

Kettlebell pendulum test setup Version 2.4

1 Introduction

This document describes the test setup for a kettlebell-and-chain pendulum test of a frangible fence. It is divided into the following two parts:

- Build of kettlebell pendulum
- Test procedure for assessment of frangible fence using kettle-bell pendulum

2 Build of kettlebell pendulum

The following lists the materials needed to build a pendulum which can be attached to a utility tractor bucket or other suitable vehicle loader

1. 40 kg Kettlebell (fig 1) from suppliers such as www.KettlebellsUSA.com
2. 10ft (3m) stainless steel chain of 5/32" (4mm) diameter (fig 2) from hardware stores such as Home Depot; load capacity > 500 lb (~ 225 kg)
3. Hooks and clevis as needed (fig 2) from hardware stores such as Home Depot



Figure 1. 40 kg kettlebell from www.KettlebellsUSA.com



Figure 2. Stainless steel 5/32" (4mm) chain and hooks etc. Load capacity >500lb.

3 Test procedure

The test setup is detailed below for impacts with strike angles of 27 deg upwards (pendulum hits in upwards direction for assessment of **front rail**) and 27 deg downwards (pendulum hits in downwards direction for assessment of **back rail**). Preload distances D, T and H are defined in tables 1 and 2 and illustrated in figures (3) and (4), for the upward and downward cases, respectively.

1. Set the pendulum length at $L=1.5$ m, 2.0 m or 2.5 m from the upper chain hitch point on the tractor bucket, to mass centre of the kettlebell.
2. The impact location for the kettlebell should be against the fence rail at the desired location of the test impact. This should be at distance X from the vertical hanging rest position of the kettlebell.
3. For a 27 deg upwards test refer to figure 3 and table 1 (upward swing test) to select for test setup the energy test level to release the kettlebell from related drop height H and preload distance D or T. Similarly, for a 27 deg downwards test refer to figure 4 and table 2 (downward swing test).
4. For safety, ensure that the pendulum has enough sway space for the full test arc fore and aft and laterally, without contacting any other objects or people

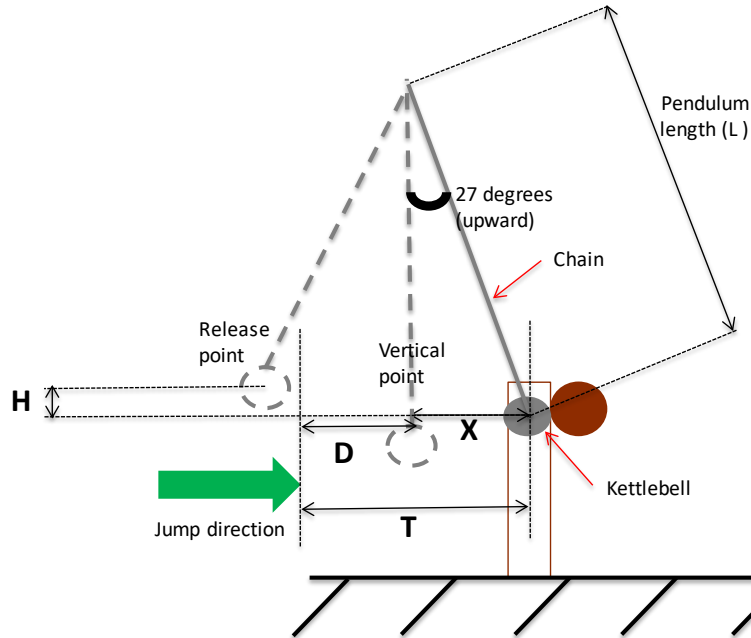


Figure 3. Pendulum upward strike test setup diagram for a **front rail**. See Table 1 for parameter values. Preload distance (D) sets the release location of the kettlebell relative to vertical. Preload distance T sets release location relative to the kettlebell at the impact point with the rail. H represents vertical drop height between release and rail impact point. Apex location X sets impact with rail location relative to vertical from the pendulum chain attach point.

Pendulum Length (L)	Parameter Value in mm			
	H	D	T	X
Impact Energy 165 J				
L = 1.5 m	420	1188	1869	681
L = 2.0 m	420	1465	2373	908
L = 2.5 m	420	1728	2862	1135
Impact Energy 250 J				
L = 1.5 m	637	1327	2008	681
L = 2.0 m	637	1640	2548	908
L = 2.5 m	637	1929	3064	1135

Table 1. Values for test setup parameters (shown in Figure 3) for **upward strike** for various pendulum length L and energy levels.

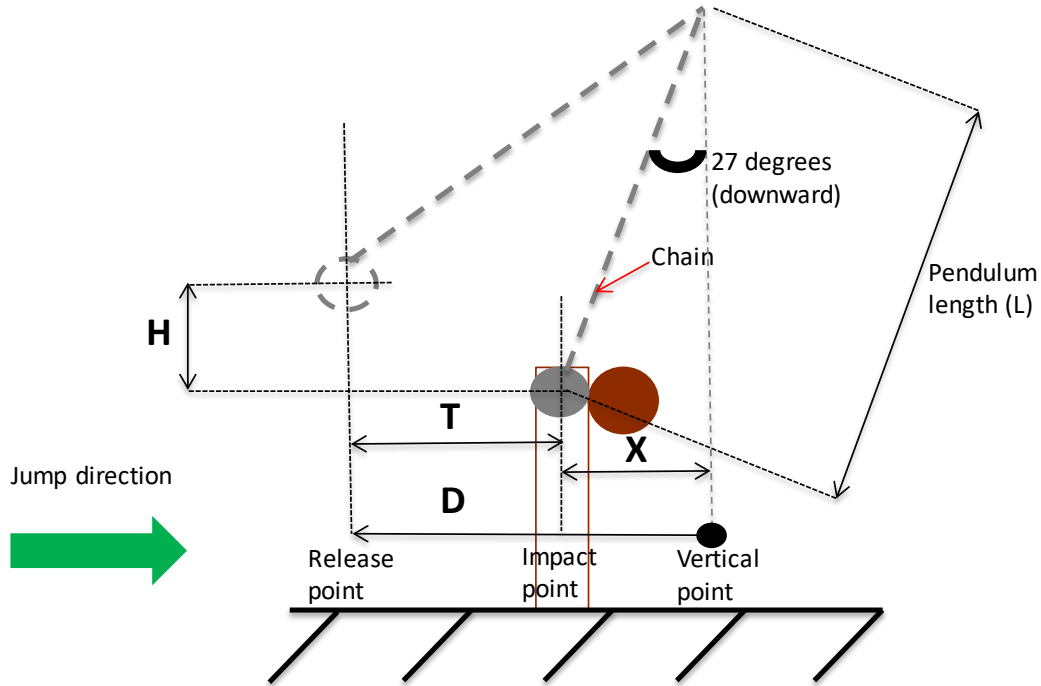


Figure 4. Pendulum **downward strike** test setup diagram for a **back rail**. See Table 2 for parameter values. Preload distance (D) sets the release location of the kettlebell relative to vertical. Preload distance T sets release location relative to the kettlebell at the impact point with the rail. H represents vertical drop height between release and rail impact point. Apex location X sets impact with rail location relative to vertical from the pendulum chain attach point.

Pendulum Length (L)	Parameter Value in mm			
	H	D	T	X
Impact Energy 165 J				
L = 1.5 m	420	1188	507	681
L = 2.0 m	420	1465	557	908
L = 2.5 m	420	1728	593	1135
Impact Energy 300 J				
L = 1.5 m	765	1387	706	681
L = 2.0 m	765	1722	814	908
L = 2.5 m	765	1992	857	1135
Impact Energy 700 J				
L = 2.5 m	1784	2460	1325	1135

Table 2. Values for test setup parameters (shown in Figure 4) for **downward strike** for various pendulum length L and energy levels.

4 Test execution

See video example below.

<https://www.youtube.com/watch?v=8cFzL0s2J9g&feature=youtu.be>