

**FIRE DEPARTMENT • CITY OF NEW YORK**



**STUDY MATERIAL FOR THE  
CERTIFICATE OF FITNESS EXAMINATION**

**A-35**

**TO OPERATE AND MAINTAIN  
AIR COMPRESSORS**

Note: This certificate of fitness incorporates sections of the:  
G-35 (To Operate Air Compressors) and W-11 (Testing Air Receivers)  
Certificate of Fitness in addition to other sources of information.

ALSO INCLUDED IN THIS BOOKLET YOU WILL FIND THE FOLLOWING:  
NOTICE OF EXAMINATION (NOE)

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## **NOTICE OF EXAMINATION**

- Title:** Examination for the Certificate of Fitness (A-35) “To Operate and Maintain Air Compressors”.
- Date of Test:** Written tests are conducted Monday through Friday (except legal holidays) 8:00 AM to 2:30 PM.

## **QUALIFICATION REQUIREMENTS**

1. Applicants must be at least 18 years of age.
2. Applicants must have a reasonable understanding of the English language.
3. Applicants must present a letter of recommendation from his/her employer. The letter must be on official letterhead, and must state the applicant’s full name, character, physical conditions, experience, and address of premises where applicant will be employed.
4. Applicants must present two (2) forms of satisfactory identification i.e., driver’s license, passport, vehicle registration, library card, or equivalent.

## **APPLICATION INFORMATION**

- Application Fees:** \$25.00 for originals and \$15.00 for renewals. The fee may be paid by credit card (no debit), in cash, money order, or personal check payable to New York City Fire Department. The \$25.00 fee must be payable by all applicants prior to taking the Certificate of Fitness test. Application forms are available at the Public Certification Unit, 1<sup>st</sup> floor, 9 Metro Tech Center, Brooklyn, NY 11201.

## **TEST INFORMATION**

- Test:** The test will be of the written, multiple choice type. A passing score of at least 70% is required in order to secure a Certificate of Fitness. Call 718-999-1988, or 2504 for additional information and forms.

## STUDY MATERIAL AND TEST DESCRIPTION

This study material contains the information you will need to prepare for the examination for the Certificate of Fitness to Operate and Maintain Air Compressors. The study material includes information taken from relevant sections of the Fire Prevention Code and the Building Code of New York.

Fire Department Certificates of Fitness are extremely important. A holder must secure and protect his or her Certificate of Fitness in much the same manner as one would a driver's license. It must be available upon demand by a duly authorized Fire Department representative. It is very important for you to review the information in the study guide very carefully. The study material does not contain all of the information you need to know in order to perform your duties. It is your responsibility to learn whatever else you need to know to do your job effectively, and in keeping with all Fire Department rules and regulations as well as all other pertinent laws.

All questions on the Certificate of Fitness examination provide a multiple choice selection of answers, with four alternative answers to each question. Only one answer is correct for each question. If you do not answer a question or if you mark more than one alternative your answer will be scored as incorrect. A score of 70% correct is required on the examination in order to qualify for the Certificate of Fitness. Read each question carefully before marking your answer. There is no penalty for guessing.

### Sample Questions

**1. An air compressor system is primarily used for:**

- A) fire fighting operations.
- B) storing and making use of pressurized air.
- C) forcing water through fire sprinklers in a building.
- D) running elevators in a high rise apartment building.

The correct answer is "B". You would press "B" on your touch-screen monitor.

**2. When air is pressurized by an air compressor it:**

- A) collects water from the surrounding air.
- B) becomes cold.
- C) becomes hot.
- D) forces dirt out of the storage tank.

The correct answer is "C". You would mark "C" on your touch screen monitor.

## **PART 1. INTRODUCTION**

Air Compressors are used in various situations. They power industrial equipment and construction tools. Air compressors enable the efficient repair of all types of vehicles and facilitate their safe operation on our public thoroughfares. They are important in manufacturing and are central to product development and creation.

Air Compressors can be very dangerous if not carefully operated and maintained. The compressing of atmospheric air may be under the general supervision of a person holding a certificate of fitness as per the 2008 edition of the New York City Fire Code.

### **PERMITS**

A permit is required for any air compressor that compresses air at pressures above 100 pounds per square inch (psi). These permits are issued by the Bureau of Fire Prevention.

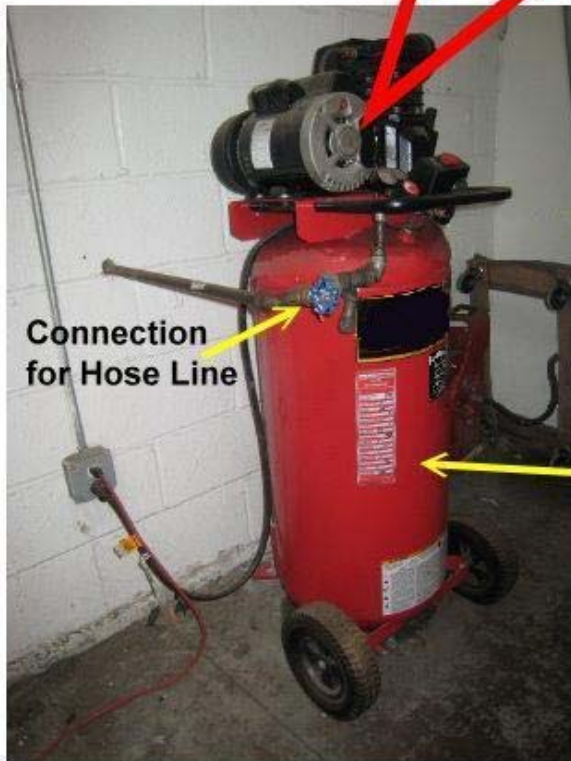
### **AIR COMPRESSORS**

An air compressor takes the air in a room and forces it into a container under pressure. The more air forced into the container the greater the air pressure that builds up inside. The compressed air can be discharged from the container at a controlled rate. The compressed air is used to power a variety of tools and machinery. For example, compressed air is used to power pneumatic wrenches and lifts in automobile service stations. Compressed air is also used for heavy machinery and paint spray booths in industrial plants.

There are several types of air compressors. The different types include the reciprocating, centrifugal, rotary and solar compressors. The only real difference between these compressors is the way in which they compress the air. The most commonly used air compressor is the reciprocating air compressor. Air compressors are sometimes called air pumps. The air compressors can be powered by electric motors, internal combustion engines or steam turbines. The most common power source is an electric motor. A typical industrial air compressor is shown on the next page.

In some locations there may be a build up of flammable gases. For example, there may be a build up of flammable gases in service stations and workshops. Flammable gases are usually heavier than air and fall to the floor before spreading outward. The flammable gases are easily ignited by sparks and high temperatures. They may be ignited by the heat generated by the air compressor. If the flammable gases are ignited inside the compressor it will cause an explosion.

For this reason steps must be taken to make sure that no flammable gases are drawn into the air compressor. This is done by raising the air compressor at least 5 feet above ground level. The raised air compressor is less likely to ignite the flammable gases. Meeting this height requirement may be done in several ways. For example, the compressor may be placed on a shelf or a bench. Or the air receiver tank may be turned and stood on end. Then the air compressor is bolted to the top of the air receiver.



## **PART 2. OPERATION OF AIR COMPRESSORS**

### **BASIC OPERATION OF AN AIR COMPRESSOR**

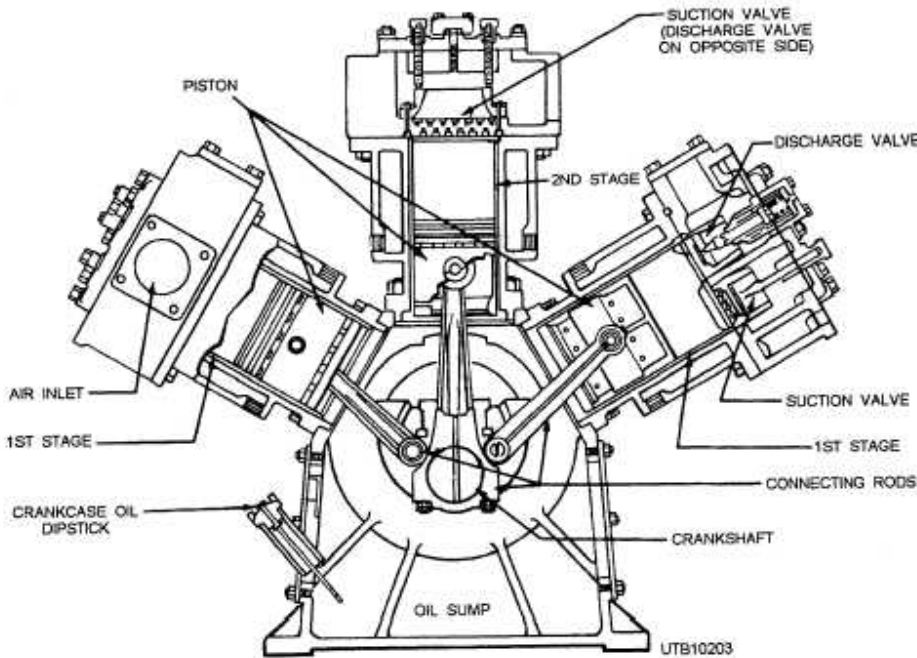
The operating principles of an air compressor are very simple. The entire unit is driven by an electric motor. This motor then activates a series of drive belts. The belts on the air compressor serve to power the moving parts of the unit. These belts are very similar to the belts that drive the power steering and alternator in an automobile.

The air is compressed in a compression chamber. The compression chamber consists of a piston inside a cylinder. The piston moves up and down. When the piston moves downward it draws air into the cylinder. The air is drawn in through an intake valve. The intake valve automatically opens when the piston moves downward. When the piston reaches the bottom of the cylinder it changes direction. As the piston moves upward the intake valve is automatically closed. The closed intake valve prevents the air from escaping from the cylinder.

The upward stroke of the piston compresses the air. When air pressure reaches a certain level it forces open a discharge valve. The discharge valve is spring loaded. When the discharge valve opens the compressed air is released into an air receiver. The air receiver is sometimes called an air tank. The compressed air is then taken from the air receiver when it is needed to supply the tools or machinery.

Ordinarily an air compressor with one cylinder and one piston is called a single stage air compressor. Air compressors with more than one piston and one cylinder are called multi-stage air compressors; however, there are air compressors with multiple pistons and cylinders that are single stage. This is because each cylinder discharges directly into the air receiver. In a multi-stage air compressor, each cylinder will increase the pressure of the air by taking air from the discharge side of the previous cylinder and increasing the pressure to a new level. Once it reaches the last cylinder the pressurized air is discharged into the air receiver. When air is compressed it becomes heated. An intercooler is installed between the stages of the air compressor. The intercooler cools the air as it travels between the compression stages.

**A Diagram of a Three-Stage Reciprocating Air Compressor is shown below:**

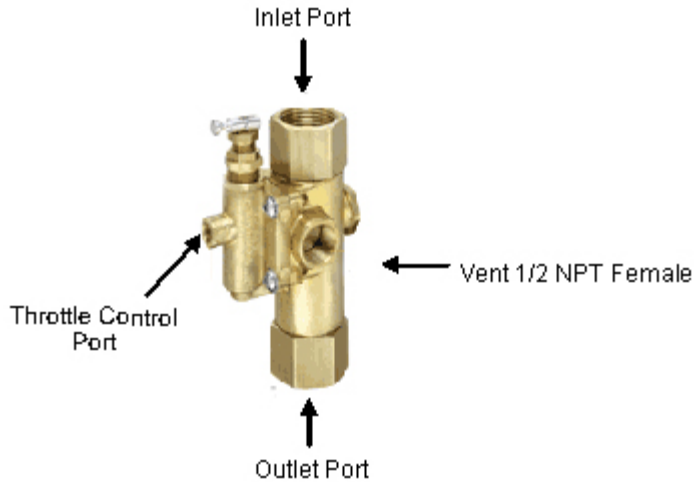


In some systems the compressed air is forced from the air receiver into storage containers. These containers allow the compressed air to be used later as needed.

Some systems may use several connected air compressors. The air is drawn into the first compressor and then forced into the second compressor. The second compressor then forces the compressed air into the next compressor. This occurs until the air has passed through all of the connected compressors. Each time the air passes through a compressor the air pressure is increased. Finally the compressed air is forced into the hose line or a storage container. This system is used when there is a need for air under very high pressure.

**SAFETY COMPONENTS OF THE AIR COMPRESSOR**

The air compressor is fitted with several safety components. These components are briefly described below. The first is an **UNLOADING VALVE**. The unloading valve allows the air to escape from the compression chamber when there is a strain on the electrical motor. The strain usually occurs when the electric motor running the compressor is first started. After a few cycles of the motor the valve is closed. In most air compressors the unloading valve operates automatically. However in older compressors it may need to be manually operated. The manufacturer's instruction manual should be followed when starting an older compressor. Note a picture of an unloading valve on the next page:



### UNLOADING VALVE

A secondary valve called a **CHECK VALVE** ensures that compressed air does not flow out when the unloading valve activates. A check valve prevents the backflow of air from the tank to the compressor head. Through the fitting, the air from the compressor head can flow out the unloading valve line. When the compressor stops after reaching cut out pressure, it commonly also activates the unloading valve.

An air compressor tank check valve must be installed between the air compressor head air line and the unloading valve air line. If this was not accomplished air would escape as soon as the air compressor stopped and the unloading valve opened. The air would bleed off from the compressor piston, and all of the air in the compressor tank would escape into the atmosphere. When the air compressor is operating properly, the pressure switch calls for air and turns on the electric compressor motor. The unloading valve is closed at the same time and air can no longer be released. **Note the Photo of a Check Valve below:**



A **PRESSURE GAUGE** is installed as part of the compression unit. It indicates the pressure inside the air receiver. The Certificate of Fitness holder should pay close attention to the reading on the pressure gauge. The pressure inside the air receiver must never exceed the manufacturer's recommendations. If the pressure is greater than the recommended level it may cause an explosion. The pressure in the air receiver is controlled by the pressure switch. Simply turn the switch in the desired direction to adjust the pressure.

**PRESSURE RELIEF VALVES** are also installed on the system. These valves allow air to escape from the system when the pressure is too great. The valves operate automatically. They may also be operated manually by pulling on the ring attached to the pressure relief valves.

The **AIR INTAKE VALVE** is fitted with an air filter. The filter prevents dust from being drawn into the compression cylinder. If dust enters the compressor it may result in a fire inside the cylinder. The heat inside the cylinder can cause the dust to catch fire. A fire inside the cylinder may cause damage to the air compressor. For this reason it is important make sure that the air filter is clean and securely connected to the compressor.

Moisture can cause problems when using an air compressor to power machinery. For this reason another filter must be installed to take out the moisture out of the compressed air. The moisture is usually removed using a **FILTER AND MOISTURE SEPARATOR ASSEMBLY (FMSA)**. The FMSA is installed between the air compressor and the air receiver. It removes the moisture and dust from the compressed air before it enters the air receiver. A drain cock is attached to the FMSA. It is used to drain the water and dirt from the FMSA. **Note the Photo of an FMSA below:**



### **FILTER AND MOISTURE SEPARATOR ASSEMBLY**

An **AUTOMATIC CONTROL DEVICE** is attached to the air receiver. It controls the starting and stopping of the air compressor. It shuts down the compressor when the air pressure in the air receiver is adequate. It then restarts the air compressor when there is a need for more pressure.

The **SAFETY RELIEF VALVES** keep an air compressor tank from bursting should your pressure switch stop working. It is recommended that a safety relief valve be installed which is rated 30 PSI higher than your pressure switch cut out pressure.

**Note below the Photo of a Safety Relief Valve:**



**A SAFETY RELIEF VALVE**

**Note below the Photo of a Destroyed Air Compressor after Safety Relief Valve Failure:**



Sometimes a **CONSTANT SPEED CONTROL SWITCH** is installed on the system. This is used when there is a steady or constant demand for compressed air. The switch allows the air compressor to run continuously. The compressor runs at a safe speed while supplying the desired amount of compressed air. If the demand drops the excess compressed air is simply allowed to escape into the atmosphere. The unneeded compressed air is released through the pressure release valve.

A **COOLING SYSTEM** is installed in each air compression unit. The compression chamber and the compressed air must be cooled. Small compressors are usually air-cooled. The air is circulated around the compressor by a fan. Large air compressors are usually water-cooled. Cold water is pumped throughout the compressor. Both the air and water-cooling systems prevent the compressors from overheating and causing serious damage.

The air compressor is also fitted with a **LOW OIL LEVEL INDICATOR SWITCH**. This indicator switch will automatically shut down the air compressor if the oil level is low. The compressor should not be operated if the oil is low. This can cause serious damage to the compressor. Do not attempt to run the air compressor until the oil is replaced.

### **PART 3. MAINTENANCE & SAFETY PROCEDURES**

When starting the compressors be sure to follow the guidelines outlined by the manufacturer when performing maintenance or making repairs.

The entire system must be visually inspected by the Certificate of Fitness holder before the air compressor is started. This visual inspection should make sure that the components listed on the following pages are correctly installed and in good working order.

The Certificate of Fitness holder should remain in the area for a few minutes after the air compressor has been started. This is to make sure that the compression unit is operating safely. Make sure that the air compressor is operated at safe speeds. Do not run the compressor at speeds above its recommended operating range. The operating range is indicated in the manufacturer's manual. Always remember that compressed air can be dangerous. Dust or debris blown off your clothing by an air compressor can drive either of those under your skin resulting in death. An eardrum can be ruptured at a blast level of 40 PSI. Compressed air entering through the mouth can destroy your lungs and rupture other internal organs. Eyesight can be easily damaged. Always wear safety glasses when operating an air compressor.

Never place any combustible materials on the air compressor. These materials may be ignited by the high operating temperatures of the air compressor. Do not use air compressors near devices, machinery or equipment which produce heat. Solar heat is not known to cause overheating of an air compressor tank.

Never make repairs to the compressor while it is running. The compressor must always be turned off when making repairs. As an added precaution, the electrical supply to the machine should be shutdown. Compressed air should also be drained from the compressor before starting any work.

The air compressor should be serviced and repaired by a qualified repair technician. An oil leak, for example, can be extremely hazardous. This is especially true in a garage where torches or flames are used. Another example pertains to maintenance. The NYC Fire Code no longer requires an affidavit indicating an air receiver is hydrostatically tested, and defect free. A hydrostatic test every 5 years at a minimum is nonetheless recommended to ensure the integrity of the tank.

All major repairs must be made by a qualified technician; however, the Certificate of Fitness holder may make minor repairs and perform maintenance on the air compressor. For example, certificate of fitness holders must know how to correct the air compressor's cooling system. They may replace belts, change the air intake filter, and the lubrication oil. A Certificate of Fitness holder must look and listen for leaks. Leaks are more prominent during the colder months when sealing materials shrink. A Holder must pay close attention to the air receiver tank, compressor tubing and fittings as these are the locations where leakage most typically occurs. They must know how and when these tasks should be accomplished. An incorrectly maintained air compressor is a potential fire hazard.

An air compressor and its storage tanks may be cleaned using a soap and water solution. Never use benzene, kerosene or other light oils for this purpose. These oils may cause an explosion if mixed with air under pressure. It is important to point out that both oil and water can be dangerous and cause an explosion if they actually enter an air compressor tank.

## **MAINTENANCE FOR AIR COMPRESSOR SYSTEM COMPONENTS**

Note maintenance information concerning the various air compressor system components as follows:

### **The Cooling System**

The cooling system should be tested every 6 months to make sure that it is working correctly. The water supply control valves should always be open when the air compressor is in operation.

### **The Air Intake Filter**

The air intake filter should be inspected and cleaned weekly. It should be replaced every 6 months. If at any time the filter is damaged it should be replaced.

### **The Lubrication Oil**

The Certificate of Fitness holder should refer to the manufacturer's manual to determine the safe operating temperatures of the lubrication oil. The level of the lubricating oil (lube oil) should be checked weekly using the dipstick. The lube oil is designed to lubricate the moving parts on the air compressor. The oil used must be of the grade specified by the compressor manufacturer. The lube oil should be replaced every six months.

### **The Automatic Low-level Oil Indicator Switch**

The automatic low-level oil indicator switch should be tested every 3 months. This is tested by manually draining the oil from the air compressor when it is running. The indicator switch will shut down the air compressor within a few minutes if it is working correctly. When testing the compressor in this way, do not run the air compressor for a long period of time. If the switch is defective, it should be repaired or replaced. The air compressor should be refilled with oil before it is used again. **Note the Photo of the Oil Drain Valve below:**



**OIL DRAIN VALVE**

## **The Air Receiver**

Water builds up in the moisture separator assembly and the air receiver must be drained daily; however, there is one exception. Do not drain moisture from the air compressor when the ambient temperature drops below 40 degrees Fahrenheit. This is done by opening the drain valve and draining off the excess water. All safety valves should be manually operated every week. This is to ensure that they will function correctly in case of an emergency. It is recommended that the air receiver tank be pressure tested at a minimum of every 5 years by a qualified technician.

## **The Hose Connections**

All hose connections on the air compressor should be checked frequently by the Certificate of Fitness holder to make sure that they are tight. Never twist, bend or curl an air hose to stop the air hose. That's the job of the air valve. You should not patch a leaking hose with duct tape. You can replace the hose, or you can repair the leak by cutting out the bad section and joining the hose back together with a connector and clamps. The safety valves and gauges should be checked regularly to make sure that they are in good working order.

## **The Belts**

The belts must be inspected by the Certificate of Fitness Holder to make sure that the air compressor is running at the correct speed. First turn off the compressor and disconnect the power supply. If the belts are covered by a protective guard, remove the guard. If the belts are frayed or visibly damaged they must be replaced. To test the belt tension, firmly press down on the belt. If the belt moves more than one the inch, the flywheel may need to be adjusted. Make the adjustments as needed. If the adjustment does not work replace the belts with the belts as specified by the manufacturer.

## **The Electrical Connections**

All electrical connections, fuses, and cables must be visually inspected by the Certificate of Fitness holder. A qualified electrician must be notified if there is evidence of any defective parts. The electrician must pay close attention to the motor starter. The motor starter protects the compressor against thermal overload. Thermal overload is caused by excessive electrical currents.

## **The Pressure Switch**

It is essential that the Certificate of Fitness holder ensures the pressure switch is working correctly. The pressure switch is a pressure regulating device. It shuts down the air compressor when pressure in the air receiver reaches a certain preset level. Then it restarts the compressor when the pressure falls below a certain level. The shut down and restart levels depend on the size of the compressor and the demand for compressed air. The pressure switch prevents the air pressure inside the tank from reaching dangerous levels. Dangerously high pressure levels may cause the tank to rupture or explode. The steps to test the pressure switch are as follows:

1. Start the air compressor. Allow the pressure in the air receiver to build up to normal operating levels. Pay close attention to the pressure gauge.
2. When the gauge indicates that the pressure is above normal operating levels the pressure switch should shut down the compressor automatically. If the compressor does not shut down automatically the pressure switch may be adjusted. If the adjustment does not correct the problem, the switch is defective. A defective pressure switch must be replaced before the compressor may be restarted.

Some air compressors are designed to operate continuously. They have a different pressure switch device. This device does not shut down the entire air compressor. Rather it allows the compressor to run but prevents the compressor from compressing air. The testing procedures should check that air is no longer compressed when the preset level is reached. The air compressor must have a warning label indicating the level of pressure which is considered dangerous. This should be clear in the air compressor manual as well.

### **The Pressure Relief Valve**

The Certificate of Fitness holder must test the pressure relief valve to ensure it is working safely and efficiently. The pressure relief valve acts as a backup safety device to the pressure switch. It is designed to automatically open when the pressure in the receiver reaches dangerous levels. The pressure relief valve is tested by running the air compressor with the pressure switch fully open. When the pressure switch is fully open it cannot shut down the compressor.

The pressure relief valve should open automatically when the pressure reaches 25 psi above the normal operating pressure. If the pressure relief valve does not open it may be defective. The valve may also be defective if it opens before the receiver reaches normal operating pressure. Defective relief valves must be replaced before the compressor is restarted. The Certificate of Fitness holder must also check to make sure that the pressure relief valve is of the correct size. The pressure relief valves must meet the manufacturer's specifications. These specifications are outlined in the air compressor maintenance manual.

### **The Operating Temperature**

The air compressor must be tested to make sure that it is running within normal operating temperature ranges. Guidelines for acceptable operating temperatures are specified in the maintenance manual. This test reduces the likelihood of the air compressor overheating. Overheating may cause irreparable damage to the compressor. An overheating air compressor is a potential fire hazard. If an overheating problem is discovered the water cooling mechanisms must be checked. The cooling mechanism is tested to make sure that an adequate water supply is reaching the air compressor. Any blockages, leaks or other defects must be repaired or defective parts replaced.

## Lockout/Tagout Safety Procedures

Lockout/Tagout is a safety procedure which is used in industrial and research settings to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work. This may include machinery making use of compressed gases, such as an air compressor. It requires that power sources be “isolated and rendered inoperative” before any repair procedure is started. “Lock and Tag” entails locking the device or the power source with a hasp, and placing it in such a position that no hazardous power sources can be turned on. The procedure also requires a tag to be affixed to the lockout device indicating that it should not be turned on.

The OSHA standard for “The Control of Hazardous Energy (Lockout/Tagout), Title 29 CFR, Part 1910.147 addresses the practices and procedures necessary to disable machinery or equipment, thereby preventing the release of hazardous energy while employees perform servicing and maintenance activities. The Certificate of Fitness holder should have an understanding of how this regulation applies to his or her work environment.

Machine operators, craft workers and laborers are among the 3 million workers who service equipment and face the greatest risk. Compliance with the lockout/tagout standard prevents an estimated 120 fatalities and 50,000 injuries each year. Workers injured on the job from exposure to hazardous energy lose an average of 24 workdays for recuperation.

