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SAMPLE TEST REPORT

Dynamic Coaster Test Report
for the
***Wild* Coaster at Fun Park, USA**

Test Date: April 3, 1999
Test Engineers:

Coaster Description

The *Wild Coaster* is a traditionally constructed wood coaster nearly 3500 ft. in length. It uses two articulating trains. The four passenger, dual axle cars are linked with rigid, spherical jointed couplers. Each seating position is equipped with redundant occupant restraints in the form of an adjustable lap belt and a ratcheting lap bar. One set of kicker tires accelerates the train out of the station and a DC drive motor allows speed control of the train on the lift hill.

Test Description

Both of the trains were instrumented for tri-axial acceleration, speed and position-along-the-track. A Doppler radar speed sensor and an optical position sensor were mounted to the front of the trains. The speed sensor detected the passing track support structure and the optical sensor detected reflectors that were placed at various known points along the coaster track. The ±10 g, tri-axial accelerometer module was rigidly fixed to the top center of the front seat back of the tested cars and oriented with the Z-axis perpendicular to the car floor. The first, fourth and seventh cars of each coaster train were instrumented, resulting in a total of six tests.

Since the measured acceleration profile of a coaster is dependent on the mounting location of the accelerometers, the data taken for this test is only representative of the acceleration forces generated at the instrumented locations of the coaster train. The tri-axial accelerometer was mounted at approximately chest height (for an average adult) and oriented such that positive readings along the X, Y and Z-axes are as indicated in Figure 1. With the instrumentation axes fixed relative to the coaster car rather than utilizing a ground based (inertial) reference frame, the Z-axis was only parallel to the gravity vector when the coaster car was level with reference to the earth. For the purposes of this test the train was considered to be level with respect to the earth when in the load-unload position at the station platform. With the train at rest within the station, the accelerometer channels were initialized to the following: $X = Y = 0$ g, $Z = +1$ g.

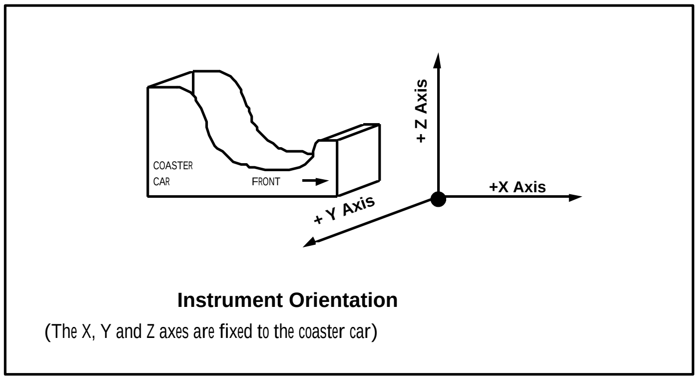

Figure 1 - Accelerometer Coordinate System.

In addition to the train mounted instrumentation, a 50th percentile male HYBRID III Anthropomorphic Test Dummy (ATD) was used. The ATD was fitted with a 6-axis upper neck transducer that allowed the measurement of the orthogonal forces and moments at the neck-skull interface. These measurements are reported in accordance with SAE recommended practices (J211). Table 1 lists the head motion that produces a positive output for each sensor. When seated in the normal occupant position with the train at rest in the load-unload position in the station house, the orthogonal axes of the ATD approximately coincide with the axes of the train mounted tri-axial accelerometer. This coincidence of the train reference axes and the ADT reference axes is not generally maintained during a dynamic test because of relative motion between the ATD and the train. Before each test, the six ATD channels were initialized to zero with the train was at rest in the station. For purposes of data analysis note that the ATD head has a weight of 10 lbm.

Table 1 - Neck Sensor Output.

Channel	Motion to produce a + output
Force X-Axis	Head rearward
Force Y-Axis	Head left
Force Z-Axis	Head up
Moment X-Axis	Left ear to left shoulder
Moment Y-Axis	Chin to chest (flexion)
Moment Z-Axis	Chin to left shoulder

Consecutively numbering the seating rows from the front row of the front car rearward gives a total of 14 rows each with a right and left seating position. For these tests the following seating positions were tested:

- Front position — ATD in seat 1L, Tri-axial accelerometer on seat back 1.
- Middle position — ATD in seat 8L, Tri-axial accelerometer on seat back 7.
- Rear position — ATD in seat 14L, Tri-axial accelerometer on seat back 13.

The ATD was restrained in the seat using the car-mounted lap bar, the car-mounted seatbelt and a strap around the ATD thorax. This additional strap ensured that the dummy remained consistently oriented in an upright position throughout the ride. All three accelerometer signals and the six neck signals were lowpass filtered at 20 Hz (using 8-Pole Bessel filters) and sampled at 100 Hz. The photoelectric position sensor was also sampled at 100 Hz, while the Doppler speed sensor was sampled at 10 Hz. No presample lowpass filtering was used for the position and speed signals due to their inherent digital nature. In addition to the presample filtering, all data channels were postfiltered to a bandwidth of 0 to 5 Hz prior to plotting.

The calculated, worst case uncertainty of the data is as follows:

Doppler speed	±0.5 ft/sec
Track position	±2.0 ft
Acceleration	±0.125 g
Neck forces	±3.0 lbf
Neck moments	±3.0 in-lbf

Both trains were tested on the afternoon of April 3, 1999. Each train was ballasted with approximately 3000 lbm. The drive motor provided train/chain hookup at approximately 5 ft/sec and then accelerated the train to 11 ft/sec on the lift hill. The brakes were automatically actuated and data was recorded until the train was stopped in the station load/unload position.

Results & Discussion

The tests results consist of the following data:

- Plots of track elevation and train speed for each train.
- Plots of train tri-axial and resultant acceleration vs. time for each car tested.
- Plots of ATD neck force and moment vs. time for each car tested.
- Table relating bent number, track length and train speed.

All time-based data channels were plotted such that T = 0 coincides with the front edge of the coaster train passing over Bent 0 at the exit edge of the station platform. Bent numbers are shown along the top graph of each data page. This provides a direct correlation between a measurement and the specific location of the train as the measurement was recorded. These bent numbers correspond to the position of the ATD and accelerometers, not to the position of the front of the train.

A careful review of the data resulted in the following observations:

1. Peak observed train speed was approximately 80 ft/sec (55 mph) for both trains with an average of about 43 ft/sec (29 mph) throughout the ride.

2. The kicker units accelerated the trains out of the station slightly over 0.1 g.

3. The peak X-axis acceleration at train/chain engagement was about 0.5 g (with 5 Hz lowpass filtering), which is approximately 25% lower than typical.

4. While three sections of track produced acceleration events that stood out from the rest of the ride, these events are not out of the envelope of typical wood coaster accelerations.

    - Bent 177. A Y-axis pulse of about 0.9 g in the 1 g left turn indicates a low right side ledger or radius discontinuity at bent 177.

    - Bents 260-263. About midway through the curve, the Y-axis acceleration drops from approximately 0.9 g to 0.1 g for about 20 feet. This suggests that the lateral slope of the track increased or the plan-view curvature of the track flattened out through this section.

    - Bents 413-416. A sharp, Y-axis 1.0 g pulse approximately 0.5 seconds in duration is imparted to the train through this short curve. Little Z-axis acceleration is present through this section.

5. No "negative g" events of any significant magnitude or duration were noted for the front or middle seating positions on either train. The rear car on each train experienced moderate events at the first drop (bents 51-53) and immediately following the helix (bents 301-308). These pulses were roughly equivalent to -0.17 g for 0.75 sec at the first drop and -0.14 g for 0.8 sec after the helix.

6. The magnitude, frequency and duration of the acceleration events on the *Wild Coaster* are within an acceleration envelope described by other operating, "state-of-the-art" wood coasters.

Conclusions

1. At the time of the test, the *Wild Coaster* produced no train or ATD measured accelerations, forces or moments that would suggest a safety concern.

Certification of Accuracy

I certify the data herein presented are, to the best of my knowledge, true and accurate representations of the speeds, acceleration forces and ATD neck forces and moments generated at the instrumented positions of the coaster tested. I further certify the instrumentation used was performance and calibration-verified before executing the coaster tests.

Respectfully Submitted,

GMH Engineer