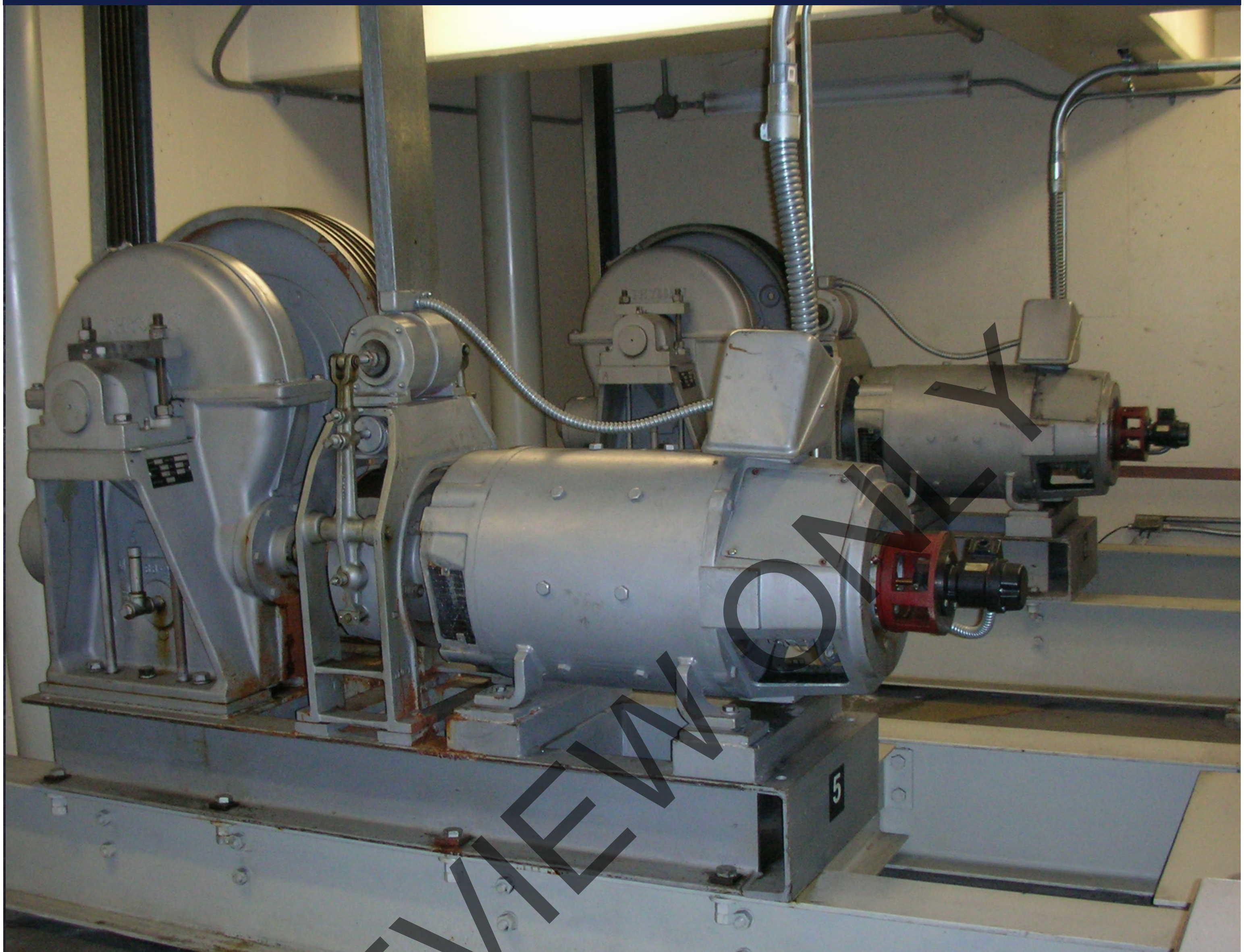

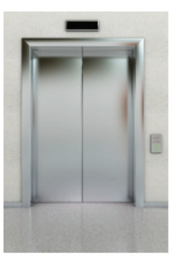

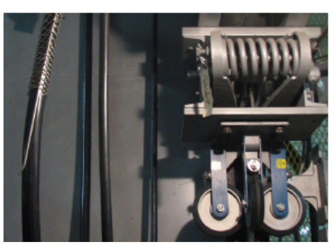


Elevator: Mechanical Drive Systems

Course 215

PARTICIPANT GUIDE

Transit Elevator/Escalator Maintenance Training Consortium

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Elevator:
Mechanical Drive Systems

Participant Guide

Transit Elevator/Escalator Maintenance Training Consortium

COURSE 215

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How To Use The Participant Guide

Purpose of the Course

The purpose of the *Elevator:Mechanical Drive Systems* course is to assist the participant in demonstrating a working knowledge of the way drive machines for various types of elevators work and are configured. This course demonstrates the differences in elevator drive technology that is in common use in a public transit system.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The *outline* will discuss the main topics to be addressed in the module. A list of *key terms* identifies important terminology that will be introduced in this module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. A list of *key terms* identifies important terminology that will be introduced in each course module.

Disclaimer: This module is intended to educate employees of transit agencies that have agreed to voluntarily participate in the Transit Elevator/Escalator Maintenance Consortium. It is intended only as informal guidance on the matters addressed, and should not be relied upon as legal advice. Anyone using this document or information provided in the associated training program should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of care in any given circumstances. The Transit Elevator/Escalator Consortium, its participating agencies and labor unions, as well as the Transportation Learning Center, make no guaranty or warranty as to the accuracy or completeness of any information provided herein. The Transit Elevator/Escalator Consortium, its participating agencies and labor unions, as well as the Transportation Learning Center, disclaims liability for any injury or other damages of any nature whatsoever, directly or indirectly, resulting from the use of or reliance on this document or the associated training program.

Module 1

GENERAL SAFETY PROCEDURES

Outline

Purpose and Objectives:

The purpose of this module is to provide the participant with general information on working safely on and around elevator driving machines.

Following the completion of this module, the participant should be able to complete the course objectives with an accuracy of 75% or greater:

- Identify restricted areas at the top and bottom of the car
- Identify hazards and hazardous areas associated with hydraulic driving machines.
- Identify hazards associated with traction elevators
- Explain the correct procedures in dealing with spills

Key Terms

- Abrasion
- Being struck
- Best practice
- Crushing
- Drive machine
- Egress
- Electrical Shock
- Entanglement
- Falling
- Guarding equipment
- Machine room
- Pinching
- Shearing
- Slipping
- Tripping

1-1 Overview

The elevator **drive machine** is the power unit that applies the energy necessary to raise and lower any elevator, material lift, dumbwaiter car, or other equipment.

Experienced elevator professionals are well aware of the **best practices** that the elevator industry has developed in order to minimize and mitigate the risks to technicians working around elevator driving machines in the machine room, top of car, and pit. This module helps the participant identify many of these hazards toward the goal of working safely in a transit elevator system.

Elevators are potential sources of serious injuries, even deaths, to those who install, repair, and maintain them. According to the Department of Labor,

> "Elevator installers and repairers have a rate of injury and illness that is slightly higher than the national average. Potential risks include injuries due to falls from ladders and scaffolding, burns or other injuries due to electrical shocks from control systems, and muscle strains from lifting and carrying equipment."

Material in this module should supplement two sets of established safety procedures with which the elevator technician should already be familiar: one, the *Elevator Industry Field Employees' Safety Handbook* published by National Elevator Industry, Inc., and, two, the safety policy of the transit authority with which the technician works. In addition, this module makes references to the American Society of Mechanical Engineers (ASME) standards A17.1 and A17.3 as well as OSHA's guidelines for elevator workers. Other standards and recommendations for working safely around elevators are also provided by the National Elevator Manufacturing Industry, Inc. (NEMI), also known as the National Elevator Industry, Inc. (NEII), and the National Elevator Industry Educational Program (NEIEP).

In this module the participant will cover the physical hazards of working around elevator driving machines. There are also chemical and biological hazards, particularly spills, that the elevator technician should be aware. In order to ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to workers. OSHA's Hazard Communication Standard (HCS or HAZCOM) requires that all employers with hazardous chemicals in their workplaces must have labels and safety data sheets for their exposed workers, and train them to handle the chemicals appropriately.

OSHA also directs that all workers exposed to the potential for body fluid spills (blood, vomit, etc.) must receive appropriate training and vaccinations before they are assigned to cleaning up body fluids.

The Elevator Industry Field Employees' Safety Handbook - 2010, Section 1.1 paragraph (ab) covers biohazards.

1-2 Machine Room Hazards

Within most traction or hydraulic elevator system, there is a **machine room** that houses large electric motors or hydraulic pumps and a controller cabinet. For traction systems this room is typically located above the hoistway and for hydraulic elevators the machine room is located at the bottom of the hoistway. Because of the hazards in machine rooms, ASME requires these rooms be clearly marked with keyed access allowed only to elevator technicians. Some transit agencies add additional information to the labels on the outside of elevator rooms. For example, New York City Transit assigns a unique number to each elevator in the system and posts this on the outside of the machine room as well as the phone number of station's central control.

Figure 1 Clear signage displayed outside elevator machine room ©WMATA

The machine room may contain machinery for a single elevator or for a group of elevators. Where there is more than one elevator, all equipment related to each elevator should be identified by number. So if there are three elevators in the machine room, each geared machine, governor, motor generator, selector, etc. for that elevator must be clearly identified with the corresponding number as illustrated in Figure 2.

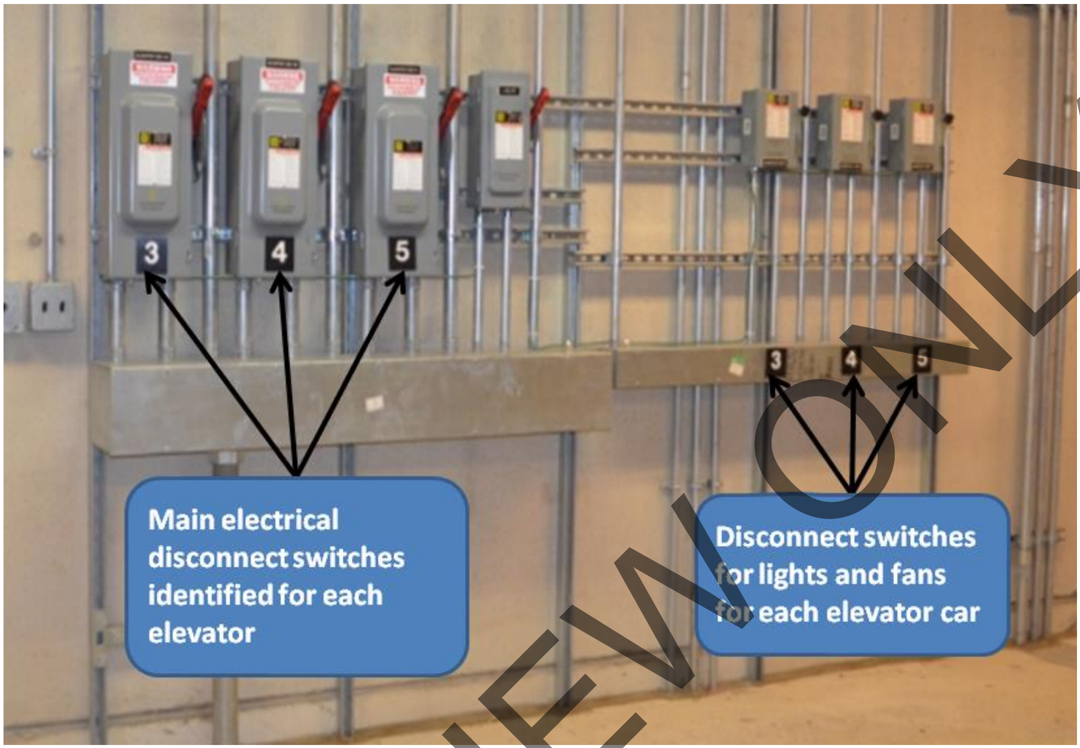


Figure 2 Labeled equipment for each elevator in machine room – Courtesy WMATA

The implementation of **guarding equipment** within elevator machine room spaces is essential in protecting the health and safety of workers and to reduce workplace injuries. No amount of training, certification, licensing or experience can prevent all workplace injuries all the time but constantly being aware of workplace safety will reduce injuries.

Moving machine parts have the potential to cause severe workplace injuries, such as crushed fingers or hands, amputations, burns, or blindness. Safeguards are essential for protecting workers from these preventable injuries. OSHA recommends any machine part, function, or process that may cause injury should be safeguarded. Whenever the operation of a machine or accidental contact causes injury to the operator or others in the vicinity, the hazards must be eliminated or controlled.

The most common hazards found within an elevator machine room or secondary level spaces are:

- **Entanglement** – exposure of limbs or clothing to being snagged by moving equipment, causing the worker to lose their balance and possibly be drawn into the moving element. The

Module 2

Geared Drive Systems

Outline

Purpose and Objectives

The purpose of this module is to provide an overview of elevator geared drive systems and how they operate as part of traction elevator driving machines.

Following the completion of this module, the participant should be able to complete the following learning objections with an accuracy of 75% or greater:

- Explain how a geared drive system operates
- Identify major components of the geared drive systems
- List methods of controlling geared drive systems

Key Terms

- Bearings
- Brake Solenoid
- Coupling
- Driving Machine
- Gear
- Gear Reduction Ratios
- Geared Traction System
- Helical Gear
- Motor
- Motor Generator Set
- Rack And Pinion
- Reduction Gear
- Spur Gear
- Tachometer
- Torque
- Variable Frequency Drive
- Worm Gear
- Worm Shaft

2-1 Overview

This module discusses geared driving machines in a transit elevator environment as well as the other components, particularly the brake and motor, which comprise the driving machine system (Figure 3).

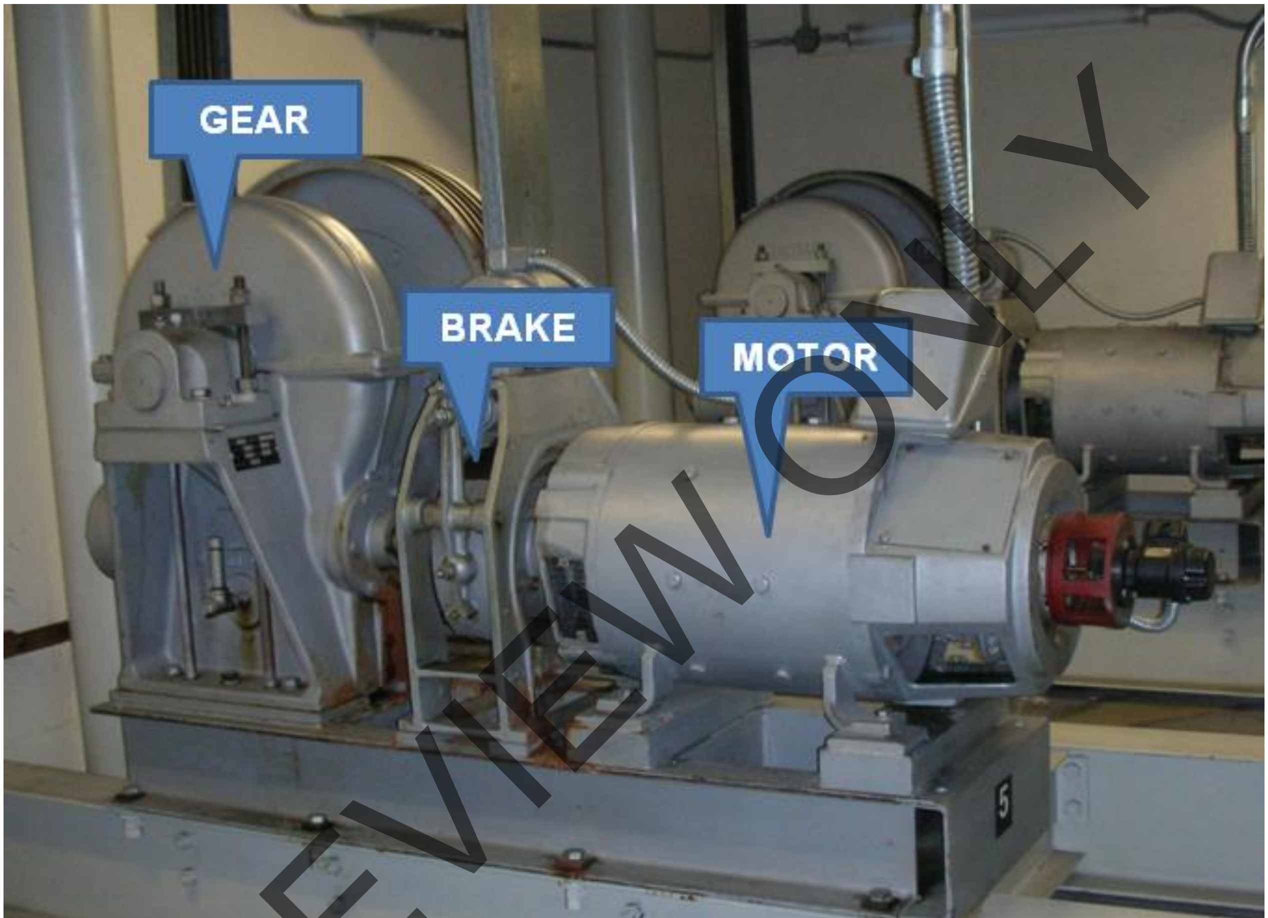


Figure 3 Driving machine system -Courtesy WMATA

To control the mechanical movement of elevator cars, gears power steel hoist ropes over a traction **drive sheave** which is attached to an output shaft of a **gear** driven by the input of a high speed **motor**.

Note: Even though experienced mechanics sometimes use the terms "driving machines" and "drives" interchangeably, it is important for this course that the participant understands the distinction between these two terms. The driving machine is the power unit that applies the energy necessary to drive an elevator. For traction elevators that energy is applied by an electric motor. The **drive** is the electrical device that provides the power to the driving machine. Electrical drives are covered in a later course, *Course 214 Elevator Electrical Systems*.

The geared elevator machine typically has a bronze spiral worm gear connected to the hoist motor which drives a bronze ring gear (Figure 6). These gears mesh at very tight tolerances. It is critical to maintain these tolerances and, if bearings fail or wear, so do the gears. This wear causes heat, pitting, rumbling, friction and undesirable noise. At the same time, a worm and gear system that is properly adjusted and consistently maintained will provide years of reliable service.

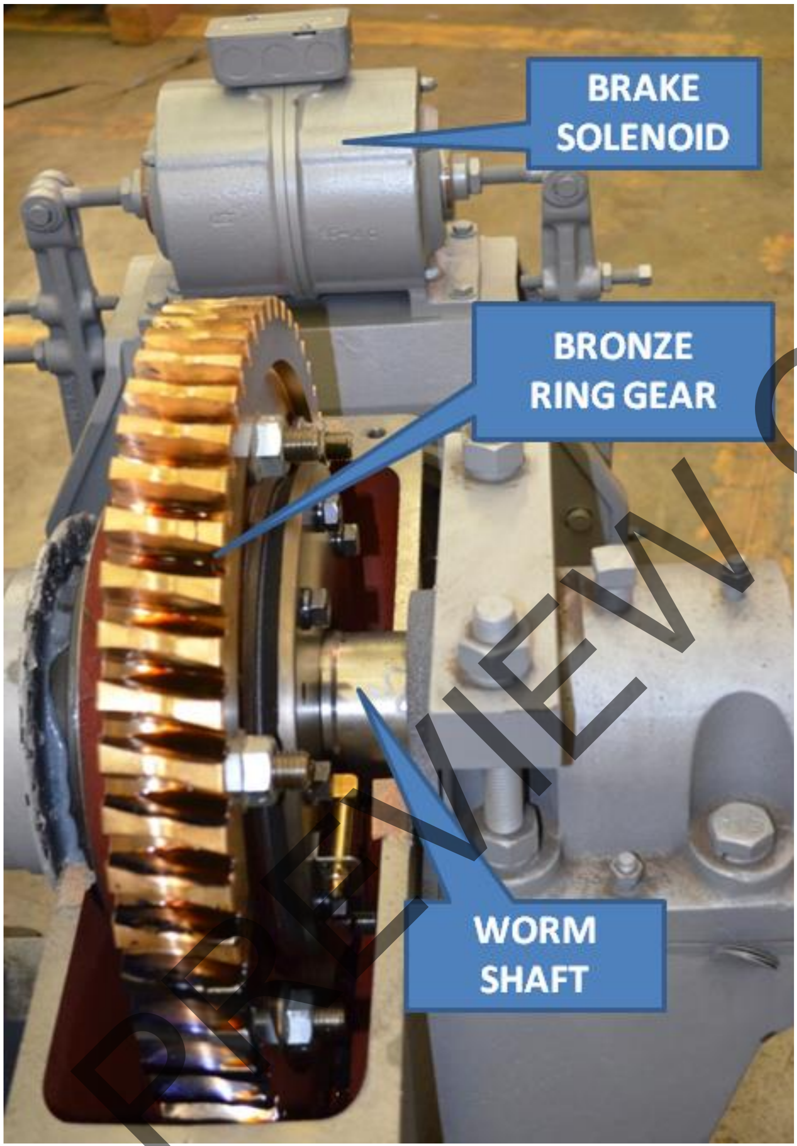


Figure 6 Geared machine (cover removed) –Courtesy WMATA

In the geared traction system the output rotation of the motor is transmitted to the **drive sheave** through the worm shaft and a **reduction gear**. It is called a reduction gear because it reduces the speed from the motor so that there is more control of elevator motion. By decreasing the rotation speed, the output torque increases adding the ability to lift larger objects for a given pulley diameter.

A **brake** is mounted between the motor and driving machine to hold the elevator stationary at a floor. This brake can be of an external drum type or disk type and is actuated by spring force.

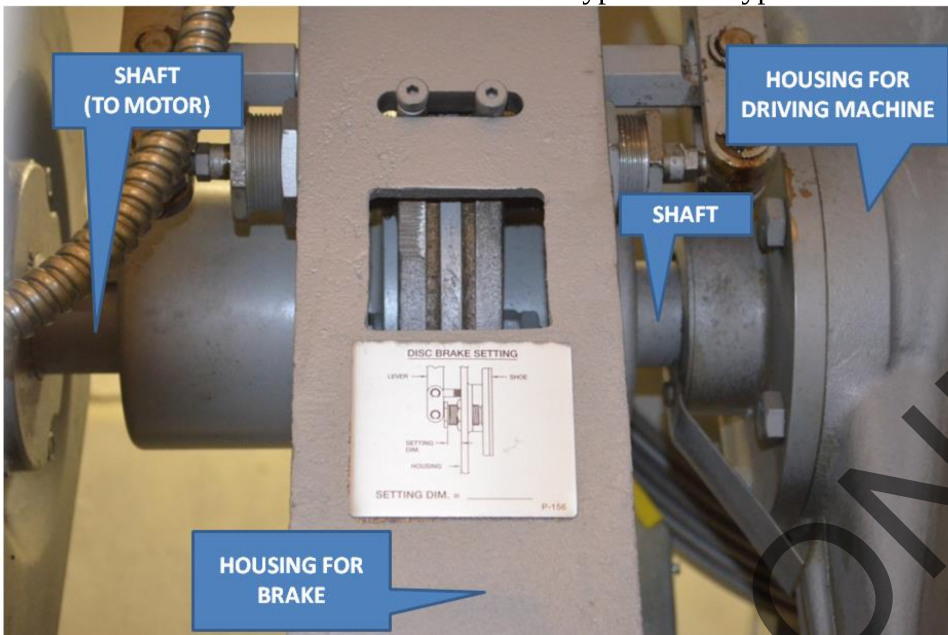


Figure 12 Brake mounted between motor and driving machine -Courtesy WMATA

In a geared elevator system many times the braking mechanism is actuated by an electric solenoid hence the term **brake solenoid**. The solenoid consists of a wire coil which is wound around a hollow core that has a **tension spring** inside. The spring engages the brake when power is removed.

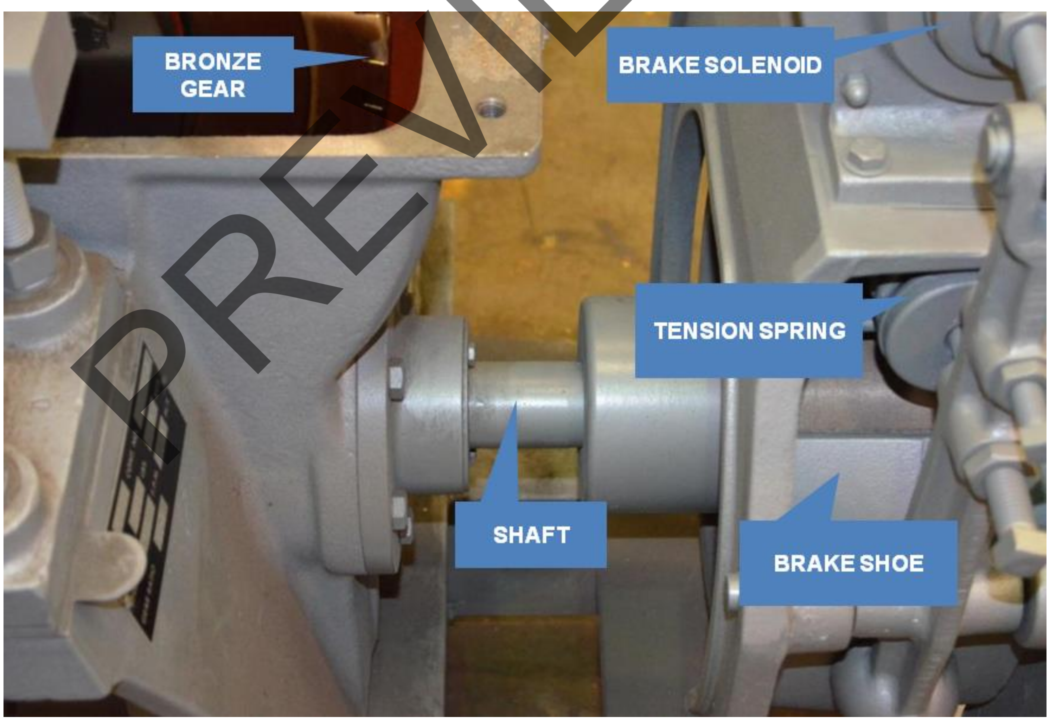


Figure 13 Components of brake system on geared machine -Courtesy WMATA

Module 3

Gearless Drive Systems

Outline

3-1 Overview
3-2 Operation of Gearless Drive Systems
3-3 Geared vs. Gearless
3-4 Summary
3-5 Review

Purpose and Objectives:

The purpose of this module is to provide an overview of gearless drive systems for elevators in use in a public transit environment.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Explain how a gearless drive system operates
- Identify major components of the gearless drive systems
- List methods of controlling gearless drive systems
- Identify the speed specifications of a gearless drive system
- Explain difference between geared and gearless drive systems

Key Terms

- Armature
- Armature shaft
- Brake drum
- Brushes
- Commutator
- Field windings
- Gearless drive
- Magnetic field
- Regenerative drives
- Rotor
- Stator

3-1 Overview

Electric traction elevators can be either geared or gearless. In the previous module, the participant learned that in geared elevators the motor turns a gear train that rotates the sheave. In **gearless elevators**, the motor rotates the sheaves directly. Geared elevators cost less but they cannot travel as fast as gearless elevators which can travel as fast as 1,200 fpm. In this module the participant will explore how a gearless drive system operates as well as explore further differences between geared and gearless drive systems.

This module is supplemented with a ten-page publication from ThyssenKrupp Elevators, *Modernization Solutions: ThyssenKrupp Elevator's Geared to Gearless Systems*.

3-2 Operation of Gearless Drive Systems

Gearless drive systems work in the same way as geared drive systems except that the drive sheave is directly attached to the end of a motor and gears are not used to transfer power from motor to drive sheave. The hoist ropes are attached to the top of the elevator and wrapped around the drive sheave while the other ends of the ropes are attached to a counterweight that moves up and down in the hoistway on its own guiderails. The combined weight of the elevator car and the counterweight presses the ropes into the drive sheave grooves, providing the necessary traction as the sheave turns.

The principal components of the gearless drive systems are the **armature** or **rotor**; the **stator** in which the field coils are mounted; the **brake drum** which is mounted on the **armature shaft**; and the traction sheave which is also mounted on the armature shaft. Most of these components are illustrated shown in Figure 15.

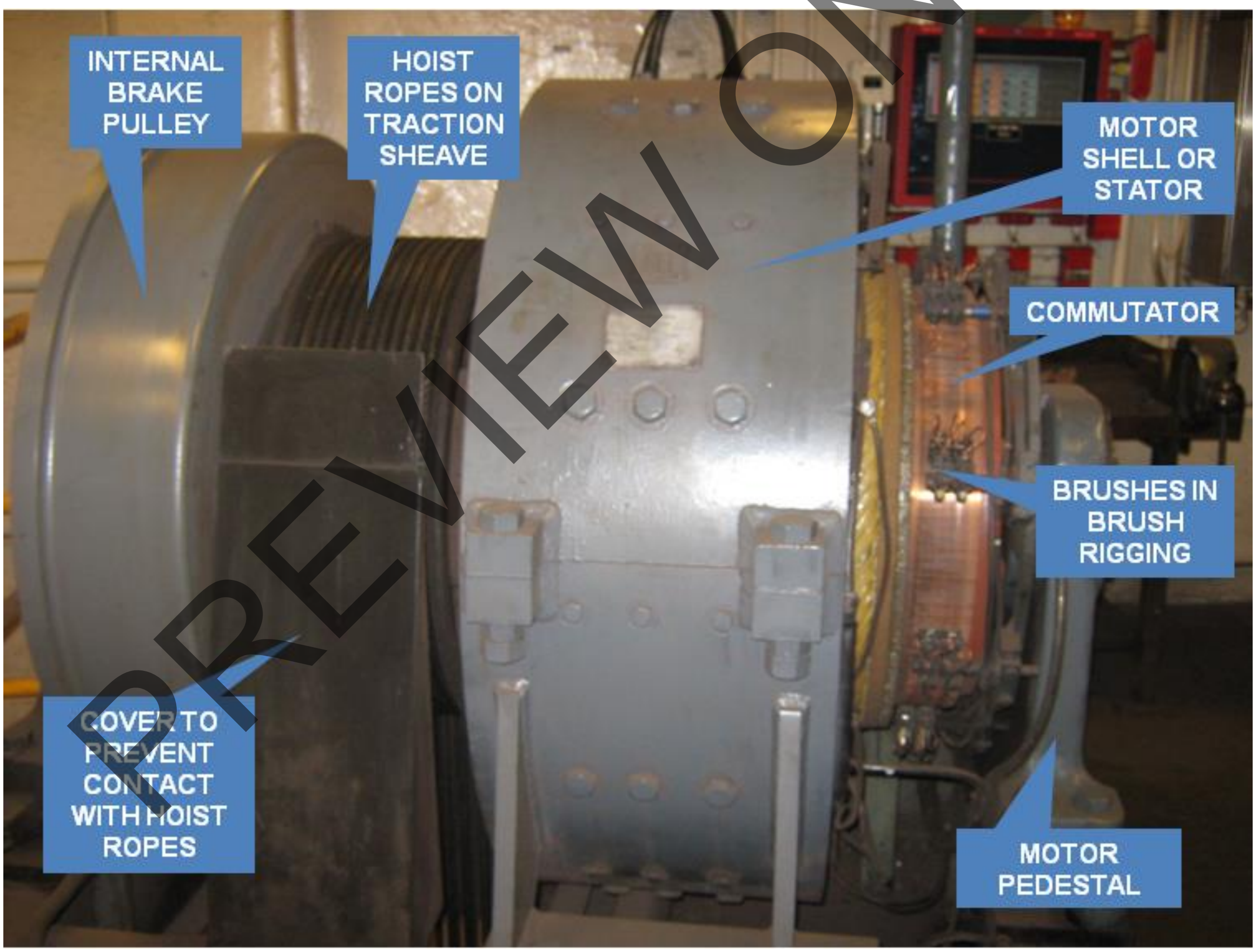


Figure 15 Components of an elevator gearless machine – courtesy NYCT

Inside of the motor are the two principal electrical components of an electromechanical machine: the armature and field windings. The armature is the rotating part and is also known as the rotor. The stator is the stationary part of an electric motor and its role is to create a **magnetic field** (magnetic flux) for the armature to interact with and thereby rotate. The stator can comprise either permanent magnets, or electromagnets formed by a conducting coil.

Field and armature wiring in elevator motors is typically comprised of copper because copper has a high electrical conductivity. Figure 16 shows a gearless traction motor with the **field windings**, **commutator**, and **brushes**.

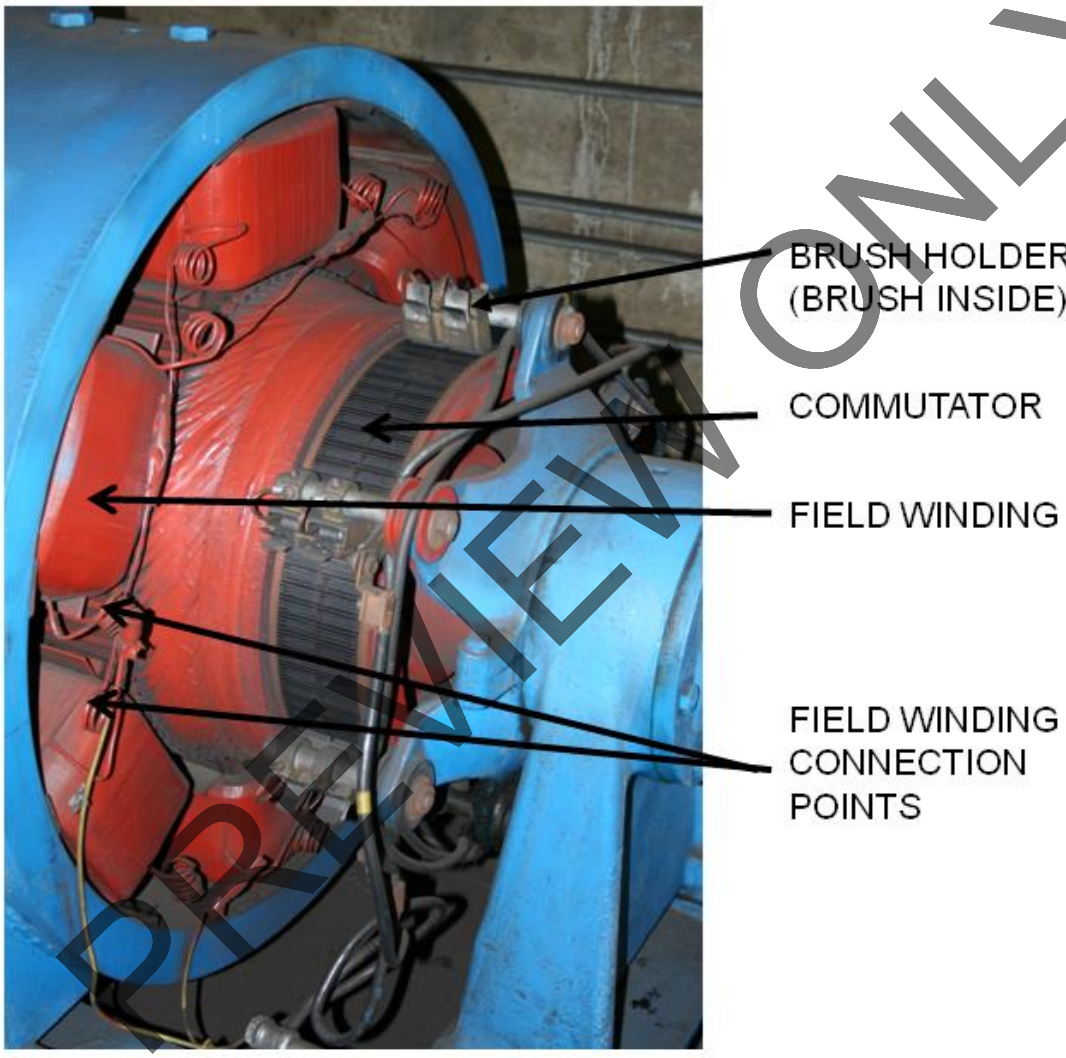


Figure 16 Gearless Traction Motor Field and Armature Windings – courtesy WMATA

The commutator is comprised of a series of split ring copper segment bars which carries electric current to the rotating component. Stationary "brushes" (made of a mixture of carbon and copper) rest against the commutator and supply electric current. As the commutator rotates, it switches the current from one coil to another in the rotor. In a motor, this maintains the proper relationship between stator and rotor magnetic fields.

Module 4

Hydraulic Drive Systems

Outline

Purpose and Objectives:

The purpose of this module is to provide an overview on the drive system functions for hydraulic elevators.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Explain how a direct-acting hydraulic cylinder operates
- Identify major components of the hydraulic drive systems
- Identify variations in the direct acting hydraulic drive systems
- Explain the differences between roped and direct acting cylinder systems
- Variation in hydraulic drive systems
- Explain how a roped hydraulic system operates

Key Terms

- "A" port
- "B" port
- Controller
- Coupling
- Cylinder
- Down (D) solenoid
- Down Stop (DS) solenoid
- Drive motor
- Fluid reservoir (tank)
- Holed (In-ground) elevator systems
- Holeless elevator systems
- Hydraulic fluid
- Hydraulic jack
- Hydraulic line
- Manual lowering button
- Motor
- Oil reservoir
- Oil cooler
- Overspeed valve
- Packing head
- Piping system
- Piston
- Pressure relief adjuster
- Roped hydraulic
- Rotary pump
- Shut-off valve
- Silencer
- Solenoid
- Solenoid coils
- Solenoid switch
- Storage tank
- Submersible pump
- System pressure
- Up (U) Solenoid
- Up Stop (US) Solenoid
- Valve

4-1 Overview

This module gives the participant an in-depth look at the major components of hydraulic drive systems. In this module the participant will identify these components as they examine the path of fluid in the hydraulic circuit. Compared to traction elevators, hydraulic elevators are less complex mechanically making them ideal for low-rise installations. The main disadvantage is that they require more power to operate. There are also environmental concerns should either the lifting cylinder leak fluid into the ground.

4-2 Major components of the hydraulic drive systems

In Course 200, *Overview of Vertical Transportation*, the participant learned that hydraulic elevators are designed to move the piston up using pressurized suspension means (hydraulic fluid) and using a gravity and control valve to bring the piston down. A hydraulic elevator is one in which liquid under pressure is available at all times for transfer into the hydraulic jack.

The major components of a hydraulic drive system are illustrated in Figure 21.

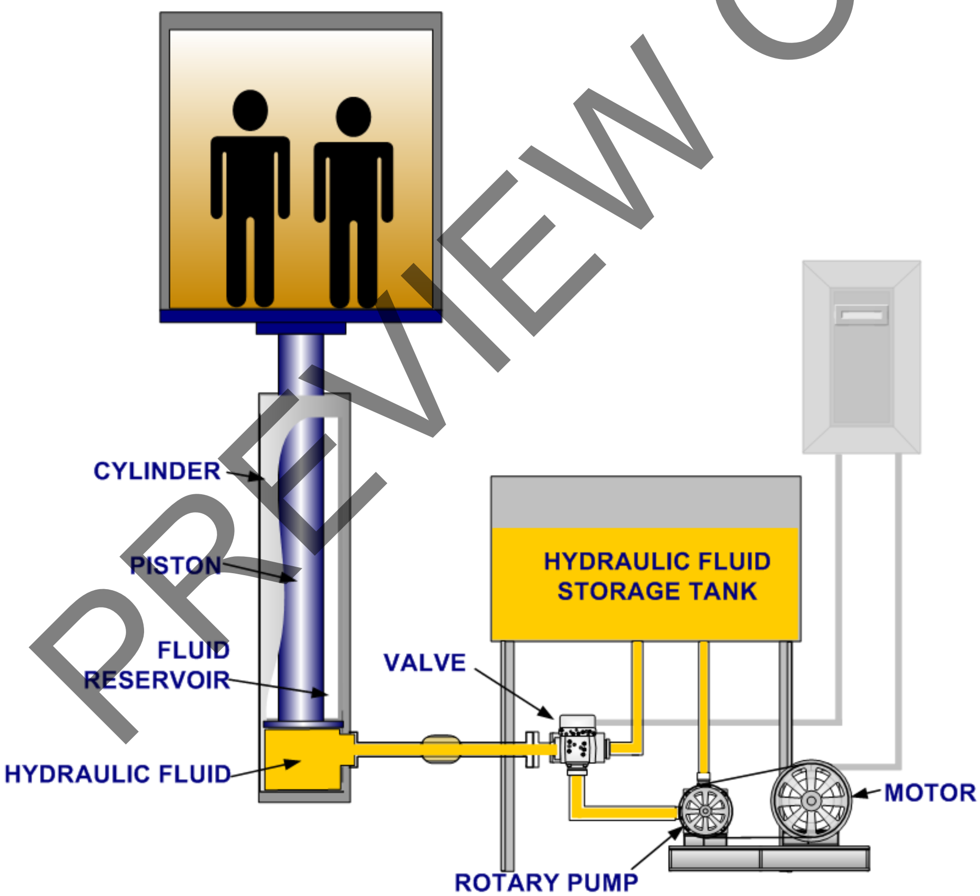


Figure 21 Components of a hydraulic elevator

Hydraulic Circuit

Hydraulic fluid is typically petroleum-based oil and is moved through the hydraulic circuit illustrated in Figure 23. Within this circuit are three important paths of the hydraulic fluid: the **storage tank**, the **rotary pump**, and the **valve**. The flow of the fluid is directed by **solenoid coils** that are controlled by the **controller**.

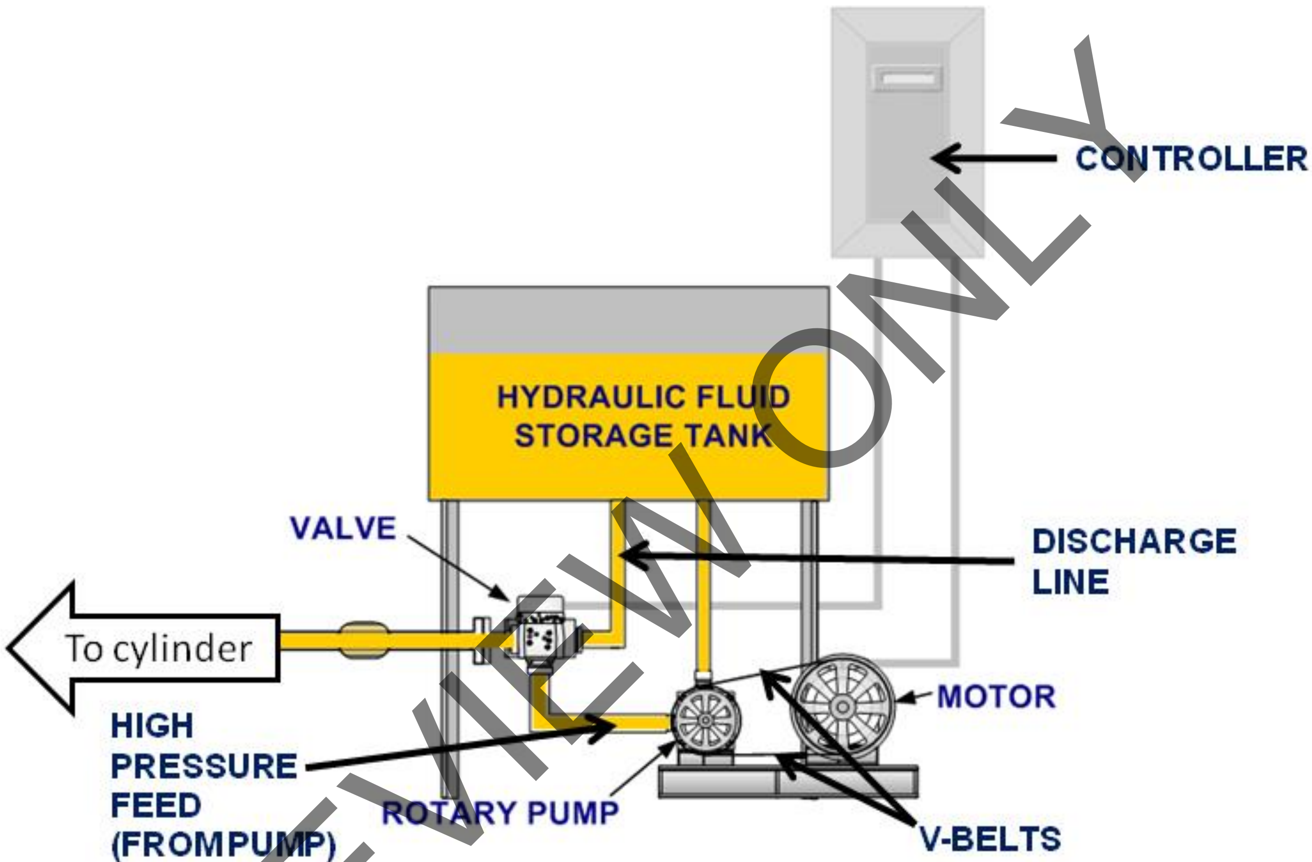


Figure 23 Hydraulic circuit

The "B" port gauges the weight of the elevator fully assembled and loaded to capacity with test weights. The weight of the elevator system is borne equally throughout the surface area of the piston. This weight is expressed in pounds per square inch (PSI). For instance, if the weight of the elevator (fully assembled and loaded to capacity) is 10,000 pounds and the diameter of the piston is 9 inches, then the surface area would be 28.26 square inches with 358 pounds per square inch.

Working pressure is determined by gauging the pump output through the "A" port (shown in Figure 26). Working pressure must exceed system pressure to overcome the check valve and open a pathway for pump output to be directed to the cylinder providing UP direction to the piston. With the aid of a **relief adjuster**, the pressure of hydraulic fluid from the pump is monitored so that it does not exceed the designed maximum limitation. This maximum is the PSI value multiplied by 125%.

Among other specifications, ASME code requires that hydraulic elevator systems be equipped with two types of valves: shut-off valves and overspeed valves.

Shut-off valves located in to the hydraulic cylinder and are therefore typically found in the elevator pit. A shut-off valve operates to shut off the flow of hydraulic oil in much the same way as a faucet valve is used to manually shut off the flow of water. Figure 27 shows a shut off valve and muffler. The muffler reduces the noise and vibration of the hydraulic power unit.

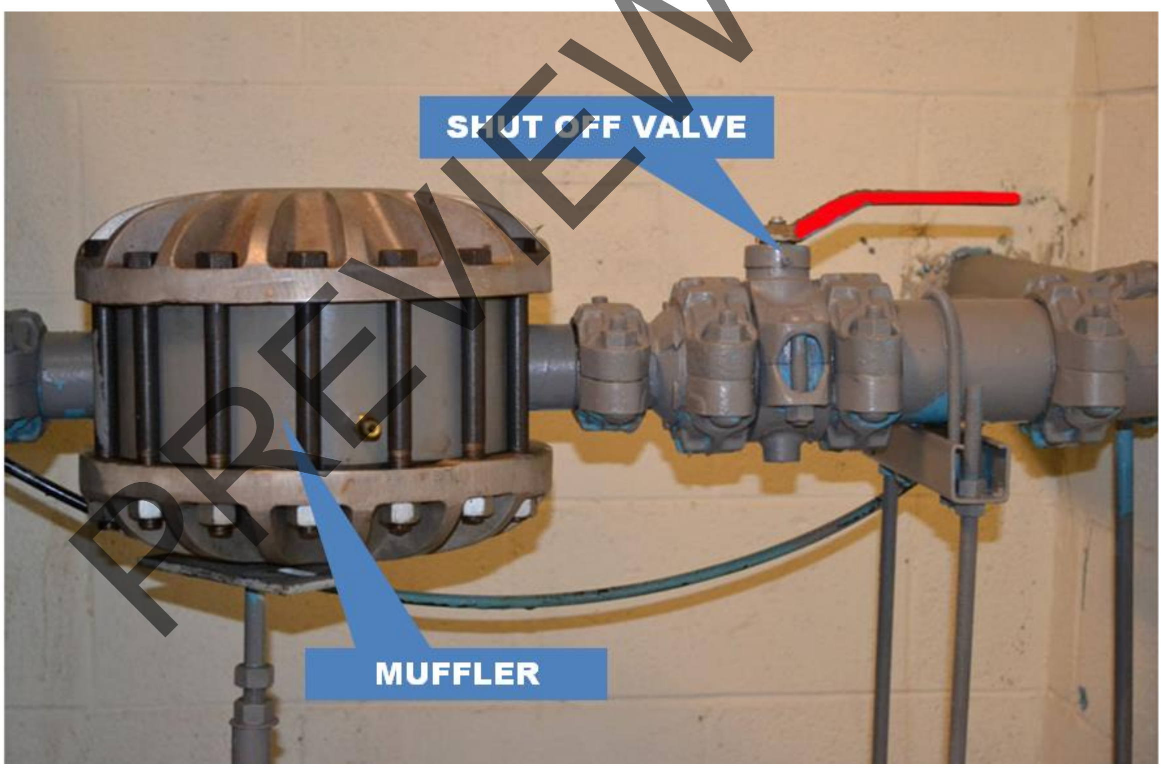


Figure 27 Shut off valve and muffler –Courtesy MARTA

Module 5

Troubleshooting

Outline

5-1 Overview
5-2 Troubleshooting Strategies for Common Problems
5-3 Documentation
5-4 Summary

Purpose and Objectives:

The purpose of this module is to provide an overview sample text sample text sample text.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Perform a sensory inspection using visual, smell, sound, and touch.
- Check for normal operation.
- List various problems which can occur in a drive system.
- Identify corrective actions related to common problems in a drive system.
- Perform correct documentation of the problems.

Key Terms

- Documentation
- Geared drive systems
- Gearless drive systems
- Hydraulic drive systems
- Maintenance log
- Maintenance Management Software
- Troubleshooting

5-1 Overview

Much of the work of the technician involves troubleshooting problems that may arise when inspecting and maintaining elevators. **Troubleshooting** is the process where the technician diagnoses the source of a problem, traces the occurrence of the problem, pinpoints the problem, and then corrects or fixes the problem.

Almost every product manual in use today has a section in the back named "Troubleshooting." Here the manufacturer will list the potential problems that the user of the product may encounter. Often these potential problems are phrased in the form of questions such as "Is the motor light blinking?" or "Is there a blue screen with no icons?"

As any experienced mechanic knows, troubleshooting equipment is both an art and a science. The art in troubleshooting is to approach the problem with creativity and technical curiosity. Technicians who are fascinated by how things work and are not discouraged by a challenging problem tend to be the best troubleshooters. The science in troubleshooting is when the technician applies the correct solution to the problem.

It takes time and experience to develop good troubleshooting skills and this module will help the participant diagnose common problems while maintaining transit elevators. A later course in this series, Course 250, is dedicated entirely to troubleshooting.

When attempting to resolve a problem with elevator drive systems, safety is always the first priority. Run the elevator in inspection mode to further troubleshoot potential problems. In inspection mode, the elevator will run slowly so there is a greater opportunity to pinpoint problems. Operating the elevator in inspection mode also reduces the risk of breaking the elevator components.

Every elevator technician should have most recent version of the *Elevator Industry Field Employees' Safety Handbook* covers safety practices that the technician should follow when constructing and maintaining elevator equipment.

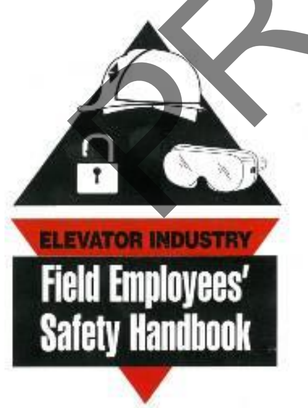


Figure 34 Field Employees' Safety Handbook

5-2 Troubleshooting Strategies for Common Problems

A good elevator technician relies on the **physical senses** of sight, smell, hearing, and touch while troubleshooting a problem. With on the job experience, an elevator technician will become so familiar with normal sights, smells, sounds and feel around elevator drive systems that they can almost immediately know when something is amiss.

The following chart presents common problems associated with a **sensory inspection** of elevator drive systems.

Sense	Common Problems
Sight 	Severe oil leakage. Oil discoloration. Elevator not responding to calls. Discoloration of paint on motor casing. Elevator not moving. Elevator will not ascend to the top floor.
Smell 	Smell of burnt wires, smell of hot gear oil.
Hearing 	Unusual noise. Extreme noise particularly with hydraulic drives. Hammering noise.
Touch 	Excessive heat. Rough spots on release rollers. Loose hardware. Unusually warm machine room. Rough cab ride. Excessive heat from motor.

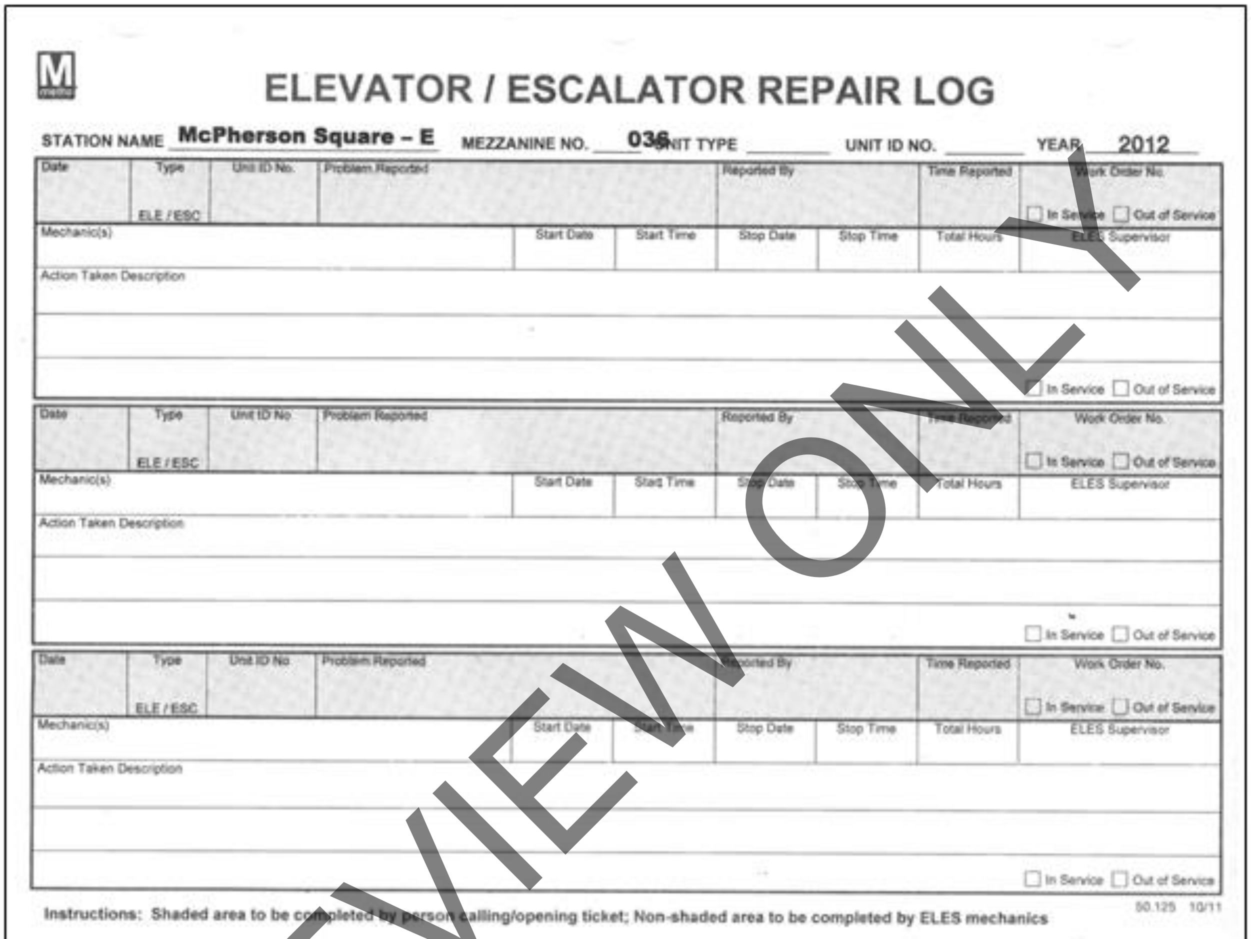
Applying a sensory inspection is but one strategy that an elevator technician can use towards troubleshooting. Many times troubleshooting elevator drives, there is a combination of symptoms rather than one symptom that result of the reported problem. The technician needs to therefore isolate the problem in order to make the correct assessment of the problem and apply the appropriate fix. Some methods that help isolate the problem are:

Prior occurrence: Look at the **maintenance log** and other records to see how this problem was resolved before. If the log shows a common solution to the problem, then the technician should check that solution first.

Recent alterations: Check to see if the problem occurred immediately after some kind of maintenance or other change to the drive. Chances are that the new problem is a result of that change.

Function vs. non-function: If the drive system is not producing the desired end result, look for what it is doing correctly; in other words, identify where the problem *is not*, and focus your

Some transit authorities rely on the use of **log books**. Log books typically contain a form that the technician needs to fill out such as illustrated Figure 36 In some instances both maintenance software and log books are used. Make sure to follow the procedures of your transit authority.



ELEVATOR / ESCALATOR REPAIR LOG

STATION NAME McPherson Square – E MEZZANINE NO. 036 UNIT TYPE ________ UNIT ID NO. ________ YEAR 2012

Date	Type ELE / ESC	Unit ID No.	Problem Reported	Reported By	Time Reported	Work Order No. ☐ In Service ☐ Out of Service
Mechanic(s)	Start Date	Start Time	Stop Date	Stop Time	Total Hours	ELES Supervisor
Action Taken Description						☐ In Service ☐ Out of Service
Date	Type ELE / ESC	Unit ID No.	Problem Reported	Reported By	Time Reported	Work Order No. ☐ In Service ☐ Out of Service
Mechanic(s)	Start Date	Start Time	Stop Date	Stop Time	Total Hours	ELES Supervisor
Action Taken Description						☐ In Service ☐ Out of Service
Date	Type ELE / ESC	Unit ID No.	Problem Reported	Reported By	Time Reported	Work Order No. ☐ In Service ☐ Out of Service
Mechanic(s)	Start Date	Start Time	Stop Date	Stop Time	Total Hours	ELES Supervisor
Action Taken Description						☐ In Service ☐ Out of Service

Instructions: Shaded area to be completed by person calling/opening ticket; Non-shaded area to be completed by ELES mechanics 50.125 10/11

Figure 36 Log sheet to be completed by technician –Courtesy WMATA

5-4 Summary

This module provided the participant with an outline to troubleshoot common problems with machine drives found in geared, gearless, and hydraulic elevator systems. Troubleshooting itself is an art as well as a science and, as the technician gains experience on the job, troubleshooting and applying the correct fix will become second nature.

This series of courses offers an entire course on troubleshooting elevators and escalators is offered in Course 250. In completing that course the participant will able to identify and describe troubleshooting strategies to solve reported problems in the transit elevator system.