



SlowStop 5" Storefront Bollard
IFC Compliance Report
Fuel Pumps and Tanks

Introduction

Impact Recovery Systems, Inc. has introduced a surface mount protective bollard specifically designed for protecting against automotive traffic. The SlowStop Bollard utilizes a patented energy absorbing system which houses an elastomer in the base to absorb energy upon impact, reducing peak forces on the bollard, anchors, and impacting vehicles. The design encapsulates the anchors to avoid any trip hazard. Patents include US 9,938,677 and 11,136,735 amongst other international patents.

SlowStop independently tested the bollard to the ASTM F3016 standard for protective devices at low speeds at Texas Transportation Institute (TTI), an A2LA accredited laboratory at Texas A&M University. The data from those test results will be used here to show compliance with International Fire Code for vehicle impact protection.



Code

International Fire Code 2021 section 312 defines a particular design for protecting fuel pumps and storage tanks, but also allows for alternate designs.

SECTION 312 VEHICLE IMPACT PROTECTION

312.1 General. Vehicle impact protection required by this code shall be provided by posts that comply with Section 312.2 or by other *approved* physical barriers that comply with Section 312.3.

312.2 Posts. Guard posts shall comply with all of the following requirements:

1. Constructed of steel not less than 4 inches (102 mm) in diameter and concrete filled.
2. Spaced not more than 4 feet (1219 mm) between posts on center.
3. Set not less than 3 feet (914 mm) deep in a concrete footing of not less than a 15-inch (381 mm) diameter.
4. Set with the top of the posts not less than 3 feet (914 mm) above ground.
5. Located not less than 3 feet (914 mm) from the protected object.

312.3 Other barriers. Barriers, other than posts specified in Section 312.2, that are designed to resist, deflect or visually deter vehicular impact commensurate with an anticipated impact scenario shall be permitted where *approved*.

Figure 1 - IFC 2021

This section is a modified version that has been in the code for decades. Earlier versions describe the intent of the design for “Other Barriers” as being able to resist 12,000 pounds of

force at 36" height. Indeed, this specification has been adopted in many local municipal codes. See figure 2.

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312.3 Other barriers. Physical barriers shall be a minimum of 36 inches (914 mm) in height and shall resist a force of 12,000 pounds (53 375 N) applied 36 inches (914 mm) above the adjacent ground surface.

Figure 2 - IFC 2000

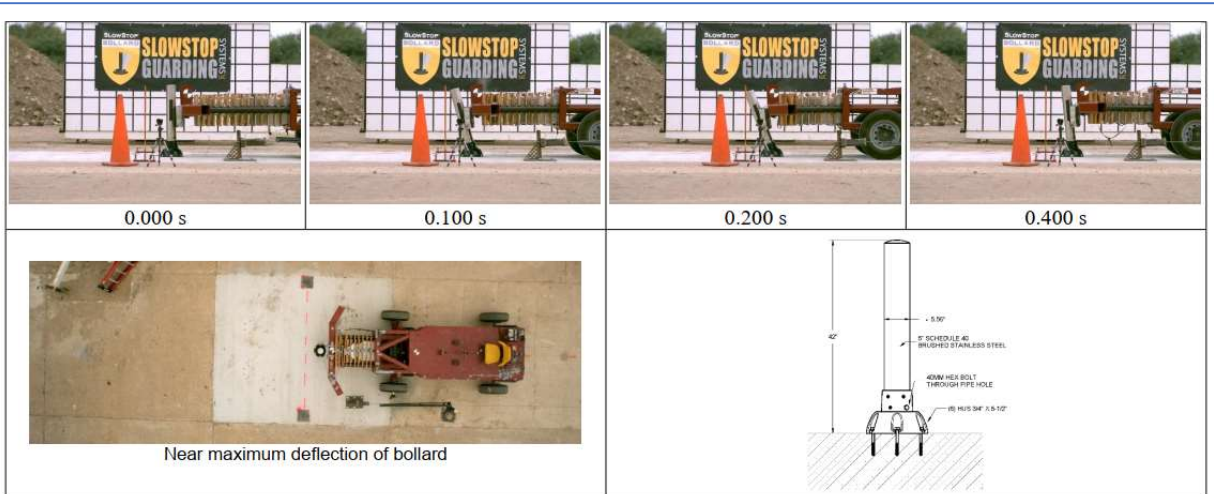
As one would expect, this code is much more stringent than International Building Code, which merely requires resisting 6,000 pounds of force at 27" impact height for general traffic such as in parking garages.

Testing

The ASTM F3016 test uses a surrogate 5,000 pound vehicle to impact a bollard. The vehicle is designed to emulate an automobile, specifically the crush zones present in the front. This vehicle has instrumentation on board to measure acceleration among other data, and high-speed video is recorded.

A stand-alone SlowStop 5" Storefront Bollard was mounted to nominally 4,000 psi 6" thick concrete with our standard 3/4" x 5-1/2" concrete screw anchors.

The bollard resisted the surrogate vehicle travelling at 10.4 mph and survived without damage. Video of that impact can be seen here: <https://youtu.be/c-hZq3BaXaY>. Below is the pertinent data that will be used to show IFC compliance for the SlowStop 5" StoreFront Bollard



<p>General Information</p> <p>Test Agency..... Texas A&M Transportation Institute (TTI)</p> <p>Test Standard Test No. ASTM F3016-19 S10</p> <p>Test No. 690900-IRS B2</p> <p>Date 2020-10-26</p> <p>Test Article</p> <p>Type..... Low Speed Bollard</p> <p>Name..... SlowStop® Bollard</p> <p>Material or Key Elements : 42-inch tall 5-inch schedule 40 brushed stainless steel bollard</p> <p>Soil/Foundation Type Steel reinforced 15-ft long, 12.5-ft wide, 6-inch thick concrete slab on native soil</p>	<p>Test Vehicle</p> <p>Type Low-Speed Bogie</p> <p>Designation Surrogate (S)</p> <p>Model ASTM F3016-19 Bogie</p> <p>Test Inertial Mass 4980 lb</p> <p>Impact Conditions</p> <p>Speed 10.4 mi/h</p> <p>Angle 90.45 degrees</p> <p>Occupant Risk Values</p> <p>Longitudinal OIV 17.7 ft/s</p> <p>Lateral OIV 0.7 ft/s</p> <p>Longitudinal RDA 0.8 g</p> <p>Lateral RDA 0.2 g</p> <p>Max. 0.050-s Average</p> <p>Longitudinal -3.4 g</p> <p>Lateral -0.2 g</p> <p>Vertical 0.4 g</p>	<p>Debris Field No debris</p> <p>Final Rest of Bogie 31.5 ft twd impact side</p> <p>Dynamic Bogie Nose Crush 17.25 inches</p> <p>Rotation/Translation of Bollard (static after impact) 1 degree (bollard 88.7° fr Horiz)</p> <p>Horizontal Movement of Foundation None</p> <p>Uplift of Foundation None</p> <p>Dynamic Penetration of Bollard ... 12.6 inches</p> <p>Dynamic Penetration of Bogie 9.8 inches</p> <p>Penetration Rating S10-P2</p>
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Figure 4.4. Summary of Results for ASTM F3016-19 Test S10 on SlowStop® Bollard.

Figure 3 - ASTM Report Summary

4.1 TARGET TEST CONDITIONS

ASTM F3016-19 Test S10 was performed on the SlowStop® Bollard. Target speed was between 9.0 and 18.9 mi/h at an impact angle of 90 degrees, and target impact height of 28 inches. Actual impact speed was 10.4 mi/h and actual impact angle was 90.5 degrees, and impact height was 28.2 inches. Target and actual impact point was the centerline of the bogie aligned with the centerline of the bollard.

Figure 4 - ASTM Report Impact Height

Calculations

Since mass and acceleration are known from the TTI report, force can be calculated simply using Newton’s second law, $f = ma$. Thus,

$$F_{28''} = 4980 \text{ lbs} \times 3.4 \text{ g}$$

$$F_{28''} = 16,932 \text{ lbf}$$

Using simple lever mechanics, we can determine the equivalent force at 36" since the post acts as a rigid body.

$$F_{36"} = F_{28"} \times (28.2" / 36")$$

$$F_{36"} = 16,932 \text{ lbs} \times 0.78$$

$$F_{36"} = 13,263 \text{ lbf}$$

This exceeds the intent of the code by 10%. This impact was not to failure point. In subsequent tests, a maximum lateral acceleration of -4.5 g was obtained before failure, representing an additional 36% safety factor.

A complete copy of the test report can be found at our website here:

https://www.slowstop.com/assets/uploads/technical_docs/TRNo690900-IRS-B2_Medium_.pdf

Conclusion

The SlowStop 5" StoreFront Bollard is a suitable protective devices per International Fire Code and local codes that define a 12,000 pound-force at 36" height requirement.