
Precision Instrument and Equipment Repairers

(O*NET 49-9061.00, 49-9062.00, 49-9063.00, 49-9064.00, 49-9069.99)

Significant Points

- Training requirements include a high school diploma and, in most cases, postsecondary education, coupled with significant on-the-job training.
- Overall employment is expected to grow about as fast as average, and good opportunities are expected for most types of jobs.
- About 1 out of 6 are 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. 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. Job descriptions vary greatly, depending on the type of instrument being repaired.

Camera and photographic equipment repairers fix broken cameras and other optical devices. The repairer must first determine whether a repair should be attempted, because many inexpensive cameras cost more to repair than to replace. The most complicated or expensive repairs are usually referred back to the manufacturer or to a large repair center. If the repairer decides to proceed with the job, the problem must be diagnosed, often by disassembling numerous small parts in order to reach the source. The defective parts are then replaced or repaired. Many problems are caused by the electronic circuits used in cameras, and fixing these circuits requires 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 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.

Repairs on digital cameras are similar to those on conventional cameras, but because digital cameras have no film to wind, they have fewer moving parts. Digital cameras rely on software, so any repair to the lens requires that it be calibrated with the use of software and by connecting the camera to a personal computer. Because digital cameras are generally more expensive and more widely used than film cameras, they are quickly becoming the most important source of business for camera repairers.

Watch and clock repairers work almost exclusively on expensive and antique timepieces, because 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 hand tools 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 often 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. These artisans, often referred to as technicians, work in four specialties: Band instruments, pianos and organs, orchestral string instruments, 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. In most cases, the problem with the instrument will be clear, but in some cases the repairers must diagnose the issue. They may unscrew and remove rod pins, keys, worn cork pads, and pistons and remove soldered parts by means of gas torches. Using filling techniques or a mallet, they repair dents in metal and wood. They also use gas torches, grinding wheels, lathes, shears, mallets, and small hand tools and, are skilled in metalworking and woodworking.

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



Watch repairers must work with very small, sensitive parts.

ments. 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. Because the specifications of all types of instruments vary greatly, custom parts machining is considered an essential skill.

Piano tuners and repairers use different techniques, skills, and tools. Most workers in this group are tuners; only a few workers in this occupation specialize in refurbishing older pianos. Tuning involves tightening and loosening different strings to achieve the proper tone or pitch. Pitch matching is usually done by ear—an experienced tuner can compare the sound of a pitch with a tuning fork, and then with other pitches on the piano to make sure it is tuned properly. Tuners must make house calls, as piano tuning is sensitive to movement and most pianos cannot be transported easily. Some repairers specialize in restoring older pianos. Restoration is complicated work, often involving replacing many of the parts, which number more than 12,000 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 with organ pipes rather than piano strings. Tuning pipe organs is very complicated, as most organs have thousands of pipes, and different pipes are tuned in different ways. Additionally, many repairers assemble new organs or expand organs with new ranks of pipes. Even with repairers working in teams or with assistants, organ maintenance can take several weeks or even months, depending upon the size of the organ.

Medical equipment repairers, also known as *biomedical equipment technicians*, maintain, adjust, calibrate, and repair electronic, electromechanical, and hydraulic equipment used in hospitals and other medical environments. They use various tools, including multimeters, specialized software, and computers designed to communicate with specific pieces of hardware. These repairers use hand tools, soldering irons, and other electronic tools to repair and adjust equipment. Among the tools they use is equipment designed to simulate water or air pressure. Faulty circuit boards and other parts are normally removed and replaced. Medical equipment repairers must maintain careful, detailed logs of all maintenance and repair that they perform on each piece of equipment.

Medical equipment repairers work on medical equipment such as defibrillators, heart monitors, medical imaging equipment (x-rays, CAT scanners, and ultrasound equipment), voice-controlled operating tables, and electric wheelchairs. Because most equipment repairs take place within a hospital, medical equipment repairers must be comfortable working around patients. In some cases, repairs may take place while equipment is being used. When this is the case, the repairer must take great care to make sure that repairs do not disturb the patient.

Other precision instrument and equipment repairers service, repair, and replace a wide range of equipment associated with automated or instrument-controlled manufacturing processes. For most of these repairers, the emphasis is on determining the problem and how to best approach the solu-

tion. In many cases, replacement is preferable to repair, since precision parts are often very sensitive and may cost more to repair than replace. Replacement parts are not always available, so repairers sometimes machine or fabricate new parts. Repairers may also be responsible for preventive maintenance and calibration, which involves regular lubrication, cleaning, and adjustment of many measuring devices. Increasingly, it also involves solving computer software problems as more control devices, such as valves, are controlled by software. To adjust a control device, a technician may need to connect a laptop computer to the control device's computer and make adjustments through changes to the software commands.

Work environment. Camera, watch, and musical instrument repairers work under fairly similar solitary, low-stress conditions with minimal supervision. A quiet, well-lit workshop or repair shop is typical. Piano and organ tuners must travel to the instruments being repaired. Often, these workers can adjust their schedules, allowing for second jobs as needed. Musical instrument repairer jobs are attractive to many professional musicians and retirees because the flexible hours common to repair work allow these individuals time for other pursuits.

Medical equipment and other precision instrument and equipment repairers normally work daytime hours, but are often expected to be on call. Still, like other hospital and factory employees, some repairers work irregular hours. Medical equipment repairers must work in a patient environment, which has the potential to expose them to diseases and other health risks, but occupational injuries are relatively uncommon.

Precision instrument repairers work under a wide array of conditions, from hot, dirty, noisy factories, to air-conditioned workshops, to the outdoors on fieldwork. Attention to safety is essential, as the work sometimes involves dangerous machinery, toxic chemicals, or radiation. Due to the individualized nature of the work, supervision is fairly minimal.

Training, Other Qualifications, and Advancement

For most precision equipment repairers, the most significant source of postsecondary education is on-the-job training. Even in positions where an associate or bachelor's degree is required, an internship or apprenticeship is generally required before a technician is fully qualified. In some cases, learning these trades can take as many as seven years.

Education and training. Most employers require at least a high school diploma for beginning precision instrument and equipment repairers. Many employers prefer applicants with some postsecondary education.

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 electronics. The job requires the ability to read electronic schematic diagrams and comprehend other technical information, in addition to manual dexterity. New employees are trained on the job in two stages over about a year. First, they learn to repair a single product over a couple of weeks. Then, they learn to repair other products and refine their skills for 6 to 12 months while

working under the close supervision of an experienced repairer. Finally, repairers continually teach themselves through studying manuals and attending manufacturer-sponsored seminars on the specifics of new models.

Training also varies for watch and clock repairers. Several associations, including the American Watchmakers-Clockmakers Institute and the National Association of Watch and Clock Collectors, offer certifications. Some certifications can be completed in a few months; others require simply passing an examination; the most demanding certifications require 3,000 hours, taken over 2 years, of classroom time in technical institutes or colleges. Those who have earned the most demanding certifications are usually the most sought-after by employers. 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 individuals with post-high school training in music repair technology. According to a Piano Technicians Guild membership survey, the overwhelming majority of respondents had at least some college education; most had a bachelor's or higher degree, although not always in music repair technology. Almost all repairers have a strong musical background; many are musicians themselves. Also, a basic ability to play the instruments being repaired is normally required. Courses in instrument repair are offered only at a few technical schools and colleges. Correspondence courses are common for piano tuners. Graduates of these programs normally receive additional training on the job, working with an experienced repairer. Many musical instrument repairers and tuners begin learning their trade on the job as assistants or apprentices. Trainees perform a variety of tasks around the shop. Full qualification usually requires 2 to 5 years of training and practice. Musical instrument repair and tuning requires good manual dexterity, a strong sense of pitch, and good hand-eye coordination.

Medical equipment repairers' training includes on-the-job training, manufacturer training classes, and associate degree programs. While an associate degree in electronics or medical technology is normally required, training varies by specialty. For those with a background in electronics, on-the-job training is more common for workers repairing less electronically sophisticated 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 complicated equipment, such as CAT scanners and defibrillators. Many repairers are trained in the military. New repairers begin by observing and assisting an experienced worker over a period of 3 to 6 months, learning a single piece of equipment at a time. Gradually, they begin working independently, while still under close supervision. Biomedical equipment repairers are constantly learning new technologies and equipment through seminars, self-study, and certification exams.

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. Because repairers need to understand blueprints, electrical schematic diagrams, and electrical, hydraulic, and electro-mechanical systems, most employers require an associate or sometimes a bachelor's degree in instrumentation and control, electronics, or a related engineering field. In addition to formal education, a year or two of on-the-job training is required before a repairer is considered fully qualified. Many instrument and equipment repairers begin by working in a factory in another capacity, such as repairing electrical equipment. As companies seek to improve efficiency, other types of repair workers are trained to repair precision measuring equipment.

Certification and other qualifications. 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 acute vision. Those working with musical instruments must also have good hearing. 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.

Because many precision instrument and equipment repairers are self-employed, they must also have business skills. Although business most often comes from word-of-mouth advertising, repairers must nevertheless work to establish themselves in the industry. Further, they must manage their business operations, which may mean purchasing insurance and managing their own accounting.

Although most of the positions in this field do not require certification, it may be helpful in finding a job or demonstrating competency to prospective clients. There are several certifications possible in this diverse group of repairers. Information on various certifications is available from the sources of additional information at the end of the statement.

Advancement. Advancement opportunities vary greatly among precision instrument and equipment repairers. For self-employed repairers, advancement may mean the ability to charge more for their services. For workers who are employed by firms, supervisory opportunities are available. In both cases, an experienced worker may become a mentor to someone who is new to the field.

Employment

Precision instrument and equipment repairers held 68,000 jobs in 2006. Employment was distributed among the detailed occupations as follows:

Medical equipment repairers	38,000
Musical instrument repairers and tuners	6,000
Camera and photographic equipment repairers.....	4,400
Watch repairers.....	3,800
Precision instrument and equipment repairers, all other	16,000

Medical equipment repairers often work for hospitals or wholesale equipment suppliers, while those in the occupation

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-16	
				Number	Percent
Precision instrument and equipment repairers.....	49-9060	68,000	77,000	8,700	13
Camera and photographic equipment repairers	49-9061	4,400	4,300	-100	-2
Medical equipment repairers.....	49-9062	38,000	46,000	8,200	22
Musical instrument repairers and tuners	49-9063	6,000	6,200	200	3
Watch repairers	49-9064	3,800	3,600	-200	-5
Precision instrument and equipment repairers, all other.....	49-9069	16,000	17,000	700	4

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

titled “all other precision instrument repairers” frequently work for manufacturing companies and wholesalers of durable goods. About 1 out of 6 precision instrument and equipment repairers was self-employed—most are proprietors of jewelry, camera, medical equipment, or music repair services.

Job Outlook

Good opportunities are expected for most types of precision instrument and equipment repairer jobs. Overall employment growth is projected to be about as fast as the average for all occupations over the 2006-16 period; however, projected growth varies by detailed occupation.

Employment change. Projected employment growth for precision instrument and equipment repairers varies greatly by specialty.

Employment of camera and photographic equipment repairers is projected to decline by about 2 percent between 2006 and 2016, and employment of watch repairers is projected to decline 5 percent over the same period. These occupations are in decline primarily because the products they service are often less expensive to replace than to repair. Most of the workers who remain in this industry will specialize in repair of expensive watches and cameras, as well as antiques.

Over the same time period, the employment of musical instrument repairers and tuners is projected to increase 3 percent, which is slower than average. Band and orchestra programs in high schools continue to provide most of the business for these workers, and they have been declining for several years. With fewer new musicians, there will be a slump in instrument rentals, purchases, and repairs. In the meantime, however, there continues to be a demand for these services, and new opportunities should continue to arise as the population grows.

The medical equipment repairer occupation is projected to increase 22 percent between 2006 and 2016, which is much faster than the average for all occupations, as a result of increased demand for medical services and increasing complexity of the equipment used in hospitals and clinics. Opportunities should be increasingly good for those who have a strong understanding of software and electronics, as many new medical devices are increasingly reliant on computers.

Over the same time period, employment of other precision instrument and equipment repairers is projected to increase 4 percent, more slowly than average, as most of them work in declining manufacturing industries. Nevertheless, these workers can expect to play an increasingly large role in those

industries, as automation continues to dominate modern manufacturing.

Job prospects. Despite varying levels of growth in the various occupations, almost all workers in these fields can expect good job prospects over the next decade. As the baby boomer generation nears retirement, many skilled workers in these occupations are expected to leave the workforce. Additionally, many technical schools and other programs offering courses in these occupations have closed, leading to a shortage of qualified workers. Individuals with strong apprenticeships or internships should have the best prospects as instrumentation continues to become more complex and requires ever greater skill to repair.

Earnings

The following tabulation shows median annual earnings for various precision instrument and equipment repairers in May 2006:

Medical equipment repairers	\$40,580
Camera and photographic equipment repairers.....	34,850
Watch repairers.....	30,900
Musical instrument repairers and tuners	29,200
Precision instrument and equipment repairers, all other	46,250

Earnings ranged from less than \$16,230 for the lowest 10 percent of musical instrument repairers and tuners to more than \$69,280 for the highest 10 percent in the occupation all other precision instrument and equipment repairers in May 2006.

Earnings within the different occupations vary significantly, depending upon skill levels. For example, a lesser skilled watch and clock repairer may simply change batteries and replace worn wrist straps, while a highly skilled watch and clock repairer with years of training and experience may rebuild and replace worn parts.

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 medical, dental, 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 mechanics and maintenance 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 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 repair work, contact:

➤ Piano Technicians Guild, 4444 Forest Ave., Kansas City, KS 66106. 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, 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>

➤ National Association of Watch and Clock Collectors, 514 Poplar St., Columbia, PA 17512-2130.

Internet: <http://www.nawcc.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., Suite 220, Arlington, VA 22201-4795. Internet: <http://www.aami.org>