by the design architect or engineer, shall review the plans and specifications for compliance with the requirements of the adopted building code. The plan review shall examine compliance conditions for emergency egress, fire protection, structural integrity, life safety, plumbing, and mechanical and electrical design. The review shall be conducted before bidding and must be conducted by a certified building code consultant. Associated fees shall be the responsibility of the school district. The reviewer shall prepare a summary list of any conditions not in conformance with the provisions of the adopted building code and is required to send a copy to the school district, design architect, or engineer. The design architect or engineer shall revise the plans and specifications as necessary and certify code compliance to the district. Any disputes shall be a matter for contract resolution.

(3) Other provisions. School districts shall comply with the provisions of the Americans with Disabilities Act of 1990 (Title I and Title II) and other local, state, and federal requirements as applicable.

Statutory Authority: The provisions of this §61.1033 issued under the Texas Education Code, §42.004, as added by House Bill 4, 75th Texas Legislature, 1997.

Source: The provisions of this §61.1033 adopted to be effective September 1, 1998, 23 TexReg 7221.

CERTIFICATION OF PROJECT COMPLIANCE

Distribution to:

District	☐	Architect/Engineer	☐
Contractor	☐	Texas Education Agency	☐
Other	☐	Building Department	☐

1. PROJECT INFORMATION:
(name, address)

ARCHITECT/ENGINEER:

CONTRACTOR:

PROJECT NUMBER:

CONTRACT DATE:

DISTRICT:

DATE DISTRICT AUTHORIZES PROJECT:

BRIEF DESCRIPTION OF PROJECT:

2. CERTIFICATION OF DESIGN AND CONSTRUCTION:

The intent of this document is to assure that the school district has provided to the architect/engineer the required information and the architect/engineer has reviewed the School Facilities Standards as required by the State of Texas, and used his/her reasonable professional judgment and care in the architectural/engineering design and that the contractor has constructed the project in a quality manner in general conformance with the design requirements and that the school district certifies to project completion.

3. **The District** certifies that the enrollment projections, educational specifications, and objectives of this facility, along with the identified building code to be used, have been provided to the architect/engineer.

DISTRICT: **BY:** **DATE:**

4. **The Architect/Engineer** certifies the above information was received from the school district, and that the building(s) were designed in accordance with the applicable building codes. Further, the facility has been designed to meet or exceed the design criteria relating to space (minimum square footage), educational adequacy, and construction quality as contained in the School Facilities Standards as adopted by the State Board of Education, July 1992, and as provided by the district.

ARCHITECT/ENGINEER: **BY:** **DATE:**

5. **The Contractor** certifies that this project has been constructed in general conformance with the construction documents as prepared by the architect/engineer listed above.

CONTRACTOR: **BY:** **DATE:**

6. **The District** certifies completion of the project (as defined by the architect/engineer and contractor).

DISTRICT: **BY:** **DATE:**

TAC §61.1033(c)(3)(A–E)

19 TAC Chapter 112 §§(A–C)
Texas Essential Knowledge and Skills for Science

The following statements represent the knowledge and skills and student expectations found in the Texas Essential Knowledge and Skills for Science. These are the state standards of what students are expected to know and be able to do from Kindergarten through Grade 9 and in the high school courses of Integrated Physics and Chemistry, Biology, Chemistry, and Physics.

Kindergarten

Students are expected to:

- participate in classroom and field investigations following home and school safety procedures demonstrating safe practices; and learning how to conserve resources and other materials.
- develop abilities to do scientific inquiry in the field and the classroom by asking questions about organisms and objects, and events; planning and conducting descriptive investigations; gathering information using equipment and tools to extend the senses; constructing reasonable explanations using information; and communicating their findings about investigations.
- know that information and critical thinking are used in making decisions by making informed decisions; discussing and justifying the merits of decisions; and explaining a problem in their own words and proposing a solution.
- use age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured by identifying and using their senses as tools of observation; and making observations using tools including hand lenses, balances, cups, bowls, and computers.
- know that organisms, objects, and events have properties and patterns by describing properties of objects and characteristics of organisms; observing and identifying patterns including seasons, growth, and day and night and predict what happens next; and recognizing and copying patterns seen in charts and graphs.
- know that systems have parts and are composed of organisms and objects by sorting organisms and objects into groups according to their parts and describing how the groups are formed; recording observations about parts of plants, including leaves, roots, stems, and flowers; recording observations about parts of animals, including wings, feet, heads, and tails; identifying parts that, when separated from the whole, may result in the part or the whole not working; and manipulating parts of objects that when put together, can do things they cannot do by themselves.
- know that many types of change occur by observing, describing, and recording changes in size, mass, color, position, quantity, time, temperature, sound, and movement; identifying that heat causes change and comparing objects according to temperature; observing and recording weather changes from day to day and over seasons; and observing and recording stages in the life cycle of organisms in their natural environment.
- know the difference between living organisms and nonliving objects by identifying a particular organism or object as living or nonliving; and grouping organisms and objects as living and nonliving.
- know that living organisms have basic needs by identifying basic needs of living organisms; giving examples of how living organisms depend on each other; and identifying ways that the Earth can provide resources for life.
- know that the natural world includes rocks, soil, and water by observing and describing properties of rocks, soil, and water; and giving examples of ways that rocks, soil, and water are useful.

Grade One

Students are expected to:

- conduct classroom and field investigations following home and school safety procedures by demonstrating safe practices during classroom and field investigations; and learning how to use and conserve resources and materials.

- develop abilities necessary to do scientific inquiry in the field and classroom by asking questions about organisms, objects, and events; planning and conducting descriptive investigations; gathering information using equipment and tools to extend the senses; constructing reasonable explanations and drawing conclusions; and communicating explanations about investigations.

- know that information and critical thinking are used in making decisions by using information to make decisions; discussing and justifying the merits of decisions; explaining a problem in their own words; and identifying a task and solution related to the problem.

- use age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured by collecting information using tools including hand lenses, clocks, computers, thermometers, and balances; recording and comparing collected information; and measuring organisms and objects and parts of organisms and objects, using non-standard units.

- know that organisms, objects, and events have properties and patterns by sorting objects and events based on properties and patterns; and identifying, predicting, and creating patterns including those seen in charts, graphs, and numbers.

- know that systems have parts and are composed of organisms and objects by sorting organisms and objects according to their parts and characteristics; observing and describing the parts of plants and animals; manipulating objects so that the parts are separated from the whole which may result in the part or the whole not working; and identifying parts, that when put together, can do things they cannot do by themselves.

- know that many types of change occur by observing, measuring, and recording changes in size, mass, color, position, quantity, sound, and movement; identifying and testing ways that heat may cause change; observing and recording changes in weather from day to day and over seasons; and observing and recording changes in the life cycle of organisms.

- distinguish between living organisms and nonliving objects by grouping living organisms and nonliving objects; and comparing living organisms and nonliving objects.

- know that living organisms have basic needs by identifying characteristics of living organisms that allow their basic needs to be met; and comparing and giving examples of the ways living organisms depend on each other for their basic needs.

- know that the natural world includes rocks, soil, and water by identifying and describing natural resources of water, including streams, lakes, and oceans; observing and describing differences in rocks and soil samples; and identifying how rocks, soil, and water are used and how they can be recycled.

Grade Two

Students are expected to:

- conduct classroom and field investigations following home and school safety procedures by demonstrating safe practices during classroom and field investigations; and learning how to use and conserve resources and dispose of materials.

- develop abilities necessary to do scientific inquiry in the field and classroom by asking questions about organisms, objects, and events; planning and conducting descriptive investigations; comparing results of investigations with what students and scientists know about the world; gathering information using equipment and tools to extend the senses; constructing reasonable explanations and drawing conclusions using information and prior knowledge; and communicating explanations about investigations.

- know that information and critical thinking are used in making decisions by using information to make decisions; discussing and justifying the merits of decisions; and explaining a problem in their own words and identifying a task and solution related to the problem.

- use age-appropriate tools and models to verify that organisms and objects can be observed, described, and measured by collecting information using tools including rulers, meter sticks, measuring cups, clocks, hand lenses, computers, thermometers, and balances; and measuring and comparing organisms and objects and parts of organisms and objects, using standard and non-standard units.

- know that organisms, objects, and events have properties and patterns by classifying and sequencing organisms, objects, and events based on properties and patterns; and identifying, predicting, replicating, and creating patterns including those seen in charts, graphs, and numbers.

- know that systems have parts and are composed of organisms and objects by manipulating, predicting, and identifying parts that, when separated from the whole, may result in the part or the whole not working; manipulating, predicting, and identifying parts that, when put together, can do things they cannot do by themselves; observing and recording the functions of plant parts; and observing and recording functions of animal parts.

- know that many types of change occur by observing, measuring, recording, analyzing, predicting, and illustrating changes in size, mass, temperature, color, position, quantity, sound, and movement; identifying, predicting, and testing uses of heat to cause change; demonstrating a change in the motion of an object by giving the object a push or a pull; and observing, measuring, and recording changes in weather, the night sky, and seasons.

- distinguish between living organisms and nonliving objects by identifying characteristics of living organisms; and identifying characteristics of nonliving objects.

- know that living organisms have basic needs by identifying the external characteristics of different kinds of plants and animals that allow their needs to be met; and comparing and giving examples of the ways living organisms depend on each other and on their environments.

- know that the natural world includes rocks, soil, water, and gases of the atmosphere by describing and illustrating the water cycle; and identifying uses of natural resources.

Grade Three

Students are expected to:

- conduct field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices by demonstrating safe practices during laboratory and field investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific inquiry methods during field and laboratory investigations by planning and implementing descriptive investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and technology; collecting information by observing and measuring; analyzing and interpreting information to construct reasonable explanations from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts to organize, examine, and evaluate information.

- know that information, critical thinking, and scientific problem solving are used in making decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strength and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; representing the natural world using models and identifying their limitations; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use a variety of tools and methods to conduct science inquiry by collecting and analyzing information using tools including calculators, microscopes, cameras, safety goggles, sound recorders, clocks, computers, thermometers, hand lenses, meter sticks, rulers, balances, magnets, and compasses; and demonstrating that repeated investigations may increase the reliability of results.

- know that systems exist in the world by observing and identifying simple systems; and observing a simple system and describing the role of various parts.

- know that forces cause change by measuring and recording changes in the position and direction of the motion of an object to which a force has been applied; and identifying that the surface of the Earth can be changed by forces.

- know that matter has physical properties by gathering information including temperature, magnetism, hardness, and mass using appropriate tools to identify physical properties of matter; and identifying matter as liquids, solids, and gases.

- know that living organisms need food, water, light, air, a way to dispose of waste, and an environment in which to live by observing and describing the habitats of organisms within an ecosystem; observing and identifying organisms with similar needs that compete with one another for resources; describing environment changes in which some organisms would thrive, become ill, or perish; and describing how living organisms modify their physical environment to meet their needs.

- know that species have different adaptations that help them survive and reproduce in their environment by observing and identifying characteristics among species that allow each to survive and reproduce; and analyzing how adaptive characteristics help individuals within a species to survive and reproduce.

- know that likenesses between offspring and parents are inherited from the parents by identifying some inherited traits of plants; and identifying some inherited traits of animals.

- know that the natural world includes earth materials and objects in the sky by identifying and describing the importance of earth materials including rocks, soil, water, and gases of the atmosphere in the local area and classifying them as renewable, nonrenewable, or inexhaustible resources; identifying and recording properties of soils; identifying the planets in our solar system and their position in relation to the Sun; and describing the characteristics of the Sun.

Grade Four

The student is expected to:

- conduct field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices by demonstrating safe practices during field and laboratory investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific inquiry methods during field and laboratory investigations by planning and implementing descriptive investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and tools; collecting information by observing and measuring; analyzing and interpreting information to construct reasonable explanations from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts to recognize, examine, and evaluate information.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; using models and identifying their limitations to represent the natural world; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use tools and methods to conduct science inquiry by collecting and analyzing information using tools including calculators, safety goggles, microscopes, cameras, sound recorders, computers, hand lenses, rulers, thermometers, meter sticks, timing devices, balances, and compasses; and demonstrating that repeated investigations may increase the reliability of results.

- know that complex systems may not work if some parts are removed by identifying and describing the roles of some organisms in living systems and parts in nonliving systems; and predicting and drawing conclusions about what happens when part of a system is removed.

- know that change can create recognizable patterns by identifying patterns of change; illustrating that certain characteristics of an object can remain constant even when the object is rotated, translated, or reflected; and using reflections to verify that a natural object has symmetry.

- know that matter has physical properties by observing and recording changes in the states of matter caused by the addition or reduction of heat; and conducting tests, comparing data, and drawing conclusions about physical properties of matter including states of matter, conduction, density, and buoyancy.

- know that adaptations may increase the survival of members of a species by identifying characteristics that allow members within a species to survive and reproduce; comparing adaptive characteristics of various species; and identifying the kinds of species that lived in the past and compare them to existing species.

- know that many likenesses between offspring and parents are inherited or learned by distinguishing between inherited traits and learned characteristics; and identifying and providing samples of inherited traits and learned characteristics.

- know that certain past events affect present and future events by identifying and observing effects of events that require time for changes to be noticeable including growth, erosion, dissolving, weathering, and flow; and drawing conclusions about what happened before using fossils or charts and tables.

- know that the natural world includes earth materials and objects in the sky by testing properties of soils including texture, capacity to retain water, and ability to support life; summarizing the effects of the oceans on land; and identifying the Sun as the major source of energy for the Earth and understanding its role in the growth of plants, in the creation of winds, and in the water cycle.

Grade Five

Students are expected to:

- conduct field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices by demonstrating safe practices during field and laboratory investigations; and making wise decisions in the use and conservation of resources and the disposal and recycling of materials.

- use scientific methods during field and laboratory investigations by planning and implementing descriptive and experimental investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and technology; collecting information to construct reasonable explanations from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate information.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; representing the natural world using models and identifying their limitations; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use a variety of tools and methods to conduct science inquiry by collecting and analyzing information using tools including computers, calculators, microscopes, cameras, sound recorders, hand lenses, rulers, thermometers, compasses, balances, hot plates, meter sticks, timing devices, magnets, collecting nets, and safety goggles; and demonstrating that repeated investigations may increase the reliability of results.

- know that a system is a collection of cycles, structures, and processes that interact by describing some cycles, structures, and processes that are found in a system; and describing some interactions that occur in a system.

- know that some change occurs in cycles by identifying events and describing changes that occur on a regular basis; identifying the significance of the water, carbon, and nitrogen cycles; and describing and comparing life cycles of plants and animals.

- know that matter has physical properties by classifying matter based on its physical properties including magnetism, physical state, and the ability to conduct or insulate heat, electricity, and sound; demonstrating that some mixtures maintain the physical properties of their ingredients; identifying changes that can occur in the physical properties of the ingredients of solutions; and observing and measuring characteristic properties of substances that remain constant.

- know that energy occurs in many forms by differentiating among forms of energy including light, heat, electrical, and solar energy; identifying and demonstrating everyday examples of how light is reflected and refracted; demonstrating that electricity can flow in a circuit and can produce heat, light, sound, and magnetic effects; and verifying that vibrating an object can produce sound.

- know that adaptations may increase the survival of members of a species by comparing the adaptive characteristics of species that improve their ability to survive and reproduce in an ecosystem; analyzing and describing adaptive characteristics that result in an organism's unique niche in an ecosystem; and predicting some adaptive characteristics required for survival and reproduction by an organism in an ecosystem.

- know that likenesses between offspring and parents can be inherited or learned by identifying traits that are inherited from parent to offspring in plants and animals; and giving examples of learned characteristics that result from the influence of the environment.

- know that certain past events affect present and future events by identifying and observing actions that require time for changes to be measurable, including growth, erosion, dissolving, weathering, and flow; drawing conclusions about what happened before using data; and identifying past events that led to the formation of the Earth's renewable, non-renewable, and inexhaustible resources.

- know that the natural world includes earth materials and objects in the sky by interpreting how land forms are the result of a combination of constructive and destructive forces; describing processes for the formation of coal, oil, gas, and minerals; identifying the physical characteristics of the Earth and comparing them to the physical characteristics of the moon; and identifying gravity as the force that keeps planets in orbit around the Sun and the moon around the Earth.

Grade 6

Students are expected to:

- conduct field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices by demonstrating safe practices during field and laboratory investigations; and making wise decisions in the use and conservation of resources and the disposal and recycling of materials.

- plan and implement investigative procedures during field and laboratory investigations including asking questions, formulating testable hypotheses, and selecting and using equipment and technology; collecting data by observing and measuring; analyzing and interpreting information to construct reasonable explanations from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate data.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; representing the natural world using models and identifying their limitations; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use a variety of tools and methods to conduct science inquiry by collecting, analyzing, and recording information using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather instruments, timing devices, hot plates, test tubes, safety goggles, spring scales, magnets, balances, microscopes, telescopes, thermometers, calculators, field equipment, compasses, computers, and computer probes; and identifying patterns in collected information using percent, average, range, and frequency.

- know that systems may combine with other systems to form a larger system by identifying and describing a system that results from the combination of two or more systems; and describing how the properties of a system are different from the properties of its parts.

- know that there is a relationship between force and motion by identifying and describing the changes in position, direction of motion, and speed of an object when acted upon by force; demonstrating that changes in motion can be measured and graphically represented; and identifying that forces shape features of the Earth including uplifting, movement of water, and volcanic activity.

- know that substances have physical and chemical properties by demonstrating that new substances can be made when two or more substances are chemically combined and comparing the properties of the new substances to the original substances; and classifying substances by their physical and chemical properties.

- know that complex interactions occur between matter and energy by defining matter and energy; explaining and illustrating the interactions between matter and energy in the water cycle and in the decay of biomass; and describing energy flow in living systems including food chains and food webs.

- know that obtaining, transforming, and distributing energy affects the environment by identifying energy transformations occurring during the production of energy for human use; comparing methods used for transforming energy in devices; and researching and describing energy types from their source to their use and determining if the type is renewable, non-renewable, or inexhaustible.

- know the relationship between structure and function in living systems by differentiating between structure and function; determining that all organisms are composed of cells that carry on functions to sustain life; and identifying how structure complements function at different levels of organization including organs, organ systems, organisms, and populations.

- know that traits of species can change through generations and the instructions for traits are contained in the genetic material of the organisms by identifying some changes in traits that can occur over several generations through natural occurrence and selective breeding; identifying cells as structures containing genetic material; and interpreting the role of genes in inheritance.

- know that the responses of organisms are caused by internal or external stimuli by identifying responses in organisms to internal stimuli; identifying responses in organisms to external stimuli; and identifying components of an ecosystem to which organisms may respond.

- know components of our solar system by identifying characteristics of objects in our solar system including the Sun, planets, meteorites, comets, asteroids, and moons; and describing types of equipment and transportation needed for space travel.

- know the structures and functions of Earth systems by summarizing the rock cycle; identifying relationships between groundwater and surface water in a watershed; and describing components of the atmosphere, including oxygen, nitrogen, and water vapor, and identifying the role of atmospheric movement in weather change.

Grade 7

Students are expected to:

- conduct field and laboratory investigations following safe, environmentally appropriate, and ethical practices during field and laboratory investigations; and making wise decisions in the use and conservation of resources and the disposal and recycling of materials.

- use scientific inquiry methods during field and laboratory investigations by planning and implementing investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology; collecting data by observing and measuring; organizing, analyzing, making inferences, and predicting trends from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate data.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; representing the natural world using models and identifying their limitations; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use tools and methods to conduct scientific inquiry by collecting, analyzing, and recording information to explain a phenomenon using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather instruments, hot plates, dissecting equipment, test tubes, safety goggles, spring scales, balances, microscopes, telescopes, thermometers, calculators, field equipment, computers, computer probes, timing devices, magnets, and compasses; and collecting and analyzing information to recognize patterns.

- know that an equilibrium of a system may change by describing how systems may reach an equilibrium; and observing and describing the role of ecological succession in maintaining an equilibrium in an ecosystem.

- know that there is a relationship between force and motion by demonstrating basic relationships between force and motion using simple machines including pulleys and levers; demonstrating that an object will remain at rest or move in a straight line if it is not being subjected to an unbalanced force; and relating forces to basic processes in living organisms including the flow of blood and the emergence of seedlings.

- know that substances have physical and chemical properties by identifying and demonstrating everyday examples of chemical phenomena; describing physical properties of elements and identifying how they are used to position an element on the periodic table; and recognizing that compounds are composed of elements.

- know that complex interactions occur between matter and energy by illustrating examples of potential and kinetic energy in everyday life; and identifying that radiant energy from the Sun is transferred into chemical energy through the process of photosynthesis.

- know the relationship between structure and function in living systems by identifying the systems of the human organism and describing their functions; and describing how organisms maintain stable internal conditions while living in changing external environments.

- know that species can change through generations and that the instructions for traits are contained in the genetic material of the organisms by identifying that sexual reproduction results in more diverse offspring and asexual reproduction results in more uniform offspring; comparing traits of organisms of different species that enhance their survival and reproduction; and distinguishing between dominant and recessive traits and recognizing that inherited traits of an individual are contained in genetic material.

- know that the responses of organisms are caused by internal and external stimuli by analyzing changes in organisms that may result from internal stimuli; and identifying responses in organisms to external stimuli found in the environment.

- know that there is a relationship between organisms and the environment by identifying components of an ecosystem; observing and describing how organisms including producers, consumers, and decomposers live together in an environment and use existing resources; describing how different environments support different varieties of organisms; and observing and describing the role of ecological succession in ecosystems.

- know components of our solar system by identifying and illustrating how the tilt of the Earth on its axis as it rotates and revolves around the Sun causes changes in seasons and the length of a day; and relating the Earth's movement and the moon's orbit to the observed cyclical phases of the moon.

- know that natural events and human activity can alter Earth systems by describing and predicting the impact of different catastrophic events on the Earth; analyzing effects of regional erosional deposition and weathering; and making inferences and drawing conclusions about effects of human activity on Earth's renewable, non-renewable, and inexhaustible resources.

Grade 8

Students are expected to:

- conduct field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices by demonstrating safe practices during field and laboratory investigations; and making wise decisions in the use and conservation of resources and the disposal and recycling of materials.

- use scientific inquiry methods during field and laboratory investigations by planning and implementing investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology; collecting data by observing and measuring; organizing, analyzing, making inferences, and predicting trends from direct and indirect evidence; communicating valid conclusions; and constructing graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate data.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on information related to promotional materials for products and services; representing the natural world using models and identifying their limitations; evaluating the impact of research on scientific thought, society, and the environment; and connecting science concepts with the history of science and contributions of scientists.

- know how to use a variety of tools and methods to conduct science inquiry by collecting, recording, and analyzing information using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather instruments, hot plates, dissecting equipment, test tubes, safety goggles, spring scales, balances, microscopes, telescopes, thermometers, calculators, field equipment, computers, computer probes, water test kits, and timing devices; and extrapolating from collected information to make predictions.

- know that relationships exist between science and technology by identifying a design problem and proposing a solution; designing and testing a model to solve the problem; and evaluating the model and making recommendations for improving the model.

- know that interdependence occurs among living systems by describing interactions among systems in the human organisms; identifying feedback mechanisms that maintain equilibrium of systems; and describing interactions within ecosystems.

- know that there is a relationship between force and motion by demonstrating how unbalanced forces cause changes in the speed or direction of an object's motion; and recognizing that waves are generated and can travel through different media.

- know that matter is composed of atoms by describing the structure and parts of an atom; and identifying the properties of an atom including mass and electrical charge.

- know that substances have chemical and physical properties by demonstrating that substances may react chemically to form new substances; interpreting information on the periodic table to understand that physical properties are used to group elements; recognizing the importance of formulas and equations to express what happens in a chemical reaction; and identifying that physical and chemical properties influence the development and application of everyday materials.

- know that complex interactions occur between matter and energy by illustrating interactions between matter and energy including specific heat; describe interactions among solar, weather, and ocean systems; and identifying and demonstrating that loss or gain of heat energy occurs during exothermic and endothermic chemical reactions.

- know that traits of species can change through generations and that the instructions for traits are contained in the genetic material of the organisms by identifying that change in the environmental conditions can affect the survival of individuals and of species; distinguishing between inherited traits and other characteristics that result from interactions with the environment; and making predictions about possible outcomes of various genetic combinations of inherited characteristics.

- know that cycles exist in Earth systems by analyzing and predicting the sequence of events in the lunar and rock cycles; relating the role of oceans to climatic changes; and predicting the results of modifying the Earth's nitrogen, water, and carbon cycles.

- know characteristics of the universe by describing characteristics of the universe; explaining the use of light years to describe distance in the universe; and researching and describing historical scientific theories of the origin of the universe.

- know that natural events and human activities can alter Earth systems by predicting land features resulting from gradual changes; analyzing how natural or human events may have contributed to the extinction of species; and describing how human activities have modified soil, water, and air quality.

Integrated Physics and Chemistry

Students are expected to:

- conduct field and laboratory investigations using safe, environmentally appropriate, and ethical practices for at least 40 percent of their instructional time by demonstrating safe practices during laboratory and field investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific methods during field and laboratory investigations by planning and implementing investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology; collecting data and making measurements with precision; organizing, analyzing, and predicting trends from data; and communicating valid conclusions.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; drawing inferences based on data related to promotional materials for products and services; evaluating the impact of research on scientific thought, society, and the environment; describing connections between physics and chemistry, and future careers; and researching and describing the history of physics, chemistry, and contributions of scientists.

- know concepts of force and motion in everyday life by calculating speed, momentum, acceleration, work, and power in systems; investigating applications of Newton's laws; analyzing the effects caused by changing force or distance in simple machines demonstrated in household devices, the human body, and vehicles; and investigating mechanical advantage and efficiency of a variety of machines.

- know the effects of waves on everyday life by demonstrating wave types and their characteristics through a variety of activities; demonstrating wave interactions including interference, polarization, reflection, refraction, and resonance within different materials; identifying uses of electromagnetic waves in technological applications; and demonstrating the application of acoustic principles.

- know the impact of energy transformations in everyday life by describing the law of conservation of energy; investigating the movement of heat through solids, liquids, and gases; analyzing the efficiency of energy conversions responsible for the production of electricity; investigating economic and environmental impacts of using energy sources; measuring the thermal and electrical conductivity of various materials; investigating different electric circuits; analyzing relationships between an electric circuit and the strength of its magnetic field using electromagnets; and analyzing effects of heating and cooling processes in systems.
- know relationships exist between properties of matter and its components by investigating and identifying properties of fluids including density, viscosity, and buoyancy; researching the historical development of the atomic theory; identifying constituents of materials or objects using spectral-analysis techniques; relating the chemical behavior of an element including bonding, to its placement on the periodic table; and classifying samples of matter as being elements, compounds, or mixtures.

- know that changes in matter affect everyday life by distinguishing between physical and chemical changes in matter; analyzing energy changes in chemical reactions; investigating the law of conservation of mass; describing types of nuclear reactions and their roles in applications; and researching and describing the environmental and economic impact of end-products of chemical reactions.

- know that solution chemistry is part of everyday life by relating the structure of water to its function as the universal solvent; relating the concentration of ions in a solution to physical and chemical properties; simulating the effects of acid rain on buildings, statues, and microorganisms; demonstrating how various factors influence solubility including temperature, pressure, and nature of the solute and solvent; and demonstrating how factors influence the rate of dissolving.

Biology

Students are expected to:

- conduct field and laboratory investigations using safe, environmentally appropriate, and ethical practices for at least 40 percent of their instructional time by demonstrating safe practices during laboratory and field investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific methods during field and laboratory investigations by planning and implementing investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology; collecting data and making measurements with precision; organizing, analyzing, and predicting trends from data; and communicating valid conclusions.

- use critical thinking and scientific problem

solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; evaluating promotional claims that relate to biological issues; evaluating the impact of research on scientific thought, society, and the environment; describing the connection between biology and future careers; evaluating models according to their adequacy in representing biological objects or events; and researching and describing the history of biology and contributions of scientists.

- know that cells are the basic structures of all living things and have specialized parts that perform specific functions, and that viruses are different from cells and have different properties and functions by identifying the parts of prokaryotic and eukaryotic cells; investigating and identifying cellular processes including homeostasis, permeability, energy production, transportation of molecules, disposal of wastes, function of cellular parts, and synthesis of new molecules; comparing the structures and functions of viruses to cells and describing the role of viruses in causing diseases and conditions; and identifying and describing the role of bacteria in maintaining health and causing diseases.

- know how an organism grows and how specialized cells, tissues, and organs develop by comparing cells from different parts of plants and animals including roots, stems, leaves, epithelia, muscles, and bones to show specialization of structure and function; identifying cell differentiation in the development of organisms; and sequencing the levels of organization in multicellular organisms to relate the parts to each other and to the whole;

- know the structures and functions of nucleic acids in the mechanisms of genetics by describing components of deoxyribonucleic acid (DNA), and illustrating how information for specifying the traits of an organism is carried in the DNA; explaining replication, transcription, and translation using models of DNA and ribonucleic acid (RNA); identifying and illustrating how changes in DNA cause mutations and evaluating the significance of these changes; comparing genetic variations observed in plants and animals; comparing the processes of mitosis and meiosis and their significance to sexual and asexual reproduction; and identifying and analyzing karyotypes.

- know the theory of biological evolution by identifying evidence of change in species using fossils, DNA sequences, anatomical similarities, physiological similarities, and embryology; and illustrating the results of natural selection in speciation, diversity, phylogeny, adaptation, behavior, and extinction.

- know applications of taxonomy and can identify its limitations by collecting and classifying organisms at several taxonomic levels using dichotomous keys; analyzing relationships among organisms and developing a model of a hierarchical classification system based on similarities and differences using taxonomic nomenclature; and identifying characteristics of kingdoms including monerans, protists, fungi, plants, and animals.

- know metabolic processes and energy transfers that occur in living organisms by comparing the structures and functions of different types of biomolecules; comparing the energy flow in photosynthesis to the energy flow in cellular respiration; investigating and identifying the effects of enzymes on food molecules; and analyzing the flow of matter and energy through different trophic levels and between organisms and the physical environment.

- know that, at all levels of nature, living systems are found within other living systems, each with its own boundary and limits by interpreting the functions of systems in organisms including circulatory, digestive, nervous, endocrine, reproductive, integumentary, skeletal, respiratory, muscular, excretory, and immune; comparing the interrelationships of organ systems to each other and to the body as a whole; and analyzing and identifying characteristics of plant systems and subsystems.

- know that organisms maintain homeostasis by identifying and describing the relationships between internal feedback mechanisms in the maintenance of homeostasis; investigating and identifying how organisms, including humans, respond to external stimuli; analyzing the importance of nutrition, environmental conditions, and physical exercise on health; and

summarizing the role of microorganisms in maintaining and disrupting equilibrium including disease in plants and decay in an ecosystem.

- know that interdependence and interactions occur within an ecosystem by analyzing the flow of energy through various cycles including the carbon, oxygen, nitrogen, and water cycles; interpreting interactions among organisms exhibiting predation, parasitism, commensalism, and mutualism; comparing variations, tolerances, and adaptations of plants and animals in different biomes; identifying and illustrating that long-term survival of species is dependent on a resource base that may be limited; and investigating and explaining the interactions in an ecosystem including food chains, food webs, and food pyramids.

- know the significance of plants in the environment by evaluating the significance of structural and physiological adaptations of plants to their environment; and surveying and identifying methods of reproduction, growth, and development of various types of plants.

Chemistry

Students are expected to:

- conduct field and laboratory investigations using safe, environmentally appropriate, and ethical practices for at least 40 percent of their instructional time by demonstrating safe practices during laboratory and field investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific methods during field and laboratory investigations by planning and implementing investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology; collecting data and observing and measuring with precision; expressing and manipulating chemical quantities using scientific conventions and mathematical procedures; organizing, analyzing, evaluating, making inferences, and predicting trends from data; and communicating valid conclusions.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; making responsible choices in selecting everyday products and services using scientific information; evaluating the impact of research on scientific thought, society, and the environment; describing the connection between chemistry and future careers; and researching and describing the history of chemistry and contributions of scientists.

- knows the characteristics of matter by differentiating between physical and chemical properties of matter; analyzing examples of solids, liquids, and gases to determine their compressibility, structure, motion of particles, shape, and volume; investigating and identifying properties of mixtures and pure substances; and describing the physical and chemical characteristics of an element using the periodic table and making inferences about its chemical behavior.

- know that energy transformations occur during physical or chemical changes in matter by identifying changes in matter, determining the nature of the change, and examining the forms of energy involved; identifying and measuring energy transformations and exchanges involved in chemical reactions; and measuring the effects of the gain or loss of heat energy on the properties of solids, liquids, and gases.

- know that atomic structure is determined by nuclear composition, allowable electron cloud, and subatomic particles by describing the existence and properties of subatomic particles; analyzing stable and unstable isotopes of an element to determine the relationship between the isotope's stability and its application; and summarizing the historical development of the periodic table to understand the concept of periodicity.

- know the variables that influence the behavior of gases by describing interrelationships among temperature, particle number, pressure, and volume of gases contained within a closed system; and illustrating the data obtained from investigations with gases in a closed system and determine if the data are consistent with the Universal Gas Law.

- know how atoms form bonds to acquire a stable arrangement of electrons by identifying characteristics of atoms involved in chemical bonding; investigating and comparing the physical and chemical properties of ionic and covalent compounds; comparing the arrangement of atoms in molecules, ionic crystals, polymers, and metallic substances; and describing the influence of intermolecular forces on the physical and chemical properties of covalent compounds.

- know the processes, effects, and significance of nuclear fission and nuclear fusion by comparing fission and fusion reactions in terms of the masses of the reactants and products and the amount of energy released in the nuclear reactions; investigating radioactive elements to determine half-life; evaluating the commercial use of nuclear energy and medical uses of radioisotopes; and evaluating environmental issues associated with the storage, containment, and disposal of nuclear wastes.

- know common oxidation-reduction reactions by identifying oxidation-reduction processes; and demonstrating and documenting the effects of a corrosion process and evaluating the importance of electroplating metals.

- know that balanced chemical equations are used to interpret and describe the interactions of matter by identifying common elements and compounds using scientific nomenclature; demonstrating the use of symbols, formulas, and equations in describing interactions of matter; and explaining and balancing chemical and nuclear equations using number of atoms, masses, and charge.

- know the factors that influence the solubility of solutes in a solvent by demonstrating and explaining effects of temperature and the nature of solid solutes on the solubility of solids; developing general rules for solubility through investigations with aqueous solutions; and evaluating the significance of water as a solvent in living organisms and in the environment.

- know relationships among the concentration, electrical conductivity, and colligative properties of a solution by comparing unsaturated, saturated, and supersaturated solutions; interpreting relationships among ionic and covalent compounds, electrical conductivity, and colligative properties of water; and measuring and comparing the rates of reaction of a solid reactant in solutions of varying concentration.

- know the properties and behavior of acids and bases by analyzing and measuring common household products using a variety of indicators to classify the products as acids and bases; demonstrating the electrical conductivity of acids and bases; identifying the characteristics of a neutralization reaction; and describing effects of acids and bases on an ecological system.

- know factors involved in chemical reactions by verifying the law of conservation of energy by evaluating the energy exchange that occurs as a consequence of a chemical reaction; and relating the rate of a chemical reaction to temperature, concentration, surface area, and presence of a catalyst.

Physics

Students are expected to:

- conduct field and laboratory investigations using safe, environmentally appropriate, and ethical practices for at least 40 percent of their instructional time by demonstrating safe practices during laboratory and field investigations; and making wise choices in the use and conservation of resources and the disposal or recycling of materials.

- use scientific methods during field and laboratory investigations by planning and implementing experimental procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology; making quantitative observations and measurements with precision; organizing, analyzing, evaluating, making inferences, and predicting trends from data; communicating valid conclusions; graphing data to observe and identify relationships between variables; and reading the scale on scientific instruments with precision.

- use critical thinking and scientific problem solving to make informed decisions by analyzing, reviewing, and critiquing scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; expressing laws symbolically and employing

mathematical procedures including vector addition and right-triangle geometry to solve physical problems; evaluating the impact of research on scientific thought, society, and the environment; describing the connection between physics and future careers; and researching and describing the history of physics and contributions of scientists.

- know the laws governing motion by generating and interpreting graphs describing motion including the use of real-time technology; analyzing examples of uniform and accelerated motion including linear, projectile, and circular; demonstrating the effects of forces on the motion of objects; developing and interpreting a free-body diagram for force analysis; and identifying and describing motion relative to different frames of reference.

- know that changes occur within a physical system and recognize that energy and momentum are conserved by interpreting evidence for the work-energy theorem; observing and describing examples of kinetic and potential energy and their transformations; calculating the mechanical energy and momentum in a physical system; and demonstrating the conservation of energy and momentum.

- know forces in nature by identifying the influence of mass and distance on gravitational forces; researching and describing the historical development of the concepts of gravitational, electrical, and magnetic force; identifying and analyzing the influences of charge and distance on electric forces; demonstrating the relationship between electricity and magnetism; designing and analyzing electric circuits; and identifying examples of electrical and magnetic forces in everyday life.

- know laws of thermodynamics by analyzing and explaining everyday examples that illustrate the laws of thermodynamics; and evaluating different methods of heat energy transfer that result in an increasing amount of disorder.

- know the characteristics and behavior of waves by examining and describing a variety of waves propagated in various types of media and describing wave characteristics and behaviors; identifying the characteristics and behaviors of sound and electromagnetic waves; and interpreting the role of wave characteristics and behaviors found in medicinal and industrial applications.

- know simple examples of quantum physics by describing the photoelectric effect; and explaining the line spectra from different gas-discharge tubes.

TEXAS ACCESSIBILITY STANDARDS (TAS)

Texas Department of Licensing and Regulation
Architectural Barriers Act
Article 9102, Texas Civil Statutes

1.	Purpose, Authority, Application.

1.1 Purpose. This document sets standards for accessibility to: public buildings and facilities; privately owned buildings and facilities leased or occupied by state agencies; places of public accommodation; and commercial facilities by individuals with disabilities. Subject buildings and facilities are addressed in more detail in Rule 68.21. These standards are to be applied during the design, construction, and alteration of such buildings and facilities to the extent required by regulations issued by the Texas Department of Licensing and Regulation, under the Architectural Barriers Act, codified as Article 9102, Texas Civil Statutes.

These standards closely follow the Americans with Disabilities Act Accessibility Guidelines (ADAAG), and are intended to facilitate equivalency certification of the state program for the elimination of architectural barriers by the United States Department of Justice by:

Bringing the state Architectural Barriers Act into alignment with the scoping requirements of the Americans with Disabilities Act (ADA), (P. L. 101-336).

- Expanding ADAAG with additional state scoping requirements and standards.
- Encouraging compliance by using common standards.
- Speeding the dissemination of required standards to owners, design professionals, and related user groups.

Some of the illustrations and text of ANSI A117.1-1980, and ANSI A117.1-1986, are included in this document and are reproduced with permission from the American National Standards Institute. Copies of those standards may be purchased from the American National Standards Institute at 11 West 42nd Street, New York, New York 10036.

1.2 Authority. Section 5(c), Article 9102, Texas Civil Statues, requires the commissioner to adopt standards and specifications that are consistent in effect to those adopted by the American National Standards Institute, Inc. (ANSI), or its federally recognized successor in function. Section 5(c) also requires adopted standards and specifications be consistent to those adopted under federal law. These standards, including the appendix, are intended to be consistent to those contained in ADAAG, and are generally the same as ADAAG except as noted by italics.

1.3 Application.

1.3.1 Minimum Requirements. The standards contained in this document shall be considered the minimum requirements for complying with the intent of Article 9102, Texas Civil Statutes. They are common to all spaces and elements of buildings and facilities constructed on or after April 1, 1994, and shall have both interior and exterior application. It is not the intent of these standards to prohibit or discourage the development and use of sites with extreme conditions. However, excavation or other site modifications, even contrary to natural terrain, may be necessary to comply with the intent of the law.

1.3.2 Equal Access. The application of these standards is to further the concept of equal treatment for people with disabilities to the maximum extent possible and reasonable.

2. General.

2.1 Provisions for Adults and Children. The specifications in ADAAG* are based upon adult dimensions and anthropometrics and do not set out adjusted specifications suitable for children. Some of the specifications contained in these standards have been derived from human data relative to children between the ages of four and 15 and are presented in 2.1.1 by age and school grade categories.

2.1.1 Mounting Heights for Adults and Children. In addition to the minimum requirements of 4.1, when children under high school age (typically 14 or 15) are the primary users of a building or facility (such as day care centers, elementary schools, children's museums or children's areas of museums, children's reading rooms in libraries, etc.) mounting heights and reach-ranges of various elements, fixtures, and equipment, shall be adjusted to meet the needs of the appropriate age group. The elements, fixtures and equipment listed in the table below shall comply with the corresponding requirements. When facilities serve children under the age of four, the lower dimensions listed shall be used.

EXCEPTION: In facilities serving children under the age of four, water closet seat heights may be lower than 14" but not higher than 15".

	Ages 4 thru 10 or 11 Grades: Pre-K thru 5 or 6	**Ages 11 thru 14 or 15 Grades: 6 thru 8 or 9**
Reach Ranges		
Frontal Approach	42" maximum	45" maximum
Side Approach	48" maximum	51" maximum
Ramps and Stairs		
Top of Handrail Gripping Surface	28"–34"	30"–34"
Elevators		
Car Control Floor Buttons		
Frontal Approach	42" maximum	45" maximum
Side Approach	48" maximum	51" maximum
Emergency Communications		
Highest Operable Part	42" maximum	45" maximum
Platform Lifts (Wheelchair Lifts)*		
Controls/Operating Mechanisms	28"–42"	28"–45"
Drinking Fountains and Water Coolers		
Frontal Approach	32" maximum	34" maximum
Spout Height (to outlet)	26" minimum	27" minimum
Knee Clearance		
Side Approach	32" maximum	34" maximum
Spout Height (to outlet)		
Water Closets		
Top of Seat	14"–15"	15"–17"
Grab Bars	28"–30"	30"–32"
Flush Controls	42" maximum	44" maximum
Urinals		
Rim of Basin	14" maximum	16" maximum
Flush Controls	42" minimum	44" minimum

*Americans with Disabilities Act Accessibility Guidelines (ADAAG)

	Ages 4 thru 10 or 11 Grades: Pre-K thru 5 or 6	Ages 11 thru 14 or 15 Grades: 6 thru 8 or 9
Lavatories and Sinks		
Rim or Counter Surface	30" maximum	32" maximum
Knee Clearance	26" minimum	28" minimum
To Faucets From Front Edge	18" maximum	20" maximum
Mirrors		
To Bottom of Reflective Surface	34" maximum	37" maximum
Bathtubs		
Top of Seat	14"–15"	15"–16"
Grab Bars	28"–32"	30"–32"
Hand Shower Head Mounting	42" maximum	45" maximum
Shower Stalls		
Top of Seat	14"–15"	15"–16"
Grab Bars	28"–30"	30"–32"
Hand Shower Head Mounting		
Frontal Approach	42" maximum	45" maximum
Side Approach	48" maximum	51" maximum
Storage		
Frontal Approach	42" maximum	45" maximum
Side Approach		
Distance From Wheelchair		
0"–10"	48" maximum	51" maximum
10"–21"	42" maximum	45" maximum
Controls and Operating Mechanisms		
Highest Operable Part		
Frontal Approach	42" maximum	45" maximum
Side Approach	48" maximum	51" maximum
Telephones		
Highest Operable Part		
Frontal Approach	42" maximum	45" maximum
Side Approach	48" maximum	51" maximum
Fixed or Built-in Seating and Tables, Reading and Study Areas, and Work Stations		
Height of Tables or Counters	28"–30"	28"–32"
Knee Clearances	26"	28"
Dressing and Fitting Rooms		
Top of Bench	14"–15"	15"–17"
Food Service Lines		
Top of Tray Slide	30" maximum	32" maximum

2.1.2 Mixed Use Buildings and Facilities. When two age groups are primary users (such as in Elementary/ Middle Schools and Junior/Senior High Schools), or when facilities are intended for use by various age groups and have no characteristics that reflect a predominant age group (such as community swimming pools and amusement parks) mounting heights shall be determined on a case-by-case basis. Contact the commission for additional information and assistance.

2.2* Equivalent Facilitation. With the approval of the commissioner in accordance with the variance procedures contained in Rule 68.31, departures from particular technical and scoping requirements of this standard by using other designs and technologies may be permitted where the alternative designs and technologies used will provide substantially equivalent or greater access to and usability of the facility.

3.4 General Terminology

3.4.1 comply with. Meet one or more specifications of these standards.

3.4.2 if, . . . then. Denotes a specification that applies only when the conditions described are present.

3.4.3 may. Denotes an option or alternative.

3.4.4 shall. Denotes a mandatory specification or requirement.

3.4.5 should. Denotes an advisory specification or recommendation.

3.5 Definitions

3.5.1 Access Aisle. An accessible pedestrian space between elements, such as parking spaces, seating, and desks, that provides clearances appropriate for use of the elements.

3.5.2 Accessible. Describes a site, building, facility, or portion thereof that complies with these standards.

3.5.3 Accessible Element. An element specified by these standards (for example, telephone, controls, and the like).

3.5.4 Accessible Route. A continuous unobstructed path connecting all accessible elements and spaces of a building or facility. Interior accessible routes may include corridors, floors, ramps, elevators, lifts, and clear floor space at fixtures. Exterior accessible routes may include parking access aisles, curb ramps, crosswalks at vehicular ways, walks, ramps, and lifts.

3.5.5 Accessible Space. Space that complies with these standards.

3.5.6 Adaptability. The ability of certain building spaces and elements, such as kitchen counters, sinks, and grab bars, to be added or altered so as to accommodate the needs of individuals with or without disabilities or to accommodate the needs of persons with different types or degrees of disability.

3.5.7 Addition. An expansion, extension, or increase in the gross floor area of a building or facility.

3.5.8 Administrative Authority. A governmental agency that adopts or enforces regulations and guidelines for the design, construction, or alteration of buildings and facilities.

3.5.9 Alteration. An alteration is a change to a building or facility made by, on behalf of, or for the use of a public entity, a lease to or occupancy by a state agency, a public accommodation or commercial facility, that affects or could affect the usability of the building or facility or part thereof. Alterations include, but are not limited to, remodeling, renovation, rehabilitation, reconstruction, historic restoration, changes or rearrangement of the structural parts or elements, and changes or rearrangement in the plan configuration of walls and full-height partitions. Normal maintenance, reroofing, painting or wallpapering, or changes to mechanical and electrical systems are not alterations unless they affect the usability of the building or facility.

3.5.10 Area of Rescue Assistance. An area, which has direct access to an exit, where people who are unable to use stairs may remain temporarily in safety to await further instructions or assistance during emergency evacuation.

3.5.11 Assembly Area. A room or space accommodating a group of individuals for recreational, educational, political, social, or amusement purposes, or for the consumption of food and drink, or awaiting transportation.

3.5.12 Automatic Door. A door equipped with a power-operated mechanism and controls that open and close the door automatically upon receipt of a momentary actuating signal. The switch that begins the automatic cycle may be a photoelectric device, floor mat, or manual switch (see power-assisted door).

3.5.13 Balcony. That portion of a seating space of an assembly room, auditorium, or theater that is raised at least four feet above the level of the main floor.

3.5.14 Building. Any structure used and intended for supporting or sheltering any use or occupancy.

3.5.15 Commissioner. The executive director of the Texas Department of Licensing and Regulation.

3.5.16 Component. An element or space in a building or facility.

3.5.17 Circulation Path. An exterior or interior way of passage from one place to another for pedestrians, including, but not limited to, walks, hallways, courtyards, stairways, and stair landings.

3.5.18 Clear. Unobstructed.

3.5.19 Clear Floor Space. The minimum level and unobstructed floor or ground space required to accommodate a single, stationary wheelchair and occupant.

3.5.20 Closed Circuit Telephone. A telephone with dedicated line(s) such as a house phone, courtesy phone or phone that must be used to gain entrance to a building or facility.

3.5.21 Common Use. Refers to those interior and exterior rooms, spaces, or elements that are made available for the use of a restricted group of people (for example, occupants of a homeless shelter, the occupants of an office building, or the guests of such occupants).

3.5.22 Cross Slope. The slope that is perpendicular to the direction of travel (see running slope).

3.5.23 Curb Ramp. A short ramp cutting through a curb or built up to it.

3.5.24 Detectable Warning. A standardized surface feature built in or applied to walking surfaces or other elements to warn visually impaired people of hazards on a circulation path or path of travel.

3.5.25 Dwelling Unit. A single unit which provides a kitchen or food preparation area, in addition to rooms and spaces for living, bathing, sleeping, and the like. Dwelling units include a single family home or a townhouse used as a transient group home; an apartment building used as a shelter; guestrooms in a hotel that provide sleeping accommodations and food preparation areas; and other similar facilities used on a transient basis. For purposes of these standards, use of the term "Dwelling Unit" does not imply the unit is used as a residence.

3.5.26 Egress, Means of. A continuous and unobstructed way of exit travel from any point in a building or facility to a public way. A means of egress comprises vertical and horizontal travel and may include intervening room spaces, doorways, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, horizontal exits, courts and yards. An accessible means of egress is one that complies with these standards and does not include stairs, steps, or escalators. Areas of rescue assistance or evacuation elevators may be included as part of accessible means of egress.

3.5.27 Element. An architectural or mechanical component of a building, facility, space, or site, e.g., telephone, curb ramp, door, drinking fountain, seating, or water closet.

3.5.28 Entrance. Any access point to a building or portion of a building or facility used for the purpose of entering. An entrance includes the approach walk, the vertical access leading to the entrance platform, the entrance platform itself, vestibules if provided, the entry door(s) or gate(s), and the hardware of the entry door(s) or gate(s).

3.5.29 Entrance Platform. The clear floor or ground area at accessible entrances required by 4.13.6.

3.5.30 Essential Features. Those supporting elements and spaces that make a building or facility usable by, or serve the needs of, its occupants or users. Essential features may include but are not limited to:

(1) Entrances
(2) Toilet Rooms
(3) Dining Areas
(4) Accessible Routes
(5) Laundry Rooms
(6) Lounges
(7) Play Areas
(8) Service Aisles
(9) Exercise or Weight Rooms
(10) Laboratories
(11) Darkrooms
(12) Swimming Pools
(13) Concession Stands
(14) Atriums
(15) Fishing Piers
(16) Boat Docks
(17) Hike and Bike Trails
(18) Picnic Areas
(19) Courtyards
(20) Plazas

Essential features do not include those spaces that house the major activities for which the building or facility is intended, such as classrooms and offices. See Functional Spaces.

3.5.31 Facility. All or any portion of buildings, structures, site improvements, complexes, equipment, roads, walks, passageways, parking lots, or other real or personal property located on a site.

3.5.32 Functional Spaces. The rooms and spaces in a building or facility that house the major activities for which the building or facility is intended. Also see Essential Features.

3.5.33 Ground Floor. Any occupiable floor less than one story above or below grade with direct access to grade. A building or facility always has at least one ground floor and may have more than one ground floor as where a split level entrance has been provided or where a building is built into a hillside.

3.5.34 lbf. Pounds-force.

3.5.35 Level. A ground or floor surface or part of a surface having a slope of not more than 1:50 (2.0%) at any point, in any direction. Slopes expressed in terms of 3 inch per foot shall be considered 2.0% and shall be acceptable as level.

3.5.36 Marked Crossing. A crosswalk or other identified path intended for pedestrian use in crossing a vehicular way.

3.5.37 Mezzanine or Mezzanine Floor. That portion of a story which is an intermediate floor level placed within the story and having occupiable space above and below its floor. Any such area exceeding one-third of the total floor area of the room or space in which it is located shall be considered a full story.

3.5.38 Multifamily Dwelling. Any building containing more than two dwelling units.

3.5.39 Occupiable. A room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes, or in which occupants are engaged at labor, and which is equipped with means of egress, light, and ventilation.

3.5.40 Operable Part. A part of a piece of equipment or appliance used to insert or withdraw objects, or to activate, deactivate, or adjust the equipment or appliance (for example, coin slot, pushbutton, handle).

3.5.41 Path of Travel. (Reserved).

3.5.42 Performing Area. See Stage.

3.5.43 Power-assisted Door. A door used for human passage with a mechanism that helps to open the door, or relieves the opening resistance of a door, upon the activation of a switch or a continued force applied to the door itself.

3.5.44 Primary Function. With respect to an alteration of a building or facility, the primary function is a major activity for which the facility is intended. Areas that contain a primary function include, but are not limited to, the customer services lobby of a bank, the dining area of a cafeteria, the meeting rooms in a conference center, as well as offices and other work areas in which the activities of the public accommodation, commercial facility, or other private entity using the facility are carried out. Mechanical rooms, boiler rooms, supply storage rooms, employee lounges or locker rooms, janitorial closets, entrances, corridors, and restrooms are not areas containing a primary function.

3.5.45 Principal or Primary Entrances. Building and facility entrances that are recognized by the occupants and visitors as the main points of entry and exit and are used as such.

3.5.46 Public Funds (Publicly Funded). Funds provided by any governmental entity including federal, state, county, city, or any other political subdivision of the state.

3.5.47 Public Use. Describes interior or exterior rooms or spaces that are made available to the general public. Public use may be provided at a building or facility that is privately or publicly owned.

3.5.48 Ramp. A walking surface which has a running slope greater than 1:20 (5.0%).

3.5.49 Running Slope. The slope that is parallel to the direction of travel (see Cross Slope).

3.5.50 Service Entrance. An entrance intended primarily for delivery of goods or services.

3.5.51 Signage. Displayed verbal, symbolic, tactile, and pictorial information.

3.5.52 Site. A parcel of land bounded by a property line or a designated portion of a public right-of-way.

3.5.53 Site Improvement. Landscaping, paving for pedestrian and vehicular ways, outdoor lighting, recreational facilities, and the like, added to a site.

3.5.54 Sleeping Accommodations. Rooms in which people sleep; for example, dormitory and hotel or motel guest rooms or suites.

3.5.55 Space. A definable area, e.g., room, toilet room, hall, assembly area, entrance, storage room, alcove, courtyard, or lobby.

3.5.56 Stage. An area of an assembly building or assembly area that is designed or used for demonstrations or the presentation of theatrical, educational, musical, or other events. See Performing Area.

3.5.57 Story. That portion of a building included between the upper surface of a floor and upper surface of the floor or roof next above. If such portion of a building does not include occupiable space, it is not considered a story for purposes of these standards. There may be more than one floor level within a story as in the case of a mezzanine or mezzanines, or a balcony or balconies.

3.5.58 Structural Frame. The structural frame shall be considered to be the columns and the girders, beams, trusses and spandrels having direct connections to the columns and all other members which are essential to the stability of the building as a whole.

3.5.59 Structurally Impracticable. With respect to new construction, those rare circumstances where full compliance has little likelihood of being accomplished because the unique characteristics of terrain prevent the incorporation of an accessibility feature. All determinations of Structural Impracticability are made by the commissioner in accordance with the variance procedures contained in Rule 68.31.

3.5.60 Tactile. Describes an object that can be perceived using the sense of touch.

3.5.61 Technically Infeasible. With respect to an alteration of a building or a facility, it has little likelihood of being accomplished because existing structural conditions would require removing or altering a load-bearing member which is an essential part of the structural frame; or because other existing physical or site constraints prohibit modification or addition of elements, spaces, or features which are in full and strict compliance with the minimum requirements for new construction and which are necessary to provide accessibility. All determinations of Technical Infeasibility are made by the commissioner in accordance with the variance procedures contained in Rule 68.31.

3.5.62 Text Telephone. Machinery or equipment that employs interactive graphic (i.e., typed) communications through the transmission of coded signals across the standard telephone network. Text telephones can include, for example, devices known as TDD's (telecommunication display devices or telecommunication devices for deaf persons) or computers.

3.5.63 Transient Lodging. A building, facility, or portion thereof, excluding inpatient medical care facilities, that contains one or more dwelling units or sleeping accommodations. Transient lodging may include, but is not limited to, resorts, group homes, hotels, motels, and dormitories.

3.5.64 Vehicular Way. A route intended for vehicular traffic, such as a street, driveway, or parking lot.

3.5.65 Walk. An exterior pathway with a prepared surface intended for pedestrian use, including general pedestrian areas such as plazas and courts.

4. Accessible Elements and Spaces: Scope and Technical Requirements.

4.1 Minimum Requirements.

4.1.1* Application.

(1) General.

(a) All areas of newly designed or newly constructed buildings and facilities required to be accessible by 4.1.2 and 4.1.3 and altered portions of existing buildings and facilities required to be accessible by 4.1.6 shall comply with these standards, 4.1 through 4.35, unless otherwise provided in this section or as modified in a special application section. All areas that are considered an Essential Feature or a Functional Space or, in the case of alterations a Primary Function, all as defined in these standards, shall be designed and constructed to be accessible in accordance with the specific requirements of these standards.

(b) Appropriate Number and Location. The standards for determining the appropriate or minimum numbers contained in this document are considered minimal and the commissioner shall have the authority to make adjustments when it is determined that the standards would cause the numbers or locations to be insufficient to adequately meet the needs of people with disabilities based on the nature, use and other circumstances of any particular building or facility. In determining the appropriate number and location of a particular element, space, or fixture, the following factors shall be among those considered:

(i) population to be served;

(ii) availability to user;

(iii) location relative to distance and time;

(iv) location relative to isolation and separation;

(v) function of the building or facility; and

(vi) equal treatment and opportunity.

(2) Application Based on Building Use. Special application sections 5 through 10 provide additional requirements for restaurants and cafeterias, medical care facilities, business and mercantile, libraries, accessible transient lodging, and transportation facilities. When a building or facility contains more than one use covered by a special application section, each portion shall comply with the requirements for that use.

(3)* Areas Used Only by Employees as Work Areas. Areas that are used only as work areas shall be designed and constructed so that individuals with disabilities can approach, enter, and exit the areas. These standards do not require that any areas used only as work areas be constructed to permit maneuvering within the work area or be constructed or equipped (i.e., with racks or shelves) to be accessible.

(4) Temporary Structures. These standards cover temporary buildings or facilities as well as permanent facilities. Temporary buildings and facilities are not of permanent construction but are extensively used or are essential for public use for a period of time. Examples of temporary buildings or facilities covered by these standards include, but are not limited to: reviewing stands, temporary classrooms, bleacher areas, exhibit areas, temporary banking facilities, temporary health screening services, or temporary safe pedestrian passageways around a construction site. Structures, sites and equipment directly associated with the actual processes of construction, such as scaffolding, bridging, materials hoists, or construction trailers are not included.

(5) General Exceptions.

(a) In new construction, a person or entity is not required to meet fully the requirements of these standards where that person or entity can demonstrate, through the variance application procedures contained in Rule 68.31, that it is structurally impracticable to do so. Full compliance will be considered structurally impracticable only in those rare circumstances when the unique characteristics of terrain prevent the incorporation of accessibility features. If full compliance with the requirements of these standards is deemed structurally impracticable, a person or entity shall comply with the requirements to the extent it is not structurally impracticable. Any portion of the building or facility which can be made accessible shall comply to the extent that it is not structurally impracticable.

(b) Accessibility is not required to (i) observation galleries used primarily for security purposes; or (ii) in non-occupiable spaces accessed only by ladders, catwalks, crawl spaces, very narrow passageways, or freight (non-passenger) elevators, and frequented only by service personnel for repair purposes; such spaces include, but are not limited to, elevator pits, elevator penthouses, piping or equipment catwalks.

4.1.2 Accessible Sites and Exterior Facilities: New Construction. (intentionally omitted)

4.1.3 Accessible Buildings: New Construction. (1–17 intentionally omitted)

(18) If fixed or built-in seating or tables (including, but not limited to, study carrels and student laboratory stations), are provided in an accessible public or common use area, at least five percent (5%), but not less than one, of the fixed or built-in seating areas or tables shall comply with 4.32. An accessible route shall lead to and through such fixed or built-in seating areas, or tables.

(19)* Assembly Areas:

(a) In places of assembly with fixed seating accessible wheelchair locations shall comply with 4.33.2, 4.33.3, and 4.33.4 and shall be provided consistent with Table 4.

Table 4

Capacity of Seating in Assembly Areas	Number of Required Wheelchair Spaces
4 to 25	1
26 to 50	2
51 to 300	4
301 to 500	6
over 500	6, plus 1 additional space for each total seating capacity increase of 100

In addition, one percent, but not less than one, of all fixed seats shall be aisle seats with no armrests on the aisle side, or removable or folding armrests on the aisle side. Each such seat shall be identified by a sign or marker. Signage notifying patrons of the availability of such seats shall be posted at the ticket office. Aisle seats are not required to comply with 4.33.4.

(b) This paragraph applies to assembly areas where audible communications are integral to the use of the space (e.g., concert and lecture halls, playhouses and movie theaters, meeting rooms, etc.). Such assembly areas, if (1) they accommodate at least 50 persons, or if they have audio-amplification systems, and (2) they have fixed seating, shall have a permanently installed assistive listening system complying with 4.33. For other assembly areas, a permanently installed assistive listening system, or an adequate number of electrical outlets or other supplementary wiring necessary to support a portable assistive listening system shall be provided. The minimum number of receivers to be provided shall be equal to 4 percent of the total number of seats, but in no case less than two. Signage complying with applicable provisions of 4.30 shall be installed to notify patrons of the availability of a listening system.

(c) Assembly areas shall also be provided with one unisex toilet room for each instance where the total fixture count (water closets and urinals) in a set of men and women's toilet rooms exceeds 20 fixtures. The unisex toilet room shall comply with 4.22 and shall be located adjacent to the men and women's toilet rooms which are used to determine that the unisex toilet room is required.

(20–21 intentionally omitted).

4.1.4 (Reserved).

4.1.5 Accessible Buildings: Additions. (intentionally omitted).

4.1.6 Accessible Buildings: Alterations.

(1) General. Alterations to existing buildings and facilities shall comply with the following:

(a) No alteration shall be undertaken which decreases or has the effect of decreasing accessibility or usability of a building or facility below the requirements for new construction at the time of alteration.

(b) If existing elements, spaces, or common areas are altered, then each such altered element, space, feature, or area shall comply with the applicable provisions of 4.1.1 to 4.1.3 Minimum Requirements (for New Construction). If the applicable provision for new construction requires that an element, space, or common area be on an accessible route, the altered element, space, or common area is not required to be on an accessible route except as provided in 4.1.6(2) (Alterations to an Area Containing a Primary Function).

(c) If alterations of single elements, when considered together, amount to an alteration of a room or space in a building or facility, the entire space shall be made accessible.

(d) No alteration of an existing element, space, or area of a building or facility shall impose a requirement for greater accessibility than that which would be required for new construction. For example, if the elevators and stairs in a building are being altered and the elevators are, in turn, being made accessible, then no accessibility modifications are required to the stairs connecting levels connected by the elevator. If stair modifications to correct unsafe conditions are required by other codes, the modifications shall be done in compliance with these standards unless technically infeasible.

(e) At least one interior public text telephone complying with 4.31.9 shall be provided if:

(i) alterations to existing buildings or facilities with less than four exterior or interior public pay telephones would increase the total number to four or more telephones with at least one in an interior location; or

(ii) alterations to one or more exterior or interior public pay telephones occur in an existing building or facility with four or more public telephones with at least one in an interior location.

(f) If an escalator or stair is planned or installed where none existed previously and major structural modifications are necessary for such installation, then a means of accessible vertical access shall be provided that complies with the applicable provisions of 4.7, 4.8, 4.10, or 4.11.

(g) In alterations, the requirements of 4.1.3(9), 4.3.10 and 4.3.11 do not apply.

(h)* Entrances: If a planned alteration entails alterations to an entrance, and the building has an accessible principal or primary entrance, the entrance being altered is not required to comply with 4.1.3(8), (except to the extent required by 4.1.6(2)), unless the altered entrance will become a principal or primary entrance by design or function. If a particular entrance is not made accessible, appropriate accessible signage indicating the location of the nearest accessible entrance(s) shall be installed at or near the inaccessible entrance, such that a person with disabilities will not be required to retrace the approach route from the inaccessible entrance.

(i) If the alteration work is limited solely to the electrical, mechanical, or plumbing system, or to hazardous material abatement, or automatic sprinkler retrofitting, and does not involve the alteration of any elements or spaces required to be accessible under these guidelines, then 4.1.6(2) does not apply.

(j) EXCEPTION: If compliance with 4.1.6 is technically infeasible, the alteration shall provide accessibility to the maximum extent feasible. Any elements or features of the building or facility that are being altered and can be made accessible shall be made accessible within the scope of the alteration.

Technically Infeasible, with respect to an alteration, is defined in section 3.5.61.

(k) EXCEPTION:

(i) These standards do not require the installation of an elevator in an altered facility that is less than three stories or has less than 3,000 square feet per story unless the building is a shopping center, a shopping mall, the professional office of a health care provider, a terminal, depot, or other station used for specified public transportation, or an airport terminal.

(ii) The exemption provided in paragraph 4.1.6(1)(k)(i) does not obviate or limit in any way the obligation to comply with the other accessibility requirements established in these standards. For example, alterations to floors above or below the ground floor must be accessible regardless of whether the altered facility has an elevator. If a facility subject to the elevator exemption set forth in paragraph 4.1.6(1)(k)(i) nonetheless has a full passenger elevator, that elevator shall meet, to the maximum extent feasible, the accessibility requirements of these guidelines.

(2) Alterations to an Area Containing a Primary Function: In addition to the requirements of 4.1.6(1), an alteration that affects or could affect the usability of or access to an area containing a primary function shall be made so as to ensure that the accessible route to the altered area and the parking, restrooms, telephones, and drinking fountains serving the altered area, are readily accessible to and usable by individuals with disabilities, unless such alterations are disproportionate to the overall alterations in terms of cost and scope, and specifically approved by the commissioner in accordance with the variance procedures contained in Rule 68.31. Related criteria established by the Attorney General of the United States shall be among the evidence considered by the commissioner.

EXCEPTION: Accessible parking required by 4.1.6(2) shall comply with 4.1.2(5)(a) except that the Total Parking in Lot column in Table 2 may be applied only to the total number of spaces assigned to, or reasonably considered for use by the occupants of and visitors to, the altered area.

(3) Special Technical Provisions for Alterations to Existing Buildings and Facilities:

(a) Ramps: With the approval of the commissioner in accordance with the variance procedures contained in Rule 68.31, curb ramps and interior or exterior ramps to be constructed on sites or in existing buildings or facilities where space limitations prohibit the use of a 1:12 slope or less may have slopes and rises as follows:

(i) A slope between 1:10 and 1:12 is allowed for a maximum rise of 6 inches.

(ii) A slope between 1:8 and 1:10 is allowed for a maximum rise of 3 inches. A slope steeper than 1:8 is not allowed.

(b) Stairs: Full extension of handrails at stairs shall not be required in alterations where such extensions would be hazardous or impossible due to plan configuration.

(c) Elevators:

(i) If safety door edges are provided in existing automatic elevators, automatic door reopening devices may be omitted (see 4.10.6).

(ii) Where existing shaft configuration or technical infeasibility prohibits strict compliance with 4.10.9, the minimum car plan dimensions may be reduced by the minimum amount necessary, but in no case shall the inside car area be smaller than 48 inches by 48 inches.

(iii) Equivalent facilitation may be provided with an elevator car of different dimensions when usability can be demonstrated and when all other elements required to be accessible comply with the applicable provisions of 4.10. For example, an elevator of 47 inches by 69 inches (1195 mm by 1755 mm) with a door opening on the narrow dimension, could accommodate the standard wheelchair clearances shown in Figure 4.

(d) Doors:

(i) Where it is technically infeasible to comply with clear opening width requirements of 4.13.5, a projection of 5/8 inches maximum will be permitted for the latch side stop.

(ii) If existing thresholds are 3/4 inches high or less, and have (or are modified to have) a beveled edge (1:2 maximum) on each side, they may remain.

(e) Toilet Rooms:

(i) Where it is technically infeasible to comply with 4.22 or 4.23, the installation of at least one unisex toilet/bathroom per floor, located in the same area as existing toilet facilities, will be permitted in lieu of modifying existing toilet facilities to be accessible. Each unisex toilet room shall contain one water closet complying with 4.16 and one lavatory complying with 4.19, and the door shall have a privacy latch.

(ii) Where it is technically infeasible to install a required standard stall (Fig. 30(a)), or where other codes prohibit reduction of the fixture count (i.e., removal of a water closet in order to create a double-wide stall), either alternate stall (Fig. 30(b)) may be provided in lieu of the standard stall.

(iii) When existing toilet or bathing facilities are being altered and are not made accessible, signage complying with 4.30.1, 4.30.2, 4.30.3, 4.30.5, and 4.30.7 shall be provided indicating the location of the nearest accessible toilet or bathing facility within the facility.

(f) Assembly Areas:

(i) Where it is technically infeasible to disperse accessible seating throughout an altered assembly area, accessible seating areas may be clustered. Each accessible seating area shall have provisions for companion seating and shall be located on an accessible route that also serves as a means of emergency egress.

(ii) Where it is technically infeasible to alter all performing areas to be on an accessible route, at least one of each type of performing area shall be made accessible.

(g) Platform Lifts (Wheelchair Lifts): Platform lifts (wheelchair lifts) complying with 4.11 and applicable state or local codes may be used as part of an accessible route when specifically approved by the commissioner in accordance with the variance procedures contained in Rule 68.31. The use of lifts is not limited to the four conditions in exception 4 of 4.1.3(5).

(h) Dressing Rooms: Where technical infeasibility can be demonstrated, one dressing room for each sex on each level shall be made accessible. Where only unisex dressing rooms are provided, accessible unisex dressing rooms may be used to fulfill this requirement.

4.1.7. Accessible Buildings: Historic Preservation. (intentionally omitted)

4.2 Space Allowances and Reach Ranges.

4.2.1* Wheelchair Passage Width. The minimum clear width for single wheelchair passage shall be 32 inches (815 mm) at a point and 36 inches (915 mm) continuously (see Fig. 1 and 24(e)).

4.2.2 Width for Wheelchair Passing. The minimum width for two wheelchairs to pass is 60 inches (1525 mm) (see Fig. 2).

4.2.3* Wheelchair Turning Space. The minimum space required for a standard wheelchair to make a 180-degree turn is a clear space of 60 inches (1525 mm) diameter (see Fig. 3(a)) or a T-shaped space (see Fig. 3(b)).

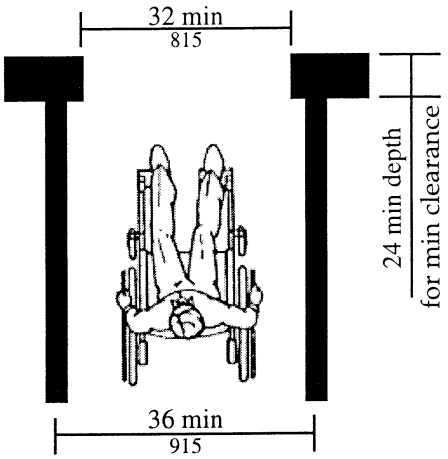


Fig. 1
Minimum Clear Width for Single Wheelchair

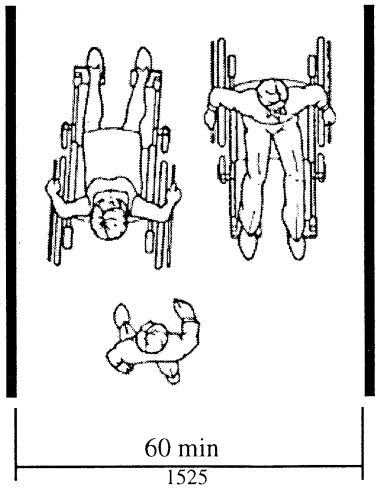
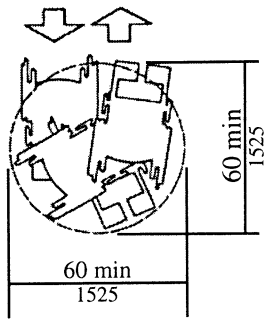
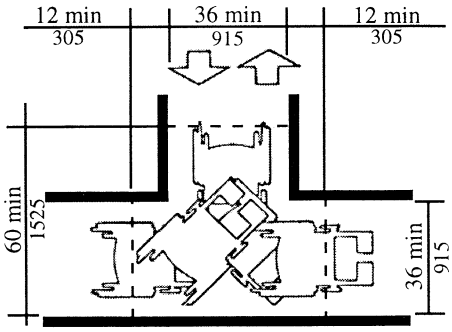


Fig. 2
Minimum Clear Width for Two Wheelchairs



(a)
60-inch (1525-mm) Diameter Space



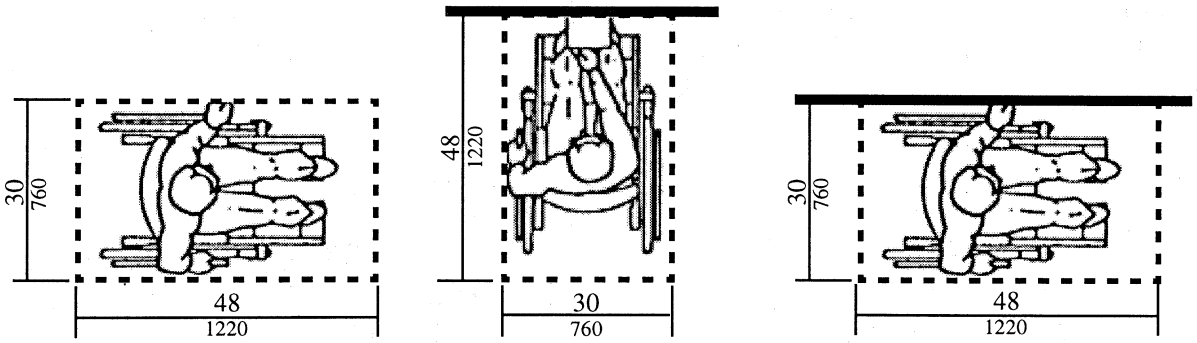
(b)
T-Shaped Space for 180-Degree Turns

Fig. 3
Wheelchair Turning Space

4.2.4* Clear Floor or Ground Space for Wheelchairs.

4.2.4.1 Size and Approach. The minimum clear floor or ground space required to accommodate a single, stationary wheelchair and occupant is 30 in by 48 inches (760 mm by 1220 mm) (see Fig. 4(a)). The minimum clear floor or ground space for wheelchairs may be positioned for forward or parallel approach to an object (see Fig. 4(b) and 4(c)). Clear floor or ground space for wheelchairs shall be centered on the element it serves and may be part of the knee space required under some objects.

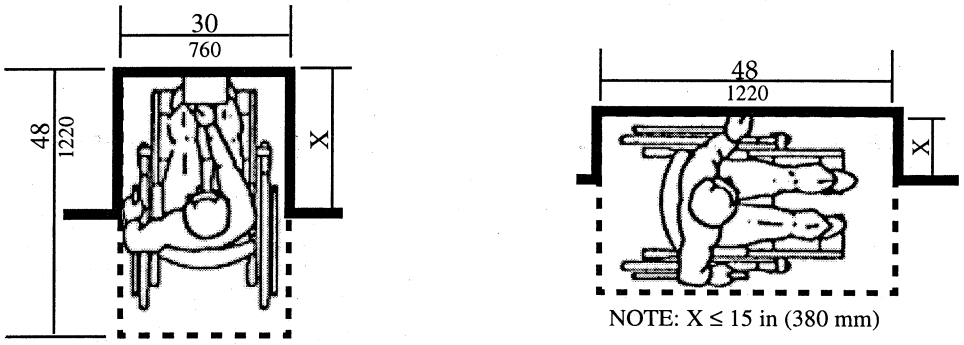
4.2.4.2 Relationship of Maneuvering Clearance to Wheelchair Spaces. One full unobstructed side of the clear floor or ground space for a wheelchair shall adjoin or overlap an accessible route or adjoin another wheelchair clear floor space. If a clear floor space is located in an alcove or otherwise confined on all or part of three sides, additional maneuvering clearances shall be provided as shown in Fig. 4(d) and 4(e).



(a) Clear Floor Space

(b) Forward Approach

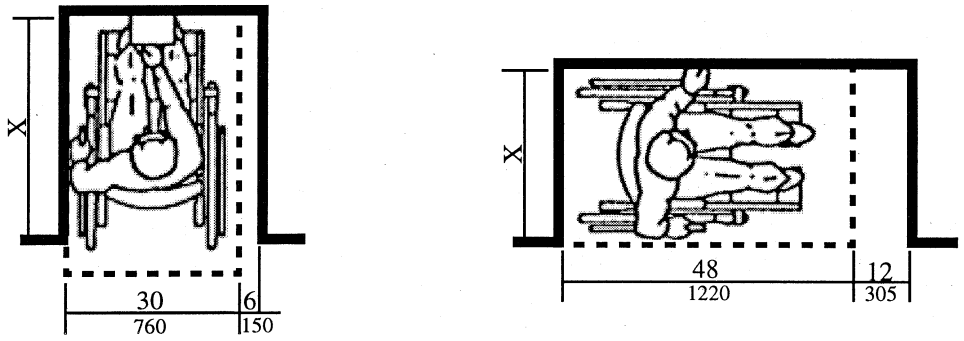
(c) Parallel Approach



NOTE: X ≤ 24 in (610 mm)

NOTE: X ≤ 15 in (380 mm)

(d)
Clear Floor Space in Alcoves



NOTE: X > 24 in (610 mm), then an additional maneuvering clearance of 6 in (150 mm) shall be provided as shown.

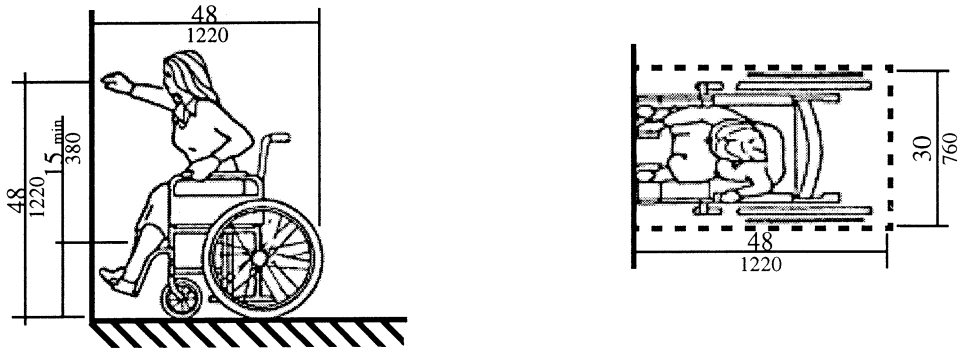
NOTE: X > 15 in (380 mm), then an additional maneuvering clearance of 12 in (305 mm) shall be provided as shown.

(e)
Additional Maneuvering Space for Alcoves

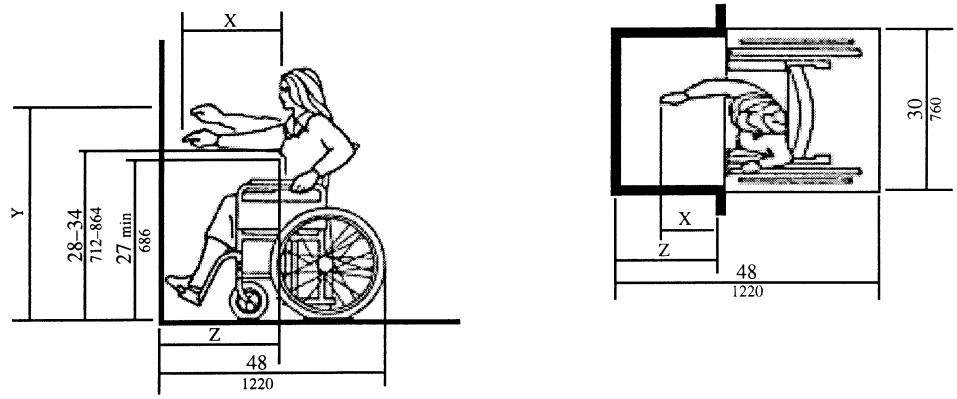
Fig. 4
Minimum Clear Floor Space for Wheelchairs

4.2.4.3 Surfaces for Wheelchair Spaces. Clear floor or ground spaces for wheelchairs shall comply with 4.5.

4.2.5* Forward Reach. If the clear floor space only allows forward approach to an object, the maximum high forward reach allowed shall be 48 inches (1220 mm) (see Fig. 5(a)). The minimum low forward reach is 15 inches (380 mm). If the high forward reach is over an obstruction, reach and clearances shall be as shown in Fig. 5(b). For mounting heights suitable in schools and other facilities used primarily by children see section 2.1.1.



(a)
High Forward Reach Limit

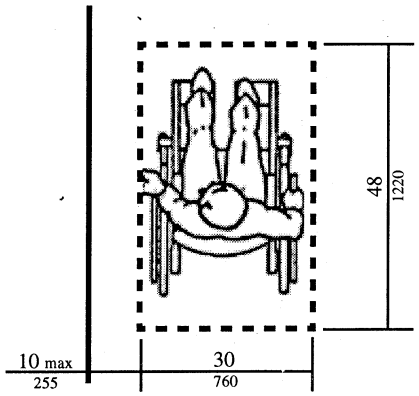


(b)
Maximum Forward Reach over an Obstruction

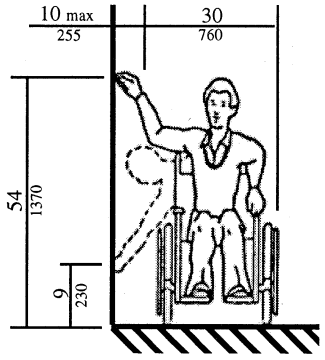
NOTE: X shall be ≤ 25 in (635 mm), Z shall be ≥ X. When X < 20 in (510 mm), then Y shall be 48 in (1220 mm) maximum. When X is 20 to 25 in (510 to 635 mm), then Y shall be 44 in (1120 mm) maximum.

Fig. 5
Forward Reach

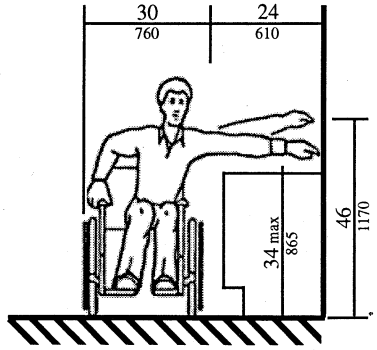
4.2.6* Side Reach. If the clear floor space allows parallel approach by a person in a wheelchair, the maximum high side reach allowed shall be 54 inches (1370 mm) and the low side shall be no less than 9 inches (230 mm) above the floor (Fig. 6(a) and 6(b)). If the side reach is over an obstruction, the reach and clearances shall be as shown in Fig. 6(c). For mounting heights suitable in schools and other facilities used primarily by children, see section 2.1.1.



(a)
Clear Floor Space Parallel Approach



(b)
High and Low Side Reach Limits



(c)
Maximum Side Reach over Obstruction

Fig. 6
Side Reach

4.3 Accessible Route.

4.3.1* General. All walks, halls, corridors, aisles, skywalks, tunnels, general circulation routes, and other spaces that are part of an accessible route shall comply with 4.3.

4.3.2 Location.

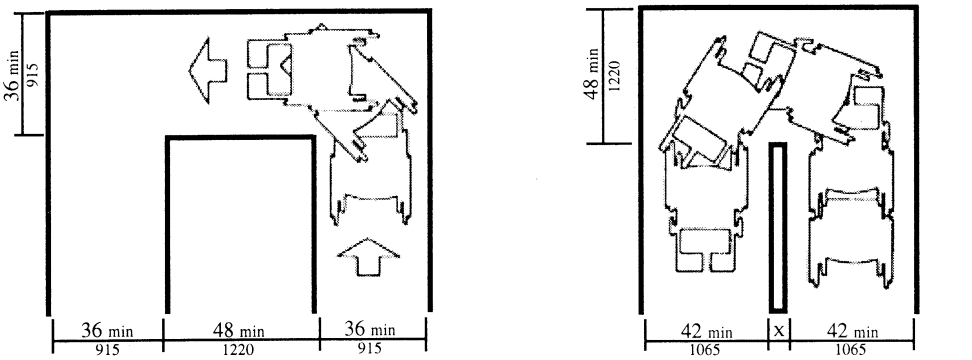
(1) At least one accessible route within the boundary of the site shall be provided from public transportation stops, accessible parking and accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve. The accessible route shall, to the maximum extent feasible, coincide with the route for the general public unless that route would violate 4.3.2(5).

(2) At least one accessible route shall connect accessible buildings, facilities, elements, and spaces that are on the same site.

(3) At least one accessible route shall connect accessible building or facility entrances with all accessible spaces and elements and with all accessible dwelling units within the building or facility.

(4) An accessible route shall connect at least one accessible entrance of each accessible dwelling unit with those exterior and interior spaces and facilities that serve the accessible dwelling unit.

(5) Accessible routes shall be located so that users are not required to wheel or walk behind parked vehicles (except the one they operate or in which they are a passenger) or in traffic lanes.



(a)
90-Degree Turn

(b)
Turn Around Obstruction

Fig. 7
Accessible Routes

4.3.3 Width. The minimum clear width of an accessible route shall be 36 inches (915 mm) except at doors (see 4.13.5 and 4.13.6). If a person in a wheelchair must make a turn around an obstruction, the minimum clear width of the accessible route shall be as shown in Fig. 7(a) and 7(b).

4.3.4 Passing Space. If an accessible route has less than 60 inches (1525 mm) clear width, then passing spaces at least 60 inches by 60 inches (1525 mm by 1525 mm) shall be located at reasonable intervals not to exceed 200 feet (61 m). A T-intersection of two corridors or walks is an acceptable passing place.

4.3.5 Head Room. Accessible routes shall comply with 4.4.2.

4.3.6 Surface Textures. The surface of an accessible route shall comply with 4.5.

4.3.7 Slope. An accessible route with a running slope greater than 1:20 is a ramp and shall comply with 4.8. Nowhere shall the cross slope of an accessible route exceed 1:50.

4.3.8 Changes in Levels. Changes in levels along an accessible route shall comply with 4.5.2. If an accessible route has changes in level greater than 1/2 inches (13 mm), then a curb ramp, elevator, or platform lift (as permitted in 4.1.3 and 4.1.6) shall be provided that complies with 4.7, 4.8, 4.10, or 4.11, respectively. An accessible route does not include stairs, steps, or escalators. See definition of "egress, means of" in 3.5.

4.3.9 Doors. Doors along an accessible route shall comply with 4.13.

4.3.10* Egress. Accessible routes serving any accessible space or element shall also serve as a means of egress for emergencies or connect to an accessible area of rescue assistance.

4.5 Ground and Floor Surfaces.

4.5.1* General. Ground and floor surfaces along accessible routes and in accessible rooms and spaces including floors, walks, ramps, stairs, and curb ramps, shall be stable, firm, slip-resistant, and shall comply with 4.5. Soft or loose materials such as sand, gravel, bark, mulch or wood chips are not suitable. Cobblestone and other irregular surfaces having a texture that constitutes an obstacle or hazard, such as improperly laid flagstone, shall not be a part of accessible routes, spaces and elements.

4.5.2 Changes in Level. Changes in level up to 1/4 inches (6 mm) may be vertical and without edge treatment (see Fig. 7(c)). Changes in level between 1/4 inches and 1/2 inches (6 mm and 13 mm) shall be beveled with a slope no greater than 1:2 (see Fig. 7(d)). Changes in level greater than 1/2 inches (13 mm) shall be accomplished by means of a ramp that complies with 4.7 or 4.8.

4.5.3* Carpet. If carpet or carpet tile is used on a ground or floor surface, then it shall be securely attached; have a firm cushion, pad, or backing, or no cushion or pad; and have a level loop, textured loop, level cut pile, or level cut/uncut pile texture. The maximum pile thickness shall be 1/2 inches (13 mm) (see Fig. 8(f)). Exposed edges of carpet shall be fastened to floor surfaces and have trim along the entire length of the exposed edge. Carpet edge trim shall comply with 4.5.2.

4.5.4 Gratings. If gratings are located in walking surfaces or along accessible routes, then they shall have spaces no greater than 1/2 inches (13 mm) wide in one direction (see Fig. 8(g)). If gratings have elongated openings, then they shall be placed so that the long dimension is perpendicular to the dominant direction of travel (see Fig. 8(h)).

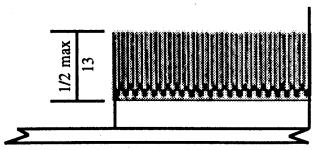


Fig. 8 (f)
Carpet Pile Thickness

4.13 Doors.

4.13.1 General. Doors required to be accessible by 4.1 shall comply with the requirements of 4.13.

4.13.2 Revolving Doors and Turnstiles. Revolving doors or turnstiles shall not be the only means of passage at an accessible entrance or along an accessible route. An accessible gate or door shall be provided adjacent to the turnstile or revolving door and shall be so designed as to facilitate the same use pattern.

4.13.3 Gates. Gates, including ticket gates, shall meet all applicable specifications of 4.13.

4.13.4 Double-Leaf Doorways. If doorways have two independently operated door leaves, then at least one leaf shall meet the specifications in 4.13.5 and 4.13.6. That leaf shall be an active leaf.

4.13.5 Clear Width. Doorways shall have a minimum clear opening of 32 inches (815 mm) with the door open 90 degrees, measured between the face of the door and the opposite stop (see Fig. 24(a), 24(b), 24(c), and 24(d)). Openings more than 24 inches (610 mm) in depth shall comply with 4.2.1 and 4.3.3 (see Fig. 24(e)).

EXCEPTION: Doors not requiring full user passage, such as shallow closets, may have the clear opening reduced to 20 inches (510 mm) minimum.

4.13.6 Maneuvering Clearances at Doors. Minimum maneuvering clearances at doors that are not automatic or power-assisted shall be as shown in Fig. 25. The floor or ground area within the required clearances shall be level and clear.

EXCEPTION: Entry doors to acute care hospital bedrooms for in-patients shall be exempted from the requirement for space at the latch side of the door (see dimension "x" in Fig. 25) if the door is at least 44 inches (1120 mm) wide.

4.13.7 Two Doors in Series. The minimum space between two hinged or pivoted doors in series shall be 48 inches (1220 mm) plus the width of any door swinging into the space. Doors in series shall swing either in the same direction or away from the space between the doors (see Fig. 26).

4.13.8* Thresholds at Doorways. Thresholds at doorways shall not exceed 3/4 inches (19 mm) in height for exterior sliding doors or 1/2 inches (13 mm) for other types of doors. Raised thresholds and floor level changes at accessible doorways shall be beveled with a slope no greater than 1:2 (see 4.5.2).

4.13.9* Door Hardware. Handles, pulls, latches, locks, and other operating devices on accessible doors shall have a shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist to operate. Lever-operated mechanisms, push-type mechanisms, and U-shaped handles are acceptable designs. When sliding doors are fully open, operating hardware shall be exposed and usable from both sides. Hardware required for accessible door passage shall be mounted no higher than 48 inches (1220 mm) above finished floor.

4.13.10* Door Closers. If a door has a closer, then the sweep period of the closer shall be adjusted so that from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches (75 mm) from the latch, measured to the leading edge of the door.

4.13.11* Door Opening Force. The maximum force for pushing or pulling open a door shall be as follows:

(1) Fire doors shall have the minimum opening force allowable by the appropriate administrative authority.

(2) Other Doors.

(a) exterior hinged doors: (Reserved).

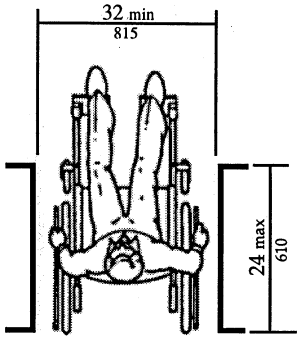
(b) interior hinged doors: 5 lbf (22.2 N)

(c) sliding or folding doors: 5 lbf (22.2 N)

These forces do not apply to the force required to retract latch bolts or disengage other devices that may hold the door in a closed position.

4.13.12* Automatic Doors and Power-Assisted Doors. If an automatic door is used, then it shall comply with ANSI/BHMA A156.10-1985. Slowly opening, low-powered, automatic doors shall comply with ANSI A156.19-1984. Such doors shall not open to back check faster than 3 seconds and shall require no more than 15 lbf (66.6 N) to stop door movement. If a power-assisted door is used, its door-opening force shall comply with 4.13.11 and its closing shall conform to the requirements in ANSI A156.19-1984. If user-operated controls are provided they shall comply with section 4.27.

(b)
Hinged Door



(e)
Maximum Doorway Depth

Fig. 24
Clear Doorway Width and Depth

4.24 Sinks.

4.24.1 General.

(1) Sinks required to be accessible by 4.1 shall comply with 4.24.

(2) For mounting heights and faucet reach-ranges suitable in schools and other facilities used primarily by children see section 2.1.1.

4.24.2 Height. Sinks shall be mounted with the counter or rim no higher than 34 inches (865 mm) above the finish floor.

4.24.3 Knee Clearance. Knee clearance that is at least 27 inches (685 mm) high, 30 inches (760 mm) wide, and 19 inches (485 mm) deep shall be provided underneath sinks.

4.24.4 Depth. Each sink shall be a maximum of 6-1/2 inches (165 mm) deep.

4.24.5 Clear Floor Space. A clear floor space at least 30 inches by 48 inches (760 mm by 1220 mm) complying with 4.2.4 shall be provided in front of a sink to allow forward approach. Sinks installed in alcoves deeper than 24 inches require additional maneuvering area (see Figure 4(e)). The clear floor space shall be on an accessible route and shall extend a maximum of 19 inches (485 mm) underneath the sink (see Fig. 32).

4.24.6 Exposed Pipes and Surfaces. Hot water and drain pipes exposed under sinks shall be insulated or otherwise configured so as to protect against contact. There shall be no sharp or abrasive surfaces under sinks.

4.30 Signage.

4.30.1* General. Signage required to be accessible by 4.1 shall comply with the applicable provisions of 4.30.

4.30.2* Character Proportion. Letters and numbers on signs shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10 using an upper-case "X" for measurement. Lower-case letters are permitted.

4.30.3 Overhead Signs. Characters and numbers on overhead signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper-case X. Lower-case characters are permitted.

Height Above Finished Floor	Minimum Character Height
Suspended or Projected Overhead in compliance with 4.4.2	3 inches (75 mm) minimum

4.30.4* Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms). Letters and numerals shall be raised 1/32 of an inch, upper case, sans serif or simple serif type and shall be accompanied with Grade 2 Braille. Raised characters shall be at least 5/8 inches (16 mm) high, but no higher than 2 inches (50 mm). Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 6 inches (152 mm) minimum in height.

4.30.5* Finish and Contrast. The characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background—either light characters on a dark background or dark characters on a light background.

4.30.6 Mounting Location and Height. Where permanent identification is provided for rooms and spaces, signs shall be installed on the wall adjacent to the latch side of the door. Where there is no wall space to the latch side of the door, including at double leaf doors, signs shall be placed on the nearest adjacent wall. Mounting height shall be 60 inches (1525 mm) above the finish floor to the centerline of the sign. Mounting location for such signage shall be so that a person may approach within 3 inches (76 mm) of signage without encountering protruding objects or standing within the swing of a door (see Fig. 43(e)).

4.30.7* Symbols of Accessibility.

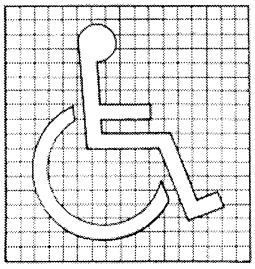
(1) Facilities and elements required to be identified as accessible by 4.1 shall use the international symbol of accessibility. The symbol shall be displayed as shown in Fig. 43(a) and 43(b).

(2) Volume Control Telephones. Telephones required to have a volume control by 4.1.3(17)(b) shall be identified by a sign containing a depiction of a telephone handset with radiating sound waves.

(3) Text Telephones. Text telephones required by 4.1.3(17)(c) shall be identified by the international TDD symbol (Fig. 43(c)). In addition, if a facility has a public text telephone, directional signage indicating the location of the nearest text telephone shall be placed adjacent to all banks of telephones which do not contain a text telephone. Such directional signage shall include the international TDD symbol. If a facility has no banks of telephones, the directional signage shall be provided at the entrance (e.g., in a building directory).

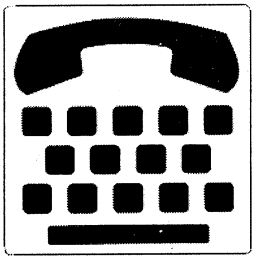
(4) Assistive Listening Systems. In assembly areas where permanently installed assistive listening systems are required by 4.1.3(19)(b) the availability of such systems shall be identified with signage that includes the international symbol of access for hearing loss (Fig. 43(d)).

4.30.8* Illumination Levels. (Reserved).



(a)
Proportions
International Symbol of Accessibility

(b)
Display Conditions
International Symbol of Accessibility



(c)
International TDD symbol

(d)
International Symbol of Access
for Hearing Loss

Fig. 43 (a–d)
International Symbols

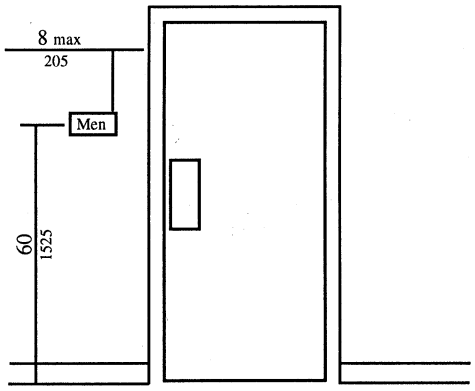


Fig. 43 (e)
Signage Mounting
Location and Height

4.32 Fixed or Built-in Seating and Tables.

4.32.1 General.

(1) Fixed or built-in seating or tables required to be accessible by 4.1 shall comply with 4.32.

(2) For mounting heights suitable in schools and other facilities used primarily by children, see section 2.1.1.

4.32.2 Seating. If seating spaces for people in wheelchairs are provided at fixed tables or counters, clear floor space complying with 4.2.4 shall be provided. Such clear floor space shall not overlap knee space by more than 19 inches (485 mm) (see Fig. 45).

4.32.3 Knee Clearances. If seating for people in wheelchairs is provided at tables or counters, knee spaces at least 27 inches (685 mm) high, 30 inches (760 mm) wide, and 19 inches (485 mm) deep shall be provided (see Fig. 45).

4.32.4* Height of Tables or Counters. The tops of accessible tables and counters shall be from 28 inches to 34 inches (710 mm to 865 mm) above the finish floor or ground.

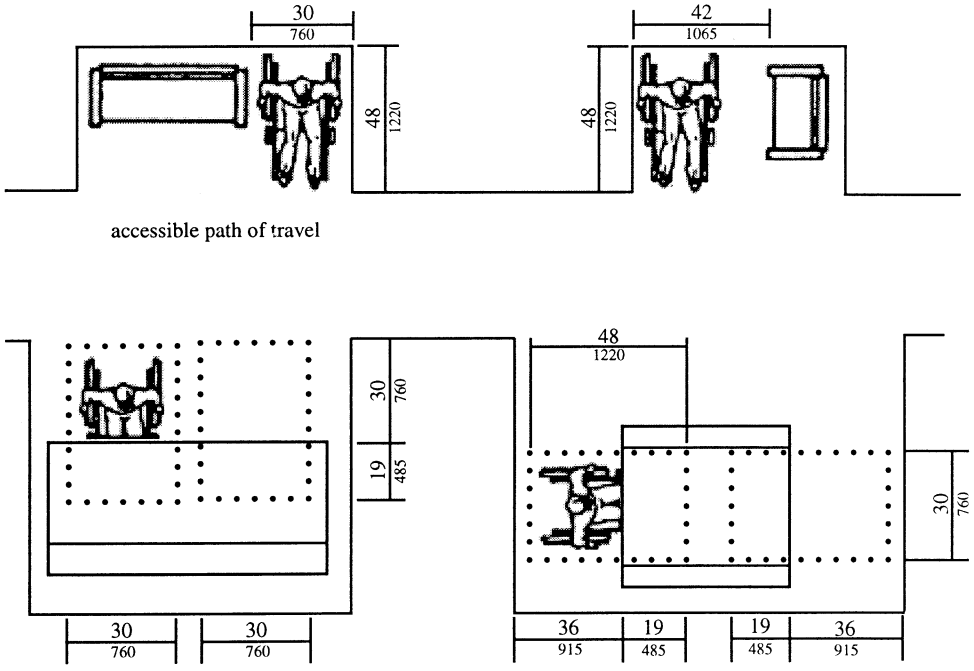


Fig. 45
Minimum Clearance for Seating and Tables

Texas Insurance Commission Article 5.43-1
Fire Extinguishers / Fire Extinguisher Rules
28 TAC Chapter 34, Sections 34.501–34.523

Article 5.43–1. Fire Extinguishers

Purpose

Section 1. The purpose of this article is to regulate the leasing, renting, selling, installing, and servicing of portable fire extinguishers and the planning, certifying, installing, or servicing of fixed fire extinguisher systems, and to prohibit portable fire extinguishers, fixed fire extinguisher systems, and extinguisher equipment not labeled or listed by a testing laboratory approved by the State Board of Insurance, in the interest of safeguarding lives and property.

Administration

Section 2. The State Board of Insurance shall administer this article and it may issue rules and regulations which it considers necessary to its administration through the State Fire Marshal. The board, in adopting necessary rules and regulations, may use recognized standards such as, but not limited to, those of the National Fire Protection Association, those recognized by federal law or regulation, and those published by any nationally recognized standards-making organization, or the manufacturer's installation manuals.

Section 2A. Repealed by Acts 1997, 75th Leg., ch. 1172, §4.14(1), eff. Sept. 1, 1997.

Definitions

Section 3. As used in this article the following terms have the meanings specified in this section.

(a) "Firm" means any person, partnership, corporation, or association.

(b) "Hydrostatic testing" means pressure testing by hydrostatic methods.

(c) "Portable fire extinguisher" means any device that contains liquid, powder, or gases for suppressing or extinguishing fires.

(d) "Service and servicing" means servicing portable fire extinguishers or fixed fire extinguisher systems by inspecting, charging, filling, maintaining, recharging, refilling, repairing, or testing.

(e) "Fixed fire extinguisher systems" means those assemblies of piping, conduits, or containers that convey liquid, powder, or gases to dispersal openings or devices protecting one or more hazards by suppressing or extinguishing fires.

Text of (f) as added by Acts 1989, 71st Leg., ch. 762, §2

(f) "Registered firm" means a person, partnership, corporation, or association that holds a current certificate of registration.

Text of (f) as added by Acts 1989, 71st Leg., ch. 823, §1

(f) "Insurance agent" means:

(1) a person, firm, or corporation licensed under Article 21.14 or 1.14-2 of this code;

(2) a salaried, state, or special agent; or

(3) a person authorized to represent an insurance fund or pool created by a city, county, or other political subdivision of the state under The Interlocal Cooperation Act (Article 4413(32c), Vernon's Texas Civil Statutes).

Registration, Licensing, and Fees

Section 4.

(a) Each firm engaged in the business of installing or servicing portable fire extinguishers or planning, certifying, installing, or servicing fixed fire extinguisher systems must have a certificate of registration issued by the State Board of Insurance. The initial fee for the certificate of registration must be in an amount not to exceed $450 and the renewal fee for each year thereafter must be in an amount not to exceed $300. Each separate office location of a firm engaged in the business of installing or servicing portable fire extinguishers or planning, certifying, installing, or servicing fixed extinguisher systems, other than the location identified on the certificate of registration, must have a branch office registration certificate issued by the board. The initial fee for a branch office registration certificate must be in an amount not to exceed $100, and the renewal fee for each year thereafter must be in an amount not to exceed $100. The board shall identify each branch office location as a part of a registered firm before a branch office registration certificate may be issued.

(b) A fee in an amount not to exceed $20 shall be charged for a duplicate certificate of registration, license, or apprentice permit issued under this article or for any request requiring changes to a certificate of registration, license, or permit. A new certificate of registration with a new number shall be issued to a registered firm on a change of ownership for a fee in an amount not to exceed $450. A fee in an amount not to exceed $100 shall be charged for a change of ownership of a branch office.

(c) Each employee, other than an apprentice, of registered firms engaged in the business of installing or servicing portable fire extinguishers or planning, installing, or servicing fixed fire extinguisher systems, must have a license issued by the State Board of Insurance before engaging in the following:

(1) installing or servicing portable fire extinguishers;

(2) installing, servicing, or certifying preengineered fixed fire extinguisher systems; or

(3) planning, supervising, or certifying the installation of fixed fire extinguisher systems other than preengineered systems or the servicing of such systems.

(c–1) The initial fee for the license required by Subsection (c) of this section must be in an amount not to exceed $50 and the license renewal fee for each year thereafter must be in an amount not to exceed $50. A nonrefundable fee for the initial examination must be in an amount not to exceed $30. A nonrefundable fee in an amount not to exceed $20 shall be charged for each reexamination.

(d) Each person installing or servicing portable fire extinguishers or installing or servicing fixed fire extinguisher systems as an apprentice shall, before engaging in installing or servicing, apply to the State Board of Insurance for an apprentice permit. The fee for the apprentice permit must be in an amount not to exceed $30. An apprentice may perform the services only under direct supervision of a person holding a valid license under this article who works for the same firm as the apprentice. An apprentice permit is valid for one year from the date of issuance.

(e) Each firm performing hydrostatic testing of fire extinguishers manufactured in accordance with the specifications and procedures of the United States Department of Transportation shall do so in accordance with the procedures specified by that department for compressed gas cylinders and shall be required to have a hydrostatic testing certificate of registration authorizing such testing issued by the state fire marshal. Persons qualified to do this work shall be given such authority on their licenses. The initial fee must be in an amount not to exceed $250, and the renewal fee for each year thereafter must be

in an amount not to exceed $150. Hydrostatic testing of fire extinguishers not performed pursuant to the United States Department of Transportation specifications shall be performed as recommended by the National Fire Protection Association.

(f) The State Board of Insurance shall, within the limits fixed by this section, prescribe the fees to be charged under this section.

Required Insurance

Section 4A.

(a) The board shall not issue a certificate of registration under this article unless the applicant files with the board evidence of a general liability insurance policy that includes products and completed operations coverage. The policy must be conditioned to pay on behalf of the insured those sums that the insured becomes legally obligated to pay as damages because of bodily injury and property damage caused by an occurrence involving the insured or the insured's servant, officer, agent, or employee in the conduct of any business registered or licensed under this article.

(b) The limits of insurance coverage required by Subsection (a) of this section shall not be less than $100,000 combined single limits for bodily injury and property damage for each occurrence and not less than $300,000 aggregate for all occurrences per policy year, unless the board increases or decreases the limits under Section 8 of this article.

(c) The evidence of insurance required by this section must be in the form of a certificate of insurance executed by an insurer authorized to do business in this state and countersigned by an insurance agent licensed in this state. A certificate of insurance for surplus lines coverage procured in compliance with Article 1.14–2 of this code through a licensed Texas surplus lines agent resident in this state may be filed with the board as evidence of coverage required by this section. Insurance certificates executed and filed with the board under this section remain in force until the insurer has terminated future liability by the notice required by the board.

(d) Failure to maintain the liability insurance required under this section constitutes grounds for the denial, suspension, or revocation of a certificate of registration issued under this article after notice and opportunity for hearing.

Selling or Leasing of Portable Fire Extinguishers or Fixed Fire Extinguisher Systems

Section 5.

(a) No portable fire extinguisher, fixed fire extinguisher system, or extinguisher equipment may be leased, sold, rented, serviced, or installed in this state unless it carries a label of approval or listing of a testing laboratory approved by the State Board of Insurance.

(b) Except as provided in Section 6 of this article, only the holder of a valid license or an apprentice permit issued pursuant to this article may install or service portable fire extinguishers or install and maintain fixed fire extinguisher systems.

(c) A person who has been issued a license pursuant to this article to install or service portable fire extinguishers or install and service fixed fire extinguisher systems must be an employee, agent, or servant of a firm that holds a certificate of registration issued pursuant to this article.

(d) A certificate of registration, license, or permit issued under this article is not transferable.

Exceptions

Section 6. The licensing provisions of this article do not apply to the following:

(a) the filling or charging of a portable fire extinguisher by the manufacturer prior to its initial sale;

(b) the servicing by a firm of its own portable fire extinguishers and/or fixed systems by its own personnel specially trained for such servicing or the installation of portable fire extinguishers in a building by the building owner, the owner's managing agent, or their employees;

(c) the installation or servicing of water sprinkler systems installed in compliance with the National Fire Protection Association's Standards for the Installation of Sprinkler Systems;

(d) firms engaged in the retailing or wholesaling of portable fire extinguishers that carry a label of approval or listing of a testing laboratory approved by the State Board of Insurance, but not engaged in the installation or servicing of them;

(e) fire departments servicing portable fire extinguishers as a public service where no charge is made, provided, however, that the members of the fire department are trained in the proper servicing of the fire extinguishers;

(f) a firm that is party to a contract which provides that the installation of portable fire extinguishers or a fixed fire extinguisher system will be performed under the direct supervision of and certified by a firm appropriately registered to install and certify portable extinguishers or fixed systems and that the registered firm assumes full responsibility for the installation; or

(g) a Texas registered professional engineer acting solely in his professional capacity.

APPENDIX B

PROFESSIONAL ORGANIZATION POSITION STATEMENTS

- American Association of Physics Teachers (AAPT): The Role of Laboratory Activities in High School Physics

- Council of State Science Supervisors (CSSS)
  - Laboratory Safety
  - Science Education Safety

- National Association of Biology Teachers (NABT): Role of Laboratory and Field Instruction in Biology Education

- National Science Education Leadership Association (NSELA)
  - Class Size in Science Laboratory Rooms
  - Science Teaching Conditions
  - Science for the Handicapped and Learning Disabled

- National Science Teachers Association (NSTA): Science Education for Middle-Level Students

- National Science Teachers Association (NSTA): Working Conditions for Secondary Science Teachers

American Association of Physics Teachers
Position Paper

The Role of Laboratory Activities in High School Physics

Subcommittee on the Role of the Laboratory: Carole Escobar, Paul Hickman, Robert Morse, Betty Preece
(Approved by the AAPT Executive Board, November 1992).

"Newton won a stunning victory for the intellect and the democratization of science, because it became possible for students to have as much authority as teachers. By knowing proper methods, a youth could conduct an experiment whose results might confound his elders."[1] Newton's program of "experimental philosophy" firmly and successfully established the central methods of physics, whereby inference from experience guides formulation of hypotheses, whose predictions are validated by experiment. Laboratory activities in high school physics provide experience with phenomena, a starting place for the systematic development of students' ideas, and a testing ground for the predictive power of their reasoning.

Learning Goals for Laboratory Activities

Laboratory activities must be designed to engage students' minds, so that students may acquire skill and confidence in their:

- measurement of physical quantities with appropriate accuracy
- recognition of factors that could affect the reliability of their measurements
- manipulations of materials, apparatus, tools, and measuring instruments
- clear descriptions of their observations and measurements
- representation of information in appropriate verbal, pictorial, graphical, and mathematical terms
- inference and reasoning from their observations
- ability to rationally defend their conclusions and predictions
- effective and valued participation with their peers and their teacher in a cooperative intellectual enterprise
- articulate reporting of observations, conclusions, and predictions in formats ranging from informal discussion to a formal laboratory report
- ability to recognize those questions that can be investigated through experiment and to plan, carry out, evaluate, and report on such experiments

Teaching Conditions for Learning from Laboratory Activities

"Theory and research suggest that meaningful learning is possible in laboratory activities if all students are provided with opportunities to manipulate equipment and materials while working cooperatively with peers in an environment in which they are free to pursue solutions to problems that interest them."[2]

The following teaching conditions enable this to occur.

For students to acquire the manual and mental skills associated with learning physics, it is essential that they be fully engaged in laboratory activities. This requires sufficient equipment and laboratory stations for laboratory groups containing only two or three students.

The number of students and of laboratory stations in a classroom must be small enough for the teacher to supervise the safety of student activities and to have sufficient time to actively work with each laboratory group.

Schools and teachers must ensure equal access to laboratory activities under appropriate supervision for all students, with provision made for adapting activities for students with a disability.

Where appropriate, laboratory activities should include equipment and phenomena that relate to the students' world, such as toys, sports equipment, tools, household items, etc.

The integration of laboratory activities with classroom work requires that students be able to move smoothly between their desks and the laboratory area and that there be sufficient space for equipment to remain set up. A classroom arrangement with space for desks, computers, and ample space for laboratory stations and equipment in the same room is ideal. At the high school level, it is especially desirable for the laboratory area to be integrated with the classroom.

Computers and modern instruments should be part of the laboratory equipment. Although excellent physics learning can take place using the simplest equipment, computers and measuring instruments incorporating modern technology can be powerful tools for learning physics concepts and developing skills of measurement, analysis, and processing information. Computer simulations should not substitute for laboratory experience, but may be used to supplement and extend such experience.

Evaluation of student learning in physics should include assessment of skills developed in laboratory activities as well as the knowledge acquired during these activities. Test questions relating directly to laboratory work act not only to assess laboratory learning, but also to communicate the importance of laboratory work to students.

Effective employment of laboratory activities requires that teachers have adequate and convenient storage for equipment; a workspace with tools to repair, maintain, or construct equipment; and enough planning time in their schedule to maintain, set up, and try out laboratory equipment prior to classes.

Safe laboratory work for students and teachers requires adequate, up-to-date safety equipment; an emphasis on safe practice in all activities; and the availability of resources and references on safety, such as the AAPT publication, *Teaching Physics Safely*.

To maintain their skills and keep abreast of new developments in physics teaching, teachers need time, money, support, and encouragement to participate in appropriate professional activities. These may include attendance at workshops and professional conferences; examining new laboratory equipment, curricula, texts and resource materials; and working and consulting with colleagues in schools and colleges and in the physics and engineering research community.

The role of the laboratory is central in high school physics courses since students must construct their own understanding of physics ideas. This knowledge cannot simply be transmitted by the teacher, but must be developed by students in interactions with nature and the teacher.

Meaningful learning will occur where laboratory activities are a well-integrated part of a learning sequence. The separation of laboratory activities from lecture is artificial, and not desirable in high school physics.

[1] I. Bernard Cohen, Sidney M. Edelstein Lecture, Baylor School, 17 April 1985.
[2] Kenneth Tobin, Research on Science Laboratory Activities: In Pursuit of Better Questions and Answers to Improve Learning, School Science and Mathematics, 90 (5), May/June 1990, p. 414.

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Council of State Science Supervisors (CSSS)
Position Paper

Laboratory Safety

The Council supports the premise that science should be taught in a space specifically dedicated to science classes with provisions for laboratory activities. A safe and well-equipped preparation and workspace for students and teacher must be provided. Adequate storage space for equipment and supplies, including a separate storage area for potentially dangerous materials, must be provided. An adequate budget for facilities, equipment, supplies, and proper waste management must be provided to support the laboratory experiences. They must be maintained and updated on a regular basis. Unique science supplies must be provided in sufficient quantity so that students have a direct, hands-on experience.

The number of students assigned to each laboratory class should not exceed 24. Students must have immediate access to the teacher in order to provide a safe and effective learning environment.

Training in laboratory safety must be provided to the teacher. Necessary safety equipment, such as safety goggles, fire extinguishers, fire blankets, fume hoods, and eye washes, must be provided and maintained.

Science Education Safety

Key Issues in School Laboratory Safety

Students and teachers must be aware of the potential for safety problems in the science classrooms and laboratories. Schools should review available safety resources and develop safety training for their teachers and students as well as safety rules for the classroom.

Teachers must choose safe laboratory investigations that cover important concepts. Thought must be given to the chemicals purchased by schools. Which chemicals are the safest for the proposed investigations, how much is needed, where will the chemicals be stored and in what arrangement? Are the storage areas locked and well ventilated?

Schools needing to dispose of unwanted or unknown (no label) chemicals should contact their state science education supervisor, state ecology agency or regional Evironmental Protection Agency (EPA) office. Teachers or school officials should be prepared to give the name or description of the chemical, amount, type of container, nearest landfill and local sewage system.

Some state education agencies have worked with their state pollution control agencies and have used polluter fines to conduct statewide school chemical clean-ups in their states. Where this can not be done, local schools should band together to engage in regional chemical clean-ups to conserve costs.

Scientific equipment must be maintained. Written laboratory instructions must be clear and safety rules emphasized in these instructions.

Most states have regulations on fume hoods, whole-room ventilation, chemical storage, eyewash, safety showers, eyewear, aprons, and gloves, fire blankets, first aid kits, and fire extinguishers in science classrooms. Schools should check with their state science supervisor for regulations, laws, and liabilities.

General Science Safety Checklist

The following is a suggested checklist of safety concerns in K–12 science laboratories.

1. Appropriate protective equipment for the science laboratory
2. Enforcement of safety procedures
3. All students and teachers know the local policies on all protective equipment
4. All students read and sign a laboratory safety contract
5. Sufficient, accessible laboratory workstations per number of students in each laboratory
6. All students must wear proper safety goggles whenever chemicals, glassware, or heat are used
7. Equipment and chemical inventory maintained
8. Chemicals properly arranged by compatibility and securely stored
9. Restricted amounts of chemicals
10. Adequate labeling on equipment, chemicals, and hazards
11. Material Safety Data Sheets
12. Unobstructed exits from laboratory
13. Uncluttered laboratories
14. Master shut-off switches for gas, water, and electricity
15. Safety rules and charts posted
16. Records kept on safety training and laboratory incidents
17. Emergency exit/escape plan posted
18. Live animals and students are protected from one another

General Laboratory Safety Recommendations

1. Always perform an experiment or demonstration prior to allowing students to replicate the activity. Look for possible hazards. Alert students to potential dangers.
2. Safety instructions should be given orally and posted each time an experiment is begun.
3. Constant surveillance and supervision of student activities are essential.
4. Never eat or drink in the laboratory or from laboratory equipment. Keep personal items off the laboratory tables.
5. Never use mouth suction in filling pipettes with chemical reagents. Use a suction bulb.
6. Never force glass tubing into rubber stoppers.
7. A bucket of 90% sand and 10% vermiculite, or kitty litter (dried bentonite particles), should be kept in all rooms in which chemicals are either handled or stored. The bucket must be properly labeled and have a lid that prevents other debris from contaminating the contents.
8. Smoke, carbon monoxide, and heat detectors are recommended in every laboratory. Units should be placed in the laboratory and related areas (storerooms, preparation rooms, closets, and offices).
9. Use heat-safety items such as safety tongs, mittens, aprons, and rubber gloves for both cryogenic and very hot materials.
10. A positive student attitude toward safety is imperative. Students should not fear doing experiments, using reagents, or equipment, but should respect them for potential hazards. Students should read the lab materials in advance, noting all cautions (written and oral).
11. Teachers must set good safety examples when conducting demonstrations and experiments. They should model good lab safety techniques such as wearing aprons and goggles.
12. Rough play or mischief should not be permitted in science classrooms or laboratories.
13. Never assume that an experiment is free from safety hazards just because it is in print.
14. Closed-toed shoes are required for laboratory investigations involving liquids, heated or heavy items that may injure the feet.
15. Confine long hair and loose clothing. Laboratory aprons should be worn.
16. Students should avoid transferring chemicals they have handled to their faces.
17. Never conduct experiments in the laboratory alone or perform unauthorized experiments.
18. Use safety shields or screens whenever there is potential danger that an explosion or implosion of an apparatus might occur.
19. All persons engaged in supervising, or observing, science activities involving potential hazards to the eye must wear proper eye protection devices.

20. Make certain all hot plates and burners are turned off when leaving the laboratory.
21. School staff should conduct frequent inspection of the laboratory's electrical, gas, and water systems.
22. Install ground fault circuit interrupters at all electrical outlets in science laboratories.
23. A single shut-off for gas, electricity, and water should be installed in the science laboratory. It is especially important that schools in the earthquake zones have such a switch.
24. Material Data Safety Sheets must be maintained on all school chemicals. Schools should maintain an inventory of all science equipment.
25. Laboratories should contain safety equipment appropriate to their use, such as an emergency shower, eyewash station (15 minutes of potable water that operates hands free), a fume hood, protective aprons, fire blankets, fire extinguishers, and safety goggles for all students and teacher(s).
26. Protective (rubber or latex) gloves should be provided when students dissect laboratory specimens.
27. New laboratories should have two unobstructed exits. Consider adding another to old laboratories if only one exit exists.
28. There should be frequent laboratory inspections, and school staff should conduct an annual, verified safety check of each laboratory.
29. Give consideration to the National Science Teachers Association's recommendation to limit science classes to 24 students or less for safety.
30. All work surfaces and equipment in the chemical or biological laboratory should be thoroughly cleaned after each use.
31. Students should properly note odors or fumes with a wafting motion of the hand.
32. Chemistry laboratories should be equipped with functional fume hoods. Fume hoods should be available for activities involving flammable and/or toxic substances.
33. The several chemical authorities believe that contact lenses do not pose additional hazards to the wearer and that contact lenses are allowed when appropriate eye and face protection are used. The wearing of contact lenses in the science laboratory has been a concern because of the possibility of chemicals becoming trapped between the lenses and the eye in the event of a chemical splash. Check with your state science supervisor for your state's recommendation.
34. All laboratory animals should be protected and treated humanely.
35. Students should understand that many plants, both domestic and wild, have poisonous parts and should be handled with care.

Criteria for scheduling special needs students into laboratory classes should be established by a team of counselors, science teachers, special education teachers, and school administrators. Aides or special equipment should be made available to the science teacher.

Adopted by the Council of State Science Supervisors

National Association of Biology Teachers
Position Statement

Role of Laboratory and Field Instruction in Biology Education

Philosophy: The study of biology provides students with opportunities to develop an understanding of our living world. Biology is the study of life and its evolution; and of organisms and their structures, functions, processes, and interactions with each other and with their environments.

Scientific inquiry is the primary process by which scientific knowledge is gained. It involves the basic skills of questioning, prediction, qualitative and quantitative observation, classification, inference, communication and, additionally, integrated skills such as identifying and controlling for variables, generating procedures, planning strategies for testing hypotheses and answering questions, and for collecting and interpreting appropriate data. The knowledge of biology includes scientific data, concepts, hypotheses, theories, methodology, use of instruments, and conceptual themes.

Biologists recognize that knowledge based upon experimental results and accurate observations is gained through a variety of experiences, including the pursuit of cause and effect relationships. Thus, the role of the laboratory and field learning becomes a key component in understanding biology. Laboratory activities and inquiry provide students with opportunities to observe, sample, experience, and experiment with scientific phenomena in their quest for knowledge of living things.

The most effective vehicle by which the process of inquiry can be learned appears to be a laboratory or field setting where the student experiences, firsthand, the inquiry process. Laboratory and field studies have also been demonstrated to be effective means for comprehension, understanding, and application of biological knowledge. Thus, study in a laboratory and/or field setting is an integral and essential part of a biology course. The following are recommendations regarding teaching strategies, physical resources, and curriculum development that will enhance the study of biology and improve the quality of biology instruction in our schools.

A Definition of a Laboratory Environment
In a laboratory or field learning environment, students work individually or in small groups on a question, problem, or hypothesis; they use the processes and materials of science to construct their own explanation of biological phenomena. They will often observe, collect data, and interpret data of life processes, living organisms, and/or simulations of living phenomena. The distinction between laboratory or field learning and traditional classroom learning is that activities are student-centered, with students actively engaged in hands-on, minds-on activities using laboratory or field materials and techniques.

Teaching Strategies:

1. *Direct experience.* The laboratory and field components of biology instruction should provide experiences for direct student involvement which emphasize the above process skills and the tentative nature of science; knowledge is gained by observing cause and effect relationships among variables. It is essential for students to be provided opportunities for questioning, hypothesis formulation, experimental design, and data analysis. Also, students must be given opportunities to pursue procedural options rather than simply to follow recipes. They must be provided opportunities to design and carry out their own experiments. While computer-assisted instruction and video materials contribute to biology learning, they should not be used to substitute for direct observation of living organisms or for experiments in which students learn cause and effect relationships between and among biological phenomena. School administrators need to recognize the expenses related to offering experiential, hands-on laboratory courses and provide adequate funding.

2. *Instructional time.* Biology courses need to have an integrated laboratory and field experience component in which students spend at least one-half of their total instructional time. Provisions for this amount of laboratory and fieldwork should be made in the curriculum of a biology course.

3. *Instruction.* While we respect the professional teacher's expertise in determining appropriate lessons and sequence of instruction, most of the student's biology education should begin with experiences in a laboratory or field setting. These experiences allow students to construct new knowledge for themselves and can provide the basis for the introduction of more abstract concepts presented in lectures, discussions, or reading assignments.

4. *Quality of instruction.* Biology laboratory instruction should provide students with frequent opportunities to observe and experiment with living materials, as opposed to nonliving specimens or artifacts. Every student should have direct, hands-on experiences with the laboratory materials.

5. *Teacher education.* Teachers of secondary biology laboratory instruction are expected to have a major in the biological sciences and should have formal training in laboratory and field teaching strategies (see NABT Biology Teaching Standards). Instruction in biology laboratory and field study should be an integral part of preservice and inservice teacher training. Ideally, preservice teachers should do "lab and/or field science" under the guidance of a research scientist. One cannot truly teach or truly understand process science until he/she has science research experience. Educational institutions should encourage their life science teachers to grow professionally by attending summer institutes and professional meetings, as well as by taking graduate courses in biology and biology education. Administrators should seek educational funding from available sources to support and compensate teachers in their efforts to update their current knowledge and to network with colleagues from different schools.

Facilities, Classroom Environment, and Teacher Load:

1. *Laboratory space.* Adequate and appropriate facilities, materials, and equipment need to be provided for students to learn biology in a laboratory and field setting. This is essential at all levels of biology instruction, including elementary school, middle school, high school, college, and university. The laboratory space should be (a) available to the teacher during the planning and preparation period and (b) available to students for special projects, makeup laboratories, etc. outside their regular class hours. Each student should have his/her own laboratory work space.

2. *Facility.* The laboratory classroom should be equipped with work areas that have sinks, a water supply, and natural gas and electrical outlets available in sufficient quantity to support a laboratory/field-oriented biology course. Adequate ventilation, fume hoods, and reference materials are also necessary, and the laboratory size must allow all students to participate in real hands-on activities. There should be adequate space for storage of materials and secure areas for storage of solvents, reactants, or potentially hazardous or dangerous chemicals as per guidelines set by the American Chemical Society. Facilities structure and configuration should be inspected for updating every 10 years. There should also be a space (living materials center) dedicated to growing living specimens for study in biology classes.

3. *Materials budget.* The National Science Education Standards address the need for making resources available; allocation of funds must provide opportunities to learn in an inquiry-based curriculum. To that end, biology teachers must be provided with an annual budget sufficient to purchase both expendable materials and equipment necessary to conduct inquiry-based learning.

4. *Safety.* Approved guidelines for the safe use, maintenance, and storage of laboratory materials must be followed. This includes classroom instruction on safety and emergency procedures. NABT Guidelines for the Use of Live Animals, Working with DNA & Bacteria in Precollege Science Classrooms (or safety guidelines from organizations such as NIH, the American Chemical Society, etc.) and appropriate safety procedures for using plants and microorganisms should be followed. Each laboratory room must be equipped with safety goggles and laboratory aprons for all students, a first-aid kit, a fire blanket, and an all-purpose fire extinguisher. A safety shower and eyewash station should be available within a 20-second walk. Safety goggles, if used by different students, must be disinfected with an alcohol swab wipe before being assigned to another user. The Texas Education Agency guidelines for safety procedures should be rigorously followed.

5. *Class size and supervision.* A student-to-instructor ratio in the biology laboratory classroom must permit safe and effective instruction. Class size should be determined by the physical design of the classroom and should not exceed 24 students in a laboratory setting for any reason when students are assigned to a single teacher.

6. *Teaching load.* Due to the extra time and preparation that laboratory courses require, life science teachers should not be assigned more than five classes per semester. Since each laboratory requires a different repertoire of organisms, equipment, materials, supplies, solutions and planning, and also demands lesson plans and grading time, teaching load should not be more than two process-oriented science course preparations and have no more than 24 students assigned to each class. Teachers should have their own science classrooms and have access to those classrooms during their preparation times. Time must also be allowed within the teaching day for the setup and dismantling of laboratory preparations. Where possible, student or adult laboratory assistance should be provided, and in high school, it is strongly recommend that a laboratory manager (or instructional aid) be hired to assist in preparation, setup, and dismantling of laboratory materials for experiential learning lessons.

Curriculum Development:
Most laboratory and field activities used in the schools are prepared commercially; NABT urges these other developers to provide instructional activities that meet the above guidelines. The most productive curricula will be those with an abundance of active learning, such as laboratory and field investigations, upon which the teacher can base further indirect learning experiences, such as lectures, discussions, and assignments.

Adopted by the National Association of Biology Teachers Board of Directors, September 1990. Revised 1994.

National Science Education Leadership Association
Position Statement

Class Size in Science Laboratory Rooms

In schools across the nation, laboratory classes are increasingly being assigned more students than the number of available "built-in" laboratory stations. It is not uncommon to find thirty students or more assigned to a laboratory room having only twenty-four "built-in" laboratory stations. When such a situation occurs, laboratory conditions are unsafe. One teacher cannot effectively supervise more than 24 students in a laboratory situation. Additionally, some schools have science laboratory/classrooms with less than the minimum net square footage of floor space per occupant than what is required by their state's fire code or administrative code. A state's fire and administrative codes generally establish the minimum acceptable square footage needed per student for a safe science laboratory/classroom.

It is important that school administrators realize they could be compromising safety and creating undesirable and unsafe conditions for their school districts when state guidelines on laboratory space and class size are not followed.

Note: A science laboratory/classroom is a room where teachers use a variety of instructional strategies including laboratory work.

In a widely read and highly respected article entitled *Overcrowding in the Science Laboratory* (published by Flinn Scientific, Inc., Batavia, IL) the following statements concerning class size and safety appear. "Class size makes a significant difference in traffic flow, individual monitoring, and student understanding of science. The facts are clear: increasing the number of students in a science laboratory increases the likelihood of accidents. A high pupil/teacher ratio constitutes a threat to laboratory safety. The average class size of the 'unsafe' classroom was 31; the average class size of those classrooms considered to be 'safe' was 23. Overcrowded conditions challenge a teacher to safely handle, transport, and use laboratory chemicals and equipment, thereby creating an unsafe working environment. Overcrowding also increases discipline problems which in turn contribute to 'unsafe' conditions."

Overcrowding in the science laboratory room has adversely affected one of the most important aspects of science: i.e., the **"hands-on" performance and involvement** of our students. To adjust to this overcrowding many science educators:

1. conduct demonstrations instead of having their students perform laboratories;
2. have only 24 students at any one time conduct a laboratory; the other students observe during the performance of that particular laboratory or work on other tasks; and/or
3. increase the number of "dry laboratories" where students do not actually perform experiments but analyze data from another source.

Major reforms are currently attempted in science education on the state and national levels, yet little attention has been given to the laboratory environment. All the national and state studies, initiatives, and programs (Project 2061, SS&C, the National Science Education Standards, state frameworks, and Statewide Systemic Initiatives) which suggest specific reforms in science education are strongly advocating more student-centered teaching that is "inquiry-based" and "hands-on."

Therefore, school districts must make appropriate science laboratory class size a major priority. The National Science Education Leadership Association strongly recommends the following:

1. The number of students assigned to a science laboratory/classroom should not exceed the number of available "built-in" laboratory stations.

2. The number of students assigned to a science laboratory/classroom should not exceed 24 if only one instructor is responsible for teaching these students in a laboratory setting (regardless of how large the classroom may be). It is important for instructor and students to have immediate access to each other in order for the conditions to be safe and acceptable for appropriate learning.

3. Science laboratory class size should also be determined by the type of course and the age and maturity level of students. It is important to note that for some classes of younger, more active students, no more than 20 students should be assigned (even if there are 24 "built-in" laboratory stations).

4. The minimum required floor area in net square feet per occupant (excluding furniture) for a science laboratory/classroom must conform to the fire code and administrative code of the state.

5. The number of students assigned to a science laboratory/classroom that is occupied with 24 "built-in" laboratory stations (and which has adhered to state administrative and fire codes for appropriate square footage per student) should not exceed 22 if at least two of these students are classified as having special needs. There should not be more than 20 students assigned if at least three of the students are so classified.

6. There should never be more than three (3) special needs students assigned to any one laboratory science course section if the class is taught by only one science instructor. IF a school district must mainstream more than three students per class, the science teacher should be provided with appropriate professional or paraprofessional assistance.

Adopted by the National Science Education Leadership Association, March 26, 1996

Science Teaching Conditions

Based on increasing enrollment and budget constraints in many schools across the nation, it is common for the following undesirable conditions to exist for science teachers:

- Science laboratory/classrooms have more students assigned than "built in" laboratory stations;
- Teachers are assigned three or four different laboratory courses to teach;
- Some of their laboratory class sizes have reached thirty or more;
- They are teaching in four or five different classrooms during a week;
- Their laboratory preparation room is often more than 200 feet from their laboratory/classroom;
- Master schedules are developed which do not allow for "team planning" among instructors who teach the same courses.

During this critical period in the history of science education, all of the national and state studies, initiatives, and programs (Project 2061, SS&C, National and State science standards, and Statewide Systemic Initiatives) have strongly advocated an improvement in science teaching prekindergarten through grade 16. Progress in science is so important that in 1990 the president and governors adopted six national goals in education. National Education Goal number four states that by the year 2000,

"U.S. students will be the first in the world in mathematics and science achievement."

Science teachers must meet many challenges as they attempt to improve science education and achieve these state and national science goals, and school districts must not place science instructors in conditions which are counterproductive to improving science education. Therefore the National Science Education Leadership Association (NSELA) advocates the following:

1. The number of different lab science courses assigned to an instructor during any academic term should not exceed two.

2. The number of students assigned to a science laboratory class section should not exceed 24 (and may be less depending upon safe occupancy levels and the specific needs of "exceptional students"). It is extremely difficult for one instructor to adequately supervise more than 24 students in a laboratory setting.

3. Teachers should not be assigned a schedule which requires them to teach the same laboratory science course in two different rooms.

4. When considering the laboratory and lecture aspects of teachers' assignments, a schedule should be developed which ensures that an instructor does not have to use more than two different rooms.

5. Teachers should be assigned a laboratory/classroom that is properly equipped for the specific science course(s) they are expected to teach. For example, a teacher should not have to teach a chemistry course in a laboratory room that has been designed and equipped for biology.

6. A laboratory preparation room should be next to the science laboratory/classroom. If this is not possible, the preparation room should be no more than 760 feet from the science laboratory/classroom, and chemistry teachers should never be assigned a room that does not have a preparation room adjoining it.

Note: Teachers should not have to prepare solutions in one area, place them on a cart, and transport them to other rooms.

7. Every laboratory science course should be designed in such a manner that at least one double period is scheduled each week, unless some innovative type of scheduling exists which provides an extended block of time.

Note: One cannot expect a quality hands-on and inquiry-oriented science program unless there are extended periods for students to perform discovery/inquiry laboratory investigations. It is very difficult to perform quality science investigations in a forty-five minute class period.

8. Teachers should be provided with release time or receive a stipend during the summer to help develop the science curriculum. They should not be expected to work on a task of this importance after completing a day of teaching.

9. A science schedule should be developed which will allow science teachers to do the following: participate in team planning with their colleagues who teach the same courses; be involved in multidisciplinary team planning with teachers from other curricular areas such as mathematics, social studies, English, and technology.

10. Professional development opportunities should be provided for members of the science staff which will enable them to remain abreast of recent developments in science. Emphasis should be placed on a variety of learning styles and instructional strategies such as cooperative learning and assessment alternatives, as well as on laboratory safety, working with diverse classrooms, and the responsibilities of the science teacher.

11. Each science laboratory/classroom should be equipped with at least one computer with appropriate software that supports the objectives of the curriculum.

12. Procedures should exist which will allow for prompt replacement or repair of equipment that is damaged or which becomes inoperable. Also, the science budget should provide for immediate purchase of consumables and early replacement and maintenance of science equipment.

13. Paraprofessional support should be provided (to prepare solutions, assemble apparatus, perform the safety checks that are listed in the district's chemical hygiene plan), and provision should be made for the proper disposal of chemicals.

14. Science laboratory classes should be scheduled in rooms that meet all appropriate safety standards.

15. Non-science classes should not be scheduled in a science laboratory/classroom.

16. Adequate and secure space must be provided to store science supplies and equipment.

17. Financial support and release time should be provided for teachers to participate in their professional association(s) and to network with colleagues in other parts of the state/nation.

18. If science instructors must be assigned a duty, it should be, whenever possible, a duty that involves science and not an administrative duty such as hall monitor or cafeteria duty.

Adopted by the National Science Education Leadership Association, March 26, 1996

Science for the Handicapped and Learning Disabled

The National Science Education Leadership Association recommends that all science supervisors/ chairpersons should help to assure that science curriculum and facilities allow access and participation for all handicapped and learning disabled individuals.

An appropriate science education is important for all people in our society. To exclude any group of people, such as handicapped or learning disabled, from pursuing an education or career goals in science not only is harmful to those people, but also limits valuable human resources in our society.

The National Science Education Leadership Association therefore affirms its commitment to equal access to quality science education for all handicapped and learning disabled individuals.

Adopted by the National Science Education Leadership Association, April 30, 1991

National Science Teachers Association
Position Statement

Science Education for Middle-Level Students

This document offers guidelines for Middle-Level science education that administrators and/or science teachers may use to reevaluate and upgrade their programs. Since a wide variety of grade structures exist in this country, the Middle Level is defined as grades five through nine.

The well-being of the United States, and indeed the world, depends on the quality and quantity of the education that its citizens receive. A major focus of recent educational debates has been the relationship of science education to the nation's scientific and technological advancement. While many significant priorities have been identified, none is greater than the need for quality science education for middle and junior high school students.

Schools for early adolescents should provide a transition between elementary and high school that helps to bridge the gap between childhood and adolescence. During this special time in children's development, schools need to provide resources and an atmosphere that will help young people mature. Yet, in spite of the good intentions held for the middle and junior high school, this is often forgotten or is sandwiched between two traditionally emphasized levels of schooling: elementary and high school. Likewise, science experiences at this middle level have all too often not provided emerging adolescents with adequate opportunities to broadly explore science in their lives. Science curricula for Middle-Level grades tend to be watered-down versions of traditional high school courses of study.

Middle-Level science is often taught as though the sole goal were to make students into scientists. Instruction is based primarily on lecture and textbook readings. Some science teachers of 10- to 14-year-olds have little science background because they were trained to teach in self-contained elementary schools. Others are well prepared to teach high school students but lack the necessary understanding of the developmental characteristics and needs of early adolescents. The few exemplary programs that do exist in this country are rare but encouraging beacons.

I. Special Needs of Early Adolescents

Middle-Level students are unique in several ways. Because radical physiological and social changes affect their cognitive, physical, and social behaviors, the teaching of early adolescents is a challenge. Regarding cognitive development, many early adolescents are beginning to make the transition from concrete to formal modes of thinking. Most Middle-Level students lack facility in abstract thinking and reasoning. Therefore, it is imperative that Middle-Level science educators provide concrete experiences that will enable students to form frameworks upon which conceptual understanding can be developed.

Perhaps the most obvious aspect of early adolescent development can be seen in the physical changes that occur in early adolescents during this period. Students grow quickly in many ways over a relatively short period of time increasing in height, weight, musculature, and sexual maturity. Awkwardness and poor coordination are often temporary results. However, not all students undergo these changes at the same rate or at the same age.

In addition, early adolescents are faced with social and emotional changes when they interact with peers and authorities such as teachers and parents. Behaviors of the child intermingle with hints of the adult to come in the early adolescent who intermittently bursts out with immature exuberance and then sinks suddenly into the more passive behavior and occasional depression of many high school students.

"What is happening to me?" is a source of constant preoccupation. The peer group gradually becomes the standard by which early adolescents define their roles both within the small group and within society as a whole.

II. A Model Program for Middle-Level Students

Curriculum and Instruction

The primary function of science education at the Middle-Level is to provide students with the opportunity to explore science in their lives and to become comfortable and personally involved with it. Certainly, the science curriculum at this level should reflect societal goals for scientific and technological literacy. The curriculum should emphasize the role of science for personal, social, and career use, as well as for the academic preparation of students.

Furthermore, when the science curriculum adequately matches the needs and capabilities of the early adolescent, it can become a powerful development strategy. The Middle-Level science goals should not stress covering the material or preparation for the next science course as ends in themselves. Science curricula that fulfill the needs of the early adolescent should address the needs of both the students and world society and involve concrete, manipulative, and physical experiences. Curricula should focus on the relationship of science to

- content from ecology, life, physical, and Earth sciences, with frequent interdisciplinary references
- process skills such as experimenting, observing, measuring, and inferring
- personal use in everyday applications and in practical problem solving that allows open-ended exploration
- the impact of science and technology on society that involves individual responsibilities and decision making
- all careers: semi-skilled and skilled as well as technical and professional career options
- limitations of science and the necessity of respecting differing, well-considered points of view
- development of written and oral communication skills, positive attitudes, and personal success.

Instruction in Middle-Level grades should call for activities appropriate to the learner's cognitive development level. Such activities should

- involve extensive use of laboratory experiences to develop students' skills with the tools of science while stressing laboratory safety; such experiences should provide opportunities for students to:
  (1) develop projects based on their interests
  (2) engage in actual research and not be limited to verifying previously documented theories
  (3) display and receive acknowledgment for their efforts
- use model-building, simulations, computer/student interactions, and other approaches that facilitate concrete, manipulative experiences
- employ a wide variety of instructional strategies to accommodate many students' cognitive levels and learning styles
- be appropriate for relatively short student attention spans
- occur in a logical sequence and be based upon elements familiar to students
- provide many opportunities for positive experiences that build student self-confidence and self-esteem
- involve social interaction and allow changes in instructional group size and composition
- balance student- and teacher-directed learning

- make optimal use of community resources on field trips, in independent study situations, and through interaction with a mix of role models and community members
- make use of information from various disciplines of science and the humanities
- involve students in experiences with the natural world to expose them to information regarding their relationships to the world as a whole
- emphasize that science is a field in which people of both sexes, all abilities, and all cultures can participate successfully.

Evaluation

Evaluation of the elements that affect the quality of science learning and instruction should be both formative and summative. It should help focus instruction towards the attainment of all program goals in the Middle-Level learning experience. Specific content knowledge is only a partial indicator of the success of the science program and its early adolescent participants. It is crucial that these young students become personally involved with science and technology and develop positive attitudes towards them.

Both student achievement and program quality need periodic evaluation. Rating student achievement should take into account their higher order cognitive understanding, science process skills, manipulative skills, creativity and imagination, and ability to find and use science information. Evaluation should be at a level appropriate to student cognitive abilities, maturation, and background. Assessing the level of student attainment of program goals necessarily goes beyond objective measures to include other indicators of growth such as various student products (written and oral, group and individual) produced during the course of the studies. Such products can, for instance, help evaluate creativity and ability to identify and solve open-ended problems.

Teachers' evaluations of students should provide opportunities for feedback and encourage ongoing self-assessment, as well as lead to focused assistance for those who fall below an appropriate level of progress.

Periodic evaluation of the Middle-Level science curriculum should also assess the degree to which it meets science-related social goals. This consideration should judge the curriculum and instructional procedures used to implement it, as well as the role of support systems (such as counselors, administration, and school board) in science instruction. Program evaluations should receive input from students of varied abilities, science teachers within and without the school system, parents, school administrators, and counselors. These evaluations should be part of a continuing, open, non-threatening process that includes self-assessment and peer interaction.

III. Model Science Teachers for the Middle-Level Grades

Because Middle-Level students are special in many ways, their science teachers must likewise be special. These instructors need a particular kind of background to instruct effectively the dynamic, challenging students at this level. Teacher-education programs for Middle-Level science certification should emphasize the qualities requisite for successful interaction with early adolescents including patience, involvement, enthusiasm for science, humor, and vitality, as well as provide adequate preparation in science content and instructional methods.

A combination of the following attributes, as specified in the NSTA Position Statement on Recommended Standards for the Preparation and Certification of Teachers of Science at the Elementary and Middle/Junior High School Levels, makes up high quality education programs. Science teachers of early adolescents should have

- a balance of life, earth, space, physical, and environmental sciences
- a minimum of 9 semester hours of mathematics and computer applications

- science methods course(s) that teach the prerequisites of how to help early adolescents learn science process skills, laboratory use, problem solving, and decision making
- experience in observing and teaching middle and junior high school science courses
- orientation to how the cognitive, psychological, social, and physical needs of early adolescents relate to science teaching,
- understanding of the relationship between student learning styles and science teaching strategies.

The Middle-Level science teacher often offers the first (and all too often also the last) contact students have with formal science. Therefore, the experiences these teachers provide can strongly influence student enrollment in additional science courses in high school and/or the pursuit of science-related careers. Teachers of early adolescents should represent a variety of positive role models as well as provide students with positive science experiences. Effective Middle-Level teachers make crucial contributions to the level of societal scientific literacy, and as such, they should be perceived as highly-valued professionals.

IV. Necessary Resources

Certain conditions will help Middle-Level science teachers best utilize their skills to help early adolescent students learn science.

Middle-Level science teachers need considerable time to plan appropriate activity-oriented courses. Therefore, the number of preparations should be limited to two per teacher. Also, each teacher should be guaranteed at least one duty-free planning period per day.

Middle-Level students should attend at least 225 minutes per week of science classes during each of their Middle-Level school years. Administrators and science teachers should strive to minimize interruptions of instructional time.

In order to keep students safe in the laboratory and to ensure effective teacher-student and student-student interactions, Middle-Level class size should never exceed 25 students.

Middle-Level science teachers need sufficient, appropriate, and readily available equipment and supplies. They must be able to purchase materials and replace consumable materials as necessary and have existing equipment upgraded on a regular schedule.

Middle-Level science classrooms and labs must be safe and well-ventilated as well as being properly equipped with laboratory tables, water, electricity, heat sources, and a movable table or desk for each student. Resident classroom microcomputer systems are increasingly important supplements to traditional instruction. Labs and classrooms should also have adequate storage, work, and wall space.

Middle-Level science teachers should be assigned to only one classroom.

Money for field trips should be available. Middle-Level science teachers should not have to spend their time raising funds for this purpose.

V. Professional Interaction and Development of Middle-Level Teachers

Continuing professional involvement and colleague support are essential elements of Middle-Level science teachers' growth and development. This development has significant impact on the growth of the students, the school system, and the community.

All Middle-Level science teachers profit from ongoing inservice education that focuses on science education goals, science content, science process, technology, instructional strategies, and classroom safety.

Middle-Level science teachers also need to communicate regularly through workshops, visitations to other schools, professional organizations and networks, and informal sharing of ideas with colleagues. In addition, they should communicate frequently with elementary, high school, and college science educators.

School districts should commit money and time to facilitate the professional activities of their teachers of early adolescents. Furthermore, Middle-Level science teachers must have resources available from each other, as well as from science supervisors, guidance and learning specialists, curriculum coordinators, membership in professional education and science organizations, and other resources such as professional journals.

Adopted by the NSTA Board of Directors, January 1990

National Science Teachers Association
Position Statement

Working Conditions for Secondary Science Teachers

The National Science Teachers Association recommends the following standards for teaching assignments:

I. Science classes should be staffed by personnel who are certified in the appropriate field. Teachers who meet NSTA standards for certification should be given priority in staffing decisions.

II. Science teachers should be assigned a maximum of four classes a day. This recommendation gives recognition to the special preparations necessary for safe and effective science teaching at this level. With double lab periods included, this could amount to 24 teaching periods. No extra duties, lunch room, study halls, etc. should be added to this load.

III. Because of the laboratory preparation required and the changing knowledge of science, teachers should not be scheduled for more than two preparations in any one day.

IV. A science teacher should have one complete preparation period per day in a setting where it is possible to complete laboratory and class preparations. A private space also should be available for conferences with students, parents, colleagues, and supervisors.

V. Science teachers should be assigned to teach in classrooms that have the facilities and space for a laboratory-oriented program.

VI. Because of safety considerations and the individual attention needed by students in laboratories, science classes should be limited to 24 students unless a team of teachers is available.

VII. Science rooms/laboratories should be used only for science classes and science activities and should be equipped with:

- a minimum of one square meter of laboratory space per student;
- sufficient gas, electrical, and water outlets for student laboratory activities;
- safety features, such as fire extinguishers, fume hoods, emergency showers, and eyewash fountains;
- audiovisual equipment such as an overhead projector, film projector, videocassette recorder, and slide projector;
- one or more computers, plus needed software and maintenance service;
- sufficient storage and preparation space;
- support equipment (photocopying machines, typewriters, word processors, etc.) in a nearby and accessible area; and
- textbooks, laboratory guides, and references as appropriate and needed.

To attract, retain, and support quality science teachers, the following conditions are necessary:

I. Salaries that are competitive with those received by others in science-related careers.

II. Opportunities and financial and administrative support available for participating in professional organizations and activities that provide assistance for science teachers.

III. Opportunities to plan, conduct, participate in, and evaluate inservice programs.

IV. Adequate budget for purchasing and maintaining needed equipment and supplies for science laboratories and other instructional activities.

V. Laboratory and clerical aides, both paid and volunteer, for each science department.

VI. Support, recognition, and appropriate compensation for supervising extracurricular science activities such as science fairs, science leagues, olympiads, and lecture series.

VII. Opportunities for professional development leaves of varying duration that will allow science teachers to attend conferences, participate in short courses, complete advanced academic study, work in science-related occupations on a short-term basis, and prepare curriculum materials.

VIII. Twelve-month contracts for "lead teachers" who provide leadership in staff development and curriculum development activities.

IX. Recognition programs that identify and reward exemplary teachers and programs.

X. Opportunities to collaborate and communicate with scientists and engineers in various occupations and positions.

XI. Opportunities for involvement and communication with parents, policy-makers, and other individuals in the community.

XII. Major responsibility for planning goals, objectives, and instructional activities for each science course in a school's curriculum.

XIII. Well-defined channels of communication with school administrators and a share in decision-making with respect to scheduling, budgets, class size, and inservice activities.

Adopted by the NSTA Board of Directors, July 1986

APPENDIX C

CHECKLISTS

- Elementary School Laboratory Facility Design Checklist
- Middle School Laboratory Facility Design Checklist
- High School Laboratory Facility Design Checklist
- Science Facility and Safety Checklist

Elementary School Laboratory Facility Design Checklist

The following checklist is intended to assist school districts that are considering new construction or renovation projects involving elementary school science facilities.

(√) Room Design

- ❑ *Student workstation location*
  - perimeter of room
  - free-standing islands
  - rows of tables
- ❑ *Floor surface*
  - grit surface for damp areas
  - acid-resistant
  - vinyl composite tile
  - carpet
- ❑ *Room size*
  - lab–40 square feet per student
  - classroom/lab–45 square feet per student
- ❑ *TAS[1] compliance**
  - five-foot turning radius
  - movement around room
- ❑ *Windows*
  - on outside wall
  - cover for darkening room
- ❑ *Exits* (two if the room is 1000 square feet or larger*)

(√) Safety Equipment

- ❑ *Fire extinguisher(s)**
  - locate by exit(s)
  - type ABC in room
- ❑ *Eye/face wash station(s)**
  - one TAS[1] compliant*
  - 10-second access
- ❑ *Master utility cutoff**
- ❑ *First-aid kit*
  - located near a sink
  - mounted on wall
- ❑ *Safety goggles**
  - storage
  - sanitizing cabinet
- ❑ *Fire blanket*
  - located near first-aid kit
  - storage
- ❑ *Emergency exhaust system*

(√) Live Organism Centers

- ❑ *Aquarium/terrarium center*
- ❑ *Animal study center*
- ❑ *Plant study center*

(√) Furniture, Fixtures, and Accessories

- ❑ *Laboratory tables*
  - perimeter or island
  - attached or moveable
  - 2–4 students
  - work surface
  - services
  - one TAS[1] compliant*
- ❑ *Demonstration table*
  - fixed station
  - mobile unit
- ❑ *Sinks*
  - one per 4 students
  - hot/cold water
  - faucet style
- ❑ *Dry marker board*
- ❑ *Base cabinets*
  - doors on hinge or slide
  - drawers
- ❑ *Upper case cabinets*
  - solid doors or glass
  - doors on hinge or slide
- ❑ *Tall storage cabinets*
  - microscopes
  - computers
  - models
  - safety goggles
  - tote trays
  - balances
- ❑ *Shelf units*
  - general storage
  - chemical storage
  - track unit
- ❑ *Utility cart*

(√) Technology

- ❑ *Communication system*
- ❑ *Computer workstations*
  - laptop
  - desktop
- ❑ *TV monitors*
  - ceiling or wall mounted
  - mobile
- ❑ *Internet connections*
- ❑ *Media systems*
  - VCR
  - laservideo
  - Elmo
  - CD player

[1] TAS (Texas Accessibility Standards)
*Required by law

Middle School Laboratory Facility Design Checklist

The following checklist is intended to assist schooldistricts that are considering new construction or renovation projects involving middle school science facilities.

(√) Room Design

- ❑ *Student workstation location*
  - perimeter of room
  - free-standing islands
  - rows of tables
- ❑ *Floor surface*
  - grit surface for damp areas
  - acid-resistant
  - vinyl composite tile
  - carpet
- ❑ *Room size*
  - lab–45 square feet per student
  - classroom/lab–50 square feet per student
- ❑ *TAS[1] compliance**
  - five-foot turning radius
  - movement around room
- ❑ *Windows*
  - on outside wall
  - cover for darkening room
- ❑ *Exits* (two if the room is 1000 square feet or larger*)

(√) Safety Equipment

- ❑ *Fire extinguisher(s)**
  - locate by exit(s)
  - type ABC in room
- ❑ *Eye/face wash station(s)**
  - one TAS[1] compliant
  - 10-second access
- ❑ *Master utility cutoff**
- ❑ *First-aid kit*
  - located near a sink
  - mounted on wall
- ❑ *Safety goggles**
  - storage
  - sanitizing cabinet
- ❑ *Fire blanket*
  - located near first-aid kit
  - storage
- ❑ *Emergency exhaust system*

(√) Live Organism Centers

- ❑ *Aquarium/terrarium center*
- ❑ *Animal study center*
- ❑ *Plant study center*

(√) Furniture, Fixtures, and Accessories

- ❑ *Laboratory tables*
  - perimeter or island
  - attached or moveable
  - one TAS[1] compliant*
  - work surface
  - 2–4 students
  - services
- ❑ *Demonstration table*
  - fixed station
  - mobile unit
- ❑ *Sinks*
  - one per 4 students
  - hot/cold water
  - faucet style
- ❑ *Dry marker board*
- ❑ *Base cabinets*
  - doors on hinge or slide
  - drawers
- ❑ *Upper case cabinets*
  - solid doors or glass
  - doors on hinge or slide
- ❑ *Tall storage cabinets*
  - microscopes
  - models
  - tote trays
  - computers
  - safety goggles
  - balances
- ❑ *Hazardous chemical cabinets*
  - corrosives cabinet
  - flammables cabinet
- ❑ *Shelf units*
  - general storage
  - chemical storage
  - track unit
- ❑ *Utility cart*

(√) Technology

- ❑ *Communication system*
- ❑ *Computer workstations*
  - laptop
  - desktop
- ❑ *TV monitors*
  - ceiling or wall mounted
  - mobile
- ❑ *Internet connections*
- ❑ *Media systems*
  - VCR
  - Elmo
  - laservideo
  - CD player

[1] TAS (Texas Accessibility Standards)
*Required by law

High School Laboratory Facility Design Checklist

The following checklist is intended to assist school districts that are considering new construction or renovation projects involving high school science facilities.

(√) Room Design

- ❑ *Student workstation location*
  - perimeter of room
  - free-standing islands
  - rows of tables
- ❑ *Floor surface*
  - grit surface (damp areas)
  - carpet
  - vinyl composite tile
  - acid-resistant
- ❑ *Room size*
  - lab–50 square feet per student
  - classroom/lab–55 square feet per student
- ❑ *TAS[1] compliance**
  - five-foot turning radius
  - movement around room
- ❑ *Windows*
  - on outside wall
  - cover for darkening room
- ❑ *Exits* (two if the room is 1000 square feet or larger*)

(√) Safety Equipment

- ❑ *Fire extinguisher(s)**
  - locate by exit(s)
  - type ABC in room
- ❑ *Eye/face wash station(s)**
  - one TAS[1] compliant*
  - 10-second access
- ❑ *Emergency shower**
- ❑ *Master utility cutoff**
- ❑ *First-aid kit*
  - located near a sink
  - mounted on wall
- ❑ *Safety goggles**
  - storage
  - sanitizing cabinet
- ❑ *Fire blanket*
  - located near first-aid kit
  - storage
- ❑ *Emergency exhaust system*
- ❑ *Ventilation system**
- ❑ *Fume hood (chemistry laboratory*)*

(√) Live Organism Centers

- ❑ *Aquarium/terrarium center*
- ❑ *Animal study center*
- ❑ *Plant study center*

(√) Furniture, Fixtures, and Accessories

- ❑ *Laboratory tables*
  - one TAS[1] compliant*
  - attached or moveable
  - perimeter or island
  - work surface
  - 2 or 4 students
  - services
- ❑ *Demonstration table*
  - fixed station
  - mobile unit
- ❑ *Sinks*
  - one per 4 students
  - hot/cold water
  - faucet style
- ❑ *Dry marker board*
- ❑ *Base cabinets*
  - doors on hinge or slide
  - drawers
- ❑ *Upper case cabinets*
  - solid doors or glass
  - doors on hinge or slide
- ❑ *Tall storage cabinets*
  - microscopes
  - models
  - tote trays
  - computers
  - balances
  - safety goggles
- ❑ *Hazardous chemical cabinets*
  - corrosives cabinet
  - flammables cabinet
- ❑ *Shelf units*
  - general storage
  - chemical storage
  - track unit
- ❑ *Utility cart*

(√) Technology

- ❑ *Communication system*
- ❑ *Computer workstations*
  - laptop
  - desktop
- ❑ *TV monitors*
  - ceiling or wall mounted
  - mobile
- ❑ *Internet connections*
- ❑ *Media systems*
  - VCR
  - Elmo
  - laservideo
  - CD player

[1] TAS (Texas Accessibility Standards)
*Required by law

Science Facility and Safety Checklist

The science facilities in your school should be checked annually to ensure a safe learning environment for you and your students. A copy of the Science Facility and Safety Checklist should be filed with the building principal and district science coordinator so that appropriate action can be taken to correct any problem.

Notification should be made in writing if a hazard is identified that could jeopardize the safety of an individual.

Communications

	√ K–5	√ 6–8	√ 9–12
Communication System			
• Intercom system available			
• Telephone accessible and nearby			
• General fire alarm system functioning for entire building			
• Fire-drill instructions posted in each room			
• Emergency lights available in rooms without exterior windows			

Personal Protection

	√ K–5	√ 6–8	√ 9–12
Emergency Showers			
• Shower (ADA compliant) present in chemistry laboratory rooms			
• Shower unobstructed			
• Valve handle functional			
• Floor drain present			
Eye/Face Wash Stations			
• Available in all laboratory rooms (5% ADA compliant)			
• Stations marked clearly with a sign			
• Provides simultaneous tepid (60–90°F) water treatment to both eyes			
• Stations flushed for five minutes each week			
Protective Clothing			
• Laboratory aprons or coats available for each student			
• Gloves (acid resistant and heat resistant) available			
Safety Goggles			
• Approved ANSI safety goggles available for each student and teacher			
• Materials available for disinfecting goggles after their use			
• Face shields available when appropriate			
First Aid			
• Kits available in each laboratory room			
• Kits clearly marked and visible			
• Kits checked on a regular basis and supplies replenished			
• Located near a sink			

Chemical Storage Room

	√ K–5	√ 6–8	√ 9–12
Combination BC Fire Extinguisher **(flammable liquids & electrical)**			
• Extinguisher located in room where chemicals are stored			
• Fire extinguisher properly charged, checked quarterly, safety seal intact			
• Located near exit, clearly visible, and marked with a sign			
Class D Fire Extinguisher **(flammable solids)**			
• Extinguisher properly charged			
• Extinguisher in rooms using metals (sodium, potassium)			
Fire Blankets			
• Standard fireproof blanket in each chemical storage room			
• Blankets located at eye level, clearly visible, and marked with a sign			
Fire or Emergency Exits			
• Two emergency exits; visible sign marking exits			
• Emergency exits unobstructed and unlocked to traffic moving out of the room			
Other Fire Protection			
• Exit signs clearly visible			
• Emergency lights available in rooms without exterior windows			
• General fire-alarm system functioning for building			
• Fire-drill procedures posted in storage rooms			
• 4- to 9-liter container of dry sand or absorbant clay (cat litter)			
• Utility carts available to transport chemicals			
Ventilation			
• Six air changes per hour			

Preparation and Equipment Storage Rooms

	√ K–5	√ 6–8	√ 9–12
General Storage Requirements			
• Combination BC extinguisher in preparatory rooms			
• Work surface of nonporous chemical-resistant materials			
• Large sink with hot water available			
• Emergency shower accessible			
• Material Safety Data Sheets (MSDS) available			
• Room well lighted and clutter-free			
• Space to store chemicals			
• Chemical waste container and broken glass container available			
• Two emergency exits, with locks on doors			
• Smoke detectors present			
• Refrigerator marked "For Chemical Storage Only—No Food Allowed"			
• Adequate storage space (15 square feet per student)			
• Ventilation–six air changes per hour			

Laboratory Room

	√ K–5	√ 6–8	√ 9–12
Laboratory Work Stations			
• Number of students does not exceed the number of work stations			
• Work surfaces nonporous and chemical resistant			
• At least one work station that is ADA compliant			
Master Utility Controls			
• Natural gas shut-off valve present, labeled with room identification			
• Electrical shut-off valve present, labeled with room identification			
• Water shut-off valve present, labeled with room identification			
Fume Hood			
• Located in rooms where hazardous chemicals are used (ADA compliant)			
• Not used for storage			
• Correct air movement provided at hood face			
• Vented to outside above roof level away from intake vent			
• Located away from doors and windows			
Spill Control Kits			
• Chemical spill kits available			
• 4- to 9-liter container of dry sand or absorbent clay (cat litter)			
Sinks			
• One available for every 4 students (15" x 15" minimum size)			
• One equipped with hot water			
• 5% of sinks ADA compliant			
Ventilation			
• Forced floor to ceiling			
• Six air changes per hour			
• Emergency exhaust fan available			
General Safety Requirements			
• 40 square feet of space per student for elementary schools; 45 square feet of space per student for middle and high schools			
• Safety rules posted and visible			
• Space available for chemical storage			
• Material Safety Data Sheets (MSDS) readily accessible			
• Broken glass container present			
• Two emergency exits in laboratory rooms larger than 1000 square feet			
• Safety and exit signs posted and visible			
• Room not cluttered; movement in work area unobstructed			

Laboratory Room

Fire Protection	√ K–5	√ 6–8	√ 9–12
• Type ABC (dry chemical) fire extinguisher located by exit			
• Class D (flammable solids) available in rooms using metals			
• Extinguishers properly charged, checked quarterly, and marked with a sign			
• Fireproof blanket available, located at eye level, and marked with a sign			

Laboratory and Chemical and Equipment Storage Rooms

Electrical System	√ K–5	√ 6–8	√ 9–12
• Electrical outlets equipped with ground fault circuit interrupter (GFCI)			
• Sufficient electrical outlets to eliminate extension cords			
• Electrical outlets located away from water source (faucets, sinks)			
• Electrical system equipped with accessible circuit breaker box			
• Circuit breakers identified by area or item controlled			

This information represents an assessment of the school's science facilities and should serve as a guide for establishing a safe working and learning environment.

Teacher _____ Date _____

APPENDIX D

RESOURCES

- Manufacturer Resources
- State and Federal Resources
- Botanical Gardens
- Common Texas Wildflowers for Butterfly Gardens

Manufacturer Resources

Fisher Hamilton
1316 18th Street
Two Rivers, Wisconsin 54241
(920) 793-1121
jtheil@fisherhamilton.com

Fisher Science Education
Educational Materials Division
485 South Frontage Road
Burr Ridge, Illinois 60521
(708) 655-4410
http://www.fisheredu.com

Flinn Scientific
P.O. Box 219
770 North Raddant Road
Batavia, Illinois 60510
(630) 879-6962
http://www.flinnsci.com

Frey Scientific
Division of Beckly Cardy
100 Paragon Parkway
Mansfield, Ohio 44903
(419) 589-1900
http://www.freyscientific.com

General Supply Corporation
P.O. Box 9347
Jackson, Mississippi 39286-9347
(601) 981-3882
gensupp@netdoor.com

HEMCO Corporation
111 Powell Road
Independence, Missouri 64056
(816) 796-2900
http://www.HEMCOcorp.com

ISIMET, LLC
Laboratory Service Panels and Utility Controllers
2612 National Circle
Garland, Texas 75041-2315
(972) 926-4601
http://www.isimet.com

Kewaunee Scientific Equipment Corporation
P.O. Box 1842
Statesville, North Carolina 28687
(704) 873-7202
http://www.kewaunee.com

Kons Scientific Company, Incorporated
P.O. Box 3
Germantown, Wisconsin 53022
(414)242-3636
kscienceco@aol.com

Lab Safety Supply
401 South Wright Road
P.O. Box 1368
Janesville, Wisconsin 53547
(608) 754-2345
custvc@labsafety.com

LSI Corporation of America
2100 Xenium Lane North
Plymouth, Minnesota 55441
http://www.lsi-casework.com

MOHON International, Incorporated
1865 North Market Street
Paris, Tennessee 38242
(901) 642-4251
http://www.mohon.com

PEPCO
10206 Rosewood
Overland, Kansas 66207
(913) 649-1800
PEPCOtiger@aol.com

Sargent-Welch
VWR Scientific Products
P.O. Box 5229
Buffalo Grove, Illinois 60089
(800) SAR-GENT
http://www.SargentWelch.com

Sheldon Laboratory Systems
102 Kirk Street
P.O. Box 836
Crystal Springs, Mississippi 39059
(601) 892-2731

State and Federal Resources

Texas Parks and Wildlife Department
Urban Wildlife Program
4200 Smith School Road
Austin, Texas 78744
(512) 389-4974
http://www.tpwd.state.tx.us/

U.S. Fish and Wildlife Services
Austin Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512) 490-0974

National Wildlife Federation
11100 Wildlife Center Drive
Reston, Virginia 20190-5362
(703) 438-6000
http://www.nwf.org/nwf/natlwild/index.html/

Gulf States Natural Resource Center
4505 Spicewood Springs, Suite 300
Austin, Texas 78759
(512) 346-3934

Native Plant Society of Texas Statewide Office
Bank One Building
1111 North IH-35, Suite 212
Round Rock, Texas 78664
(512) 836-4751
http://lonestar.texas.net/~jleblanc/npsot_austin.html/

Ladybird Johnson Wildflower Research Center
4801 LaCrosse Avenue
Austin, Texas 78739-1702
(512) 292-4100
http://www.wildflower.org/

USDA Natural Resource Conservation Commission
P.O. Box 13087
Austin, Texas 78711-3087
(512) 239-5440

Texas Agricultural Extension Service
Jack K. Williams Adminstration Building
Room 112
College Station, Texas 77843-7101
(409) 845-7800

Texas Forest Service
1101 Camino La Costa Road
Room 215
Austin, Texas 78752

Fredricksburg Herb Farm
402 Whitney Street
Fredricksburg, Texas 78624
(800) 259-HERB
http://www.fredericksburgherbfarm.com/

Wildseed Farms
7 miles East on Highway 290
Fredricksburg, Texas (800) 848-0078
http://www.wildseedfarms.com/

The Gardening Launch Pad
http://GardeningLaunchPad.com/

Botanical Gardens

Bayou Bend Collection and Gardens
P.O. Box 6826
Houston, Texas 77265-6826

Botanical Research Institute of Texas
509 Pecan Street
Fort Worth, Texas 76102-1079
(817) 332-4441

Carleen Bright Arboretum
9001 Bosque Boulevard
Woodway, Texas 7612
(254) 399-9204

Corpus Christi Botanical Gardens
8545 South Staples Street
Corpus Christi, Texas 78413
(361) 852-2100

Dallas Arboretum & Botanical Society, Inc.
8617 Garland Road
Dallas, Texas 75218
(214) 327-8263

Dallas Horticulture Center
P.O. Box 152537
Dallas, Texas 75315
(214) 428-7476

Fort Worth Botanical Garden
3220 Botanical Garden Boulevard
Fort Worth, Texas 76107
(817) 871-7686

Heard Natural Science Museum & Wildlife Sanctuary
One Nature Place
McKinney, Texas 75069
(972) 562-5566

Houston Arboretum & Nature Center
4501 Woodway Drive
Houston, Texas 77024
(713) 681-8433

Mast Arboretum
Stephen F. Austin State University
P.O. Box 13000
Nacogdoches, Texas 75962

Mercer Arboretum & Botanical Gardens
22306 Aldine-Westfield Road
Humble, Texas 77338-1071
(281) 443-8731

Moody Gardens
One Hope Boulevard
Galveston, Texas 77554
(800) 582-4673

Native Prairies Association of Texas
301 Nature Center Drive
Austin, Texas 78746
(512) 476-1663

San Antonio Botanical Gardens
555 Funston Place
San Antonio, Texas
(210) 207-3255

Texas Botanical Garden Society
P.O. Box 5642
Austin, Texas 78763
(512) 478-0010

Texas Nursery & Landscape Association
7730 South IH-35
Austin, Texas 78745
(512) 280-5182
http://www.txnla.org/

WaterWise Council of Texas
7730 South IH-35
Austin, Texas 78745
(512) 280-5182
http://www.waterwisetexas.org/

Zilker Botanical Garden
2220 Barton Springs Road
Austin, Texas 78746
(512) 478-8672

Common Texas Wildflowers for Butterfly Gardens

Common Name	Scientific Name	Plant Height	Blooming Period	Light Requirement
Bishop's flower	*Ammi majus*	2 1/2"–3"	May–August	Full sun
Black-eyed Susan	*Rudbeckia hirta*	2'–3'	June–August	Full sun
Blanketflower	*Gaillardia aristata*	1 1/2'–2'	May–September	Full sun
Blue flax	*Linum lewisii*	1'–2'	May–September	Full sun
Butterfly weed	*Asclepias tuberosa*	1'–2'	June–September	Full sun
Clasping coneflower	*Rudbeckia amplexicaulis*	1 1/2'–2'	June–September	Full sun
Bachelor's button	*Centaurea cyanus*	2'–3'	March–May	Full sun
Blazing star	*Liatris spicata*	2'–6'	June–September	Full sun
Drummond phlox	*Phlox drummondii*	8"–24"	April–June	Full sun
Evening primrose	*Oenothera lamarckiana*	2'–4'	May–June	Full sun
Gay feather	*Liatris pycnostachya*	2'–4'	August–December	Full sun
Firewheel	*Gaillardia puchella*	1 1/2'–2'	May–September	Full sun
Gold yarrow	*Achillea filipendulina*	2'–4'	May–November	Full sun
Lemon mint	*Monarda citriodora*	1'–3'	May–August	Full sun
Maximilian sunflower	*Helianthus maximiliani*	3'–10'	July–October	Full sun
Mealy blue sage	*Salvia farinacea*	1'–2'	March–November	Full sun
Mexican hat	*Ratibida columnaris*	2'–3'	June–September	Full sun
Missouri primrose	*Oenothera missouriensis*	6"–14"	May–September	Full sun
Moss verbena	*Verbena tenuisecta*	12"–18"	March–July	Full sun

(table continues)

Common Texas Wildflowers for Butterfly Gardens—*Continued*

Common Name	Scientific Name	Plant Height	Blooming Period	Light Requirement
Narrow-leafed coneflower	*Echinacea angustifolia*	1'–2'	May–October	Full sun
Plains coreopsis	*Coreopsis tinctoria*	1'–3'	May–August	Full sun
Purple coneflower	*Echinacea purpurea*	2'–3'	June–October	Full sun or partial shade
Purple prairie clover	*Petalotemum purpureum*	1'–3'	May–September	Full sun
Rose mallow	*Lavatera trimestris*	3'–5'	June–September	Full sun or partial shade
Scarlet sage	*Salvia coccinea*	1'–3'	April–Frost	Full sun or partial shade
Showy primrose	*Oenothera speciosa*	8"–16"	March–July	Full sun
Tahoka daisy	*Machaeranthera tanacetifolia*	12"–18"	May–September	Full sun
Lance-leafed coreopsis	*Coreopsis lanceolata*	2'–3'	May–June	Full sun
Texas bluebonnet	*Lupinus texensis*	1'–2'	March–May	Full sun
Texas paintbrush	*Castilleja indivisa*	18"–24"	April–June	Full sun
Tidy-tips	*Layia platyglossa*	12"–24"	March–May	Full sun
Toadflax	*Linaria maroccana*	1 1/2'–2'	March–June	Full sun or partial shade
Wine cup	*Callirhoe involucrata*	1/2'–1 1/2'	February–July	Full sun
Yarrow	*Achillea millefolium*	1'–3'	May–November	Full sun
Autumn sage	*Salvia greggii*	2'–4'	March–November	Full sun or partial shade
Ox-eye daisy	*Borrichia frutescens*	1'–4'	April–November	Full sun
Prairie verbena	*Verbena bipinnatifida*	6"–1'	March–August	Full sun
Red gaillardia	*Gaillardia amblyodon*	10"–12"	May–September	Full sun

Chapter Credits

The examples in the figures and specifications presented in these chapters were provided through the courtesy of the following companies and publications.

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Figure 2.6: Encon Safety Products®
Figure 2.7: *Best's Safety Directory*
Figure 2.8: *Best's Safety Directory*
Figure 2.9: *Best's Safety Directory*
Figure 2.10: Encon Safety Products®
Figure 2.11: Haws Corporation®
Figure 2.12: Haws Corporation®
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Figure 2.19: Sheldon Laboratories
Figure 2.20: Sargent-Welch
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Figure 2.22: Sargent-Welch
Figure 2.23: Sargent-Welch
Figure 2.24: Sargent-Welch

Eyewash station specifications: Guardian Equipment
Emergency shower specifications: Guardian Equipment
Emergency shower/eyewash specifications: Guardian Equipment
Eyewash and drench hose specifications: Guardian Equipment
Fume hood specifications: Sheldon Laboratories
Fire extinguisher specifications: Sargent-Welch

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Figures 5.1–5.2: Texas Parks and Wildlife Department

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COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION
Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a nonsegregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

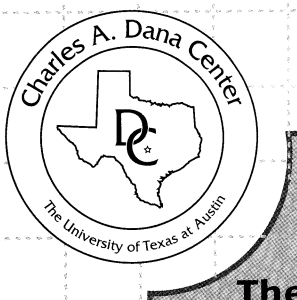
In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, U.S. Department of Education.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964 AS AMENDED BY THE EQUAL EMPLOYMENT OPPORTUNITY ACT OF 1972; EXECUTIVE ORDERS 11246 AND 11375; EQUAL PAY ACT OF 1964; TITLE IX, EDUCATION AMENDMENTS; REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED; IMMIGRATION REFORM AND CONTROL ACT OF 1986; AMERICANS WITH DISABILITIES ACT OF 1990; AND THE CIVIL RIGHTS ACT OF 1991.

The Texas Education Agency shall comply fully with the nondiscrimination provisions of all federal and state laws, rules, and regulations by assuring that no person shall be excluded by consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any educational programs or activities which it operates on the grounds of race, religion, color, national origin, sex, disability, age, or veteran status (except where age, sex, or disability constitutes a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency is an Equal Employment Opportunity/Affirmative Action employer.



about . . .

The Charles A. Dana Center at the University of Texas at Austin works to support education leaders and policymakers in strengthening Texas education. As a research unit of UT Austin's College of Natural Sciences, the Dana Center maintains a special emphasis on mathematics and science education. We offer professional development institutes and produce research-based mathematics and science resources for educators to use in helping all students achieve academic success.

Early in its history, the Dana Center took a leadership role in strengthening precollegiate mathematics and science education and was central to developing the Texas Essential Knowledge and Skills, or TEKS, that articulate what more than 4 million Texas children must know and be able to do in mathematics and science.

The Dana Center reinforced this work by collaborating with community-based organizations and school districts to increase educational access for all Texas students, especially those challenged by poverty. Today, the Dana Center has a presence in more than 1,000 Texas schools and in virtually every county across the state.

For more information, visit the Dana Center website at **www.utdanacenter.org.**