HAWAII ADMINISTRATIVE RULES

TITLE 12 DEPARTMENT OF LABOR AND INDUSTRIAL RELATIONS

SUBTITLE 8

DIVISION OF OCCUPATIONAL SAFETY AND HEALTH

CHAPTER 233

AERIAL PASSENGER TRAMWAYS

Historical Note: Chapter 233 to title 12 is based upon chapter 362 of the Hawaii Occupational Safety and Health Standards, Rules and Regulations. [Eff. 7/11/74; am 8/22/77; R 12/19/83]

§12-233-1 Definitions. As used in this chapter:

"Chair attachment" means the method of or the device for securing the chair hanger to the rope;

"Diameter" means tread diameter when used in specifying sheaves, wheels, or pulleys;

"Drive sheave" or "Bull-wheel" means the main drive sheave, the tread diameter or which will range from 3 to 14 feet depending upon the type of installation;

"Federal Specification RR-W-410c" means Federal Specification RR-W-410c, cartridge 4227, frame 0877, Military Specifications and Standards, September 18, 1968;

"Rated capacity" means the capacity established by the designer of the equipment;

"Rollers" means sheaves of small tread diameter, often used to guide the cable or restrain it from leaving its proper alignment, but does not mean regular tower sheaves, although the term is sometimes used as a synonym for the phrases "small sheave," "line sheave," or "tower sheave";

"Safety support" or "safety withstand" means a safety factor of not less than 4 for static structures and of not less than 5 for mechanical devices;

"Safety bar" means a movable bar of flexible closure on chairlift chairs so arranged that when in place a passenger will have protection from falling from the chair;

"Safety factor" means the number of times that a permissible force or load could be multiplied before the structure, machine, or device would reach its ultimate strength;

"Safety gate stop" means a type of automatic stop which, due to the passenger's weight or contact, will automatically stop the tramway;

"Safety stop" means a device that will stop the aerial passenger tramway to prevent passengers from getting into the driving mechanism, bullwheel, or other obstructions;

"Sheaves" means pulleys or wheels grooved for rope. [Eff. 12/19/83; am and comp 12/6/90] (Auth: HRS §397-4) (Imp: HRS §397-4)

§12-233-2 General. This chapter contains standards for aerial passenger tramways. These are devices for transporting persons by the use of overhead wire ropes in one or more spans. They include:

(1) Chair lifts, gondola lifts, and skimobiles which are types of transportation in which persons are carried on chairs on cars or in gondola cabs attached to and suspended from a moving wire rope, or attached to a moving wire rope or chain and supported on a standing or stationary wire rope.

(2) Aerial cable cars or tramways which are any types of transportation in which persons are carried in one or more enclosed cars attached to and suspended from a moving rope, or attached to a moving rope and supported on a standing or stationary rope including those that reciprocate between terminals such as the single-and double-reversible aerial tramways;

(3) "J" bar lifts, "T" bar lifts, "platter lifts," and similar devices which are types of transportation that pull skiers sliding on skis by means of devices propelled by a main overhead traveling wire rope; and

(4) "Rope tow" which are types of transportation that pull skiers riding on skis by means of a traveling fiber rope which the skier grasps by hand.

Aerial passenger tramways under the jurisdiction of the United States government shall be exempt from the requirements of this chapter. [Eff. 12/19/83; comp 12/6/90] (Auth: HRS §397-4) (Imp: HRS §397-4)

§12-233-3 New and existing installations. (a) All new and existing installations of aerial passenger tramways shall be reasonably safe to persons and property and in conformity with the provisions of this chapter and other applicable laws or rules of the State and all orders or rules issued by the director. Conformity of all new and existing installations of aerial passenger tramways with the applicable parts of ANSI B77.1, in force at the time of installation, and the provisions of this chapter shall be prima facie evidence that these installations are reasonably safe to persons and property.

(b) Conditions which are not in conformance with subsection (a) above and of which the employer could not reasonably have been aware shall constitute discrepancies. All discrepancies shall be satisfactorily resolved as soon as possible. When a discrepancy constitutes a serious or imminent hazard, the condition shall be abated within an appropriate time and the use of the equipment may be prohibited until the condition is abated. Failure to correct discrepancies or failure to abate an unsafe condition within the time specified shall be a violation. [Eff. 12/19/83; am and comp 12/6/90] (Auth: HRS §397-4) (Imp: HRS §397-4)

§12-233-4 Design. (a) All electrical wiring and apparatus shall comply with the National Electric Code.

(b) The average passenger shall be considered as having a weight of

170 pounds (77.3 kg).

(c) It has been assumed in all cases that tramways will run in a straight line, in plan, between the terminals. Proposals involving lines with angles will require special consideration.

(d) Provision shall be made to render first aid in the event persons are injured on the tramway. This shall include provision for transporting an injured person out of areas where accessibility by land is difficult. [Eff. 12/19/83; am and ren §12-233-4 and comp 12/6/90] (Auth: HRS §397-4) (Imp: HRS §397-4)

§12-233-5 Strength of wire ropes. The wire rope strength on which the designer shall base the calculations for factor of safety shall be determined as follows:

(1) Where the wire rope manufacturer lists the minimum guaranteed breaking strength of the finished rope, this value is to be used as safe strength, and is referred to in this chapter as "Catalog Breaking Strength"; and

(2) Where the wire rope manufacturer lists breaking strengths which are obtained by multiplying the guaranteed minimum ultimate unit stress of the individual wire by the published area of the rope, these values are referred to herein as "aggregate" strengths. In these cases, rope strength shall be determined as "aggregate" strengths, and the rope strength shall be reduced by applying the manufacturer's published efficiency factor. The result is referred to in this chapter as the "calculated breaking strength." Rope strength shall be taken as 94 per cent of the calculated breaking strength. [Eff. 12/19/83; am and ren §12-233-5 and comp 12/6/90] (Auth: HRS §397-4) (Imp: HRS §397-4)

§12-233-6 Single- and double-reversible aerial tramways. (a) This section addresses that class of aerial tramways wherein the carriers reciprocate between the terminals. The types of tramways usually referred to as "to-and-fro" (single reversible) tramways and "jigback" (double reversible) tramways fall within this class. The former term refers to a tramway wherein a single carrier or line of carriers moves back and forth between the terminals on a single path of travel. The latter term refers to a tramway wherein two cars or two lines of cars oscillate back and forth between the terminals on two paths of travel. A tramway in this class may be either "monocable" or "bicable." A bicable tramway incorporates standing tracks, usually made of wire cable, on which the carriers ride. A monocable tramway uses a hauling or traction wire rope to support as well as propel the carriers.

(b) The tramway shall not be in proximity to, nor cross over or under, electric power lines, railways, highways, or structures, except where permitted and approved by the department.

(c) The clearing shall be wide enough to prevent interference with the tramway by adjacent vegetation.

(d) Clearings shall be protected, if necessary, to avoid washouts which might endanger the tramways or its foundations.

(e) Potentially dangerous trees shall be cleared out far enough back from the line to avoid their falling on the tramway.

(f) Towers shall be located to conform to the profile of the

installation and designed to provide clearance of the carriers and ropes from all obstructions and ski or hiking trails.

(g) Under the most adverse loading conditions, a minimum space of 5 feet (1.5 m) shall exist between the lower edge of the carrier or ropes and the terrain or other possible obstacles, including snow pack. Whenever the clearance is less than 15 feet (4.5 m), provisions shall be made to insure that no surface transportation or persons shall be permitted access to this section of the ground beneath the tramway. Whenever the clearance is less than 8 feet (2.4 m), protective fencing shall be erected to insure that no surface transportation or persons shall have access to this section of the ground beneath the tramway.

(h) On bicable tramways, the tower arrangement shall be such that the track cable under the most adverse operating conditions will have a positive breakover angle at the saddle. If angles of less than one degree are unavoidable, provisions shall be made to keep the track cable in the saddle. These provisions shall not interfere with any track cable brake operation

(i) On bicable tramways, haul rope sheave units shall be of a support type. The following requirements apply to haul rope sheave units.

(1) All sheaves shall be provided with fair leads which will positively return the haul rope to the sheave units whenever it leaves the unit for any cause.

(2) Auxiliary intermediate structures shall be provided to support sheave units in spans to maintain a minimum clearance between the haul rope and snow profile of 8 feet (2.4 m).

(j) On monocable tramways, the towers shall be so arranged that the hauling rope cannot depart from a group of tower sheaves in the event that the tension in the hauling rope were to become two times its most unfavorable design value at that point. If a factor of less than two is used, adequate retaining sheaves, properly placed, shall be provided.

(k) In the case of towers for monocable tramways where the rope load is normally upward (i.e., where "hold-down" or "depression" sheaves are used for normal operating conditions) the rope shall not leave the group of sheaves under the more severe of these conditions:

(1) Under a condition where two times the normal concentrated design load passes the tower when the rope is under normal minimum design tension; or

(2) Under a condition where the normal design concentrated load passes the tower when the rope is under 1/2 the normal minimum design tension.

(l) Towers shall also be located so as to minimize the surge of the line under operating conditions.

(m) Local wind conditions shall be taken into consideration.

(n) At passing places, the distances between the two carriers swung 10 degrees inward from the vertical shall be at least 2-1/2 feet (6.2 cm). In no case shall this distance be less than 1/2 of one per cent of the span length when the carriers pass at the center of the span.

(o) When the carriers pass at a location in the span different from the center of the span, the distance between the two carriers swung 10 degrees

inward from the vertical should be at least equal to the figure arrived at in the following equation.

Clearance distance	=	0.02 x (1-X/S)
Where	S =	the slope length of the span, and
	X =	the slope distance from the point of carrier passing to the nearest tower or track rope supporting structure.

(p) Towers containing provision for change in height of rope and cable supports shall not be used.

(q) Capacity and speed.

(1) The design capacity of each carrier shall be posted in a conspicuous place in each carrier and at each loading platform.

(2) The maximum carrier speed shall be, for bicable tramways, 2000 feet (606.1 m) per minute and, for monocable tramways, 1000 feet (303 m) per minute across tower sheaves and 2000 feet (606.1 m) per minute in clear spans. When there is no conductor in a carrier, these maximum speeds shall be reduced by 25 per cent and speeds when passing over tower saddles shall be reduced to 2/3 of the speeds permitted elsewhere.

(3) For either bicable or monocable installations, speed of the carriers entering terminals shall not exceed 300 feet (91 m) per minute. The permissible speeds for bicable tramways are based on the assumption that track cable saddles are so designed that the carriage wheels ride directly on the track cables over the saddles as well as in the spans, and do not come in contact with or ride on any part of the saddles, or retaining clips if used. If this condition does not exist, speed over the saddles shall be reduced to a maximum of 800 feet (242.4 m) per minute.

(r) Terminals and stations.

(1) Power source.

(A) Electrical.

(i) All exposed electrical transmission wiring shall be so located that in case of collapse or breakage of the power line it will not come in contact with the carrier, cables, or passengers.

(ii) All electrical work shall comply with the National Electric Code. The edition in effect at the time the contract for the tramway is signed shall govern the work on a particular tramway. All transformer stations and other electrical equipment shall be protected so as to prevent unauthorized persons from entering the area or coming in contact with any portion of the equipment or wiring. All power equipment shall be protected against overloads by proper circuit breakers or fuses.

(B) Internal combustion.

(i) Fuel tanks shall be of adequate capacity to permit uninterrupted operation during normal operating hours.

The fuel tank shall be refilled only while the carriers are at the stations.

(ii) Fuel tanks shall be buried or located so as to be free of fire hazards.

(iii) The engine shall always be shut down during refueling.

(iv) The fuel entry opening shall be capped and located to avoid toxic fumes and fire hazard during refueling.

(v) Exhaust stacks within the reach of personnel shall be equipped with guards or heat shields. Exhausts shall be designed to discharge to the atmosphere.

(2) Prime mover.

(A) All prime movers shall have capacity to handle the most unfavorable design loading conditions.

(B) An auxiliary power unit with an independent power source shall be provided which can readily be used to move the carriers to the terminals in the event of power failure, unless other means are provided to return the carrier to the terminal.

(C) A single auxiliary power unit shall not be used except to unload passengers and for maintenance purposes.

(3) All speed reducers and gears shall have capacity for starting the tramway under the most unfavorable design load conditions.

(4) Provision shall be made for adjustment and lubrication of all bearings and couplings as and where required.

(5) Bearings and couplings shall be selected on the basis of the manufacturer's published recommendations for the particular use. If published data are not available to cover the use, the manufacturer's approval shall be obtained for the intended use. Bearings and couplings of special design, if used, shall have the approval of a competent mechanical engineer.

(6) Any clutch device used between the prime mover and the drive sheave shall meet the same requirements as the bearings and couplings.

(7) Acceleration and speed controls are prime requirements for this type of tramway in order to avoid discomfort to the passengers caused by undue longitudinal swinging of the carriers or by excessive acceleration or deceleration and in order to start and stop the carriers smoothly and safely.

(A) Provision shall be made for smooth deceleration of the tramway prior to the actuation of one of the automatic drive terminal brakes. The operation of the drive sheave brake or track cable brake shall not result in deceleration of the tramway that exceeds 8 feet (2.4 m) per second square under the most adverse design conditions.

(B) Carriers shall be brought to stop for loading and unloading, and provision shall be made to make the tramway immobile during loading and unloading periods. The control room shall contain, in full view of the operator, indicators which will show the location of the carriers at all times.

(C) Provision shall be made for an overhauling load so that the system shall always operate at a controlled speed not

exceeding rated speed by more than 6 per cent. The power developed by the overhauling load shall be automatically dissipated either electrically, hydraulically, or pneumatically.

(8) Brakes and manual stops.

(A) The tramway system shall have at least:

(i) An automatic brake to stop and hold the tramway system under maximum load when power is shut off or the tramway is stopped for any reason. This brake shall be applied to a drive shaft such that there is no clutch, V-belt, chain drive, or similar device between the brake and the drive wheel. The brake shall be electrically released and applied by springs or gravity. In all cases the brake shall be normally in the applied position. It shall be held open for operation of the tramway by a device that is automatically cut out when the power is shut off or the tramway is stopped. This device shall be placed in operation before the tramway is started;

(ii) An automatic overspeed device which will interrupt the power to the prime mover and actuate the automatic brake or a similar independent brake when the speed of the tramway exceeds its rated value by more than 10 per cent;

(iii) A manually operated brake on the main drive sheave with controls located near the operator; and

(iv) On bicable tramways, an automatic track cable brake.

(B) Stops.

(i) Electric switches to stop the tramway shall be installed on both terminal platforms. One shall also be installed on the conductor's control board in each carrier (except where no conductor is required).

(ii) The stopping system shall be so arranged that the tramway cannot be started by anyone until the device that stopped the tramway has been reset, and the operator has obtained clearance from the point at which the device was actuated, from the attendants at both stations, and from the conductors.

(iii) A wind gauge shall be installed on the most exposed point along the tramway line. A conspicuous warning device shall function to alert the operator when wind velocity reaches the established maximum. When wind conditions, as determined by this device, or by observation of an attendant or the operator, make operations dangerous, the tramway shall be unloaded and stopped.

(iv) The tramway shall never be started except by the operator.

(9) All motive power shall be housed in a well-ventilated machine room in a manner that will permit proper maintenance and keep the public away from the machinery. Adequate lighting shall be provided, as well as protection against lightning and static

electricity.

(A) A minimum of 18 inches (45 cm) clearance shall be provided between machinery and machine room enclosures, and passageways between units of machinery shall have the same minimum width.

(B) The machine room shall be fire proof, and fire prevention measures and fire fighting devices shall be installed.

(C) A door with a suitable lock shall be installed on all machine rooms.

(10) Moving machine parts which normally may be within reach of personnel shall be fitted with safety guards conforming to ANSI B15.1.

(11) Sheaves and bearings in terminals.

(A) General.

(i) All sheaves, mountings, and frames shall be designed to withstand static and dynamic loads. Sheaves, mountings, and bearings shall be designed and installed in accordance with the recommendations of the manufacturers of the bearings.

(ii) Where sheaves are mounted on vertical shafts, the shafts shall be equipped with bearings which will adequately resist the vertical thrust loadings.

(iii) When unlined sheave grooves are used, they shall be V-shaped and shall have rounded bottoms having a radius equal to 55 per cent of the rope diameter.

(iv) When lined sheave grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

(B) Haul rope terminal sheaves (bull wheels and deflecting sheaves).

(i) Haul rope terminal sheave frames shall be so designed as to retain the sheave in the event of shaft or mounting failure.

(ii) The minimum diameter of terminal sheaves shall be 72 times the diameter of the rope, provided that no gripping device passes around the sheave. In cases where a gripping device passes around the sheave, the minimum diameter shall be 96 times the diameter of the rope.

(iii) Haul rope terminal sheaves which act as driving, braking, or holding sheaves shall be designed that the hauling rope does not slip in the sheave groove. The required coefficient of friction, based upon the most extreme design condition for the particular sheave, shall not exceed the values listed in the following table.

(C) The minimum sheave diameters for counterweight rope sheaves and sheaves not specifically addressed elsewhere shall be those in table 233-2.

TABLE 233-1

For steel or cast iron grooves	0.07
For leather liners	0.15
For liners or rubbers, neoprene, etc.	0.20
For soft aluminum linings (Brinnel 50*)	0.20
For other rope liner combinations, the values used shall not exceed 75 per cent of those obtained by tests under the most adverse conditions, such as wet, greasy rope.	

*500 kg (1100 pounds) load, 10 mm (7/16 inch) ball.

TABLE 233-2

Rope Classification	Sheave Diameter Condition A	Condition B	Condition C
6 x 7	72d	42d	24d
6 x 19	45d	30d	20d
6 x 37	27d	18d	12d

d = nominal rope diameter

Condition A is applicable to sheaves which rotate continuously in normal operation or to counterweight sheaves which have an oscillating motion equal to or more than the rope contact length plus one rope lay--in each direction.

Condition B is applicable to sheaves of smaller motions.

Condition C is applicable to sheaves which are not intended to rotate due to any tension sheave movement but are intended to rotate only due to counterweight adjustment whether the motion is large or small, frequent or infrequent.

Provisions shall be made to assure that all counterweight sheaves rotate freely.

(i) The requirements of subsection (s)(4) below are applicable to haul rope line sheaves (rollers) used in terminals except that single sheave units are permissible for use as terminal sheave guides, and sheave groove and flange requirements may be modified to meet the specific requirements of the guide sheave.

(ii) The diameter of a track cable deflecting sheave shall not be less than that recommended by the track cable manufacturer for the particular installation.

(12) Tension sheave carriages.

(A) The available travel of the tension sheave and carriage shall be adequate for the maximum limits of motion under

normal operation. This travel should be sufficient so as not to require the haul rope to be resocketed or respliced due to travel limitation.

(B) For all carriage arrangements other than those whose motion is vertical, the mounting that travels under the action of the counterweight shall be supported on rigid straight rails by means of wheels. For carriage arrangements with vertical motion guides shall be provided.

(13) Track cable saddles and mounts.

(A) The radius of a track cable saddle shall be determined by that one of the following criteria which requires of the largest radius:

(i) That it should be large enough to minimize bending stresses in the cable and thus prolong cable life;

(ii) That it should be large enough to provide smooth transition of the carriage from span to span;

(iii) That it should be large enough to reduce the bearing pressure to a value that will permit the cable to slide in the saddle groove;

(iv) That it should be large enough so that if the carriage were to travel the saddle at two times normal speed, the centrifugal force would not produce enough uplift to make the carriage wheels lose contact.

(B) If saddles in the terminals are located so that the carriage wheels do not pass over them, subparagraph (A)(ii) and (iv) above need not be applied.

(C) The saddle shall be long enough to ensure that under maximum loading conditions the cable will not come into contact with the end of the saddle groove.

(D) Saddles shall be designed so that the track cable brake, if any, may function at the time the carrier is passing the saddle without derailment of the tracks.

(E) Saddles shall permit free passage of the carriage even when the carrier is swinging laterally to design limit as it approaches or passes the tower.

(F) If the gauge of the tramway is varied at any point along the line, horizontal departures at any one tower shall be kept to a minimum to avoid derailment of the carriage as it passes over the saddle.

(14) End connections for track cables, counterweight ropes, and tower or station anchor cable or guys.

(A) Rope and cable sockets shall be designed so they will not fail when the ropes or cables which they anchor are under tensions equal to the strength of the wire rope.

(B) End connections consisting of wire rope clips and thimbles shall satisfy the recommendation of the Wire Rope Technical Board of the American Wire Manufacturers.

(C) Other types of end connections, if used, shall not fail or slip under tension equal to 80 per cent of the strength of the rope or cable.

(D) Winches, if used for take-up, shall not be loaded in excess of the manufacturer's rated capacity. A safety device shall

be installed on the rope ahead of the winch. This safety device shall be in the form of a clamp, tag line, or another device.

(E) End connections should be above ground. Any part of the anchorage below ground shall be protected against loss of strength due to corrosion.

(15) Counterweight ropes shall have a minimum safety factor of 6, when new, based on wire rope strength. The safety factor is equal to the strength of the rope divided by the static load applied. On systems involving rope reeving, the maximum design static tension, with sheave friction taken into account, is the basis for determining safety factor.

(A) A copy of the wire rope manufacturer's specifications shall be available to the director. These specifications shall include size, grade of rope, construction, type of core, and braking strength.

(B) Before installation, the manufacturer shall test to destruction a sample of the rope furnished and the installer shall submit a certified report of the test results to the department.

(C) In the case of ropes of foreign origin, a test shall be made by a reputable testing agency approved by the director in order to obtain adequate proof that the rope meets specification. Tests shall be in accordance with Federal Specification RR-W-410c and shall include the:

(i) Standard tension test;

(ii) Tension test on main wires;

(iii) Torsion test; and

(iv) Wrapping test.

(D) No splices shall be permitted in counterweight ropes.

(E) Since counterweight ropes are usually "long life" ropes, corrosion becomes an important factor. These ropes should be lubricated regularly with a lubricant specifically recommended for this type of service.

(F) Counterweight ropes shall be adjusted so that the counterweight will reach the end of its travel when the corresponding bull-wheel carriage comes within not less than 6 inches (15 cm) of the end of its travel.

(16) Counterweights.

(A) Counterweights shall be provided for all hauling ropes. These counterweights shall be arranged to move freely up and down. Enclosures for counterweights shall be provided where necessary to prevent snow or ice from accumulating under and around the counterweights and interfering with their free movement. Where snow enclosures are not required, guard rails or enclosures shall be provided to prevent unauthorized persons from coming in contact with or passing under counterweights.

(B) The counterweight shall have sufficient travel to take care of all normal operating changes in loading and temperature. It should have a travel equal to that of the bull-wheel carriage that moves in response to it. If this amount of

travel is not available, means shall be provided to shorten the counterweight ropes so that the counterweight will be in full suspension at all times. Where counterweights are used for track cables, the same provision shall apply.

(17) With respect to static loads, terminal structures shall be designed in conformance with applicable criteria listed in section 12-233-4.

(A) Applied design loads include dead, live, snow when applicable, and wind loads, plus impact, as well as earthquake loadings.

(B) Attention shall be paid to those portions of the structure which are subject to vibration from moving parts. In these cases, the governing criterion may be deflection or natural period of vibration. To this end, the design shall be made or reviewed by an engineer competent to handle these problems.

(C) Terminals located in snow creep areas shall be designed for these loads or be protected by snow breakers or shears.

(D) All terminals shall be grounded so as to satisfy all national and local codes.

(18) Foundations for vertical loads shall satisfy the design requirements of section 12-233-6(r). For foundations for inclined or horizontal loads (e.g., anchorages) the structure of the anchorage shall also satisfy the design requirements of section 12-233-6(r). In determining the resistance of the earth to motion of the anchorage, the subsoil conditions at the site shall be considered including any buoyancy due to ground water which may be present. If the resistance of the soil is not practically determinable, the anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. The design shall have a safety factor of 2 in resisting overturning or sliding under dead load and live load, and 1.5 under these loadings plus wind acting simultaneously. Bottoms of foundations shall be below the normal frost line unless they rest on solid rock, and tops shall be a minimum of 6 inches (15 cm) above finished grade. Foundations on rock shall be firmly anchored to the rock.

(19) Loading and unloading platforms.

(A) Steps shall be avoided where possible.

(B) The platform shall be as level as practical.

(C) There shall be sufficient space for passengers waiting to ascend and descend.

(D) Railings shall be provided to guide passengers safely to and from the cabins.

(E) Guide rails with curved ends shall be provided so that entrance and exit of cabin to and from platforms can be accomplished smoothly and without impact when the cabins are deflected from the vertical by 10 degrees.

(20) Attendants.

(A) At least one platform attendant shall be present each time that a carrier enters or leaves each terminal. The conductor may serve as this attendant if no loading

passengers are permitted on the platform until it has been cleared of all unloading passengers.

(B) There shall be a conductor who has knowledge of normal and emergency duties in each car having a capacity of more than six passengers during each trip.

(C) The tramway operator shall be located where there is the best possible view of the tramway. Controls and communicating devices shall be within reach without leaving the position.

(21) Limit switches or other equivalent devices shall be installed to take over the operation of the drive automatically if the operator fails to decelerate the tramway when the carrier enters the terminal area. A further limiting device shall be installed to cut power and stop the tramway before the carrier reaches its limit of travel. An adequate bumper system shall also be installed.

(A) Limit switches shall be installed to stop the tramway before any counterweight or bull-wheel carriage reaches either end of its travel.

(B) "Deadman" controls shall be provided to stop the tramway in case the operator suddenly becomes incapacitated.

(C) All electrical stop circuits shall be closed circuits so that, in the event of power failure or of malfunction of a stop switch, the system will fail safe. Circuit shall be all-metallic, unless otherwise approved by the director. Circuits shall not be grounded during normal operation, but it is recommended that grounding be provided for during lightning storms and when the tramway is left unattended.

(D) After any actuation of a safety stop, the cause shall be determined and removed. The safety-stop stop shall be reset. Safety stop circuits shall not be by-passed during normal passenger operation.

(E) The tramway shall never be started except by an experienced operator.

(s) Line structures.

(1) Towers.

(A) The design of the towers shall satisfy the requirements of 2.1.3.1 of ANSI B77.1. On bicable tramways, the maximum displacement of the ends of the saddles due to torsionalrotation of the tower under the most unfavorable design loads shall not be such as to cause the track cables to be derailed from the saddle under any operating condition.

(B) Where clearance is not adequate, towers shall be equipped with guards designed to prevent the carriers from swinging into the towers.

(C) When guyed towers are used and guys intersect the ground within or near ski runs or trails, the guys shall be marked for visibility, preferably with boards painted with black and yellow stripes. Guyed towers are not recommended in these areas.

(D) All towers shall be equipped with access ladders located in

such a manner as to prevent any moving parts from becoming engaged in the rungs.

(E) All towers shall be grounded. This may be done by individual grounds, by buried ground wires connecting all towers, or by tying all towers into a suspended ground wire, which may also be used as a ground for signal system, and is itself grounded.

(F) Towers shall be clearly identified with successive numbers.

(2) The foundations shall be designed to satisfy the requirements of 2.1.1.6.2 of ANSI B77.1.

(3) Suitable guards shall be provided to prevent the carriers from contacting intermediate towers or other fixed objects. On bicable tramways with track rope brakes, the guards shall be designed to limit swing to that permitted by relationship between brake and saddle. If open windows are used on the tower side, a clearance of at least 18 inches (45 cm) must be maintained at the window height when the carrier is swinging.

(4) Haul rope sheaves (or rollers) and mounts.

(A) This paragraph applies generally to sheaves (rollers) which support or hold down the haul rope at the towers. The angle of deflection of the haul rope per sheave is usually small. Where the angle of deflection per sheave is not more than 4-1/2 degrees for a sheave with a resilient liner, or 2-1/2 degrees for an unlined sheave, the sheave diameter should not be less than 10 times the nominal diameter of the rope for multiple, fully articulated, sheave units. When single sheaves are used for other than guide sheaves, which normally carry no load, the sheave diameter should not be less than 20 times the nominal rope diameter. Where sheaves on line structures deflect the rope more than the amounts specified above, sheave diameters shall be specified in sections 12-233-6(r)(11)(B) and (C).

(B) The allowable load per sheave should be determined after consultation with the manufacturer of the material with which the sheave is lined.

(C) Sheave flanges should be as deep as possible. At the same time, rope grips should be designed in relation to the sheave groove so as not to contact sheave flanges during normal operation, taking into consideration the anticipated amount of wear on the sheave grooves. Furthermore, rope grips, sheave flanges, and hanger guides shall be designed so that hangers cannot be caught behind guides, and ropes and grips cannot be derailed from sheaves if the carrier is swinging as it approaches or passes the tower.

(D) Suitable guards shall be installed to prevent the rope from falling into dangerous positions within the tower structure.

(E) The construction of the entire sheave unit shall be such that the rope cannot become entangled in the structure in the event it leaves the sheaves from either side.

(F) On hold-down sheave units, suitable guards shall be installed to prevent the rope from moving upwards in the event of derailment.

(G) Devices shall be incorporated on support sheave units to prevent the rope from falling in the event of derailment. Suitable devices shall be installed to stop the tramway in the event the rope is restrained by such a device.

(H) If the gauge of the tramway is varied at any point along the line, the horizontal departure at any one tower shall be kept to a minimum so that the rope cannot become derailed from the sheaves by virtue of the departure.

(I) Sheave mounts or mounting frames shall be designed to be adjustable laterally and rotationally, so that the sheave units can be lined up and held in the plane of the rope.

(5) Track cable saddles and mounts.

(A) The radius of a track cable saddle shall be determined by that one of the following criteria which requires the largest radius to be large enough:

(i) To provide smooth transition of the carriage from span to span;

(ii) To minimize bending stresses in the cable and thus prolong cable life;

(iii) To reduce the bearing pressure to a value that will permit the cable to slide in the saddle groove; or

(iv) So that if the carriage were to travel over the saddle at two times normal speed, the centrifugal force would not produce enough uplift to make the carriage wheels lose contact.

(B) The saddle shall be long enough to ensure that under maximum loading conditions the cable will not come into contact with the end of the saddle groove.

(C) Saddles shall be designed so that the track cable brake, if any, may function at the time the carrier is passing the saddle without derailment of the track.

(D) Saddles shall permit free passage of the carriage even when the carrier is swinging laterally to design limit as it approaches or passes the tower.

(E) If the gauge of the tramway is varied at any point along the line, horizontal departures at any one tower shall be kept to a minimum to avoid derailment of the carriage as it passes over the saddle.

(t) Line equipment.

(1) Haul rope.

(A) A copy of the wire rope manufacturer's specifications shall be available to the director. These specifications shall include size, grade of rope, construction, type of core, and breaking strength.

(i) Before installation, the manufacturer shall test to destruction a sample of the rope furnished and the employer shall submit a certified report of the test results.

(ii) In the case or rope of foreign origin, tests shall be made by a reputable testing agency approved by the director in order to obtain adequate proof that the rope meets specifications. Tests shall be in

accordance with Federal Specification RR-W-410c and shall include the:

Standard tension test;
Tension test of main wires;
Torsion test; and
Wrapping test.

(B) Tension limitations.

(i) All haul ropes shall have a minimum static safety factor of 5 when new. Static safety factor is equal to the rope strength divided by the computed maximum tension caused by design loads, including effects of friction, but excluding dynamic loads, in that section of the rope which is most highly stressed. In the case of a spliced wire rope with an independent wire rope center, the design strength of an equivalent wire rope with a fiber core shall be used.

(ii) Operating tension shall be controlled by use of a freely moving counterweight.

(C) End fittings or splices.

(i) Splicing of haul ropes on bicable tramways shall not be permitted, except for the infrequent case that this would result in a shipping package that is too large to handle by existing means of transportation and when two haul ropes are used, each of which would sustain the maximum load with a safety factor of 5 if the other haul rope were broken.

(ii) On monocable tramways, splicing of the main hauling rope should never be done by other than an experienced splicer, and, where cable links with swaged end fittings are used as in the case of monorail lifts, the end fittings shall be so designed and applied that, in a test of a complete link, the rope will break without slippage of the fittings.

(iii) On monocable tramways, when permitted as a special exception by the director, where cable links with swaged end fittings are used as in the case of monorail lifts, the rope may have an independent wire rope core or a strand core rather than a fiber core, but an adequate safety wire rope shall be installed to safeguard the carriers, to the satisfaction of the director, in the event of failure or disengagement of cable links, the parts which connect them, or other parts of the hauling system. In a test of a complete link, there shall be no slippage of the fittings at a tension equal to five times the working tension in the link when that tension is held for 15 minutes, and the rope shall not break at any tension below five times the same working tension.

(iv) Sockets shall be so designed that they will not fail when the ropes are stressed to their breaking strength.

(v) If types of end attachments are proposed which are other than the current standard types used in this country, their suitability shall be established by tests. The director reserves the right to approve or disapprove the use of the proposed connection even though tests may have been made.

(2) The carrier and all its parts shall be designed by qualified engineers in accordance with accepted practices of design. If the design has not had prior successful use for passenger transportation, its adequacy shall be verified by test loadings, trial runs, and tests under repeated loadings.

(A) Cabin body.

(i) Passenger cabins shall be enclosed and ventilated. They shall be equipped with doors that fill the entire entrance opening and each door shall be locked during each trip in such a manner that it cannot be unlocked except by the conductor or other authorized personnel. The key shall be kept where it is not accessible to the public passengers.

(ii) A key shall also be placed under glass, posted to prohibit use except under specified emergency conditions.

(iii) The capacity of each cabin shall be posted in a conspicuous place in the cabin.

(iv) Cabins shall be equipped with means of emergency evacuation of passengers which are acceptable to the director.

(v) All windows shall be of shatter-proof material.

(vi) If open chairs or cars are proposed instead of closed cabins, they shall be considered as special exceptions by the department.

(B) Frame.

(i) The frame shall be securely fastened to the carriage trucks and the cabin in such a manner that it cannot work loose.

(ii) The frame hanger shall be of sufficient length vertically so that under the worst condition of longitudinal sway the top of the cabin cannot strike the hauling rope or the bottom of a tower saddle and thus expose the trucks to danger of derailment. The hanger may be shorter in length if effective sway dampers are used.

(iii) In any event, the carrier must be able to swing longitudinally, without interference, to an angle of at least 16 degrees from the vertical at the most adverse location along the line.

(C) Trucks.

(i) On bicable tramways, the weight of the loaded carrier shall be so distributed over all wheels that the load per wheel shall not exceed that recommended by the track cable manufacturer. In no event, however, shall

the load per wheel exceed 1/20 of the minimum tension in the track cable. Diameter of the wheels shall be selected on the basis of recommendation of the track cable manufacturer or the allowable bearing pressure on the material, if any, with which the wheels are lined, whichever requires the greater diameter. Wheels shall be designed to prevent them from leaving the track cable under all operating conditions.

(ii) Each carriage on a bicable tramway shall be equipped with a brake that will grip the track cable. The brake shall be capable of stopping and holding a fully loaded carrier at the point of maximum slope. The brake shall function automatically in case of a hauling rope failure and also shall be capable of being manually applied by the cabin conductor. The track cable brake shall be capable of providing smooth stops without damage to the track cable carrier, or structures, under the condition of a fully loaded carrier moving downward at the point of maximum slope, of an empty carrier moving upward at the point of maximum slope, and all intermediate conditions. The director may permit the track cable brake to be omitted if two or more hauling ropes are used, or if the profile of the tramway will not permit an uncontrolled cabin to gain abnormal speed or crash into a terminal.

(iii) Sway dampers to reduce the longitudinal sway of the carrier shall be used if recommended by the tramway designer or the director. Where used, they shall be designed to operate smoothly and without danger of derailment of the carriage trucks.

(D) Each carrier having a capacity of more than six passengers shall be served by a conductor who shall be trained in carrier operation, emergency control, and evacuation.

(3) Track cables.

(A) Specifications.

(i) A copy of the track cable manufacturer's specifications shall be available to the director. These specifications shall include size, grade of track cable, construction, and breaking strength.

(ii) Before installation, the manufacturer shall test to destruction a sample of the cable furnished and the employer shall submit a certified report of the test results to the department. In the case of cables of foreign origin, a test shall be made by a reputable testing agency approved by the director in order to obtain adequate proof that track cable meets specifications.

(iii) Track cables consisting of one or more single strands each made up entirely of round wires shall not be permitted. Wire rope track cables, if used, shall have wire center, not fiber core.

(B) The track cable shall be designed to have the minimum factors of safety specified in table 233-3 when new.

TABLE 233-3

Track Cable	Factor of Safety	
	Static	**Dynamic**
Strand	3.0	2.5
Wire Rope	5.0	4.0

Dynamic loads shall include that imposed upon the track rope due to application of track cable brakes.

(C) Rope and cable sockets shall be designed so they will not fail when the ropes or cables which they anchor are under tensions equal to the strength of the wire rope.

(D) Couplings.

(i) Track cable couplings shall not be used without consent of the director. In case of long length of track cable, couplings may be necessary, but this situation should not preclude the use of a carriage brake designed accordingly.

(ii) Track cable couplings shall not be reused.

(E) Haul ropes and track cables shall be connected metallically to one or both terminal structures so as to be grounded through those structures. Where haul ropes are used as conductors in the communication system, lightning protection shall be provided while the tramway is in operation; at all other times, the ropes shall be grounded.

(u) Communications.

(1) A terminal-to-terminal, two-way telephone or radiophone communication system shall be provided. This system shall be independent of all other forms of communications.

(2) An additional system of two-way telephone or radiophone

communication from operating room to all carriers and to opposite terminal platform shall be provided where the carriers are attended by a cabin conductor.

(3) This system may be omitted on short installations where the distance between a carrier and a terminal platform would allow the cabin conductor and a platform attendant to discuss any necessary problem.

(4) Where telephone, control, or electric wires are suspended between towers, they must be designed to resist breaking, sagging, or contacting ropes or carriers under the most adverse conditions of icing, wind, and temperature.

(v) Signs are not specifically required. Signs, if used, should be short, simple, bold in design, and to the point.

(w) Means having the approval of the director shall be provided to evacuate passengers from stranded carriers and operating crews shall be properly trained in the use of the devices and procedures.

(x) Before the tramway is placed in operation, it shall be subjected to thorough inspection and tests by the department to confirm that it meets the requirements of the approved plans and specifications in every respect. The inspection and tests shall include but not necessarily be limited to:

(1) A final check for tightness of all structural connections;

(2) A final check of the lubrication of all moving parts;

(3) A check for alignment and clearance of open gearing;

(4) A check for alignment and fit of all bearings, couplings, and shafting;

(5) A check for proper tightness of belting;

(6) A final check for freedom of movement and of position of counterweights and bull-wheel carriages;

(7) A check for sag of track cable and haul ropes, under the most adverse static loadings;

(8) A check for alignment of track cable saddles and haul-rope, line-sheave units in the planes of their respective cables or ropes;

(9) A check for alignment of haul rope at the entrance to the bull-wheels;

(10) Thorough operating tests made under full loading and under partial loading which provide the most unfavorable conditions. The test load per carrier, on tramways wherein carriers are suspended, shall be 10 per cent greater than design live load. This shall include an operational check of motive power, acceleration, deceleration, all brakes, all push-button stops, all automatic stops and limit switches, and communication devices. The tests shall include at least one full day's continuous operation for the purpose of checking for overheating of moving parts, excessive vibration or deflection of any mechanical or structural components, and free movement of counterweights; and

(11) A survey made of all as-built footings by a person qualified to make the survey and submitted to the designer for approval or corrective instructions. This can be done while the work is in progress and attested by certificate at the time of final inspection. No later than the time of final inspection, the height and angle of each tower should be checked against the designer's instructions. Demonstration and test of evacuation

equipment and procedures shall be conducted at the most unfavorable location. Certificate by the owner that the owner's representative has observed these checks and tests shall be acceptable as adequate compliance with these items.

(y) Maintenance.

(1) Routine.

(A) A schedule for systematic maintenance shall be developed and set down in writing. It shall be based on a maintenance manual which shall be provided by the designer of the tramway. The manual shall include the type of lubricant and frequency of lubrication of each element involving moving parts. It shall stipulate that parts showing excessive wear shall be replaced immediately and, when possible, shall establish yardsticks to define "excessive wear." It shall include a schedule for checking and tightening all bolts, especially on rope attachments. Special attention is called to the need for regular and careful inspection of parts subject to repeated loadings and impact such as carriers, hangers, and grips.

(B) The maintenance schedule shall establish a specific period of time which will represent one complete cycle of maintenance operations including all component parts, assigning a time within that cycle for the maintenance work on each component. The schedule shall include a daily check of all normal operating brakes, all communications, and all stopping devices, both manual and automatic, and a daily check to make sure that the counterweight sheaves are free to turn. It shall include periodic checks of all emergency brakes.

(C) A signed complete log or diary shall be kept wherein the actual execution of maintenance work shall be recorded daily. This log shall not only state that the component has been given attention on that day, but shall also state the condition of the component if it has shown any signs of deterioration, and shall record the replacement of any components. It shall also contain a daily record of the position of all counterweights and bull-wheel carriages.

(2) At least once each year the tramway shall be inspected by an inspector from the department.

(3) End connections and areas near saddles shall be inspected at established intervals of time for broken wires and worn spots. At longer intervals, the whole length shall be inspected. These intervals shall not be longer than those recommended by the track cable manufacturer.

(4) The general condition of haul ropes and other ropes and cables, including splices, and counterweights shall be noted each day by a qualified employee of the operator.

(A) At established intervals not exceeding one year, the entire length of haul rope shall be examined by a qualified person for conditions such as broken wires, worn spots, pitting, and lubrication.

(B) Fixed grips shall be moved and the rope inspected at these

locations at least once a year, but not at longer periods than recommended by the tramway designer. For purposes of maintaining orderly and useful records, it is suggested that they be moved uniform distances and always in the same direction.

(C) Each time a fixed grip is moved, the rope that has been under and near the grip shall be examined for deterioration, and records shall be made which will make it possible at any future time during the life of the rope to locate the spots where grips have previously been located. On detachable chair lifts and gondola lifts, the splice must be inspected at regular intervals to be certain that the carrier grips can attach properly and safely on the splice.

(D) On link-type hauling ropes of monorail lifts with swaged button end fittings, links shall be removed at random and proof-tested for safety factor and signs of corrosion, annually or more often as required.

(5) Lubrication for all ropes and cables shall be carried out in accordance with the recommendations of the designer of the tramway. Retirement of rope from service shall be decided on the basis of the general condition and history of the rope and of its predecessors as indicated by the inspection reports. Consideration shall be given to the condition of the splices, the deterioration or corrosion, the surface wear, and the number of broken wires in the worst rope lay.

(z) An aerial passenger tramway shall not be operated to carry passengers unless an operating permit has been issued by the department and only then in accordance with the following requirements.

(1) The requirements regarding marshalling of passengers for smooth and safe loading and unloading without interference are subject to a clear-cut plan of operations. The plan shall be established by management, and training of attendants shall be conducted.

(2) When wind conditions reach such a point as to make operation hazardous to passengers or equipment, the tramway shall be shut down. All lifts operating under wind conditions shall be provided with:

(A) An automatic brake to stop and hold the system under maximum load when power is shut off or the lift is stopped for any reason. This brake shall be electrically released and applied by springs or gravity, except in cases where another type of brake has been specifically approved by the director. In all cases the brake shall be normally in the applied position. It shall be held open for operation of the tramway by a device which is automatically cut out when power is shut off or the tramway is stopped. This device shall, without exception, be placed in operation before the tramway is started. This brake shall be applied to a drive shaft so that there is no clutch, V-belt or chain drive, or similar device between the brake and the drive wheel. This restriction on the location of the brake is not required in cases where the gear pitch or gear reduction is such that the lift cannot overhaul with a capacity load plus 10 per

cent after the interruption of power;

(B) A manually operated brake on the main-drive sheave with controls located near the operator; and

(C) A backstop to prevent reverse rotation of the tramway, unless the gearing will prevent gravity reversal.

(3) When icing conditions make operation hazardous to passengers or equipment, passengers shall not be carried.

(4) Evacuation drills shall be held at regular intervals so that, at all times, personnel will be sufficiently familiar with evacuation equipment and procedure to unload the tramway safely if the need arises.

(5) One individual shall be responsible for all operating personnel and attendants. That individual shall be responsible for safe operation, and shall have authority to deny access to the tramway by any persons who are not fit or competent to ride the tramway without danger to themselves or others. That individual shall also have the authority to prohibit operation of the lift under adverse wind or ice conditions.

(6) A daily operation log book shall be maintained for each tramway. The log shall:

(A) List operating personnel and location;

(B) Contain inspection and operational checks of controls and safety switches;

(C) Specify the operating period;

(D) Record any abnormal occurrences during operation; and

(E) Be signed daily by the operator. [Eff. 12/19/83; am and ren §12-233-6 and comp 12/6/90] (Auth: HRS §397-4, §397-6) (Imp: HRS §397-4, §397-6)