

Hokie Vibration Consultants, Inc.
1 Main St
Blacksburg, VA 24060
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To: Manager, New River Manufacturing Corporation
From: Mary Kasarda, Senior Vibration Engineer
Subject: Damping Values Necessary for Limiting Oscillations of a Boxcar Stopping System

Introduction

This memo discusses the determination of damping values necessary to limit the oscillations of a boxcar stopping system to under 18 inches upon contact of a boxcar. New River Manufacturing Corporation (NRMC) has requested damping values as a basis for their design of a hydraulic damper system for the loading dock boxcar stop system. NRMC has requested the value of damping necessary to limit vibrations of the boxcar stopping system to under 18 inches after the impact of a loaded boxcar traveling at one mph. In order to allow for possible variations in the system parameters, we have determined a range of damping values to limit the oscillations of the boxcar stop system to 20-30% below the requested limit (these values result in maximum calculated displacements of 14.4 and 12.6 inches). *The range of damping necessary to achieve this response has been determined to be 420–560 lb_f-s/in.*

Procedure

Boxcars loaded with supplies are de-coupled from the main freight and rolled down a side rail to the stop at the loading dock at NRMC. It has been determined that upon impact of the boxcar, the coupled boxcar stopping system can be modeled as a single-degree-of-freedom system with a response due to an initial displacement. The modeling of the system is detailed in our full report, “The Calculation of Damping for NRMC Boxcar Stop,” and the equation of motion used in the analysis is of the form

$$m\ddot{x} + c\dot{x} + kx = 0 \quad (1)$$

where m is the total mass of the boxcar and loading dock stop system, c is the damping to be supplied by the hydraulic damper, and k is the stiffness of the stop system. NRMC has supplied us with specific information on loaded boxcar and boxcar stop parameters for this analysis as listed in Table 1.

Table 1. System Parameters.

System Parameter	Value
Weight of Loaded Boxcar	150 tons
Stiffness of Boxcar Stop	500 lb _f /in
Initial Velocity of Boxcar/Stop System	1 mph
Initial Displacement of Boxcar/Stop System	0 in

To complete the analysis, Equation 1 is solved utilizing a modified Euler integration solution method as detailed in the full report for various values of damping until the required response is obtained. This method is implemented by programming the modified Euler algorithm using Matlab[®] software. This program is developed so that it could be easily modified for future analyses where parameters (such as stiffness or damping) may be non-linear in nature.

Conclusion

A vibration analysis of the NRMC boxcar stopping system has been completed. In this analysis, we have determined that the appropriate damping value range for the damper design is 420–560 lb_f-s/in which limits the system motion to 14.4 and 12.6 inches, respectively.