

UNIFIED FACILITIES (UFS)

ELEVATORS



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FOREWORD

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UNIFIED FACILITIES SUPPLEMENT (UFS)

ELEVATORS

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

This UFC Supplement (UFS) provides documentation requirements, commentary, best practices, and other information related to UFC 3-490-06.

1-2 COMMENTARY.

Commentary has been provided for content in UFC 3-410-01. The General Design Requirements and IMC Modifications are restated for convenience with the associated commentary with paragraph numbering matching the UFC. Requirements and modifications paragraphs without commentary will not have content and are marked “No Commentary”. Commentary is designated by a “[C]” with the section number repeated and the commentary highlighted in light gray.

1-3 BEST PRACTICES.

The best practices chapter contains information that are not requirements but include background information and best practices based on experience and lessons learned.

CHAPTER 2 PLANNING AND DESIGN REQUIREMENTS

2-1 PLATFORM LOADING.

Passenger elevators may be utilized for movement of furniture, office equipment, and other material.

2-2 ENERGY EFFICIENCY.

Energy-efficient technologies are available for new construction and modernization of elevator installations and can be effective in buildings with 10 stories or greater. “Regenerative Drive” motor control systems have been developed for use with gearless traction elevators. This motor control system uses the energy that is developed when the elevator is running in an overhauling load condition. The drive converts the mechanical energy into electrical energy and feeds it back to the facility power grid. The use of gearless traction machines, and regenerative drive motor control, should be considered for installations over 5 stories.

2-3 UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS).

Electric Traction elevator equipment requirements are specified in the following UFGS:

- UFGS 14 21 13: Electric Traction Freight Elevators
- UFGS 14 21 23: Electric Traction Passenger Elevators

Table 2-1 Recommended Elevator Types and Usage

Number of Landings	Travel	Service	Minimum Speed	Recommended Elevator Type
2 - 3	Up to 16' (< 4.9 m)	Passenger or Freight	125 ft/min (38.1 m/min)	Hole-less or In-ground Direct Plunger Hydraulic
3 - 4	16' - 44' (4.9–13.4 m)	Passenger or Freight	150 ft/min (45.7 m/min)	In-ground Direct Plunger Hydraulic
2 – 4 4 - 5 5 – 10 >10	16' - 24' (4.9-7.3 m) 24' - 44' (7.3–13.4 m) 44' – 100' (13.4-30.5 m) >100' (>30.5 m)	Passenger	150 ft/min (45.7 m/min) 200 ft/min (61.0 m/min) 350 ft/min (106.7 m/min) 500 ft/min (152.4 m/min)	Gearless Traction

2 - 4 5 - 9	Up to 44'(<13.4 m) 44'–100' (13.4-30.5 m) >100' (>30.5 m)	Freight	200 ft/min (61.0 m/min) 350 ft/min (106.7 m/min) 500 ft/min (152.4 m/min)	Geared Traction
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[C]: Table 2-1 These recommendations, and speed and travel requirements as listed above, are only relevant for new construction projects. System configuration is at the discretion of the DOR. Alterations to existing facilities may retain original design criteria.

CHAPTER 3 FIRE PROTECTION

3-1 FIRE ALARM SYSTEM.

Design all elevator installations with Firefighters' Emergency Operation (FEO). Provide fire alarm detection and alarm system for actuation of elevator FEO and automatic elevator operational response to fire alarm initiating devices located in the elevator machine room, elevator lobbies, and elevator hoistway, as required by UFC 3-600-01.

3-2 ELEVATOR CONTROLLER INTERFACE.

Utilize FEO operation relay modules for the interface between the building fire alarm panel and the elevator controller. Indicate fire alarm initiating devices, FEO relay modules, and connections on fire protection drawings or on electrical drawings if fire protection drawings are not provided. Coordinate with Electrical Engineer.

On MR drawings, indicate fire extinguisher placement on the wall, inside the elevator machine room, on the strike-jamb side of the MR door.

CHAPTER 4 BEST PRACTICES

This information is considered to be guidance and not requirements. The main purpose is to communicate proven system/facility solutions and lessons learned and may not be the only solution to meet UFC requirements. It is not intended to be a textbook or to repeat information from industry standards and non-government references. The Best Practices Appendices are not intended to parallel the chapter organization and numbering of the technical requirements section of the main text.

This appendix identifies and describes standard elevator systems that are available in the elevator industry and best practices associated with each type of elevator. The best practices represent design concepts adopted by the DOD to address typical facility types, proven facility solutions, lessons learned, facility system safety, and total ownership cost.

4-1 ELEVATOR MACHINE ROOM.

The elevator Machine Room is the most critical building component of an elevator installation. The elevator machine room is the one functional area in the building that is designed and designated for the safe and effective maintenance, service, repair, and safety code mandated inspection and testing of the elevator system. During diagnostic evaluation and testing of the elevator, the certified elevator technician must operate the elevator from the elevator controller and simultaneously observe and evaluate the operation of the elevator drive machine. In addition, the certified elevator inspector is required to observe the operation of the elevator drive machine and overspeed governor during safety code mandated annual performance tests of the elevator car speed, safeties, hoist ropes, drive sheave, and overspeed governor. Performance of service, repair, inspection, and testing is more effective and more efficient when the elevator controller, the elevator drive machine, and the overspeed governor are all located in the same functional area, the elevator MR. For DoD facilities, elevator systems with a machine room for each elevator or elevator group, and the elevator controller and drive machine in the MR, are the preferred design approach.

4-1.1 Safety.

Elevator systems are comprised of complex and sophisticated mechanical, electrical, hydraulic, and electronic systems that require diagnostic evaluation, maintenance, service, repair, inspection, and testing. Elevator service personnel utilize mechanical tools and electronic equipment to perform the repair, and replacement of elevator components, including the microprocessor controller, drive machine, drive motor, overspeed governor, safeties, rope-gripper, hoist ropes, traction drive sheave, machine brake, and hydraulic elevator control valve. In addition, elevator safety code officials conduct periodic inspection and testing of the elevator system. The elevator machine room is the one functional area in the building that provides a suitable area for the staging of personnel, components, service manuals, tools, and equipment and for the safe and effective performance of these critical functions.

The elevator controller, electric motor, and motor drive, are powered by electrical power circuits that range from 30 VAC to 480 VAC. During elevator service, repair, and testing, elevator personnel are exposed to electrical safety hazards that include both electric shock and arc flash. Safety hazard exposure to any other occupants of the building is minimized by locating the elevator controller, electric motor, and motor drive in the machine room vice public space areas of the facility.

4-1.2 Clearances.

Elevator machine room minimum clearances, between elevator equipment and the MR building components, are provided to facilitate maintenance, replacement, inspection, and testing of elevator components within the machine room. While these clearances may slightly exceed the ASME A17.1 code requirements, they are designed to maximize effective lifecycle sustainment of the elevator system by DOD maintenance personnel and/or contracted services.

4-1.3 Hoistway Pit Entrapment Area.

The ASME A17.1 provides a minimum standard for refuge area and accepts the potential temporary entrapment of elevator personnel under a car in the pit. Should elevator personnel become trapped, and this occurs concurrently with fire sprinkler discharge and/or catastrophic hydraulic fluid line rupture in the hoistway, entrapped personnel would be at risk of drowning.

This UFC provides egress from the pit in this scenario by requiring a hoistway pit entrapment area. DoD considers the benefit of providing egress from the pit in this scenario to outweigh its additional cost. The purpose of this area is that if an entrapment occurs emergency personnel could lower a ladder in the entrapment area to rescue trapped personnel. If the pit starts flooding before emergency personnel arrives at the scene, the entrapped personnel will have an area to self-rescue by floating up the side of the elevator.

4-2 MACHINE-ROOM-LESS ELEVATOR DESIGN.

ASME A17.1 requires an elevator drive machine to be located in either an elevator Machine Room (MR) or an elevator Machinery Space (MS). When the elevator drive machine is not located in a machine room, the elevator is referred to as a Machine-Room-Less (MRL) elevator.

4-2.1 Location and Access.

In an MRL elevator design, the elevator drive machine is relocated from the elevator machine room (MR) to the elevator hoistway. For MRL electric traction elevators, the MRL machine is typically located in the top of the hoistway. For hydraulic elevators, the hydraulic pump unit is relocated to a position along the side wall of the hoistway pit. For both types, the elevator operation controller will be located in what is then referred to as the Control Room (CR).

Machine-Room-Less (MRL) elevator design may be utilized in the design and construction of DoD Facilities. ASME A17.1 requires elevators to be designed and constructed with an accessible machinery space whenever the elevator drive machine is located within the elevator hoistway. This UFC provides specific direction for the location and access to the MS and for clearances around mechanical and electrical equipment in the MS. These safety code and criteria design requirements are intended to facilitate the safety code mandated safe and effective maintenance, service, repair, and safety code certification inspection and testing of the elevator system.

4-2.2 Construction Cost and Leasable Space.

The construction cost and leasable space benefit of using an MRL design is that the size of the elevator equipment room can be reduced since it no longer contains the elevator drive machine. Instead of having a 72 sq ft (6.69 m²) MR, the elevator equipment room can be reduced to a 40 sq ft (3.72 m²) Control Room.

However, this perceived advantage is offset by the fact that the building must also be designed with an additional mechanical area, the machinery space described in paragraphs A-2 and A-2.1, above. For an electric traction elevator, a typical machinery space will require approximately 36 sq ft (3.34 m²). In developing the building design, and determining the associated costs, designers must take into consideration the duplicate electrical, mechanical, and fire protection utility systems that are required for both the CR and the MS. Building and safety codes require both the CR and the MS to be equipped with lighting, electrical disconnects, fire alarm and fire protection systems, and independent HVAC systems for each area. For electric traction elevators, electrical design considerations must also include the additional run of electrical power conductors from the CR to the MS in the top of the elevator hoistway.

4-2.3 Sustainment (Maintenance) Costs.

Although often costing more initially than MRL designs, machine room designs can realize lower maintenance costs over an expected building service life when considering operating costs, preventative maintenance, testing, repair, and modernization. These avoided costs can make machine-room designs life-cycle cost effective over a building service life in most applications.

4-3 HYDRAULIC ELEVATORS.

The conventional hydraulic elevator consists of an elevator machine room (MR) located adjacent to elevator hoistway, with the elevator operation controller and hydraulic pump unit located in the elevator MR. The hydraulic pump unit consists of a hydraulic fluid reservoir, an electric motor and hydraulic pump, and control valves that regulate the movement of hydraulic fluid in and out of the pump unit. The hydraulic cylinder/plunger assembly is located in the elevator hoistway and is fully supported by the pit floor.

Hydraulic fluid supply piping is installed from the pump unit to the hydraulic cylinder/plunger assembly in the elevator hoistway. When the pump unit supplies

hydraulic fluid to the cylinder, the hydraulic plunger is forced up and out of the cylinder, driving the elevator up the hoistway. Downward movement of the elevator is powered by gravity and controlled by the elevator control valve in the pump unit. Current hydraulic elevator control valve technology that controls elevator acceleration, deceleration, and leveling, limits effective hydraulic elevator speed to a maximum of 150 fpm (45.7 m/min). At higher speeds, excessive slowdown and leveling time and travel distances are required for acceleration and deceleration.

4-3.1 Restricted Designs and Technology.

Roped hydraulic elevators and hydraulic elevators with a telescopic cylinder/plunger assembly (jack) are available in the elevator industry to allow the use of hydraulic elevator systems for higher rise applications. However, the acquisition and sustainment cost of these systems, including cost of equipment, installation, maintenance, and service, is comparable to electric traction elevators without the benefits of greater speed, efficiency, and performance offered by electric traction elevators. Telescopic jacks can have up to four pistons in each jack, each traveling inside each other. As such, there are inherent problems utilizing telescopic systems compared to single stage hole-less, or in-ground systems, such as more moving parts, the initial set-up is far more complex (bleeding the jack completely, is required), and there are simply more packing and seals due to multiple pistons necessitating increased maintenance. Depending on overall travel distance, follower guides will be needed, requiring additional engineering. Synchronization issues between stages also continues to be an issue for some configurations and installations. Therefore, hole-less usage is limited to single stage hydraulic systems. There are some, limited, applications where a roped hydraulic elevator can be the best choice, including Air Traffic Control Tower (ATCT) installations and modernizations of existing buildings that cannot support an electric traction elevator.

A non-standard, inverted hydraulic cylinder/plunger design is also available from a limited number of hydraulic cylinder manufacturers. In this design, the hydraulic cylinder is attached to the elevator cab in an upside-down configuration. The plunger protrudes from the bottom of the cylinder and presses against the pit floor. There is no inherent cost or performance benefit to this design and the sustainment cost is much greater than for a standard hydraulic cylinder design.

4-4 ELECTRIC TRACTION ELEVATORS.

Electric traction elevators may be used for all buildings. The traditional overhead-traction elevator consists of an elevator machine room (MR) located above the elevator hoistway. The elevator operation controller and drive machine are located in the elevator MR. Steel hoist ropes (cables) are suspended on the elevator machine drive sheave and the ends of the hoist ropes hang down into the elevator hoistway. In the hoistway, the elevator cab is fastened to one end of the hoist ropes and the elevator counterweight is fastened to the other end of the hoist ropes. The counterweight is used to counterbalance the weight of the elevator cab and the load in the cab, thereby reducing required motor torque and increasing energy efficiency. Alternative roping

configurations are also used (e.g., 2:1) for greater energy efficiency and to allow a smaller drive machine to support a higher capacity load than it could otherwise. As identified in Section 2-4, speed limitations are directly related to the height of the building and the number of landings served by the elevator.

4-4.1 Drive Machines.

There are two types of electric traction hoist machines, geared and gearless. Elevator travel and car speed typically determine the most effective application of each type.

Geared Traction Machine: The elevator drive motor drives a worm and ring gear assembly in the elevator drive machine. The ring gear turns the drive sheave, which moves the hoist ropes that raise and lower the elevator cab in the hoistway.

Gearless Traction Machine: The gearless drive machine consists of an electric motor that connects directly to the elevator drive sheave; there is no gear reduction unit. Gearless machines are available with a conventional asynchronous induction AC motor with electrically excited fields or with the more energy efficient AC Permanent Magnet (PM) motor. Rapid advances in AC PM motor and machine technology have made this a standard option for electric traction elevator drive machines. The PMAC motor, drive, and machine technology provides the same energy efficiency whether it is located in the elevator machine room or in a machinery space in the top of the elevator hoistway.

4-4.2 Energy Efficiency.

Electric motor and motor-drive energy-efficient technologies are available in the elevator industry for electric traction elevators. High-efficiency alternating current (AC) permanent magnet (PM) gearless machines have been incorporated into elevator design in the elevator industry and can provide up to 30 - 40% efficiency gains over standard geared traction drive machines. The machine utilizes an electric motor design with permanent magnets, in lieu of electrically energized field coils, to increase energy efficiency of the drive machine. In addition, "Regenerative Drive" motor control systems have been developed for use with the AC PM motor drives. This motor control system uses the energy that is developed when the elevator is running in an overhauling load condition and converts the mechanical energy into electrical energy which is fed back to the building power grid.

Electric motor and motor-drive energy-efficient technologies should be considered for all buildings. However, the current AC PM motor and drive technology provides a service life of only 35% - 60% of the standard geared traction machine. Prior to providing direction for use of regenerative elevator motor drives, additional research and cost analysis is required with regard to a comparison of motor drive energy savings versus excessive cost of replacement of elevator motor and motor drive systems.

4-4.3 Suspension Means.

Elevator traction-steel wire rope is the industry standard for elevator suspension means (hoist ropes). Non-coated steel hoist ropes are specified for use in UFGS 14 21 13:

Electric Traction Freight Elevators and UFGS 14 21 23: Electric Traction Passenger Elevators. Elevator certifying officials are required to verify safety code compliance with minimum hoist rope diameters and maximum allowable number of broken wires in the strands of the rope. The use of non-coated steel hoist ropes provides for the effective application of elevator safety code inspection and certification requirements related to hoist rope wear and fatigue. In addition, in the event that the elevator runs past a terminal landing and bottoms out on the car or counterweight buffer, non-coated steel wire rope can slip traction with the drive sheave without damaging the wire rope.

4-5 COST, PERFORMANCE, AND SAFETY. ELECTRIC TRACTION VS HYDRAULIC

Section 2-4 of this UFC provides direction for the application of elevator types to building design, based on the length of travel and number of landings served by the elevator. These limitations are driven by several factors, including effective elevator performance, cost of the elevator system, and safety of the elevator occupants.

When an electric traction elevator is included in the design of a building, building design and construction is more expensive than for buildings with hydraulic elevators. The primary reason is that, for electric traction elevators, the building structure must be designed and constructed to support the weight of the elevator equipment, the elevator capacity, and the vertical and lateral reaction loads associated with elevator operation. In addition, the costs for the electric traction elevator equipment, installation, and sustainment are greater than the associated costs for hydraulic elevators.

4-5.1 Application.

For lower rise buildings, hydraulic elevators were developed as an economic alternative to electric traction elevators. By using a hydraulic elevator, cost savings are realized in the design and construction of the building since the building structure does not have to support the weight of the elevator equipment, the elevator capacity, and vertical reaction loads associated with elevator operation. The elevator is supported by the hydraulic cylinder/plunger (jack) which is supported by the elevator hoistway pit floor. All vertical loading is transferred directly to the pit floor. For low rise applications, the costs for the elevator equipment, installation, and sustainment in most cases are lower for hydraulic elevators than the cost of these items for a comparable electric traction elevator.

The selection of a hydraulic elevator is effective for buildings of 2 to 4 stories. For buildings of 5 stories and greater, however, the cost of the elevator equipment, the installation cost, and the cost of sustainment begin to rise substantially for hydraulic elevator systems. In addition, the speed limitations associated with hydraulic elevators has a detrimental impact on traffic flow within the building and results in excessive wait times for elevator response to hall calls and car calls. For these reasons, an electric traction elevator is the more appropriate choice for higher rise applications.

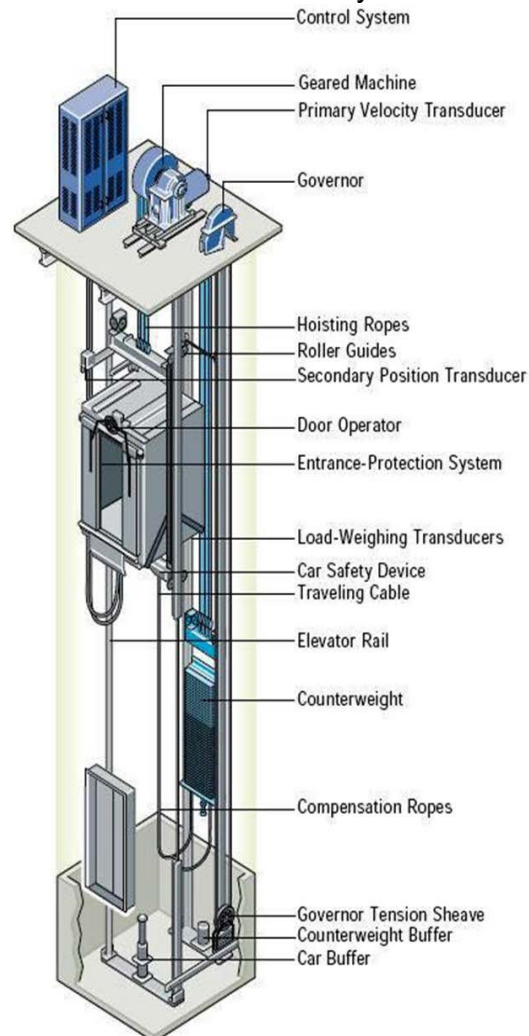
4-5.2 Safety.

One other critical consideration, for hydraulic elevators, has to do with safety of personnel who will be using the elevator for the life of the building. The ASME A17.1, Safety Code for Elevators & Escalators, requires all elevators suspended by wire rope to be equipped with a speed governor and elevator car safeties. The speed governor monitors the speed of the elevator and actuates elevator car safeties in the event that the elevator accelerates to an over-speed condition. These safety devices are designed to bring the elevator to a sliding stop and are effective for over-speed emergency actuation in both the up and down directions. However, ASME A17.1 does not require direct plunger hydraulic elevators to be equipped with a speed governor or safeties.

The travel limitation of 44 feet (13.41 m) for hydraulic elevators serves to minimize the risk associated with catastrophic failure of the hydraulic cylinder/plunger or the hydraulic oil supply line.

Figure 4-1 Electric Traction Elevator with Geared Machine

Elevator Machine Room is located Directly Over the Elevator Hoistway.



4-6 HYDRAULIC ELEVATORS.

The hydraulic drive system consists of a hydraulic fluid reservoir, hydraulic pump, and hydraulic piping from the elevator MR to the cylinder/plunger assembly located in the elevator hoistway. There are two types of cylinder/plunger configurations: direct plunger and indirect plunger.

4-6.1 Direct Plunger Hydraulic Elevator.

There are two types of direct plunger hydraulic elevators: in-ground and hole-less. The use of one or the other is governed the building design characteristics and site conditions.

4-6.1.1 In-ground Direct Plunger.

An elevator cylinder and plunger assembly is installed in the ground, below the elevator cab. The elevator cab frame is connected to the top of the plunger and moves up as hydraulic fluid is pumped into the cylinder from the hydraulic elevator pump-unit reservoir.

4-6.1.2 Hole-less Direct Plunger.

Either one or two hydraulic cylinder/plunger assemblies are installed vertically, in the elevator hoistway, with the bottom of the cylinder supported by the hoistway pit floor. The cab frame is attached to the top of the plunger and moves up as hydraulic fluid is pumped into the cylinder from a reservoir.

4-6.2 Indirect Plunger Hydraulic Elevator.

4-6.2.1 Roped Hydraulic Elevator.

The roped design is similar to the standard hole-less elevator design. The difference is that a wire rope sheave is mounted to the top of the hydraulic plunger and steel hoist ropes are attached to the cylinder base, run over the sheave, and down to the cab frame. As the cylinder runs up, the 1:2 roping moves the elevator cab twice the distance of the plunger travel. The cost of acquisition, maintenance, and service for a roped-hydraulic elevator is substantially greater than for the direct plunger types and is not permitted in DOD facilities except in the event of compelling design conditions.

Figure 4-2 In-ground Direct Plunger Hydraulic Elevator

Elevator Machine Room is located directly adjacent to the elevator hoistway.

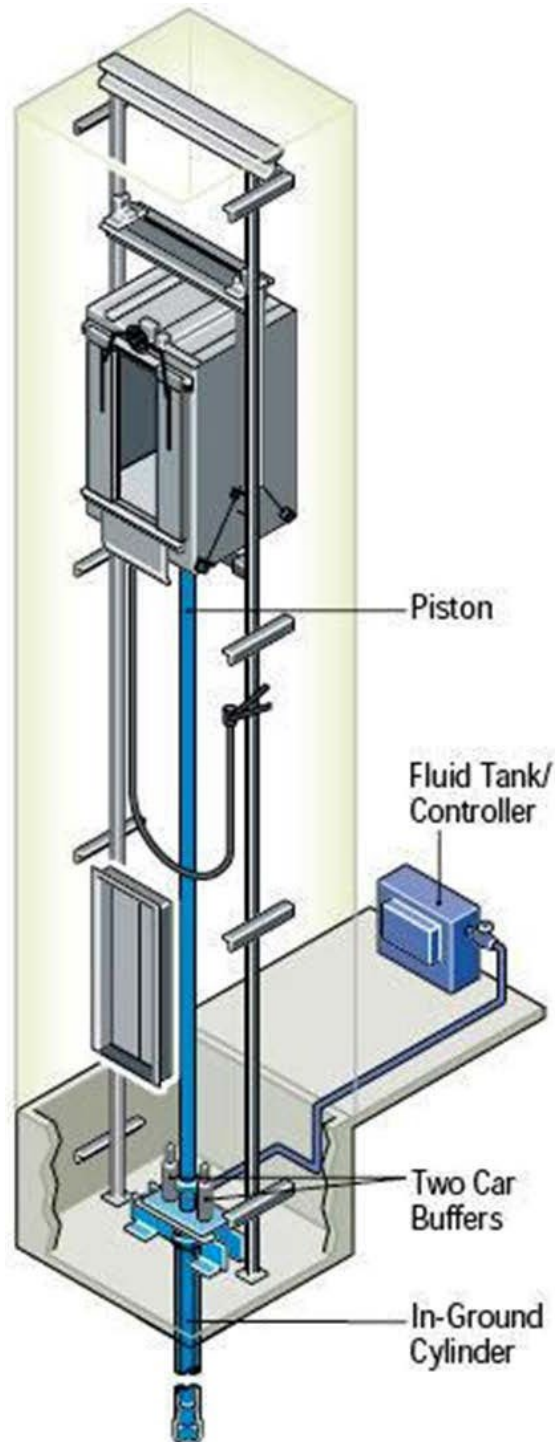
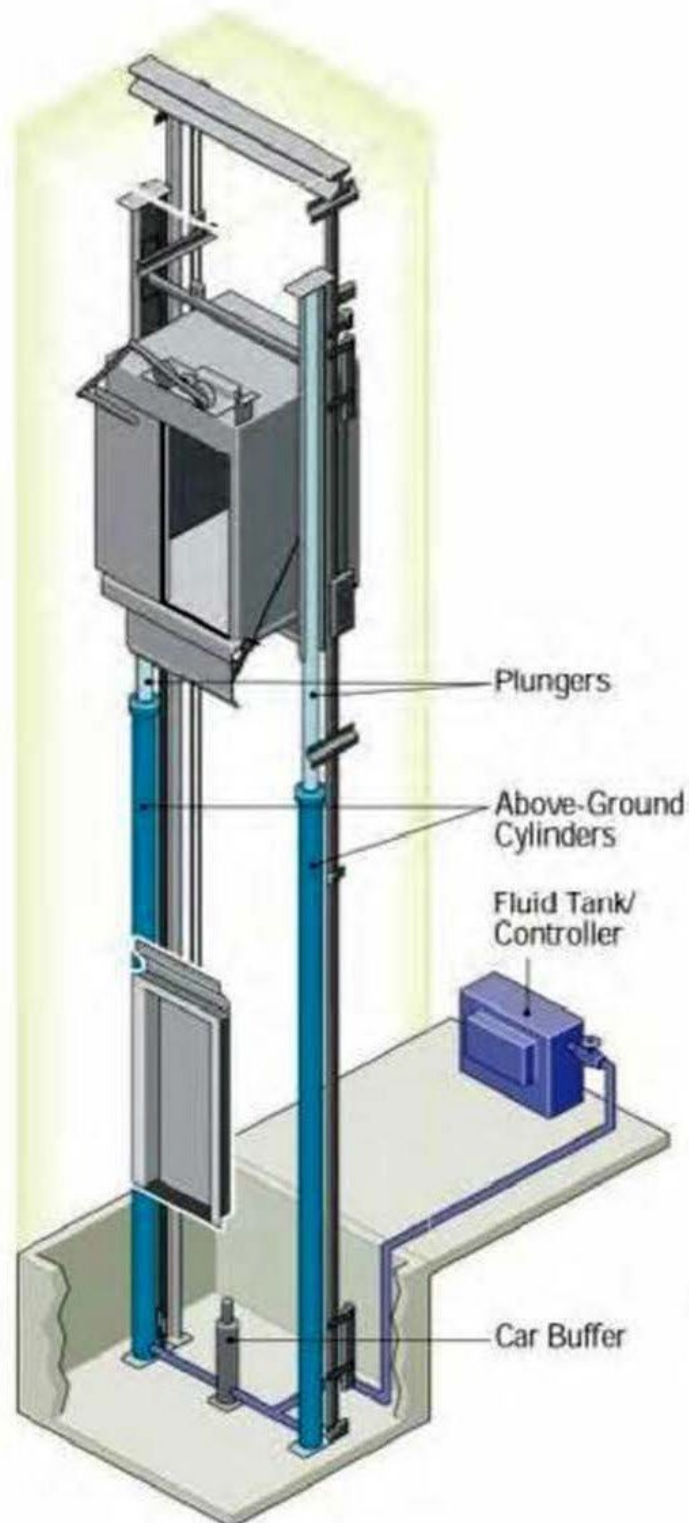


Figure 4-3 Hole-less, Dual Post, Direct Plunger Hydraulic Elevator

Elevator Machine Room is located directly adjacent to the elevator hoistway.



APPENDIX A GLOSSARY

A-1 ACRONYMS.

AC	Alternating Current
AFCEC	Air Force Civil Engineer Center
ATCT	Air Traffic Control Tower
ATS	Automatic Transfer Switch
BIA	Bilateral Infrastructure Agreement
CR	Control Room
DOD	Department of Defense
EMS	Emergency Medical Services
FEO	Firefighters' Emergency Operation
GFCI	Ground Fault Circuit Interrupter
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreements
MR	Machine Room
MRL	Machine-Room-Less
MS	Machine Space
NAVFAC	Naval Facilities Engineering Command
PM	Permanent Magnet
PMAC	Permanent Magnet Alternating Current
SME	Subject Matter Expert
SOFA	Status of Forces Agreements
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
U.S.	United States

A-2 DEFINITION OF TERMS.

Personnel Hoist: A personnel hoist is a mechanism for use in connection with the construction, alteration, maintenance, or demolition of a building, structure, or other work. It is used for hoisting and lowering workers or materials, or both, is equipped with a car that moves on guide members during its vertical movement and includes its hoistway.

APPENDIX B REFERENCES

AMERICAN SOCIETY OF CIVIL ENGINEERS

<https://www.asce.org>

ASCE/SEI 24-0514, *Flood Resistant Design and Construction*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

<https://www.asme.org/>

ASME A17.1, *Safety Code for Elevators and Escalators*

ASME A17.3, *Safety Code for Existing Elevators and Escalators*

INTERNATIONAL CODE COUNCIL

<https://www.iccsafe.org>

International Building Code (IBC)

NATIONAL FIRE PROTECTION ASSOCIATION

<https://www.nfpa.org>

NFPA 70, *National Electric Code*

NATIONAL ELECTRICAL MANUFACTURES ASSOCIATION

NEMA ICS 6, *Industrial Control and Systems: Enclosures*

UNIFIED FACILITIES CRITERIA

<https://www.wbdg.org/dod/ufc>

UFC 1-200-01, *DoD Building Code*

UFC 3-301-01, *Structural Engineering*

UFC 3-600-01, *Fire Protection Engineering for Facilities*

UFC 4-510-01, *Design: Medical Military Facilities*

UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems (FRCS)*

UFC 4-021-02, *Electronic Security Systems*

UNITED STATES DEPARTMENT OF DEFENSE

ABA Accessibility Standard for Department of Defense Facilities

<https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-aba-standards/aba-standards>

https://www.lrl.usace.army.mil/Portals/64/docs/Engineering/Design_AF/aba.pdf

DEPSECDEF *Memorandum, Subject: Access for People with Disabilities*, 31 October 2008

<https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-aba-standards/background/dod-memorandum>