Harsh environment acoustic emission and ultrasonic wave sensing applications often benefit from placing the sensor in a remote and more benign physical location by using waveguides to transmit elastic waves between the structural location under test and the transducer. Waveguides are normally designed to have high fidelity over broad frequency ranges to minimize distortion – often difficult to achieve in practice. This paper reports on an examination of using nonlinear ball chain waveguides for the transmission of acoustic emission and ultrasonic waves for the monitoring of thermal protection systems undergoing severe heat loading, leading to ablation and similar processes. Experiments test the nonlinear propagation of solitary, harmonic and mixed harmonic elastic waves through a copper tube filled with steel and elastomer balls. Mechanical pulses of varying time widths and amplitudes are launched into one end of the ball chain waveguide and observed at the other end in both time and frequency domains. Similarly, harmonic and mixed harmonic mechanical loads are applied to one end of the waveguide. The corresponding frequency responses, including intermodulation products, are compared based on amplitude and preloads. A nonlinear mechanical model describes the motion of the dimer chains in a vacuum. Based on the results of these studies it is anticipated that a nonlinear waveguide will be designed, built and tested as a possible replacement for the high-fidelity waveguides presently being using in an Inductively Coupled Plasma Torch facility for high heat flux thermal protection system testing. The design is intended to accentuate acoustic emission signals of interest, while suppressing other forms elastic wave noise.