



SURFACE VEHICLE RECOMMENDED PRACTICE

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Considerations for Suspension Modification

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Foreword—It is well recognized that a percentage of the motoring public expects to be able to modify their vehicle suspension ride characteristics from its originally designed and manufactured condition. It is further recognized that certain modifications can have various and potentially serious side effects that must be considered. This document is intended for use by trained professionals, with access to analytical engineering tools, involved in the engineering and development of aftermarket suspension components and systems. This paper is not intended for use by the consumer or end user. It is also noted that a need exists to communicate the intentions and effects of a planned change in suspension design, handling, and ride characteristics to the end user. It is the intention of this document to promote a systems approach to design as opposed to individual component consideration.

The terminology used in this document will be easier to understand and use with reference to SAE J670e.

1. Scope—The scope of this document is limited specifically to the following types of passenger vehicles: automobiles, light trucks, and sport/utility vehicles. This document addresses modifications as they apply to legal use of the vehicle, and examines suspension modification as it applies to stock (as manufactured) ride height, and changed (raised or lowered) ride height. Note that modifications of ride height are considered, exclusive of wheel and/or tire modifications, which can also have potentially serious side effects, and are outside the scope of this document.

1.1 Purpose—This document is not intended to endorse or discourage modification of original equipment chassis or settings. This paper provides guidelines describing some of the issues that must be considered when undertaking any form of vehicle suspension modification. While every effort has been made to address most types of suspension modification, this document is qualitative and is not all-inclusive. This document is not intended to endorse, regulate, or limit the degree of modification, or to be interpreted by regulatory or enforcement groups as establishing such limits. Sound engineering principles must be applied in the development of any and all proposed alterations. It is recommended that all aspects of modification must be supported through analysis, and should be verified with actual vehicle and/or laboratory testing.

2. References

2.1 Applicable Publication—The following publication forms a part of this specification to the extent specified herein.

2.1.1 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI Z535—

2.2 Related Publications—Following is a list of SAE publications which were reviewed during the compilation of this document. While these documents were not specifically referred to in this document, it is felt that they are useful as references in the application of this document. This list is not all-inclusive. It is up to the individual user of this document to search for adequate reference material for any modification being considered.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J193—Ball Stud and Socket Assembly—Test Procedures
SAE J274—Rated Suspension Spring Capacity
SAE J490—Surface Vehicle Standard, Ball Joints
SAE J491—Steering Ball Studs and Socket Assemblies
SAE J670e—Vehicle Dynamics Terminology
SAE J1367—Performance Test Procedure-Ball Joints and Spherical Rod Ends
SAE J1574/2—Measurement of Vehicle and Suspension Parameters for Directional Control Studies
SAE 660102—Simulation of Field Loading in Fatigue Testing
SAE 690234—Considerations in Determining Vehicle Handling Requirements
SAE 726019—Vehicle Handling
SAE 800845—Subjective Evaluation and Vehicle Behavior in Lane - Change Maneuvers
SAE 806084—Vehicle Handling Characteristics During Braking in a Turn
SAE 820676—Overview of Design Approaches for Optimizing Fatigue Performance of Suspension Systems
SAE 830663—Suspension Design for Optimum Road-Holding
SAE 834110—The Influence of Different Vehicle Parameters on Steering Controllability and Stability
SAE 834114—Influence of Front-Wheel Drive on Vehicle Handling at Low Levels of Lateral Acceleration
SAE 834115—Some Aspects on Suspension Design Parameters for Improved Vehicle Response at the Limit of Adhesion
SAE 852184—A Study on Vehicle Turning Behavior in Acceleration and Braking
SAE 856040—Maneuverability and New Suspension for Four-Wheel Drive Vehicles
SAE 856041—Behavior of a Vehicle During Turning
SAE 860245—The Effects of Tire Camber Angle on Vehicle Controllability and Stability
SAE 861114—A Magazine's View on Automotive Testing
SAE 865087—Concept Selection, Analysis and Realization of the Suspension System of a New Off-Road Vehicle
SAE 865114—HICAS—Improvement of Vehicle Stability and Controllability by Rear Suspension Steering Characteristics
SAE 865124—Steering Geometry Errors Induced by Braking
SAE 865137—The Concept of Rear Suspension for Front Drive Vehicles
SAE 870241—Tire-Pavement Interaction
SAE 870495—Steady State and Transient Analysis of Ground Vehicle Handling
SAE 870497—Investigation into the Effects of Suspension Design of Stability of Light Vehicles
SAE 870542—Controllability and Stability of Various Types of Four Wheel Drive Cars
SAE 870577—Suspension Testing Using the Suspension Parameter Measurement Device
SAE 871154—Simulation of Cornering Properties of a Vehicle Over a Whole Range of Working Conditions
SAE 871940—Vehicle Modeling and Service Loads Analysis
SAE 874728—The Roll-Centre Concept in Vehicle Handling Dynamics
SAE 874810—Limit Steady State Vehicle Handling
SAE 876054—4WD Vehicle Behavior During Braking in a Turn
SAE 891212—Effect of the Nonlinearity of the Suspension Roll Stiffness on the Vehicle Handling
SAE 900666—Dynamic Simulation of Chassis Component Loads
SAE 904727—Invariant Properties of Automotive Suspensions
SAE 905080—Main Steps in the Experimental Tuning Process of a 4WD Vehicle
SAE 911872—An Investigation of a Road-Vehicle Directional Behavior Under Steady-State Conditions
SAE 92A006—A Method for Measuring the Load Condition on a Car Suspension
SAE 921595—Combining Properties for Driving Pleasure and Driving Safety: A Challenge for the Chassis Engineer

SAE 925047—Vehicle Cornering Behavior Analysis Using a General Purpose Simulation Methodology
SAE 930760—A Computer Simulation Analysis of Safety Critical Maneuvers for Assessing Ground Vehicle Dynamic Stability
SAE 940872—The Influences of Chassis Geometric Characteristics on Vehicle Dynamic Performances
SAE 942505—Modeling Steady-State Suspension Kinematics and Vehicle Dynamics of Road Racing Cars
SAE 970098—Ride and Handling Development of the 1997 Chevrolet Corvette

- 2.2.2 ORIGINAL EQUIPMENT MANUFACTURER'S DOCUMENTATION—Care should be taken to obtain the OEM documentation available regarding the specific platform chosen for modification. This documentation should include, but is not limited to: service manuals, service bulletins, and recall notices.

3. General Considerations

- 3.1 The following are general considerations that must be addressed when applied to any considered suspension modification.

3.1.1 PHYSICAL/STRUCTURAL ASPECTS OF MODIFICATIONS

- a. Assure that all add-on components are of sufficient structural capacity to accommodate the loads incurred during operation, and have proper fit/function.
- b. Assure that the modifications meet the dimensional constraints defined by the existing chassis and components during both static and dynamic conditions.
- c. Assure that the modifications do not transmit loads to surrounding structural components to the extent they may fail or wear prematurely.
- d. Consideration must be given for the ability of the suspension components and chassis system to absorb and manage road induced and crash energy.
- e. Assure that there is sufficient operating clearance to other components (including the intended wheel and tire selection, and also non-chassis/suspension related components such as brake cables and hoses, wiring, wheel wells, etc...) throughout the full range of suspension and steering travel.
- f. If track width and/or wheelbase dimensions have been changed, assure that all affected components will function properly in the new configuration, (including driveshafts and splines, brake cables and hoses for wheelbase length; axle shaft loads, axle/wheel bearing loads, and balljoint structure for track width).
- g. Assure that chassis or driveline components have not been forced beyond normal operating limits (examples: tie rod end/balljoint stud articulation, CV joint operating angle)
- h. Assure that wheel alignment (static and/or dynamic) can be adjusted to minimize tire wear and handling compromises.
- i. It is recommended that component loads be determined through analysis, and confirmed with vehicle and/or laboratory testing. Parts should be life-tested to ensure adequate structural and wear durability.

3.1.2 HANDLING AND STABILITY ISSUES

- a. Make an assessment of the degree to which the modifications alter the handling and stability characteristics of the vehicle under varying load conditions, from curb weight plus driver, to full GVWR\GAWR, under steady state and transient conditions.
 1. Understeer, oversteer, steering response, directional stability
 2. Bump steer, roll steer, compliance steer
 3. Acceleration and braking performance (squat and dive)
 4. Cornering capacity (high lateral g conditions)
- b. Assure that the modifications do not compromise suspension compliance and tire/road surface contact capability through the range of suspension travel in jounce and rebound, and under varying road surface conditions.