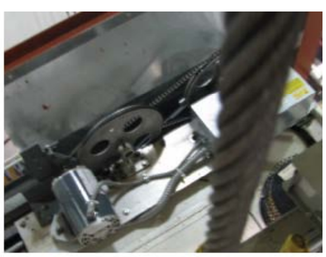

Elevator Specific Hydraulic Elevators

Course 218

PARTICIPANT GUIDE

Transit Elevator/Escalator Training Consortium

Elevator Specific
Hydraulic Elevators

Participant Guide

Transit Elevator/Escalator Maintenance Training Consortium

COURSE 218

REVISION INDEX

Any additions, deletions, or revisions are to be listed below.

Revision No.	Date	Section	Description of Change	Revision Author
1.	01-11-2016		Final edits of 04-16-2013 version	Transportation Learning Center – Amri Joyner

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HOW TO USE THE PARTICIPANT GUIDE

Purpose of the Course

The purpose of the *Elevator Specific Hydraulic Elevators* course is to assist the participant in demonstrating a working knowledge of the way a transit hydraulic elevator works including its control system and components. A very introductory look is also taken at maintenance of a transit hydraulic elevator. This will be covered more in depth in a later course.

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.

Module 1

SAFETY PROCEDURES

Outline

1-1 Overview
1-2 Safely Maintaining a Hydraulic Elevator
1-3 Effective Communication Techniques
1-4 Working Safely Under the Car
1-5 Summary

Purpose and Objectives

The purpose of this module is to provide an overview of basic safety practices to be used when maintaining hydraulic elevators. Working around elevators is a hazardous activity. This module is intended to make participants aware of the specific hazards and to provide actions that can reduce the risks involved with working on hydraulic elevators.

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

- Discuss specific precautions necessary to perform elevator maintenance
- Identify effective communication techniques according to a distance situation
- Identify proper safety methods for working in the pit

Key Terms

- Buffers
- Bump Cap
- Catch Basin
- Cleanliness
- Communication
- Electrical Shock
- Hard Hat
- Landing The Car
- Lockout/Tagout (LOTO)
- Material Safety Data Sheet
- Overhead Clearance
- Pinch Points
- Repetition
- Scavenger Pump
- Slipping Hazard
- Standing Water
- Stop Switch
- Top Of Car Control Box
- Up Call

1-1 OVERVIEW

Safety around hydraulic elevators requires much the same attitude and many of the same procedures as working safely around traction elevators. This course focuses on the unique safety requirements of hydraulic elevators, safety involving elevators in general are covered in the introductory course on elevators and the specific safety requirements around traction elevators are discussed in the course on traction elevators. The features of hydraulic elevators that make the safety requirements different revolve around the use of hydraulic fluid to supply the lifting force and the location of much of the equipment used to power and control the units.

It is recommended that you review basic elevator safety before beginning training on hydraulic elevators.

Warning: Safety Precautions!

Always review the Field Employees Safety Handbook before accessing the hoistway, either above or below the car. This manual is invaluable as a source for safe working policies and habits.

1-2 SAFELY MAINTAINING A HYDRAULIC ELEVATOR

We will be looking at the points listed below with respect to basic safety around hydraulic elevators. Remember that the focus is on the specific safety issues concerning hydraulic elevators.

- Basic hydraulic safety
- Machine room cleanliness
- Overhead clearance
- Lockout/Tagout
- Stop Switch

Safety around a *roped hydraulic* elevator involves all the concepts discussed in this module and includes many of the safety issues discussed with respect to traction elevators. Safety around roping, sheaves, pulleys and other moving components is specifically covered in the safety module for traction elevators. That module should be studied before beginning work on a roped hydraulic elevator.

Basic Hydraulic Safety

Elevators present a set of obvious safety concerns dealing with an open hoistway, **electrical shock**, mechanical **pinch points** and other dangers. Hydraulic elevators in addition include the added hazard of working around highly pressurized hydraulic fluid. Hydraulic fluid under pressure can puncture the skin and cause significant injury, including death.

Warning: Safety Precautions!

Never use your hand to check for a leak, but instead a piece of cardboard, wood or other substance.

The fluid itself depending on the specific composition may present additional chemical issues. When working with a hydraulic elevator system refer to the **Material Safety Data Sheet** for the hydraulic fluid used.

Keep machine room and pit clean

Cleanliness is always an excellent habit to be in with regard to safety as a clean and orderly workspace is inherently safer than one that is cluttered. When dealing with hydraulic elevators cleanliness takes on an additional dimension. Hydraulic fluid spilled on the floor is a **slipping hazard**. Modern hydraulic elevator systems are efficient and have reduced seepage around the cylinder and other components, however the systems still do leak.

Methods to collect the fluid vary but tend to group around a simple **catch basin** placed in such a way that leaking fluid runs or drips into the basin or a **scavenger pump** system to collect and store the fluid. As illustrated in ***Figure 1.2***, a used five gallon hydraulic oil bucket is frequently employed for this purpose. Using an old hydraulic oil bucked provides a container that is sufficiently large to contain the fluid and is designed to hold hydraulic fluid while not breaking down chemically.

Scavenger pumps (***Figure 1.1***) collect the fluid and stores it. Check the fluid level in the storage tank frequently to insure that it does not over fill and either overflow or shut down the system. When the fluid is removed be sure to measure carefully, record the amount of fluid collected, and then dispose of the fluid according to authority guidelines.

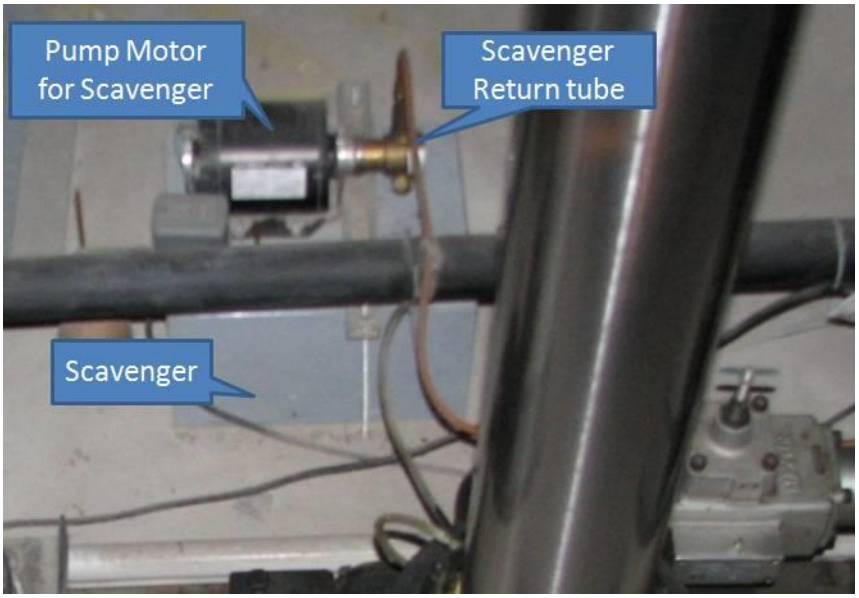


Figure 1.1 Scavenger Pump, Return Tube, Scavenger –Courtesy NYCT

Catch basins are a passive system of basins located in places that routinely leak. These basins also must be emptied regularly to insure that the fluid does not contaminate the floor. The amount of fluid in the containers should be measured, the amount of fluid recorded to track the rate of fluid loss, and the fluid disposed of according to authority guidelines.

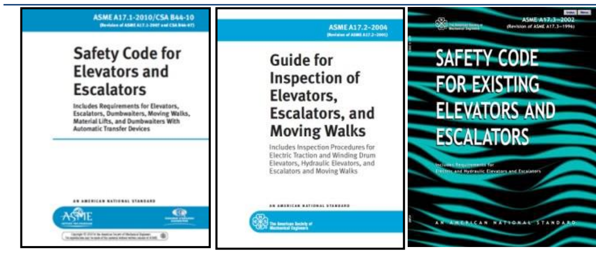
Figure 1.2 Used Five Gallon Bucket used as a Catch Basin for Hydraulic Elevator –Courtesy WMATA

Wet areas not associated with the catch basins should be investigated and the source of the fluid determined and repaired as needed. If the recorded leakage of either is excessive the system will have to be examined and the leaks fixed. If the amount of fluid leaked is significantly different than the amount used to refill the system the system may have a hidden leak that must be located and corrected as soon as possible.

Overhead Clearance

Overhead clearance in the hoistway of a hydraulic elevator varies. The space may be very spacious but depending on conditions the available space can be very limited. All the lifting equipment is either located under the unit or in an associated machine room. This means that since there is little equipment on top of the unit the distance between the top of the car and the ceiling of the hoistway may be too small to allow room for personnel when the unit is taken to the top floor. Before getting on top of and operating the car verify the space available and take the steps necessary to insure your safety.

Figure 1.3 shows an elevator with clearance of about three and a half feet. Some elevators have an even more limited clearance. With as little as 18 to 20 inches clearance when extended to the top floor these units are required by code to be clearly labeled.



See A17.1 Sections 1 and 2.4.7.1, A17.2 Section 3.4.1 and A17.3 Sections 1 and 2.4, for a detailed review of code requirements for overhead clearance

Top of Car Control Box

Before working on the car you should locate and test the **stop switch** which is located on the **top of car control box** (***Figure 1.4*)**. The switch should be tested in accordance with both manufacturer's recommendations and Authority procedures. Additionally make sure the directional controls work properly in both directions before leaving the floor level. There is a light on the top of car control box and should be a light associated with the stop switch. Ensure that the light both works and is guarded.

The top of an elevator car can be quite cluttered. Electrical cabling, lights, door opening mechanisms, air conditioning and other equipment are located on the top of the car. Keeping the top of the car clear of debris is important to reduce the chance of slipping or tripping. This can be particularly dangerous when multiple units are in the same hoistway. As you enter the car top you should also follow all fall protection procedures that apply the location.

In some locations a platform is built onto the side of the elevator car to provide technicians a location to inspect the operation of the elevator. When inspecting the operation of the unit be sure to follow procedures involving riding outside the car including fall protection.

A **hard hat** or **bump cap** should be worn when working near the top of the hoistway to reduce the chances of head injury.

Figure 1.3 Limited Space in the Overhead –Courtesy WMATA

Figure 1.4 Top of Car Control Box –Courtesy WMATA

Lockout/Tagout

Lockout/Tagout procedures should be used when working on equipment that can store or access a potential energy source. This would include locking out electrical power when working on the pump and motor. In addition to electrical lockout the hydraulic system would have to have its stored energy discharged (car lowered to bumpers) and the pump locked out when working on the pump, piping or cylinder.

Hydraulic elevators have both electrical energy available and mechanical energy stored in the extended hydraulic cylinder and car. The unit must be locked and tagged out to remove the electrical power and mechanically support the car and cylinder (Install Stand pipes above).

Follow your Authority's LOTO procedures carefully as a minimum protection. Make sure that main power to the unit is securely disabled and locked out before beginning work. Also remember that though main power to the unit is locked out auxiliary power is still on in most cases. Outlets, lighting and other equipment will still have power. Take care around powered equipment as much of it will still be a shock or mechanical hazard.

The Elevator Industry Field Employees' Safety Handbook - 2010, Section 7, p. 49, gives details for lockout/tagout procedures.

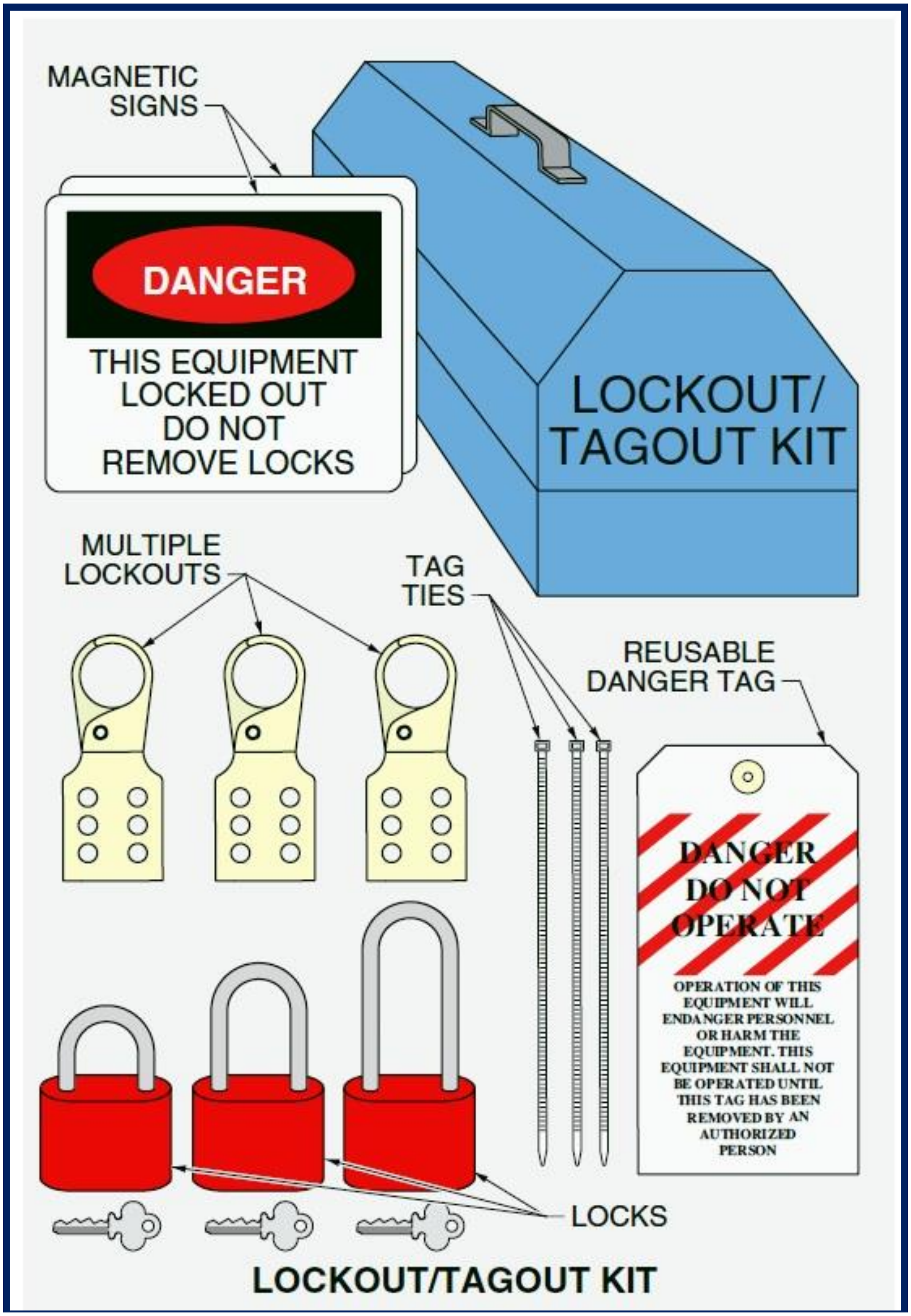


Figure 1.5 Lock Out/Tag Out Kit

1-3 EFFECTIVE COMMUNICATION TECHNIQUES

Elevator machine rooms and the equipment they service may be located a considerable distance apart. This is particularly true if the car is on a different floor from the machine room. When considerable distance is involved **communication** becomes difficult or at times impossible. Other factors can make communication difficult including sound insulated walls, ambient noise, and individual vocal and auditory conditions.

Figure 1.6 Noisy Platform Elevator –Courtesy MARTA

As always, use your authority specific guidelines.

Any time one or more technicians will be working in the machine room and other(s) at the unit communication becomes critical. Miscommunication can result in equipment that suddenly becomes energized or moves. When this happens the result can be serious injury and possibly death. Effective communication can prevent this from happening. The following can assist in developing a solid communication process.

- Establish a channel of communication
- Be clear
- Make no moves without repetition

Establish Channel of Communication

There are several channels of communication including simple voice, telephone, email/text, and radio. Some locations may have several available - others will have one or even none. Select the one channel available that creates a clear and direct means of communication. Generally that will be radio unless there is a dedicated maintenance phone installed. Communication by radio should be on a direct link not through a trunked radio line if at all possible as trunked lines do not give immediate and direct communication at all times.

Figure 1.7 Communication Techniques –Courtesy MARTA

Be Clear

Once a definite communication link is established the next step is to insure clarity of communication. What one technician says should be what the other technician hears. All discussions should be done using an established set of "commands." The technicians should use Authority approved terms for any action that would result in equipment moving or becoming energized. If Authority approved terms are not available the technicians should discuss and agree on the terms to be used before beginning work.

Simple terms can be some of the most confusing when communicating from a distance. For instance, the definition of left side and right side of the car could be a problem. Simply review the convention of facing the car from the platform. The side to the right is the right side the side to the left is the left side. This kind of clarification before beginning work can save time, money, and reduce confusion.

When additional personnel arrive the terms should be reviewed with everyone who may be giving or executing instructions.

Repeat

Even with an established set of terms to use, misunderstandings can occur. Misunderstanding an instruction then moving a car or energizing equipment all too often results in damage or injury. Each piece of communication that can result in movement or energy being applied to equipment should be repeated for certainty. **Repetition** may sound unnecessary but it takes only a few seconds and can save damage to equipment or injury to employees.

1-4 WORKING SAFELY UNDER THE CAR

When working in the space under the car extra caution must be exercised. Several hazards exist in the pit. The elevator car is suspended by the pressure in the hydraulic system. Several pieces of equipment in the pit are electrified. Frequently water stands in the pit. The pit is a confined space and in some limited cases the pit could be a permitted confined space (follow proper procedure for permit confined space in addition to the steps outlined here).

Follow your Authority's procedures when working in the elevator pit. Important things to consider when working under the car will be covered in this section and include the following:

- Up call
- Remove water
- Install **landing blocks**, especially when working on piping
- Lockout/Tagout
- Doorway hazard

Up call

ne simple but effective thing that can be done when working under the car is to put an **up call** on the unit. If for some reason the elevator becomes energized the first move will be up. This will give technicians in the pit time to either leave the pit or deal with the elevator in another manner.

Remove water

Elevator pits frequently have water standing in the bottom (***Figure 1.8***). This standing water must be removed before beginning work on the unit. **Standing water** can hide hazards. Standing water is also very dangerous around live electrical circuits. Even though the elevator may be locked out and tagged out electrical outlets, lighting, and other equipment in the pit will still be powered. That means that the standing water can become a path to ground, making shock a very real hazard.

Figure 1.8 Flooded Pit Area ©Elevator Bob

Install Pipe stands or Landing Blocks

For some maintenance such as plumbing, piping and packing, maintenance personnel will need to situate themselves in the pit. At other times work may have to be done under the car inside the hoistway. In these incidences it is necessary to "land the car." **Landing the car** basically means resting the elevator car on pipe stands, landing blocks or buffers to ensure that it does not move. **Buffers** are the springs mounted in the pit, pipe stands are installed in the pit frequently in place of the buffer, and landing blocks are attached to the rails anywhere they are needed in the hoistway. It is especially needed to land the car when work is being performed on components of the hydraulic system where pressure loss is very possible. The only thing normally supporting a hydraulic elevator is the column of fluid in the cylinder. Should something happen to one of the hydraulic components the pressure will escape and the elevator may drop to the bottom of the hoistway.

Figure 1.9 Elevator Car on Buffer – Courtesy WMATA

Warning: Safety Precautions!

- When landing a car, two maintenance personnel should be present in all time, equipped with the proper PPE
- Be sure to use the appropriate pipes when supporting the car. The pipe must be strong enough to support the car.

If work is being done underneath the car it should be mechanically supported. To accomplish this with pipes, follow these steps:

1. First move the car slightly above the desired position.
2. Take the pipes, which are either provided by the manufacturer for the installation or the piping provided by the Authority for that installation, to the location for use (Figure 1.10).
3. Pull off the buffer spring (Figure 1.11).
4. Next place the pipes on the buffer stand (Figure 1.12).
5. Finally lower the car so that it sits on the pipes (Figure 1.13).

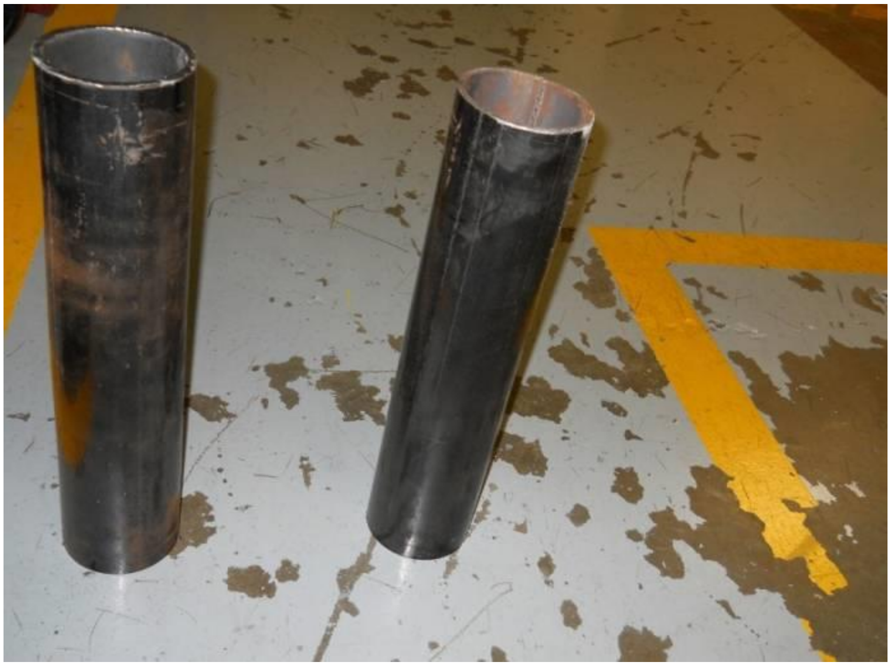


Figure 1.10 Different length pipes –Courtesy WMATA

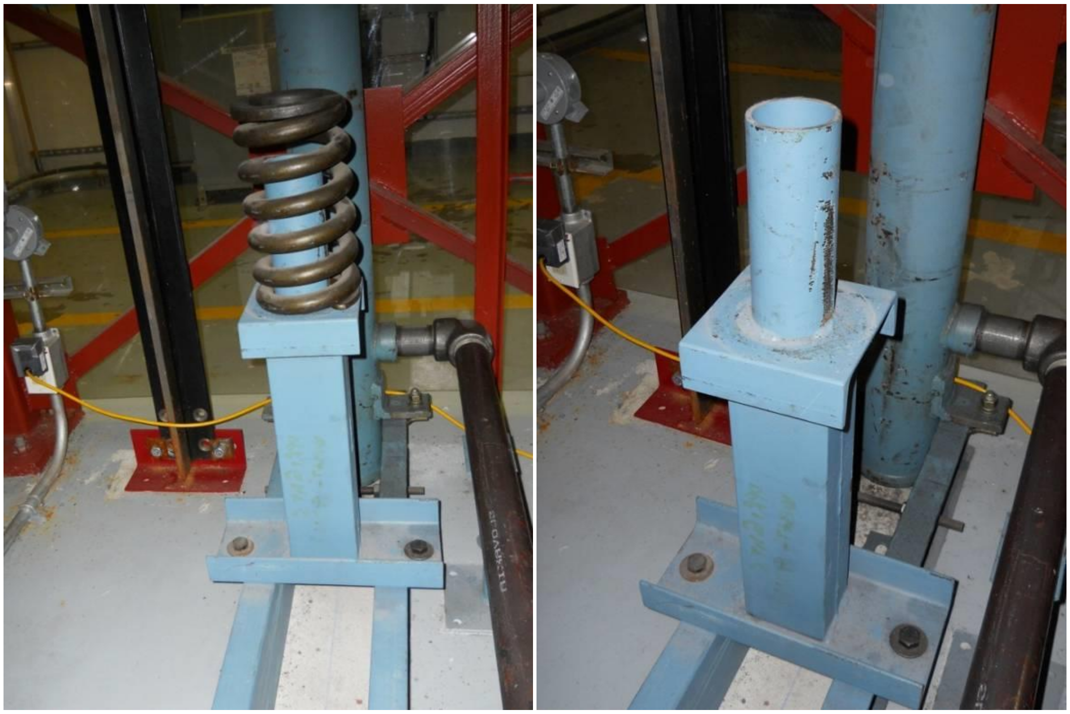


Figure 1.11 Buffer stand with and without buffer spring –Courtesy WMATA

Figure 1.12 Placing the pipes on the buffer stand –Courtesy WMATA

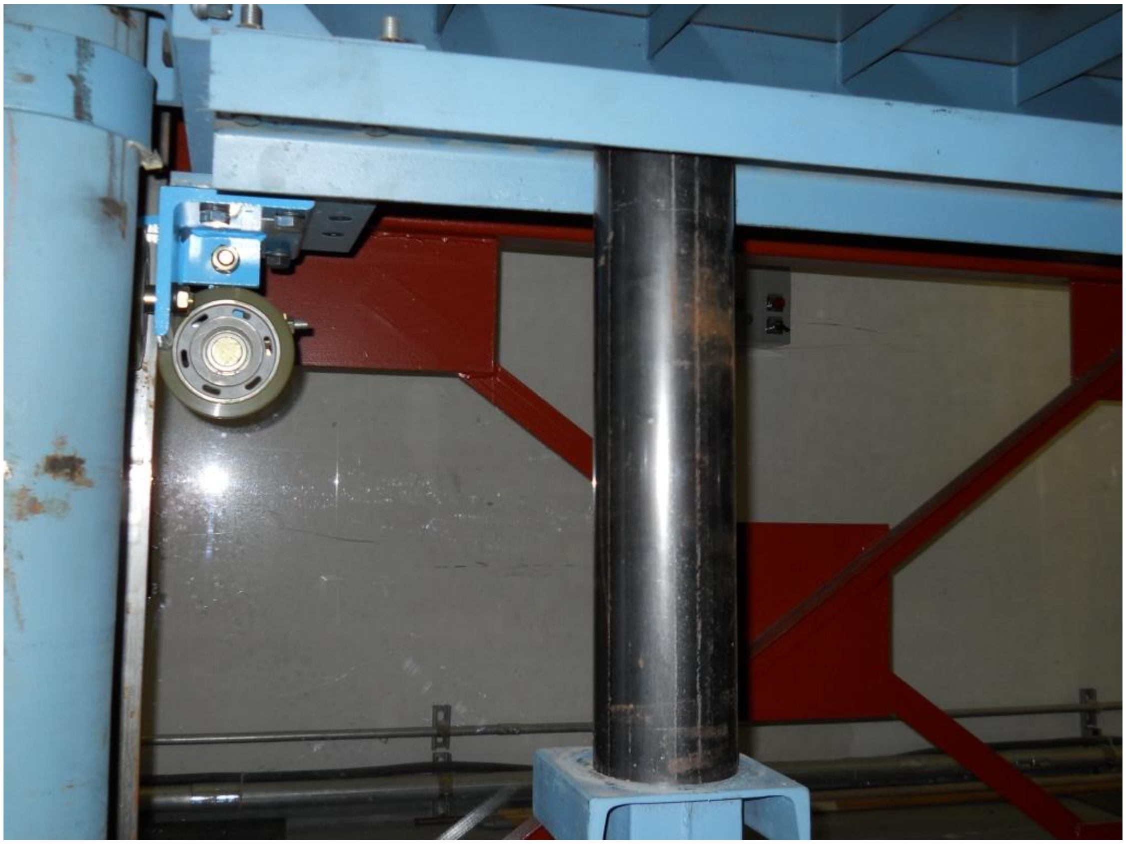


Figure 1.13 Car Sitting on Pipe –Courtesy WMATA

The process for landing a car on landing blocks, also called rail clamps, is very similar to that of installing stand pipes, except that landing blocks can be used at any point in the hoistway. This allows a car to be placed where it is needed and mechanically supported at that point. As with pipes, first raise the car slightly above the desired position. Install the blocks to the rails using all the included hardware and following the directions of the manufacturer and appropriate authority procedures. Lower the car gently to the blocks.

If only the pressure on the hydraulic system needs to be relieved, simply rest the car directly on the buffers (Figure 1.14).

Figure 1.14 Spring Buffer –Courtesy WMATA

After the car is sitting on the pipe stand, landing blocks, or buffers, turn off power and perform LOTO procedures. Use shut off valves as needed - for example when replacing packing and pumps.

Stand pipes and landing blocks are also a form of Lockout/Tagout and are absolutely critical for protecting workers from the potential energy contained in the elevator car and cylinder. Installation of the stand pipes or landing blocks will vary depending on the stand pipes or landing block used and on the specific conditions of the location. Care must be taken that the stand pipes or landing blocks are installed properly and securely.

Each Authority will have specific procedures that will also vary. Be sure to follow all Authority procedures when installing these protective devices.

Do not stop in doorway

When working on elevator equipment enter and leave the hoistway quickly. Do not stop in doorway. Personnel sitting, laying, or otherwise remaining stationary in the doorway can be caught by an elevator that is moves suddenly or unexpectedly. The result can be serious injury or death.

1-5 SUMMARY

Hydraulic elevators are relatively simple in concept and in their execution. Working safely around hydraulic elevators is also relatively simple.

1. Exercise care working with hydraulics as outlined in basic hydraulic safety training,

2. Keep the work area clear and clean.

3. Carefully and completely perform Lockout/Tagout procedures to protect from electrical, hydraulic, and mechanical hazards

4. Make every effort needed to establish and maintain clear, effective communications.

5. Work safely under the car by positively supporting the car using pipe stands, buffers or landing blocks.

Module 2

PRINCIPLES OF OPERATION

OUTLINE

2-1 Overview
2-2 Hydraulic Elevator Components
2-3 Variations in Configuration
2-4 Properties of Hydraulic Fluid
2-5 Summary

Purpose and Objectives:

The purpose of this module is to provide a more in depth understanding of how hydraulic elevators function including variations in configurations.

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

- Identify and describe all components of a hydraulic lift system
- Explain the operation of a life jacket
- Describe different types of power units used to pressurize hydraulic fluid
- Explain the operation of a cantilever installation and associated benefits and drawbacks
- Compare and contrast the different types of hydraulic pistons
- Describe a compound piston
- Describe viscosity of hydraulic fluid and how it relates to the operation of a hydraulic elevator

Key Terms

- Baffle Plates
- Cantilevered Elevators
- Compound Pistons
- Constant Output Screw Pump
- Control Valve
- Cooling Fan
- Direct Action Cylinder
- Direct Action Piston
- Electrolysis
- Exterior Motor And Pump
- Flange
- Hole Less Hydraulic Cylinder
- Isolation Couplings
- Machine Roomless Elevators (MRL)
- Manual Lowering Valves
- Manual Shut Off Valves
- Muffler
- Overspeed Valve
- Packing Head
- Particulate Free
- Pilot Flow
- Plunger Gripper
- Plunger Gripper Controller
- Power Unit
- Pressure Switch
- Pump
- Rubber Diaphragms
- Scavenger
- Strainers
- Submerged Motor And Pump
- System Pressure
- Tachometer
- Tank Heater
- Telescopic Cylinder
- Telescopic Pistons
- Temperature Probe
- Viscosity

2-1 OVERVIEW

Hydraulic elevators predate electric elevators as they have existed since the middle ages. In today's elevator industry hydraulic elevators serve a niche in the vertical transportation market. Hydraulic elevators will have a place even with the advent of **Machine Roomless Elevators (MRL).** Hydraulic elevators are relatively less expensive than traditional roped traction installations and are easier and faster to install. Hydraulic elevators do however have their limits as they are slower - seldom operating at over 200 fpm and are limited in their rise - 6-8 floor levels is their upper limit. The advantage of hydraulic elevators over traction elevators is that the power unit does not have to be installed in proximity of the elevator shaft.

2-2 HYDRAULIC ELEVATOR COMPONENTS

Power Units and Pumps

The **power unit** (Figure 2.1) converts electrical energy into fluid energy by sending it through a pump. The pump is powered by a three phase AC motor which is controlled by the controller. Power units come in two types: the submerged motor and pump and the exterior motor and pump unit.

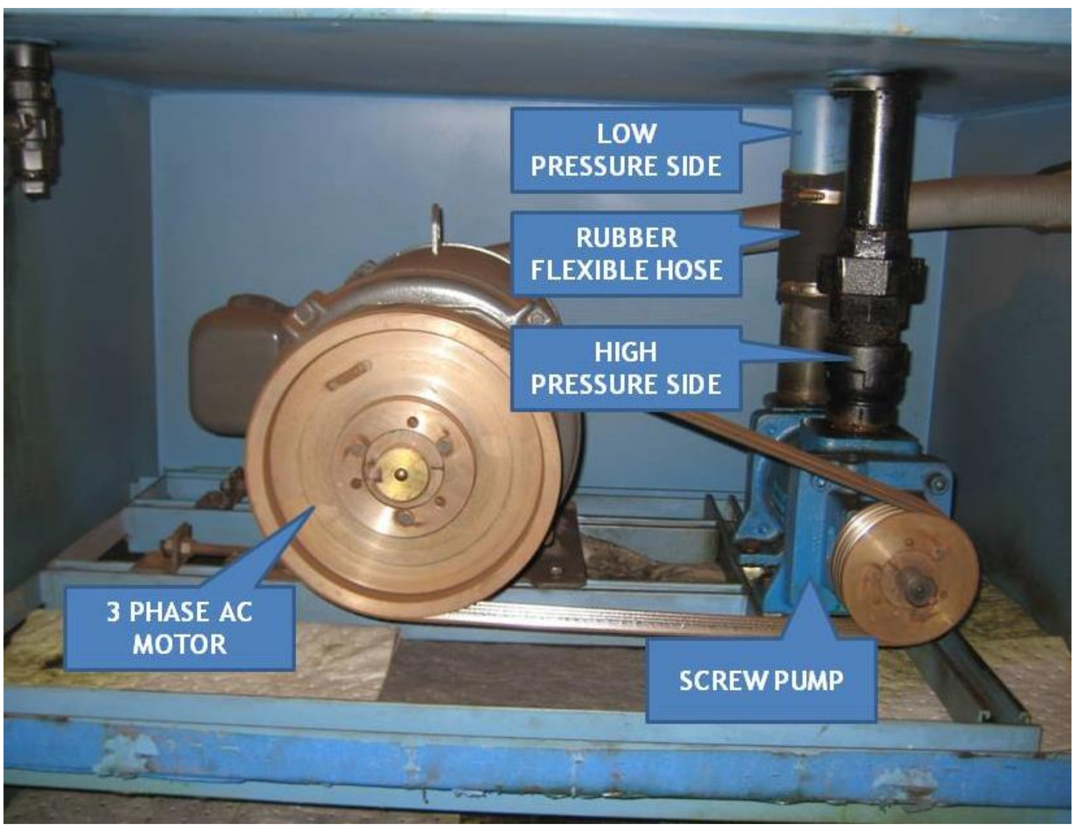


Figure 2.1 Hydraulic Power Unit –Courtesy NYCT

The **submerged motor and pump** are quieter as being submerged the sound is lessened using the hydraulic fluid as a sound barrier. It also uses the hydraulic fluid as a cooling fluid. The submerged motor and pump also requires less space than the exterior mounted motor and pump type.

The **exterior motor and pump** have no hydraulic fluid to act as a coolant and sound barrier. Therefore they tend to be noisier and are more prone to overheating. Since the exterior motor and pump are out in the open instead of inside of the hydraulic fluid reserve, they require more space.

In each of these types of power units, the **pump** is a **constant output screw pump**, meaning that for every revolution of the pump shaft the same amount of hydraulic fluid is displaced. The hydraulic fluid enters the low pressure side of the pump. The input side is under constant pressure of the weight of the hydraulic fluid in the reservoir which keeps the input side constantly fed with hydraulic fluid. As the screw of the pump spins, oil is pulled thru the pump. and begins to pressurize the fluid on the output side. The fluid exits the pump thru a smaller diameter pipe.

Because they are self-lubricated, pumps have a very long service life. The main concern with service life of hydraulic pumps is that the hydraulic fluid stay **particulate free**. Transit environments make this a particular challenge as environmental contamination from the motor room greatly affects the quality of the fluid. Great care should be taken to make sure that the tank cover is always in its proper place.

Valves

The **control valve** is located at the output side of the installation it directs the pressurized fluid either to the cylinder or back to the reservoir. Modern control valves (Figure 2.2) are unified in one piece of hardware as opposed to previous systems when the up and down directions had separate solenoids and up and down lines. The control valve functions by controlling the **pilot flow** of fluid. The pilot flow is directed with the use of solenoids to close or open different paths of hydraulic fluid thus directing the pressure to act upon the up and down piston located in the valve and control the speed and direction. Direct pressure to different pistons sends the flow of the bulk of fluid either to the cylinder or back to the tank.

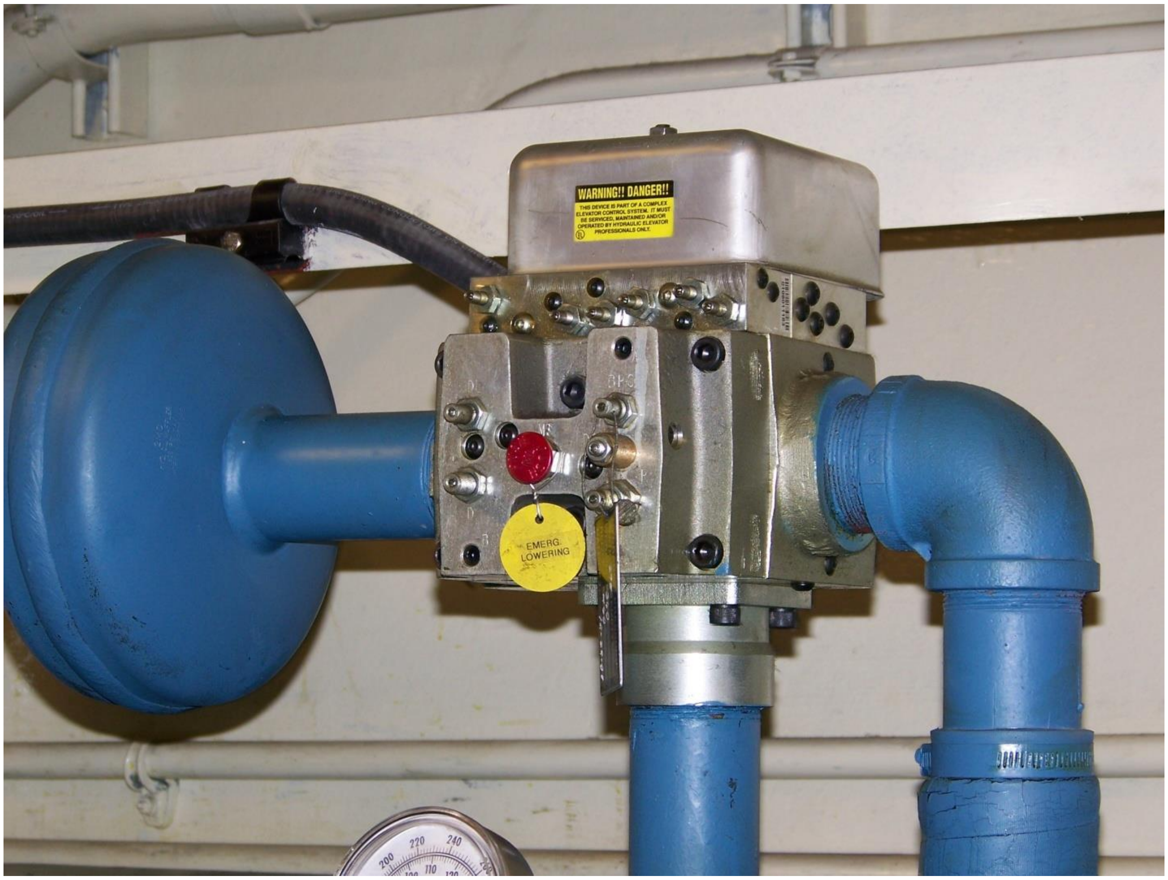


Figure 2.2 UC4MR Control Valve - ©Maxton

There are two types of **manual lowering valves** that are used in the hydraulic elevator industry:

1. Direct Action
2. Constant pressure manual lowering button or spring loaded disc

The type of valve installed is determined by the installation of the type of cylinder and plunger that is used.

The manual lowering method uses a twist open type of valve in direct action below grade pistons (the packing head is below the power unit). This is because if the valve is accidently left open hydraulic fluid will not return to the tank.

The other type of lowering device is the constant pressure manual lowering button and **s**pring loaded disc. These devices have to be manually depressed to permit the lowering of the elevator. Their use is required by code in systems where the packing head is located above the power unit.

If constant pressure is not maintained on the device, it resets to its default position and the hydraulic fluid remains in the hydraulic line. If the manual lowering valve was not automatically reset with its release the possibility of injury to the passenger(s) or mechanic would increase. If the elevator becomes bound in the hoistway, the weight of the elevator and piston will be put on the rails or some other obstruction rather than the hydraulic fluid. It is possible that the hydraulic fluid could return to the reservoir through the open solenoids. This would cause a situation that once the elevator is unbound in the hoistway the piston would fall at an accelerated rate until the suspension means was met causing catastrophic injury to the mechanic or passengers.

Two other types of valve, manual shut off valves and overspeed valves, will covered in pit components.

Components Inside the Hydraulic Line

The pressure that is present when a hydraulic elevator is fully loaded with the full weight of the piston, car and operators with the test weights and sitting on the suspension is called **system pressure**. System pressure is measured at the valve through a test port, with a pressure gauge (Figure 2.3).

Establishing the system pressure is necessary because the mandatory relief adjuster is set at 125 percent of normal system pressure and also measured on the valve, thru the input side of the valve. If the car should become bound in the hoistway and the pump continues to pump resulting in excessive pressure, the relief adjuster acts to prevent component failure or a hydraulic fitting failure.

The **pressure switch**'s contact is normally open and monitors the positive displacement of the cylinder and piston. It is used in installations where the packing head is above the power unit such as a holeless hydraulic piston. If the piston and the elevator become bound in the hoistway and the hydraulic fluid is no longer under pressure, the pressure switch contact will open causing Down (D) and the Down Level (DL) solenoids to drop out (Figure 2.4 and Table 1). This chain of reactions prevent the hydraulic fluid from returning to the reservoir. The return of fluid to the reservoir would lead to a catastrophic system failure such as the elevator and piston falling at an unsafe and uncontrolled speed until contacting the remaining hydraulic fluid.

Figure 2.3 Pressure Gauge with Pressure Switch –Courtesy NYCT

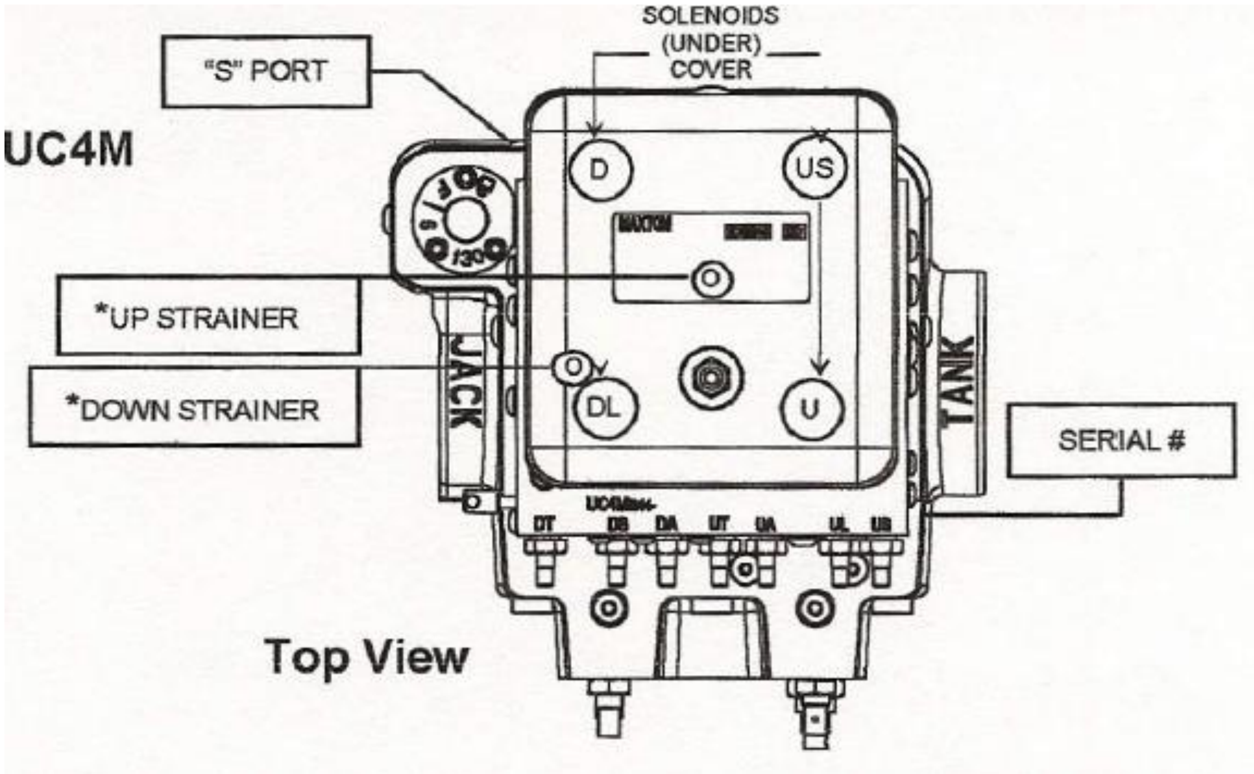


Figure 2.4 Control Valve - ©Maxton

Table 1 Control Valve Solenoid Designations - ©Maxton

Control	Function
U	UP
US	UP STOP
D	DOWN
DS	DOWN LEVEL

A **muffler** dampens the flow of hydraulic fluid as it leaves and returns to the power unit. The size of the muffler is determined by the amount of hydraulic fluid flow. There are two types of hydraulic mufflers used in the hydraulic elevator industry.

In smaller piston applications the muffler is a series of **baffle plates** that diffuse the mass of the fluid as it returns from the cylinder. This reduces the noise that is created when oil is returned to the tank.

The second type of muffler is larger and is composed of two spring loaded **rubber diaphragms**. The diaphragms oppose each other and work the same way as the smaller muffler - absorbing and slowing the fluid as it returns to the reservoir. Note that over time, these diaphragms are degraded due to exposure of the hydraulic fluid.

The muffler also absorbs the pulsation created by the pump output and evens the flow of hydraulic fluid to the cylinder.

Figure 2.5 Small Muffler Used in Down Regulated Systems –Courtesy NYCT

Isolation couplings are used to electrically isolate the piston from the power unit. The hydraulic cylinder and the hydraulic line are metal and conductive and the cylinder acts as a giant grounding rod for all stray voltages and for all static electricity produced by the power unit itself. Placing an isolation coupling in the hydraulic circuit keeps these voltages from oxidizing the cylinder. This coupling provides a non-conductive connection in the hydraulic system. It also acts as a noise reduction filter providing a non-metallic connection between the power unit and the hydraulic cylinder.

Figure 2.6 Isolation Coupling Installed Between the Power Unit and Hydraulic Cylinder –Courtesy NYCT

Components in the Pit

There are three components that exist in the pit of all hydraulic elevators that are not on traction elevators. They are:

1. Scavenger or Fill Bucket
2. Manual Shutoff valve
3. Overspeed Valve

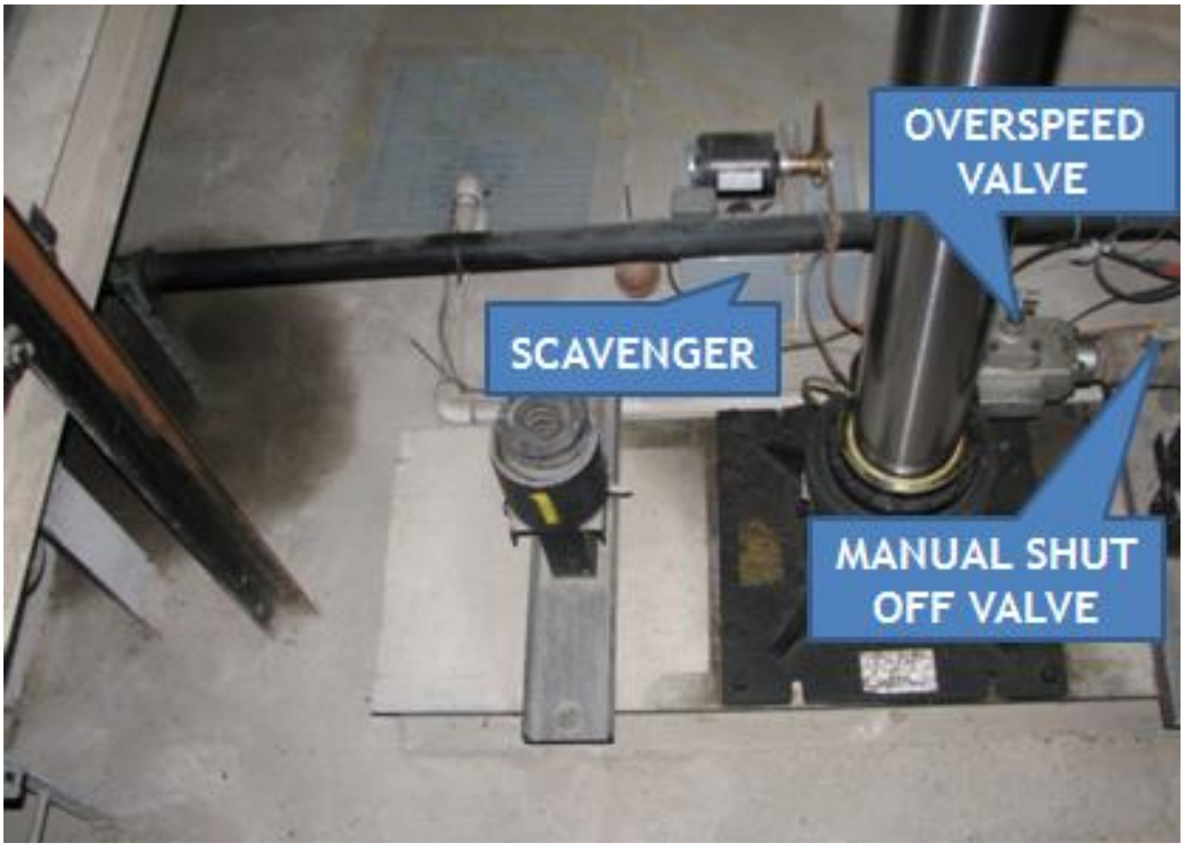
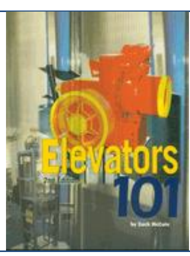


Figure 2.7 Hydraulic Specific Components in the Pit –Courtesy NYCT

Some systems use a **plunger gripper** also known as *life jacket*.



Elevators 101 2nd Edition, Chapter 9, pp. 88-91, gives overview and illustrations of elevator pits including pit construction, spring buffers, and oil buffers.

The **scavenger** captures oil that slips from the packing and wiper ring. In some cases there is a motor that enables the return of the escaped oil to the main hydraulic reservoir (Figure 2.8). In other instances, the scavenger is simply a bucket that captures this oil (Figure 2.9). It should be emptied back into the hydraulic reservoir manually - as per your locations procedures.

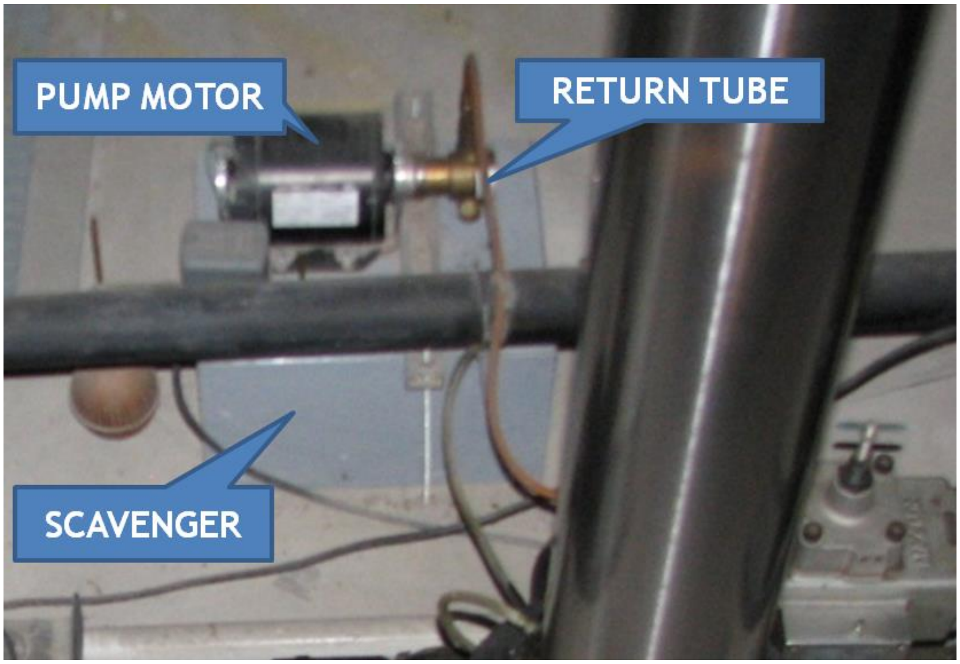


Figure 2.8 Motorized Scavenger –Courtesy NYCT

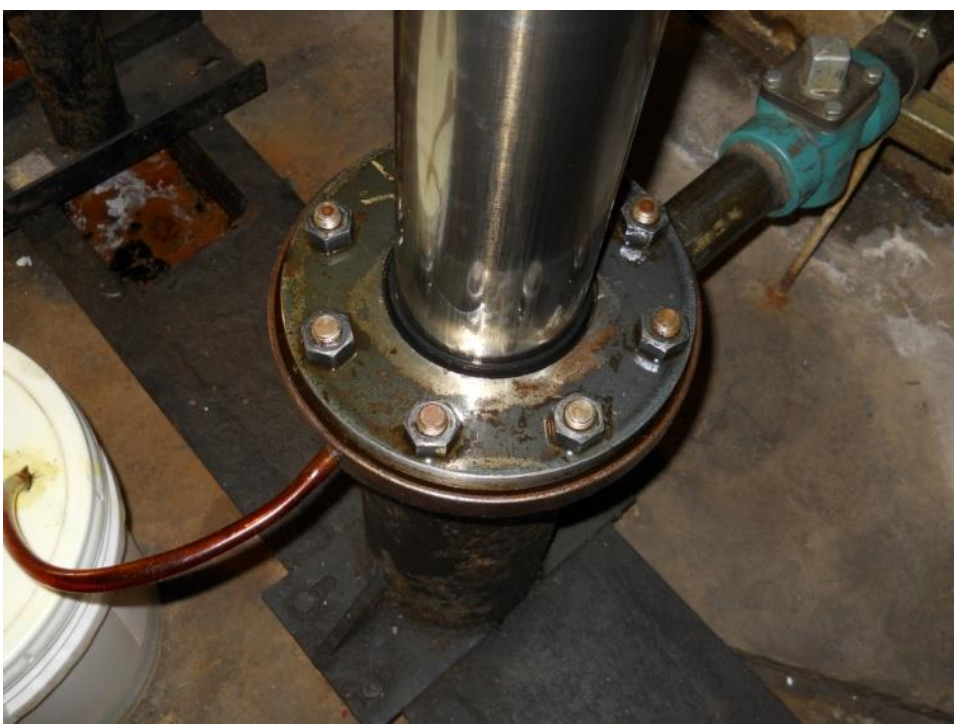


Figure 2.9 Bucket Style Scavenger –Courtesy WMATA

There are a minimum of two **manual shut off valves** required by code. One is in the motor room after the power unit. This allows for a quick shut off of the hydraulic fluid line and makes it easier to depressurize the line in preparation for valve maintenance.

The second shut off valve is located in the pit - preventing accidental movement of the elevator car, therefore protecting the maintenance personnel in the pit. If working for an extended period of time the elevator should be landed on landing blocks or pipes.

	Warning: Safety Precautions!
⚠	Never perform maintenance on a valve under pressure.

Hydraulic systems are very flexible in that the power unit does not have to be in close proximity of the cylinder. In fact the power unit could be hundreds of feet from the cylinder. This is important to transit applications where space is often at a premium. However, with every foot in length, the possibility of line failure increases.

To provide protection from loss of hydraulic pressure that would allow the elevator to descend at a catastrophic rate the industry created the **overspeed val**ve (Figure 2.10) also known as a *rupture valve* which automatically shuts the flow of hydraulic fluid back to the tank in cases when the main hydraulic line is breached/broken. This valve is installed as per code within 12" of the cylinder to provide the most protection against hydraulic line failure. It is calibrated to set should the elevator overspeed past a set gallon per minute (GPM) rating.

There are various ways to determine this rate such as a **tachometer** against the rail, or a "SafeTach" from Maxton Valve. This device measures the speed and motion of the elevator cab and provides protection in the event of catastrophic hydraulic line failure.

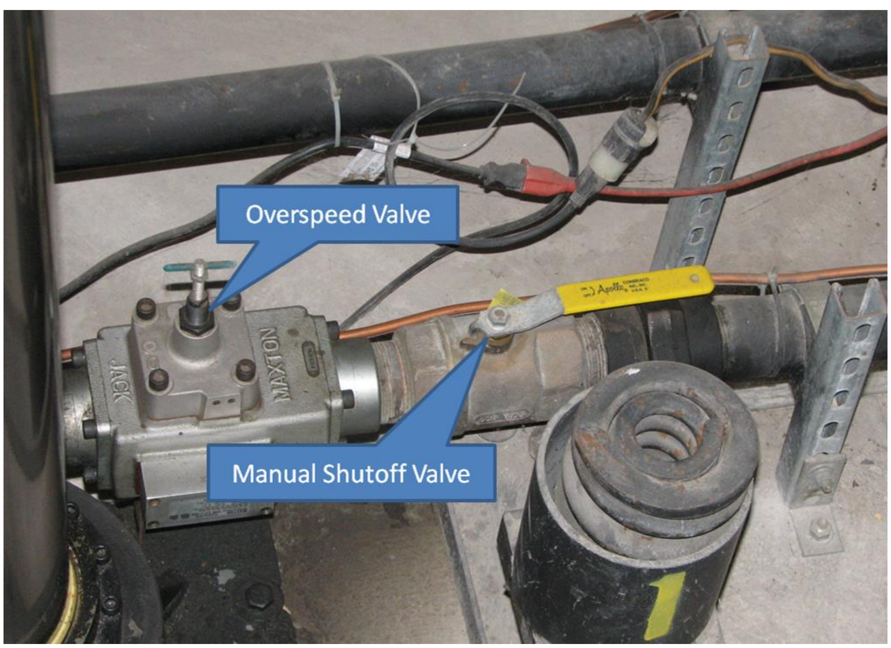


Figure 2.10 Overspeed and Manual Shutoff Valves in the Pit –Courtesy WMATA

Additionally, installation of a **plunger gripper** and add-on **plunger gripper controller** are crucial for safety**.** Together, they stop the uncontrolled descent of an elevator. The controller works with the input of an encoder that provides descent speeds to the control board. If the elevator should descend at a rate faster than contract speed the life jacket will stop the elevator.

This feature protection in case of catastrophic suspension means failure and elevator overspeed in the down direction. Overspeed can be caused by failure of the hydraulic line connection or if the cylinder should lose its structural integrity through **electrolysis**.

Electrolysis is an unwanted process in which stray electrons find a path to ground through the cylinder - most common in direct action pistons that are buried below the pit floor. The stray electrons will find a path to ground at the weakest point in the construction of the cylinder. As the electrons bleed off, the cylinder will begin oxidizing. Unchecked, the cylinder will oxidize until the cylinder loses its ability to contain the pressurized hydraulic fluid.

2-3 VARIATIONS IN CONFIGURATION

As you learned in course 213, the cylinder is actually two pieces - the cylinder that receives the pressurized fluid and the piston which is displaced by the pressurized fluid. The cylinder is stationary and does not move, the piston is what is displaced and what drives the elevator up. The cylinder is constructed to withstand pressure generated by the power unit.

Cylinders

There are three types of cylinders:

1. Direct Action
2. Hole less Hydraulic
3. Telescopic

A **direct action cylinder** is as deep in the earth as the elevator rises from the packing head. The disadvantage in a direct action cylinder is it cannot be visually inspected for leaks.
In the **hole less hydraulic cylinder** is mounted in the elevator pit above the pit floor, the advantage of this installation is that the cylinder can be inspected for leakage.

Then there is **telescopic cylinder** which has two or more stages. It is installed like the hole less hydraulic but the stages of the cylinder collapse into each other and is deployed incrementally to raise the elevator. The advantage of this type is it has more rise than a single stage hole less hydraulic.

Table 2 Comparison of Cylinder Types

Type of Cylinder	Location	Advantages	Disadvantages
Direct Action	In the ground	Takes up less space than hole less or telescopic configuration	Cannot be visually inspected for leaks
Hole Less	Elevator Pit	Cylinder can be inspected for leakage	Takes up more space than the direct action configuration
Telescopic	Elevator Pit	Cylinder can be inspected for leakage Takes up less space than a hole less configuration	Takes up more space than the direct action configuration

Pistons

The piston is suspended on hydraulic fluid, the weight of the piston, platform, cab, doors, and the door operator weight rests on hydraulic fluid. This is what establishes the system pressure. Hydraulic pressure is measured in pounds per square inch. This means that any point in the high pressure side has the same pressure on it.

Compound pistons are most commonly used in construction equipment where control of the arms and blades of the equipment is required. In a compound piston the cylinder has two ports that allow pressurized fluid to enter at either end of a sealed cylinder. Action of the piston directs pressurized hydraulic fluid through either port to raise or lower the piston under pressure. This is most often used in twin piston configurations where if the weight is not distributed equally on the platform there is a possibility that the platform could wedge in the hoistway. If a compound piston is used, the platform will be powered in both directions preventing the possibility that the platform could wedge in the hoistway.

In a **direct action piston** the pressurized hydraulic fluid is directed through the one and only entry port and the cylinder is lowered by gravity - providing a path back to the reservoir for the hydraulic fluid.

Telescopic pistons are pistons that deploy in stages as pressurized hydraulic fluid enters the cylinder. The piston is composed of two or more pistons that are all contained in a single cylinder. The stages nest in to each segment and are deployed in time as pressurized hydraulic fluid enters the cylinder. The advantage of a telescopic piston is that you can get a higher lift from an above ground piston instead of using a direct acting piston that would be buried below the pit.

Packing Head

The **packing head** (Figure 2.11) is located at the top of the cylinder where the piston exits the cylinder. The cylinder has a **flange** that accepts the packing head which is also flanged. In the packing head is the piston packing. The cylinder and the piston needs a pliable seal that can expand and contract with the changing temperatures of the hydraulic fluid, this seal must also withstand the system pressure. Provided that the cylinder is installed correctly and the elevator and the rails are installed correctly a piston seal will provide years of service. Even if the seal is installed perfectly, it will still allow a tiny bit of hydraulic fluid to escape. Above the packing seal is a rubber wiper ring which collects this excess hydraulic fluid.

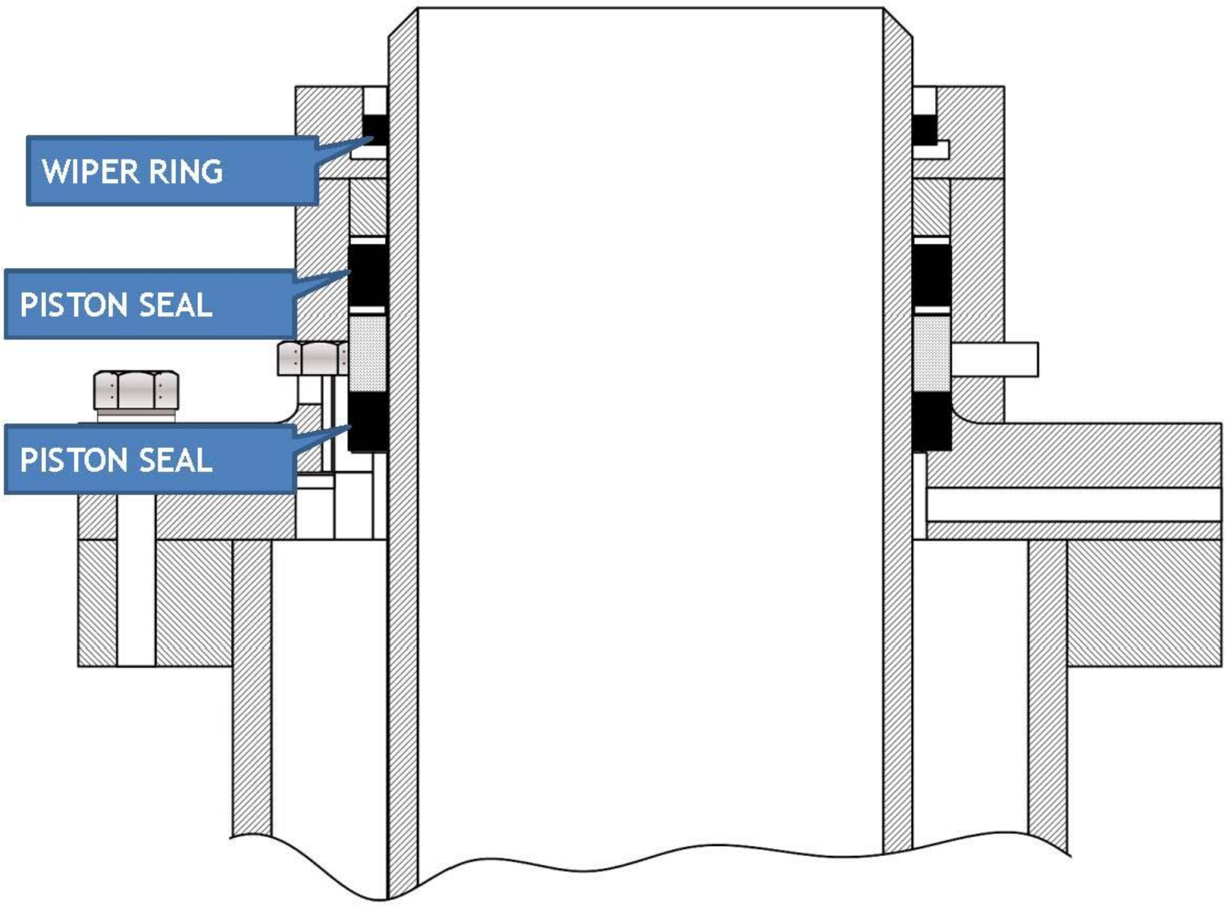


Figure 2.11 Flanged (Double Seal) Cylinder Head –Courtesy Tom Waugh

Cantilevered Elevators

Cantilevered elevators (Figure 2.12) are unique in that the cylinder, piston and the running rails are in the back of the elevator. The elevator is supported from the side of the hoistway rather than from beneath. The platform is mounted to the piston and rollers also mounted on the side of the elevator. This is a solution when the area surrounding the shaft is limited but the depth of the shaft is not an issue, such as a subway platform.

Cantilevered elevators come in two configurations allowing for a more versatile installation. If the piston is mounted to the side of the hoistway, the openings can be can be on different sides of the elevator allowing for a wheelchair bound person to enter and then exit the elevator without turning around on the platform. The rear mounted piston allows for more openings because the piston does not block the side of the elevator. Two or possibly three doors to enter and exit the platform permits versatility and allows designers to install a cantilevered elevator where a traditional under the car center piston would be impractical or impossible to install.

Cantilevered elevators can be mounted on direct acting pistons or can be roped. The roped hydraulic has a sheave mounted on top of the piston, this configuration allows for a higher vertical lift serving additional landings. The ropes are dead ended in the pit and on the platform; this is a 2:1 roping configuration. The 2:1 roping configuration also means that for every two feet the piston travels the car travels one foot allowing for a higher output put to be installed but keeping the car speed at 100 fpm.

The roped cantilevered elevator has hoist ropes as the suspension means and requires a speed governor to protect from catastrophic suspension means failure so an addition governor cable must be attached to the elevator and a governor tension sheave in the pit. This is in addition to the overspeed valve in the hydraulic line.

Cantilevered elevators allow for scenic views since the rails and the piston are mounted on one wall allowing for unobstructed views in glass enclosed hoistway and the elevator is constructed of glass panels. Cantilevered elevators the platform is supported from the side, this puts great pressure on the rollers that guide the elevator and maintain proper car position in the hoistway.

Pros	Cons
• More versatility • Can accommodate three separate entry points Lower costs on installation because you don't need to drill into the ground to accommodate a below ground piston • Useful in narrow hoistways where people in wheelchairs would not be able to turn around inside the car. • Single piston instead of dual because there is less to maintain.	• Everything has to be completely level/straight- If things do not stay in complete alignment, there will be issues • More maintenance is associated • The guide rollers on the bottom of the car bear most of the weight and wear at an accelerated rate and therefore need more maintenance

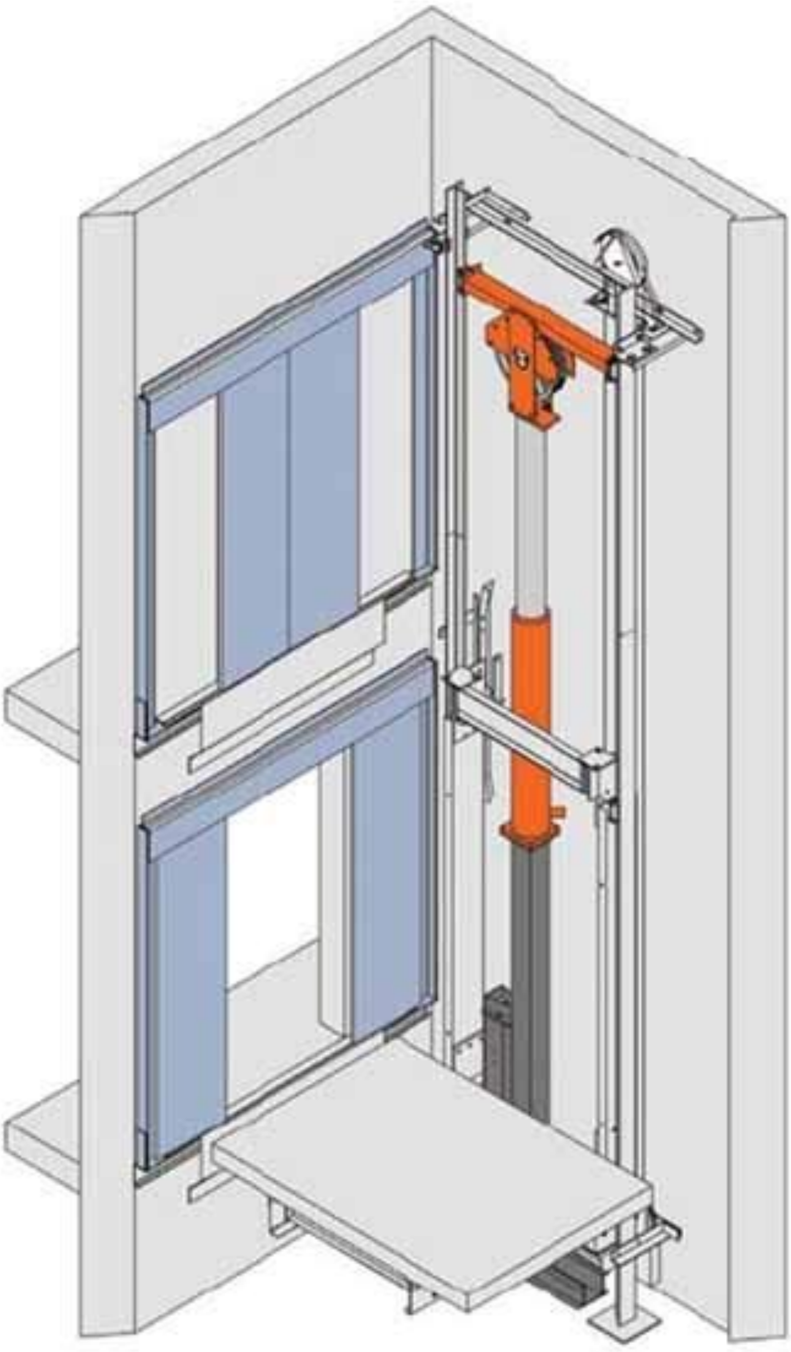


Figure 2.12 Side Slung Cantilever Hydraulic Elevator - ©Minnesota Elevator

2-4 PROPERTIES OF HYDRAULIC FLUID

Viscosity

Viscosity of hydraulic fluid is a measure of its density and the area that it will displace at a certain temperature. Hydraulic fluid will increase its displacement and flow at a greater rate at higher temperature. For every 50 degrees of heating it will increase its volume by 2%. An ideal temperature for hydraulic fluid is between 80-90 degrees Fahrenheit.

The viscosity of hydraulic fluid is of great importance in some installations adjustments that are made in the heat of the summer might have to be readjusted in the cold of the winter. This is because the fluid has more viscosity at a cooler temperature and will not flow as easily and will not displace the same mass. Therefore the floor and valve adjustments will not be in adjustment

Temperature and Contamination of Hydraulic Fluid

In modern elevator installations the temperature is monitored by a **temperature probe**.

At the upper end of the temperature scale when the fluid becomes too hot the PLC will send the reservoir fluid thru a heat exchanger to cool the fluid. The hydraulic fluid is pumped from the low pressure reservoir side thru a radiator with a **cooling fan**. This reduces the heat of the fluid to try to maintain the 80-90 degree range. If the temperatures reaches or exceeds 150 degrees, the elevator will automatically shut down. The reasoning for this is that fluid this hot becomes oxidizing and begins to degrade the rubber O-rings in the valve - shortening the life of the valve.

If the fluid becomes too cold the heater element in the **tank heater** is activated and begins to heat the oil. The tank heater is mounted in the bottom of the tank reservoir and thermostatically controlled to heat the hydraulic fluid, it is installed near the bottom of the tank because heat always rises and cold always sinks to the bottom.

The tank heater also cycles the hydraulic fluid through the valve and back to the reservoir to mix the cold fluid with the warmer fluid. It is monitored by the PLC and tries to maintain the ideal temperature of 80-90 degrees.

The most important element of long valve life is the purity of the hydraulic fluid. All contaminants that are in the elevator motor room - dust, human hair, paint, lint, etc. - find their way into the reservoir tank and then into the control orifices and adjuster ports that effect pilot flow and the adjustments of a control valve. The control valve does have **strainers** that collect particulate debris. These strainers must be cleaned or replaced periodically.

2-5 SUMMARY

Hydraulic elevators predate electric elevators as they have existed since the middle ages. In today's elevator industry hydraulic elevators serve a niche in the vertical transportation market. Hydraulic elevators will have a place even with the advent of **Machine Roomless Elevators (MRL).** Hydraulic elevators are relatively less expensive than traditional roped traction installations and are easier and faster to install. Hydraulic elevators do however have their limits as they are slower - seldom operating at over 200 fpm and are limited in their rise - 6-8 floor levels is their upper limit. The advantage of hydraulic elevators over traction elevators is that the power unit does not have to be installed in proximity of the elevator shaft.

Module 3

CONTROL SYSTEMS

Outline

3-1 Overview
3-2 System Operation
3-3 Selector Controllers
3-4 Door Controllers
3-5 Traveling Cables
3-6 Drive Control
3-7 Safety Circuit and Devices
3-8 Summary

Purpose and Objectives:

The purpose of this module is to provide the participant with the foundation of control systems in transit hydraulic elevator systems. Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Identity the different types of control systems encountered in elevator systems
- Discuss methods of interfacing between elevator car and controller
- Explain purpose of traveling cable, (fastening, securing, looping)
- Identify control systems and associated components
- Name the associated safety circuit and safety devices
- Identify and describe types of selectors

Key Terms:

- Car operating panel
- Control key switch
- Control system
- Controller
- Door Close Limit Switch
- Door controller
- Door edge sensor
- Door Open Limit Switch
- Door zone switch
- Down level switch
- Floor switches
- Hoistway Access Limit Switches
- Input devices
- Inspection key switch
- Inspection service
- Position indicator (PI)
- Programmable Logic Control (PLC)
- Pump Unit
- Remote control panels
- Safety circuit
- Selective-collective
- Selector
- Selector controller
- Selector tape
- Signal indicators
- Silicone Control Rectifier (SCR)
- Simplex
- Terminal landing final limit switch
- Terminal landing normal limit switch
- Terminal landing slowdown limit switch
- Travelling cables
- Up level switch
- Variable Frequency Drive (VFD)
- Variable-Voltage Variable-Frequency (VVVF)

3-1 OVERVIEW

Hydraulic elevator lift systems include a hydraulic jack which is mounted in the hoistway pit and supports the elevator car. A **pump unit** supplies hydraulic fluid from a reservoir to the jack through a solenoid-operated valve that includes flow regulating pistons for selectively raising and lowering the car.

In addition to controlling the valve and the car movement between floors, the **control system** also performs the function of receiving hall calls and car calls, dispatching the car to the appropriate floors, stopping the car level with the floor landings, and opening and closing the doors. Part of the overall control system is the **selector** which senses the position of the elevator car in the hoistway and determines slowdown and stopping points.

As **Programmable Logic Control** (PLC) systems have advanced, many of the older relay-based control systems are now obsolete and are being replaced by PLC's to improve overall efficiency of the elevator system. The PLC controller is a field programmable microprocessor based system, simplex selective-collective, automatic operation with variable voltage, variable frequency motor control.

Note: **Simplex** refers to the type of communication employed in most elevator controls. In a simplex system only one message can be sent in either direction at one time. **Selective-collective** refers to the elevator operation where the system accepts and remembers an infinite number of calls and answers them as the car moves in the appropriate direction.

3-2 SYSTEM OPERATION

The **controller** acts as the brain for all elevator operations. Older controller systems typically use relay logic; however, many agencies have installed a programmable hydraulic controller, which relies on programmable logic controls (PLCs) with solid state systems. The elevator controller performs the following functions, many of them simultaneously: controls the elevator car movement upward and downward; levels the elevator car at each floor; determines when to open and close the elevator doors for the hoistway and for the elevator car; operates the car **position indicator (PI),** floor-passing sound, car riding and hall direction lighting (lanterns), and the car arrival chime; monitors the elevator safety circuit and the controller computer; checks for AC electric power loss or reversal and if there is a safe elevator occupancy level; and determines if there is the right level of hydraulic oil in the power unit and recovery tanks to move and maintain the elevator car where it needs to be.

The controller monitors and controls how the system is operating in each section of the elevator. Figure 3.1 illustrates a hydraulic elevator controller system.

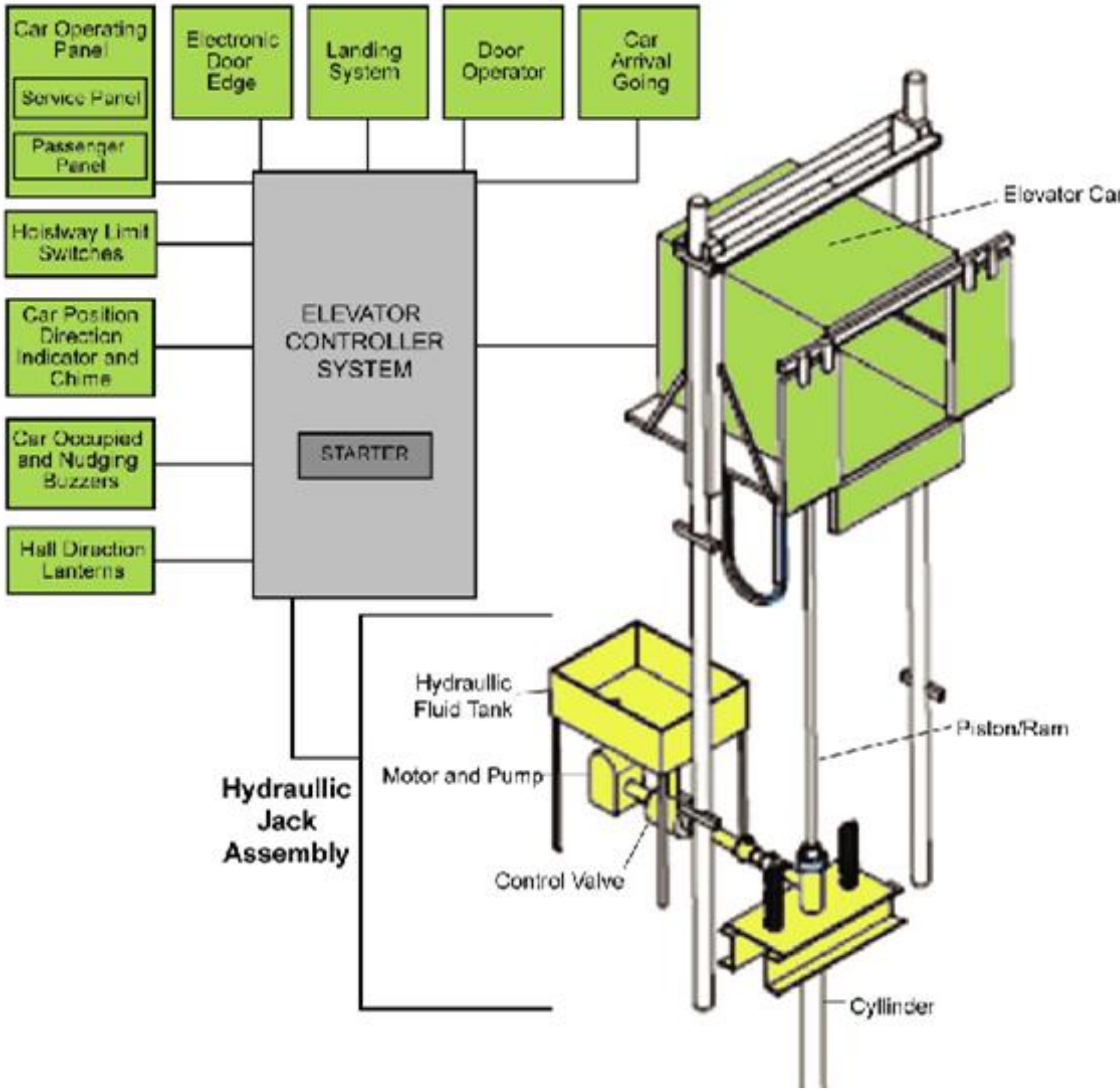


Figure 3.1 Hydraulic Elevator Controller System

The PLC controls all up and down run operations of the drive system. Signals for hall calls and car calls are sent to the controller which latches the call and provides an output to the call registered lights. If the doors are open, the controller dispatches a closed door signal to the door operator. Once the doors are closed the controller then issues a command to the selector to step up or down. Once the step up/down signal is received by the selector controller the level command is removed and the door operator locks the doors. The selector advances the target floor to the next floor and transmits the new target floor the controller.

If a stop is requested at the target floor, the controller removes the run signal. If a stop is not issued the car continues to run, and the selector issues a late car refusal signal, at the last chance to stop, to the controller. The controller then advances the target floor and the process is repeated. If a stop has been requested at the target floor, the selector sends the interrupt signal at the slowdown point to the controller and the controller relinquishes control to the hydraulic control valve for leveling. Final leveling is then done by the control valve and the selector. When the car is level, the selector issues a level command to the controller and the controller permits the doors to open. The controller is programmed to retain in memory certain operating parameters of the elevator system such as door open times, automatic recall timeouts, fire service landing, etch. Preferably, the controller, as well as the other control subsystems, also monitor operations through the I/O inputs and store elevator faults when detected. Providing external access, such as through a serial port, permits faults to be read for troubleshooting purposes and also permits setting operating parameters externally.

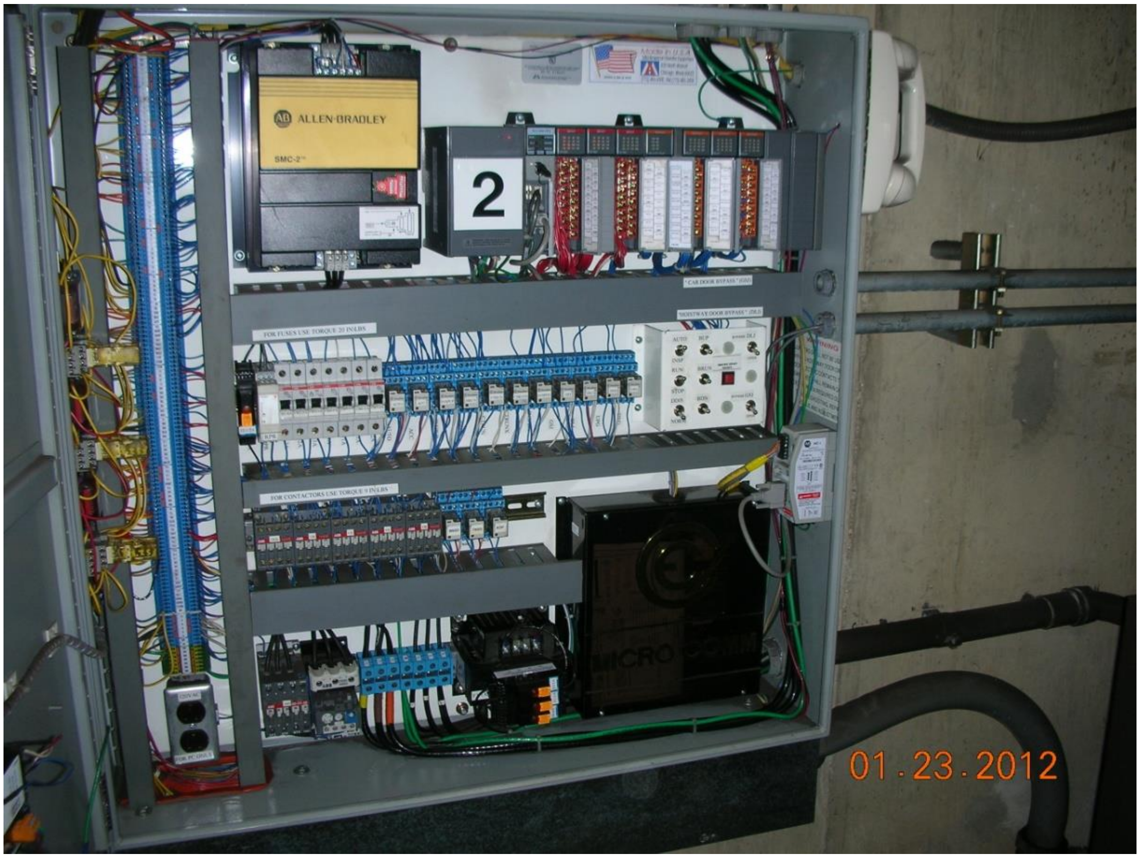


Figure 3.2 Controller for Hydraulic Elevator –Courtesy WMATA

The elevator is operated through user commands by means several **input devices** and when any one is selected, electronic signals initiate a demand to the main controller. Some input devices include:

- Hall call buttons
- Indicator Push buttons inside the car which are located on the **Car Operating Panel**, numbered to correspond to the landings served
- Stop Switch
- Door controls
- Emergency non-operational controls (including emergency bell & phone or intercom)
- by CALL pushbuttons at the terminal landings
- by UP and DOWN pushbuttons at intermediate landings
- Hall Chimes
- Hall Position Indicators (arrow or direction indicator)
- Fire Service Switch
- Some elevator hall call stations include ON/Off key switches

From the hall call station for example (Figure 3.3), when passengers on different floors press the UP pushbutton, the elevator car is dispatched in the order that it reaches the landings and not in the order of when the calls were registered.

Figure 3.3 Hall Call Panel With Up and Down Buttons –Courtesy WMATA

If hall calls are received for the opposite direction of travel, the car will continue in the same direction until all calls in the initial direction are answered, then the car will reverse direction to collect calls in the opposite direction. If no calls are registered and the car is unoccupied, the car will remain at the current landing until further calls are registered or it may be dispatched by the controller to a home landing and stop without door operation. Various devices shown in Figure 3.4 may be activated during this process.

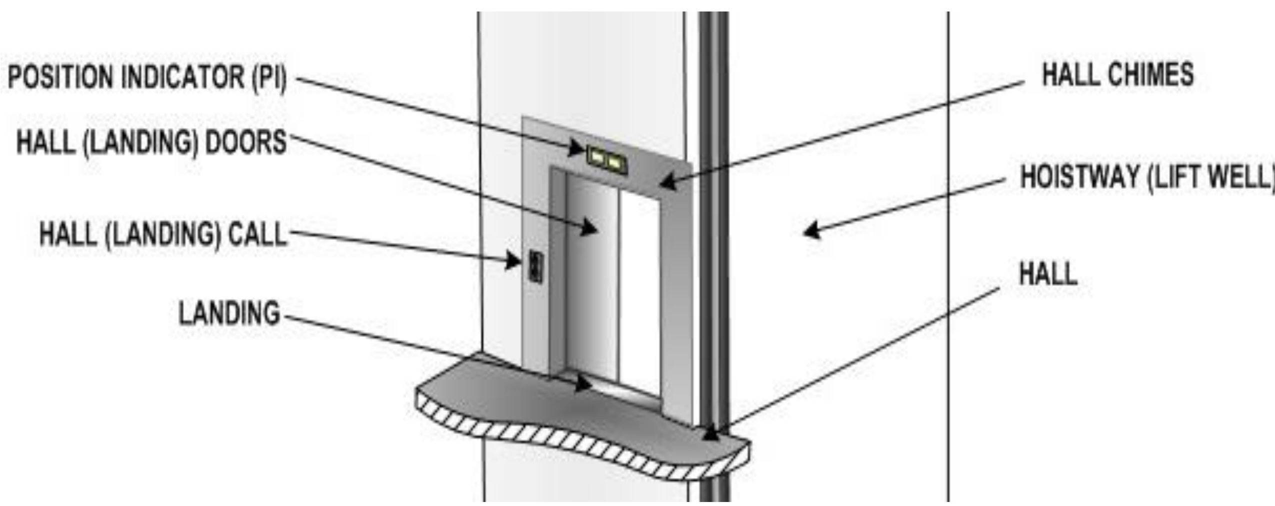


Figure 3.4 Hall Call Devices

Inside the elevator car is the **car operating panel** which, along with floor buttons, may include an **inspection key switch** for normal "run" or "inspection" operation.

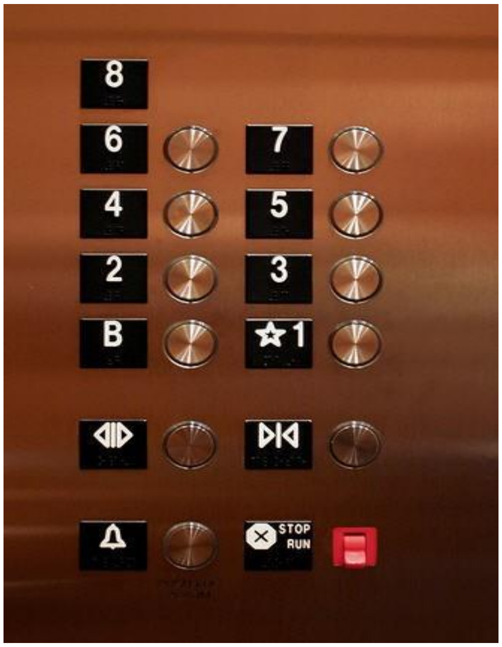


Figure 3.5 Car Operating Panel –Courtesy WMATA

For **inspection service**, there are typically three means to control car movement: at the car top inspection station, by the hoistway access key switches, and inside the controller. Car movements initiated by the car top inspection station or by the hoistway key switches may be at either low or high speed and would disable the controller inspection switch. The controller may also be equipped with a low or full speed selection. Activating any of the run/stop switches to the stop position renders the car inoperative to hall calls. Turning the inspection switch to the "run" position will restore the car to automatic operation.

On some elevators there may be another type of **control key switch** that is designated for independent service (Figure 3.6). When activated the car can be removed from automatic operation and be operated manually. Independent service has full control of starting, stopping, and direction of the car travel. The car responds only to the car buttons.

Figure 3.6 Independent Control Key-Switch - ©Elevator Bob

Modern systems tend to locate the main PLC and the power unit in the elevator machine room for accessibility and to minimize the amount of power wiring. Each PLC has inherent limitations in terms of its input/output capabilities – the number of I/O ports – processing capability, and speed. For any elevator system, it is critical to have little or no delays in processing and transmitting critical information such as slow-down and stop signals, certain door control signals, and safety information

Elevator controllers may also be equipped with **remote control panels** and **signal indicators** located within the station or facility. The panels can be visually checked at any time to observe the location of all cars. Cars can be added or removed from service at this panel. Manual overrides are also possible for selected cars at any time from the panel. These elevator panels are typically located within station kiosks or station agent booths for most transit rail facilities. Signals and operation controls on these panels may include: indications for car moving up and car moving down; control, indication, and hall call activation for the concourse, mezzanine, or platform levels; alarm or indication for car occupied; and control and indication of elevator shutdown.

Figure 3.7 presents a schematic overview of the elevator control systems and related electrical communications. Initially, power is supplied electrically to the hoistway, cab, lift system, and control system. When someone presses a call button, commands are sent to the control system via the user interface. The control system then sends commands to the lift system and receives communication back from the lift system, cab, and hoistway prompting the elevator to move according to user commands and elevator location within the hoistway. The control system sends feedback to the user interface which then communicates and supplies feedback to the elevator user alerting the user to the location and movement of the cab, or car. The entire system operates much like a relay type race with communication being passed from one place to another using electrical systems and elevator components instead of runners and batons.

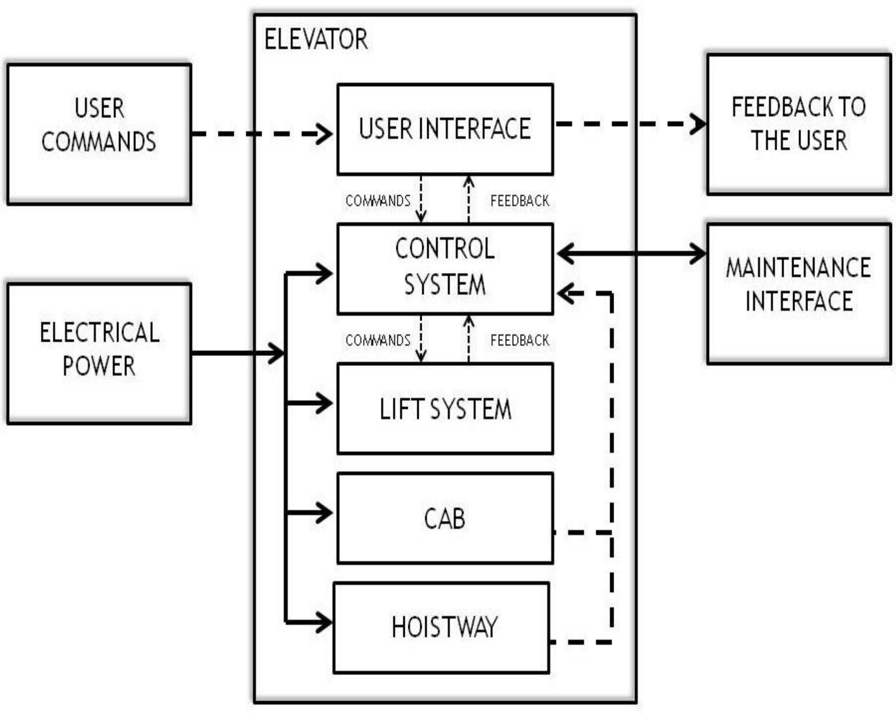


Figure 3.7 Schematic Representation of an Elevator Control System

3-3 SELECTOR CONTROLLERS

On modern transit elevators, a **selector controller** also known as a *selector reader* is mounted on top of each car and its purpose is to read a **selector tape** which runs the length of the hoistway illustrated in Figure 3.8. Selector tapes vary: some include a series of vertically spaced holes and others are solid tape with no holes.

Figure 3.8 Selector Tape and Sensors in Hoistway –Courtesy WMATA

The selector tape is read by the selector controller which counts optical or magnetic pulses along the selector tape. The pulses are then interpreted by the PLC as it tracks the position of the elevator car. Selector controllers are therefore of two varieties: optical, Figure 3.9, or magnetic, Figure 3.10.

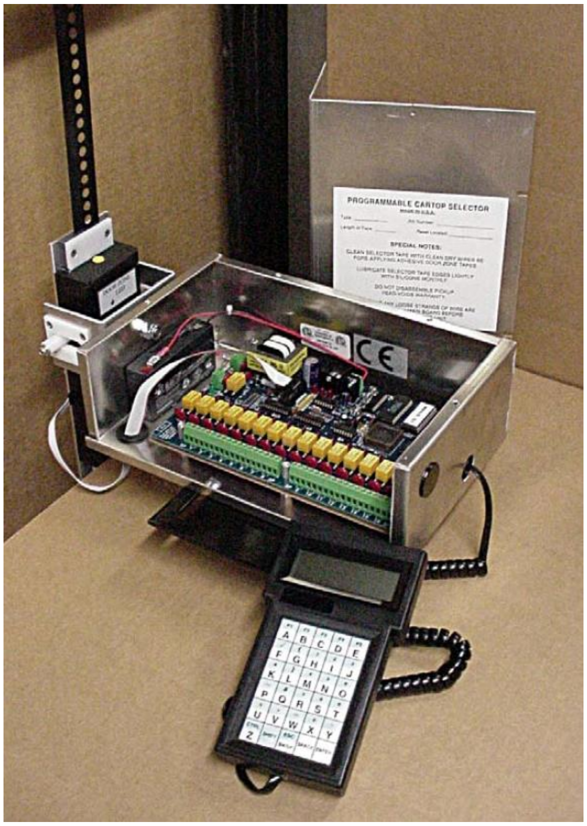


Figure 3.9 Optic selector controller ©Virginia Controls

Figure 3.10 Magnetic selector controller ©EECO

3-4 DOOR CONTROLLERS

The elevator doors and the car doors open automatically and simultaneously when the car arrives at the destination landing. Each elevator door is equipped with a **door controller** (***Figure 3.11***) which provides independently adjustable door hold-open times when that car stops for a car or hall call. The doors close after a preset time provided there is no obstruction detected in the door opening; the car is not called and dispatched to another landing; or the door close button or a car call is not activated.

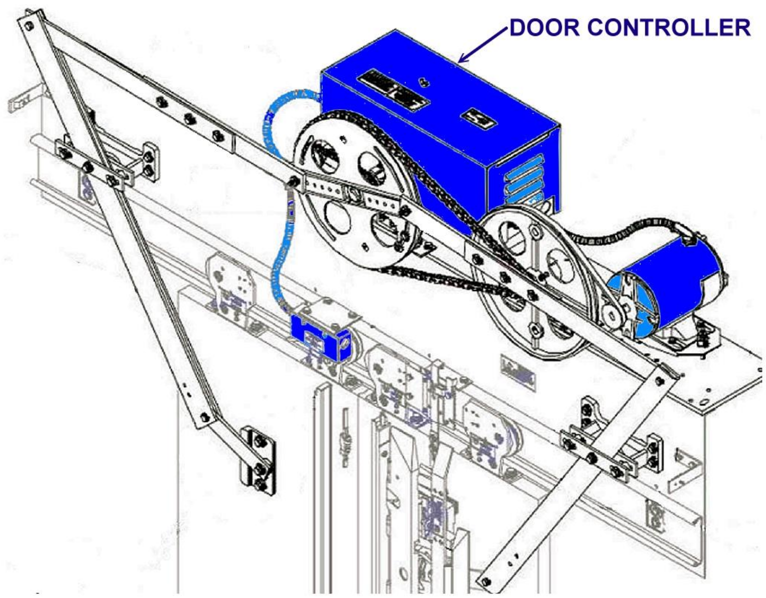


Figure 3.11 Door controller atop elevator car - ©G.A.L.

All closing times are adjustable from the door controller. The door dwell times are adjusted in some systems depending whether it is a hall call, car call, reopening of the door, or nudging.

Elevator doors are also equipped with an electronic **door edge sensor** installed along the edge of the elevator doors outside of the car door frame structure. The door edge sensor provides a full light curtain door protective system which does not rely on physical contact with, or the motion of, a person or object to inhibit door movement or initiate door reversal. The light curtain, shown in Figure 3.12, operates in the invisible light spectrum. Detection of an intrusion into the protected area causes the doors, if fully open, to be held in the open position and, if closing, to stop and reverse to the fully open position. The first intrusion during a stop at any landing will cancel the normal dwell time for the doors and substitute a door protective system time commencing with the removal of the intrusion. If during this period another intrusion occurs, the same delay period shall apply and this cycle will continue until traffic through the doorway ceases. The doors will commence to close immediately after the expiration of the determined period once the last intrusion has been removed. If the doors are prevented from closing for a longer period, they will close at a reduced speed and a buzzer alarm will sound indicating a possible problem with the system. This condition is sometimes described as "nudging."

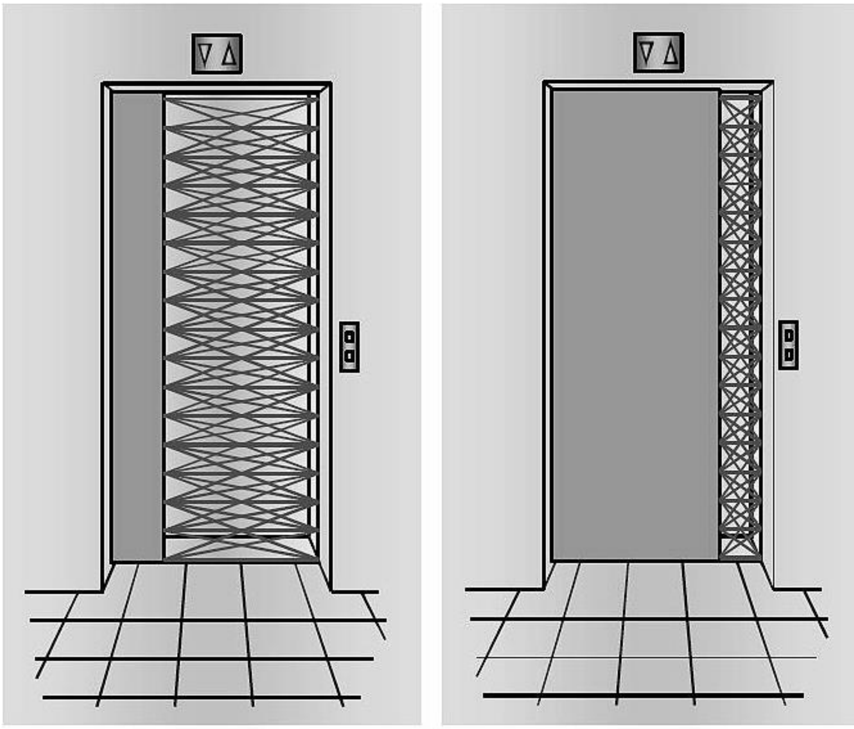


Figure 3.12 Gatekeeper light curtain ©Adams Elevator

3-5 TRAVELING CABLES

In an elevator system **traveling cables** have two functions. First, they provide an electrical pathway for control and power circuits from the elevator car to the controller in the machine room. Second, the traveling cable provide a conduit for the various communication demands of the elevator system and this is continuous from the car to the communications interface cabinet in the elevator machine room via the halfway box. Figure 3.13 shows an elevator system with two traveling cables: one dedicated to control and power circuits and the other dedicated to communication and CCTV circuits.

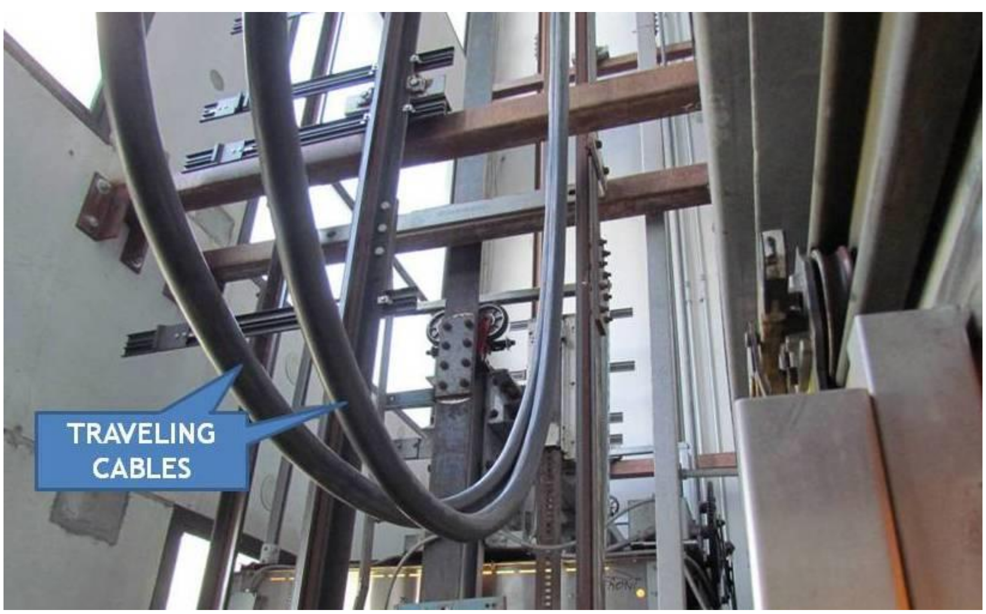


Figure 3.13 Traveling cables in hoistway –Courtesy WMATA

Traveling cables are designed with extra control, signal, and power feed wires as backups also referred to as "spares." The traveling cable also includes a steel support cable which is flexible as core and it is incased in a heavy duty closed mesh multi-weave stainless steel wire grip sheathing which provides support for the cable on both ends and is properly anchored to relieve strain on the individual conductors. The cable is supported to prevent from rubbing against the hoistway and car parts.

3-6 DRIVE CONTROL

The drive control in an elevator system may be characterized as the "muscle" that runs the elevator because it supplies the power for the hoist motors. The motor component of the elevator machine can be either a direct current (DC) motor or an alternating current (AC) motor. Hydraulic elevator applications typically use AC motors.

An elevator drive motor is chosen depending on design intent for the elevator. Power required to start the car in motion is equal to the power to overcome static, or stationary friction, and to accelerate the mass from rest to full speed. Considerations that must be included in the choice of an acceptable drive system are: good speed regulation and good starting torque.

Common drives that are in use in transit elevator systems include **Variable-Voltage Variable-Frequency** (VVVF); **Silicone Control Rectifier** (SCRs); **Variable Frequency Drive** (VFD); and several others. In a later course on *Elevator Electrical Systems*, the participant will be able to identify and describe the various drives commonly used in current elevator systems.

A modern VVVF drive controls the amount of oil traveling to the piston. Only as much oil is pumped as is effectively required. The speed of the motor-pump combination is controlled directly by the VVVF drive, the same flow feedback signal is used as for the electronic valve. Using variable frequency drive for the up ride, only as much oil is pumped as is effectively required. The speed of the motor-pump combination is controlled directly by the VVVF drive, the same flow feedback signal is used as for the electronic valve.

Using pressurized fluid to lift and lower the car, hydraulic elevators are typically used in low-rise transit installations (six floors and fewer). The car has a piston in a cylinder beneath or attached on the side; the elevator lifts when an electric motor powers a hydraulic pump to pressurize a fluid (typically oil) the control valve directs the pressurized fluid into the cylinder, which displaces the piston up. To lower the car, the control system opens a valve and the fluid flows back into the tank as the weight of the car and the piston presses down on the hydraulic fluid.

In a conventional hydraulic drive, after the start signal, the motor (submerged or external) runs up from zero to maximum revolutions. The pump delivers the maximum possible flow. In order for the hydraulic piston to move the elevator car upward from a resting position and then to stop at the destination level the speed needs to be controlled. This is accomplished by using either a solenoid or an electronic control valve which allows excess oil to flow back into the storage tank. More oil is pumped than is effectively used. To move up, out of the starting level, and to stop at the destination level speed needs to be controlled.

A hydraulic elevator using an electronic valve uses less energy than the same one using a mechanical valve. It is foreseeable that the mechanical valve will be rendered obsolete by further advances in the development of electronic control valves. The modern generation of low cost, machine room-less traction elevators made possible by advances in motor and motor drive technology is beginning to challenge the supremacy of the hydraulic elevator in their traditional market role.

3-7 SAFETY CIRCUIT AND DEVICES

The **safety circuit** is a series circuit containing electrical contacts from safety devices so that, in the event of an unsafe condition, they send signals to the controller to stop the operation of the elevator. Within a hydraulic elevator system, safety devices consist of a series of **switches** to signal conditions affecting the floor, leveling, door, landing, and hoistway.

If used, **floor switches** are normally open contacts that should close under each of the following conditions:

(1) The car is at the slowdown point above the floor, or
(2) The car is at the slowdown point below the floor, or
(3) The car is at the floor (optional), or
(4) The car is between the up and down slowdown points of that landing (optional).

Conditions (1) and (2) are required to change the floor relays and initiate slowdown. Condition (3) is required at the terminal landings, but is optional at the intermediate landings. Condition (4) is optional. There are many acceptable methods of providing the floor switch signals, such as by having a single floor switch at floor level, and an adjustable length cam on the car, or by having two floor switches per floor, and a fixed length cam on the car. The floor switches may be mounted on the car if they are in separate rows.

The **up level switch** is a normally open contact that closes when the car is in the leveling zone below the floor, and the **down level switch** is a normally open contact that closes when the car is in the leveling zone above the floor.

The **door zone switch** is a switch (or switches) activated by the leveling vane/target when the car is within 3" of floor level. If the leveling vane/target is 6" long, then only one switch is required, mounted between the up and down leveling switches, otherwise two switches wired in series should be provided.

The **slowdown limit switch** is a normally closed contact that opens when the car is closer to a landing than the minimum slowdown distance. It will prevent the car from running into the landing at full speed. It should be adjusted to open approximately one inch beyond the point where the normal slowdown (from the floor switches or the car top selector) is initiated.

The **terminal landing normal limit switch** also known as a *directional limit switch* is a normally closed contact that opens when the car has traveled one inch past floor level at a terminal landing. The car should not be on the terminal landing normal limit switch when the car is floor level at the terminal landing. The limit switch will prevent the car from traveling further away from the normal area of car travel, but allows the car to run back towards the normal area of car travel.

The **terminal landing final limit switch**, where required by code, is a normally closed contact that opens when the car has traveled past the normal limit, this will prevent any further movement of the car in either direction. Consult the applicable codes for the proper setting of this switch.

The **hoistway access limit switches** limit the motion of the car by disabling the car if it moves away from the access floor. The zone switches are installed to stop the car from running down if the top of the car goes below floor level at the top access floor, and to stop the car from running up if the car goes above the second floor while on Hoistway Access at the bottom floor.

The **door open limit switch** is open when the doors are fully open, and closed at all other times. It will de-energize the door open relays in the door operator when the doors have opened fully.

The **door close limit switch** is open when the doors are fully closed, and closed at all other times. It will de-energize the door close relays in the door operator when the doors have closed fully.

3-8 SUMMARY

This module provided the participant with an overview of control systems in a transit elevator system. There are different types of control systems – from those that control doors to those that control the movement of the elevator – and this module covered operational controls, door and hoistway controls while highlighting the methods of interfacing between the elevator and controller. This module provided the foundation for the technician to operate and test a working elevator control system.

Module 4

HOISTWAY

Outline

Purpose and Objectives:

The purpose of this module is to provide a more in depth explanation of components within the hoistway of hydraulic transit elevators, focusing specifically on common equipment failures on these components.

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

- Identify areas and associated components of the hoistway
- List common areas in the hoistway which would require repair or replacement

Key Terms

- Buffer
- Cable support grip
- Connecting "fish" plate
- Door Frame
- Dust Cover
- Final limit switch
- Fire sprinkler
- Guide rails
- Guide shoes
- Halfway junction box
- Heat detector
- Hoistway
- Hoistway fascia plate
- Hoistway vents
- Homerun
- Intermediate Limit Switch
- Jack
- Ladder
- Light
- Limit switch
- Normal limit switch
- Overhead
- Overspeed Valve
- Pit area
- Rail brackets
- Rapid Rate
- Refuge
- Roller Guides
- Roped hydraulic system
- Runby
- Scavenger
- Scavenger pump
- Selector tape
- Shut-off Valve
- Smoke detector
- Spring Buffer
- Stop switch
- Sump pump
- Terminal slow down limit switch
- Traveling cables

4-1 OVERVIEW

A **hoistway** is a shaft or space typically enclosed by fireproof walls to permit passage of an elevator, dumbwaiter, or material lift between the floors of a building. A more simplistic definition for the hoistway is the shaft that encompasses the elevator car. The hoistway extends from the bottom pit to the top of the shaft, which is generally the underside of the overhead machine room floor or the underside of the roof. Hoistway doors on each floor provide access to the elevator. Many hoistways are constructed with strategic access points along the shaft in the event of a mechanical failure.

The construction of a hydraulic hoistway will typically include ventilation, sliding hoistway doors, pit access ladder, pit stop switch, pit drain or sump pump, pit and/or hoistway lighting, buffers, guide rails, sensors mounted in the shaft to relay information to the controller concerning the position of the car within the hoistway, and a fire detection system which include sprinkler heads and

smoke and heat detectors. In a **roped hydraulic system**, there are counterweights and hoisting ropes which are components also found in traction elevators (more on roped hydraulics in the traction elevator course).

All transit authorities have strict guidelines for working in an elevator hoistway. These guidelines are within ASME A17.1, *Safety Code for Elevators and Escalators*, and all applicable local jurisdiction codes that govern the operation of passenger elevators.

All elevator technicians, such as the participants in this course, should adhere to the guidelines of ASME A17.1 as well as the *Elevator Industry Field Employees' Safety Handbook*, particularly Section 8.

4-2 THE HOISTWAY

The hoistway in a hydraulic elevator system may be divided into four areas (see Figure 4.1):

1. **Overhead** - this is the space above the car when it is at the top floor level
2. **Length of hoistway** - this is the space from underneath the overhead to the top of the pit area
3. **Pit area** - this is the space below the car when it is at the bottom floor level
4. **Attached to the car**

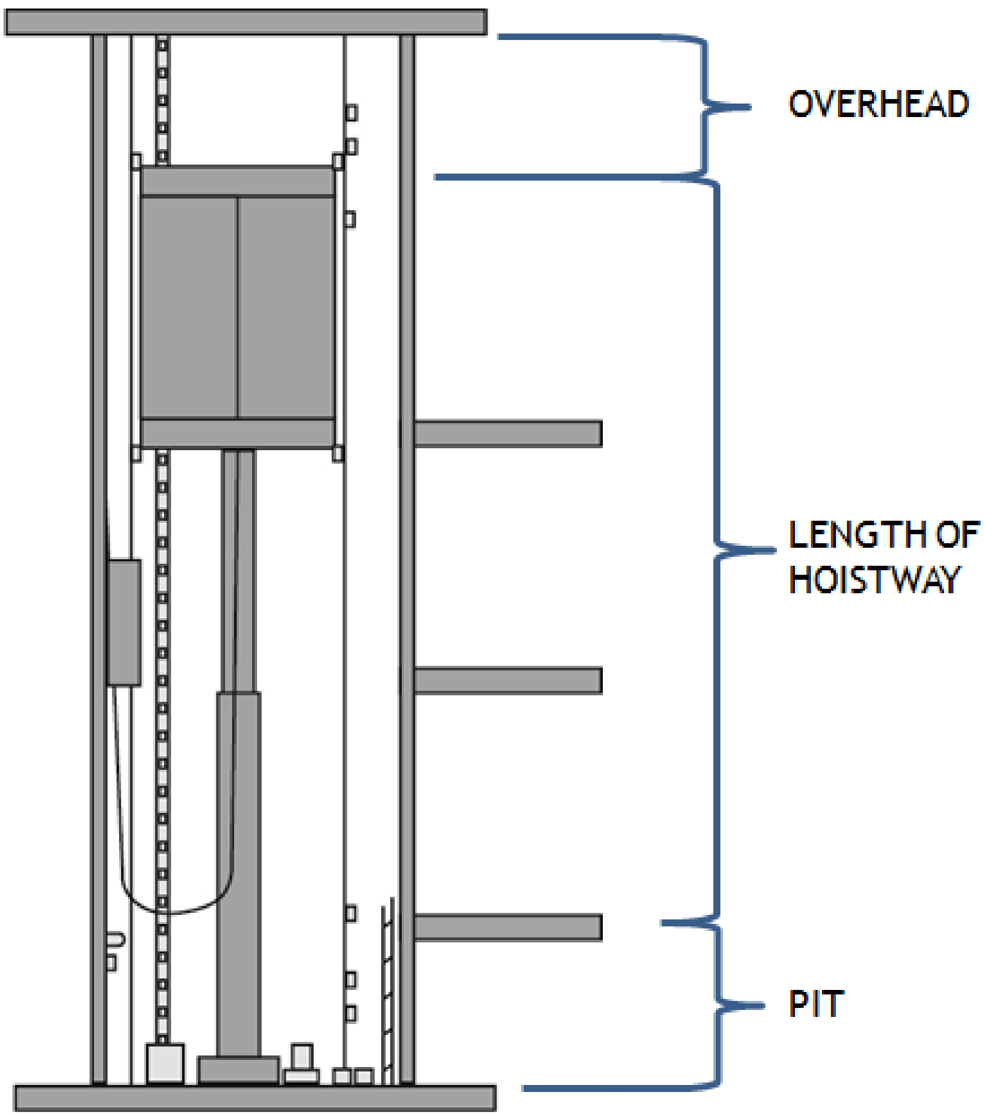


Figure 4.1 Hoistway Areas in a Hydraulic Elevator System

4-3 HOISTWAY OVERHEAD COMPONENTS

Components found in the hoistway overhead of hydraulic transit elevators include:

Hoistway Vents

- Limit Switches
- Sprinkler Head
- Smoke Detector
- Heat Detector
- Refuge Space
- Runby Area

These items are described below and their locations are illustrated in Figure 4.6.

In order to dissipate heat in the hoistway, transit elevators have **hoistway vents** (Figure 4.2) installed at the top of the overhead.

Figure 4.2 Hoistway Vent –Courtesy WMATA

A **limit switch** is a mechanical device that is activated by movement of the elevator. It mechanically opens a contact and limits the operation of the car.

When activated, limit switches send signals to the controller regarding the position of the elevator car in the hoistway. Figure 4.3 shows a limit switch on a transit elevator.

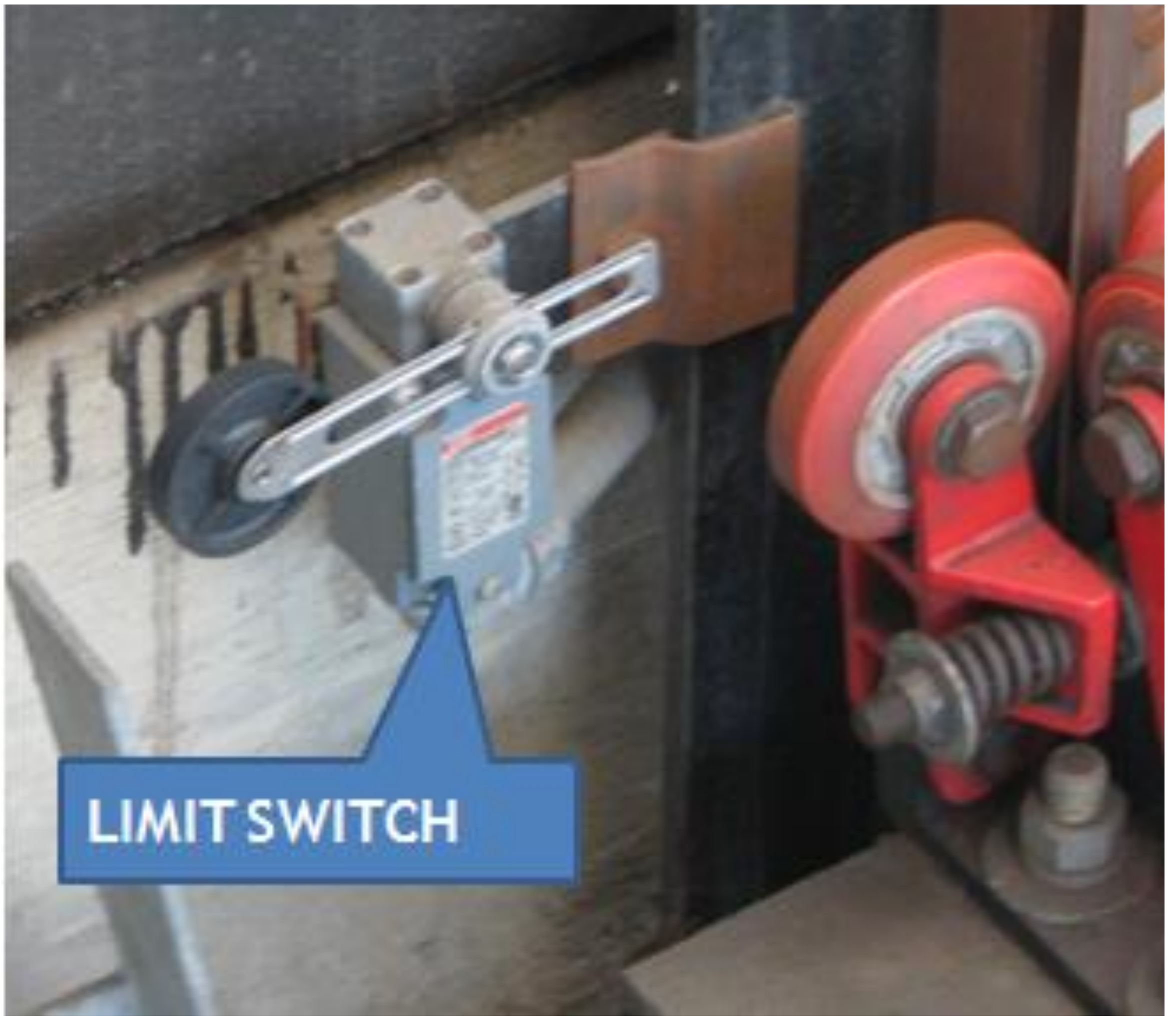


Figure 4.3 Limit switch –Courtesy NYCT

Typically in a hydraulic elevator system there are three limit switches located in the hoistway overhead and pit area: terminal slow down, normal, and final.

The **terminal slow down limit switch** signals the controller that the car is reaching the end of the hoistway. If the elevator overshoots the landing in the up direction, the **normal limit switch** is engaged and removes power to the elevator. If the elevator overshoots the last floor level in either the upward or downward direction, the **final limit switch** is engaged. The final limit removes power to the controller board.

In older installations where there is no selector tape, there are other **intermediate limit switches** along the length of the hoistway to signal to the controller the location of the car is in the hoistway. Discussion on the function of the elevator's selector tape occurs later in the module.

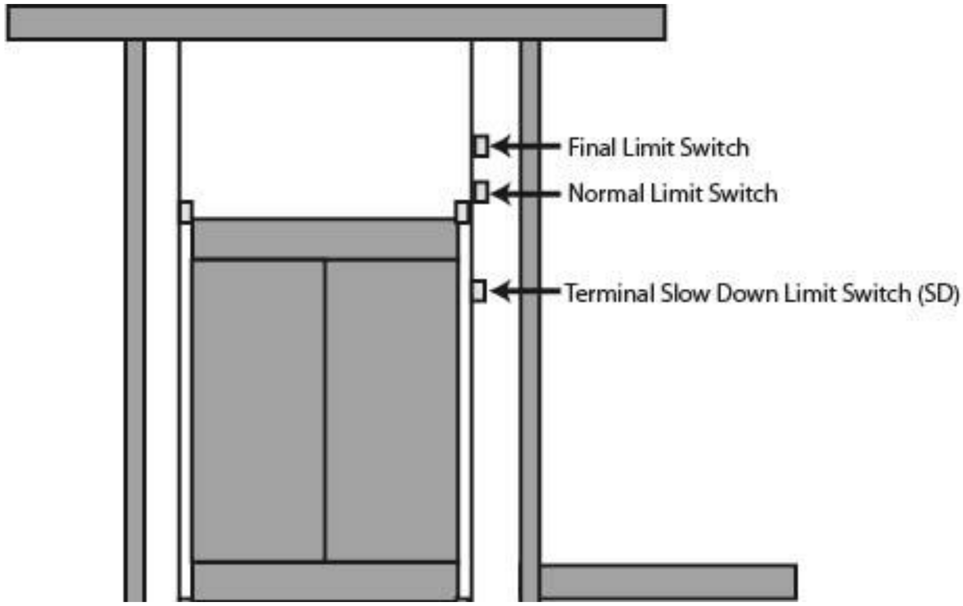


Figure 4.4 Location of Limit Switches in the Overhead

Fire safety devices are also located in the hoistway overhead. A **heat detector** is a fire alarm device that is activated when the temperature of a heat sensitive element has detected a **rapid rate** also known as a *"rate-of-rise"* or is above a fixed temperature gauge.

Other devices such as a **smoke detector** and a **fire sprinkler** are required by code to be installed in elevator hoistways.

Figure 4.5 Smoke detector located in hoistway

ASME A17.1 Safety Code requires **refuge** space on top of the elevator car enclosure so that, if required, an elevator technician can work on top. This refuge space must have a clear unobstructed area of at least 43 inches from the top of the car to the closest obstruction in the hoistway when the elevator is at its upper extreme of travel Figure .

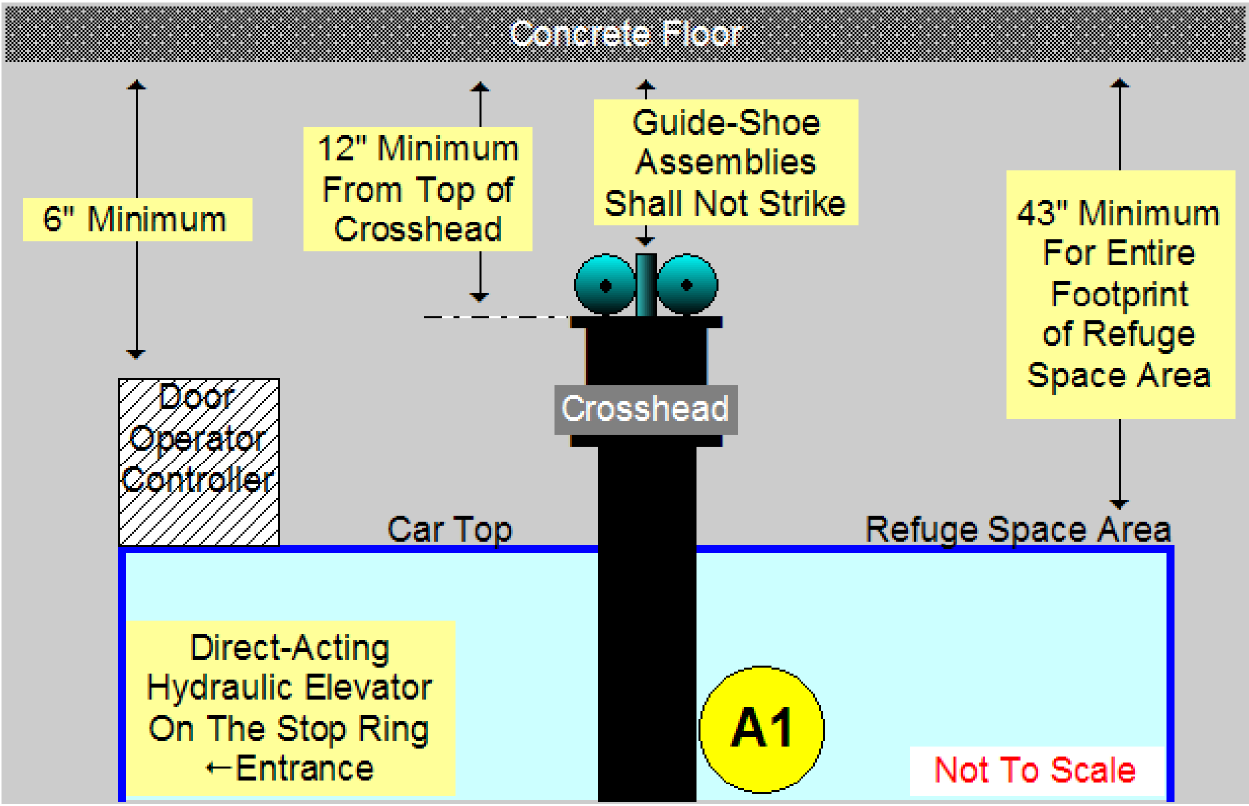


Figure 4. Refuge Space - ©Elevator Bob

Also required by ASME code are minimal distances for the **runby** areas (top and bottom) of the hoistway. The bottom runby is that area that is between the car buffer striker plate and the striking surface of the car buffer when the car floor is level with the bottom terminal landing. The top runby in a direct-plunger hydraulic elevator is that area the elevator car can run above its top terminal landing before the plunger strikes its mechanical stop.

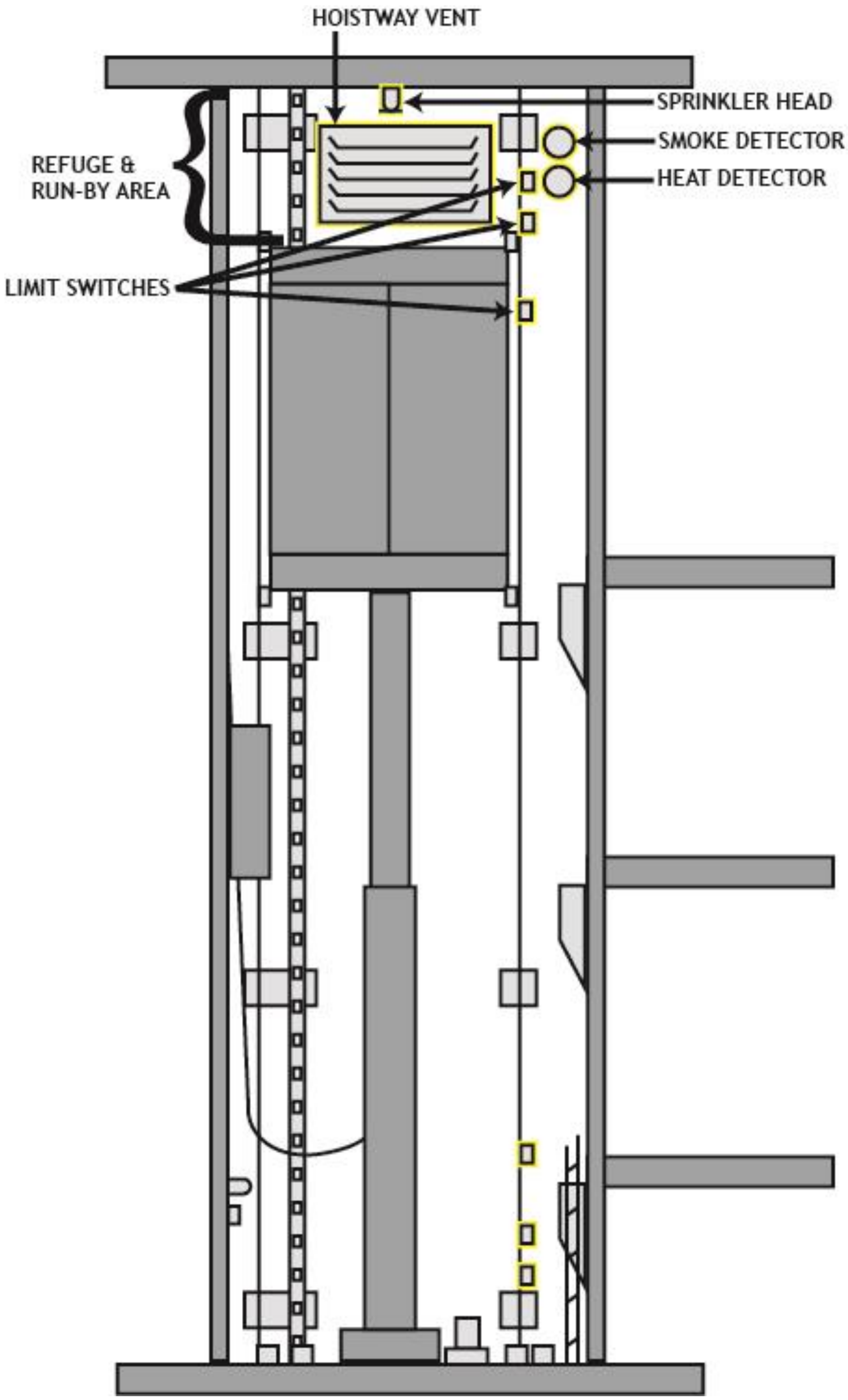


Figure 4.6 Hydraulic Hoistway Highlighting Components Found in the Overhead

4-4 LENGTH OF HOISTWAY COMPONENTS

Components which run the length of the hoistway of hydraulic transit elevators include:

- Selector tape
- Guide rails
- Rail brackets
- Traveling cables
- Halfway junction box
- Cable support grip
- Connecting plate
- Hoistway fascia plate
- Dust cover
- Door frames

These items are described below and located in Figure 4.15.

The **selector tape** (Figure 4.7) must run the entire length of the hoistway as it is needed to communicate to the selector regarding which floor the car is located at any given point. At the bottom part of the selector is a selector tape tension spring which is the support assembly for the selector tape. As mentioned above, when a selector tape is not in place, limit switches are used along the length of the hoistway instead.

Guide rails and **rail brackets** (Figure 4.7 and Figure 4. 8) also run the length of the hoistway. Guide rails function as vertical tracks to direct the course of travel of an elevator up and down the hoistway. They are constructed of long lengths of steel, which are T-shaped with the running surface machined on three sides. Their size and design are directly related to the speed and weight capacity of the elevator.

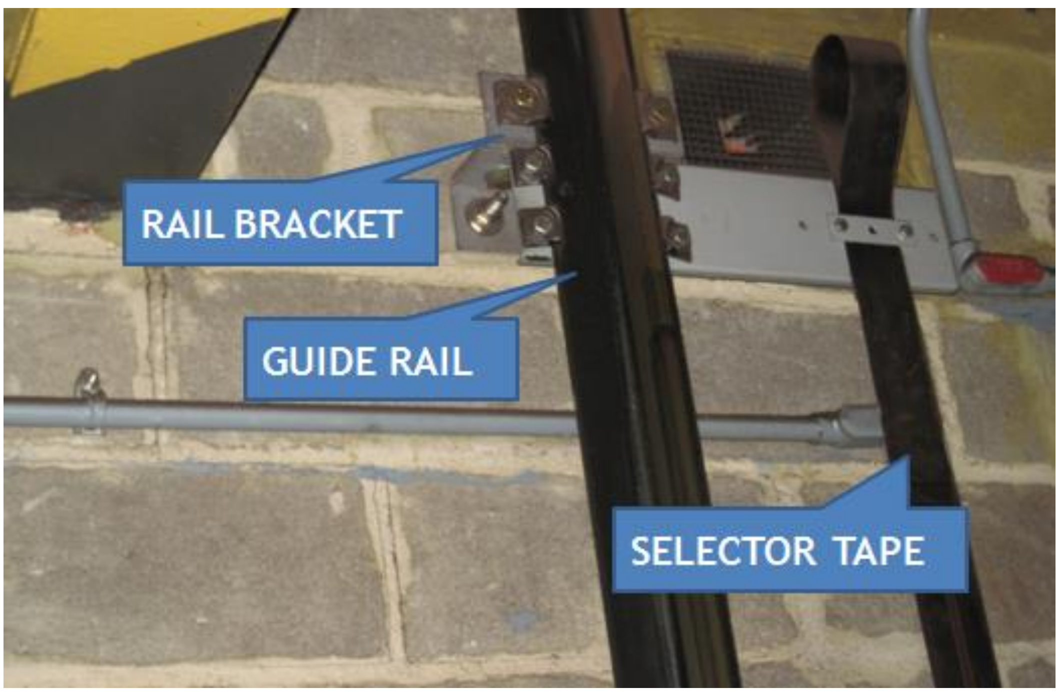


Figure 4.7 Selector Tape, Guide Rails and Rail Brackets at the Top of The Hoistway –Courtesy NYCT

Figure 4. 8 Guide rail and brackets ©Hollister Whitney

Traveling cables connect the car to the hoistway through a series of electrical conductors. One end is attached to the bottom of the car (Figure 4.9) and one is attached to the hoistway. A traveling cable is a sheathed bundle of flexible wires hanging from under the elevator car at one end while anchored at a *junction* box located halfway up the hoistway. There, they can be terminated at a terminal strip in the **halfway junction box** (Figure 4.10) or continue directly to the machine room in a configuration called a **homerun**.

The travelling cable connects equipment in or on the car (buttons, lights, switches, door operator, etc.) to the control equipment in the machine room. Traveling cables may also contain shielded wiring, coaxial cable and, possibly fiber optics. Modern elevators have a **cable support grip** also known as a *kellum grip* which bears the weight of the cable evenly across the wires. This even distribution of weight is accomplished by tension caused by the cable support grip which functions much like a Chinese finger trap.

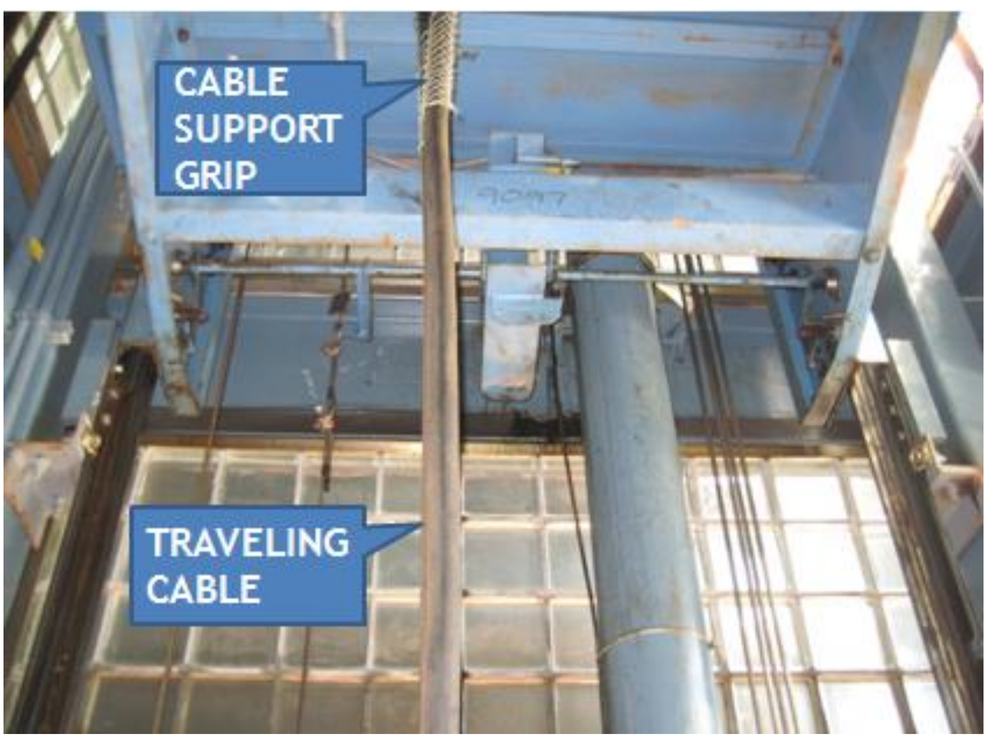


Figure 4.9 Traveling Cable in a Transit Hydraulic Elevator System –Courtesy NYCT

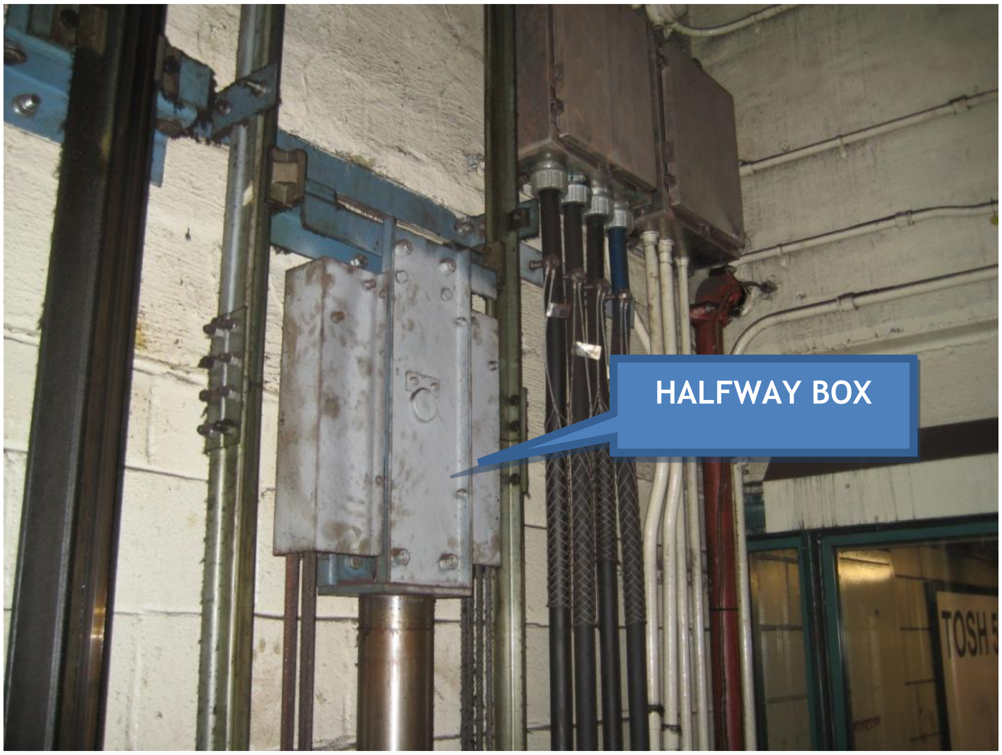


Figure 4.10 Halfway Box –Courtesy NYCT

Figure 4.11 Cable Support Grip Close Up

Note that in some places two sections of guide rail may be joined together. The rails are milled with a tongue and groove that accepts the sections of rail and provides a stable seamless surface for the roller to ride over. Figure 4.12 shows this **connecting plate** also known as a *"fish plate."*

Figure 4.12 "Fish Plate" –Courtesy NYCT

Located in the length of the hoistway is the **hoistway fascia plate**. These are normally provided to maintain clearances at the lower and upper ends of the hoistway. ASME A17.1 provides that these clearance measurements should be taken at the following hoistway locations:

1. At the lower end of the hoistway, the specified clearance must be maintained to the location of the car sill when the car is resting on its fully compressed buffer.
2. At the upper end of the hoistway, the clearance must be maintained to the location of the car sill when it has reached its maximum upward travel.

Figure 4.13 Hoistway fascia plate. ©GAL

Elevator **dust covers** and **door frames** (Figure 4.14) are required by ASME code to be constructed of steel with a primed finish. Doors and frames shall be UL certified with a 1½ hour fire rating. Doors shall have a concealed locking device, interlocked with the car operation to interrupt electrical power when the door is not securely closed. The entrance door shall be locked until car door opens. Dust covers are used to protect the door hangers and door rails/tracks from dirt and debris.

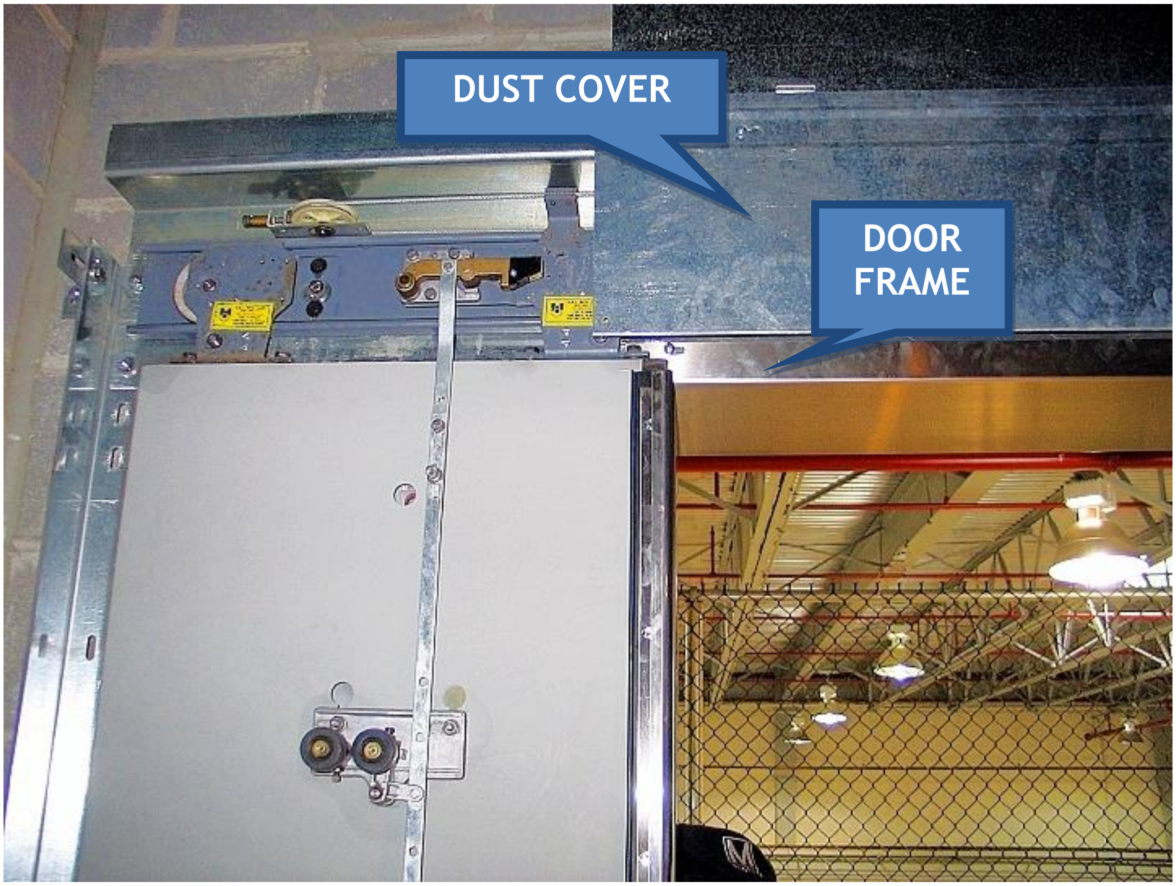


Figure 4.14 Dust Cover and Door Frame –Courtesy WMATA

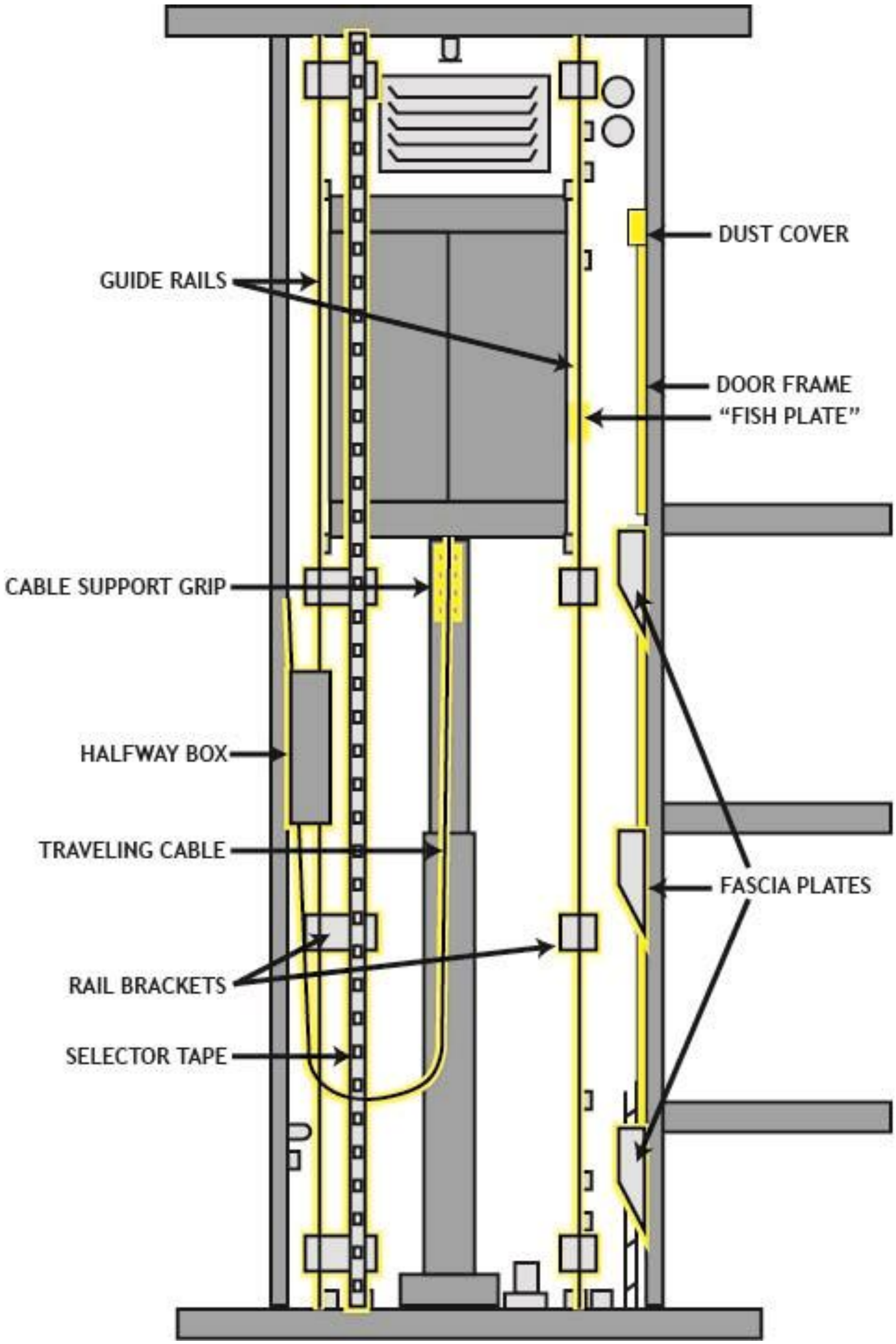


Figure 4.15 Hydraulic Hoistway Highlighting Components Found in the Length of the Hoistway

4-5 PIT AREA COMPONENTS

Important components found in the pit of a transit hydraulic elevator include:

- Jack
- Sump Pump
- Scavenger
- Ground Fault Circuit Interrupter (GFI Receptacle)
- Overspeed valve
- Light
- Ladder
- Stop Switch
- Buffer

These items are described below and located in Figure 4.23.

The most obvious component in the pit is the **jack** (Figure 4.16) - made up of a cylinder and piston. It is the jack that pushes the car up as hydraulic pressure increases and lowers the car as hydraulic pressure decreases.

Because transit elevators are often exposed to weather elements, water can collect in the elevator pit and a **sump pump** is necessary to remove this excess water. A sump pump is an automatic water pump powered by an electric motor for the removal of drainage, except raw sewage, from the pit area.

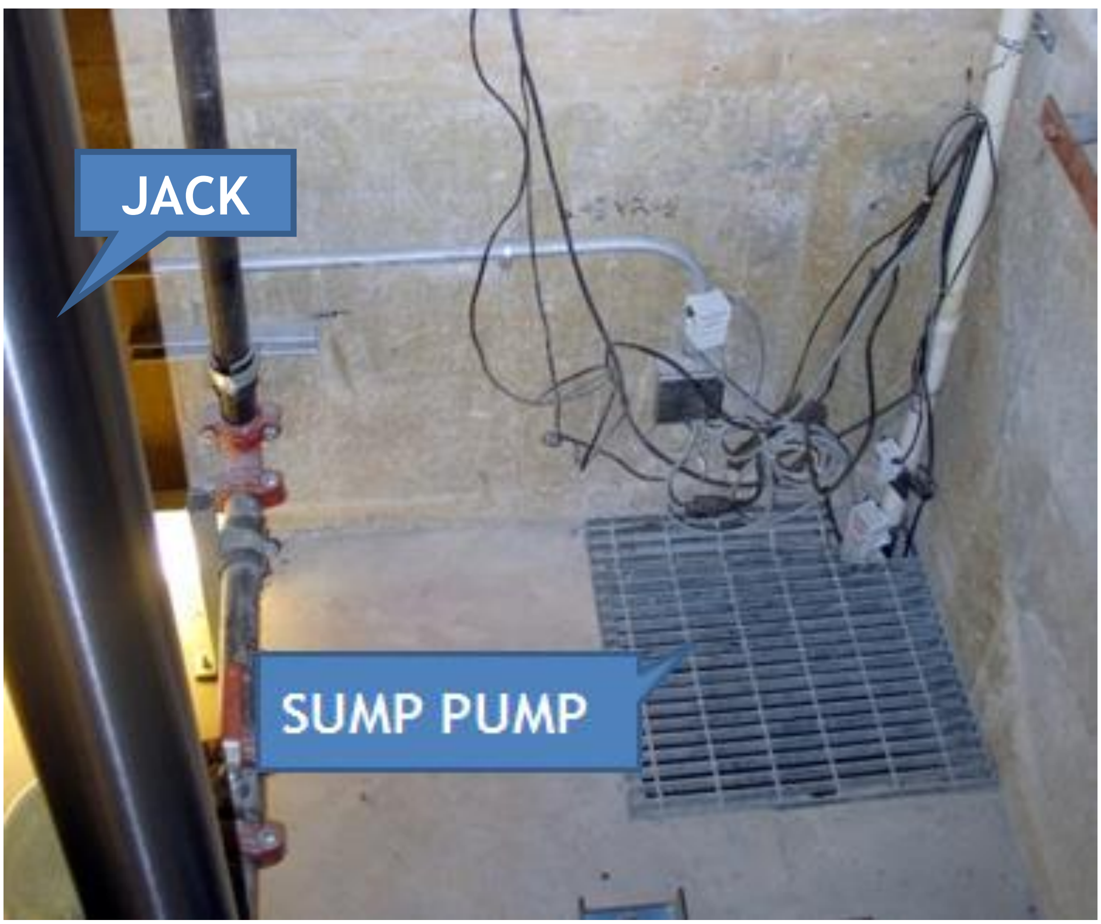


Figure 4.16 Sump pump in Hydraulic Elevator –Courtesy WMATA

The **scavenger** is a trough around the cylinder head that collects any oil leakage in the elevator pit. The oil is returned to the hydraulic pump unit by means of a **scavenger pump**, also known as an *oil return pump*.

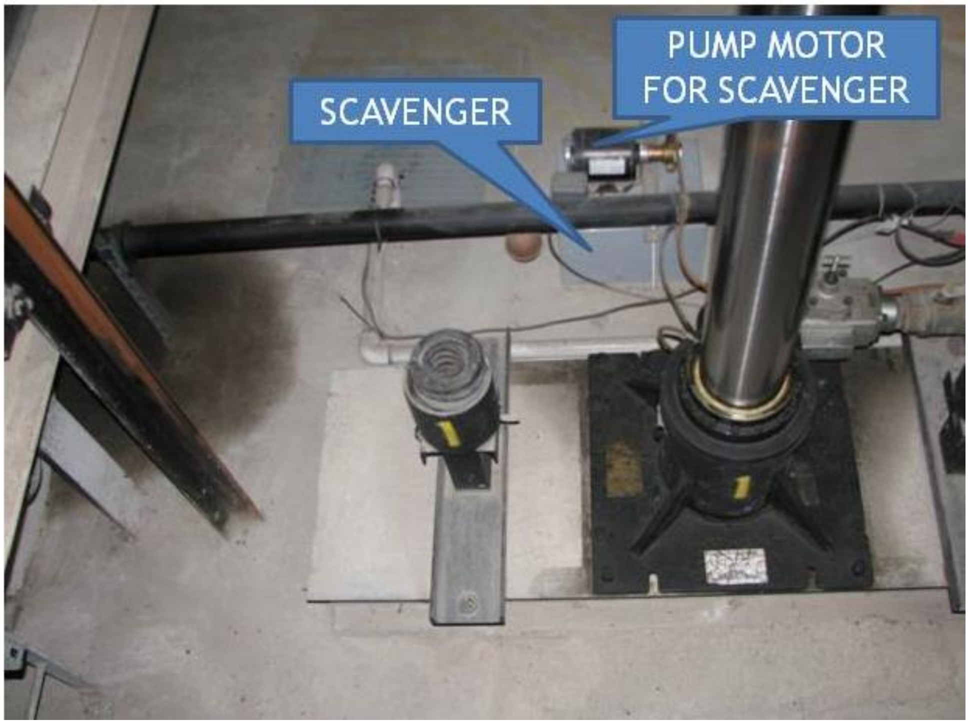


Figure 4.17 Scavenger and pump –Courtesy WMATA.

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 are typically found in the elevator pit. Figure 4.18 shows a shut off valve with label indicating its rated PSI complying with ASME A17.1.

Figure 4.18 Shut Off Valve ©Maxton

Overspeed valves (OSVs) provide protection against a failure in the supply line or overspeed in the down direction. The OSV can be adjusted to a pre-determined value to stop the elevator in case there is an over speed condition. Overspeed valves must be installed within twelve inches of the cylinder.

Near the overspeed valve is the **spring buffer**. The spring buffer is there to stop the car in case of emergency.

Figure 4.19 Overspeed valve and buffer –Courtesy WMATA

As required by ASME code, elevator pits must be equipped with a **light**, **ladder,** and **stop switch**. The light, which must have an external guard to prevent contact and accidental breakage, gives the technician the necessary illumination as well as an outlet to power other devices.

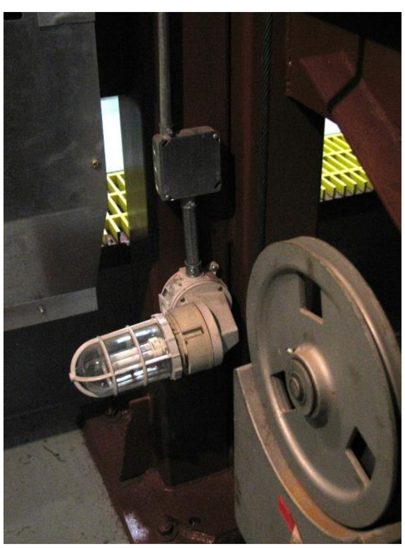


Figure 4.20 Light with outlet –Courtesy WMATA

Pit ladders are required in all pits that extend more than 35 inches below the bottom landing sill. The pit ladder must extend 48 inches above the landing entrance and the ladder rungs must be at least 16 inches wide unless obstructions prevent this, and in that case it can be no less than 9 inches wide.

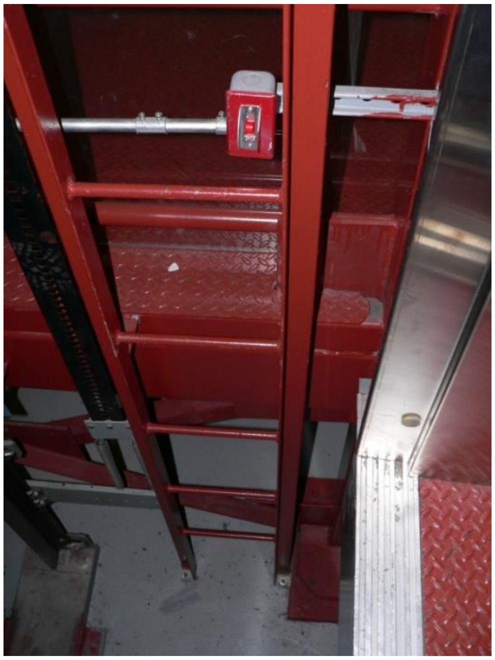


Figure 4.21 Pit Ladder -- Courtesy WMATA

Experienced mechanics will agree that the most important of these three components is the pit stop switch, which, in emergency situations inside the pit, gives the technician the ability to stop the car from moving. ASME code indicates that the pit stop switch will have red operating handles or buttons and should be permanently marked “STOP” indicating the stop and run positions. ASME code also indicates that the pit stop switch shall be located within reach of the access floor, adjacent to the pit ladder and located about 18" above the landing in order to be accessible before stepping onto the pit ladder.

Figure 4.22 Pit stop switch –Courtesy WMATA

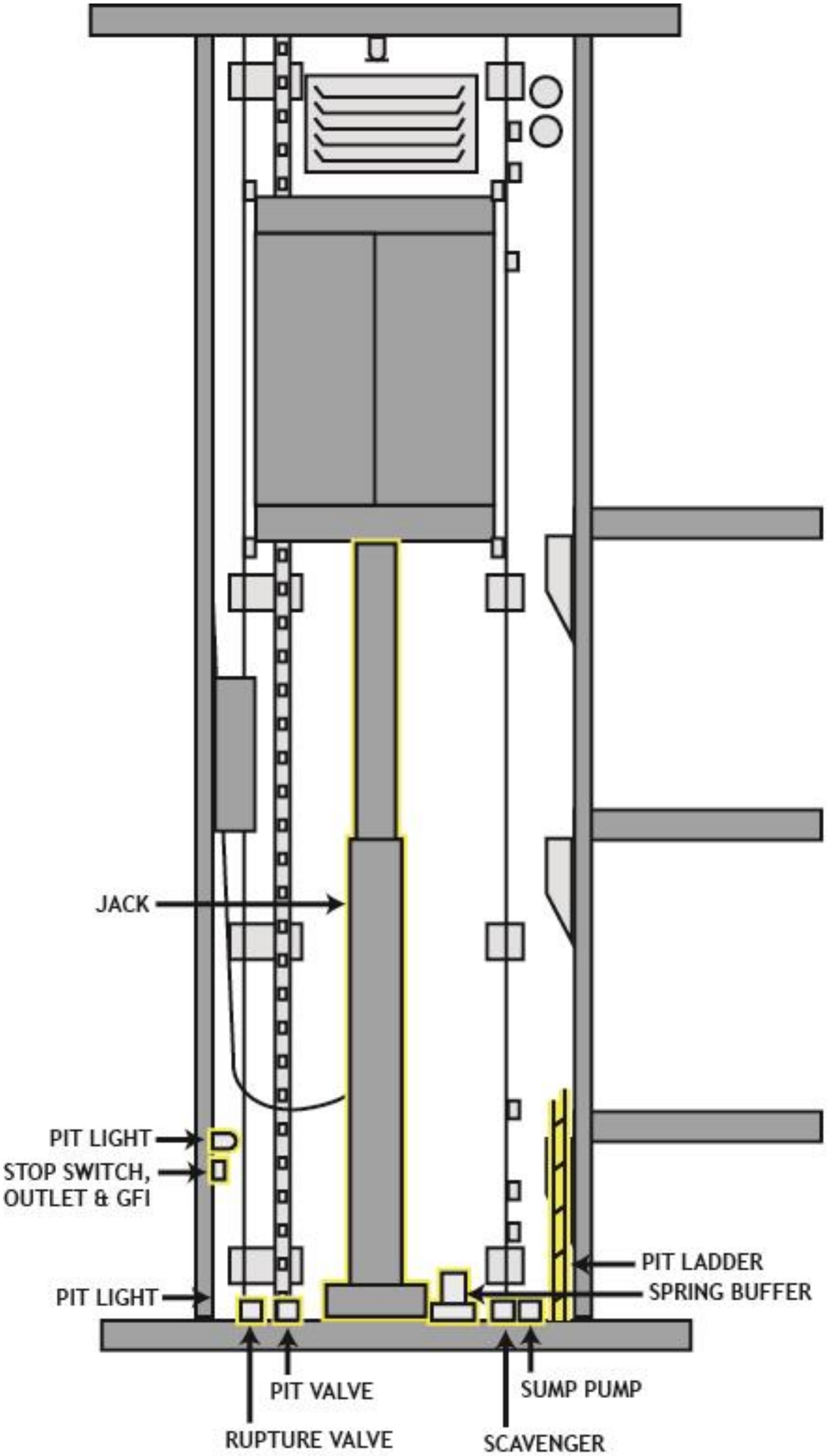


Figure 4.23 Hydraulic Elevator Hoistway Highlighting Components in the Pit

4-6 COMPONENTS ATTACHED TO THE CAR

On hydraulic elevators, the only component attached to the car is either a roller guide or a guide shoe. The elevator car travels the length of the hoistway by rolling along the guide rails. This is done by either **roller guides** (Figure 4.24) or **guide shoes** which are attached to the elevator car.

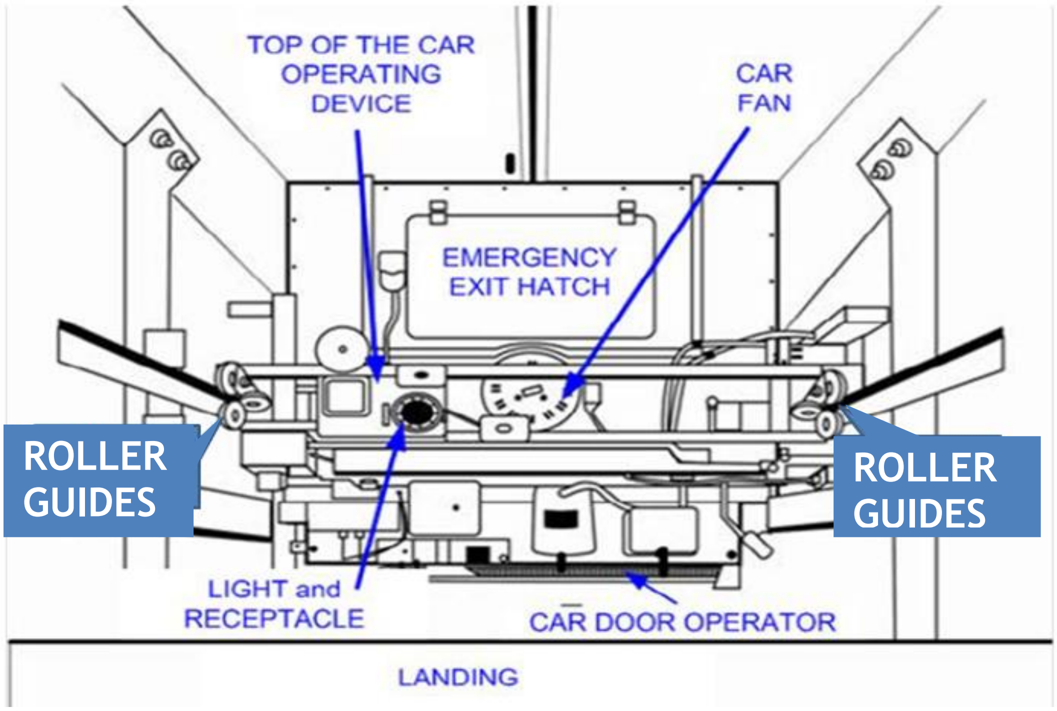


Figure 4.24 Top of Car Illustrating Location of Roller Guides

Roller guides *roll* along the guide rails while guide shoes *slide* along the guide rails. These are illustrated in Figure 4.25 and Figure 4.26.

Figure 4.25 Roller guide on guide rail –Courtesy NYCT

Figure 4.26 Rigid guide shoes -©Hollister Whitney

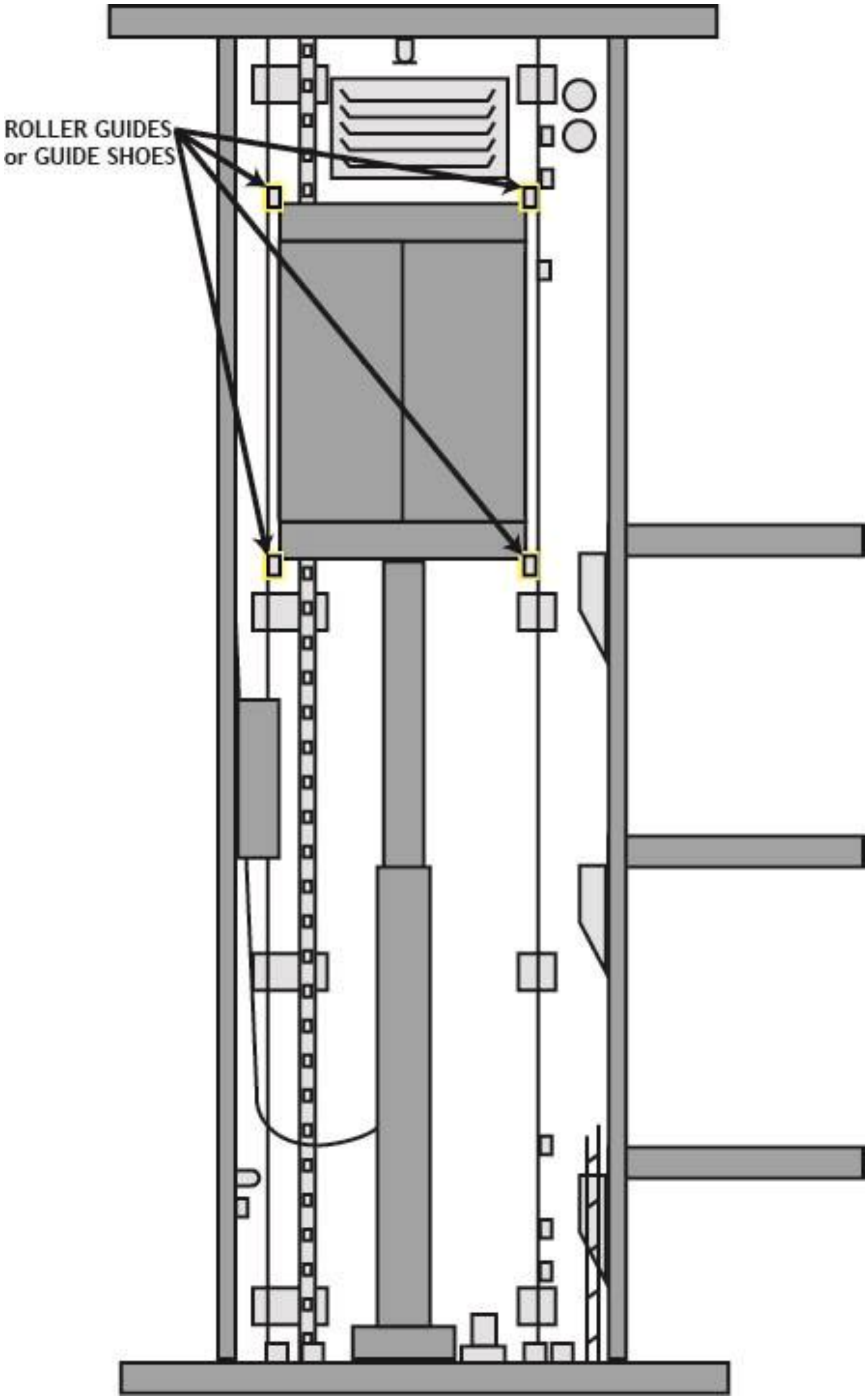


Figure 4.27 Hydraulic Hoistway Highlighting Rollers Guides/Guide Shoes

4-7 COMMON ISSUES IN HOISTWAY

Warning: Safety Precautions!

When performing maintenance on transit elevators, remember to properly land the car.

Once the elevator car is properly secured and all work safety guidelines are followed, the experienced elevator technician can perform required maintenance. While it is beyond the scope of this course to present the participant with a detailed list of maintenance requirements for a hydraulic elevator system, there are some common problems in the hoistway that the course participant should note.

Hydraulic Elevators		
Problem	**Component**	**Notes**
Leaks	Packing head, flexible coupling, Victaulic fittings, etc.	
Oil in the pit, car will not move correctly	Pipes	
Not stopping or leveling correctly	Valves	
Misalignment	Roller guides/guide Shoes	
No slow down of car	Rollers on the limit switches	
Unusual noises (scraping) as car travels	Fascia plate, roller guides/guide shoe	
No lights or fan in car; call buttons or communications not operating correctly.	Traveling Cable, halfway box	

4-5 SUMMARY

This module provides the course participant an overview of the hoistway of a hydraulic elevator system. The hoistway is the behind-the-scenes operation of an elevator system and this is where the elevator technician spends much of his or her time. It cannot be emphasized enough that the technician should follow established safety procedures at all times when working on elevators.

This module grouped the major components in the hoistway into four locations: Overhead, Length of Hoistway, Pit Area, and Attached to the Car. Below is a summary of the different components in each area.

Overhead	Length of the Hoistway	Pit Area	Attached to the Car
Hoistway Vents Limit Switches Sprinkler Head Smoke Detector Heat Detector Refuge Space Runby Area	Selector tape Guide rails Rail brackets Traveling cables Halfway junction box Cable support grip Connecting plate Hoistway fascia plate Dust Cover Door Frame	Jack Sump Pump Scavenger/recycling system Overspeed valve Light Ladder Stop Switch Buffer Ground Fault Circuit Interrupter (GFI Receptacle)	Roller Guides/Guide Shoes

Module 5

MAINTENANCE REQUIREMENTS

OUTLINE

Purpose and Objectives:

The purpose of this module is to provide an overview of general procedures in the maintenance of transit hydraulic elevators.

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

- Describe general maintenance practices for hydraulic elevators
- List the lubrication points and applicable schedule
- Describe the procedures for lubrication of components
- Describe authority-specific maintenance requirements

References

1. McCain, Zack. *Elevator Maintenance Manual, 2nd Edition (*Mobile, Alabama: Elevator World, 2008), pages 141-239.

2. Ontario Non-Profit Housing Association. “Elevators Preventative Maintenance,” uploaded February 2009. http://www.youtube.com/watch?v=YKUSCznUDLs

Lesson Plan

Instructional Outline	CW Ref	Notes
5-1 Overview		The participant may have done some basic preventative maintenance on elevators or even escalators before taking this course. This module guides the participant through standard maintenance procedures in the elevator machine room, hoistway, pit, and elevator car. For each of these areas of the elevator system, the elevator technician essential duties involve inspecting, cleaning, lubricating, testing, and, where indicated, repairing, adjusting, or replacing components. Time is built into this course for participants to review the maintenance procedures of each transit authority.
5-2 General Maintenance Practices • **Maintenance Control** • **Maintenance Practices**	Elevator Maintenance Manual, 2nd Edition Pages 13-20 Pages 39-46	Three categories of maintenance: breakdown, preventative, predictive. Focus on **preventative maintenance** or "PM." Proper lubrication is the most important part of maintenance. Properties of lubricants and application to elevator components.
5-3 Authority-specific Maintenance Procedures	Authority-specific hydraulic elevator maintenance requirements.	Go over requirements. Demonstrate to participants how to complete and process checklists for preventative maintenance procedures
5-4 Summary	http://www.youtube.com/watch?v=YKUSCznUDLs	Show 8-minute video on overview of standard elevator maintenance with demonstration of PM checklist.