

7. Heavy Duty Transportation System Escalator Design Guidelines

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Heavy Duty Elevator Design Working Group

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Abstract: This recommended practice contains guidelines for transit systems to use to specify heavy duty escalators for use in a transit environment.

Keywords: escalators, heavy duty escalators, transit escalators

Introduction

(This introduction is not a part of APTA RT-RP-FS-007-02, *Heavy Duty Transportation System Escalator Design Guidelines*.)

This design guideline is the result of the combined efforts of the members of the APTA Elevator and Escalator Technical Forum over the past several years. The objective is to address the specific heavy-duty escalator needs of North American transportation systems. It is intended as a guideline of technical provisions for the design and construction of escalators which can provide safe, reliable service in the harsh, heavy usage, high abuse environment of transportation systems. Membership of the Technical Forum includes transportation systems, consultants, and escalator/component manufacturers.

This design guideline is not intended to be a 100%, ready technical specification for all transportation systems. Each Owner may find it necessary to make changes to suit their specific needs. However, the stringent provisions are the result of the members combined experiences and, in general, reflect transportation requirements and the need for improved safety and reliability. There are also “comments” in the text to guide the user in preparation of a procurement specification document.

It is expected that some manufacturers will be quick to tell us that these requirements will “add to the cost of the procurement”. We all know, from past experience, the high life cycle maintenance costs associated with the manufacturer’s “standard” product when used in a transportation environment. Paying “more up front” will be more than compensated for by the overall reduced life cycle costs. Most importantly, it will improve customer safety, satisfaction, and convenience. The results can only be an increase in the public’s confidence in a transportation system’s ability to meet their needs, and thus, an increase in ridership.

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Heavy-Duty, Transportation System Escalator Design Guidelines

PART I - GENERAL

1.01 GENERAL DESCRIPTION

This section specifies requirements for design, fabrication, installation, and testing of escalators.

1.02 DEFINITIONS

Note to specifier: Special care must be taken to coordinate definitions with other parts of a larger procurement contract.

- A. **Heavy duty escalator:** An escalator designed specifically for transportation system usage.
- B. **Flat steps:** the distance, expressed in step lengths, that the leading edge of the escalator step travels after emerging from the comb before moving vertically.
- C. **Working points:** Points of intersection of step nosing line and the horizontal line of the top and bottom landing plates at finish elevation.
- D. **Special tools:** Tools designed specifically for tasks associated with escalator examinations, maintenance, and repair or those which are required for these tasks and are not readily available through normal purchasing channels.
- E. **Step width:** The horizontal distance between skirt panels.
- F. **Escalator support:** The upper, lower, and intermediate supports needed to support the total loads of the escalator.
- G. **Slip joints:** A sliding joint required to support escalators in transportation system and high-rise applications. Location can be at top or bottom support areas but are generally located at the platform level or as indicated on the contract drawings.
- H. **SCADA (System Control and Data Acquisition):** a system to connect various equipment in a geographic area.
- J. Contractor: The General Contractor.
- K. Installer: The responsible party who installs the escalator.
- L. OEM: Original Equipment Manufacturer.
- M. Owner: The Owner in control of the facility.
- N. Substantial completion: The point at which the escalator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.

- O. Final Acceptance: The point at which the owner accepts the escalator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
- P. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
- Q. Beneficial Use: When the escalator is placed into service, may be prior to the site being ready for public use.
- R. Revenue Service: The station or facility opening date.
- T. Notice to Proceed (NTP): within this document shall mean the date which the escalator installer is notified to proceed with the project.
- U. Owner Having Jurisdiction (AHJ): as defined by ASME A17.1.

1.03 TEMPORARY AND PERMANENT ELECTRICAL POWER SERVICES

- A. Three phase temporary power with the same characteristics as the permanent power shall be made available to Installer at the time of the setting of truss. Permanent power shall be made available for testing. All power shall be provided at no cost to Installer.

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| Note to specifier: close coordination with the electrical engineer is recommended to provide the proper power supply for a given installation. Some manufacturers may require transformers for certain voltages. |
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- B. For the escalator drive systems: 208, 220 or 480 volts, 3 phase, 3 wire, 60 Hertz terminating in a disconnect switch within sight of the controller.
- C. For lighting and GFCI receptacles: 120 volts, 1 phase, 3 wire, 60 Hertz terminating in the escalator truss.

1.04 APPLICABLE CODES, STANDARDS, AND PUBLICATIONS

Escalator designs and installations shall be of the heavy duty, and shall comply with the following:

- A. American National Standards Institute (ANSI)
 - 1. ASME A17.1, A17.2.3, A17.5 applicable edition
- B. Canadian Standards Association, CSA B44
- C. National Fire Protection Association (NFPA)
 - 1. NFPA No. 130, "Fixed Guideway Transit and Passenger Rail Systems"
 - 2. ANSI C1, National Electric Code (NFPA 70)
- D. Americans with Disabilities Act (ADA)
- E. Canadian Welding Bureau (CWB)
- F. American Welding Society (AWS)
- G. American Society of Testing and Material (ASTM)
- H. International Standards Organization, ISO 281/I-1997
- I. American Federation of Bearing Manufacturers Association, AFBMA, Std. 9 and 11
- J. Occupational Safety & Health Act (OSHA)
- K. Any additional requirements imposed by local agencies shall be incorporated into escalator installations.

- L. In case of a conflict between codes, regulations, or standards, the most stringent requirement shall take precedence.

1.05 DESIGN CRITERIA

A. General:

1. Escalators shall be designed with provisions for thermal expansion and contraction of complete escalator assemblies and for any movement of the facility caused by trains braking when fully loaded.

Comment: speeds up to 125 FPM may be permitted in some jurisdictions. APTA recommends certain changes if permitting this higher speed over 10m in rise. These recommended changes permit the higher speed provided the following conditions are met:

- Track radius is increased,
- Lighting improved
- Require 4 flat steps
- Larger safety zone.

B. Operational Requirements

1. Hours of operation shall be considered as twenty-four (24) hours per day, seven (7) days per week.
2. Direction of travel shall be considered as either direction, and unit shall be up and down reversible.
3. Rated Speed shall not exceed 100 feet per minute (FPM).- The no-load-to-full-load speed shall not exceed 4% of the rated speed.
4. Escalator components shall be designed based on the following applied duty cycle during operation:

Three (3) Hours with 100% Rated Load
Six (6) Hours with 50% Rated Load
Fifteen (15) Hours with 25% Rated Load

Note to specifier: The above noted duty cycle is a general reference to stipulate anticipated load cycles encountered during normal operation. Duty cycles are utilized in design calculations for components to determine compliance with design and life requirements. Anticipated load, or duty, cycles should be reviewed and amended as needed for the anticipated usage requirements.

Note to specifier: close coordination with various manufacturers requirements for intermediate supports are necessary, especially where seismic requirements apply.

C. Structural Requirements

1. Installer shall provide escalator truss mounting angles and intermediate truss supports with attachments, sized as required to install escalators into wellway structural support system shown on the contract drawing.
2. Escalator intermediate support points shall be provided by Installer where indicated on drawings. Details and calculations shall be submitted by escalator Installer for approval by the Owner.
3. Reaction loads shall be indicated on contract drawings.

Note to specifier: The provisions included in items 1.05.C 2,3 and 5 are intended to provide the escalator manufacturer with information regarding the load bearing capacity of the structure and require the designer to develop a contract drawing that defines the loading the structure is designed to accept. Inclusion of items 2,3 and 5 is necessary in cases where escalators are installed in existing wellways, or in any other situation which it is necessary to define constraints on escalator loading.

D. Environmental Requirements

Note to specifier: Interior installations include facilities such as airports and controlled environments with no corrosive elements. Exterior installations should be used for all subway, rail and bus applications whether exposed to the weather or not. The need for truss heaters should be evaluated as appropriate for all installations.

1. General: Escalators shall be capable of operating with full-specified performance capability while exposed to the following climatic and environmental conditions:
 - a. Interior installations: Escalators shall be designed to operate in a temperature range of plus five (+5) to plus one hundred and twenty (+120) degrees Fahrenheit, dry bulb; and all conditions of relative humidity while exposed to airborne dust and debris.
 - b. Exterior installations: Escalators shall be designed to operate while exposed to the natural elements of weather including sunlight, rain, slush, snow and ice; all conditions of relative humidity while exposed to salt, de-icing chemicals, airborne dust, and debris, and corrosive elements; and in a drybulb temperature range of minus ten (10) to plus one hundred and five (+105) degrees Fahrenheit.

E. Vibration:

Note to specifier: The Owner should be aware that this sophisticated FFT requirement is recommended for future preventative maintenance efforts.

1. Vibration: Escalator shall be tested for vibration levels. A maximum velocity reading of four-tenths (0.4) of an inch per second root mean square (RMS) shall not be exceeded. The metering device used to perform the test shall be a Fast Fourier Transform (FFT) analyzer.

Where specified bearing housings shall be provided with a drilled, tapped and spot faced area in the vertical and axial axis accommodate a transducer that FFT analyzer requires. Permanently mount transducers on the drive bearings and run the wires into the controller to a panel with BNC connectors on the ends to accommodate the FFT analyzer.

2. Bearings shall be rated for an AFBMA L10 life as required in the duty cycle specified. All bearings shall have basic dynamic load ratings.

F. Fire Protection

Escalators shall be constructed of noncombustible materials as defined in ASTM A 136 throughout, with the exception of, handrails, handrail rollers, chain step wheels, and electrical equipment, Handrails shall have a flame spread rating of seventy-six (76) to two hundred (200), when tested in accordance with ASTM E 84.

1.06 JOB CONDITIONS

- A. Protection: During installations, and until escalator systems are fully operative, contractor shall make necessary provisions to protect systems from damage, deterioration, and environmental conditions.

Note to specifier: if the escalator is completed prior to station revenue, special care must be taken to protect the escalator from damage during the remainder of construction at the site.

B. Coordination Requirements

1. Alterations: Installer shall coordinate any alterations required to accommodate escalators with the Owner.
2. Cladding: Installer shall review all appropriate contract drawings dealing with proposed methods of securing cladding to truss. Installer shall coordinate with other appropriate contractors prior to any such actual work.
3. Floor finish at landing plates and newels: Installer shall coordinate with other appropriate contractors and/or trades.
4. Escalator pit heating and ventilation: Installer shall install heaters and ventilating fans where required.
5. Lock and key requirements: Installer shall coordinate with the Owner.
6. Pit Drainage: Provide a means to prevent water from accumulating in the pit for outdoor escalators and indoor escalators subject to ground water or station wash downs.
7. Rigging Plan: Installer shall supply a rigging plan that is approved by the Owner.
8. Safety Training: Installer shall attend appropriate safety training programs provided by the Owner at no extra cost.
9. As-Built Drawings: Installer is responsible to provide revised contract drawings to reflect the actual as-built condition including all structural, architectural, electrical, mechanical and plumbing connections to the escalators.
10. Methodology: The Installer shall meet with the Owner and provide a written method of installation for approval.

1.07 QUALITY ASSURANCE

- A. Regulatory agencies: escalator design, materials, construction clearances, workmanship, and tests shall conform to the requirements of the codes and regulations listed in part 1.04, APPLICABLE CODES, STANDARDS, AND PUBLICATIONS.
- B. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
- C. Dimensions
 - 1. Each escalator shall be forty (40) inch (1000mm), or thirty-two (32) inch (800mm) nominal step width as specified and designed for a maximum of 30 degrees.

Comment: ADA prohibits 24 inch wide steps in below ground Transportation applications. However, there may be certain structural impediments when installing a new escalator in an existing wellway or station that may require an escalator with a 24-inch step. Also note that 40 inch wide steps are preferred to permit two lanes of pedestrian travel on the escalator, allowing fast moving pedestrians to walk by standing pedestrians on the escalator steps.

- 2. Structural dimension requirements:
 - a. Installer shall design and fabricate escalators to fit within dimensions shown on contract drawings.
 - b. Installer shall verify dimensions of wellways prior to manufacturing trusses.
 - 3. In the event of a discrepancy, Installer shall notify the Owner immediately and shall not proceed with installation in the areas of discrepancy until the discrepancy has been fully resolved and the Owner has instructed Installer to proceed. Failure of Installer to report discrepancies shall constitute an acceptance of existing work as fit and proper for the execution and completion of Installer's work.
- D. Labeling: Every escalator shall be clearly marked permanently on the controller with rated load and speed, braking torque, manufacture serial number, manufactured date, and the designated Owner identification. Duplicate data plates for all motors, brakes and switches shall be mounted and labeled on the inside of the escalator controller.
- E. Requirements of Regulatory Agencies
 - 2. Installer shall obtain and pay for all necessary permits, and perform such tests as may be required for acceptance and approval of escalators by jurisdictional agencies.
 - 3. Installer shall notify the proper inspectors to witness required testing.

Note to specifier: The following section may be appropriate in order to inspect and observe construction methods that would be difficult or impossible to observe after installation is complete.

F. Factory Visit

1. The contractor shall provide for the costs of up to three of the owner's representatives to visit the factory where the escalator is being manufactured.
2. The escalator shall be tested with the controller to be shipped with the escalator. The operating Owner shall observe the steps and chain in operation and to test selected devices.
3. The Installer shall not ship the escalator without the approval of the Owner after the conclusion of the factory visit.

1.08 SUBMITTALS

A. Shop drawings:

1. The Installer shall provide six (6) copies of the shop drawings.
2. Drawings shall include but not be limited to:
 - a. Facsimile outline of escalator truss in profile and plan
 - b. Facsimile elevation of escalator balustrade
 - c. Vertical section through balustrade
 - d. Truss midway between working points
3. Drawings shall show:
 - a. truss stanchion
 - b. track system and supports
 - c. drive system
 - d. step nosing radius at upper and lower ends
 - e. drive chains and gear train
 - f. step chain or step links (including chain pitch, step, and trailer wheels)
 - g. step assembly (including axle, step tread, frame, and riser)
 - h. handrail system (including profile, guides, drive, and tension device)
 - i. support details (including upper, lower, intermediate, and slip joint), balustrade deck cover, interior panels, skirt panels, and their moldings
 - j. safety switches and operating devices
 - k. motor and emergency brakes
 - l. floor plates
 - m. speed governor
 - n. metal gauges

- o. radial, vertical, and horizontal dimensions required for manufacture, and positions of lower and upper working points
 - p. attachment of truss to structure
 - q. major mechanical and electrical components within truss
 - r. drainage and electrical interfaces
 - s. hand and finger guards
 - t. ceiling intersection guards
 - u. passenger instruction signs
 - v. emergency stop button
 - w. operating panel in upper and lower balustrades (including stop button, start and direction selection switches, and fault finder receptacle)
4. All bearing ratings, identification and catalog numbers shall be provided.
5. A complete schematic diagram shall be provided for the controller and all electrical devices.
6. Test certificates for step chain shall be provided for approval.

Comment: the specifier should stipulate a time frame from Notice to Proceed to obtain these drawings.

B. As built drawings

1. Shall be submitted for the following: Drawings shall show truss stanchion; track system and supports; drive system; step nosing radius at upper and lower ends; drive chains and gear train; step chain or step links (including chain pitch, step, and trailer wheels); step assembly (including axle, step tread, frame, and riser); handrail system (including profile, guides, drive, and tension device); support details (including upper, lower, intermediate, and slip joint), balustrade deck cover, interior panels, skirt panels, and their moldings; safety switches and operating devices; motor and emergency brakes; floor plates; speed governor; metal gauges; radial, vertical, and horizontal dimensions required for manufacture, and positions of lower and upper working points; attachment of truss to structure; major mechanical and electrical components within truss; drainage and electrical interfaces; hand and finger guards; ceiling intersection guards; passenger instruction signs; emergency stop button; and operating panel in upper and lower balustrades (including stop button, start and direction selection switches, and fault finder receptacle).

- C. Maintenance programs: within sixty (60) days after notice to proceed, and prior to installation, Installer shall submit detailed interim and revenue service maintenance programs, showing functions to be performed and their scheduled frequency.

Note to specifier: Due to the critical nature of O&M manuals, it is recommended that this item be itemized in the project schedule of values.

- D. Operating and Maintenance manuals: Prior to installation, Installer shall submit

six (6) draft sets of Operation and Maintenance manuals for approval: After Owner approval and prior to the beginning of acceptance testing, two (2) sets of the approved manuals shall be provided by the Installer. The manuals shall include the following:

1. Complete table of contents.
 2. Complete instructions regarding operation and maintenance of equipment, including disassembly and assembly of drive system, handrail drive assembly, and track system. Included will be complete illustrated, exploded views of all assemblies, and a complete, illustrated, exploded view for identifying all system parts.
 3. Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Installer shall include name and address of other vendor.
 4. Sample copies of a preventive maintenance chart.
 5. Descriptions of safety devices.
 6. Safety rules, tests, and procedures, including testing of all systems and subsystems.
 7. Procedures for adjusting brake, handrail tension, handrail chain drive tension, step chain tension, track system, and mechanical components, including pictorials.
 8. Instructions for removing floor plate, replacing comb segments, and removing and installing steps, and interior panels.
 9. Troubleshooting techniques.
 10. Detailed lubrication and cleaning schedule indicating weekly, monthly, quarterly, semiannual, and annual lubrication; and a description of each lubrication point, lubrication type, and specification.
 11. Control and schematic electrical wiring diagrams of controller, including wiring of safety devices to connections with remote indication and control panels for each escalator and group of escalators.
 12. Electrical layout showing placement of lighting, light switches, receptacles, light fixtures, disconnect switches, and convenience outlets in machinery room, truss envelope, and pits.
 13. Complete detailed drawings and wiring diagram of escalator fault finding device and connection to annunciator panel.
 14. Provide all material on CD-ROM in a format approved by the Owner.
- E. Documentation: The referenced material shall be provided within thirty (30) days of publication or internal distribution of any safety related updates or changes to the equipment provided in this contract. The material, even if labeled PROPRIETARY, shall be delivered to the Owner without prejudice or delay and at no additional cost.
- F. MSDS and product data sheets: Shall be submitted with an index listing each product, along with the application method of the product, approximate quantity of product per escalator, and the component the product is applied to or associated with. The Installer shall allow 6 (six) weeks for review of MSDS.

- G. The training syllabus shall be submitted within 60 days of the NTP.

1.10 TRAINING

Note to specifier: Properties with a 3rd party maintenance Contractor should not require as much time and training by the Contractor and can be reduced to 8 hours. Special consideration to itemizing training on the project schedule of values.

Owner maintained facilities may want to consider specifying a custom training video specific to the equipment in this procurement. Be aware that there is a significant cost involved to produce a professional video.

The Installer will provide 40 hours of local training for the Owner and his representatives in the proper use, operations, and daily maintenance of escalators. Review emergency provisions, including emergency access and procedures to be followed at the time of failure in operation and other building emergencies. Train Owner personnel in normal procedures to be followed in checking for sources of operational failures or malfunctions. Provide manuals for all material covered in the training program. This training will take place at the discretion of the Owner at any time prior to the end of the warranty period.

1.11 WARRANTY

- A. The acceptance is conditional on the understanding that their warranty covers defective material and workmanship. The warranty period shall be one (1) year from the date of Beneficial Use. The warranty excludes ordinary wear and tear or improper use, vandalism, abuse, misuse, or neglect or any other causes beyond the control of the Escalator Contractor and this express warranty is in lieu of all other warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose.

Note to specifier: Consider adding time to the warranty period if special circumstances warrant.

PART 2 PRODUCTS

2.01 GENERAL

- A. Installer shall furnish and install escalators that shall comply with the following requirements:
1. All escalators supplied under this contract shall be the products of a single manufacturer.
- B. Escalators shall comply with the following requirements:
1. Vertical Rise As Shown On Contract Drawings

Note to specifier: Consider 27 degree escalators for very high rise escalators, generally over 10m.

- 2. Inclination not to exceed 30 Degrees
- 3. Nominal Step Width 1000mm (40 in.) or 800mm (32 in)
- 4. Speed not to exceed 100 FPM <10m rise
- 5. Flat Steps 3 minimum <10m (32' 10") rise
4 minimum >10m (32' 10") rise

Note to specifier: Existing structural conditions often prohibit installations of escalators with more than 3 flat steps. Note that code minimum is 2 flat steps at both landings.

Note that the flat step requirements does not mean that the escalator will have 3 flat steps simultaneously at both ends.

- 6. Maintenance Speed No greater than 25% of rated speed.
- 7. Upper track radius <10m: 2.6m (8' 6 ") >10m (32'10") rise,
CONSIDER LARGER RADIUS
- 8. Lower track radius 2.0m (6' 6 3/4")

Note to specifier: Existing structural conditions often make difficult to installation escalators with a radius as recommended here. Every effort should be made to obtain the largest radius possible when planning a new escalator installation.

- 9. Static Brake Load (the load per step the total number of exposed steps on the incline):
 - a. 1000mm step: 306 kg (674lbs)
 - b. 800mm step: 245 kg (540lbs)
- 10. Dynamic Brake Load: The load per step running in down direction on exposed steps on the incline.
 - a. 1000mm step: 145 kg (320lbs)
 - b. 800mm step: 116 kg (256lbs)
- 11. Motor Duty Load: Continuous operations with a minimum step load per step (on incline only) as follows:
 - a. 1000mm step: 145 kg (320lbs)
 - b. 800mm step: 116 kg (256lbs)
- 12. Step Chain Load: Is to be based on the step loads as follows:
 - a. 1000mm step: 145 kg (320lbs)
 - b. 800mm step: 116 kg (256lbs)

C. Controls and safety devices

1. Operating controls:

- a. Escalators shall have key operated switches, accessible at both upper and lower landings, located on the exterior deck above the newel base. Alternate locations may be used subject to approval by the Owner.
- b. Each keyed switch shall be clearly and permanently labeled, including starting and direction selection.
- c. Interlocks shall be provided to bring the escalator to a smooth stop, in either direction of travel, before a change of direction may be made.

2. Safety Devices:

- a. Safety devices include but are not limited to those which are required by the edition of ASME A17.1 in effect for this installation.
- b. A lockable stop switch or disconnect shall be provided in both pits of escalators.
- c. A switch to prevent operation of the escalator if any part of the floor plate is not in place. This shall not be a manual reset device.

D. Balustrades, skirt panels, and decking

Note to specifier: If a the escalator must be resistant to salt and dust (presumably containing corrosive pollutants) and there are humidity levels of 45% or above, Type 304 can start to corrode at least superficially. It is presumed that all of the escalators will be in sheltered locations, which are exposed to the atmosphere. Sheltered areas are far more aggressive environments than exposed locations. In urban locations with moderate to high pollution, industrial areas within 10 miles of a large salt water body, where deicing salt is used, or where exposure to urine is likely, Type 316 with a smooth (no rougher than Ra 20 micro-inches or 0.5 microns) should be used. In urban areas with high pollution levels or industrial areas with moderate to high pollution, the Type 316 should be cleaned at least quarterly to remove pollutants or if cleaning is not likely, a higher grade of stainless steel should be used such as 317L, 317 LMN, or 904L. Type 304, with the same surface roughness restriction, should only be considered in rural areas and low pollution urban areas where there is no possibility of salt or urine exposure. This is suggested based on the assumption that no staining of the surface is desired.

1. Balustrades and skirt panels:

- a. Panels shall be a minimum of 3mm solid type 316 stainless steel. Backing panels, where used, shall be noncombustible and subject to Owner approval.
- b. Panels shall be constructed, when practical, in equal lengths for interchangeability.
- c. Panels shall be attached to permit easy removal for inspection, lubrication, and adjustment of safety devices.
- d. Panels shall be sized so that not more than two (2) persons shall be required to remove a panel and without the aid of special handling equipment.
- e. Exposed panel fastener requirements (where used): Panels shall be fastened to their respective supports or mating portions with

- tamper-proof, flathead machine screws.
- f. When framework to which panels are fastened is less than one quarter (1/4) of an inch thick, steel backup plates with a minimum one quarter (1/4) of an inch thickness shall be added which have tapped holes or clearance holes where necessary.

Note to specifier: Escalator cladding consists of enclosing the sides and bottom of the escalator, typically with 2mm stainless steel #4 finish. It is typically performed by an ornamental metals contractor. It is critical to ensure that this work is specified in the appropriate section, even if only for the newel ends that may be exposed.

2. Decking shall be a minimum of 2mm thick solid type 316 stainless steel, identical in finish to balustrade.
3. Decking between escalators shall be designed to support a live load of one hundred and seventy-five (175) pounds per square foot, without permanent deformation.
4. Paneling, decking, and other enclosures shall be supported on steel frame.

E. Electrical Equipment

1. Motors: The driving motors shall be AC induction motors with starters. Voltage 480 V.A.C., 3 phase, Frequency 60 Hertz.

Note to specifier: Other motor voltages are permitted where different voltage is present.

- a. The motors shall be totally enclosed with external cooling fins.
- b. The motor protection class shall be equivalent to. IP 55 Insulation group: F.
- c. Driving motors and motor switch gear shall provide a smooth start.

2. Controller

- a. The escalator control equipment shall contain diagnostic capabilities as required for the ease of complete maintenance. The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controls. All such systems shall be free from decaying circuits that must be periodically reprogrammed by the manufacturer.
- b. Switch gear shall be mounted in NEMA 4X cabinets with strip heaters and labeled terminal strips.
- c. The main controller shall use an Allen Bradley control Logix® Programmable Logic Controller (PLC) or approved equal, to control and monitor the status of the escalator. The PLC shall be designed to communicate over Ethernet or approved equal.
- d. The PLC racks shall provide space for two (2) future single-slot modules.
- e. The PLC in the remote control panel shall also have hardware and firmware provisions to communicate with interactive operator interface (monitor).
- f. The PLC shall store the last 99 faults, accessible via laptop connection, panel view or remote communications.
- g. Provide a copy of all working programs on approved computer

- medium as well as a printed program listing.
- h. The Programmable Controller shall have one dedicated serial port, which supports RS-232-C signals. It shall be accessible in ladder logic and provide support for Point to Point and Slave SCADA communication protocol systems. Alternatively, it must be usable for programming purposes or for access to remote programmers via modems.
3. The main control switchgear of an escalator shall contain at least the following devices:
- a. Lockable main switch thermal and magnetic motor protection starter for up and down travel, hour counter, auxiliary contactors, phase failure device, phase sequence monitor, and ground fault monitor.
 - b. The controller cabinet shall contain a permanently mounted full color view panel capable of providing fault and operating data. The panel shall be Panelview 600® or approved equal.
 - c. The indication shall be locked automatically. Reset shall be done by a separate switch installed in the controller. The emergency stop shall not be locked.
 - d. All terminals shall have identification markings and all cables shall be provided with cable markers.
 - e. The controller shall be equipped with an AC induction motor reduced voltage starter; installed in line between the standard type contactor and the drive motor. The starter shall be solid state, capable of starting motors smoothly and gradually, reducing inrush current and mechanical shock upon start up. Adjustable settings for accelerating time and starting torque shall be provided. The starter shall also contain auxiliary contacts and a thermal overload relay for motor protection.
 - f. Maintenance Receptacles: Electric power receptacles shall be furnished and installed in the upper and lower pits. Each receptacle shall be of the GFCI duplex type, waterproof, grounded, and rated for one hundred and twenty (120) volts at twenty (20) amperes. The receptacles in the pits shall be surface mounted on the walls, not less than thirty (30) inches from the floor.
 - g. Relays shall be provided with visual indication that they are energized.
 - h. Adjustable settings for accelerating time and starting torque shall be provided. The starter shall also contain auxiliary contacts and a thermal overload relay for motor protection.
 - i. Controllers in escalator pits shall have a flexible liquid tight connection or suitable length to permit removal for maintenance purposes.

3. . Truss Wiring and Conduit

- A. Galvanized rigid pipe shall be used in the truss. Liquid tight flexible metal conduit up to six feet in length shall be permitted.

Note to specifier: When using a maintenance drive, be aware of the consequences of using a variable frequency drive to accomplish this. Different requirements for overspeed, grounding and electrical noise protection must be considered.

- F. Maintenance Drive Unit: Means shall be provided for reduced speed maintenance operation that shall be controlled by a pendant type, portable inspection control. This device shall be stored in the upper pit of every escalator provided in this contract. When operated, the escalator shall run in the direction selected, at a speed of not more than 25% of rated speed. This speed shall be maintained when steps are removed for servicing. Escalator operation shall be continuous so long as an up or down button on the handset is being pressed. The cord length shall not exceed 10 feet.. When plugged into receptacle, there shall be no means of operating or running the escalator except by the inspection control. Receptacles shall be located in both the upper and lower pits.

2.02 MATERIALS

A. Stainless steel

1. Shapes and bars: ASTM A-276, type 304 or 316, A-554 for tubes.
2. Plate, sheet, and strip ASTM A-240. Type 304 for interior installations for 316 for exterior installations.

B. Fasteners

1. Fasteners shall be compatible with materials being fastened. Fasteners shall be furnished with self locking nuts or retaining rings (spring washers, toothed disks).
2. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

2.03 FINISHES

A. Stainless Steel: No. 4 finish ASTM A-480

B. Aluminum Castings and Extrusions: Commercial mill finish:

C. Galvanizing

1. Sheet Steel: ASTM A446, or A526, as applicable. Coating designation G185.
2. Other galvanizing ASTM A123, AS1M A 153, ASTM A 385, or ASTM A 386, as applicable.

D. Galvanizing Touch Up: Zinc dust coating, MIL-P-21035 or MIL-P-26915.

E. Paint and Corrosion Protection. Each escalator shall have the following minimum corrosion protection:

1. After welding, the truss shall be hot dipped galvanized with a coating in accordance with ASTM A90. A 100% zinc thermal spray coating to ASNI/AWS C.18-93 is an acceptable alternative.
2. Cast metal parts such as gear housings, chain sprockets and return station half circles, shall be painted with a rust inhibitor primer coat after preparation by sandblasting.
3. Steel parts which are not specified to be galvanized shall be painted as follows:
 - a. Primer coat two (2) mil (dry film thickness), minimum thickness.
 - b. Second finish coat two (2) mil (dry film thickness), minimum thickness.
4. Bright or uncoated axles, shafts, etc., shall be protected by zinc chromate or chrome plating.
5. Oil collector chutes and collection trays shall be fabricated of galvanized steel.

2.04 MECHANICAL EQUIPMENT

A. Tracks

1. Fabrication of tracks shall retain steps and running gear safely under load requirements and at the highest speed specified.
2. Installer shall assemble and secure sections of track together for easy removal and replacement of defective sections. The system shall be adjustable, and welding of the track sections is not acceptable.
3. Design of the mechanical components shall provide for easy installation and removal without the dismantling of parts of the structure.
4. Tracks shall be properly supported on trusses to provide correct alignment and smooth transition to return stations. The rolling surface of the track shall be a minimum thickness of 3mm.
5. The guiding system for the step chains and step wheels shall be of zinc plated or galvanized steel profiles with smooth and even running surfaces and with the joints cut diagonally to the running direction. The guide profiles shall not be welded together at the joints.
6. A second, continuous guiding profile shall be provided above the step chain rollers so that the step chains are positively guided in the area of the escalator open to passengers.

Note to Specifier: the APTA EETF recommends following the most up to date version of A17.1-d 2000 for optimum safety regarding step to skirt gaps. However, careful coordination with the local jurisdictional Owner is recommended since there are potential conflicts with previous versions of A17.1.

B. Steps

1. The step to skirt gap shall comply with the requirements of ASME A17.1-d 2000 regardless of any previous version of ASME A17.1 in effect.
2. The entire step assembly shall be unpainted natural aluminum finish or treated with not less than one (1) coat of zinc chromate primer or iron phosphate and one (1) coat of powder coated enamel for corrosion resistance.
3. Steps and their various attachments shall permit removal of steps without disturbing balustrades.
4. The design shall permit the running of the drive without steps for convenience in cleaning and inspection.
5. Step rollers shall have polyurethane tires on hubs, sealed roller bearings, and a diameter of no less than four (4) inches. Step rollers shall not require any additional lubrication and must be rated for severe, heavy-duty service.
6. Steps shall be constructed so as to be driven by step linkages to step or step rollers.
7. Washers and nuts shall be provided as follows:
 - a. Tap bolts: Lock washers
 - b. Through bolts: Lock nuts or Owner approved equal
8. Rated Loads:
 - a. In addition to the minimum requirements given in the Codes, Installer shall design the Steps for a minimum load of three hundred and twenty (320) lbs. (140 Kg) per forty (40) inch step or two hundred and fifty six (256) lbs. (112 Kg) per thirty two (32) inch step with an ultimate strength safety factor of eight (8).
 - b. The steps shall carry the load under maximum concentric and eccentric loading conditions without failure.
 - c. Die cast aluminum steps shall not have more than 0.3% copper content.
 - d. (Optional) Installer shall perform dynamic testing, witnessed by Owner representatives if requested, at the Installer's expense to verify the structural strength and serviceability requirements.

Note to specifier: Low lubrication chains are becoming available in the U.S. market. The APTA working group does not have sufficient experience with these new chains to provide a complete set of recommendations. Owners interested in these types of chains should research appropriate sources for their application.

C. Step Chain

1. Chain shall be endless, roller-type step chains with one (1) on each side of step.
2. Step chains shall be of heat-treated steel construction, supported at intervals by linkage wheels.
3. A means to prevent steps from coming into physical contact with each other and to prevent chains from sagging or buckling shall be provided.
4. A means to maintain constant distance between step axles shall be provided.
5. An automatic tensioning device to maintain tension under load and to compensate for wear shall be provided. The device shall be located within the truss at the lower end.
6. A means for individual fine adjustment of tension for each linkage shall be provided.
7. Step chains shall be constructed to permit removal of segments as may be required for replacement purposes at a minimum of every 6-axle section. Each escalator shall have at least two one-axle sections.
8. Support wheels spaced to distribute load and to guide linkage throughout run shall be provided. Rollers shall be constructed of polyurethane material, with diameter sufficient to provide reliability, maintainability, smoothness of motion, and to operate within noise level requirements specified. The chain rollers shall have polyurethane tires on metallic hubs, sealed bearings, a diameter of not less than four (4) inches, must require no additional lubrication, and be mounted outside the chain link.
9. Wheels shall be affixed to permit rapid replacement.
10. Each pair of step chains shall be a matched set within manufacturing tolerances. Only precision, rollerfishplate chains of high-grade heat-treated steel shall be used as step chains. The pins, axles, bushing, and rollers shall be hardened and ground.
11. Step chain and chain pins shall have a minimal diameter of at least five-eighths (5/8) of an inch. In addition, the diameter will be of a size so that the surface pressure at engaging points will not exceed 30N/mm²

(3,450 p.s.i.). This is to be based on the step loads as follows:

12. The safety factor shall be 6.
13. A test certificate for the chain-breaking load shall be provided.
14. A shielding device shall be provided to protect chain, track guides, and rollers against water, dirt, and debris.

D. Combplate Assemblies

1. Complete assemblies of wear resisting, non-corrosive metal material with exposed anti-slip surfaces shall be fabricated.
2. Combplate sections meeting the following requirements shall be provided:
 - a. Shall be removable to permit ease of replacement.
 - b. Shall be yellow in color for safety/demarcation.
 - c. d.Provisions for lateral and vertical fine adjustments shall be provided so that cleats of step treads pass between combteeth with minimum clearances.

E. Floor Plates

1. Shall have 316 stainless steel frames at floor openings, designed to be supported on truss heads.
2. Shall be designed to cover entire area of upper and lower landings.
3. Shall be reinforced, as necessary, to be rigid and able to withstand a live load of two hundred and fifty (250) pounds per square foot with zero permanent deformation.
4. Shall be extruded or die cast aluminum in a ribbed pattern transverse to the escalator axis. Ribs shall be designed to provide maximum traction, and will be finished in the same manner as the combplates.
5. Shall have exposed portions constructed of material and finish to harmonize with steps and combplates.

F. Drive Machinery

Note to specifier: The drive may be located within the truss for most applications. Where very high rise escalators require larger HP motors, or if the client prefers to work on machinery while the escalators are being used as stairs, you can select a drive outside the truss envelope. Be prepared for a cost increase of about 300% for the entire installation as well as additional general construction costs to build and maintain the new room to locate the drive. Select one:

1. Motor and drive mechanism shall be mounted within the truss envelope at the upper end. Shafts shall be designed for ease of assembly or disassembly.
2. Motor and drive mechanism shall be mounted outside the truss envelope in the upper head section. The drive shall be securely fastened to a bedplate and have chain guards provided around the drive chains. Shafts

3. Gear Box Requirements.

- a. Gear bearings shall be rated with an AFBMA L10 life of 200,000 hours and housed in an oil tight, dust proof case. The case shall provide a convenient method of draining the oil.
 - b. Use synthetic lubricants, subject to Owner approval, are used.
 - c. The assembly shall have no openings in order to minimize accumulation of dust and debris.
 - d. Rotating parts shall be provided with a means for lubrication and retention of lubricants.
 - e. Sealed bearings shall be used in those environmental conditions where entry of water or dust may adversely affect bearing performance.
 - f. Exposed, moving, drive elements shall be protected by sealed metal housings, which shall provide continuous lubrication to components.
 - g. Provide a low oil sensor to prohibit starting of the escalator on automatic operation with low oil in the gearcase.
4. V-belt and tooth belt drives shall not be considered acceptable. If chain drives are used, they shall be protected against dirt and water by sealed housings, and shall have an automatic lubricating device and a means of taking up any slack in the chain.
 5. Main drive bearings shall be rated for AFBMA L10, 200,000 hours.

G. Drip Pans

1. Galvanized, 3mm steel, watertight drip pans for the entire length and width of trusses shall be provided. They shall also be sloped for proper drainage and collection of spent lubricants as well as any moisture or water, which may enter the escalator. They shall be constructed to prevent oil from leaking below the truss.
2. Drip pans of sufficient size to collect and maintain, within truss areas, oil and grease drippings from step linkage and all forms of loose debris that

maybe deposited in drip pans from steps at turn around points at upper and lower portions of truss shall be provided. This system shall be separate from the water drain in order to prevent the discharge of spent lubricants into sewer system.

3. Access to drip pans at lower landings of escalators for the purpose of cleaning drain catch basins shall be provided.

H. Handrails:

1. General

- a. Handrails shall receive their motion from main escalator drive through direct gearing and drive shaft or drive chains, so that handrail and steps operate at the same speed in each direction of travel. Driving and guiding wheels shall have a groove to accept the wedge on the underside of the handrail. The handrail shall have a V-shape wedge.
- b. A means to take up handrail slack using a tensioning device, where required, shall be located within escalators. In addition, an approved method of releasing the device for repair or removal of handrails shall be provided pre tensioning of handrail shall be considered unacceptable.
- c. Newels meeting the following requirements shall be provided:
 - 1) Newels shall be designed and constructed so that handrail shall return into newel end at a point inconspicuous and difficult for passengers to reach.
 - 2) Newel sheaves shall be provided at upper and lower newels.
 - 3) Handrails, handrail drive system, and guides shall be so designed and installed that handrail cannot be thrown off or disengaged while running, and special design attention shall be given to area where handrail passes from drive system to guides.
 - 4) Handrail rollers shall have sealed bearings rated at AFBMA L10, 100,000 hours and have provision for retention of lubricant to ensure satisfactory lubrication and operation. Additional lubrication shall not be required.
 - 5) Friction drive sheaves and idlers shall be designed and positioned so that lubricant cannot reach surface of handrail. Marking and spotting of handrail by drive equipment shall not be permitted. Provide sealed bearings rated at AFBMA L10, 100,000 hours.
 - 6) Handrail shall be a composite of either vulcanized rubber or approved equal with a synthetic fabric slider and shall be constructed with a steel cable tension member providing a minimum strength of 25kN over the splice area.

- 7) Handrail guides shall be continuous on exposed portion of handrails, constructed of 316 stainless steel which shall not subject to corrosion nor pitting, and shall have a polished or specially coated, permanent finish to minimize frictional wear to under surface of handrail. On the unexposed portion, guiding shall be by adjustable rollers having sealed bearings, and set in a way so as not to cause wear on the handrail.
- 8) Handrail gearbox, if provided, shall have bearings rated at AFBMA L10, 200,000 hours.

I. Braking Requirements

1. Motor Brake

- a. Brake shall be capable of stopping and holding a descending escalator with a load on the exposed steps in the incline area of:
 - 1) 1000mm wide step 145kg (320 lbs.) Per step
 - 2) *00mm wide step 116kg (256 lbs.) Per step
- b. The brake coil shall be insulated to class F.
- c. A monitor shall be provided, and if brake lining becomes insufficient for safe usage, restart of escalator shall be prevented.

2. Step Band Lock

- a. Shall be manually applied and mechanically engaged to prevent movement of linkages, while escalator is disconnected from its power supply.
- b. Electrical interlock that shall prevent escalator drive motors from starting while step band lock is engaged shall be provided.

J. Trusses

1. General

- a. The deflection of the loaded truss shall not exceed one thousandth (1/1000) of the span under a live load of 320 pounds per 40 inch step and 256 pounds per 32 inch step.
- b. The slip joint slide bearings shall not use grease for lubrication.
- c. Provide a permanent identification on the truss for the centerline at both ends of the escalator and in both transition curves.
- d. No intermediate supports are permitted for spans less than 50 feet.

Note to specifier: local conditions may require the use of an intermediate support at lower spans than what are in these guidelines. Close coordination with the structural engineer is advised for these circumstances.

2. Field Splices, Connections and shims
 - a. Field splices shall be rigid, non deforming, and shall maintain alignment.
 - b. Field modification shall not compromise the paint and corrosion protection specified in section 2.03.B.10.
 - c. Shims shall be 316 stainless steel with a maximum shim height of 2 inches.

Note to specifier: define clearly who is to provide cladding on the escalator truss. Coordination with the OEM on weight and fastening methods is essential. Generally, welding and drilling into the escalator truss should be avoided. Coordinate with the OEM to determine truss cladding installation methods to minimize impact on the truss integrity. If access is desired into the truss with an access panel, we recommend coordination with the OEM.

K. Step Chain Tensioning Device

1. The step chain tensioning device shall be of a design that keeps the step chains at the correct tension.
2. A pointer and scale shall be provided to gauge step chain tensioning and wear.
3. Bearings, if used, shall be rated: AFBMA L10, 200,000.

L. Lubrication System Requirements

1. Step Chain:
 - a. All parts, other than sealed items, requiring lubrication shall be designed for an automatic or remote lubricating system, The system shall operate only when escalator is running and the amount of lubrication shall be fully adjustable. A reservoir with a low oil signal to the controller, and a minimum capacity of two and one-half (2 1/2) gallons shall be provided.
 - b. System shall be positive acting, located in escalator pit.
 - c. Reservoir level indications shall be provided where lubricants are contained within housings, supply tanks and larger filler cups.
 - d. Electric heaters installed and connected to panel shall be employed to maintain lubricant viscosity where required.
2. Miscellaneous Lubrication:
 - a. Installer shall furnish and mount on the controller cabinet a laminated lubrication chart for each escalator. The chart shall show the location of each lubrication point, type of lubricant to be used, and the frequency of lubrication.

b. Bearings

- 1) Sealed bearings shall be used where possible.
 - 2) Bearings requiring manual lubrication shall be furnished with fittings to accommodate the use of a pressure gun for lubrication.
 - 3) Self lubricating bearings or material other than ball or roller type
3. Manual Lubrication:
- a. Location of manual lubrication points shall be easily accessible and available.

M. Indicators

1. Escalator users shall be informed by means of indicator lights of the predetermined running direction of the escalator.
2. Two (2) circular cut outs, minimum diameter two and three quarter (2 $\frac{3}{4}$ ") inches. Shall be provided in the upper and lower right hand balustrade newels, each containing an inset red and green light. The green light shall be illuminated at the entrance for escalator running direction and the red lamp shall have a horizontal white stripe and shall be illuminated at the exiting end. No incandescent lamps shall be permitted.

N. OPTIONAL: Room Storage Cabinet

1. A metal cabinet of not less than twenty (20) cubic feet in volume (52 inches high x 36 inches wide x 18 inches deep) shall be provided in a room assigned by the Owner.
2. Cabinet shall have lockable doors and be mounted on legs or a pedestal, a minimum of four (4) inches off the floor.
3. Cabinet shall be painted and marked for control purposes, as directed by the Owner, and Installer shall store small parts, supplies, tools and other materials within.

O. Lock Cylinders

1. All locks and keys shall be as per Owner approval.
 - a) Owner shall verify with the Installer that the requirements for hardware have not been amended or superseded.
 - b) Installer shall provide the Owner with length, finish, and camming requirements of each cylinder required.

- P. Demarcation Lights
 - 1. Shall be U.L. labeled suitable for wet locations.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installer shall install complete and operating escalators in accordance with manufacturer's instruction and approved shop drawings.
- B. Installer shall install special tools in the room storage cabinet as specified in part 2.04.

3.02 FIELD TESTING:

- A. General
 - 1. Installer shall notify the Owner seven (7) days prior to each scheduled test. Installer shall perform testing in the presence of an Owner representative.
 - 2. Installer shall notify the appropriate local authorities having jurisdiction a minimum of seven (7) days in advance of final acceptance tests.
 - 3. Installer shall provide all instruments, materials, and labor required for tests specified herein.
- B. Acceptance Testing Requirements
 - 1. Testing shall be performed in accordance with ASME A17.2.3 procedures with the following additions or adaptations.
 - 2. Installer shall perform the following tests on each escalator without load:
 - a. Comb impact device shall be tested and calibrated with an appropriate scale at both ends of the escalator in both the horizontal and vertical direction.
 - b. Brakes: Measure deceleration rate with no load over 5 consecutive stops in the down direction using test equipment designed to obtain this information.
 - c. *(Use only if sound requirements of 1.05 are specified)* Escalator shall produce no noise louder than sixty five (65) decibels measured five (5) feet above the floor or stair level at the entrance combs at both ends with the escalator operating normally, either free running or under load. For multiple escalator installations, the noise measurement at each group shall be made with only the one (1) escalator unit under evaluation in operation. Ambient noise level shall not exceed forty-nine (49) decibels.

- d. *(Use only if vibration requirements of 1.05 are specified)* Escalator shall be tested to meet vibration requirements of section 1.05. The meter and the method shall be identical for all tests.
3. Installer shall perform the following tests on each escalator under full load:
 - a. Each escalator shall have a full load as specified in 2.01.B. 10 dynamic brake test performed on it. The stopping distance in the down direction shall meet all requirements of ASME A17.1.
 - b. Forty four hour test: The escalator shall operate continuously for 40 hours after the acceptance test with no faults. If any fault occurs that shuts the escalator down, the fault must be corrected and a new 40 hour test will begin
 4. If either the no load or full load brake tests fail, both tests must be repeated with the same torque setting on the brake.