Designation: F3158 – 16

Standard Practice for Patron Transportation Conveyors Used with a Water Related Amusement Ride or Device[1]

This standard is issued under the fixed designation F3158; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice applies to the classification, design, manufacture, construction, and operation of patron transportation conveyors, integral with the operation of water related amusement rides or devices as scoped in Practice F2376.

1.2 This practice applies to conveyors used for patron loading/unloading or to transport patrons on rafts, tubes, or other vehicles. Loading, sequencing, transitioning, starting, and unloading conveyors that carry patrons are included in the scope of this practice.

1.3 This practice shall affect new conveying systems or major modifications of conveyors used in an amusement ride or attraction.

1.4 This practice includes an appendix (non-mandatory), which provides additional information (for example, rationale, background, interpretations, drawings, commentary, and so forth) to improve the user's understanding and application of the criteria presented in this practice. The appendix information shall not be interpreted as mandatory design criteria.

1.5 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F747 Terminology Relating to Amusement Rides and Devices

F770 Practice for Ownership, Operation, Maintenance, and Inspection of Amusement Rides and Devices

F1193 Practice for Quality, Manufacture, and Construction of Amusement Rides and Devices

F2291 Practice for Design of Amusement Rides and Devices

F2376 Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems

2.2 *ANSI Standards:*[3]

ANSI/ASME B20.1 Safety Standard for Conveyors and Related Equipment

ANSI B77.1 Passenger Ropeways—Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors—Safety Requirements

2.3 *ASME Standard:*[4]

ASME A17.1 Safety code for Elevators and Escalators

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 This space is reserved (see X1.1).

4. Classification

4.1 *Type 1 Riding Position Conveyor*—The conveyor may not move while a patron is on the conveyor unless the patron is in riding position on a ride vehicle. Type I conveyors may perform, but are not limited to, one or more of the following functions:

4.1.1 Transport,

4.1.2 Sequencing,

4.1.3 Acceleration,

4.1.4 Ingress, and

4.1.5 Egress.

4.2 *Type 2 Walk On/Off Conveyor*—Conveyors in which patrons are allowed to walk on or off of the moving conveyor during vehicle loading or unloading. These conveyors are also known as moving station conveyors.

[1] This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.70 on Water Related Amusement Rides and Devices.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

5. Significance and Use

5.1 The purpose of this practice is to provide designers, engineers, manufactures, owners, and operators with criteria and references for use in designing, inspecting, and operating patron transportation conveyor systems which are integral with a water related ride or device.

6. Design Criteria

6.1 In addition to the design requirements of Section 5, Practice F2291, the following considerations and requirements shall be included.

6.2 *Geometry:*

6.2.1 The length of a conveyor is defined from the center of the tail pulley to the center of the head pulley.

6.2.2 *Belt Width*—The actual width of the belt.

6.2.3 *Riding Surface Width*—The exposed width of the belt surface.

6.2.3.1 *Minimum Riding Surface Width for a Type 1 Riding Position Conveyor*—The width of the vehicle traction surface plus 4 in. (10 cm).

6.2.3.2 *Minimum Riding Surface Width for a Type 2 Walk On/Off Conveyor*—36 in. (0.92 m) minimum is required for patron travel.

6.2.4 The carrying side of the conveyor belt shall maintain a fixed path of travel under all load conditions and maintain contact with the support track, slide deck or support rollers.

6.2.5 *Limits to the Maximum Slope Angle of the Belt:*

6.2.5.1 *Type 1 Riding Position Conveyor*—The maximum slope shall be determined by ride analysis and shall be limited such that loaded vehicles being transported by the conveyor will not slide in a reverse direction. This slope analysis shall consider the maximum and minimum operational design conditions such as ride vehicle, live load, belt wear, expected water from the ride, and environmental conditions.

6.2.5.2 *Type 2 Walk On/Off Conveyor*—The maximum slope shall be determined by ride analysis and shall not exceed the following limitations:

(1) The angle of inclination from the horizontal shall not exceed 3° within 36 in. (0.92 m) of the ingress and egress ends.

(2) At the vehicle load position, the slope of the conveyor shall match the slope of vehicle travel at the load position.

(3) For conveyors running up an incline the angle of inclination of the conveyor shall not exceed 18° at any point. For conveyors intended to be accessible the inclination shall not exceed 10° at any point.

(4) The ride analysis for declining conveyors shall consider the slope of the conveyor, the deceleration rate under braking and the patron restraints.

6.2.6 *Maximum Cross Slope*—2 %.

6.3 *Patron Restraint, Clearance Envelope, and Containment Design Criteria:*

6.3.1 *Restraints*—The designer/engineer shall consider accelerations generated by the conveyor system in the ride analysis.

6.3.2 *Clearance Envelope:*

6.3.2.1 *Type 1 Riding Position Conveyor:*

(1) The clearance envelope shall be determined based on the "Patron Clearance Envelope Analysis" as outlined in subsection 6.6 of Practice F2291.

(2) If the pathway of the conveyor belt is used for emergency evacuation egress, then the minimum head room shall match the value listed in 6.3.2.2(2).

6.3.2.2 *Type 2 Walk On/Off Conveyor:*

(1) The clearance envelope shall be determined based on the "Patron Clearance Envelope Analysis" as outlined in subsection 6.6 of Practice F2291.

(2) The headroom shall be 7 ft (2.14 m) minimum over the patron path of travel, as measured vertically from the conveyor belt and ride vehicle access surfaces.

(3) Handrails and solid balustrades may be used as needed to assist and guide patrons while on the conveyor. These shall be considered in the "Patron Clearance Envelope Analysis."

6.4 *Speed and Acceleration Limits:*

6.4.1 *Maximum Belt Speed:*

6.4.1.1 *Type 1 Riding Position Conveyor*—The conveyor belt must remain stationary until the patron is in riding position on the ride vehicle. Once the patron is in riding position on the ride vehicle, the maximum speed shall be based on the ride analysis, however the designer/engineer shall consider the accelerations entering a belt, between succeeding belts, and launch speed required at the belt exit in the ride analysis. These accelerations shall meet the requirements of 6.4.2.

6.4.1.2 *Type 2 Walk On/Off Conveyor:*

(1) The design speed of a Type 2 Walk On/Off Conveyor should be considered as part of the ride analysis.

(2) The designer/engineer shall consider lateral accelerations of the pedestrian when loading/unloading a conveyor.

(3) Additional design consideration should be taken when loading/unloading a conveyor at angles not parallel with the direction of travel. At a minimum the edge of the belt in the loading and unloading areas shall be marked in accordance with 6.11.9.

6.4.2 *Acceleration/Deceleration:*

6.4.2.1 *Type 1 Riding Position Conveyor*—The maximum acceleration/deceleration rates of the patron shall be determined by the ride analysis with regard to the patron restraints, conveyor belt construction, profile, and speed transitions.

6.4.2.2 *Type 2 Walk On/Off Conveyor*—The maximum accelerations/decelerations of the patron shall be determined by the ride analysis with regard to the conveyor belt construction, profile, and speed transitions.

6.4.2.3 When the conveyor may transport more than one patron at a time, the ride analysis shall consider the effects of acceleration and deceleration on all patrons standing or walking on the conveyor.

6.5 *Loads and Strengths*—The loads and strengths used in performing the calculations and analyses used in the design process shall be as defined in Practice F2291, Section 8. In addition to these referenced criteria, the following conditions shall apply.

6.5.1 The environmental conditions associated with water related amusement rides or attractions can be very corrosive, especially for those conveyors which are adjacent to or submerged in treated water. The design shall consider these operating conditions.

6.5.2 Plastic and plastic composite structural elements strengths shall be designed in accordance with Practice F2376, subsection 7.10.

6.6 *Hydraulic Equipment for Conveyors*—The criteria used in selecting and sizing hydraulic components, designing the hydraulic system, and performing the analyses used in the process of hydraulic system design shall be in accordance with Practice F2291, Section 9.

6.7 *Pneumatic Systems and Components*—The criteria used in selecting and sizing pneumatic components, designing the pneumatic system, and performing the analyses used in the process of pneumatic system design shall be in accordance with Practice F2291, Section 10.

6.8 *Safety Related Control Systems*—The safety related control system shall be designed and installed in accordance with Practice F2291, Section 11.

6.9 *Electrical Requirements*—The criteria used in selecting and sizing electronic components, assemblies, designing the electronic systems, and performing the analyses used in the process of electronic system design shall be in accordance with Practice F2291, Section 12.

6.10 *Mechanical Systems and Components*—Unless otherwise noted in the following, the criteria used in selecting and sizing mechanical components, designing mechanical systems, and performing the analyses used in the process of mechanical system design shall be in accordance with Practice F2291, Section 13.

6.10.1 *Conveyor Belt Material:*

6.10.1.1 The maximum design tension shall not exceed the working strength published by the belt manufacturer under any normal operating condition.

6.10.1.2 Conveyor splices shall be in accordance with the design and any related belt manufacturer requirements. Splicing of the conveyor belt shall be made in such a manner as to result in a continuous conveyor belt surface.

6.10.2 *Service Brake*—A service brake shall be required if the stopping distance, including dynamic braking by the drive, exceeds the maximum stopping distance as determined in 6.12.2 or otherwise in the ride analysis.

6.10.2.1 If installed, the service brake shall be located at any point in the drive train such that there is no drive belt, friction clutch, or similar friction-type device between the brake and the drive drum.

6.10.2.2 The service brake shall be applied by springs, weights, or other forms of stored energy when any stop circuit is interrupted.

6.10.3 *Rollback Device*—The occupied portion of the conveyor belt shall be designed to limit reverse travel. Either the ride analysis shall determine that the belt maintains a safe state in the event that the conveyor belt breaks, or the safety related control system shall continuously monitor and stop the conveyor for belt damage.

6.11 *Machine Guards:*

6.11.1 Machine safeguarding methods shall be implemented to inhibit persons from contacting drive belts, chains, pulleys, gears, drivelines, and similar moving machinery while the conveyor is in operation.

6.11.2 When the ride analysis determines that parts can break free on power transmissions provisions shall be made to contain the components.

6.11.3 Equipment guards shall be provided to minimize the hazard associated with a drive shaft failure.

6.11.4 Material used in the construction of guards shall be of such design and strength as to protect individuals from identified hazards. The design and construction of the guard shall ensure that individuals cannot inadvertently reach the hazard by reaching over, under, around, or through the guard.

6.11.5 When tasks such as testing, setup, repair, adjustment, or maintenance require removing, disabling, bypassing, or suspending one or more safeguards, alternate risk reduction measures shall be required. Only properly trained and authorized personnel shall be allowed access to areas behind guards. The bypass process shall be documented and shall include specific procedures and appropriate training of personnel.

6.11.6 Protection against static electricity shall be provided.

6.11.7 All stationary surfaces along the conveying path and within limb's reach of a patron being transported shall be smooth and free from any points of entrapment or entanglement in accordance with the patron clearance envelope analysis. The designer shall consider the probability that the typical patron of a water related amusement ride or attraction will not be wearing foot wear, and may have minimal clothing.

6.11.8 *Edge Guards*—The designer/engineer shall consider the entrapment point between the edge of the belt and the conveyor frame. In the case in which belt edge guards are used to maintain the opening at the edge of the belt, the edge guard should completely cover the edge of the belt, under each operating conditions, and the gap between the top of the belt and lower lip of the edge guard should be no larger than ¼ in. (6 mm). This gap shall be measured from the top of the exposed belt surface.

6.11.9 *Edge Marking*—For Type 2 Walk on/off conveyors where the patron may load or unload the conveyor from the side, the transition from the moving belt to the fixed surface shall be marked with a contrasting color to clearly designate the surface change.

6.11.10 Where any portion of a conveyor is located under water, the pool space around the conveyor shall be physically guarded so as to minimize risk of entanglement or entrapment. The guards shall meet the requirements of 6.5.1.

6.12 *Exit Transition Zone (see Fig. 1):*

6.12.1 The ride analysis shall consider hazards associated with the exit transition zone.

6.12.2 The ride analysis shall consider any potential for entanglement in the transition zone and determine the maximum stopping distance for the conveyor belt in the event of such an entanglement. An appropriate automatic or manual control shall be provided for this purpose.

6.13 *Fencing, Guardrails, Handrails, and Gates:*

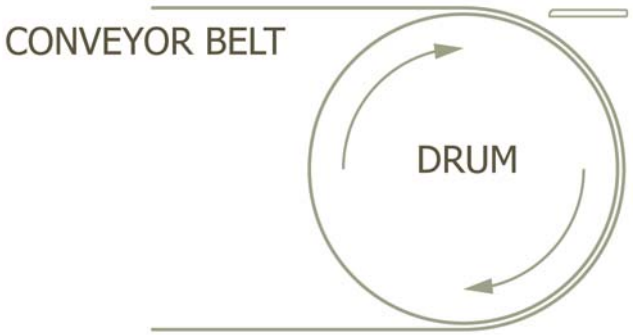

FIG. 1 Transition Zone

6.13.1 Fencing, guardrails, handrails, and gates shall be in accordance with the requirements of Practice F2291, Section 14.

6.13.2 There shall not be an unprotected drop of more than 7 in. along the side of any Type 1 Riding Position Conveyor belt.

6.13.3 For a Type 2 Walk On/Off Conveyor the design shall minimize any trip hazard along the edge of the conveyor belt.

6.13.4 On areas where the conveying path rises more than 30 in. (0.76 m) above finished grade, guardrails shall be used on both sides of the conveying path to accommodate patron evacuation and equipment access. The guardrail shall be in accordance with Practice F2291, 14.3.2.

6.13.4.1 The location of the guardrail shall be in accordance with 6.3.2.

6.14 *Evacuation Walkway:*

6.14.1 Conveyors that carry more than one ride vehicle at a time shall include provisions to allow patrons to evacuate without having to climb over a ride vehicle.

6.14.2 If ride vehicles can be readily moved out of the way, the belt may be used as the evacuation path.

6.14.3 The evacuation pathway must meet the requirements of Practice F2291, 14.8 through 14.8.3.

6.15 *Welding*—Welding specifications, procedures, and joint and welder qualifications shall be in accordance with Practice F2291, Section 15.

6.16 *Fasteners*—Fastened connections that are bolted, riveted, or other types of fasteners as applicable, shall be designed in accordance with Practice F2291, Section 16.

7. Quality Assurance

7.1 The minimum requirements for a quality assurance program and the manufacturing of a conveyor shall be in accordance with Practice F1193.

8. Maintenance

8.1 The maintenance practices and procedures for conveyors shall be in accordance with Practice F770.

9. Operation

9.1 Unless noted otherwise in the following, the operational practices and procedures for conveyors shall be in accordance with Practice F770.

9.1.1 *Minimum Personnel for Operation of a Conveyor System:*

9.1.1.1 *Type 1 Riding Position Conveyors*—A Type 1 Riding Position conveyor is required to be under observation. In accordance with Practice F1193, Section 11, the operator(s), whose zone of responsibility includes the conveyor, shall have the means to observe every patron on the conveyor.

9.1.1.2 *Type 2 Walk On/Off Conveyors:*

(1) An operator shall be stationed near a conveyor stop button near the exit transition zone when the belt is moving unless determined otherwise by ride analysis.

(2) For conveyors longer than 400 ft (122 m), a minimum of two operators are required with access to conveyor stop buttons unless determined otherwise by ride analysis.

10. Major Modification and Relocation

10.1 Major modifications as specified in Terminology F747 shall not occur without review and approval of a designer/engineer.

10.2 Any relocation of a fixed or permanent conveyor shall be reviewed by a designer/engineer.

11. Keywords

11.1 conveyor; conveyor belt; transition zone

APPENDIX

(Nonmandatory Information)

X1. REASONING FOR STANDARD REQUIREMENTS

X1.1 Definitions of Terms Specific to This Standard (see 3.1)

X1.1.1 The following words and definitions have been submitted to the Terminology Task Group for approval. They may be proposed in future ballots. Please feel free to make comments now, but know that these words are not on this current ballot.

X1.1.1.1 *belt transition, n*—end of a conveyor where the conveyor belt bends around a drum or sprocket and returns on the bottom side of the conveyor.

X1.1.1.2 *conveyor, n*—common piece of mechanical handling equipment that moves ride vehicles or patrons, or both, from one location to another using a flexible moveable element.

X1.1.1.3 *conveyor belt, n*—carrying medium of a conveyor.

X1.1.1.4 *vehicle, n*—any tube, raft, or hard shell amusement device designed to transport patrons, in a designed riding position, on an amusement ride and conveyor.

X1.2 Classification (see Section 4)

X1.2.1 The committee has considered two additional types of conveyors which are being utilized in the amusement industry; conveyors carrying empty ride vehicles and conveyors which are integral to dry rides. These two additional uses of belted conveyors may be incorporated into the standard in future revisions by the task group.

X1.2.2 *Type 2 Walk On/Off Conveyor (see 4.2)*—The dynamic that occurs as a patron walks from a stationary surface to a moving conveyor requires more stringent design and operating conditions.

X1.3 Design Criteria (see Section 6)

X1.3.1 *Minimum Riding Surface Width for a Type 1 Riding Position Conveyor (see 6.2.3.1)*—This width restriction is limited to the traction surface assumed in the ride analysis. So a ride vehicle may be wider than the width of the belt surface.

X1.3.2 *Minimum Riding Surface Width for a Type 2 Walk On/Off Conveyor (see 6.2.3.2)*—The 36 in. (0.92 m) was chosen because it corresponds to the clearance width required for accessibility. The task committee did not want a physical aid to partially fit onto the conveyor.

X1.3.3 *Type 2 Walk On/Off Conveyors (see 6.2.5.2)*—These numbers come from the experience of the conveyor manufacturers of installations where patrons ride the conveyors in standing position.

X1.3.4 *Maximum Cross Slope (see 6.2.6)*—This value matches the Americans with Disabilities Act (ADA) requirements for walkways.

X1.3.5 *Clearance Envelope – Type 2 Walk On/Off Conveyor (see 6.3.2.2(2))*—The value 7 ft vertical clearance is consistent with the International Building Code (IBC) and would be required anytime a patron is expected to walk along the conveyor belt.

X1.3.6 *Maximum Belt Speed – Type 2 Walk On/Off Conveyor (see 6.4.1.2)*—ASME A17.1 has various maximum allowable speeds up to 180 ft/min based on belt width and slope. ANSI B77.1 restricts the speed of conveyors to 160 ft/min (0.51 m/s). The designer should take caution in designing Type 2 Walk On/Off conveyors with speeds greater than these established speed limits.

X1.3.7 *Acceleration/Deceleration – Type 1 Riding Position Conveyor (see 6.4.2.1)*—The acceleration limit of 7 ft/s^2 (2.1 m/s^2) is used in ANSI B77.1. Care should be taken when considering accelerations higher than this limit.

X1.3.8 *Acceleration/Deceleration – Type 2 Walk On/Off Conveyor (see 6.4.2.2)*—The acceleration limit of 3 ft/s^2 (0.91 m/s^2) is used in ASME A17.1 for standing patrons. Care should be taken when considering accelerations higher than this limit.

X1.3.9 *Conveyor Belt Material (see 6.10.1)*—The Rubber Manufacturers Association (RMA) suggests an 8:1 safety factor. A similar design factor for a link belt conveyor uses 2:1. Because of the large variation in design factors based on belt construction, a specific belt safety factor was not provided.

X1.3.10 *Exit Transition Zone (see 6.12)*—Both ASME A17.1 and ANSI B77.1 require an automatic safety control function at the transition point; however, there are multiple-patron-carrying conveyors associated with a water ride that do not have automatic safety devices. They are designed to eliminate the entrapment point. Additionally, ANSI B77.1 has additional provisions for loading conveyors which do not require an automatic safety device because they require an operator to be present very close to the transition point.