

Installation, Maintenance, and Repair Occupations



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Occupations Included in this Reprint

Aircraft and avionics equipment
mechanics and service technicians
Automotive body and related repairers
Automotive service technicians and mechanics
Coin, vending, and amusement
machine servicers and repairers
Computer, automated teller, and
office machine repairers
Diesel service technicians and mechanics
Electrical and electronics installers and repairers
Electronic home entertainment
equipment installers and repairers
Heating, air-conditioning, and refrigeration
mechanics and installers
Heavy vehicle and mobile equipment
service technicians and mechanics
Home appliance repairers
Industrial machinery installation, repair, and
maintenance workers, except millwrights
Line installers and repairers
Maintenance and repair workers, general
Millwrights
Precision instrument and equipment repairers
Radio and telecommunications
equipment installers and repairers
Small engine mechanics

Aircraft and Avionics Equipment Mechanics and Service Technicians

(0*NET 49-2091.00, 49-3011.01, 49-3011.02, 49-3011.03)

Significant Points

- The majority of these workers learn their job in 1 of about 200 trade schools certified by the Federal Aviation Administration.
- Opportunities should be excellent, but competition is likely for the best paying airline jobs.

Nature of the Work

To keep aircraft in peak operating condition, aircraft and avionics equipment mechanics and service technicians perform scheduled maintenance, make repairs, and complete inspections required by the Federal Aviation Administration (FAA).

Many aircraft mechanics, also called airframe, powerplant, and avionics aviation maintenance technicians, specialize in preventive maintenance. They inspect engines, landing gear, instruments, pressurized sections, accessories—brakes, valves, pumps, and air-conditioning systems, for example—and other parts of the aircraft, and do the necessary maintenance and replacement of parts. Inspections take place following a schedule based on the number of hours the aircraft has flown, calendar days since the last inspection, cycles of operation, or a combination of these factors. Large, sophisticated planes are equipped with aircraft monitoring systems, consisting of electronic boxes and consoles that monitor the aircraft's basic operations and provide valuable diagnostic information to the mechanic. To examine an engine, aircraft mechanics work through specially designed openings while standing on ladders or scaffolds, or use hoists or lifts to remove the entire engine from the craft. After taking an engine apart, mechanics use precision instruments to measure parts for wear and use x-ray and magnetic inspection equipment to check for invisible cracks. Worn or defective parts are repaired or replaced. Mechanics may also repair sheet metal or composite surfaces, measure the tension of control cables, and check for corrosion, distortion, and cracks in the fuselage, wings, and tail. After completing all repairs, they must test the equipment to ensure that it works properly.

Mechanics specializing in repairwork rely on the pilot's description of a problem to find and fix faulty equipment. For example, during a preflight check, a pilot may discover that the aircraft's fuel gauge does not work. To solve the problem, mechanics may troubleshoot the electrical system, using electrical test equipment to make sure that no wires are broken or shorted out, and replace any defective electrical or electronic components. Mechanics work as fast as safety permits so that the aircraft can be put back into service quickly.

Some mechanics work on one or many different types of aircraft, such as jets, propeller-driven airplanes, and helicopters. Others specialize in one section of a particular type of aircraft, such as the engine, hydraulics, or electrical system. *Powerplant mechanics* are authorized to work on engines and do limited work on propellers. *Airframe mechanics* are authorized to work on any part of the aircraft except the instruments, powerplants, and propellers. *Combination airframe-and-powerplant mechanics*—called A & P mechanics—work on all parts of the plane, except instruments. The majority of mechanics working on civilian aircraft today are A & P mechanics. In small, independent repair shops, mechanics usually inspect and repair many different types of aircraft.

Avionics systems are now an integral part of aircraft design and have vastly increased aircraft capability. *Avionics technicians* repair and maintain components used for aircraft navigation and radio communications, weather radar systems, and other instruments and computers that control flight, engine, and other primary functions. These duties may require additional licenses, such as a radio-telephone license issued by the U.S. Federal Communications Commission (FCC). Because of technological advances, an increasing amount of time is spent repairing electronic systems, such as computerized controls. Technicians also may be required to analyze and develop solutions to complex electronic problems.

Working Conditions

Mechanics usually work in hangars or in other indoor areas, although they can work outdoors—sometimes in unpleasant weather—when hangars are full or when repairs must be made quickly. Mechanics often work under time pressure to maintain flight schedules or, in general aviation, to keep from inconveniencing customers. At the same time, mechanics have a tremendous responsibility to maintain safety standards, and this can cause the job to be stressful.

Frequently, mechanics must lift or pull objects weighing as much as 70 pounds. They often stand, lie, or kneel in awkward positions and occasionally must work in precarious positions on scaffolds or ladders. Noise and vibration are common when engines are being



Aircraft mechanics and service technicians inspect, maintain, and repair airplanes in accordance with Federal Aviation Administration regulations.

tested, so ear protection is necessary. Aircraft mechanics usually work 40 hours a week on 8-hour shifts around the clock. Overtime work is frequent.

Employment

Aircraft and avionics equipment mechanics and service technicians held about 154,000 jobs in 2002; about 1 in 6 of these workers was an avionics technician. Nearly 40 percent of aircraft and avionics equipment mechanics and technicians worked for air transportation companies and close to 20 percent worked for private maintenance and repair facilities. About 20 percent worked for the Federal Government, and about 13 percent worked for aerospace products and parts manufacturing firms. Most of the rest worked for companies that operate their own planes to transport executives and cargo. Few mechanics and technicians were self-employed.

Most airline mechanics and service technicians work at major airports near large cities. Civilian mechanics employed by the U.S. Armed Forces work at military installations. Large proportions of mechanics who work for aerospace manufacturing firms are located in California or in Washington State. Others work for the FAA, many at the facilities in Oklahoma City, Atlantic City, Wichita, or Washington, DC. Mechanics for independent repair shops work at airports in every part of the country.

Training, Other Qualifications, and Advancement

The majority of mechanics who work on civilian aircraft are certified by the FAA as “airframe mechanic,” “powerplant mechanic,” or “avionics repair specialist.” Mechanics who also have an inspector’s authorization can certify work completed by other mechanics and perform required inspections. Uncertificated mechanics are supervised by those with certificates.

The FAA requires at least 18 months of work experience for an airframe, powerplant, or avionics repairer’s certificate. For a combined A & P certificate, at least 30 months of experience working with both engines and airframes is required. Completion of a program at an FAA-certified mechanic school can substitute for the work experience requirement. Applicants for all certificates also must pass written and oral tests and demonstrate that they can do the work authorized by the certificate. To obtain an inspector’s authorization, a mechanic must have held an A & P certificate for at least 3 years. Most airlines require that mechanics have a high school diploma and an A & P certificate.

Although a few people become mechanics through on-the-job training, most learn their job in 1 of about 200 trade schools certified by the FAA. About one-third of these schools award 2- and 4-year degrees in avionics, aviation technology, or aviation maintenance management.

FAA standards established by law require that certified mechanic schools offer students a minimum of 1,900 actual class hours. Coursework in these trade schools normally lasts from 24 to 30 months and provides training with the tools and equipment used on the job. Aircraft trade schools are placing more emphasis on technologies such as turbine engines, composite materials—including graphite, fiberglass, and boron—and aviation electronics, which are increasingly being used in the construction of new aircraft. Additionally, employers prefer mechanics who can perform a variety of tasks.

Some aircraft mechanics in the Armed Forces acquire enough general experience to satisfy the work experience requirements for the FAA certificate. With additional study, they may pass the certifying exam. In general, however, jobs in the military services are too specialized to provide the broad experience required by the FAA. Most Armed Forces mechanics have to complete the entire training

program at a trade school, although a few receive some credit for the material they learned in the service. In any case, military experience is a great advantage when seeking employment; employers consider trade school graduates who have this experience to be the most desirable applicants.

Courses in mathematics, physics, chemistry, electronics, computer science, and mechanical drawing are helpful, because they demonstrate many of the principles involved in the operation of aircraft, and knowledge of these principles is often necessary to make repairs. Courses that develop writing skills also are important because mechanics are often required to submit reports.

FAA regulations require current experience to keep the A & P certificate valid. Applicants must have at least 1,000 hours of work experience in the previous 24 months or take a refresher course. As new and more complex aircraft are designed, more employers are requiring mechanics to take ongoing training to update their skills. Recent technological advances in aircraft maintenance necessitate a strong background in electronics—both for acquiring and retaining jobs in this field. FAA certification standards also make ongoing training mandatory. Every 24 months, mechanics are required to take at least 16 hours of training to keep their certificate. Many mechanics take courses offered by manufacturers or employers, usually through outside contractors.

Aircraft mechanics must do careful and thorough work that requires a high degree of mechanical aptitude. Employers seek applicants who are self-motivated, hard-working, enthusiastic, and able to diagnose and solve complex mechanical problems. Agility is important for the reaching and climbing necessary to do the job. Because they may work on the tops of wings and fuselages on large jet planes, aircraft mechanics must not be afraid of heights.

As aircraft mechanics gain experience, they may advance to lead mechanic (or crew chief), inspector, lead inspector, or shop supervisor positions. Opportunities are best for those who have an aircraft inspector’s authorization. In the airlines, where promotion often is determined by examination, supervisors sometimes advance to executive positions. Those with broad experience in maintenance and overhaul might become inspectors with the FAA. With additional business and management training, some open their own aircraft maintenance facilities. Mechanics learn many different skills in their training that can be applied to other jobs, and some transfer to other skilled repairer occupations or electronics technician jobs.

Job Outlook

Opportunities for aircraft and avionics equipment mechanics and service technician jobs should be excellent for persons who have completed aircraft mechanic training programs. Employment of aircraft mechanics is expected to increase about as fast as the average for all occupations through the year 2012, and large numbers of additional job openings should arise from the need to replace experienced mechanics who retire. Avionics technicians are projected to increase at a slower than average rate. Despite the long-term forecast, these occupations are currently in a period of little to no growth. Reduced passenger traffic resulting from a weak economy and the events of September 11, 2001, have forced airlines to cut back flights and take aircraft out of service. As the economy improves and public reluctance to board aircraft decreases, a growing population should increase passenger traffic and create the need for more aircraft mechanics and service technicians over the next decade. If the number of graduates from aircraft mechanic training programs continues to fall short of employer needs, opportunities for graduates of mechanic training programs should be excellent.

Most job openings for aircraft mechanics through the year 2012 will stem from replacement needs. A large number of mechanics

are expected to retire over the next decade and create several thousand job openings per year. In addition, others will leave to work in related fields, such as automobile repair, as much of their skills are transferable to other maintenance and repair occupations. Also contributing to favorable future job opportunities for mechanics is the long-term trend towards fewer students entering technical schools to learn skilled maintenance and repair trades. Many of the students who have the ability and aptitude to work on planes are choosing to go to college, work in computer-related fields, or go into other repair and maintenance occupations with better working conditions. If the trend continues, the supply of trained aviation mechanics will not be able to keep up with air transportation industry needs when growth resumes in the industry.

Job opportunities are likely to be the best at small commuter and regional airlines, at FAA repair stations, and in general aviation. Commuter and regional airlines are the fastest growing segment of the air transportation industry, but wages in these companies tend to be lower than those in the major airlines, so they attract fewer job applicants. Also, some jobs will become available as experienced mechanics leave for higher paying jobs with the major airlines or transfer to another occupation. At the same time, general aviation aircraft are becoming increasingly sophisticated, boosting the demand for qualified mechanics. Mechanics will face more competition for jobs with large airlines because the high wages and travel benefits that these jobs offer generally attract more qualified applicants than there are openings. In spite of this, job opportunities with the airlines are expected to be better than they have been in the past. But, in general, prospects will be best for applicants with experience. Mechanics who keep abreast of technological advances in electronics, composite materials, and other areas will be in greatest demand. The number of job openings for aircraft mechanics in the Federal Government should decline as the government increasingly contracts out service and repair functions to private repair companies.

Earnings

Median hourly earnings of aircraft mechanics and service technicians were about \$20.71 in 2002. The middle 50 percent earned between \$16.94 and \$25.23. The lowest 10 percent earned less than \$13.16, and the highest 10 percent earned more than \$28.92. Median hourly earnings in the industries employing the largest numbers of aircraft mechanics and service technicians in 2002 were:

Air transportation, scheduled	\$23.48
Federal Government	20.59
Air transportation, nonscheduled	19.84
Aerospace product and parts manufacturing	19.68
Support activities for air transportation	17.64

Median hourly earnings of avionics technicians were about \$20.21 in 2002. The middle 50 percent earned between \$17.44 and \$23.91. The lowest 10 percent earned less than \$14.01, and the highest 10 percent earned more than \$27.00.

Mechanics who work on jets for the major airlines generally earn more than those working on other aircraft. Airline mechanics and their immediate families receive reduced-fare transportation on their own and most other airlines.

Almost 4 in 10 aircraft and avionics equipment mechanics and service technicians are members of or covered by union agreements. The principal unions are the International Association of Machinists and Aerospace Workers and the Transport Workers Union of America. Some mechanics are represented by the International Brotherhood of Teamsters.

Related Occupations

Workers in some other occupations that involve similar mechanical and electrical work are electricians, electrical and electronics installers and repairers, and elevator installers and repairers.

Sources of Additional Information

Information about jobs with a particular airline can be obtained by writing to the personnel manager of the company.

For general information about aircraft and avionics equipment mechanics and service technicians, write to:

► Professional Aviation Maintenance Association, 717 Princess St., Alexandria, VA 22314. Internet: <http://www.pama.org>

For information on jobs in a particular area, contact employers at local airports or local offices of the State employment service.

Automotive Body and Related Repairers

(0*NET 49-3021.00, 49-3022.00)

Significant Points

- Both formal and on-the-job training are suggested if a worker wants to become a fully skilled automotive body repairer, because advances in technology have greatly changed the structure, components, and materials used in automobiles.
- Repairers need good reading ability and basic mathematics and computer skills in order to follow instructions and diagrams in print and computer-based technical manuals.

Nature of the Work

Thousands of motor vehicles are damaged in traffic accidents every day. Although some of these vehicles are beyond repair, others can be made to look and drive like new. Automotive body repairers straighten bent bodies, remove dents, and replace crumpled parts that cannot be fixed. They repair all types of vehicles, but work mostly on cars and small trucks, although some work on large trucks, buses, or tractor-trailers.

Automotive body repairers use special equipment to restore damaged metal frames and body sections. Repairers chain or clamp frames and sections to alignment machines that use hydraulic pressure to align damaged components. “Unibody” vehicles—designs built without frames—must be restored to precise factory specifications for the vehicle to operate correctly. To do so, repairers use benchmark systems to make accurate measurements of how much each section is out of alignment and hydraulic machinery to return the vehicle to its original shape.

Body repairers remove badly damaged sections of body panels with a pneumatic metal-cutting gun or by other means and weld in replacement sections. Repairers pull out less serious dents with a hydraulic jack or hand prying bar or knock them out with handtools or pneumatic hammers. They smooth out small dents and creases in the metal by holding a small anvil against one side of the damaged area while hammering the opposite side. Repairers also remove very small pits and dimples with pick hammers and punches in a process called metal finishing.

Body repairers also repair or replace the plastic body parts that are increasingly being used on new-model vehicles. They remove damaged panels and identify the type and properties of the plastic used on the vehicle. With most types of plastic, repairers can apply heat from a hot-air welding gun or by immersion in hot water and press the softened panel back into its original shape by hand. They replace plastic parts that are badly damaged or very difficult to repair.

Body repairers use plastic or solder to fill small dents that cannot be worked out of the plastic or metal panel. On metal panels, they file or grind the hardened filler to the original shape and clean the surface with a media blaster before painting. In many shops, automotive painters do the painting. (These workers are discussed in the *Handbook* statement on painting and coating workers, except construction and maintenance.) In small shops, workers often do both body repairing and painting. A few body repairers specialize in repairing fiberglass car bodies.

The advent of assembly-line repairs in large shops enables the establishment to move away from the one-vehicle, one-repairer

method to a team approach and allows body repairers to specialize in one type of repair, such as straightening frames or repairing doors and fenders. Some body repairers specialize in installing and repairing glass in automobiles and other vehicles. *Automotive glass installers and repairers* remove broken, cracked, or pitted windshields and window glass. Glass installers apply a moisture-proofing compound along the edges of the glass, place the glass in the vehicle, and install rubber strips around the sides of the windshield or window to make it secure and weatherproof.

Body repair work has variety and challenges: each damaged vehicle presents a different problem. Using their broad knowledge of automotive construction and repair techniques, repairers must develop appropriate methods for each job. They usually work alone, with only general directions from supervisors. In some shops, helpers or apprentices assist experienced repairers.

Working Conditions

Most automotive body repairers work a standard 40-hour week, although some, including the self-employed, work more than 40 hours a week. Repairers work indoors in body shops that are noisy with the clatters of hammers against metal and the whine of power tools. Most shops are well ventilated, in order to disperse dust and paint fumes. Body repairers often work in awkward or cramped positions, and much of their work is strenuous and dirty. Hazards include cuts from sharp metal edges, burns from torches and heated metal, injuries from power tools, and fumes from paint. However, serious accidents usually are avoided when the shop is kept clean and orderly and when safety practices are observed.

Employment

Automotive body and related repairers held about 220,000 jobs in 2002; about 1 in 10 specialized in automotive glass installation and repair. Most repairers worked for automotive repair and maintenance shops or automobile dealers. Others worked for organizations that maintain their own motor vehicles, such as trucking companies. A small number worked for wholesalers of motor vehicles, parts, and supplies. More than 1 automotive body repairer in 10 was self-employed, almost twice the proportion for all installation, maintenance, and repair occupations.

Training, Other Qualifications, and Advancement

Most employers prefer to hire persons who have completed formal training programs in automotive body repair, but these programs supply only a portion of employers' needs. Therefore, most new



Automotive body repairers use their broad knowledge of automotive construction and repair techniques.

repairers receive primarily on-the-job training, supplemented, when available, with short-term training sessions given by vehicle, parts, and equipment manufacturers. Some degree of training is necessary because advances in technology have greatly changed the structure, components, and materials used in automobiles. As a result, proficiency in new repair techniques is necessary. For example, bodies of many newer automobiles are a combination of materials—traditional steel, aluminum, and a growing variety of metal alloys and plastics. Each of these materials or composites requires the use of somewhat different techniques to reshape parts and smooth out dents and small pits. Many high schools, vocational schools, private trade schools, and community colleges offer automotive body repair training as part of their automotive service programs.

A fully skilled automotive body repairer must have good reading ability and basic mathematics and computer skills. Restoring unibody automobiles to their original form requires body repairers to follow instructions and diagrams in technical manuals in order to make precise three-dimensional measurements of the position of one body section relative to another.

A new repairer begins by assisting experienced body repairers in tasks such as removing damaged parts, sanding body panels, and installing repaired parts. Novices learn to remove small dents and to make other minor repairs. They then progress to more difficult tasks, such as straightening body parts and returning them to their correct alignment. Generally, to become skilled in all aspects of body repair requires 3 to 4 years of on-the-job training.

Certification by the National Institute for Automotive Service Excellence (ASE), although voluntary, is the recognized standard of achievement for automotive body repairers. ASE offers a series of four exams for collision repair professionals twice a year. Repairers may take from one to four ASE Master Collision Repair and Refinish Exams. Repairers who pass at least one exam and have 2 years of hands-on work experience earn ASE certification. The completion of a postsecondary program in automotive body repair may be substituted for 1 year of work experience. Those who pass all four exams become ASE Master Collision Repair and Refinish Technicians. Automotive body repairers must retake the examination at least every 5 years to retain their certification.

Continuing education is required throughout a career in automotive body repair. Automotive parts, body materials, and electronics continue to change and to become more complex and technologically advanced. To keep up with the technological advances, repairers must continue to gain new skills, read technical manuals, and attend seminars and classes.

As beginners increase their skills, learn new techniques, and complete work more rapidly, their pay increases. An experienced automotive body repairer with supervisory ability may advance to shop supervisor. Some workers open their own body repair shops. Others become automobile damage appraisers for insurance companies.

Job Outlook

Employment of automotive body repairers is expected to increase about as fast as the average for all occupations through the year 2012. The need to replace experienced repairers who transfer to other occupations or who retire or stop working for other reasons will account for the majority of job openings. Opportunities should be best for persons with formal training in automotive body repair and mechanics.

Demand for qualified body repairers will increase as the number of motor vehicles in operation continues to grow in line with the Nation's population. With each rise in the number of motor vehicles in use, the number of vehicles damaged in accidents also will grow. New automobile designs increasingly have body parts made

of steel alloys, aluminum, and plastics—materials that are more difficult to work with than are traditional steel body parts. In addition, new automotive designs of lighter weight are prone to greater collision damage than are older, heavier designs and, consequently, more time is consumed in repair.

However, increasing demand due to growth in the number of vehicles in operation will be somewhat tempered by improvements in the quality of vehicles and technological innovations that enhance safety and reduce the likelihood of accidents. Employment growth also will be limited by changes in body shop management that will increase productivity, reduce overhead expenses, and improve standardization. Larger shops will employ a team approach to repairs to decrease repair time and expand their volume of work. Insurers are increasingly looking to shop networks for repair services. In addition, demand for repair services will grow slowly as more vehicles are declared a total loss after accidents. In many such cases, the vehicles are not repaired because of the high cost of fixing the extensive damage that results when airbags deploy and of replacing the increasingly complex parts and electronic components of new vehicles.

Employment growth will continue to be concentrated in automotive repair and maintenance shops and automobile dealers. The automotive repair business is not very sensitive to changes in economic conditions, and experienced body repairers are rarely laid off. However, although major body damage must be repaired if a vehicle is to be restored to safe operating condition, repair of minor dents and crumpled fenders often can be deferred during an economic slowdown. In times of economic contractions, most employers will hire few new workers, some unprofitable body shops may go out of business, and some dealers might consolidate body shops.

Earnings

Median hourly earnings of automotive body and related repairers, including incentive pay, were \$15.71 in 2002. The middle 50 percent earned between \$11.64 and \$20.94 an hour. The lowest 10 percent earned less than \$8.70, and the highest 10 percent earned more than \$27.10 an hour. In 2002, median hourly earnings of automotive body and related repairers were \$16.96 in automobile dealers and \$15.45 in automotive repair and maintenance.

Median hourly earnings of automotive glass installers and repairers, including incentive pay, were \$12.93 in 2002. The middle 50 percent earned between \$9.90 and \$16.58 an hour. The lowest 10 percent earned less than \$7.91, and the highest 10 percent earned more than \$20.24 an hour. Median hourly earnings in 2002 in automotive repair and maintenance shops, the industry employing the largest number of automotive glass installers and repairers, were \$12.86.

The majority of body repairers employed by automotive dealers and repair shops are paid on an incentive basis. Under this method, body repairers are paid a predetermined amount for various tasks, and earnings depend on the amount of work assigned to the repairer and how fast it is completed. Employers frequently guarantee workers a minimum weekly salary. Body repairers who work for trucking companies, buslines, and other organizations that maintain their own vehicles usually receive an hourly wage.

Helpers and trainees typically earn from 30 percent to 60 percent of the earnings of skilled workers. Helpers and trainees usually receive an hourly rate, until they are skilled enough to be paid on an incentive basis.

Related Occupations

Repairing damaged motor vehicles often involves working on mechanical components, as well as vehicle bodies. Automotive body repairers often work closely with individuals in several related occupations, including automotive service technicians and mechanics, diesel service technicians and mechanics, auto damage insurance appraisers, and painting and coating workers, except construction and maintenance.

Sources of Additional Information

Additional details about work opportunities may be obtained from automotive body repair shops, automobile dealers, locals of the unions previously mentioned, or local offices of your State employment service. State employment services also are a source of information about training programs.

For general information about automotive body repairer careers, write to any of the following sources:

- ▶ Automotive Service Association, P.O. Box 929, Bedford, Texas 76095-0929. Internet: <http://www.asashop.org>
- ▶ National Automobile Dealers Association, 8400 Westpark Dr., McLean, VA 22102. Internet: <http://www.nada.org>
- ▶ Inter-Industry Conference On Auto Collision Repair Education Foundation (I-CAR), 3701 Algonquin Rd., Suite 400, Rolling Meadow, IL 60008. Telephone (tollfree): 800-422-7872.

For information on how to become a certified automotive body repairer, write to:

- ▶ National Institute for Automotive Service Excellence (ASE), 101 Blue Seal Dr. SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.asecert.org>

For a directory of certified automotive body repairer programs, contact:

- ▶ National Automotive Technician Education Foundation, 101 Blue Seal Dr., SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.natef.org>

For a directory of accredited private trade and technical schools that offer training programs in automotive body repair, contact:

- ▶ Accrediting Commission of Career Schools and Colleges of Technology, 2101 Wilson Blvd., Suite 302, Arlington, VA 22201. Internet: <http://www.accsct.org>

For a list of public automotive body repair training programs, contact:

- ▶ SkillsUSA-VICA, P.O. Box 3000, Leesburg, VA 20177-0300. Internet: <http://www.skillsusa.org>

Automotive Service Technicians and Mechanics

(0*NET 49-3023.01, 49-3023.02)

Significant Points

- Formal automotive technician training is the best preparation for these challenging technology-based jobs.
- Opportunities should be very good for automotive service technicians and mechanics with diagnostic and problem-solving skills and knowledge of electronics and mathematics.
- Automotive service technicians and mechanics must continually adapt to changing technology and repair techniques as vehicle components and systems become increasingly sophisticated.

Nature of the Work

Anyone whose car or light truck has broken down knows the importance of the jobs of automotive service technicians and mechanics. The ability to diagnose the source of a problem quickly and accurately requires good reasoning ability and a thorough knowledge of automobiles. Many technicians consider diagnosing hard-to-find troubles one of their most challenging and satisfying duties.

The work of automotive service technicians and mechanics has evolved from mechanical repair to a high technology job. Today, integrated electronic systems and complex computers run vehicles and measure their performance while on the road. Technicians must have an increasingly broad base of knowledge about how vehicles' complex components work and interact, as well as the ability to work with electronic diagnostic equipment and computer-based technical reference materials.

Automotive service technicians and mechanics use their high-tech skills to inspect, maintain, and repair automobiles and light trucks that have gasoline engines. The increasing sophistication of automotive technology now requires workers who can use computerized shop equipment and work with electronic components while maintaining their skills with traditional handtools. (Service technicians and mechanics who work on diesel-powered trucks, buses, and equipment are discussed in the *Handbook* statement on diesel service technicians and mechanics. Motorcycle mechanics—who repair and service motorcycles, motor scooters, mopeds, and, occasionally, small all-terrain vehicles—are discussed in the *Handbook* statement on small engine mechanics.)

When mechanical or electrical troubles occur, technicians first get a description of the symptoms from the owner or, if they work in a large shop, the repair service estimator who wrote the repair order. To locate the problem, technicians use a diagnostic approach. First, they test to see whether components and systems are proper and secure. Then, they isolate the components or systems that could not logically be the cause of the problem. For example, if an air-conditioner malfunctions, the technician's diagnostic approach can pinpoint a problem as simple as a low coolant level or as complex as a bad drive-train connection that has shorted out the air conditioner. Technicians may have to test drive the vehicle or use a variety of testing equipment, such as onboard and hand-held diagnostic computers or compression gauges, to identify the source of the problem. These tests may indicate whether a component is salvageable or whether a new one is required to get the vehicle back in working order.

During routine service inspections, technicians test and lubricate engines and other major components. In some cases, the technician may repair or replace worn parts before they cause breakdowns that could damage critical components of the vehicle. Technicians usually follow a checklist to ensure that they examine every critical part. Belts, hoses, plugs, brake and fuel systems, and other potentially troublesome items are among those closely watched.

Service technicians use a variety of tools in their work—power tools, such as pneumatic wrenches to remove bolts quickly; machine tools like lathes and grinding machines to rebuild brakes; welding and flame-cutting equipment to remove and repair exhaust systems, and jacks and hoists to lift cars and engines. They also use common handtools, such as screwdrivers, pliers, and wrenches, to work on small parts and in hard-to-reach places.

In modern repair shops, service technicians compare the readouts from diagnostic testing devices with the benchmarked standards given by the manufacturer of the components being tested. Deviations outside of acceptable levels are an indication to the technician that further attention to an area is necessary. The testing devices diagnose problems and make precision adjustments with calculations downloaded from large computerized databases. The computerized systems provide automatic updates to technical manuals and unlimited access to manufacturers' service information, technical service bulletins, and other databases that allow technicians to keep current on problem spots and to learn new procedures.

Automotive service technicians in large shops have increasingly become specialized. For example, *transmission technicians and rebuilders* work on gear trains, couplings, hydraulic pumps, and other parts of transmissions. Extensive knowledge of computer controls, the ability to diagnose electrical and hydraulic problems, and other specialized skills are needed to work on these complex components, which employ some of the most sophisticated technology used in vehicles. *Tuneup technicians* adjust the ignition timing and valves, and adjust or replace spark plugs and other parts to ensure efficient engine performance. They often use electronic testing equipment to isolate and adjust malfunctions in fuel, ignition, and emissions control systems.

Automotive air-conditioning repairers install and repair air-conditioners and service their components, such as compressors, condensers, and controls. These workers require special training in Federal and State regulations governing the handling and disposal of refrigerants. *Front-end mechanics* align and balance wheels and repair steering mechanisms and suspension systems. They frequently



Automotive service technicians work with computerized equipment and electronic components.

use special alignment equipment and wheel-balancing machines. *Brake repairers* adjust brakes, replace brake linings and pads, and make other repairs on brake systems. Some technicians and mechanics specialize in both brake and front-end work.

Working Conditions

About half of automotive service technicians work a standard 40-hour week, but almost 30 percent work more than 40 hours a week. Many of those working extended hours are self-employed technicians. To satisfy customer service needs, some service shops offer evening and weekend service. Generally, service technicians work indoors in well-ventilated and -lighted repair shops. However, some shops are drafty and noisy. Although they fix some problems with simple computerized adjustments, technicians frequently work with dirty and greasy parts, and in awkward positions. They often lift heavy parts and tools. Minor cuts, burns, and bruises are common, but technicians usually avoid serious accidents when the shop is kept clean and orderly and safety practices are observed.

Employment

Automotive service technicians and mechanics held about 818,000 jobs in 2002. The majority worked for automotive repair and maintenance shops, automobile dealers, and retailers and wholesalers of automotive parts, accessories, and supplies. Others found employment in gasoline stations; home and auto supply stores; automotive equipment rental and leasing companies; Federal, State, and local governments; and other organizations. About 16 percent of service technicians were self-employed, more than twice the proportion for all installation, maintenance, and repair occupations.

Training, Other Qualifications, and Advancement

Automotive technology is rapidly increasing in sophistication, and most training authorities strongly recommend that persons seeking automotive service technician and mechanic jobs complete a formal training program in high school or in a postsecondary vocational school. However, some service technicians still learn the trade solely by assisting and learning from experienced workers.

Many high schools, community colleges, and public and private vocational and technical schools offer automotive service technician training programs. The traditional postsecondary programs usually provide a thorough career preparation that expands upon the student's high school repair experience.

Postsecondary automotive technician training programs vary greatly in format, but normally provide intensive career preparation through a combination of classroom instruction and hands-on practice. Some trade and technical school programs provide concentrated training for 6 months to a year, depending on how many hours the student attends each week. Community college programs normally spread the training over 2 years; supplement the automotive training with instruction in English, basic mathematics, computers, and other subjects; and award an associate degree or certificate. Some students earn repair certificates and opt to leave the program to begin their career before graduation. Recently, some programs have added to their curriculums training on employability skills such as customer service and stress management. Employers find that these skills help technicians handle the additional responsibilities of dealing with the customers and parts vendors.

High school programs, while an asset, vary greatly in quality. The better programs, such as the Automotive Youth Education Service (AYES), with about 150 participating schools and more than 300 participating dealers, conclude with the students receiving their technician's certification and high school diploma. Other programs offer only an introduction to automotive technology and service for

the future consumer or hobbyist. Still others aim to equip graduates with enough skills to get a job as a mechanic's helper or trainee mechanic.

The various automobile manufacturers and their participating dealers sponsor 2-year associate degree programs at postsecondary schools across the Nation. The Accrediting Commission of Career Schools and Colleges of Technology (ACCSCT) currently certifies a number of automotive and diesel technology schools. Schools update their curriculums frequently to reflect changing technology and equipment. Students in these programs typically spend alternate 6- to 12-week periods attending classes full time and working full time in the service departments of sponsoring dealers. At these dealerships, students get practical experience while assigned to an experienced worker who provides hands-on instruction and time-saving tips.

The National Automotive Technicians Education Foundation (NATEF), an affiliate of the National Institute for Automotive Service Excellence (ASE), establishes the standards by which training facilities become certified. Once the training facility achieves these minimal standards, NATEF recommends the facility to ASE for certification. The ASE certification is a nationally recognized standard for programs offered by high schools, postsecondary trade schools, technical institutes, and community colleges that train automobile service technicians. Automotive manufacturers provide ASE certified instruction, service equipment, and current-model cars on which students practice new skills and learn the latest automotive technology. While ASE certification is voluntary, it does signify that the program meets uniform standards for instructional facilities, equipment, staff credentials, and curriculum. To ensure that programs keep up with ever-changing technology, repair techniques, and ASE standards, the certified programs are subjected to periodic compliance reviews and mandatory recertification. NATEF program experts also review and update program standards to match the level of training and skill-level achievement necessary for success in the occupation. In 2002, about 1,200 high school and postsecondary automotive service technician training programs had been certified by ASE.

For trainee automotive service technician jobs, employers look for people with strong communication and analytical skills. Technicians need good reading, mathematics, and computer skills to study technical manuals and to keep abreast of new technology and learn new service and repair procedures and specifications. Trainees also must possess mechanical aptitude and knowledge of how automobiles work. Most employers regard the successful completion of a vocational training program in automotive service technology as the best preparation for trainee positions. Experience working on motor vehicles in the Armed Forces or as a hobby also is valuable. Because of the complexity of new vehicles, a growing number of employers require completion of high school and additional postsecondary training. Courses in automotive repair, electronics, physics, chemistry, English, computers, and mathematics provide a good educational background for a career as a service technician.

Many new cars have several onboard computers, operating everything from the engine to the radio. Some of the more advanced vehicles have global positioning systems, Internet access, and other high-tech features integrated into the functions of the vehicle. Therefore, knowledge of electronics and computers has grown increasingly important for service technicians. Engine controls and dashboard instruments were among the first components to use electronics but, now, everything from brakes to transmissions and air-conditioning systems to steering systems is run primarily by computers and electronic components. In the past, a specialist usually

handled any problems involving electrical systems or electronics. Now that electronics are so common, it is essential for service technicians to be familiar with at least the basic principles of electronics. Electrical components or a series of related components account for nearly all malfunctions in modern vehicles.

In addition to electronics and computers, automotive service technicians will have to learn and understand the science behind the alternate-fuel vehicles that have begun to enter the market. The fuel for these vehicles will come from the dehydrogenization of water, electric fuel cells, natural gas, solar power, and other nonpetroleum-based sources. Some vehicles will even capture the energy from brakes and use it as fuel. As vehicles with these new technologies become more common, technicians will need additional training to learn the science and engineering that makes them possible.

Beginners usually start as trainee technicians, mechanics' helpers, lubrication workers, or gasoline service station attendants, and gradually acquire and practice their skills by working with experienced mechanics and technicians. With a few months' experience, beginners perform many routine service tasks and make simple repairs. It usually takes 2 to 5 years of experience to become a journey-level service technician, who is expected to quickly perform the more difficult types of routine service and repairs. However, some graduates of postsecondary automotive training programs are often able to earn promotion to the journey level after only a few months on the job. An additional 1 to 2 years of experience familiarizes mechanics and technicians with all types of repairs. Difficult specialties, such as transmission repair, require another year or two of training and experience. In contrast, brake specialists may learn their jobs in considerably less time because they do not need a complete knowledge of automotive repair.

In the past, many persons became automotive service technicians through 3- or 4-year formal apprenticeship programs. However, apprenticeships have become rare, as formal vocational training programs in automotive service technology have become more common.

At work, the most important possessions of technicians and mechanics are their handtools. Technicians and mechanics usually provide their own tools, and many experienced workers have thousands of dollars invested in them. Employers typically furnish expensive power tools, engine analyzers, and other diagnostic equipment, but technicians accumulate handtools with experience. Some formal training programs have alliances with tool manufacturers that help entry-level technicians accumulate tools during their training period.

Employers increasingly send experienced automotive service technicians to manufacturer training centers to learn to repair new models or to receive special training in the repair of components, such as electronic fuel injection or air-conditioners. Motor vehicle dealers also may send promising beginners to manufacturer-sponsored mechanic training programs. Employers typically furnish this additional training to maintain or upgrade employees' skills and thus increase the employees' value to the dealership. Factory representatives also visit many shops to conduct short training sessions.

Voluntary certification by the National Institute for Automotive Service Excellence (ASE) has become a standard credential for automotive service technicians. Certification is available in 1 or more of 8 different service areas, such as electrical systems, engine repair, brake systems, suspension and steering, and heating and air-conditioning. For certification in each area, technicians must have at least 2 years of experience and pass a written examination. Completion of an automotive training program in high school, vo-

ational or trade school, or community or junior college may be substituted for 1 year of experience. In some cases, graduates of ASE-certified programs achieve certification in up to three specialties. For certification as a master automotive mechanic, technicians must be certified in all eight areas. Mechanics and technicians must retake each examination at least once every 5 years to maintain their certifications.

Experienced technicians who have leadership ability sometimes advance to shop supervisor or service manager. Those who work well with customers may become automotive repair service estimators. Some with sufficient funds open independent repair shops.

Job Outlook

Job opportunities in this occupation are expected to be very good for persons who complete automotive training programs in high school, vocational and technical schools, or community colleges. Persons with good diagnostic and problem-solving skills, and whose training includes basic electronics skills, should have the best opportunities. For well-prepared people with a technical background, automotive service technician careers offer an excellent opportunity for good pay and the satisfaction of highly skilled work with vehicles incorporating the latest in high technology. However, persons without formal automotive training are likely to face competition for entry-level jobs.

Employment of automotive service technicians and mechanics is expected to increase about as fast as the average through the year 2012. Over the 2002-12 period, population growth will boost demand for motor vehicles, which will require regular maintenance and service. Growth of the labor force and in the number of families in which both spouses need vehicles to commute to work will contribute to increased vehicle sales and employment in this industry. As personal incomes continue to rise, greater numbers of persons will be able to afford the luxury of owning multiple vehicles, which also should increase the number of passenger cars in operation. However, a slowdown in the growth of the driving-age population, as the smaller post-baby boom generation comes of age, may curb demand for cars and trucks. In addition, increasing demand due to growth in the number of vehicles in operation will be partially offset by improvements in vehicle quality and durability that improve reliability and reduce the need for extensive repair and maintenance.

Employment growth will continue to be concentrated in automobile dealerships and independent automotive repair shops. Many new jobs also will be created in small retail operations that offer after-warranty repairs, such as oil changes, brake repair, air-conditioner service, and other minor repairs generally taking less than 4 hours to complete. Employment of automotive service technicians and mechanics in gasoline service stations will continue to decline, as fewer stations offer repair services.

In addition to job openings due to growth, a substantial number of openings will be created by the need to replace experienced technicians who transfer to other occupations or who retire or stop working for other reasons. Most persons who enter the occupation can expect steady work, because changes in general economic conditions and developments in other industries have little effect on the automotive repair business.

Earnings

Median hourly earnings of automotive service technicians and mechanics, including commission, were \$14.71 in 2002. The middle 50 percent earned between \$10.61 and \$19.84. The lowest 10 percent earned less than \$8.14, and the highest 10 percent earned more

than \$25.21. Median annual earnings in the industries employing the largest numbers of service technicians in 2002 were as follows:

Local government	\$18.04
Automobile dealers	17.66
Gasoline stations	13.04
Automotive repair and maintenance	12.77
Automotive parts, accessories, and tire stores	12.60

Many experienced technicians employed by automobile dealers and independent repair shops receive a commission related to the labor cost charged to the customer. Under this method, weekly earnings depend on the amount of work completed. Employers frequently guarantee commissioned mechanics and technicians a minimum weekly salary.

Some automotive service technicians are members of labor unions such as the International Association of Machinists and Aerospace Workers; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the Sheet Metal Workers' International Association; and the International Brotherhood of Teamsters.

Related Occupations

Other workers who repair and service motor vehicles include automotive body and related repairers, diesel service technicians and mechanics, and small engine mechanics.

Sources of Additional Information

For more details about work opportunities, contact local automobile dealers and repair shops or local offices of the State employment service. The State employment service also may have information about training programs.

A list of certified automotive service technician training programs can be obtained from:

► National Automotive Technicians Education Foundation, 101 Blue Seal Dr., SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.natef.org>

For a directory of accredited private trade and technical schools that offer programs in automotive service technician training, contact:

► Accrediting Commission of Career Schools and Colleges of Technology, 2101 Wilson Blvd., Suite 302, Arlington, VA 22201 Internet: <http://www.accscet.org>

For a list of public automotive service technician training programs, contact:

► SkillsUSA-VICA, P.O. Box 3000, Leesburg, VA 20177-0300. Internet: <http://www.skillsusa.org>

Information on automobile manufacturer-sponsored programs in automotive service technology can be obtained from:

► Automotive Youth Educational Systems (AYES), 50 W. Big Beaver, Suite 145, Troy, MI 48084. Internet: <http://www.ayes.org>

Information on how to become a certified automotive service technician is available from:

► National Institute for Automotive Service Excellence (ASE), 101 Blue Seal Dr. SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.asecert.org>

For general information about a career as an automotive service technician, contact:

► National Automobile Dealers Association, 8400 Westpark Dr., McLean, VA 22102. Internet: <http://www.nada.org>

► Automotive Retailing Today, 8400 Westpark Dr., MS #2, McLean, VA 22102. Internet: <http://www.autoretailing.org>

Coin, Vending, and Amusement Machine Servicers and Repairers

(0*NET 49-9091.00)

Significant Points

- Most workers in this occupation learn their skills on the job.
- Opportunities should be especially good for persons with some knowledge of electronics.

Nature of the Work

Coin, vending, and amusement machines are a familiar sight in offices, convenience stores, arcades, and casinos. These coin-operated machines give out change, dispense refreshments, test our gaming skills, and spit out lottery tickets nearly everywhere we turn. Coin, vending, and amusement machine servicers and repairers install, service, and stock such machines and keep them in good working order.

Vending machine servicers, often called route drivers, visit machines that dispense soft drinks, candy and snacks, and other items. They collect money from the machines, restock merchandise, and change labels to indicate new selections. They also keep the machines clean and appealing.

Vending machine repairers, often called mechanics or technicians, make sure that the machines operate correctly. When checking complicated electrical and electronic machines, such as beverage dispensers, they ascertain whether the machines mix drinks properly and whether the refrigeration and heating units work correctly. If the machines are not in good working order, the mechanics repair them. On the relatively simple gravity-operated machines, repairers check the keypads, motors, and merchandise chutes. They also test coin, bill, and change-making mechanisms.

When installing machines, vending machine repairers make the necessary water and electrical connections and check the machines for proper operation. They also make sure that the installation complies with local plumbing and electrical codes. Because many vending machines dispense food, these workers, along with vending machine servicers, must comply with State and local public health and sanitation standards.

Amusement machine servicers and repairers work on jukeboxes, video games, pinball machines, and slot machines. They make sure that the various levers, joysticks, and mechanisms function properly, so that the games remain fair and the jukebox selections are accurate. They update selections, repair or replace malfunctioning parts, and rebuild existing equipment. Those who work in the gaming industry must adhere to strict guidelines, because Federal and State agencies regulate many gaming machines.

Preventive maintenance—avoiding trouble before it starts—is a major job of repairers. For example, they periodically clean refrigeration condensers, lubricate mechanical parts, and adjust machines so that they perform properly.

If a machine breaks down, vending and amusement machine repairers inspect it for obvious problems, such as loose electrical wires, malfunctions of the coin mechanism or bill validator, and leaks. When servicing electronic machines, repairers test them with hand-held diagnostic computers that determine the extent and location of any problem. Repairers may only have to replace a circuit board or other component to fix the problem. However, if the problem cannot be readily located, these workers refer to technical manuals and

wiring diagrams and use testing devices, such as electrical circuit testers, to find defective parts. Repairers decide whether they must replace a part and whether they can fix the malfunction onsite or whether they have to send the machine to the repair shop.

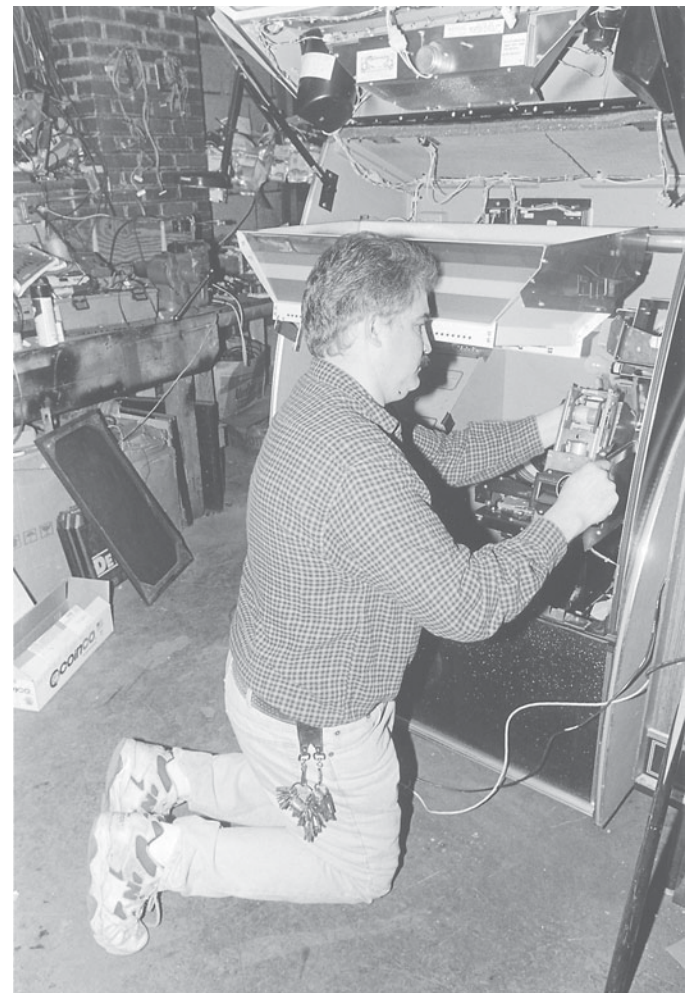
In the repair shop, vending and amusement machine repairers use power tools, such as grinding wheels, saws, and drills, as well as voltmeters, ohmmeters, oscilloscopes, and other testing equipment. They also use ordinary repair tools, such as screwdrivers, pliers, and wrenches.

Vending machine servicers and repairers employed by small companies may both fill and fix machines on a regular basis. These combination servicers-repairers stock machines, collect money, fill coin and currency changers, and repair machines when necessary.

Servicers and repairers also do some paperwork, such as filing reports, preparing repair cost estimates, ordering parts, and keeping daily records of merchandise distributed and money collected. However, new machines with computerized inventory controls reduce the paperwork that a servicer must complete.

Working Conditions

Some vending and amusement machine repairers work primarily in company repair shops, but many spend substantial time on the road,



When servicing electronic machines, repairers use hand-held diagnostic computers to determine the extent and location of any problem.

visiting machines wherever they have been placed. Repairers generally work a total of 40 hours a week. However, vending and amusement machines operate around the clock, so repairers may be on call to work at night and on weekends and holidays.

Vending and amusement machine repair shops generally are quiet, are well lighted, and have adequate workspace. However, when machines are serviced on location, the work may be done where pedestrian traffic is heavy, such as in busy supermarkets, industrial complexes, offices, casinos, or arcades. Repair work is relatively safe, although servicers and repairers must take care to avoid hazards such as electrical shocks and cuts from sharp tools and other metal objects. They also must follow safe work procedures, especially when moving heavy vending and amusement machines.

Employment

Coin, vending, and amusement machine servicers and repairers held about 43,000 jobs in 2002. Most repairers work for vending machine operators that sell food and other items through machines. Others work for beverage manufacturing companies that have their own coin-operated machines. A growing number of servicers and repairers work for amusement, gambling, and recreation establishments that own video games, pinball machines, jukeboxes, slot machines, and similar types of amusement equipment. Although vending and amusement machine servicers and repairers are employed throughout the country, most are located in areas with large populations and, thus, many vending and amusement machines.

Training, Other Qualifications, and Advancement

Most workers learn their skills on the job. New workers are trained informally on the job to fill and fix machines by observing, working with, and receiving instruction from experienced repairers. Employers normally prefer to hire high school graduates; high school or vocational school courses in electricity, refrigeration, and machine repair are an advantage in qualifying for entry-level jobs. Employers usually require applicants to demonstrate mechanical ability, either through work experience or by scoring well on mechanical-aptitude tests.

Because coin, vending, and amusement machine servicers and repairers sometimes handle thousands of dollars in merchandise and cash, employers hire persons who seem to have a record of honesty. Also, the ability to deal tactfully with people is important, because the servicers and repairers play a significant role in relaying customers' requests and concerns. A driver's license and a good driving record are essential for most vending and amusement machine servicer and repairer jobs. Some employers require their servicers to be bonded.

As electronics become more prevalent in vending and amusement machines, employers will increasingly prefer applicants who have some training in electronics. Technologically advanced machines with features such as multilevel pricing, inventory control, and scrolling messages use electronics and microchip computers extensively. Some vocational high schools and junior colleges offer 1- to 2-year training programs in basic electronics.

Beginners start training with simple jobs, such as cleaning or stocking machines. They then learn to rebuild machines by removing defective parts and repairing, adjusting, and testing the machines. Next, they accompany an experienced repairer on service calls and, finally, make visits on their own. This learning process takes from 6 months to 2 years, depending on the individual's abilities, previous education, types of machines serviced, and quality of instruction.

The National Automatic Merchandising Association has a self-study technician training program for vending machine repairers. Manuals give instruction in subjects such as customer relations, safety, electronics, and reading schematics. Upon completion of the program, repairers must pass a written test to become certified as a technician or journeyman.

To learn about new machines, repairers and servicers sometimes attend training sessions sponsored by manufacturers and distributors that may last from a few days to several weeks. Both trainees and experienced workers sometimes take evening courses in basic electricity, electronics, microwave ovens, refrigeration, and other related subjects to stay on top of new techniques and equipment. Skilled servicers and repairers may be promoted to supervisory jobs or go into business for themselves.

Job Outlook

Employment of coin, vending, and amusement machine servicers and repairers is expected to grow about as fast as the average for all occupations through the year 2012, primarily because of the increasing number of vending and amusement machines in operation. Job openings for coin, vending, and amusement machine servicers and repairers will arise from employment growth and from the need to replace experienced workers who transfer to other occupations or leave the labor force.

Establishments are likely to install additional vending machines in industrial plants, hospitals, stores, and schools to meet the public demand for inexpensive snacks and other food items. Also, there is an increased need for vending machines in businesses with few employees. The range of products dispensed by the machines is expected to increase, as vending machines continue to become increasingly automated and begin to incorporate microwave ovens, minirefrigerators, and freezers. In addition, casinos, arcades, and other amusement establishments are becoming an increasing source of entertainment. State and multi-State lotteries are increasingly using coin-operated machines to sell scratch-off tickets in grocery stores and other public places.

Opportunities should be especially good for persons with some knowledge of electronics, because electronic circuitry is an important component of vending and amusement machines. If firms cannot find trained or experienced workers for these jobs, they are likely to train qualified route drivers or hire inexperienced people who have acquired some mechanical, electrical, or electronics training by taking high school or vocational courses.

Improved technology in newer machines will moderate employment growth because these machines require maintenance less frequently than do older ones. The new machines will need repairing and restocking less often, and they contain computers that record sales and inventory data, reducing the amount of time-consuming paperwork that otherwise would have to be filled out. The Internet is beginning to play a large role in the monitoring of vending machines from remote locations. In addition, some new machines use wireless data transmitters to signal the vending machine company when the machine needs restocking or repairing. This allows servicers and repairers to be dispatched only when needed, instead of having to check each machine on a regular schedule.

Earnings

Median hourly earnings of coin, vending, and amusement machine servicers and repairers were \$13.16 in 2002. The middle 50 percent earned between \$10.31 and \$16.43 an hour. The lowest 10 percent earned less than \$8.07 an hour, and the highest 10 percent earned more than \$20.12 an hour. Median hourly earnings were

\$11.69 in vending machine operators, the industry employing the largest number of coin, vending, and amusement machine servicers and repairers in 2002.

Typically, States with some form of legalized gaming have the highest wages. Most coin, vending, and amusement machine servicers and repairers work 8 hours a day, 5 days a week, and receive premium pay for overtime. Some union contracts stipulate higher pay for night work and for emergency repair jobs on weekends and holidays than for regular hours. Some vending machine repairers and servicers are members of the International Brotherhood of Teamsters.

Related Occupations

Other workers who repair equipment with electrical and electronic components include electrical and electronics installers and repairers; electronic home-entertainment equipment installers and repairers; heating, air-conditioning, and refrigeration mechanics and installers; and home appliance repairers.

Sources of Additional Information

Information on job opportunities in this field can be obtained from local vending machine firms and local offices of your State employment service. For general information on vending machine repair, contact:

- ▶ National Automatic Merchandising Association, 20 N. Wacker Dr., Suite 3500, Chicago, IL 60606-3102. Internet: <http://www.vending.org>
- ▶ Automatic Merchandiser Vending Group, Cygnus Business Media, P.O. Box 803, 1233 Janesville Ave., Fort Atkinson, WI 53538-0803.

Computer, Automated Teller, and Office Machine Repairers

(0*NET 49-2011.01, 49-2011.02, 49-2011.03)

Significant Points

- Workers qualify for these jobs by receiving training in electronics from associate degree programs, the military, vocational schools, equipment manufacturers, or employers.
- Job growth reflects the increasing dependence of business and residential customers on computers and other sophisticated office machines.
- Job prospects will be best for applicants with knowledge of electronics, as well as repair experience; opportunities for computer repairers should be excellent, given that employers are reporting difficulty finding qualified applicants.

Nature of the Work

Computer repairers, also known as *computer service technicians* or *data-processing equipment repairers*, service mainframe, server, and personal computers; printers; and disc drives. These workers perform primarily hands-on repair, maintenance, and installation of computers and related equipment. Workers who provide technical assistance, in person or by telephone, to computer system users are known as computer support specialists or computer support technicians. (See the statement on computer support specialists and systems administrators elsewhere in the *Handbook*.)

Automated teller machines (ATMs) allow customers to carry out bank transactions without the assistance of a teller. ATMs now provide a growing variety of other services, including stamp, phone card, and ticket sales. *Automated teller machine servicers* repair and service these machines.

Office machine and cash register servicers work on photocopiers, cash registers, mail-processing equipment, and fax machines. Newer models of office machinery increasingly include computerized components that allow them to function more effectively than earlier models.

To install large equipment, such as mainframe computers and ATMs, repairers connect the equipment to power sources and communication lines that allow the transmission of information over computer networks. For example, when an ATM dispenses cash, it transmits the withdrawal information to the customer's bank. Workers also may install operating software and peripheral equipment, checking that all components are configured to function together correctly. The installation of personal computers and other small office machines is less complex and may be handled by the purchaser.

When equipment breaks down, many repairers travel to customers' workplaces or other locations to make the necessary repairs. These workers, known as *field technicians*, often have assigned areas in which they perform preventive maintenance on a regular basis. *Bench technicians* work in repair shops located in stores, factories, or service centers. In small companies, repairers may work both in repair shops and at customer locations.

Computer repairers usually replace subsystems instead of repairing them. Replacement is common because subsystems are expensive and businesses are reluctant to shut down their computers for time-consuming repairs. Subsystems commonly replaced by computer repairers include video cards, which transmit signals from

the computer to the monitor; hard drives, which store data; and network cards, which allow communication over the network. Defective modules may be given to bench technicians, who use software programs to diagnose the problem and who may repair the modules, if possible.

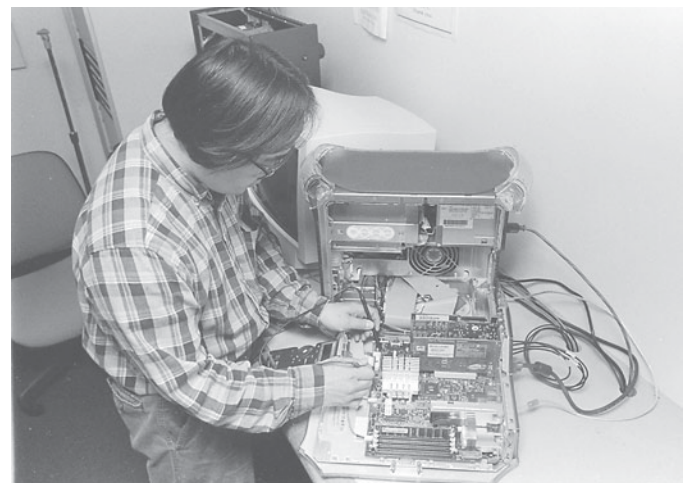
When ATMs malfunction, computer networks recognize the problem and alert repairers. Common problems include worn magnetic heads on card readers, which prevent the equipment from recognizing customers' bankcards, and "pick failures," which prevent the equipment from dispensing the correct amount of cash. Field technicians travel to the locations of ATMs and usually repair equipment by removing and replacing defective components. Broken components are brought to a repair shop, where bench technicians make the necessary repairs. Field technicians perform routine maintenance on a regular basis, replacing worn parts and running diagnostic tests to ensure that the equipment functions properly.

Office machine repairers usually work on machinery at the customer's workplace; alternatively, if the machines are small enough, customers may bring them to a repair shop for maintenance. Common malfunctions include paper misfeeds, due to worn or dirty parts, and poor-quality copy, due to problems with lamps, lenses, or mirrors. These malfunctions usually can be resolved simply by cleaning the relevant components. Breakdowns also may result from the failure of commonly used parts. For example, heavy usage of a photocopier may wear down the printhead, which applies ink to the final copy. In such cases, the repairer usually replaces the part instead of repairing it.

Workers use a variety of tools for diagnostic tests and repair. To diagnose malfunctions, they use multimeters to measure voltage, current, resistance, and other electrical properties; signal generators to provide test signals; and oscilloscopes to monitor equipment signals. To diagnose computerized equipment, repairers use software programs. To repair or adjust equipment, workers use handtools, such as pliers, screwdrivers, soldering irons, and wrenches.

Working Conditions

Repairers usually work in clean, well-lighted surroundings. Because computers and office machines are sensitive to extreme temperatures and to humidity, repair shops usually are air conditioned and well ventilated. Field repairers must travel frequently to various locations to install, maintain, or repair customers' equipment.



Computer repairers usually replace defective components, such as video and network cards, instead of repairing them.

ATM repairers may have to perform their jobs in small, confined spaces that house the equipment.

Because computers and ATMs are critical for many organizations to function efficiently, data-processing equipment repairers and ATM field technicians often work around the clock. Their schedules may include evening, weekend, and holiday shifts, sometimes assigned on the basis of seniority. Office machine and cash register servicers usually work regular business hours because the equipment they repair is not as critical.

Although their job is not strenuous, repairers must lift equipment and work in a variety of postures. Repairers of computer monitors need to discharge voltage from the equipment to avoid electrocution. Workers may have to wear protective goggles.

Employment

Computer, automated teller, and office machine repairers held about 156,000 jobs in 2002. Wholesale trade establishments employed about one-third of the workers in this occupation; most of these establishments were wholesalers of professional and commercial equipment and supplies. Many workers also were employed in electronics, appliance, and office supplies stores. Others worked in electronic and precision equipment repair shops and computer systems design firms. A small number were found in computer and peripheral equipment manufacturing, government agencies, and internet service providers. About 1 computer, automated teller, and office machine repairer in 8 was self-employed, more than twice the proportion for all installation, maintenance, and repair occupations.

Training, Other Qualifications, and Advancement

Knowledge of electronics is necessary for employment as a computer, automated teller, or office machine repairer. Employers prefer workers who are certified as repairers or who have training in electronics from associate degree programs, the military, vocational schools, or equipment manufacturers. Employers generally provide some training to new repairers on specific equipment; however, workers are expected to arrive on the job with a basic understanding of equipment repair. Employers may send experienced workers to training sessions to keep up with changes in technology and service procedures.

Most office machine and ATM repairer positions require an associate degree in electronics. A basic understanding of mechanical equipment also is important, because many of the parts that fail in office machines and ATMs are mechanical, such as paper loaders. Entry-level employees at large companies normally receive on-the-job training lasting several months. Such training may include a week of classroom instruction, followed by a period of 2 weeks to several months assisting an experienced repairer.

Field technicians work closely with customers and must have good communications skills and a neat appearance. Employers normally require that field technicians have a driver's license.

Various organizations offer certification, including ACES International, the Computing Technology Industry Association, the Electronic Technicians Association International, and the International Society of Certified Electronics Technicians. Repairers may specialize in a variety of skill areas. To receive certification, repairers must pass qualifying examinations corresponding to their level of training and experience.

Newly hired computer repairers may work on personal computers or peripheral equipment. With experience, they can advance to positions maintaining more sophisticated systems, such as networking equipment and servers. Field repairers of ATMs may advance to bench-technician positions responsible for more complex repairs. Experienced workers may become specialists who help other re-

pairers diagnose difficult problems or who work with engineers in designing equipment and developing maintenance procedures. Experienced workers also may move into management positions responsible for supervising other repairers.

Because of their familiarity with equipment, experienced repairers may move into customer service or sales positions. Some experienced workers open their own repair shops or become wholesalers or retailers of electronic equipment.

Job Outlook

Employment of computer, automated teller, and office machine repairers is expected to grow about as fast as the average for all occupations through 2012. Job growth will be driven by the increasing dependence of business and residential customers on computers and other sophisticated office machines. The need to maintain this equipment in working order will create new jobs for repairers. In addition, openings will result from the need to replace repairers who retire or transfer into new occupations.

Job prospects will be best for applicants with knowledge of electronics as well as repair experience; opportunities for computer repairers should be excellent, given that employers are reporting difficulty finding qualified applicants and that computers are increasingly being relied on. Although computer equipment continues to become less expensive and more reliable, malfunctions still occur and can cause severe problems for users, most of whom lack the knowledge to make repairs. Computers are critical to most businesses today and will become even more so to companies that do business on the Internet and to households that bank, pay bills, or make purchases online.

People also are becoming increasingly reliant on ATMs. Besides offering bank and retail transactions, ATMs provide an increasing number of other services, such as employee information processing and distribution of government payments. Improvements in ATM design have increased reliability and simplified repair tasks, reducing the number and extent of repairs. Opportunities for ATM repairers should be available, arising primarily from the need to replace workers who leave the specialty, rather than from employment growth.

Conventional office machines, such as calculators, are inexpensive, and often are replaced instead of repaired. However, digital copiers and other, newer office machines are more costly and complex. This equipment often is computerized, designed to work on a network, and able to perform multiple functions. The growing need for repairers to service such sophisticated equipment should result in job opportunities for office machine repairers.

Earnings

Median hourly earnings of computer, automated teller, and office machine repairers were \$15.98 in 2002. The middle 50 percent earned between \$12.44 and \$20.38. The lowest 10 percent earned less than \$9.99, and the highest 10 percent earned more than \$25.06. Median hourly earnings in the industries employing the largest numbers of computer, automated teller, and office machine repairers in 2002 were as follows:

Computer systems design and related services	\$17.33
Professional and commercial equipment and supplies merchant wholesalers	17.28
Office supplies, stationery, and gift stores	14.79
Electronics and appliance stores	13.89
Electronic and precision equipment repair and maintenance	13.46

Related Occupations

Workers in other occupations who repair and maintain electronic equipment include broadcast and sound engineering technicians and radio operators; electronic home entertainment equipment installers and repairers; electrical and electronics installers and repairers; industrial machinery installation, repair, and maintenance workers; and radio and telecommunications equipment installers and repairers.

Sources of Additional Information

For information on careers and certification, contact:

- ▶ ACES International, 5241 Princess Anne Rd., Suite 110, Virginia Beach, VA 23462. Internet: <http://www.acesinternational.org>
- ▶ Computing Technology Industry Association, 1815 S Meyers Rd., Suite 300, Oakbrook Terrace, IL 60181-5228. Internet: <http://www.comptia.org>
- ▶ Electronics Technicians Association International, 5 Depot St., Greencastle, IN 46135.
- ▶ International Society of Certified Electronics Technicians, 3608 Pershing Ave., Fort Worth, TX 76107-4527. Internet: <http://www.iscet.org>

Diesel Service Technicians and Mechanics

(0*NET 49-3031.00)

Significant Points

- A career as a diesel service technician or mechanic offers relatively high wages and the challenge of skilled repair work.
- Opportunities are expected to be good for persons who complete formal training programs.
- National certification is the recognized standard of achievement for diesel service technicians and mechanics.

Nature of the Work

The diesel engine is the workhorse powering the Nation's trucks and buses, because it delivers more power and is more durable than its gasoline-burning counterpart. Diesel-powered engines also are becoming more prevalent in light vehicles, including pickups and other work trucks.

Diesel service technicians and mechanics, also known as *bus and truck mechanics and diesel engine specialists*, repair and maintain the diesel engines that power transportation equipment such as heavy trucks, buses, and locomotives. Some diesel technicians and mechanics also work on heavy vehicles and mobile equipment, including bulldozers, cranes, road graders, farm tractors, and combines. A small number of technicians repair diesel-powered passenger automobiles, light trucks, or boats. (For information on technicians and mechanics working primarily on automobiles, heavy vehicles, mobile equipment, or boats, see the *Handbook* statements on automotive, heavy vehicle, and mobile equipment; and small engine service mechanics.

Technicians who work for organizations that maintain their own vehicles spend most of their time doing preventive maintenance, to ensure that equipment will operate safely. These workers also eliminate unnecessary wear on, and damage to, parts that could result in costly breakdowns. During a routine maintenance check on a vehicle, technicians follow a checklist that includes inspecting brake systems, steering mechanisms, wheel bearings, and other important parts. Following inspection, technicians repair or adjust parts that do not work properly or remove and replace parts that cannot be fixed.

Increasingly, technicians must be flexible, in order to adapt to customers' needs and new technologies. It is common for technicians to handle all kinds of repairs, from working on a vehicle's electrical system one day to doing major engine repairs the next. Diesel maintenance is becoming increasingly complex, as more electronic components are used to control the operation of an engine. For example, microprocessors now regulate and manage fuel timing, increasing the engine's efficiency. In modern shops, diesel service technicians use hand-held computers to diagnose problems and adjust engine functions. Technicians must continually learn about new techniques and advanced materials.

Diesel service technicians use a variety of tools in their work, including power tools, such as pneumatic wrenches, to remove bolts quickly; machine tools, such as lathes and grinding machines, to rebuild brakes; welding and flame-cutting equipment, to remove and repair exhaust systems; and jacks and hoists, to lift and move large parts. Common handtools—screwdrivers, pliers, and wrenches—are used to work on small parts and get at hard-to-reach

places. Diesel service technicians and mechanics also use a variety of computerized testing equipment to pinpoint and analyze malfunctions in electrical systems and engines.

In large shops, technicians generally receive their assignments from shop supervisors or service managers. Most supervisors and managers are experienced technicians who also assist in diagnosing problems and maintaining quality standards. Technicians may work as a team or be assisted by an apprentice or helper when doing heavy work, such as removing engines and transmissions.

Working Conditions

Diesel technicians usually work indoors, although they occasionally make repairs to vehicles on the road. Diesel technicians may lift heavy parts and tools, handle greasy and dirty parts, and stand or lie in awkward positions to repair vehicles and equipment. Minor cuts, burns, and bruises are common, although serious accidents can usually be avoided if the shop is kept clean and orderly and if safety procedures are followed. Technicians normally work in well-lighted, heated, and ventilated areas; however, some shops are drafty and noisy. Many employers provide lockers and shower facilities.

Employment

Diesel service technicians and mechanics held about 267,000 jobs in 2002. About 20 percent serviced buses, trucks, and other diesel-powered equipment for customers of automotive repair and maintenance shops, motor vehicle and parts wholesalers, or automotive equipment rental and leasing agencies. About 19 percent maintained the buses, trucks, and other equipment of buslines, public transit companies, school systems, or State and local governments, and another 17 percent worked for freight trucking companies. The remaining technicians maintained vehicles and other equipment for manufacturing, construction, or other companies. A relatively small number were self-employed. Nearly every section of the country employs diesel service technicians and mechanics, although most work in towns and cities where trucking companies, buslines, and other fleet owners have large operations.

Training, Other Qualifications, and Advancement

Although many persons qualify for diesel service technician and mechanic jobs through years of on-the-job training, authorities recommend the completion of a formal diesel engine training program. Employers prefer to hire graduates of formal training programs be-



Diesel service technicians use a variety of testing equipment to pinpoint and analyze malfunctions in electrical systems and engines.

cause those workers often have a head start in training and are able to advance quickly to the journey level.

Many community colleges and trade and vocational schools offer programs in diesel repair. These programs, lasting 6 months to 2 years, lead to a certificate of completion or an associate degree. Programs vary in the degree of hands-on training they provide on equipment. Some offer about 30 hours per week on equipment, whereas others offer more lab or classroom instruction. Training provides a foundation in the latest diesel technology and instruction in the service and repair of the vehicles and equipment that technicians will encounter on the job. Training programs also improve the skills needed to interpret technical manuals and to communicate with coworkers and customers. In addition to the hands-on aspects of the training, many institutions teach communication skills, customer service, basic understanding of physics, and logical thought. Increasingly, employers work closely with representatives of training programs, providing instructors with the latest equipment, techniques, and tools and offering jobs to graduates.

Whereas most employers prefer to hire persons who have completed formal training programs, some technicians and mechanics continue to learn their skills on the job. Unskilled beginners generally are assigned tasks such as cleaning parts, fueling and lubricating vehicles, and driving vehicles into and out of the shop. Beginners usually are promoted to trainee positions as they gain experience and as vacancies become available. In some shops, beginners with experience in automobile service start as trainee technicians.

Most trainees perform routine service tasks and make minor repairs after a few months' experience. These workers advance to increasingly difficult jobs as they prove their ability and competence. After technicians master the repair and service of diesel engines, they learn to work on related components, such as brakes, transmissions, and electrical systems. Generally, technicians with at least 3 to 4 years of on-the-job experience will qualify as journey-level diesel technicians. The completion of a formal training program speeds advancement to the journey level.

For unskilled entry-level jobs, employers usually look for applicants who have mechanical aptitude and strong problem-solving skills and who are at least 18 years of age and in good physical condition. Nearly all employers require the completion of high school. Courses in automotive repair, electronics, English, mathematics, and physics provide a strong educational background for a career as a diesel service technician or mechanic. Technicians need a State commercial driver's license to test-drive trucks or buses on public roads. Many companies also require applicants to pass a drug test. Practical experience in automobile repair at a gasoline service station, in the Armed Forces, or as a hobby is valuable as well.

Employers often send experienced technicians and mechanics to special training classes conducted by manufacturers and vendors, in which workers learn the latest technology and repair techniques. Technicians constantly receive updated technical manuals and instructions outlining changes in techniques and standards for repair. It is essential for technicians to read, interpret, and comprehend service manuals in order to keep abreast of engineering changes.

Voluntary certification by the National Institute for Automotive Service Excellence (ASE) is recognized as the standard of achievement for diesel service technicians and mechanics. Technicians may be certified as master truck technicians or in specific areas of truck repair, such as gasoline engines, drivetrains, brakes, suspension and steering, electrical and electronic systems, or preventive maintenance and inspection.

For certification in each area, a technician must pass one or more of the ASE-administered exams and present proof of 2 years of relevant hands-on work experience. Two years of relevant formal training from a high school, vocational or trade school, or community or junior college program may be substituted for up to 1 year of the work experience requirement. To remain certified, technicians must be retested every 5 years. Retesting ensures that service technicians and mechanics keep up with changing technology. Diesel service technicians and mechanics also may opt for ASE certification as master school bus technicians or master truck equipment technicians.

The most important work possessions of technicians and mechanics are their handtools. Technicians and mechanics usually provide their own tools, and many experienced workers have thousands of dollars invested in them. Employers typically furnish expensive power tools, computerized engine analyzers, and other diagnostic equipment, but individual workers ordinarily accumulate handtools with experience.

Experienced technicians and mechanics with leadership ability may advance to shop supervisor or service manager. Technicians and mechanics with sales ability sometimes become sales representatives. Some open their own repair shops.

Job Outlook

Employment of diesel service technicians and mechanics is expected to increase about as fast as the average for all occupations through the year 2012. Besides openings resulting from employment growth, opportunities will be created by the need to replace workers who retire or transfer to other occupations.

Employment of diesel service technicians and mechanics is expected to grow as freight transportation by truck increases. Additional trucks will be needed to keep pace with the increasing volume of freight shipped nationwide. Trucks also serve as intermediaries for other forms of transportation, such as rail and air. Due to the greater durability and economy of the diesel engine relative to the gasoline engine, buses and trucks of all sizes are expected to be increasingly powered by diesels. In addition, diesel service technicians will be needed to maintain and repair the growing number of schoolbuses in operation.

Careers as diesel service technicians attract many because they offer relatively high wages and the challenge of skilled repair work. Opportunities should be good for persons who complete formal training in diesel mechanics at community and junior colleges or vocational and technical schools. Applicants without formal training may face stiffer competition for entry-level jobs.

Most persons entering this occupation can expect relatively steady work, because changes in economic conditions have less of an effect on the diesel repair business than on other sectors of the economy. During a downturn in the economy, however, some employers may lay off workers or be reluctant to hire new workers.

Earnings

Median hourly earnings of bus and truck mechanics and diesel engine specialists, including incentive pay, were \$16.53 in 2002. The middle 50 percent earned between \$13.13 and \$20.54 an hour. The lowest 10 percent earned less than \$10.66, and the highest 10 percent earned more than \$24.61 an hour. Median hourly earnings in the industries employing the largest numbers of bus and truck mechanics and diesel engine specialists in 2002 were as follows:

Local government	\$19.58
Motor vehicle and motor vehicle parts and supplies merchant wholesalers	16.80
General freight and trucking	15.62
Automotive repair and maintenance	15.36
Elementary and secondary schools	15.10

Because many experienced technicians employed by truck fleet dealers and independent repair shops receive a commission related to the labor cost charged to the customer, weekly earnings depend on the amount of work completed. Beginners usually earn from 50 to 75 percent of the rate of skilled workers and receive increases as they become more skilled, until they reach the rates of skilled service technicians.

The majority of service technicians work a standard 40-hour week, although some work longer hours, particularly if they are self-employed. A growing number of shops have expanded their hours, either to perform repairs and routine service in a more timely fashion or as a convenience to customers. Those technicians employed by truck and bus firms providing service around the clock may work evenings, nights, and weekends, usually at a higher rate of pay than those working traditional hours.

Many diesel service technicians and mechanics are members of labor unions, including the International Association of Machinists and Aerospace Workers; the Amalgamated Transit Union; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the Transport Workers Union of America; the Sheet Metal Workers' International Association; and the International Brotherhood of Teamsters.

Related Occupations

Diesel service technicians and mechanics repair trucks, buses, and other diesel-powered equipment. Related technician and mechanic occupations include aircraft and avionics equipment mechanics and service technicians, automotive service technicians and mechanics, heavy vehicle and mobile equipment service technicians and mechanics, and small engine mechanics.

Sources of Additional Information

More details about work opportunities for diesel service technicians and mechanics may be obtained from local employers such as trucking companies, truck dealers, or buslines; locals of the unions previously mentioned; and local offices of your State employment service. Local State employment service offices also may have information about training programs. State boards of postsecondary career schools have information on licensed schools with training programs for diesel service technicians and mechanics.

For general information about a career as a diesel service technician or mechanic, write:

► Detroit Diesel, Personnel Director, MS B39, 13400 West Outer Dr., Detroit, MI 48239.

Information on how to become a certified diesel technician of medium to heavy-duty vehicles or a certified bus technician is available from:

► National Institute for Automotive Service Excellence (ASE), 101 Blue Seal Dr. SE, Suite 101, Leesburg, VA 20175. Internet: <http://www.asecert.org>

For a directory of accredited private trade and technical schools with training programs for diesel service technicians and mechanics, contact:

► Accrediting Commission of Career Schools and Colleges of Technology, 2101 Wilson Blvd., Suite 302, Arlington, VA 22201. Internet: <http://www.accsct.org>

► National Automotive Technicians Education Foundation, 101 Blue Seal Dr., SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.natef.org>

For a list of public training programs for diesel service technicians and mechanics, contact:

► SkillsUSA-VICA, P.O. Box 3000, Leesburg, VA 20177-0300. Internet: <http://www.skillsusa.org>

Electrical and Electronics Installers and Repairers

(0*NET 49-2092.01, 49-2092.02, 49-2092.03, 49-2092.04, 49-2092.05, 49-2092.06, 49-2093.00, 49-2094.00, 49-2095.00, 49-2096.00)

Significant Points

- Knowledge of electrical equipment and electronics is necessary for employment; many applicants complete 1 to 2 years at vocational schools and community colleges, although some less skilled repairers may have only a high school diploma.
- Employment is projected to grow more slowly than average, but will vary by occupational specialty.
- Job opportunities will be best for applicants with a thorough knowledge of electrical and electronic equipment, as well as repair experience.

Nature of the Work

Businesses and other organizations depend on complex electronic equipment for a variety of functions. Industrial controls automatically monitor and direct production processes on the factory floor. Transmitters and antennae provide communication links for many organizations. Electric power companies use electronic equipment to operate and control generating plants, substations, and monitoring equipment. The Federal Government uses radar and missile control systems to provide for the national defense and to direct commercial air traffic. These complex pieces of electronic equipment are installed, maintained, and repaired by electrical and electronics installers and repairers.

Electrical equipment and electronic equipment are two distinct types of industrial equipment, although much equipment contains both electrical and electronic components. In general, electrical portions provide the power for the equipment, while electronic components control the device, although many types of equipment still are controlled with electrical devices. Electronic sensors monitor the equipment and the manufacturing process, providing feedback to the programmable logic control (PLC), which controls the equipment. The PLC processes the information provided by the sensors and makes adjustments to optimize output. To adjust the output, the PLC sends signals to the electrical, hydraulic, and pneumatic devices that power the machine—changing feed rates, pressures, and other variables in the manufacturing process. Many installers and repairers, known as *field technicians*, travel to factories or other locations to repair equipment. These workers often have assigned areas in which they perform preventive maintenance on a regular basis. When equipment breaks down, field technicians go to a customer's site to repair the equipment. *Bench technicians* work in repair shops located in factories and service centers, fixing components that cannot be repaired on the factory floor.

Some industrial electronic equipment is self-monitoring and alerts repairers to malfunctions. When equipment breaks down, repairers first check for common causes of trouble, such as loose connections or obviously defective components. If routine checks do not locate the trouble, repairers may refer to schematics and manufacturers' specifications that show connections and provide instructions on how to locate problems. Automated electronic control systems are increasing in complexity, making diagnosis more challenging. Repairers use software programs and testing equipment to diagnose malfunctions. Among their diagnostic tools are multimeters, which measure voltage, current, and resistance; and advanced multimeters,

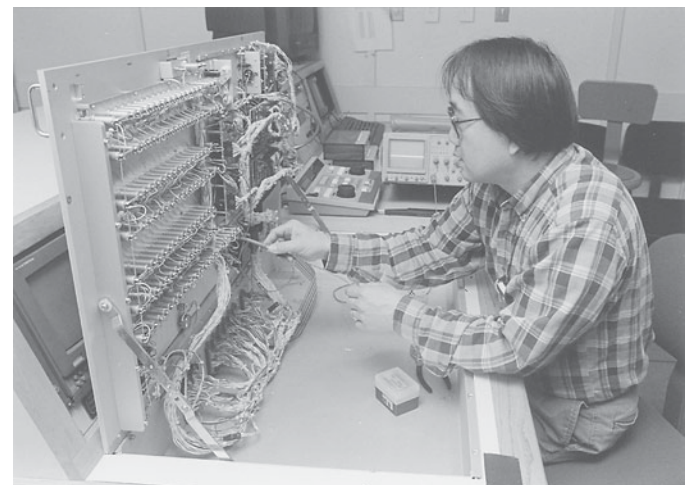
which measure capacitance, inductance, and current gain of transistors. Repairers also use signal generators, which provide test signals, and oscilloscopes, which display signals graphically. Finally, repairers use handtools such as pliers, screwdrivers, soldering irons, and wrenches to replace faulty parts and adjust equipment.

Because repairing components is a complex activity and factories cannot allow production equipment to stand idle, repairers on the factory floor usually remove and replace defective units, such as circuit boards, instead of fixing them. Defective units are discarded or returned to the manufacturer or a specialized shop for repair. Bench technicians at these locations have the training, tools, and parts needed to thoroughly diagnose and repair circuit boards or other complex components. These workers also locate and repair circuit defects, such as poorly soldered joints, blown fuses, or malfunctioning transistors.

Electrical and electronics installers often fit older manufacturing equipment with new automated control devices. Older manufacturing machines are frequently in good working order, but are limited by inefficient control systems for which replacement parts are no longer available. Installers replace old electronic control units with new PLCs. Setting up and installing a new PLC involves connecting it to different sensors and electrically powered devices (electric motors, switches, and pumps) and writing a computer program to operate the PLC. Electronics installers coordinate their efforts with those of other workers who are installing and maintaining equipment. (See the statement on industrial machinery installation, repair, and maintenance workers elsewhere in the *Handbook*.)

Electrical and electronics installers and repairers, transportation equipment install, adjust, or maintain mobile electronic communication equipment, including sound, sonar, security, navigation, and surveillance systems on trains, watercraft, or other mobile equipment. *Electrical and electronics repairers, powerhouse, substation, and relay* inspect, test, repair, or maintain electrical equipment in generating stations, substations, and in-service relays. These workers may be known as powerhouse electricians, relay technicians, or power transformer repairers. *Electric motor, power tool, and related repairers*—such as armature winders, generator mechanics, and electric golf cart repairers—specialize in repairing, maintaining, or installing electric motors, wiring, or switches.

Electronic equipment installers and repairers, motor vehicles have a significantly different job. They install, diagnose, and repair communication, sound, security, and navigation equipment in motor vehicles. Most installation work involves either new alarm or sound systems. New sound systems vary significantly in cost and com-



Electrical and electronic repairers use software and testing equipment to diagnose malfunctions.

plexity of installation. Replacing a head unit (radio) with a new computer disc (CD) player is quite simple, requiring the removal of a few screws and the connection of a few wires. Installing a new sound system with a subwoofer, amplifier, and fuses is far more complicated. The installer builds a fiberglass or wood box designed to hold the subwoofer and to fit inside the unique dimensions of the automobile. Installing sound-deadening material, which often is necessary with more powerful speakers, requires an installer to remove many parts of a car (for example, seats, carpeting, or interiors of doors), add sound-absorbing material in empty spaces, and reinstall the interior parts. The installer also runs new speaker and electrical cables. The new system may require additional fuses, a new electrical line to be run from the battery through a newly drilled hole in the firewall into the interior of the vehicle, or an additional or more powerful alternator or battery. Motor vehicle installers and repairers work with an increasingly complex range of electronic equipment, including DVD players, satellite navigation equipment, passive-security tracking systems, and active-security systems.

Working Conditions

Many electrical and electronics installers and repairers work on factory floors, where they are subject to noise, dirt, vibration, and heat. Bench technicians work primarily in repair shops, where the surroundings are relatively quiet, comfortable, and well lighted.

Installers and repairers may have to do heavy lifting and work in a variety of positions. They must follow safety guidelines and often wear protective goggles and hardhats. When working on ladders or on elevated equipment, repairers must wear harnesses to prevent falls. Before repairing a piece of machinery, these workers must follow procedures to ensure that others cannot start the equipment during the repair process. They also must take precautions against electric shock by locking off power to the unit under repair.

Motor vehicle electronic equipment installers and repairers normally work indoors in well-ventilated and well-lighted repair shops. Minor cuts and bruises are common, but serious accidents usually are avoided when safety practices are observed.

Employment

Electrical and electronics installers and repairers held about 172,000 jobs in 2002. The following tabulation breaks down their employment by occupational specialty:

Electrical and electronics repairers, commercial and industrial equipment	85,000
Electric motor, power tool, and related repairers	31,000
Electrical and electronics repairers, powerhouse, substation, and relay	21,000
Electronic equipment installers and repairers, motor vehicles	18,000
Electrical and electronics installers and repairers, transportation equipment	18,000

Many repairers worked for utilities, building equipment contractors, machinery and equipment repair shops, wholesalers, the Federal Government, retailers of automotive parts and accessories, rail transportation companies, and manufacturers of electrical, electronic, and transportation equipment.

Training, Other Qualifications, and Advancement

Knowledge of electrical equipment and electronics is necessary for employment. Many applicants gain this knowledge through programs lasting 1 to 2 years at vocational schools or community colleges, although some less skilled repairers may have only a high

school diploma. Entry-level repairers may work closely with more experienced technicians who provide technical guidance.

Installers and repairers should have good eyesight and color perception in order to work with the intricate components used in electronic equipment. Field technicians work closely with customers and should have good communication skills and a neat appearance. Employers also may require that field technicians have a driver's license.

Various organizations offer certification, including ACES International, the Consumer Electronics Association, the Electronics Technicians Association International, and the International Society of Certified Electronics Technicians. Repairers may specialize—in industrial electronics, for example. To receive certification, repairers must pass qualifying exams corresponding to their level of training and experience.

Experienced repairers with advanced training may become specialists or troubleshooters who help other repairers diagnose difficult problems. Workers with leadership ability may become supervisors of other repairers. Some experienced workers open their own repair shops.

Job Outlook

Job opportunities should be best for applicants with a thorough knowledge of electrical equipment and electronics, as well as with repair experience. Overall employment of electrical and electronics installers and repairers is expected to grow more slowly than the average for all occupations over the 2002-12 period, but varies by occupational specialty. In addition to employment growth, many job openings should result from the need to replace workers who transfer to other occupations or leave the labor force.

Average employment growth is projected for electrical and electronics installers and repairers of commercial and industrial equipment. This equipment will become more sophisticated and will be used more frequently as businesses strive to lower costs by increasing and improving automation. Companies will install electronic controls, robots, sensors, and other equipment to automate processes such as assembly and testing. As prices decline, applications will be found across a number of industries, including services, utilities, and construction, as well as manufacturing. Improved reliability of equipment should not constrain employment growth, however: companies increasingly will rely on repairers because any malfunction that idles commercial and industrial equipment is costly.

Employment of motor vehicle electronic equipment installers and repairers also is expected to grow as fast as the average. However, motor vehicle manufacturers will install more and better sound, security, entertainment, and navigation systems in new vehicles, limiting employment growth for aftermarket electronic equipment installers. In addition, newer electronic systems are more reliable and require less maintenance.

Employment of electric motor, power tool, and related repairers is expected to grow more slowly than average. Improvements in electrical and electronic equipment design should limit job growth by simplifying repair tasks. More parts are being designed to be easily disposable, further reducing employment growth.

Employment of electrical and electronic installers and repairers of transportation equipment is expected to grow more slowly than the average, due to declining industry employment in rail transportation, aerospace product and parts manufacturing, and ship- and boatbuilding.

Employment of electrical and electronics installers and repairers, powerhouse, substation, and relay is expected to decline slightly. Consolidation and privatization in utilities industries should improve

productivity, reducing employment. Newer equipment will be more reliable and easier to repair, further limiting employment.

Earnings

Median hourly earnings of electrical and electronics repairers, commercial and industrial equipment were \$19.77 in 2002. The middle 50 percent earned between \$15.13 and \$24.03. The lowest 10 percent earned less than \$11.71, and the highest 10 percent earned more than \$27.08. In 2002, median hourly earnings were \$23.68 in the Federal government and \$16.87 in building equipment contractors, the industries employing the largest numbers of electrical and electronics repairers, commercial and industrial equipment.

Median hourly earnings of electric motor, power tool, and related repairers were \$15.49 in 2002. The middle 50 percent earned between \$11.82 and \$19.99. The lowest 10 percent earned less than \$9.32, and the highest 10 percent earned more than \$25.34. In 2002, median hourly earnings were \$14.05 in commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance, the industry employing the largest number of electronic motor, power tool, and related repairers.

Median hourly earnings of electrical and electronics repairers, powerhouse, substation, and relay were \$24.85 in 2002. The middle 50 percent earned between \$20.81 and \$27.90. The lowest 10 percent earned less than \$15.92, and the highest 10 percent earned more than \$32.08. In 2002, median hourly earnings were \$25.69 in electric power generation, transmission, and distribution—the industry employing the largest number of electrical and electronics repairers, powerhouse, substation, and relay.

Median hourly earnings of electronics installers and repairers, motor vehicles were \$12.51 in 2002. The middle 50 percent earned between \$9.97 and \$16.02. The lowest 10 percent earned less than \$8.47, and the highest 10 percent earned more than \$19.45.

Median hourly earnings of electrical and electronics repairers, transportation equipment were \$18.56 in 2002. The middle 50 percent earned between \$13.85 and \$22.96. The lowest 10 percent earned less than \$10.68, and the highest 10 percent earned more than \$26.87.

Related Occupations

Workers in other occupations who install and repair electronic equipment include broadcast and sound technicians and radio operators; computer, automated teller, and office machine repairers; electronic home entertainment equipment installers and repairers; and radio and telecommunications equipment installers and repairers. Industrial machinery installation, repair, and maintenance workers also install, maintain, and repair industrial machinery.

Sources of Additional Information

For information on careers and certification, contact any of the following organizations:

- ▶ ACES International, 5241 Princess Anne Rd., Suite 110, Virginia Beach, VA 23462. Internet: <http://www.acesinternational.org>
- ▶ Consumer Electronics Association, 2500 Wilson Blvd, Arlington VA. 22201-3834. Internet: <http://www.ce.org>
- ▶ Electronics Technicians Association International, 5 Depot St., Greencastle, IN 46135.
- ▶ International Society of Certified Electronics Technicians, 3608 Pershing Ave., Fort Worth, TX 76107-4527. Internet: <http://www.iscet.org>

Electronic Home Entertainment Equipment Installers and Repairers

(0*NET 49-2097.00)

Significant Points

- Employment is expected to grow more slowly than the average for all occupations, because it often is cheaper to replace equipment than to repair it.
- Job opportunities will be best for applicants with knowledge of electronics and with related hands-on experience.

Nature of the Work

Electronic home entertainment equipment installers and repairers, also called *service technicians*, repair a variety of equipment, including televisions and radios, stereo components, video and audio disc players, video cameras, and video recorders. They also install and repair home security systems, intercom equipment, satellite television dishes, and home theater systems, which consist of large-screen televisions and sophisticated surround-sound audio components.

Customers usually bring small, portable equipment to repair shops for servicing. Repairers at these locations, known as *bench technicians*, are equipped with a full array of electronic tools and parts. When larger, less mobile equipment breaks down, customers may pay repairers to come to their homes. These repairers, known as *field technicians*, travel with a limited set of tools and parts, and attempt to complete the repair at the customer's location. If the job is complex, technicians may bring defective components back to the shop for thorough diagnosis and repair.

When equipment breaks down, repairers check for common causes of trouble, such as dirty or defective components. Many repairs consist simply of cleaning and lubricating equipment. If routine checks do not locate the trouble, repairers may refer to schematics and manufacturers' specifications that provide instructions on how to locate problems. Repairers use a variety of test equipment to diagnose and identify malfunctions. Multimeters detect short circuits, failed capacitors, and blown fuses by measuring voltage, current, and resistance. Color-bar and dot generators provide onscreen test patterns, signal generators to test signals, and oscilloscopes and digital storage scopes to measure complex waveforms produced by electronic equipment. Repairs may involve removing and replacing a failed capacitor, transistor, or fuse. Repairers use handtools such as pliers, screwdrivers, soldering irons, and wrenches to replace faulty parts. They also make adjustments to equipment, such as focusing and converging the picture of a television set or balancing the audio on a surround-sound system.

Improvements in technology have miniaturized and digitized many audio and video recording devices. Miniaturization has made repairwork significantly more difficult, because both the components and the acceptable tolerances are smaller. For example, an analog video camera operates at 1,800 revolutions per minute (rpm), while a digital video camera may operate at 9,000 rpm. Also, components now are mounted on the surface of circuit boards, instead of plugged into slots, requiring more precise soldering when a new part is installed. Improved technologies have lowered the price of electronic home entertainment equipment, to the point where customers often replace broken equipment instead of repairing it.

Working Conditions

Most repairers work in well-lit electrical repair shops. Field technicians, however, spend much time traveling in service vehicles and working in customers' residences.

Repairers may have to work in a variety of positions and carry heavy equipment. Although the work of repairers is comparatively safe, they must take precautions against minor burns and electric shock. Because television monitors carry high voltage even when they are turned off, repairers need to discharge the voltage before servicing such equipment.

Employment

Electronic home entertainment equipment installers and repairers held about 43,000 jobs in 2002. Most repairers worked in electronics and appliance stores that sell and service electronic home entertainment products or in electronic and precision equipment repair and maintenance shops. About 1 electronic home entertainment equipment installer and repairer in 4 was self-employed, more than 4 times the proportion for all installation, maintenance, and repair occupations.

Training, Other Qualifications, and Advancement

Employers prefer applicants who have basic knowledge and skills in electronics. Applicants should be familiar with schematics and have some hands-on experience repairing electronic equipment. Many applicants gain these skills at vocational training programs and community colleges. Training programs should include both hands-on experience and theoretical education in digital consumer electronics. Entry-level repairers may work closely with more experienced technicians, who provide technical guidance.

Field technicians work closely with customers and must have good communication skills and a neat appearance. Employers also may require that field technicians have a driver's license.

Various organizations offer certification for electronic home entertainment equipment installers and repairers, including ACES International, the Custom Electronic Design and Installation Association, the Electronic Technicians Association International, and the International Society of Certified Electronics Technicians. Repairers may specialize in a variety of skill areas, including consumer electronics. To receive certification, repairers must pass qualifying exams corresponding to their level of training and experience.



Most electronic home entertainment equipment installers and repairers work in retail stores or repair shops.

Experienced repairers with advanced training may become specialists or troubleshooters, helping other repairers diagnose difficult problems. Workers with leadership ability may become supervisors of other repairers. Some experienced workers open their own repair shops.

Job Outlook

Employment of electronic home entertainment equipment installers and repairers is expected to grow more slowly than average through 2012, due to decreased demand for repair work. In addition to job openings arising from employment growth, some will also result from the need to replace workers who retire or who transfer to higher paying jobs in other occupations requiring electronics experience. Opportunities will be best for applicants with hands-on experience and knowledge of electronics.

The need for repairers is expected to grow slowly because home entertainment equipment is less expensive than in the past. As technological developments have lowered the price and improved the reliability of equipment, the demand for repair services has slackened. When malfunctions do occur, it often is cheaper for consumers to replace equipment rather than to pay for repairs.

Employment growth will be spurred somewhat by the introduction of sophisticated digital equipment, such as DVDs, digital televisions, and digital camcorders. So long as the price of such equipment remains high, purchasers will be willing to hire repairers when malfunctions occur.

Earnings

Median hourly earnings of electronic home entertainment equipment installers and repairers were \$13.08 in 2002. The middle 50 percent earned between \$10.20 and \$17.00. The lowest 10 percent earned less than \$8.18, and the highest 10 percent earned more than \$21.48. In 2002, median hourly earnings of electronic home entertainment equipment installers and repairers were \$12.73 in electronics and appliance stores and \$11.99 in electronic and precision equipment repair and maintenance.

Related Occupations

Other workers who repair and maintain electronic equipment include broadcast and sound engineering technicians and radio operators; computer, automated teller, and office machine repairers; electrical and electronics installers and repairers; and radio and telecommunications equipment installers and repairers.

Sources of Additional Information

For information on careers and certification, contact:

- ▶ ACES International, 5241 Princess Anne Rd., Suite 110, Virginia Beach, VA 23462. Internet: <http://www.acesinternational.org>
- ▶ Custom Electronic Design and Installation Association, 7150 Winton Dr., Suite 300, Indianapolis, IN 46268. Internet: <http://www.cedia.org>
- ▶ Electronics Technicians Association International, 5 Depot St., Greencastle, IN 46135.
- ▶ International Society of Certified Electronics Technicians, 3608 Pershing Ave., Fort Worth, TX 76107-4527. Internet: <http://www.iscet.org>

Heating, Air-Conditioning, and Refrigeration Mechanics and Installers

(0*NET 49-9021.01, 49-9021.02)

Significant Points

- Job prospects for heating, air-conditioning, and refrigeration mechanics and installers are expected to be good, particularly for those with technical school or formal apprenticeship training.
- The Air-Conditioning Excellence program, offered through North American Technician Excellence, is the standard for certification of experienced technicians.

Nature of the Work

What would those living in Chicago do without heating, those in Miami do without air-conditioning, or blood banks all over the country do without refrigeration? Heating and air-conditioning systems control the temperature, humidity, and the total air quality in residential, commercial, industrial, and other buildings. Refrigeration systems make it possible to store and transport food, medicine, and other perishable items. Heating, air-conditioning, and refrigeration mechanics and installers—also called technicians—install, maintain, and repair such systems. Because heating, ventilation, air-conditioning, and refrigeration systems often are referred to as HVACR systems, these workers also may be called HVACR technicians.

Heating, air-conditioning, and refrigeration systems consist of many mechanical, electrical, and electronic components, such as motors, compressors, pumps, fans, ducts, pipes, thermostats, and switches. In central heating systems, for example, a furnace heats air that is distributed throughout the building via a system of metal or fiberglass ducts. Technicians must be able to maintain, diagnose, and correct problems throughout the entire system. To do this, they adjust system controls to recommended settings and test the performance of the entire system using special tools and test equipment.

Technicians often specialize in either installation or maintenance and repair, although they are trained to do both. Some specialize in one type of equipment—for example, oil burners, solar panels, or commercial refrigerators. Technicians may work for large or small contracting companies or directly for a manufacturer or wholesaler. Those working for smaller operations tend to do both installation and servicing, and work with heating, cooling, and refrigeration equipment. Service contracts—which involve heating, air-conditioning, and refrigeration work for particular customers on a regular basis—are becoming more common. Service agreements help to reduce the seasonal fluctuations of this work.

Heating and air-conditioning mechanics install, service, and repair heating and air-conditioning systems in both residences and commercial establishments. *Furnace installers*, also called *heating equipment technicians*, follow blueprints or other specifications to install oil, gas, electric, solid-fuel, and multiple-fuel heating systems. *Air-conditioning mechanics* install and service central air-conditioning systems. After putting the equipment in place, they install fuel and water supply lines, air ducts and vents, pumps, and other components. They may connect electrical wiring and controls and check the unit for proper operation. To ensure the proper functioning of the system, furnace installers often use combustion test equipment, such as carbon dioxide and oxygen testers.

After a furnace has been installed, heating equipment technicians often perform routine maintenance and repair work to keep the system operating efficiently. During the fall and winter, for example, when the system is used most, they service and adjust burners and blowers. If the system is not operating properly, they check the thermostat, burner nozzles, controls, or other parts to diagnose and then correct the problem.

During the summer, when the heating system is not being used, heating equipment technicians do maintenance work, such as replacing filters, ducts, and other parts of the system that may accumulate dust and impurities during the operating season. During the winter, air-conditioning mechanics inspect the systems and do required maintenance, such as overhauling compressors.

Refrigeration mechanics install, service, and repair industrial and commercial refrigerating systems and a variety of refrigeration equipment. They follow blueprints, design specifications, and manufacturers' instructions to install motors, compressors, condensing units, evaporators, piping, and other components. They connect this equipment to the ductwork, refrigerant lines, and electrical power source. After making the connections, they charge the system with refrigerant, check it for proper operation, and program control systems.

When heating, air-conditioning, and refrigeration mechanics service equipment, they must use care to conserve, recover, and recycle chlorofluorocarbon (CFC) and hydrochlorofluorocarbon



Service contracts—which involve heating, air-conditioning, and refrigeration maintenance on a regular basis—are becoming more common.

(HCFC) refrigerants used in air-conditioning and refrigeration systems. The release of CFCs and HCFCs contributes to the depletion of the stratospheric ozone layer, which protects plant and animal life from ultraviolet radiation. Technicians conserve the refrigerant by making sure that there are no leaks in the system; they recover it by venting the refrigerant into proper cylinders; and they recycle it for reuse with special filter-dryers.

Heating, air-conditioning, and refrigeration mechanics and installers are adept at using a variety of tools, including hammers, wrenches, metal snips, electric drills, pipe cutters and benders, measurement gauges, and acetylene torches, to work with refrigerant lines and air ducts. They use voltmeters, thermometers, pressure gauges, manometers, and other testing devices to check airflow, refrigerant pressure, electrical circuits, burners, and other components.

Other craftworkers sometimes install or repair cooling and heating systems. For example, on a large air-conditioning installation job, especially where workers are covered by union contracts, ductwork might be done by sheet metal workers and duct installers; electrical work by electricians; and installation of piping, condensers, and other components by pipelayers, plumbers, pipefitters, and steamfitters. Home appliance repairers usually service room air-conditioners and household refrigerators. (Additional information about each of these occupations appears elsewhere in the *Handbook*.)

Working Conditions

Heating, air-conditioning, and refrigeration mechanics and installers work in homes, stores of all kinds, hospitals, office buildings, and factories—anywhere there is climate-control equipment. They may be assigned to specific jobsites at the beginning of each day, or if they are making service calls, they may be dispatched to jobs by radio, telephone, or pager. Increasingly, employers are using cell phones to coordinate technicians' schedules.

Technicians may work outside in cold or hot weather or in buildings that are uncomfortable because the air-conditioning or heating equipment is broken. In addition, technicians might have to work in awkward or cramped positions and sometimes are required to work in high places. Hazards include electrical shock, burns, muscle strains, and other injuries from handling heavy equipment. Appropriate safety equipment is necessary when handling refrigerants because contact can cause skin damage, frostbite, or blindness. Inhalation of refrigerants when working in confined spaces also is a possible hazard.

The majority of mechanics and installers work at least a 40-hour week. During peak seasons they often work overtime or irregular hours. Maintenance workers, including those who provide maintenance services under contract, often work evening or weekend shifts and are on call. Most employers try to provide a full workweek year-round by scheduling both installation and maintenance work, and many manufacturers and contractors now provide or even require service contracts. In most shops that service both heating and air-conditioning equipment, employment is stable throughout the year.

Employment

Heating, air-conditioning, and refrigeration mechanics and installers held about 249,000 jobs in 2002; almost half worked for cooling and heating contractors. The remainder was employed in a variety of industries throughout the country, reflecting a widespread dependence on climate-control systems. Some worked for fuel oil dealers, refrigeration and air-conditioning service and repair shops, schools, and stores that sell heating and air-conditioning systems. Local governments, the Federal Government, hospitals, office build-

ings, and other organizations that operate large air-conditioning, refrigeration, or heating systems employed others. About 15 percent of mechanics and installers were self-employed.

Training, Other Qualifications, and Advancement

Because of the increasing sophistication of heating, air-conditioning, and refrigeration systems, employers prefer to hire those with technical school or apprenticeship training. Many mechanics and installers, however, still learn the trade informally on the job.

Many secondary and postsecondary technical and trade schools, junior and community colleges, and the U.S. Armed Forces offer 6-month to 2-year programs in heating, air-conditioning, and refrigeration. Students study theory, design, and equipment construction, as well as electronics. They also learn the basics of installation, maintenance, and repair.

Apprenticeship programs frequently are run by joint committees representing local chapters of the Air-Conditioning Contractors of America, the Mechanical Contractors Association of America, the National Association of Plumbing-Heating-Cooling Contractors, and locals of the Sheet Metal Workers' International Association or the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada. Other apprenticeship programs are sponsored by local chapters of the Associated Builders and Contractors and the National Association of Home Builders. Formal apprenticeship programs normally last 3 to 5 years and combine on-the-job training with classroom instruction. Classes include subjects such as the use and care of tools, safety practices, blueprint reading, and the theory and design of heating, ventilation, air-conditioning, and refrigeration systems. Applicants for these programs must have a high school diploma or equivalent. Math and reading skills are essential.

Those who acquire their skills on the job usually begin by assisting experienced technicians. They may begin by performing simple tasks such as carrying materials, insulating refrigerant lines, or cleaning furnaces. In time, they move on to more difficult tasks, such as cutting and soldering pipes and sheet metal and checking electrical and electronic circuits.

Courses in shop math, mechanical drawing, applied physics and chemistry, electronics, blueprint reading, and computer applications provide a good background for those interested in entering this occupation. Some knowledge of plumbing or electrical work also is helpful. A basic understanding of electronics is becoming more important because of the increasing use of this technology in equipment controls. Because technicians frequently deal directly with the public, they should be courteous and tactful, especially when dealing with an aggravated customer. They also should be in good physical condition because they sometimes have to lift and move heavy equipment.

All technicians who purchase or work with refrigerants must be certified in their proper handling. To become certified to purchase and handle refrigerants, technicians must pass a written examination specific to the type of work in which they specialize. The three possible areas of certification are: Type I—servicing small appliances, Type II—high-pressure refrigerants, and Type III—low-pressure refrigerants. Exams are administered by organizations approved by the U.S. Environmental Protection Agency, such as trade schools, unions, contractor associations, or building groups.

Several organizations have begun to offer basic self-study, classroom, and Internet courses for individuals with limited experience. In addition to understanding how systems work, technicians must be knowledgeable about refrigerant products and the legislation and regulations that govern their use. The Air-Conditioning Excellence

program, which is offered through North American Technician Excellence (NATE), generally has been adopted as the standard for certification of experienced technicians.

Advancement usually takes the form of higher wages. Some technicians, however, may advance to positions as supervisor or service manager. Others may move into areas such as sales and marketing. Still others may become building superintendents, cost estimators, or, with the necessary certification, teachers. Those with sufficient money and managerial skill can open their own contracting business.

Job Outlook

Job prospects for heating, air-conditioning, and refrigeration mechanics and installers are expected to be good, particularly for those with technical school or formal apprenticeship training. Employment of heating, air-conditioning, and refrigeration mechanics and installers is expected to increase faster than the average for all occupations through the year 2012. As the population and economy grow, so does the demand for new residential, commercial, and industrial climate-control systems. Technicians who specialize in installation work may experience periods of unemployment when the level of new construction activity declines, but maintenance and repair work usually remains relatively stable. People and businesses depend on their climate-control systems and must keep them in good working order, regardless of economic conditions.

Renewed concern for energy conservation should continue to prompt the development of new energy-saving heating and air-conditioning systems. An emphasis on better energy management should lead to the replacement of older systems and the installation of newer, more efficient systems in existing homes and buildings. Also, demand for maintenance and service work should increase as businesses and homeowners strive to keep systems operating at peak efficiency. Regulations prohibiting the discharge of CFC and HCFC refrigerants took effect in 1993, and regulations banning CFC production became effective in 2000. Consequently, these regulations should continue to result in demand for technicians to replace many existing systems, or modify them to use new environmentally safe refrigerants. In addition, the continuing focus on improving indoor air quality should contribute to the creation of more jobs for heating, air-conditioning, and refrigeration technicians. Also, growth of business establishments that use refrigerated equipment—such as supermarkets and convenience stores—will contribute to a growing need for technicians. In addition to job openings created by employment growth, thousands of openings will result from the need to replace workers who transfer to other occupations or leave the labor force.

Earnings

Median hourly earnings of heating, air-conditioning, and refrigeration mechanics and installers were \$16.78 in 2002. The middle 50 percent earned between \$12.95 and \$21.37 an hour. The lowest 10 percent earned less than \$10.34, and the top 10 percent earned more than \$26.20. Median hourly earnings in the industries employing the largest numbers of heating, air-conditioning, and refrigeration mechanics and installers in 2002 were as follows:

Hardware, and plumbing and heating equipment and supplies merchant wholesalers	\$18.78
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	17.16
Direct selling establishments	17.14
Elementary and secondary schools	16.80
Building equipment contractors	16.03

Apprentices usually begin at about 50 percent of the wage rate paid to experienced workers. As they gain experience and improve their skills, they receive periodic increases until they reach the wage rate of experienced workers.

Heating, air-conditioning, and refrigeration mechanics and installers enjoy a variety of employer-sponsored benefits. In addition to typical benefits such as health insurance and pension plans, some employers pay for work-related training and provide uniforms, company vans, and tools.

About 20 percent of heating, air-conditioning, and refrigeration mechanics and installers are members of a union. The unions to which the greatest numbers of mechanics and installers belong are the Sheet Metal Workers' International Association and the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada.

Related Occupations

Heating, air-conditioning, and refrigeration mechanics and installers work with sheet metal and piping, and repair machinery, such as electrical motors, compressors, and burners. Other workers who have similar skills include boilermakers; home appliance repairers; electricians; sheet metal workers; and pipelayers, plumbers, pipefitters, and steamfitters.

Sources of Additional Information

For more information about opportunities for training, certification, and employment in this trade, contact local vocational and technical schools; local heating, air-conditioning, and refrigeration contractors; a local of the unions or organizations previously mentioned; a local joint union-management apprenticeship committee; or the nearest office of the State employment service or apprenticeship agency.

For information on career opportunities, training, and technician certification, contact:

- ▶ Air-Conditioning Contractors of America (ACCA), 2800 Shirlington Rd., Suite 300, Arlington, VA 22206. Internet: <http://www.acca.org>
- ▶ Refrigeration Service Engineers Society (RSES), 1666 Rand Rd., Des Plaines, IL 60016-3552. Internet: <http://www.rses.org>
- ▶ Plumbing-Heating-Cooling Contractors (PHCC), 180 S. Washington St., P.O. Box 6808, Falls Church, VA 22046. Internet: <http://www.phccweb.org>
- ▶ Sheet Metal and Air-Conditioning Contractors' National Association, 4201 Lafayette Center Dr., Chantilly, VA 20151-1209. Internet: <http://www.smacna.org>

For information on technician testing and certification, contact:

- ▶ North American Technician Excellence (NATE), 4100 North Fairfax Dr., Suite 210, Arlington, VA 22203. Internet: <http://www.natex.org>

For information on career opportunities and training, contact:

- ▶ Associated Builders and Contractors, Workforce Development Department, 4250 North Fairfax Dr., 9th Floor, Arlington, VA 22203.
- ▶ Home Builders Institute, 1201 15th St. NW., 6th Floor, Washington, DC 20005-2800. Internet: <http://www.hbi.org>
- ▶ Mechanical Contractors Association of America, 1385 Piccard Dr., Rockville, MD 20850-4329. Internet: <http://www.mcaa.org>
- ▶ Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Dr., Suite 200, Arlington, VA 22203. Internet: <http://www.coolcareers.org> or <http://www.ari.org>

There are more than 500 occupations registered by the U.S. Department of Labor's National Apprenticeship System. For more information on the Labor Department's registered apprenticeship system and links to State apprenticeship programs, check their Web site: <http://www.doleta.gov>

Heavy Vehicle and Mobile Equipment Service Technicians and Mechanics

(0*NET 49-3041.00, 49-3042.00, 49-3043.00)

Significant Points

- Opportunities should be good for persons with formal postsecondary training in diesel or heavy equipment mechanics, especially if they also have training in basic electronics and hydraulics.
- This occupation offers relatively high wages and the challenge of skilled repair work.
- Skill in using computerized diagnostic equipment is becoming more important.

Nature of the Work

Heavy vehicles and mobile equipment are indispensable to many industrial activities, from construction to railroads. Various types of equipment move materials, till land, lift beams, and dig earth to pave the way for development and production. *Heavy vehicle and mobile equipment service technicians and mechanics* repair and maintain engines and hydraulic, transmission, and electrical systems powering farm equipment, cranes, bulldozers, and railcars. (For more detailed information on service technicians specializing in diesel engines, see the statement on diesel service technicians and mechanics elsewhere in the *Handbook*.)

Service technicians perform routine maintenance checks on diesel engines and on fuel, brake, and transmission systems to ensure peak performance, safety, and longevity of the equipment. Maintenance checks and comments from equipment operators usually alert technicians to problems. With many types of modern heavy and mobile equipment, technicians can plug hand-held diagnostic computers into onboard computers to diagnose any component needing adjustment or repair. After locating the problem, these technicians rely on their training and experience to use the best possible technique to solve the problem. If necessary, they may partially dismantle the component to examine parts for damage or excessive wear. Then, using hand-held tools, they repair, replace, clean, and lubricate parts as necessary. In some cases, technicians calibrate systems by typing codes into the onboard computer. After reassembling the component and testing it for safety, they put it back into the equipment and return the equipment to the field.

Many types of heavy and mobile equipment use hydraulics, to raise and lower movable parts. When hydraulic components malfunction, technicians examine them for fluid leaks, ruptured hoses, or worn gaskets on fluid reservoirs. Occasionally, the equipment requires extensive repairs, as when a defective hydraulic pump is replaced.

In addition to conducting routine maintenance checks, service technicians perform a variety of other repairs. They diagnose electrical problems and adjust or replace defective components. They also disassemble and repair undercarriages and track assemblies. Occasionally, technicians weld broken equipment frames and structural parts, using electric or gas welders.

It is common for technicians in large shops to specialize in one or two types of repair. For example, a shop may have individual specialists in major engine repair, transmission work, electrical systems, and suspension or brake systems. The technology used in heavy equipment is becoming more sophisticated with the increased use of electronic and computer-controlled components. Training in electronics is essential for these technicians to make engine adjustments and diagnose problems. Training in the use of hand-held

computers also is necessary, because computers help technicians diagnose problems and adjust the functions of components.

Service technicians use a variety of tools in their work: power tools, such as pneumatic wrenches, to remove bolts quickly; machine tools, like lathes and grinding machines, to rebuild brakes; welding and flame-cutting equipment, to remove and repair exhaust systems; and jacks and hoists, to lift and move large parts. Service technicians also use common handtools—screwdrivers, pliers, and wrenches—to work on small parts and to get at hard-to-reach places. They may use a variety of computerized testing equipment to pinpoint and analyze malfunctions in electrical systems and other essential systems. For example, tachometers and dynamometers serve to locate engine malfunctions. Service technicians also use ohmmeters, ammeters, and voltmeters when working on electrical systems.

Mobile heavy equipment mechanics and service technicians keep construction and surface mining equipment, such as bulldozers, cranes, crawlers, draglines, graders, excavators, and other equipment, in working order. Typically, these workers are employed by equipment wholesale distribution and leasing firms, large construction and mining companies, local and Federal governments, and other organizations operating and maintaining heavy machinery and equipment fleets. Service technicians employed by the Federal Government may work on tanks and other armored equipment.

Farm equipment mechanics service, maintain, and repair farm equipment, as well as smaller lawn and garden tractors sold to suburban homeowners. What typically was a general repairer's job around the farm has evolved into a specialized technical career. Farmers have increasingly turned to farm equipment dealers to service and repair their equipment because the machinery has grown in complexity. Modern equipment uses more electronics and hydraulics, making it difficult to perform repairs without some specialized training.

Farm equipment mechanics work mostly on equipment brought into the shop for repair and adjustment. During planting and harvesting seasons, they may travel to farms to make emergency repairs to minimize delays in farm operations.

Railcar repairers specialize in servicing railroad locomotives and other rolling stock, streetcars and subway cars, or mine cars. Most work for railroads, public and private transit companies, and railcar manufacturers.



With many types of modern heavy and mobile equipment, technicians can plug hand-held diagnostic computers into onboard computers to diagnose components needing adjustment or repair.

Working Conditions

Service technicians usually work indoors, although many make repairs at the worksite. To repair vehicles and equipment, technicians often lift heavy parts and tools, handle greasy and dirty parts, and stand or lie in awkward positions. Minor cuts, burns, and bruises are common; serious accidents normally are avoided when the shop is kept clean and orderly and when safety practices are observed. Technicians usually work in well-lighted, heated, and ventilated areas. However, some shops are drafty and noisy. Many employers provide uniforms, locker rooms, and shower facilities.

When heavy or mobile equipment breaks down at a construction site, it may be too difficult or expensive to bring it into a repair shop, so the shop often sends a field service technician to the site to make repairs. Field service technicians work outdoors and spend much of their time away from the shop. Generally, the more experienced service technicians specialize in field service. They usually drive trucks specially equipped with replacement parts and tools. On occasion, they must travel many miles to reach disabled machinery. Field technicians normally earn a higher wage than their counterparts, because they are required to make on-the-spot decisions that are necessary to serve their customers.

The hours of work for farm equipment mechanics vary according to the season of the year. During the busy planting and harvesting seasons, mechanics often work 6 or 7 days a week, 10 to 12 hours daily. In slow winter months, however, mechanics may work fewer than 40 hours a week.

Employment

Heavy vehicle and mobile equipment service technicians and mechanics held about 176,000 jobs in 2002. Approximately 126,000 were mobile heavy equipment mechanics, 35,000 were farm equipment mechanics, and 15,000 were railcar repairers. About a third were employed by machinery, equipment, and supplies merchant wholesalers. More than 12 percent were employed by Federal, State, and local governments, and another 12 percent worked in construction, primarily for specialty trade contractors and highway, street, and bridge construction companies. Other service technicians worked in agriculture; mining; rail transportation and support activities; and commercial and industrial machinery and equipment rental, leasing, and repair. A small number repaired equipment for machinery and railroad rolling stock manufacturers or lawn and garden equipment and supplies stores. Less than 5 percent of service technicians were self-employed.

Nearly every section of the country employs heavy and mobile equipment service technicians and mechanics, although most work in towns and cities where equipment dealers, equipment rental and leasing companies, and construction companies have repair facilities.

Training, Other Qualifications, and Advancement

Many persons qualify for service technician jobs through years of on-the-job training, but most employers prefer that applicants complete a formal diesel or heavy equipment mechanic training program after graduating from high school. They seek persons with mechanical aptitude who are knowledgeable about the fundamentals of diesel engines, transmissions, electrical systems, and hydraulics. In addition, the constant change in equipment technology makes it necessary for technicians to be flexible and have the capacity to learn new skills quickly.

Many community colleges and vocational schools offer programs in diesel technology. Some tailor programs to heavy equipment mechanics. These programs educate the student in the basics of analytical and diagnostic techniques, electronics, and hydraulics. The increased use of electronics and computers makes training in

the fundamentals of electronics essential for new heavy and mobile equipment mechanics. Some 1- to 2-year programs lead to a certificate of completion, whereas others lead to an associate degree in diesel or heavy equipment mechanics. These programs not only provide a foundation in the components of diesel and heavy equipment technology, but also enable trainee technicians to advance more rapidly to the journey, or experienced worker, level.

A combination of formal and on-the-job training prepares trainee technicians with the knowledge to service and repair equipment handled by a shop. After a few months' experience, most beginners perform routine service tasks and make minor repairs. As they prove their ability and competence, they advance to harder jobs. After trainees master the repair and service of diesel engines, they learn to work on related components, such as brakes, transmissions, and electrical systems. Generally, a service technician with at least 3 to 4 years of on-the-job experience is accepted as fully qualified.

Many employers send trainee technicians to training sessions conducted by heavy equipment manufacturers. The sessions, which typically last up to 1 week, provide intensive instruction in the repair of the manufacturer's equipment. Some sessions focus on particular components found in the equipment, such as diesel engines, transmissions, axles, and electrical systems. Other sessions focus on particular types of equipment, such as crawler-loaders and crawler-dozers. As they progress, trainees may periodically attend additional training sessions. When appropriate, experienced technicians attend training sessions to gain familiarity with new technology or equipment.

High school courses in automobile repair, physics, chemistry, and mathematics provide a strong foundation for a career as a service technician or mechanic. It is also essential for technicians to be able to read and interpret service manuals in order to keep abreast of engineering changes. Experience working on diesel engines and heavy equipment acquired in the Armed Forces is valuable as well.

Voluntary certification by the National Institute for Automotive Service Excellence is recognized as the standard of achievement for heavy vehicle and mobile equipment service technicians, who may be certified as a master heavy-duty diesel technician or in a specific area of heavy-duty equipment repair, such as brakes, gasoline engines, diesel engines, drivetrains, electrical systems, or suspension and steering. For certification in each area, technicians must pass a written examination and have at least 2 years' experience. High school, vocational or trade school, or community or junior college training in gasoline or diesel engine repair may substitute for up to 1 year's experience. To remain certified, technicians must be retested every 5 years. Retesting ensures that service technicians keep up with changing technology. However, there are currently no certification programs for other heavy vehicle and mobile equipment repair specialties.

The most important work possessions of technicians are their handtools. Service technicians typically buy their own handtools, and many experienced technicians have thousands of dollars invested in them. Employers typically furnish expensive power tools, computerized engine analyzers, and other diagnostic equipment, but handtools are normally accumulated with experience.

Experienced technicians may advance to field service jobs, wherein they have a greater opportunity to tackle problems independently and earn additional pay. Technicians with leadership ability may become shop supervisors or service managers. Some technicians open their own repair shops or invest in a franchise.

Job Outlook

Opportunities for heavy vehicle and mobile equipment service technicians and mechanics should be good for those who have com-

pleted formal training programs in diesel or heavy equipment mechanics. Persons without formal training are expected to encounter growing difficulty entering these jobs.

Employment of heavy vehicle and mobile equipment service technicians and mechanics is expected to grow slower than the average for all occupations through the year 2012. Most job openings will arise from the need to replace experienced repairers who retire. Employers report difficulty finding candidates with formal postsecondary training to fill available service technician positions, because many young people with mechanic training and experience opt to take jobs as automotive service technicians, diesel service technicians, or industrial machinery repairers—jobs that offer more openings and a wider variety of locations in which to work.

Faster employment growth is expected for mobile heavy equipment mechanics than for farm equipment mechanics or railcar repairers. Increasing numbers of heavy duty and mobile equipment service technicians will be required to support growth in the construction industry, equipment dealers, and rental and leasing companies. Because of the nature of construction activity, demand for service technicians follows the Nation's economic cycle. As the economy expands, construction activity increases, resulting in the use of more mobile heavy equipment to grade construction sites, excavate basements, and lay water and sewer lines. The increased use of such equipment increases the need for periodic service and repair. In addition, the construction and repair of highways and bridges requires more technicians to service equipment. As equipment becomes more complicated, repairs increasingly must be made by specially trained technicians. Job openings for farm equipment mechanics and railcar repairers are expected to arise mostly because of replacement needs.

Construction and mining are particularly sensitive to changes in the level of economic activity; therefore, heavy and mobile equipment may be idled during downturns. In addition, winter is traditionally the slow season for construction and farming activity, particularly in cold regions. Few technicians may be needed during periods when equipment is used less; however, employers usually try to retain experienced workers. Employers may be reluctant to hire inexperienced workers during slow periods.

Earnings

Median hourly earnings of mobile heavy equipment mechanics were \$17.29 in 2002. The middle 50 percent earned between \$14.13 and \$20.88. The lowest 10 percent earned less than \$11.54, and the highest 10 percent earned more than \$24.90. Median hourly earnings in the industries employing the largest numbers of mobile heavy equipment mechanics in 2002 were as follows:

Federal Government	\$19.44
Local government	18.03
Other specialty trade contractors	17.72
Machinery, equipment, and supplies merchant wholesalers	17.10
Commercial and industrial machinery and equipment rental and leasing	15.81

Median hourly earnings of farm equipment mechanics were \$13.03 in 2002. The middle 50 percent earned between \$10.50 and \$16.01. The lowest 10 percent earned less than \$8.73, and the highest 10 percent earned more than \$18.86.

Median hourly earnings of railcar repairers were \$18.78 in 2002. The middle 50 percent earned between \$15.65 and \$21.18. The lowest 10 percent earned less than \$12.07, and the highest 10 percent earned more than \$23.76. In 2002, median hourly earnings

were \$19.72 in rail transportation, the industry employing the largest number of railcar repairers.

Many heavy vehicle and mobile equipment service technicians and mechanics are members of unions, including the International Association of Machinists and Aerospace Workers, the International Union of Operating Engineers, and the International Brotherhood of Teamsters.

Related Occupations

Workers in related repair occupations include aircraft and avionics equipment mechanics and service technicians; automotive service technicians and mechanics; diesel service technicians and mechanics; heating, air-conditioning, and refrigeration mechanics and installers; and small engine mechanics.

Sources of Additional Information

More details about job openings for heavy vehicle and mobile equipment service technicians and mechanics may be obtained from local heavy and mobile equipment dealers and distributors, construction contractors, and government agencies. Local offices of the State employment service also may have information on job openings and training programs.

For general information about a career as a heavy vehicle and mobile equipment service technician or mechanic, contact:

- ▶ The Equipment Maintenance Counsel, P.O. Box 1368, Glenwood Springs, CO 81602. Internet: <http://www.equipment.org>
- ▶ The AED Foundation (Associated Equipment Dealers affiliate), 615 W. 22nd St., Oak Brook, IL 60523. Internet: http://www.aednet.org/aed_foundation

For a directory of public training programs in heavy and mobile equipment mechanics, contact:

- ▶ SkillsUSA-VICA, P.O. Box 3000, Leesburg, VA 20177-0300. Internet: <http://www.skillsusa.org>

A list of certified diesel service technician training programs can be obtained from:

- ▶ National Automotive Technician Education Foundation (NATEF), 101 Blue Seal Dr., Suite 101, Leesburg, VA 20175. Internet: <http://www.natef.org>

Information on certification as a heavy-duty diesel service technician is available from:

- ▶ National Institute for Automotive Service Excellence (ASE), 101 Blue Seal Dr. SE., Suite 101, Leesburg, VA 20175. Internet: <http://www.asecert.org>

Home Appliance Repairers

(0*NET 49-9031.01, 49-9031.02)

Significant Points

- Repairers of small appliances commonly learn the trade on the job; repairers of large household appliances often receive their training in a formal trade school, community college, or directly from the appliance manufacturer.
- Knowledge of electronics is increasingly important.
- Job prospects are expected to be good as job openings will continue to outnumber jobseekers.

Nature of the Work

Anyone whose washer, dryer, or refrigerator has ever broken knows the importance of a dependable repair person. Home appliance repairers, often called service technicians, keep home appliances working and help prevent unwanted breakdowns. Some repairers work specifically on small appliances such as microwaves and vacuum cleaners; others specialize in major appliances such as refrigerators, dishwashers, washers, and dryers.

Home appliance repairers visually inspect appliances and check for unusual noises, excessive vibration, fluid leaks, or loose parts to determine why the appliances fail to operate properly. They use service manuals, troubleshooting guides, and experience to diagnose particularly difficult problems. Repairers disassemble the appliance to examine its internal parts for signs of wear or corrosion. They follow wiring diagrams and use testing devices such as ammeters, voltmeters, and wattmeters to check electrical systems for shorts and faulty connections.

After identifying problems, home appliance repairers replace or repair defective belts, motors, heating elements, switches, gears, or other items. They tighten, align, clean, and lubricate parts as necessary. Repairers use common handtools, including screwdrivers, wrenches, files, and pliers, as well as soldering guns and special tools designed for particular appliances. When repairing appliances with electronic parts, they may replace circuit boards or other electronic components.

When repairing refrigerators and window air-conditioners, repairers must use care to conserve, recover, and recycle chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants used in the cooling systems, as required by law. Repairers conserve the refrigerant by making sure there are no leaks in the system; they recover the refrigerant by venting it into proper cylinders; and they recycle the refrigerant, with special filter-dryers, so that it can be used again. Federal regulations also require that home appliance repairers document the capture and disposal of refrigerants.

Home appliance repairers generally install household durable goods such as refrigerators, washing machines, and cooking products. They may have to install pipes in a customer's home to connect the appliances to the gas line. They measure, lay out, cut, and thread pipe and connect it to a feeder line and to the appliance. They may have to saw holes in walls or floors and hang steel supports from beams or joists to hold gas pipes in place. Once the gas line is in place, they turn on the gas and check for leaks. *Gas appliance repairers* check the heating unit and replace tubing, thermocouples, thermostats, valves, and indicator spindles. They also answer emergency calls about gas leaks.

Repairers also answer customers' questions about the care and use of appliances. For example, they demonstrate how to load au-

tomatic washing machines, arrange dishes in dishwashers, or sharpen chain saws to maximize performance.

Repairers write up estimates of the cost of repairs for customers, keep records of parts used and hours worked, prepare bills, and collect payments. Self-employed repairers also deal with the original appliance manufacturers to recoup monetary claims for work performed on appliances still under warranty.

Working Conditions

Home appliance repairers who handle portable appliances usually work in repair shops that are generally quiet and adequately lighted and ventilated. Those who repair major appliances usually make service calls to customers' homes. They carry their tools and a number of commonly used parts with them in a truck or van for use on their service calls. Repairers may spend several hours a day driving to and from appointments and emergency calls. They may work in clean comfortable rooms such as kitchens, or in damp, dirty, or dusty areas of a home. Repairers sometimes work in cramped and uncomfortable positions when they are replacing parts in hard-to-reach areas of appliances. Repairer jobs generally are not hazardous, but workers must exercise care and follow safety precautions to avoid electrical shocks and injuries when lifting and moving large appliances. When repairing gas appliances and microwave ovens, repairers must be aware of the dangers of gas and radio frequency energy leaks.

Home appliance repairers usually work with little or no direct supervision, a feature of the job that is appealing to many people. Many home appliance repairers work a standard 40-hour week but may work overtime and weekend hours in the summer months, when they are in high demand to fix air-conditioners and refrigerators. Some repairers work early morning, evening, and weekend shifts and may remain oncall in case of emergency.

Employment

Home appliance repairers held nearly 42,000 jobs in 2002. About 41 percent of salaried repairers worked in retail trade establishments such as department stores and electronics and appliance stores. About 17 percent of repairers are self-employed. Almost every community in the country employs appliance repairers; a high concentration of jobs is found in more populated areas.



Home appliance repairers keep home appliances working and help to prevent unwanted breakdowns.

Training, Other Qualifications, and Advancement

Employers generally require a high school diploma for home appliance repairer jobs. Repairers of small appliances commonly learn the trade on the job; repairers of large household appliances often receive their training in a formal trade school, community college, or directly from the appliance manufacturer. Mechanical and electrical aptitudes are desirable, and those who work in customers' homes must be courteous and tactful.

Employers prefer to hire people with formal training in appliance repair and electronics. Many repairers complete 1- or 2-year formal training programs in appliance repair and related subjects in high schools, private vocational schools, and community colleges. Courses in basic electricity and electronics are increasingly important as more manufacturers install circuit boards and other electronic control systems in home appliances.

Whether their basic skills are developed through formal training or on the job, trainees usually receive additional training from their employer and from manufacturers. In shops that fix portable appliances, they work on a single type of appliance, such as a vacuum cleaner, until they master its repair. Then they move on to others, until they can repair all those handled by the shop. In companies that repair major appliances, beginners assist experienced repairers on service visits. They may also study on their own. They learn to read schematic drawings, analyze problems, determine whether to repair or replace parts, and follow proper safety procedures. Up to 3 years of on-the-job training may be needed for a technician to become skilled in all aspects of repair.

Some appliance manufacturers and department store chains have formal training programs that include home study and shop classes, in which trainees work with demonstration appliances and other training equipment. Many repairers receive supplemental instruction through 2- or 3-week seminars conducted by appliance manufacturers. Experienced repairers also often attend training classes and study service manuals. Repairers authorized for warranty work by manufacturers are required to attend periodic training sessions.

The U.S. Environmental Protection Agency (EPA) has mandated that all repairers who buy or work with refrigerants must be certified in their proper handling; a technician must pass a written examination to become certified to buy and handle refrigerants. Exams are administered by organizations approved by the EPA, such as trade schools, unions, and employer associations. There are even EPA-approved take-home certification exams. Though no formal training is required for certification, many of these organizations offer training programs designed to prepare workers for the certification examination.

In addition to certification required by the EPA, home appliance repairers may exhibit their competence by passing a certification examination offered by various organizations. Although voluntary, such certification can be helpful when one is seeking employment. The National Appliance Service Technician Certification (NASTeC), which is administered by the International Society of Certified Electronics Technicians (ISCET), requires repairers to pass a comprehensive examination testing their competence in the diagnosis, repair, and maintenance of major home appliances. Examinations are given in three specialty areas of appliance repair: Refrigeration and air-conditioning, cooking, or laundry and dishwashing. Although the NASTeC credential does not expire, continuing education classes are available so repairers can keep abreast of technological changes. The Professional Service Association (PSA) also administers a certification program, with goals similar to the NASTeC program. Those who pass the PSA examination earn the Certified Appliance Professional (CAP) designation, which is valid for 4 years. If certified repairers complete

at least 60 credit hours of instruction every year during the 4 years, they need not take the recertification examination. Otherwise, they must take the examination again.

Repairers in large shops or service centers may be promoted to supervisor, assistant service manager, or service manager. Some repairers advance to managerial positions such as regional service manager or parts manager for appliance or tool manufacturers. Preference is given to those who demonstrate technical competence and show an ability to get along with other workers and customers. Experienced repairers who have sufficient funds and knowledge of small-business management may open their own repair shop.

Job Outlook

Good job prospects are expected as job openings will continue to outnumber jobseekers. Many potential workers may choose not to enter this occupation because they prefer work that is less strenuous and that has more comfortable working conditions. Employment of home appliance repairers is expected to increase more slowly than average for all occupations through the year 2012. Although employment of self-employed home appliance repairers is projected to decline, employment of wage and salary workers will increase about as fast as average.

The number of home appliances in use is expected to increase with growth in the numbers of households and businesses. Appliances are also becoming more technologically advanced and will increasingly require a skilled technician to diagnose and fix problems. In recent years, many consumers have tended to purchase new appliances when existing warranties expired rather than invest in repairs on old appliances. However, over the next decade, as more consumers purchase higher priced appliances designed to have much longer lives, they will be more likely to use repair service than to purchase new appliances. Employment is relatively steady during economic downturns because there is still demand for appliance repair services. In addition to new jobs created over the 2002-12 period, openings will arise as home appliance repairers retire or transfer to other occupations.

Self employment of home appliance repairers will continue to decline due to the availability of manufacturer-sponsored training programs. Manufacturers often make these programs available only to large equipment dealers, thereby discouraging repairers from becoming self-employed or working for small shops. Many self-employed repairers are forced to join larger shops so that they can stay abreast of developments in the industry. Jobs are expected to be increasingly concentrated in larger companies as the numbers of smaller shops and family-owned businesses decline. However, repairers who maintain strong industry relationships may still go into business for themselves.

Earnings

Median annual earnings, including commission, of home appliance repairers were \$30,390 in 2002. The middle 50 percent earned between \$22,900 and \$39,800 a year. The lowest 10 percent earned less than \$18,210, and the highest 10 percent earned more than \$48,170 a year. Median annual earnings of home appliance repairers in 2002 in the electronics and appliance stores industry, which employs the largest number of these workers was \$27,340.

Earnings of home appliance repairers vary according to the skill level required to fix equipment, geographic location, and the type of equipment repaired. Because many repairers receive commission along with their salary, earnings increase along with the number of jobs a repairer can complete in a day.

Many larger dealers, manufacturers, and service stores offer typical benefits such as health insurance coverage, sick leave, and

retirement and pension programs. Some home appliance repairers belong to the International Brotherhood of Electrical Workers.

Related Occupations

Other workers who repair electrical and electronic equipment include electrical and electronics installers and repairers; electronic home entertainment equipment installers and repairers; small-engine mechanics; coin, vending, and amusement machine servicers and repairers; and heating, air-conditioning, and refrigeration mechanics and installers.

Sources of Additional Information

For general information about the work of home appliance repairers, contact:

- ▶ North American Retail Dealers Association, 10 E. 22nd St., Suite 310, Lombard, IL 60148.
- ▶ National Appliance Service Association, P.O. Box 2514, Kokomo, IN 46904.
- ▶ United Servicers Association, Inc., 6428 Coldwater Canyon Ave., North Hollywood, CA 91606.

For information on the NASTeC certification program, contact:

- ▶ International Society of Certified Electronics Technicians, 3608 Pershing Ave., Fort Worth, TX 76107. Internet: <http://www.iscet.org>

For information on the Certified Appliance Professional program, contact:

- ▶ Professional Service Association, 71 Columbia St., Cohoes, NY 12047.

Industrial Machinery Installation, Repair, and Maintenance Workers, Except Millwrights

(0*NET 49-9041.00, 49-9043.00)

Significant Points

- Highly skilled mechanics usually learn their trade through a 4-year apprenticeship program, while lower skilled maintenance workers receive short-term on-the-job training.
- Employment is projected to grow more slowly than average, but applicants with broad skills in machine repair and maintenance should have favorable job prospects.
- Unlike many other manufacturing occupations, these workers usually are not affected by seasonal changes in production.

Nature of the Work

A wide range of employees is required to keep sophisticated industrial machinery running smoothly—from highly skilled industrial machinery mechanics to lower skilled machinery maintenance workers who perform routine tasks. Their work is vital to the success of industrial facilities, not only because an idle machine will delay production, but also because a machine that is not properly repaired and maintained may damage the final product or injure an operator.

The most basic tasks in this process are performed by *machinery maintenance workers*. These employees are responsible for cleaning and lubricating machinery, performing basic diagnostic tests, checking performance, and testing damaged machine parts to determine whether major repairs are necessary. In carrying out these tasks, maintenance workers must follow machine specifications and adhere to maintenance schedules. Maintenance workers may perform minor repairs, but major repairs are generally left to machinery mechanics.

Industrial machinery mechanics, also called industrial machinery repairers or maintenance machinists, are highly skilled workers who maintain and repair machinery in a plant or factory. To do this effectively, they must be able to detect minor problems and correct them before they become major problems. For example, after hearing a vibration from a machine, the mechanic must decide whether it is due to worn belts, weak motor bearings, or some other problem. Computerized maintenance, vibration analysis techniques, and self-diagnostic systems are aiding in this task, but mechanics still need years of training and experience to perform effectively.

After diagnosing the problem, the industrial machinery mechanic disassembles the equipment to repair or replace the necessary parts. When repairing electronically controlled machinery, mechanics may work closely with electronic repairers or electricians who maintain the machine's electronic parts. (Statements on electrical and electronic installers and repairers, as well as electricians, appear elsewhere in the *Handbook*.) Increasingly, mechanics need electronic and computer skills in order to repair sophisticated equipment on their own. Once a repair is made, mechanics perform tests to ensure that the machine is running smoothly.

Although repairing machines is the primary responsibility of industrial machinery mechanics, they also may perform preventive maintenance and install new machinery. For example, they adjust and calibrate automated manufacturing equipment, such as indus-

trial robots. As plants retool and invest in new equipment, they increasingly rely on mechanics to properly situate and install the machinery. In many plants, this has traditionally been the job of millwrights, but mechanics are increasingly called upon to carry out this task. (See the statement on millwrights elsewhere in the *Handbook*.)

Industrial machinery mechanics and machinery maintenance workers use a variety of tools to perform repairs and preventive maintenance. They may use a screwdriver and wrench to adjust a motor, or a hoist to lift a printing press off the ground. When replacements for broken or defective parts are not readily available, or when a machine must be quickly returned to production, mechanics may sketch a part to be fabricated by the plant's machine shop. Mechanics use catalogs to order replacement parts and often follow blueprints and engineering specifications to maintain and fix equipment. By keeping complete and up-to-date records, mechanics try to anticipate trouble and service equipment before factory production is interrupted.

Working Conditions

In production facilities, these workers are subject to common shop injuries such as cuts, bruises, and strains. They also may work in awkward positions, including on top of ladders or in cramped conditions under large machinery, which exposes them to additional



After diagnosing a problem with an industrial machine, the industrial machinery mechanic disassembles the equipment and repairs or replaces the problem parts.

hazards. They often use protective equipment such as hardhats, safety glasses, steel-tipped shoes, hearing protectors, and belts.

Because factories and other facilities cannot afford to have industrial machinery out of service for long periods, mechanics may be called to the plant at night or on weekends for emergency repairs. Overtime is common among industrial machinery mechanics; about 33 percent work over 40 hours a week.

Employment

Industrial machinery installation, repair, and maintenance workers, except millwrights held about 289,200 jobs in 2002. Of these, 197,300 were held by the more highly skilled industrial machinery mechanics, while machinery maintenance workers accounted for 91,900 jobs. Two out of three workers were employed in the manufacturing sector, in industries such as food processing, textile mills, chemicals, fabricated metal products, motor vehicles, and primary metals. Others worked for government agencies, public utilities, mining companies, and other establishments in which industrial machinery is used.

Training, Other Qualifications, and Advancement

Machinery maintenance workers typically receive short-term on-the-job training in order to perform routine tasks, such as setting up, cleaning, lubricating, and starting machinery. This training may be offered by experienced workers, professional trainers, or product representatives.

Industrial machinery mechanics, on the other hand, often learn their trade through 4-year apprenticeship programs that combine classroom instruction with on-the-job-training. These programs usually are sponsored by a local trade union. Other mechanics start as helpers and learn the skills of the trade informally or by taking courses offered by machinery manufacturers and community colleges.

Mechanics learn from experienced repairers how to operate, disassemble, repair, and assemble machinery. Classroom instruction focuses on subjects such as shop mathematics, blueprint reading, welding, electronics, and computer training.

Employers prefer to hire those who have completed high school or technical college and have taken courses in mechanical drawing, mathematics, blueprint reading, computers, and electronics. Mechanical aptitude and manual dexterity are important characteristics for workers in this trade. Good physical conditioning and agility also are necessary because repairers sometimes have to lift heavy objects or climb to reach equipment.

Opportunities for advancement are limited. Machinery maintenance workers may gain additional skills to make more complex repairs to machinery or work as supervisors. Industrial machinery mechanics also may advance either by working with more complicated equipment or by becoming supervisors. The most highly skilled repairers can be promoted to master mechanic or can become machinists, millwrights, or tool and die makers.

Job Outlook

Employment of industrial machinery installation, repair, and maintenance workers, except millwrights is projected to grow more slowly than the average for all occupations through 2012. Nevertheless, applicants with broad skills in machine repair and maintenance should have favorable job prospects. Many mechanics are expected to retire in coming years, and employers have reported difficulty in recruiting young workers with the necessary skills to be industrial machinery mechanics. Most job openings will stem

from the need to replace workers who transfer to other occupations or who retire or leave the labor force for other reasons.

As more firms introduce automated production equipment, these workers will be needed to ensure that these machines are properly maintained and consistently in operation. However, many new machines are capable of self-diagnosis, increasing their reliability and somewhat reducing the need for repairers. Increasing imports and the relocation of production facilities abroad also are expected to dampen employment growth for these workers.

Unlike many other manufacturing occupations, industrial machinery installation, repair, and maintenance workers, except millwrights are not usually affected by seasonal changes in production. During slack periods, when some plant workers are laid off, mechanics often are retained to do major overhaul jobs and to keep expensive machinery in working order. Although these workers may face layoff or a reduced workweek when economic conditions are particularly severe, they usually are less affected than other workers because machines have to be maintained regardless of production level.

Earnings

Median hourly earnings of industrial machinery mechanics were \$18.26 in 2002. The middle 50 percent earned between \$14.62 and \$22.95. The lowest 10 percent earned less than \$11.91, and the highest 10 percent earned more than \$27.48.

Machinery maintenance workers earned less than the higher skilled machinery mechanics. Median hourly earnings of machinery maintenance workers were \$15.63 in 2002. The middle 50 percent earned between \$12.11 and \$19.81. The lowest 10 percent earned less than \$9.57, and the highest 10 percent earned more than \$24.19.

Earnings vary by industry and geographic region. Median hourly earnings in the industries employing the largest numbers of industrial machinery mechanics in 2002 are shown below:

Electric power generation, transmission, and distribution	\$26.25
Motor vehicle parts manufacturing	22.02
Local government	19.14
Converted paper products manufacturing	18.04
Machinery, equipment, and supplies merchant wholesalers	15.93

About 26 percent of industrial machinery installation, repair, and maintenance workers, except millwrights are union members. Labor unions that represent these workers include the United Steelworkers of America; the United Automobile, Aerospace, and Agricultural Implement Workers of America; the International Association of Machinists and Aerospace Workers; the United Brotherhood of Carpenters and Joiners of America; and the International Union of Electronic, Electrical, Salaried, Machine, and Furniture Workers.

Related Occupations

Other occupations that involve repairing and maintaining machinery include aircraft and avionics equipment mechanics and service technicians; automotive service technicians and mechanics; diesel service technicians and mechanics; elevator installers and repairers; heating, air-conditioning, and refrigeration mechanics and installers; heavy vehicle and mobile equipment service technicians and mechanics; machinists; maintenance and repair workers, general; millwrights; and small engine mechanics.

Sources of Additional Information

Information about employment and apprenticeship opportunities may be obtained from local employers, from local offices of the State employment service, or from:

- ▶ United Brotherhood of Carpenters and Joiners of America, 101 Constitution Ave. NW., Washington, DC 20001. Internet: <http://www.carpenters.org>
- ▶ National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: <http://www.ntma.org>

Line Installers and Repairers

(0*NET 49-9051.00, 49-9052.00)

Significant Points

- Line installers and repairers work outdoors; conditions can be hazardous.
- Line installers and repairers are trained on the job; employers prefer applicants with a technical knowledge of electricity and electronics.
- Employment is expected to grow about as fast as average.
- Earnings are higher than in most other occupations that do not require postsecondary education.

Nature of the Work

Vast networks of wires and cables provide customers with electrical power and communications services. Networks of electrical power lines deliver electricity from generating plants to customers. Communications networks of telephone and cable television lines provide voice, video, and other communications services. These networks are constructed and maintained by line installers and repairers.

Line installers, or *line erectors*, install new lines by constructing utility poles, towers, and underground trenches to carry the wires and cables. Line erectors use a variety of construction equipment, including digger derricks, trenchers, cable plows, and borers. Digger derricks are trucks equipped with augers and cranes; workers use augers to dig holes in the ground, and cranes are used to set utility poles in place. Trenchers and cable plows are used to cut openings in the earth for the laying of underground cables. Borers, which tunnel under the earth, are used to install tubes for the wire without opening a trench in the soil.

When construction is complete, line installers string cable along the poles, towers, tunnels, and trenches. While working on poles and towers, installers first use truck-mounted buckets to reach the top of the structure or physically climb the pole or tower. Next, they pull up cable from large reels mounted on trucks. The line is then set in place and pulled so that it has the correct amount of tension. Finally, line installers attach the cable to the structure using hand and hydraulic tools. When working with electrical power lines, installers bolt or clamp insulators onto the poles before attaching the cable. Underground cable is laid directly in a trench, pulled through a tunnel, or strung through a conduit running through a trench.

Other installation duties include setting up service for customers and installing network equipment. To set up service, line installers string cable between the customers' premises and the lines running on poles or towers or in trenches. They install wiring to houses and check the connection for proper voltage readings. Line installers also may install a variety of equipment. Workers on telephone and cable television lines install amplifiers and repeaters that maintain the strength of communications transmissions. Workers on electrical powerlines install and replace transformers, circuitbreakers, switches, fuses, and other equipment to control and direct the electrical current.

In addition to installation, line installers and repairers also are responsible for maintenance of electrical, telecommunications, and cable television lines. Workers periodically travel in trucks, helicopters, and airplanes to visually inspect the wires and cables. Sensitive monitoring equipment can automatically detect malfunctions on the network, such as loss of current flow. When line repairers

identify a problem, they travel to the location of the malfunction and repair or replace defective cables or equipment. Bad weather or natural disasters can cause extensive damage to networks. Line installers and repairers must respond quickly to these emergencies to restore critical utility and communications services. This can often involve working outdoors in adverse weather conditions.

Installation and repair work may require splicing, or joining together, separate pieces of cable. Each cable contains numerous individual wires; splicing the cables together requires that each wire in one piece of cable be joined to another wire in the matching piece. Line installers splice cables using small handtools, epoxy, or mechanical equipment. At each splice, they place insulation over the conductor and seal the splice with moistureproof covering.

Many communications networks now use fiber optic cables instead of conventional wire or metal cables. Fiber optic cables are made of hair-thin strands of glass, which convey pulses of light. These cables can carry much more information at higher speeds than can conventional cables. The higher transmission capacity of fiber optic cable has allowed communication networks to offer upgraded services, such as high-speed Internet access. Splicing fiber optic cable requires specialized equipment that carefully slices, matches, and aligns individual glass fibers. The fibers are joined by either electrical fusion (welding) or a mechanical fixture and gel (glue).

Working Conditions

Line installers and repairers must climb and maintain their balance while working on poles and towers. They lift equipment and work in a variety of positions, such as stooping or kneeling. Their work often requires that they drive utility vehicles, travel long distances, and work outdoors under a variety of weather conditions. Many line installers and repairers work a 40-hour week; however, emergencies may require overtime work. For example, when severe weather damages electrical and communications lines, line installers and repairers may work long and irregular hours to restore service.

Line installers and repairers encounter serious hazards on their jobs and must follow safety procedures to minimize potential danger. They wear safety equipment when entering utility holes and test for the presence of gas before going underground. Electric powerline workers have the most hazardous jobs. High-voltage powerlines can cause electrocution, and line installers and repairers must consequently use electrically insulated protective devices and tools when working with live cables. Powerlines are typically higher than telephone and cable television lines, increasing the risk of se-



Line installers work on both telecommunications and electrical lines.

vere injury due to falls. To prevent these injuries, line installers and repairers must use fall-protection equipment when working on poles or towers.

Employment

Line installers and repairers held about 268,000 jobs in 2002. Approximately 167,000 were telecommunications line installers and repairers; the remainder were electrical powerline installers and repairers. Nearly all line installers and repairers worked for telecommunications, construction or electric power generation, transmission, and distributions companies. Approximately 9,300 line installers and repairers were self-employed.

Training, Other Qualifications, and Advancement

Line installers and repairers are trained on the job, and employers require at least a high school diploma. Employers also prefer a technical knowledge of electricity, electronics, and experience obtained through vocational/technical programs, community colleges, or the Armed Forces. Prospective employees should possess a basic knowledge of algebra and trigonometry, and mechanical ability. Customer service and interpersonal skills also are important. Because the work entails lifting heavy objects (many employers require applicants to be able to lift at least 50 pounds), climbing, and other physical activity, applicants should have stamina, strength, and coordination, and must be unafraid of heights. The ability to distinguish colors is necessary because wires and cables may be color-coded.

Many community or technical colleges offer programs in telecommunications, electronics, and/or electricity. These programs often are operated with assistance from local employers and unions. Some schools, working with local companies, offer 1-year certificate programs that emphasize hands-on field work; graduates get preferential treatment in the hiring process at companies participating in the program. More advanced 2-year associate degree programs provide students with a broader knowledge of telecommunications and electrical utilities technology through courses in electricity, electronics, fiber optics, and microwave transmission.

Electrical line installers and repairers complete formal apprenticeships or employer training programs. These are sometimes administered jointly by the employer and the union representing the workers. The unions include the International Brotherhood of Electrical Workers, the Communications Workers of America, and the Utility Workers Union of America. Apprenticeship programs last up to 5 years and combine formal instruction with on-the-job training. Government safety regulations strictly define the training and education requirements for apprentice electrical line installers.

Line installers and repairers in telephone and cable television companies receive several years of on-the-job training. They also may attend training or take online courses provided by equipment manufacturers, schools, unions, or industry training organizations. The Society of Cable Television Engineers (SCTE) provides certification programs for line installers and repairers. Applicants for certification must be employed in the cable television industry and attend training sessions at local SCTE chapters.

Entry-level line installers may be hired as ground workers, helpers, or tree trimmers, who clear branches from telephone and power lines. These workers may advance to positions stringing cable and performing service installations. With experience, they may advance to more sophisticated maintenance and repair positions responsible for increasingly larger portions of the network. Promotion to supervisory or training positions also is possible, but more advanced supervisory positions often require a college diploma.

Job Outlook

Overall employment of line installers and repairers is expected to grow about as fast as the average for all occupations through 2012. Much of this increase will result from growth in the construction and telecommunications industries. With the increasing competition in electrical distribution, many companies are contracting out construction of new lines. The introduction of new technologies, especially fiber optic cable, has increased the transmission capacity of telephone and cable television networks. This higher capacity has allowed the creation of new and popular services, such as high-speed Internet access. At the same time, deregulation of the telecommunications industry has reduced barriers to competition. Competition for local phone service and demand for high-speed Internet access is forcing former local telephone companies to update and modernize their networks. In some regions, underground telephone lines may be up to 50 years old and incapable of providing advanced services. Job growth also will stem from the maintenance and modernization of telecommunications networks. Besides those due to employment growth, many job openings will result from the need to replace the large number of older workers reaching retirement age.

Employment of telecommunications line installers and repairers is expected to grow about as fast as average as telephone and cable television companies expand and improve networks that provide customers with high-speed access to data, video, and graphics. Line installers and repairers will be needed not only to construct and install networks, but also to maintain the ever-growing systems of wires and cables. The average residential customer already has more than two telephone lines. Increased demand for high-speed Internet access and multiple telephone lines will require the improvement and expansion of local telephone-line networks. However, excess transmission capacity due to the overexpansion of fiber optic lines, especially long-distance lines, in recent years should significantly reduce employment demand. The need for maintenance work will be reduced by the improved reliability of fiber optic lines. The demand for additional telephone lines also will be tempered by the increasing use of wireless telephones. Wireless networks do not require as many technicians to maintain and expand their systems, a characteristic that will reduce job growth in the industry.

Little or no growth in employment of electrical powerline installers and repairers is expected through 2012. The demand for electricity has been consistently rising, driving the expansion of powerline networks, which tends to increase employment. However, industry deregulation is pushing companies to cut costs and maintenance, which tends to reduce employment. Most new jobs are expected to arise in the construction industry. Because electrical power companies have reduced hiring and training in past years, opportunities are best for workers who possess experience and training.

Earnings

Earnings for line installers and repairers are higher than those in most other occupations that do not require postsecondary education. Median hourly earnings for electrical powerline installers and repairers were \$23.33 in 2002. The middle 50 percent earned between \$18.02 and \$27.43. The lowest 10 percent earned less than \$13.22, and the highest 10 percent earned more than \$32.08. Median hourly earnings in the industries employing the largest numbers of electrical powerline installers and repairers in 2002 are shown below:

Electric power generation, transmission and distribution	\$24.72
Wired telecommunications carriers	23.80
Local government	22.07
Utility system construction	17.22
Building equipment contractors	16.27

Median hourly earnings for telecommunications line installers and repairers were \$19.06 in 2002. The middle 50 percent earned between \$13.36 and \$24.70. The lowest 10 percent earned less than \$10.31, and the highest 10 percent earned more than \$27.70. Median hourly earnings in the industries employing the largest numbers of telephone and cable television line installers and repairers in 2002 are shown below:

Wired telecommunications carriers	\$24.20
Cable and other subscription programming	18.48
Cable and other program distribution	15.01
Building equipment contractors	15.00
Utility system construction	13.58

Most line installers and repairers belong to unions, principally the Communications Workers of America, the International Brotherhood of Electrical Workers, and the Utility Workers Union of America. For these workers, union contracts set wage rates, wage increases, and the time needed to advance from one job level to the next.

Related Occupations

Other workers who install and repair electrical and electronic equipment include broadcast and sound engineering technicians and radio operators, electricians, and radio and telecommunications equipment installers and repairers.

Sources of Additional Information

For more details about employment opportunities, contact the telephone, cable television, or electrical power companies in your community. For general information and some educational resources on line installer and repairer jobs, write to:

- ▶ Communications Workers of America, 501 3rd St. NW., Washington, DC 20001.
- ▶ International Brotherhood of Electrical Workers, Telecommunications Department, 1125 15th St. NW., Washington, DC 20005.

For training and professional certifications for those already employed by cable telecommunications firms, contact:

- ▶ Society of Cable Telecommunications Engineers, Certification Department, 140 Phillips Rd., Exton, PA 19341-1318. Internet: <http://www.scte.org>

Maintenance and Repair Workers, General

(0*NET 49-9042.00)

Significant Points

- General maintenance and repair workers are employed in almost every industry.
- Most workers are trained on the job; others learn by working as helpers to other repairers or to construction workers such as carpenters, electricians, or machinery repairers.
- Job openings should be plentiful due to significant turnover in this large occupation.

Nature of the Work

Most craft workers specialize in one kind of work, such as plumbing or carpentry. General maintenance and repair workers, however, have skills in many different crafts. They repair and maintain machines, mechanical equipment, and buildings and work on plumbing, electrical, and air-conditioning and heating systems. They build partitions, make plaster or drywall repairs, and fix or paint roofs, windows, doors, floors, woodwork, and other parts of building structures. They also maintain and repair specialized equipment and machinery found in cafeterias, laundries, hospitals, stores, offices, and factories. Typical duties include troubleshooting and fixing faulty electrical switches, repairing air-conditioning motors, and unclogging drains. New buildings sometimes have computer-controlled systems, requiring workers to acquire basic computer skills. For example, new air-conditioning systems often can be controlled from a central computer terminal. In addition, light sensors can be electronically controlled to turn off lights automatically after a set amount of time.

General maintenance and repair workers inspect and diagnose problems and determine the best way to correct them, frequently checking blueprints, repair manuals, and parts catalogs. They obtain supplies and repair parts from distributors or storerooms. Using common hand and power tools such as screwdrivers, saws, drills, wrenches, and hammers, as well as specialized equipment and electronic testing devices, these workers replace or fix worn or broken parts, where necessary, or make adjustments to correct malfunctioning equipment and machines.

General maintenance and repair workers also perform routine preventive maintenance and ensure that machines continue to run smoothly, building systems operate efficiently, and the physical condition of buildings does not deteriorate. Following a checklist, they may inspect drives, motors, and belts, check fluid levels, replace filters, and perform other maintenance actions. Maintenance and repair workers keep records of their work.

Employees in small establishments, where they are often the only maintenance worker, make all repairs, except for very large or difficult jobs. In larger establishments, their duties may be limited to the general maintenance of everything in a workshop or a particular area.

Working Conditions

General maintenance and repair workers often carry out several different tasks in a single day, at any number of locations. They may work inside of a single building or in several different buildings.

They may have to stand for long periods, lift heavy objects, and work in uncomfortably hot or cold environments, in awkward and cramped positions, or on ladders. They are subject to electrical shock, burns, falls, cuts, and bruises. Most general maintenance workers work a 40-hour week. Some work evening, night, or weekend shifts or are on call for emergency repairs.

Those employed in small establishments often operate with only limited supervision. Those working in larger establishments frequently are under the direct supervision of an experienced worker.

Employment

General maintenance and repair workers held 1.3 million jobs in 2002. They were employed in almost every industry. Around 1 in 5 worked in manufacturing industries, almost evenly distributed through all sectors. About 17 percent worked for different government bodies. Others worked for wholesale and retail firms and for real-estate firms that operate office and apartment buildings.

Training, Other Qualifications, and Advancement

Many general maintenance and repair workers learn their skills informally on the job. They start as helpers, watching and learning from skilled maintenance workers. Helpers begin by doing simple jobs, such as fixing leaky faucets and replacing lightbulbs, and progress to more difficult tasks, such as overhauling machinery or building walls. Some learn their skills by working as helpers to other repair or construction workers, including carpenters, electricians, or machinery repairers.

Necessary skills also can be learned in high school shop classes and postsecondary trade or vocational schools. It generally takes from 1 to 4 years of on-the-job training or school, or a combination of both, to become fully qualified, depending on the skill level required. Because a growing number of new buildings rely on computers to control various of their systems, general maintenance and repair workers may need basic computer skills, such as how to log onto a central computer system and navigate through a series of menus. Usually, companies that install computer-controlled equipment provide on-site training for general maintenance and repair workers.

Graduation from high school is preferred for entry into this occupation. High school courses in mechanical drawing, electricity,



General maintenance and repair workers in small establishments, where they are often the only maintenance worker, do all repairs except for very large or difficult jobs.

woodworking, blueprint reading, science, mathematics, and computers are useful. Mechanical aptitude, the ability to use shop mathematics, and manual dexterity are important. Good health is necessary because the job involves much walking, standing, reaching, and heavy lifting. Difficult jobs require problem-solving ability, and many positions require the ability to work without direct supervision.

Many general maintenance and repair workers in large organizations advance to maintenance supervisor or become a craftworker such as an electrician, a heating and air-conditioning mechanic, or a plumber. Within small organizations, promotion opportunities are limited.

Job Outlook

Job openings should be plentiful. General maintenance and repair is a large occupation with significant turnover, and many job openings should result from the need to replace workers who transfer to other occupations or stop working for other reasons.

Employment of general maintenance and repair workers is expected to grow about as fast as average for all occupations through 2012. Employment is related to the number of buildings—for example, office and apartment buildings, stores, schools, hospitals, hotels, and factories—and the amount of equipment needing maintenance and repair. However, as machinery becomes more advanced and requires less maintenance, the need for general maintenance and repair workers diminishes.

Earnings

Median hourly earnings of general maintenance and repair workers were \$14.12 in 2002. The middle 50 percent earned between \$10.61 and \$18.48. The lowest 10 percent earned less than \$8.25, and the highest 10 percent earned more than \$22.78. Median hourly earnings in the industries employing the largest numbers of general maintenance and repair workers in 2002 are shown in the following tabulation:

Local government	\$14.83
Elementary and secondary schools	14.01
Activities related to real estate	11.79
Lessors of real estate	11.64
Traveler accommodation	10.58

Some general maintenance and repair workers are members of unions, including the American Federation of State, County, and Municipal Employees and the United Automobile Workers.

Related Occupations

Some duties of general maintenance and repair workers are similar to those of carpenters; pipelayers, plumbers, pipefitters, and steamfitters; electricians; and heating, air-conditioning, and refrigeration mechanics. Other duties are similar to those of coin, vending, and amusement machine servicers and repairers; electrical and electronics installers and repairers; electronic home entertainment equipment installers and repairers; and radio and telecommunications equipment installers and repairers.

Sources of Additional Information

Information about job opportunities may be obtained from local employers and local offices of the State Employment Service.

Millwrights

(0*NET 49-9044.00)

Significant Points

- Training through apprenticeship programs, or through community colleges coupled with on-the-job training, generally lasts 4 years.
- Despite projected slower-than-average employment growth, skilled applicants should have good job opportunities.
- About 6 in 10 millwrights belong to labor unions, one of the highest rates of membership in the economy.

Nature of the Work

Millwrights install, repair, replace, and dismantle the machinery and heavy equipment used in many industries. The wide range of facilities and the development of new technology require millwrights to continually update their skills—from blueprint reading and pouring concrete to diagnosing and solving mechanical problems.

The millwright's responsibilities begin when machinery arrives at the jobsite. New equipment must be unloaded, inspected, and moved into position. To lift and move light machinery, millwrights use rigging and hoisting devices, such as pulleys and cables. With heavier equipment, they may require the assistance of hydraulic lift-truck or crane operators to position the machinery. Because millwrights often decide which device to use for moving machinery, they must know the load-bearing properties of rope, cables, hoists, and cranes.

Millwrights consult with production managers and others to determine the optimal placement of machines in a plant. When this placement requires building a new foundation, millwrights either prepare the foundation themselves or supervise its construction. As a result, they must know how to read blueprints and work with a variety of building materials.

To assemble machinery, millwrights fit bearings, align gears and wheels, attach motors, and connect belts, according to the manufacturer's blueprints and drawings. Precision leveling and alignment are important in the assembly process, so millwrights measure angles, material thickness, and small distances with tools such as squares, calipers, and micrometers. When a high level of precision is required, devices such as lasers and ultrasonic measuring tools may be used. Millwrights also work with hand and power tools, such as cutting torches, welding machines, and soldering guns, and with metalworking equipment, including lathes and grinding machines.

In addition to installing and dismantling machinery, many millwrights work with mechanics and maintenance workers to repair and maintain equipment. This includes preventive maintenance, such as lubrication and fixing or replacing worn parts. (For further information on machinery maintenance, see the statement on industrial machinery installation, repair, and maintenance workers, except millwrights, elsewhere in the *Handbook*.)

Increasingly sophisticated automation means more complicated machines for millwrights to install and maintain. For example, millwrights may install and maintain numerical control equipment—computer-controlled machine tools that fabricate manufacturing parts. This machinery requires special care and knowledge, so millwrights often work closely with computer or electronics experts, electricians, engineers, and manufacturers' representatives to install it. (Statements on electrical and electronics installers and repairers, as well as electricians, appear elsewhere in the *Handbook*.)

Working Conditions

Working conditions vary by industry. Millwrights employed in manufacturing often work in a typical shop setting and use protective equipment to avoid common hazards. For example, protective devices, such as safety belts, protective glasses, and hardhats may be worn to prevent injuries from falling objects or machinery. Those employed in construction may work outdoors in difficult weather conditions.

Millwrights work independently or as part of a team. Their tasks must be performed quickly and precisely, because disabled machinery costs a company time and money. Many millwrights work overtime; about 1 in 3 full-time millwrights report working more than 40 hours during a typical week. During power outages or other emergencies, millwrights are often assigned overtime and shift work.

Employment

Millwrights held about 69,000 jobs in 2002. Most work in manufacturing, primarily in durable goods industries, such as motor vehicle and parts manufacturing and iron and steel mills. About 36 percent of all millwrights are employed in construction, where most work for contracting firms. Although millwrights work in every State, employment is concentrated in heavily industrialized areas.

Training, Other Qualifications, and Advancement

Millwrights normally receive training for 4 years, through apprenticeship programs that combine on-the-job training with classroom



Most millwrights who work with complicated machinery need mechanical aptitude.

instruction or through community college coupled with informal on-the-job training. These programs include training in dismantling, moving, erecting, and repairing machinery. Trainees also may work with concrete and receive instruction in related skills, such as carpentry, welding, and sheet-metal work. Classroom instruction is provided in mathematics, blueprint reading, hydraulics, electricity, computers, and electronics.

Employers prefer applicants with a high school diploma or equivalency and some vocational training or experience. Courses in science, mathematics, mechanical drawing, computers, and machine shop practice are useful. Millwrights are expected to keep their skills up-to-date and may need additional training on technological advances, such as laser shaft alignment and vibration analysis.

Because millwrights assemble and disassemble complicated machinery, mechanical aptitude is very important. Strength and agility also are necessary for lifting and climbing. Millwrights need good interpersonal and communication skills to work as part of a team and to effectively give detailed instructions to others.

Advancement for millwrights usually takes the form of higher wages. Some advance to the position of supervisor or superintendent, while others may become self-employed contractors.

Job Outlook

Employment of millwrights is projected to grow more slowly than the average for all occupations through the year 2012. Because millwrights will be needed to maintain and repair existing machinery, dismantle old machinery, and install new equipment, skilled applicants should have good job opportunities. Prospects will be best for millwrights with training in installing new production technologies. In addition to employment growth, many job openings for these workers will stem from the need to replace experienced millwrights who transfer to other occupations or retire.

Employment of millwrights has historically been cyclical, rising and falling in line with investments in automation in the Nation's factories and production facilities. To remain competitive in coming years, firms will continue to require the services of millwrights to dismantle old equipment and install new machinery. Employment growth from new automation will be dampened somewhat by foreign competition and the introduction of new technologies, such as hydraulic torque wrenches, ultrasonic measuring tools, and laser shaft alignment, which allow fewer millwrights to perform more work. In addition, the demand for millwrights may be adversely affected as lower paid workers, such as electronics technicians and industrial machinery mechanics and maintenance workers, assume some installation and maintenance duties.

Earnings

Median hourly earnings of millwrights were \$20.19 in 2002. The middle 50 percent earned between \$15.77 and \$25.48. The lowest 10 percent earned less than \$12.39, and the highest 10 percent earned more than \$29.49. Earnings vary by industry and geographic location. Median hourly earnings in the industries employing the largest numbers of millwrights in 2002 are shown below.

Motor vehicle parts manufacturing	\$28.14
Building equipment contractors	19.33
Nonresidential building construction	18.98

About 60 percent of millwrights belong to labor unions, one of the highest rates of membership in the economy.

Related Occupations

To set up machinery for use in a plant, millwrights must know how to use hoisting devices and how to assemble, disassemble, and sometimes repair machinery. Other workers with similar job duties include industrial machinery installation, repair, and maintenance workers, except millwrights; aircraft and avionics equipment mechanics and service technicians; structural and reinforcing iron and metal workers; assemblers and fabricators; and heavy vehicle and mobile equipment service technicians and mechanics.

Sources of Additional Information

For further information on apprenticeship programs, write to the Apprenticeship Council of your State's labor department, local offices of your State employment service, or local firms that employ millwrights. In addition, you may contact:

- ▶ United Brotherhood of Carpenters and Joiners of America, 101 Constitution Ave. NW., Washington DC 20001. Internet: <http://www.carpenters.org>
- ▶ Associated General Contractors of America, 333 John Carlyle St., Suite 200, Alexandria, VA 22314. Internet: <http://www.agc.org>
- ▶ National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: <http://www.ntma.org>

Precision Instrument and Equipment Repairers

(0*NET 49-9061.00, 49-9062.00, 49-9063.01, 49-9063.02, 49-9063.03, 49-9063.04, 49-9064.00, 49-9069.99)

Significant Points

- Training requirements include a high school diploma and, in some cases, postsecondary education, coupled with significant on-the-job training.
- Good opportunities are expected for most types of jobs.
- Overall employment is expected to grow more slowly than average, but projected growth varies by detailed occupation.
- About 1 out of 5 is self-employed.

Nature of the Work

Repairing and maintaining watches, cameras, musical instruments, medical equipment, and other precision instruments requires a high level of skill and attention to detail. For example, some devices contain tiny gears that must be manufactured to within one one-hundredth of a millimeter of design specifications, and other devices contain sophisticated electronic controls.

Camera and photographic equipment repairers work through a series of steps in fixing a camera. The first step is determining whether a repair should be attempted, because many inexpensive cameras cost more to repair than to replace. Of the problems for which repair seems worthwhile, the most complicated or expensive are referred back to the manufacturer. If the repairers decide to proceed with the job themselves, they diagnose the problem, often by disassembling numerous small parts in order to reach the source. They then make needed adjustments or replace a defective part. Many problems are caused by the electronic circuits used in many cameras, which require an understanding of electronics. Camera repairers also maintain cameras by removing and replacing broken or worn parts and cleaning and lubricating gears and springs. Because many of the components and parts involved are extremely small, repairers must have a great deal of manual dexterity. Frequently, older camera parts are no longer available, requiring repairers to build replacement parts or to strip junked cameras. When machining new parts, workers often use a small lathe, a grinding wheel, and other metalworking tools.

Camera repairers also repair the increasingly popular digital cameras. Repairs on such cameras are similar to those for most modern cameras, but, because digital cameras have no film to wind, they have fewer moving parts.

Watch and clock repairers work almost exclusively on expensive and antique timepieces, as moderately priced timepieces are cheaper to replace than to repair. Electrically powered clocks and quartz watches and clocks function with almost no moving parts, limiting necessary maintenance to replacing the battery. Many expensive timepieces still employ old-style mechanical movements and a manual or automatic winding mechanism. This type of timepiece must be regularly adjusted and maintained. Repair and maintenance work on a mechanical timepiece requires using handtools to disassemble many fine gears and components. Each part is inspected for signs of wear. Some gears or springs may need to be replaced or machined. Exterior portions of the watch may require polishing and buffing. Specialized machines are used to clean all

of the parts with ultrasonic waves and a series of baths in cleaning agents. Reassembling a watch requires lubricating key parts.

As with older cameras, replacement parts are frequently unavailable for antique watches or clocks. In such cases, watch repairers must machine their own parts. They employ small lathes and other machines in creating tiny parts.

Musical instrument repairers and tuners combine their love of music with a highly skilled craft. Musical instrument repairers and tuners, often referred to as technicians, work in four specialties: Band instruments, pianos and organs, violins, and guitars. (Repairers and tuners who work on electronic organs are discussed in the *Handbook* statement on electronic home entertainment equipment installers and repairers.)

Band instrument repairers, brass and wind instrument repairers, and percussion instrument repairers focus on woodwind, brass, reed, and percussion instruments damaged through deterioration or by accident. They move mechanical parts or play scales to find problems. They may unscrew and remove rod pins, keys, worn cork pads, and pistons and remove soldered parts using gas torches. They repair dents in metal and wood using filling techniques or a mallet. These repairers use gas torches, grinding wheels, lathes, shears, mallets, and small handtools and are skilled in metalworking and woodworking. Percussion instrument repairers often must install new drumheads, which are cut from animal skin.

Violin repairers and guitar repairers adjust and repair stringed instruments. Some repairers work on both stringed and band in-



Some musical instrument repairers and tuners specialize in stringed instruments.

struments. Initially, repairers play and inspect the instrument to find any defects. They replace or repair cracked or broken sections and damaged parts. They also restring the instruments and repair damage to their finish.

Piano tuners and repairers use similar techniques, skills, and tools. Most workers in this group are piano tuners, tuning and making minor repairs. Tuning involves tightening and loosening different strings to achieve the proper tone or pitch. Because pianos are difficult to transport, tuners normally make house calls. Some repairers specialize in restoring older pianos. Restoration is complicated work, often involving replacing many of the more than 12,000 parts in some pianos. With proper maintenance and restoration, pianos often survive more than 100 years.

Pipe organ repairers do work similar to that of piano repairers, but on a larger scale. Additionally, they assemble new organs. Because pipe organs are too large to transport, they must be assembled onsite. Even with repairers working in teams or with assistants, the organ assembly process can take several weeks or even months, depending upon the size of the organ.

Medical equipment repairers and *other precision instrument and equipment repairers* maintain, adjust, calibrate, and repair electronic, electromechanical, and hydraulic equipment. They use various tools, including multimeters, specialized software, and computers designed to communicate with specific pieces of hardware. Some of their tools are specialized, such as equipment designed to simulate water or air pressure. These repairers use handtools, soldering irons, and other electronic tools to repair and adjust the equipment. Faulty circuit boards and other parts are normally removed and replaced. Medical equipment and other precision instrument repairers must maintain careful, detailed logs of all maintenance and repair on each piece of equipment.

Medical equipment repairers, often called *biomedical equipment technicians*, work on medical equipment such as defibrillators, heart monitors, medical imaging equipment (x rays, CAT scanners, and ultrasound equipment), and electric wheelchairs.

Other precision instrument and equipment repairers service, repair, and replace a wide range of equipment associated with automated or instrument-controlled manufacturing processes. A precision instrument repairer working at an electric powerplant, for example, would repair and maintain instruments that monitor the operation of the plant, such as pressure and temperature gauges. Replacement parts are not always available, so repairers sometimes machine or fabricate a new part. Preventive maintenance involves regular lubrication, cleaning, and adjustment of many measuring devices.

Working Conditions

Camera, watch, and musical instrument repairers work under fairly similar solitary, low-stress conditions with minimal supervision. A quiet, well-lighted workshop or repair shop is typical, while a few of these repairers travel to the instrument being repaired, such as a piano, organ, or grandfather clock.

Medical equipment and precision instrument and equipment repairers normally work daytime hours, but are often expected to be on call. But, like other hospital and factory employees, some repairers work irregular hours. Precision instrument repairers work under a wide array of conditions, from hot, dirty, noisy factories to air-conditioned workshops to outdoor fieldwork. Attention to safety is essential, as the work sometimes involves dangerous machinery or toxic chemicals. Due to the individual nature of the work, supervision is fairly minimal.

Employment

Precision instrument and equipment repairers held 64,000 jobs in 2002. Medical equipment repairers often work for hospitals or wholesale equipment suppliers, while precision instrument repairers, all other, often work for manufacturing companies and durable goods wholesalers. About 1 out of 5 precision instrument and equipment repairers was self-employed—they may own jewelry, camera, medical equipment, or music stores. The following tabulation presents employment by detailed occupation:

Medical equipment repairers	29,000
Camera and photographic equipment repairers	6,900
Musical instrument repairers and tuners	6,200
Watch repairers	4,800
All other precision instrument and equipment repairers	17,000

Training, Other Qualifications, and Advancement

Most employers require at least a high school diploma for beginning precision instrument and equipment repairers. Many employers prefer applicants with some postsecondary education. Much training takes place on the job. The ability to read and understand technical manuals is important. Necessary physical qualities include good fine motor skills and vision. Also, precision equipment repairers must be able to pay close attention to details, enjoy problem solving, and have the desire to disassemble machines to see how they work. Most precision equipment repairers must be able to work alone with minimal supervision.

The educational background required for camera and photographic equipment repairers varies, but some knowledge of electronics is necessary. Some workers complete postsecondary training, such as an associate degree, in this field. The job requires the ability to read an electronic schematic diagram and comprehend other technical information, in addition to good manual dexterity. New employees are trained on the job in two stages over about a year. First, they assist a senior repairer for about 6 months. Then, they refine their skills by performing repairs on their own for an additional 6 months. Finally, repairers continually hone and improve their skills by attending manufacturer-sponsored seminars on the specifics of particular models.

Training also varies for watch and clock repairers. Several associations, including the American Watchmakers-Clockmakers Institute (AWI) and the National Association of Watch and Clock Collectors, offer certifications. Some certifications can be completed in a few months; some require simply passing an examination; and the most demanding certifications require 3,000 hours, over 2 years, of classroom time in technical institutes or colleges. Clock repairers generally require less training than do watch repairers because watches have smaller components and require greater precision. Some repairers opt to learn through assisting a master watch repairer. Nevertheless, developing proficiency in watch or clock repair requires several years of education and experience.

For musical instrument repairers and tuners, employers prefer people with post-high school training in music repair technology. According to a Piano Technicians Guild membership survey, the overwhelming majority of respondents had completed at least some college work; most had a bachelor's or higher degree, although not always in music repair technology. Almost all repairers have a strong musical background. A basic ability to play the instruments being repaired is helpful, but not always required. A few technical schools and colleges offer courses in instrument repair, and correspondence courses also are common. Graduates of these programs normally receive additional training on the job, working with an experienced repairer. A few musical instrument repairers and tuners begin learning their trade on the job as assistants or apprentices. Trainees per-

form a variety of tasks around the shop. Full qualification usually requires 2 to 5 years of training and practice.

Medical equipment repairers are trained in a similar manner. An associate degree in electronics or medical technology is helpful, but not always required. The required training varies by specialty. On-the-job training, for those with a background in electronics, is more common for workers repairing less critical equipment such as hospital beds or electric wheelchairs. An associate or even a bachelor's degree, often in medical technology or engineering, and a passing grade on a certification exam is likely to be required of persons repairing more critical equipment such as CAT scanners and defibrillators. Some repairers are trained in the military. New repairers begin by observing and assisting an experienced worker over a period of 3 to 6 months. Gradually, they begin working independently, while still under close supervision.

Educational requirements for other precision instrument and equipment repair jobs also vary, but include a high school diploma, with a focus on mathematics and science courses. Most employers require an associate or sometimes a bachelor's degree in instrumentation and control, electronics, or a related engineering field, as repairers need to understand blueprints, electrical schematic diagrams, and electrical, hydraulic, and electromechanical systems. In addition to formal education, a year or two of on-the-job training is required before a repairer is considered fully qualified. Some advancement opportunities exist, but many supervisory positions require a bachelor's degree.

Job Outlook

Good opportunities are expected for most types of precision instrument and equipment repairer jobs. Overall employment growth is projected to be slower than the average for all occupations over the 2002-12 period. However, projected growth varies by detailed occupation.

Job growth among medical equipment repairers should be about as fast as the average for all occupations over the projected period. The rapidly expanding healthcare industry and elderly population should spark demand for increasingly sophisticated medical equipment and, in turn, create good employment opportunities in this occupation.

On the other hand, employment of musical instrument repairers is expected to increase more slowly than the average. Replacement needs will provide the most job opportunities as many repairers and tuners are expected to retire. While an increase in the number of school-age children involved with music should spur demand for repairers, music must compete with other extracurricular activities and interests. Without new musicians, there will be a slump in instrument rentals, purchases, and repairs. Because training in the repair of musical instruments is difficult to obtain—there are only a few schools that offer training programs, and few experienced workers are willing to take on apprentices—opportunities should be good for those who receive training.

Employment of camera and photographic equipment repairers is expected to decline. The popularity of inexpensive cameras adversely affects employment in this occupation, as most point-and-shoot cameras are cheaper to replace than repair. The rapid technological progress in digital cameras also has hurt the job prospects of repairers. When a digital camera breaks, not only is replacing the camera often not much more expensive, but the new model is also far more advanced.

Employment of watch repairers is expected to increase more slowly than the average. Over the past few decades, changes in technology, including the invention of digital and quartz watches that need few repairs, caused a significant decline in the demand for

watch repairers. In recent years, this trend was somewhat reversed, as the growing popularity of expensive mechanical watches increased the need for watch repairers. While the demand for watch repairers has risen, however, few new repairers have entered the field. The small number of entrants, coupled with the fact that a large proportion of watch and clock repairers are approaching retirement age, should result in very good job opportunities in this field.

The projected slower-than-average employment growth of other precision instrument and equipment repairers reflects the expected lack of employment growth in manufacturing and other industries in which they are employed. Nevertheless, good employment opportunities are expected for these precision instrument and equipment repairers due to the relatively small number of people entering the occupation and the need to replace repairers who retire.

Earnings

The following tabulation shows median hourly earnings for various precision instrument and equipment repairers in 2002. Earnings ranged from less than \$7.59 for the lowest 10 percent of watch repairers, to more than \$30.68 for the highest 10 percent of precision instrument and equipment repairers, all other. Median hourly earnings of all precision instrument and equipment repairers by occupation are:

Precision instrument and equipment repairers, all other	\$21.20
Medical equipment repairers	17.49
Camera and photographic equipment repairers	15.09
Musical instrument repairers and tuners	14.15
Watch repairers	12.77

Earnings within the different occupations vary significantly, depending upon skill levels. For example, a watch and clock repairer may simply change batteries and replace worn wrist straps, while highly skilled watch and clock repairers, with years of training and experience, may rebuild and replace worn parts. According to a survey by the American Watchmakers-Clockmakers Institute, the median annual earnings of highly skilled watch and clock repairers were about \$42,500 in 2001.

Related Occupations

Many precision instrument and equipment repairers work with precision mechanical and electronic equipment. Other workers who repair precision mechanical and electronic equipment include computer, automated teller, and office machine repairers and coin, vending, and amusement machine servicers and repairers. Other workers who make precision items include dental laboratory technicians and ophthalmic laboratory technicians. Some precision instrument and equipment repairers work with a wide array of industrial equipment. Their work environment and responsibilities are similar to those of industrial machinery installation, maintenance, and repair workers. Much of the work of watch repairers is similar to that of jewelers and precious stone and metal workers. Camera repairers' work is similar to that of electronic home entertainment equipment installers and repairers; both occupations work with consumer electronics that are based around a circuit board, but that also involve numerous moving mechanical parts.

Sources of Additional Information

For more information about camera repair careers, contact:

► National Association of Photographic Equipment Technicians (NAPET), 3000 Picture Pl., Jackson, MI 49201.

For information on musical instrument repair, including schools offering training, contact:

► National Association of Professional Band Instrument Repair Technicians (NAPBIRT), P.O. Box 51, Normal, IL 61761. Internet: <http://www.napbirt.org>

For additional information on piano tuning and repairwork, contact:

► Piano Technicians Guild, 3930 Washington St., Kansas City, MO 64111-2963. Internet: <http://www.ptg.org>

For information about training, mentoring programs, employers, and schools with programs in precision instrumentation, automation, and control, contact:

► ISA-The Instrumentation, Systems, and Automation Society, 67 Alexander Dr., P.O. Box 12277, Research Triangle Park, NC 27709. Internet: <http://www.isa.org>

For information about watch and clock repair and a list of schools with related programs of study, contact:

► American Watchmakers-Clockmakers Institute (AWI), 701 Enterprise Dr., Harrison, OH 45030-1696. Internet: <http://www.awi-net.org>

For information about medical equipment technicians and a list of schools with related programs of study, contact:

► Association for the Advancement of Medical Instrumentation (AAMI), 1110 North Glebe Rd., Arlington, VA 22201-4795. Internet: <http://www.aami.org>

Radio and Telecommunications Equipment Installers and Repairers

(0*NET 49-2021.00, 49-2022.01, 49-2022.02, 49-2022.03, 49-2022.04, 49-2022.05)

Significant Points

- Employment is projected to decline.
- Applicants with electronics training and computer skills should have the best opportunities.
- Weekend and holiday hours are common; repairers may be on call around the clock in case of emergencies.

Nature of the Work

Telephones and radios depend on a variety of equipment to transmit communications signals. Electronic switches route telephone signals to their destinations. Switchboards direct telephone calls within a single location or organization. Radio transmitters and receivers relay signals from wireless phones and radios to their destinations. Newer telecommunications equipment is computerized and can communicate a variety of information, including data, graphics, and video. The workers who set up and maintain this sophisticated equipment are radio and telecommunications equipment installers and repairers.

Central office installers set up switches, cables, and other equipment in central offices. These locations are the hubs of a telecommunications network—they contain the switches and routers that direct packets of information to their destinations. Although most telephone lines connecting houses to central offices and switching stations are still copper, the lines connecting these central hubs are fiber optic. Fiber optic lines have led to a revolution in switching equipment. The greatly increased transmission capacity of each line has allowed a few fiber optic lines to replace many copper lines. Packet switching equipment is evolving rapidly, ever increasing the amount of information that a single fiber optic line can carry. These switches and routers have the ability to transmit, process, amplify, and direct a massive amount of information. Installing and maintaining this equipment requires a high level of technical knowledge.

The increasing reliability of telephone switches and routers has simplified maintenance. New telephone switches are self-monitoring and alert repairers to malfunctions. Some switches allow repairers to diagnose and correct problems from remote locations. When faced with a malfunction, the repairer may refer to manufacturers' manuals that provide maintenance instructions.

When problems with telecommunications equipment arise, telecommunications equipment repairers diagnose the source of the problem by testing each of the different parts of the equipment, which requires an understanding of how the software and hardware interact. Repairers often use spectrum and/or network analyzers to locate the problem. A network analyzer sends a signal through the equipment to detect any distortion in the signal. The nature of the signal distortion often directs the repairer to the source of the problem. To fix the equipment, repairers may use small handtools, including pliers and screwdrivers, to remove and replace defective components such as circuit boards or wiring. Newer equipment is easier to repair because whole boards and parts are designed to be quickly removed and replaced. Repairers also may install updated software or programs that maintain existing software.

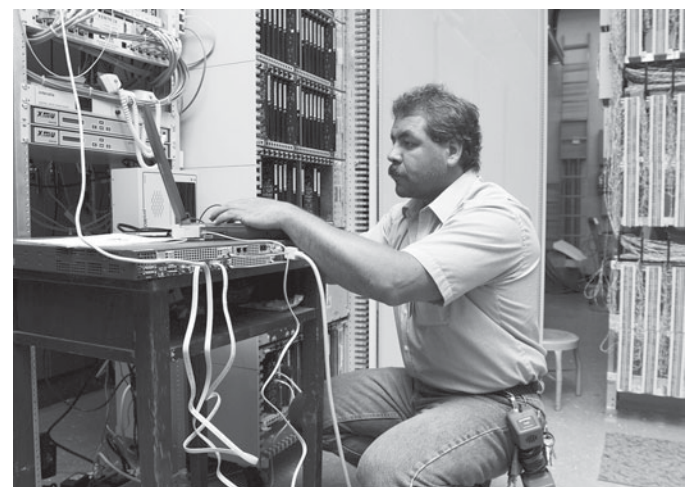
PBX installers and repairers set up private branch exchange (PBX) switchboards, which relay incoming, outgoing, and interof-

fice calls within a single location or organization. To install switches and switchboards, installers first connect the equipment to power lines and communications cables and install frames and supports. They test the connections to ensure that adequate power is available and that the communication links function. They also install equipment such as power systems, alarms, and telephone sets. New switches and switchboards are computerized; workers install software or program the equipment to provide specific features. For example, as a cost-cutting feature, an installer may program a PBX switchboard to route calls over different lines at different times of the day. However, other workers, such as computer support specialists generally handle complex programming. (The work of computer support specialists is described in the *Handbook* statement on computer support specialists and systems administrators.) Finally, the installer performs tests to verify that the newly installed equipment functions properly. If a problem arises, PBX repairers determine whether it is located within the PBX system or originates in the telephone lines maintained by the local phone company.

Due to rapidly developing technologies, PBX installers must adapt and learn new technologies. Instead of installing PBX systems, many companies are choosing to install voice-over Internet protocol (VoIP) systems. VoIP systems operate like a PBX system, but they use a company's computer wiring to run Internet access, network applications, and telephone communications. Specialized phones have their own Internet protocol (IP) addresses. The phones can be plugged into any port in the system and still use the same number.

Station installers and repairers, telephone—commonly known as *telephone installers and repairers* or *telecommunications service technicians*—install and repair telephone wiring and equipment on customers' premises. They install telephone or digital subscriber line (DSL) service by connecting customers' telephone wires to outside service lines. These lines run on telephone poles or in underground conduits. The installer may climb poles or ladders to make the connections. Once the connection is made, the line is tested. When a maintenance problem occurs, repairers test the customers' lines to determine if the problem is located in the customers' premises or in the outside service lines. When onsite procedures fail to resolve installation or maintenance problems, repairers may request support from their technical service center. Line installers and repairers, covered elsewhere in the *Handbook*, install the wires and cables that connect customers with central offices.

Radio mechanics install and maintain radio transmitting and receiving equipment. This includes stationary equipment mounted



Telecommunications equipment repairers set up, adjust, and maintain central-office switches and routers.

on transmission towers and mobile equipment, such as radio communications systems in service and emergency vehicles. Radio mechanics do not work on cellular communications towers and equipment. Newer radio equipment is self-monitoring and may alert mechanics to potential malfunctions. When malfunctions occur, these mechanics examine equipment for damaged components and loose or broken wires. They use electrical measuring instruments to monitor signal strength, transmission capacity, interference, and signal delay, as well as handtools to replace defective components and parts and to adjust equipment so that it performs within required specifications.

Working Conditions

Radio and telecommunications equipment installers and repairers generally work in clean, well-lit, air-conditioned surroundings, such as a telephone company's central office, a customer's PBX location, or an electronic repair shop or service center. Telephone installers and repairers work on rooftops, ladders, and telephone poles. Telephone and PBX installers must travel to a customer's location. Radio mechanics may maintain equipment located on the tops of transmission towers. While working outdoors, these workers are subject to a variety of weather conditions.

Nearly all radio and telecommunications equipment installers and repairers work full time. Many work regular business hours to meet the demand for repair services during the workday. Schedules are more irregular at companies that need repair services 24 hours a day or where installation and maintenance must take place after business hours. At these locations, mechanics work a variety of shifts, including weekend and holiday hours. Repairers may be on call around the clock, in case of emergencies, and may have to work overtime.

The work of most repairers involves lifting, reaching, stooping, crouching, and crawling. Adherence to safety precautions is important in order to guard against work hazards. These hazards include falls, minor burns, electrical shock, and contact with hazardous materials.

Employment

Radio and telecommunications equipment installers and repairers held about 226,000 jobs in 2002. About 219,000 were telecommunications equipment installers and repairers, except line installers, mostly working in the telecommunications industry, and the rest were radio mechanics. Radio mechanics worked in electronic and precision equipment repair and maintenance, telecommunications, electronics and appliance stores, and many other industries.

Training, Other Qualifications, and Advancement

Most employers seek applicants with postsecondary training in electronics and a familiarity with computers. Training sources include 2- and 4-year college programs in electronics or communications, trade schools, and equipment and software manufacturers. Military experience with communications equipment is valued by many employers. Many equipment repairers begin working in telecommunications companies as line-installers or telephone installers, before moving up to the job of central office installer and other more complex work.

Newly hired repairers usually receive some training from their employers. This may include formal classroom training in electronics, communications systems, or software and informal hands-on training assisting an experienced repairer. Large companies may send repairers to outside training sessions to keep them informed about new equipment and service procedures. As networks have become more sophisticated—often including equipment from a va-

riety of companies—the knowledge needed for installation and maintenance also has increased.

Telecommunications equipment companies provide much of the training on specific equipment. With the rapid advances in switches, routers, and other equipment, repairers need to continually take courses and work to obtain manufacturers' certifications on the latest technology.

Repairers must be able to distinguish colors, because wires are color-coded, and they must be able to hear distinctions in the various tones on a telephone system. For positions that require climbing poles and towers, workers must be in good physical shape. Repairers who handle assignments alone at a customer's site must be able to work without close supervision. For workers who frequently contact customers, a pleasant personality, neat appearance, and good communications skills also are important.

Experienced repairers with advanced training may become specialists or troubleshooters who help other repairers diagnose difficult problems, or may work with engineers in designing equipment and developing maintenance procedures. Because of their familiarity with equipment, repairers are particularly well qualified to become manufacturers' sales workers. Workers with leadership ability also may become maintenance supervisors or service managers. Some experienced workers open their own repair services or shops, or become wholesalers or retailers of electronic equipment.

Job Outlook

Employment of radio and telecommunications equipment installers and repairers is expected to decline through 2012. Although the need for installation work will remain as companies seek to upgrade their telecommunications networks, there will be a declining need for maintenance work—performed by telecommunications equipment installers and repairers, except line installers—because of increasingly reliable self-monitoring and self-diagnosing equipment and because installation of higher capacity equipment will reduce the amount of equipment needed. The replacement of two-way radio systems with wireless systems, especially in service vehicles, will eliminate the need in many companies for onsite radio mechanics. The increased reliability of wireless equipment and the use of self-monitoring systems also will continue to lessen the need for radio mechanics. Applicants with electronics training and computer skills should have the best opportunities for radio and telecommunications equipment installer and repairer jobs.

Job opportunities will vary by specialty. For example, opportunities should be available for central office and PBX installers and repairers experienced in current technology, as the growing popularity of VoIP, expanded multimedia offerings such as video on demand, and other telecommunications services continue to place additional demand on telecommunications networks. These new services require high data transfer rates, which can be achieved only by installing new optical switching and routing equipment. Extending high-speed communications from central offices to customers also will require the installation of more advanced switching and routing equipment. Whereas increased reliability and automation of switching equipment will limit opportunities, these effects will be somewhat offset by the demand for installation and upgrading of switching equipment.

Station installers and repairers can expect keen competition. Prewired buildings and the increasing reliability of telephone equipment will reduce the need for installation and maintenance of customers' telephones. Upgrading internal lines in businesses and the wiring of new homes and businesses with fiber optic lines should offset some of these losses. As cellular telephones have increased in popularity, the number of pay phones is declining, which also

will adversely affect employment of station installers and repairers as pay phone installation and maintenance is one of their major functions.

Earnings

In 2002, median hourly earnings of telecommunications equipment installers and repairers, except line installers were \$22.78. The middle 50 percent earned between \$18.07 and \$26.38. The bottom 10 percent earned less than \$13.27, whereas the top 10 percent earned more than \$29.09. Median hourly earnings in the wired telecommunications carriers (telephone) industry were \$24.07 in 2002.

Median hourly earnings of radio mechanics in 2002 were \$17.42. The middle 50 percent earned between \$13.17 and \$22.78. The bottom 10 percent earned less than \$10.34, whereas the top 10 percent earned more than \$28.38.

Related Occupations

Related occupations that involve work with electronic equipment include broadcast and sound engineering technicians and radio operators; computer, automated teller, and office machine repairers; electronic home entertainment equipment installers and repairers; and electrical and electronics installers and repairers. Line installers and repairers also set up and install telecommunications equipment. Engineering technicians also may repair electronic equipment as part of their duties.

Sources of Additional Information

For information on career and training opportunities, contact:

- ▶ International Brotherhood of Electrical Workers, Telecommunications Department, 1125 15th St. NW., Room 807, Washington, DC 20005.
- ▶ Communications Workers of America, 501 3rd St. NW., Washington, DC 20001.

For information on careers and schools, contact:

- ▶ Electronics Technicians Association International, 5 Depot St., Greencastle, IN 46135.

For information on training and professional certifications for those already employed by cable telecommunications firms, contact:

- ▶ Society of Cable Telecommunications Engineers, Certification Department, 140 Phillips Rd., Exton, PA 19341-1318. Internet: <http://www.scte.org>

Small Engine Mechanics

(0*NET 49-3051.00, 49-3052.00, 49-3053.00)

Significant Points

- Employment is expected to grow as fast as the average for all occupations, and persons with formal training as a mechanic should enjoy good job prospects.
- The use of motorcycles, motorboats, and outdoor power equipment is seasonal in many areas, so mechanics may service other types of equipment or work reduced hours in the winter.

Nature of the Work

Small engines powering motorcycles, motorboats, and outdoor power equipment share many characteristics with their larger counterparts, including breakdowns. Small engine mechanics repair and service power equipment ranging from racing motorcycles to chain saws.

Like large engines, small engines require periodic service to minimize the chance of breakdowns and to keep them operating at peak performance. During routine equipment maintenance, mechanics follow a checklist that includes the inspection and cleaning of brakes, electrical systems, fuel injection systems, plugs, carburetors, and other parts. Following inspection, mechanics usually repair or adjust parts that do not work properly or replace unfixable parts. Routine maintenance is normally a major part of the mechanic's work.

When a piece of equipment breaks down, mechanics use various techniques to diagnose the source and extent of the problem. The mark of a skilled mechanic is the ability to diagnose mechanical, fuel, and electrical problems and to make repairs in a minimal amount of time. Quick and accurate diagnosis requires problem-solving ability and a thorough knowledge of the equipment's operation.

In larger repair shops, mechanics may use special computerized diagnostic testing equipment as a preliminary tool in analyzing equipment. This computerized equipment provides a systematic performance report of various components to compare against normal ratings. After pinpointing the problem, the mechanic makes the needed adjustments, repairs, or replacements. Some jobs require minor adjustments or the replacement of a single item, such as a carburetor or fuel pump. In contrast, a complete engine overhaul requires a number of hours to disassemble the engine and replace worn valves, pistons, bearings, and other internal parts. Some highly skilled mechanics use highly specialized components and the latest computerized equipment to customize and tune motorcycles and motorboats for racing.

Small engine mechanics use common handtools, such as wrenches, pliers, and screwdrivers. They also utilize power tools, such as drills and grinders, when customized repairs warrant their use. Computerized engine analyzers, compression gauges, ammeters and voltmeters, and other testing devices help mechanics locate faulty parts and tune engines. Hoists may be used to lift heavy equipment such as motorcycles, snowmobiles, or motorboats. Mechanics often refer to service manuals for detailed directions and specifications while performing repairs.

Motorcycle mechanics repair and overhaul motorcycles, motor scooters, mopeds, dirt bikes, and all-terrain vehicles. Besides repairing engines, they may work on transmissions, brakes, and ignition systems and make minor body repairs. Mechanics usually

specialize in the service and repair of one type of equipment, although they may work on closely related products. Mechanics may service just a few makes and models of motorcycles, because dealers usually service only the products they sell.

Motorboat mechanics, or marine equipment mechanics, repair and adjust the electrical and mechanical equipment of inboard and outboard boat engines. Most small boats have portable outboard engines that are removed and brought into the repair shop. Larger craft, such as cabin cruisers and commercial fishing boats, are powered by diesel or gasoline inboard or inboard-outboard engines, which are removed only for major overhauls. Most of these repairs are performed at the docks or marinas. Motorboat mechanics also may work on propellers, steering mechanisms, marine plumbing, and other boat equipment.

Outdoor power equipment and other small engine mechanics service and repair outdoor power equipment, such as lawnmowers, garden tractors, edge trimmers, and chain saws. They also may occasionally work on portable generators and go-carts. In addition, small engine mechanics in northern parts of the country may work on snowblowers and snowmobiles, but demand for this type of repair is seasonal.

Working Conditions

Small engine mechanics usually work in repair shops that are well lighted and ventilated, but are sometimes noisy when engines are tested. Motorboat mechanics may work outdoors at docks or marinas, as well as in all weather conditions, when making repairs aboard boats. They may work in cramped or awkward positions to reach a boat's engine.

During the winter months in the northern United States, mechanics may work fewer than 40 hours a week, because the amount of repair and service work declines when lawnmowers, motorboats, and motorcycles are not in use. Many mechanics work only during the busy spring and summer seasons. However, many schedule time-consuming engine overhauls or work on snowmobiles and snowblowers during winter downtime. Mechanics may work considerably more than 40 hours a week when demand is strong.

Employment

Small engine mechanics held about 67,000 jobs in 2002. Motorcycle mechanics held around 15,000 jobs. Motorboat mechanics



Small engine mechanics inspect and clean engine parts during routine equipment maintenance.

held approximately 22,000 and outdoor power equipment and other small engine mechanics about 30,000. Almost half worked for other motor vehicle dealers, an industry that includes retail dealers of motorcycles, boats, and miscellaneous vehicles; or for retail hardware, lawn, and garden stores. Most of the remainder were employed by independent repair shops, marinas and boatyards, equipment rental companies, wholesale distributors, and landscaping services. About 15 percent were self-employed, compared to about 6 percent of workers in all installation, maintenance, and repair occupations.

Training, Other Qualifications, and Advancement

Due to the increasing complexity of motorcycles and motorboats, most employers prefer to hire mechanics who graduate from formal training programs for small engine mechanics. Because the number of these specialized postsecondary programs is limited, most mechanics learn their skills on the job or while working in related occupations. For trainee jobs, employers hire persons with mechanical aptitude who are knowledgeable about the fundamentals of small two- and four-stroke engines. Many trainees develop an interest in mechanics and acquire some basic skills through working on automobiles, motorcycles, motorboats, or outdoor power equipment as a hobby. Others may be introduced to mechanics through vocational automotive training in high school or one of many postsecondary institutions.

Trainees learn routine service tasks under the guidance of experienced mechanics by replacing ignition points and spark plugs or by taking apart, assembling, and testing new equipment. As they gain experience and proficiency, trainees progress to more difficult tasks, such as advanced computerized diagnosis and engine overhauls. Up to 3 years of on-the-job training may be necessary before a novice worker becomes competent in all aspects of the repair of motorcycle and motorboat engines.

Employers often send mechanics and trainees to special courses conducted by motorcycle, motorboat, and outdoor power equipment manufacturers or distributors. These courses, which last as long as 2 weeks, upgrade the worker's skills and provide information on repairing new models. They are usually a prerequisite for any mechanic who performs warranty work for manufacturers or insurance companies.

Most employers prefer to hire high school graduates for trainee mechanic positions, but will accept applicants with less education if they possess adequate reading, writing, and arithmetic skills. Many equipment dealers employ students part time and during the summer to help assemble new equipment and perform minor repairs. Helpful high school courses include small engine repair, automobile mechanics, science, and business arithmetic.

Knowledge of basic electronics is essential for small engine mechanics, because electronic components control an engine's performance, the vehicle's instrument displays, and a variety of other functions of motorcycles, motorboats, and outdoor power equipment.

The most important work possessions of mechanics are their handtools. Mechanics usually provide their own tools, and many experienced mechanics have invested thousands of dollars in them. Employers typically furnish expensive power tools, computerized engine analyzers, and other diagnostic equipment, but mechanics accumulate handtools with experience.

The skills used as a small engine mechanic generally transfer to other occupations, such as automobile, diesel, or heavy vehicle and mobile equipment mechanics. Experienced mechanics with leadership ability may advance to shop supervisor or service manager jobs.

Mechanics with sales ability sometimes become sales representatives or open their own repair shops.

Job Outlook

Employment of small engine mechanics is expected to grow about as fast as the average for all occupations through the year 2012. Most of the job openings are expected to be replacement jobs, because many experienced small engine mechanics are expected to transfer to other occupations, retire, or stop working for other reasons. Job prospects should be especially favorable for persons who complete mechanic training programs.

Growth of personal disposable income over the 2002-12 period should provide consumers with more discretionary dollars to buy motorboats, lawn and garden power equipment, and motorcycles. This type of spending will require more mechanics to keep the growing amount of equipment in operation. In addition, routine service will always be a significant source of work for mechanics. While advancements in technology will lengthen the interval between checkups, the need for qualified mechanics to perform this service will increase.

Employment of motorcycle mechanics should increase as the popularity of motorcycles rebounds. Motorcycle usage should continue to be popular with persons between 18 and 24 years, an age group that historically has had the greatest proportion of motorcycle enthusiasts. Motorcycles also are becoming increasingly popular with persons over the age of 40. Traditionally, this group has more disposable income to spend on recreational equipment such as motorcycles and motorboats.

Over the next decade, more people will be entering the 40-and-older age group, the group responsible for the largest segment of marine craft purchases. These potential buyers will help expand the market for motorboats, while maintaining the demand for qualified mechanics.

The construction of new single-family houses will result in an increase in the lawn and garden equipment in operation, increasing the need for mechanics. However, equipment growth will be slowed by trends toward smaller lawns and the contracting out of maintenance to lawn service firms. Growth also will be tempered by the tendency of many consumers to dispose of and replace relatively inexpensive items rather than have them repaired.

Earnings

Median hourly earnings of motorcycle mechanics were \$13.03 in 2002. The middle 50 percent earned between \$10.14 and \$16.65. The lowest 10 percent earned less than \$8.17, and the highest 10 percent earned more than \$21.04. Median hourly earnings in 2002 in other motor vehicle dealers, the industry employing the largest number of motorcycle mechanics, were \$13.00.

Median hourly earnings of motorboat mechanics were \$13.97 in 2002. The middle 50 percent earned between \$10.91 and \$17.32. The lowest 10 percent earned less than \$8.89, and the highest 10 percent earned more than \$21.20. Median hourly earnings in 2002 in other motor vehicle dealers, the industry employing the largest number of motorboat mechanics, were \$13.43.

Median hourly earnings of outdoor power equipment and other small engine mechanics were \$11.93 in 2002. The middle 50 percent earned between \$9.45 and \$14.99. The lowest 10 percent earned less than \$7.39, and the highest 10 percent earned more than \$18.24. Median hourly earnings in 2002 in lawn and garden equipment and supplies stores, the industry employing the largest number of outdoor power equipment and other small engine mechanics, were \$10.97.

Small engine mechanics tend to receive few benefits in small shops, but those employed in larger shops often receive paid vacations, sick leave, and health insurance. Some employers also pay for work-related training and provide uniforms.

Related Occupations

Mechanics and repairers who work on mobile equipment other than small engines include automotive service technicians and mechanics, diesel service technicians and mechanics, and heavy vehicle and mobile equipment service technicians and mechanics.

Sources of Additional Information

For more details about work opportunities, contact local motorcycle, motorboat, and lawn and garden equipment dealers, boatyards, and marinas. Local offices of the State employment service also may have information about employment and training opportunities.

General information about motorcycle mechanic careers may be obtained from:

- American Motorcycle Institute, 3042 West International Speedway Blvd., Daytona Beach, FL 32124. Telephone (toll free): 800-881-2264.
- Motorcycle Mechanics Institute, 2844 West Deer Valley Rd., Phoenix, AZ 85027. Telephone (toll free): 800-528-7995.

General information about motorboat mechanic careers is available from:

- American Marine and Watercraft Institute, 3042 West International Speedway Blvd., Daytona Beach, FL 32124. Telephone (toll free): 800-881-2264.
- Marine Mechanics Institute, 9751 Delegates Dr., Orlando, FL 32827. Telephone (toll free): 800-342-9253.