



SURFACE VEHICLE RECOMMENDED PRACTICE	J1301™	JUN2022
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Superseding J1301 FEB2017		
Truck Deformation Classification		

RATIONALE

Five-Year Review of this standard. Updated for current industry nomenclature, formatting, and clarification.

1. SCOPE

The scope and purpose of this SAE Recommended Practice is to provide a classification system for deformation sustained by trucks involved in collisions on the highway. Application of the document is limited to medium trucks, heavy trucks, and articulated combinations.¹

The Truck Deformation Classification (TDC) classifies collision contact deformation, as opposed to induced deformation, so that the deformation is segregated into rather narrow limits or categories. Studies of collision deformation can then be performed on one or many data banks with assurance that data under study are of essentially the same type.²

Many of the features of the SAE J224 MAR80 have been retained in this document, although the characters within specific columns vary. Each document must therefore be applied to the appropriate vehicle type. It is also important to note that the TDC does not identify specific vehicle configurations and body types.

The TDC is an expression, useful to persons engaged in vehicle safety, to appropriately describe a collision-damaged truck with conciseness in oral and written communications. The TDC is also a research tool; however, it has not been designed for use in impact energy computation. The research community is cautioned not to attempt direct conversion calculations from the TDC to energy equivalents required to duplicate the damage.

The system consists of seven alphanumeric characters arranged in a specific order to form a descriptive composite of the vehicle damage (see Figure 1). The characters describe the principal force direction, location, specific area, type, and extent of damage.

The individual character positions are referenced by column number for identification. The definition of each classification is provided in subsequent sections.

¹ For cars and light trucks, refer to SAE J224.

² Stonex, K., Nelson, W., Siegel, A., Garrett, J., et al., "Collision Damage Severity Scale," SAE Technical Paper 700136, 1970, doi:10.4271/700136.

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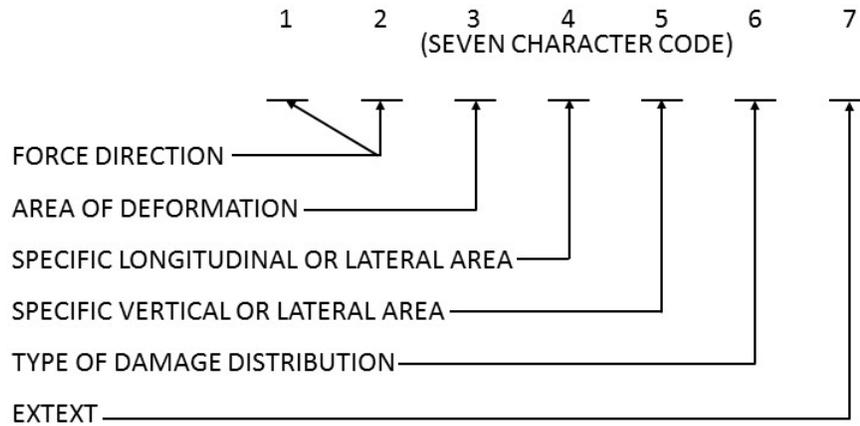


Figure 1 - Classification character codes

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J224 Collision Deformation Classification

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

Stonex, K., Nelson, W., Siegel, A., Garrett, J., et al., "Collision Damage Severity Scale," SAE Technical Paper 700136, 1970, doi:10.4271/700136.

Hendricks, D., "Collision Deformation Classification for Trucks," SAE Technical Paper 810215, 1981, doi:10.4271/810215.

2.2.2 Other Publications

Hendricks, D.L., "Collision Deformation Classification Training Program: Intermediate Level Training/Reference Module." Calspan Field Service, Inc., NHTSA DOT HS-806-061, July 1981.

3. CLASSIFICATION OF COLLISION DAMAGE

3.1 General Guidelines

A TDC is assigned to each impact sustained by the vehicle. Since many configurations are found in over-the-road vehicles, the guidelines which follow define the number of classifications to be assigned for a single continuous impact involving both the power unit and/or trailer(s).

As a general rule, articulated combinations should be treated as a single vehicle, utilizing one TDC, rather than assigning separate classifications to the power unit and trailer(s). Rollover events are classified with one TDC even though separation of one or more of the units occurs during the rollover.

Individual classifications may be assigned to each unit of multiple-unit vehicles involved in single continuous impacts. Contact damage on one or more of the units must be from the same impact as follows:

- a. Intra-unit damage, such as that generated by a jackknife or fifth wheel failure.
- b. Multiple unit articulated combinations with damage extending beyond the first trailer or cargo area.
- c. Cases where the trailer separates from the tractor prior to collision/rollover.

Damage to exposed cargo being transported by a heavy truck resulting from a collision with another vehicle or object, without direct contact to the heavy truck or trailer, shall be classified 999999X, even though the impact resulted in induced damage to the truck or trailer, or injury to an occupant.

3.2 Unknown Classifications

If the damage pattern resulting from a specific impact is not defined, the TDC “9999999” is assigned as an unknown classification. Whenever a portion of the classification is unknown, the entire classification is considered unknown, and “9999999” is used.

The vehicle must have been inspected and/or photographed to be classified. Estimations of classifications from police reports, third-party descriptions, etc., are not permissible due to the possible inaccuracies associated with the estimates.

4. REFERENCE SYSTEM

Truck collision damage is classified in a three-dimensional system. Column 3, location of deformation, defines an orthogonal set of axes for columns 4, 5, and 7 (as summarized in Figure 2). Columns 1, 2, and 6 provide additional description. The concepts of left, right, forward, back, etc., are always referenced from the driver’s position, irrespective of the direction from which the vehicle is viewed.

Column 3 Classifications	Column 3 Projected Plane	ORTHOGONAL AXES		
		Column 4	Column 5	Column 7
F, B, D, C, or V	Lateral- Vertical	Lateral	Vertical	Longitudinal
L or R	Longitudinal- Vertical	Longitudinal	Vertical	Lateral
T or U	Horizontal	Longitudinal	Lateral	Vertical

Figure 2 - Reference system

4.1 Columns 1 and 2: Direction of Principal Force

The available codes in columns 1 and 2 are 00, 13, and the hour sectors from 01 to 12 (see Figure 3). Each hour sector contains 30 degrees of the 360 degree clock face. A specific hour designation contains all resultant force directions of origin which are within 15 degrees to the left or right of the indicated hour value, as shown in Figure 3.

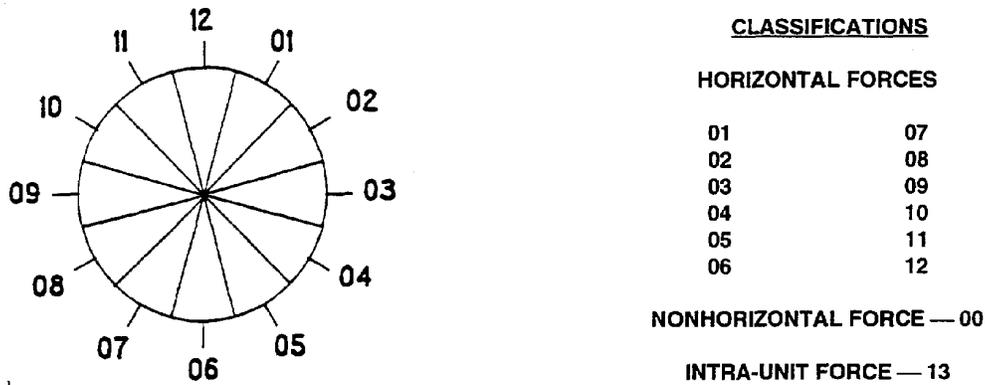


Figure 3 - Direction of principal force (columns 1 and 2)

The entry “00” indicates the impact is not horizontal. This classification should be used whenever the resultant force direction is more than 15 degrees above or below the horizontal plane of the vehicle.

A “13” classification indicates the contact damage generated by an event was intra-unit, such as a jackknife or fifth wheel failure. This entry signifies more than one unit has been damaged. Each of those classifications will be coded with a “13.” The “13” is not used for load shifts and similar phenomena.

4.2 Column 3: Location of Deformation

This character identifies the projected plane of the vehicle which contains the deformation. Valid codes are illustrated in Figure 4 and shown in Table 1.

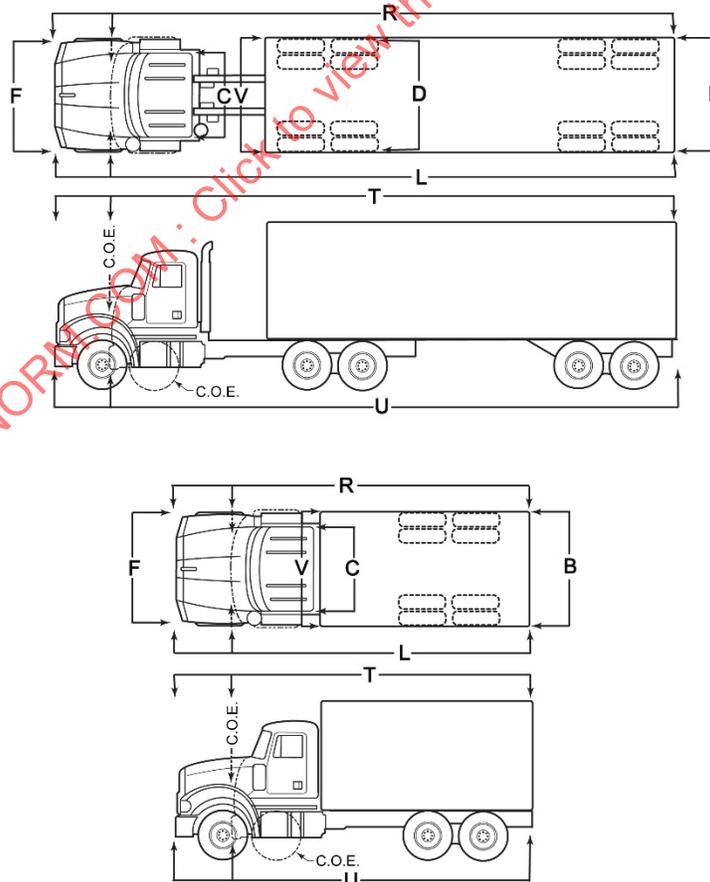


Figure 4 - Location of deformation (column 3)

Table 1 - Location of deformation (column 3)

Location	Classification
Front	F
Right side	R
Left side	L
Back of unit with cargo area (rear of trailer or straight truck)	B
Back (rear of tractor)	D
Rear of cab	C
Front of cargo area	V
Top	T
Undercarriage	U

Characters F, R, L, B, D, C, and V are used to define damage to vertical surfaces of the vehicle. These surfaces are often irregularly shaped. Therefore, specific characters are appropriate for classifying certain damage patterns.

Override impacts where a portion of the truck structure intrudes over the basic structure of the other object or vehicle require the appropriate end or side classification for column 3, and a specific override character in column 6.

The F projected area for horizontal force applications includes the windshield and items which are an integral part of the top surface of the cab.

Tubular shaped cargo areas, such as tankers, project in both longitudinal-vertical (L or R) and horizontal planes (T). However, for purposes of uniform classification, these areas are considered to be in the longitudinal-vertical plane and damage on these surfaces is classified with L or R.

The D character is used for the rear area of tractors with or without trailers. The B character is used for the rear area of units with cargo areas (rear of trailer or straight truck). Neither of these characters are used if the damage is limited to the rear of the cab area.

Characters C and V are used to designate damage to the rear of the cab and the front of the cargo area or trailer, respectively. These areas may include intra-unit damage.

The T character is defined as the top plane of the vehicle. This classification would be used whenever the top plane is involved and the resultant principal force direction is nonhorizontal.

The U character is defined as the bottom plane of the vehicle (undercarriage), including all projections, but excluding the tires and wheels. This classification is used whenever the appropriate area is involved and the resultant principal force direction is nonhorizontal.

Impacts involving only the tires or wheels are classified F, R, L, B, or D in column 3 as determined by the projected area of initial contact.

Angular horizontal impacts (45 degrees), initially involving the corner, should be classified F, R, L, B, D, C, or V in accordance with the following guidelines (listed in a descending order of priority):

- a. If the projected area of initial contact can be determined, use the appropriate character.
- b. If the projected area of initial contact cannot be determined, use the principal force direction to determine the appropriate character. If the horizontal force direction is less than 45 degrees from the 12 o'clock or 6 o'clock directions, use F, B, D, C, or V. If the horizontal force direction is greater than 45 degrees, use R or L.
- c. If the force direction cannot be determined with sufficient accuracy, use the projected area of greatest direct contact to determine the appropriate character. If the length of contact across the front or rear of the unit exceeds the length of contact along the side, use F, B, D, C, or V, respectively. Use R or L if the length of contact along the side is greater.

In rollover configurations, one TDC is assigned for rollover damage regardless of the number of revolutions or surfaces damaged during the rollover. The recommendations for the selection of the appropriate character for column 3 are as follows:

- a. The first consideration is the selection of the surface or projected area with the greatest crush rather than the initial contact.
- b. If equal crush or equivalent damage exist on two or more surfaces, the selection will be made on the basis of the following recommendations (listed in the order of descending priority).
 1. The surface which involves damage to the cab or occupant perimeter generally denoted by P in column 4.
 2. The damaged surface of initial contact.
 3. The angle of force in a vertical plane producing the damage at the corner to the surfaces. For example, select T if the force direction is downward and within ± 45 degrees from the vertical axis. Select U if the force direction is upward and within ± 45 degrees from the vertical axis. Other nonhorizontal angles of forces between the limits described in this paragraph require the selection of L or R for side rollovers or F or B in cases of unusual end-over-end rollovers.
 4. The projected area of largest contact. If the deformation area on the left or right side exceeds the deformation area on the top, use L or R, respectively. Use T if the deformation area is larger on the top.

4.3 Column 4: Specific Longitudinal or Lateral Area

The codes refer to either the longitudinal or lateral areas of the vehicle as listed in Table 2 and illustrated in Figure 5.

Table 2 - Specific longitudinal or lateral area (column 4)

Areas of Vehicle	Codes
End (front or rear)	
Left	L
Center	C
Right	R
Side (left or right, top or bottom)	
Front (forward of windshield)	F
Cab	P
Rear of cab in front of semitrailer	W
Tractor (P+W)	K
Tractor (F+P+W)	S
Rear of cab to rear of trailer or cargo area	B
Trailer	T
Side or end	
F+P or L+C	Y
B+P or R+C	Z
Distributed (F+P+B or L+C+R)	D

The plan view of the vehicle, provided in Figure 5, illustrates the horizontal areas listed in Table 2 to be used in classifying deformation location. The letters illustrated at the end of the vehicles in Figure 5 are used for any end area for all appropriate vehicle types.

The letter characters shown at the sides of the vehicles are used for either side, or if T or U are used in column 3.

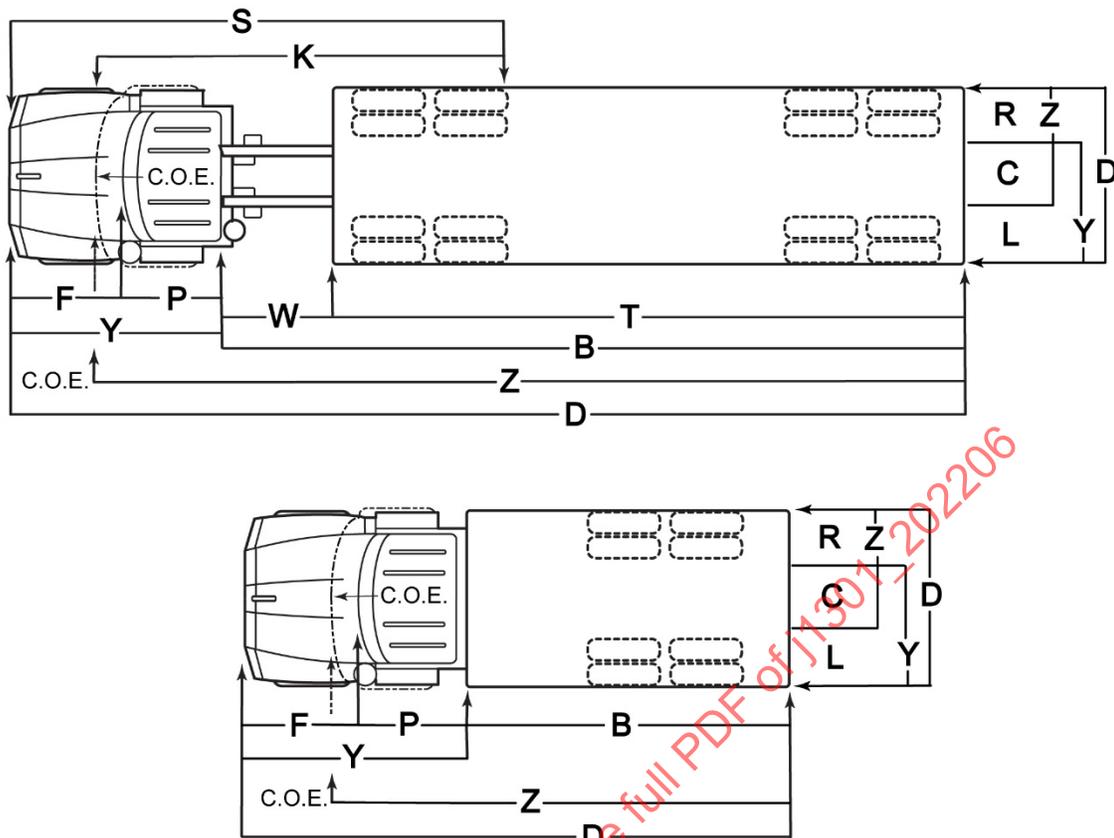


Figure 5 - Specific longitudinal or lateral area (column 4)

4.3.1 End Characters

Used with F, B, D, C, or V in column 3, where:

L, C, and R—Equal thirds of lateral width of vehicle.

Y—Left portion of vehicle (comprising all or part of both C and L).

Z—Right portion of vehicle (comprising all or part of both C and R).

D—Distributed lateral damage patterns involving C and all or part of both R and L.

4.3.2 Side Characters

Used with R, L, T, or U in column 3, where:

F—Damage area forward of the base of the windshield. F is not used for cab-over-engine configurations.

P—Occupant compartment involvement and may include a sleeper berth.

W—Damage in the area extending from rear of cab to front of semitrailer.

K—Damage in the area extending from base of windshield to rear of tractor chassis (comprising all or part of both P and W).

S—Distributed damage patterns involving side area of conventional tractors.

B—Damage in the area extending from rear of cab to rear of cargo area or semitrailer (for tractor-semitrailer combinations the damaged area must include part of both the W and T areas).

T—Longitudinal damage pattern on side of the trailer unit(s).

Y—Damage pattern involving all or part of both F and P areas. (Not used for cab-over-engine configurations.)

Z—Damage pattern involving all or part of both B and P areas. (For cab-over-engine configuration, this character is used to indicate a distributed damage pattern.)

D—Distributed damage patterns involving side area of conventional tractors with semitrailer(s) or trucks.

4.4 Column 5: Specific Vertical or Lateral Area

Classifications for this column refer to codes along either the vertical or lateral axis of the vehicle and are orthogonal to column 4. Valid classifications are shown in Figure 6 and are listed in Table 3 for tractors and power units and Table 4 for cargo areas and trailers.

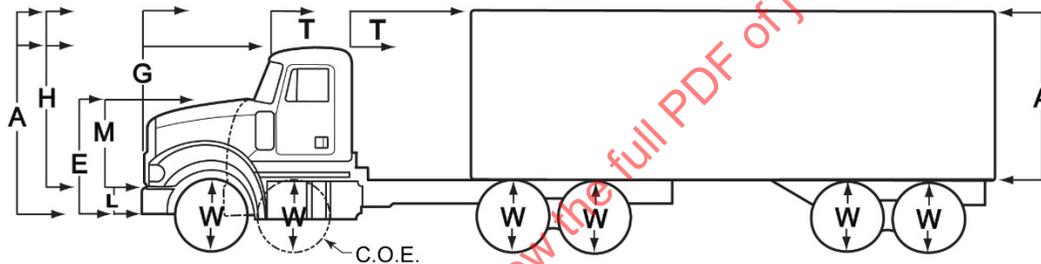


Figure 6 - Specific vertical area (column 5)

Table 3 - Specific vertical areas for tractors and power units (column 5)

Vertical Location—Front, Rear, or Side Impacts	Classification
Top of vehicle to bottom of vehicle exclusive of wheels	A
Top of frame to top of vehicle	H
Everything above cab	T
Belt line and above	G
Belt line and below	E
Middle—Top of frame to belt line or hood	M
Low—Top of frame, frame, and bottom of frame (including undercarriage)	L
Wheels and tires only (excluding undercarriage)	W

Table 4 - Specific vertical areas for cargo areas and trailers (column 5)

Vertical Location—Front, Rear, or Side Impacts	Classification
Top of vehicle to bottom of vehicle exclusive of wheels	A
Belt line and above	B
Belt line and below (including undercarriage)	F
Wheels and tires only (excluding undercarriage)	W

4.4.1 Vertical Location Characters

Used with F, R, L, B, D, C, or V in column 3. For the purpose of this document, the vehicle belt line location is defined as follows:

- Power Unit—The belt line is located at the bottom of the side glass. For unusual side glass or cab configurations, use the steering wheel hub location to define the height of the belt line.
- Trailer/Cargo Area—The belt line is located at the floor height of the unit.

If damage involves both the power unit and the trailer/cargo area, the power unit characters should be used, where:

A—Vertical distance from top of vehicle to bottom of the vehicle.

T—Everything above normal height of cab roofline. (To include lights, wind deflectors, etc.)

4.4.2 Lateral Location Characters

Used with T or U in column 3.

The plan view of the vehicle, provided in Figure 7, illustrates the horizontal areas listed in Table 5 to be used in classifying deformation location. The letters illustrated at the right of Figure 7 are used for either the front or rear (F, B, D, V, C) of all vehicle types.

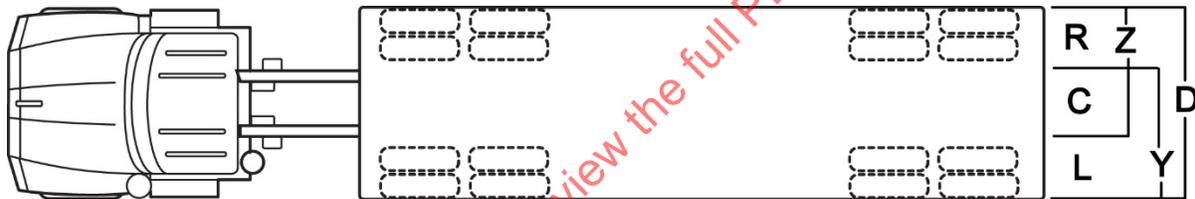


Figure 7 - Specific lateral area (column 5)

Table 5 - Specific lateral areas (column 5)

Lateral Location—Top and Undercarriage Impacts	Classification
Left	L
Center	C
Right	R
L and C	Y
R and C	Z
Distributed	D

where:

L, C, and R—Equal thirds of lateral width of the vehicle.

Y—For left portion of vehicle (comprising all or part of both C and L).

Z—For right portion (comprising all or part of both C and R).

D—For distributed lateral width damage patterns which involve C and all or part of both R and L.

4.5 Column 6: Type of Damage

Definitions of the classifications are provided in Table 6.

Table 6 - Type of damage (column 6)

Type	Classification
Wide impact area	W
Narrow impact area	N
Sideswipe	S
Rollover (including rolling onto side)	O
Overhanging structures (inverted step)	A
Corner	E
No residual deformation	U
Override	R

where:

S—To classify three types of damage: (1) an impact which overlaps corner of the vehicle by 100 mm (4 inches) or less and swipes along the surface, approximately parallel to principal force direction; (2) a classic sideswipe; and (3) a classic endswipe. These damage types are further defined in Appendix A.

A—In column 6 impacts where deformation resulted from an overhanging structure shaped like an inverted step. Both vertical surfaces of inverted step must have contributed to the direct damage.

E—Corner impacts where contact pattern must involve corner and extend for more than 100 mm (4 inches), but not more than 410 mm (16 inches), across end or alongside.

U—Impacts where no residual deformation of the vehicle is noted. An extent code of 1 or A must be used in column 7 with this character.

R—Vehicle overrides, or underrides by, a second vehicle or object.

The use of S, O, A, E, U, and R takes precedence over N and W. N and W distinguish between small and large areas of deformation which do not fall into one of the other six categories. If an area is less than 410 mm (16 inches) wide, or less than 150 mm (6 inches) high, N is appropriate. For small rectangular or circular areas of deformation, if the perimeter is less than 1626 mm (64 inches), use N; otherwise, use W.

4.6 Column 7: Deformation Extent

The extent of residual deformation is classified as shown in Figure 8. A nine-zone numeric system is reserved for the power unit portion of the tractor-semitrailer or straight truck. A four-zone alphanumeric system is reserved for the trailer/cargo area. Guidelines for the alphanumeric system are provided in Table 7:

Table 7 - Deformation extent for cargo area or trailer

Deformation Extent	Range of Extent
A	Crushing or shifting of structural members or rear axle assembly up to the limit of 410 mm (16 inches). Puncturing side walls or top up to 410 mm (16 inches) in diameter.
B	Crushing or shifting of structural members, or the rear axle assembly, greater than 410 mm (16 inches), and not exceeding 810 mm (32 inches). Puncturing of the sidewalls or top greater than 410 mm (16 inches) and not exceeding 810 mm (32 inches) in diameter. Also included are sidewall seam (joint) failures, providing that not more than two seams are involved. Trailer or cargo area bowing is limited to a maximum of 200 mm (8 inches).
C	Any damage above the limits of B providing that no more than 25% of the sidewall/top areas are punctured or torn open. Trailer or cargo area bowing is limited to a maximum of 410 mm (16 inches).
D	All damage above the limits of C to total destruction of the trailer/cargo area.
X	May only be used when all the preceding characters are nines as described in 3.1.

Undercarriage extents for the power unit portion of a tractor-semitrailer or a straight truck relate to zones of the same size as illustrated in Figure 8; however, the numbering order is reversed. For example, the three equal zones, 8, 7, and 6 become 2, 3, and 4.

The nine-zone numeric extent guide is used when damage overlaps both the power unit and the cargo area. Priority is assigned to the power unit. However, if involvement of the power unit is minimal the four-zone alphanumeric extent guide may be used to describe damage to the trailer/cargo area.

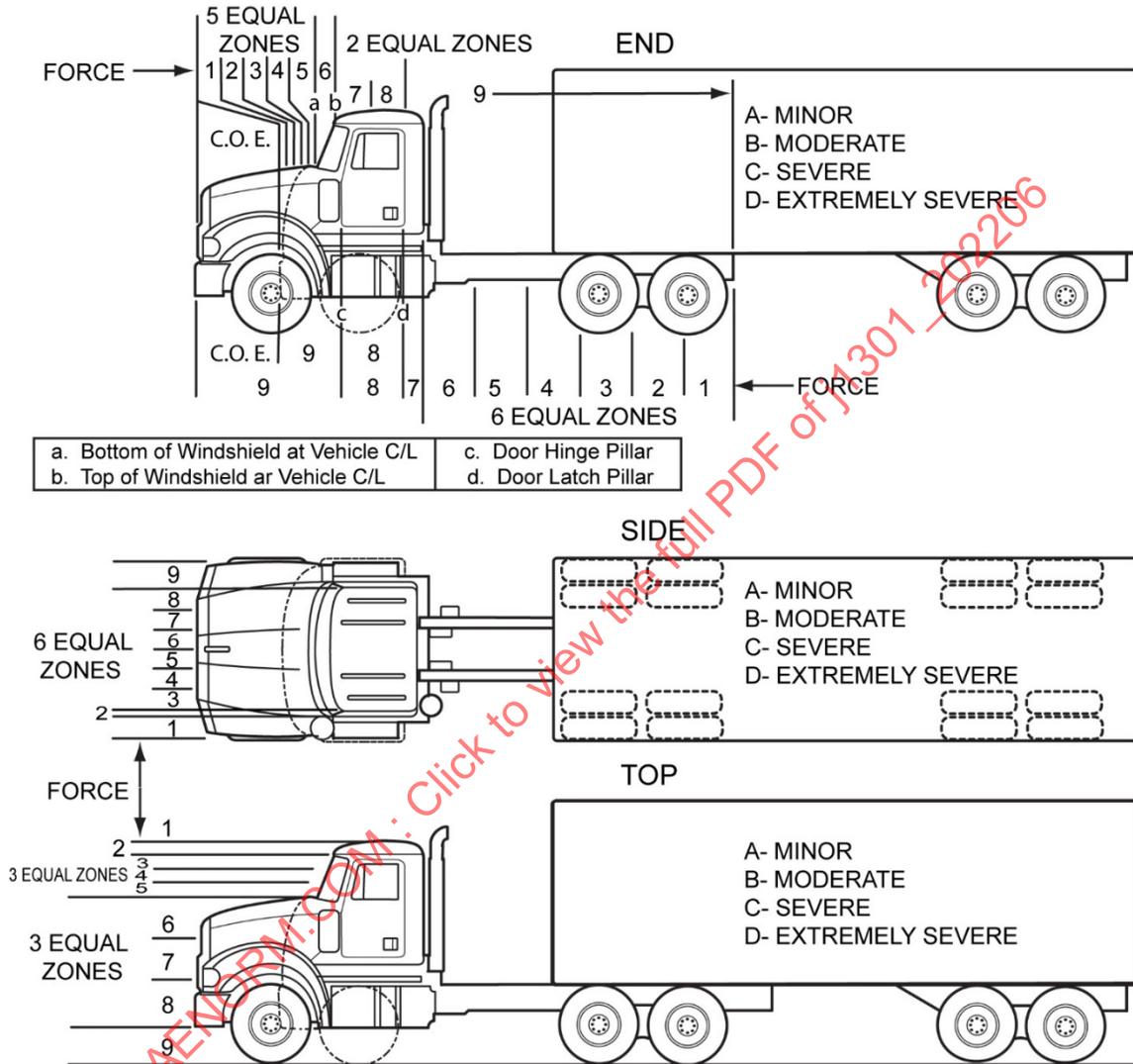


Figure 8 - Deformation extent guide (column 7)

5. NOTES

5.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

APPENDIX A

PREFACE

This appendix is supplemental to SAE J1301 and is intended as an aid to using SAE J1301 and to promote uniform interpretation of difficult or commonly misused classifications. Subdivisions of this appendix are numbered to correspond with sections of this SAE Recommended Practice and does not include all possible situations which can occur in the field. This SAE Recommended Practice, therefore, is the final document from which all classification decisions should be made.

Appendix sections contain cautionary notes to the users at the end of each section pertaining to codes for that column of the TDC expression. These notes will help when damage patterns result in evaluations which tend to lead to subjective classifications. Since TDC classifications are a descriptive composite of the damaged vehicle, the user is also cautioned not to separate code or column features. The latter practice very often results in inadvertent errors. For example, in searching for the Fs in column 3, the user may assume that since the frontal area of the vehicle is involved, all occupant kinematics will be parallel to the longitudinal axis of the vehicle. However, the F character in column 3 does not preclude lateral forces (for example, 9 o'clock) which can cause occupant kinematics to become lateral, rather than longitudinal.

A.1 SCOPE AND PURPOSE

It is important to note that vehicle damage specified for classification in SAE J1301 is limited to contact damage as opposed to induced damage. Contact damage is defined as all damage sustained by the vehicle while physically touching or in contact with the striking/struck, object/vehicle. Induced damage is all damage sustained beyond the limits of the contact area (that is, all noncontact damage).

The primary reason for not including induced damage in the classification system is to maintain uniformity of reporting techniques. The criterion of using contact damage has been included in SAE J1301 in order to maintain continuity with SAE J224 and previous classification systems. It is extremely important that data collected in current and future studies have a firm basis of comparability, over time, with previous studies.

A.2 REFERENCES

This document has evolved over the years through the SAE publications listed in Section 2.

A.3 CLASSIFICATION OF COLLISION DAMAGE

To obtain a more complete understanding of the intent of the classification system, it may be of assistance to visualize the vehicle as being contained within or surrounded by a rectangular box, or in the case of an articulated vehicle, in a series of boxes. Impacts are classified according to the sides or planes of the box onto which they are most appropriately projected. For example, the two ends of the vehicle (that is, the front and the rear) are contained within lateral vertical planes of the box(es), the two sides within longitudinal vertical planes, and the top and undercarriage within horizontal planes. Column 3 of the classification system specifies which plane of the box is involved. An F character in column 3, therefore, indicates the frontal, lateral-vertical plane.

A.4 REFERENCE SYSTEM

Truck collision damage is classified in a three-dimensional system.

A.4.1 Direction of Principal Force

These characters of a TDC expression define the force which produced the deformation pattern classified in the remaining columns. Definition, however, is related to the direction of principal force, rather than the magnitude of force. A paradox arises, in that the direction of principal force is an analytical quantity, usually determined on a somewhat subjective basis. This is resolved by providing direction of principal force classifications containing 30 degree increments rather than smaller and more precise increments. A knowledge of vector addition is helpful for making direction-of-principal-force determination.

A.4.1.1 Application and Example

Although classifiers³ generally do not calculate principal force direction assignments, it is important to understand the basic theory associated with columns 1 and 2. A brief theoretical discussion is provided as follows, followed by a discussion of how principal force direction is determined in the field.

Theory—The force assessments used with TDC are vector quantities. That is, they are the resultant of all impact forces acting on the vehicle during the contact sequence. As vector quantities, impact forces have both magnitude (algebraic product of Mass x Acceleration) and direction. With respect to force analysis, these properties may be represented by scaled linear arrows. The length of the arrow indicates the magnitude of the force and its orientation represents the direction of force.

The length of the impact force arrows for a large truck and a small car sustaining the same acceleration would be considerably different due to the mass (weight) differences. Likewise, two vehicles of equal mass but different accelerations would have impact force arrows of different lengths proportional to the accelerations.

Figure A1 demonstrates simplistic vector analysis for a typical 90 degree intersection impact. Note that the required computations are not shown. Assume that all force arrows are correctly scaled representations of the magnitude of force produced.

Schematic “a,” in Figure A1, depicts the impact configuration (zero steer angle and tracking characteristics are assumed for both vehicles). Schematic “b” demonstrates parallelogram analysis of the forces exerted on Vehicle #1 and #2 during the impact sequence. In each case, F_N is the component of force which acts normal to the contact surface, while F_T is related to the frictional or pocketing interaction at the contact surfaces. The arrows or vectors F_{R1} and F_{R2} are the resultant forces acting on Vehicle #1 and #2, respectively. Note that the equilibrant to the resultant on one vehicle is also the resultant for the other vehicle. Both vehicles respond to these forces; that is, the vehicles follow post-impact trajectories determined or influenced by the resultant directions of force (assuming that snagging and spinout phenomena are minimal).

The quantities F_{R1} and F_{R2} are shown in schematic “c” as they apply to each vehicle. The angular position of the arrow is determined by acceleration characteristics of both vehicles. It can be rotated in either a clockwise or counterclockwise direction by altering these characteristics for the respective vehicles. The direction of the forces F_{R1} and F_{R2} are coded in TDC classifications for these vehicles (after translation to the appropriate 30 degree sectors of the clock face).

Note that, in schematics “b” and “c,” the resultant forces acting on Vehicle #1 and #2 are equal in magnitude and opposite in direction. In any given impact sequence involving two vehicles, the resultant directions of force must be collinear, that is, the resultant principal force directions must be 180 degrees opposed. Although these statements represent extensive simplification of complex events, they are merely a restatement of Newton’s Third Law. For the purpose of achieving uniform TDC applications, the concept of collinearity must be maintained.

³ Classifiers are those who originate the TDC as opposed to “users” who work with completed TDC descriptions.

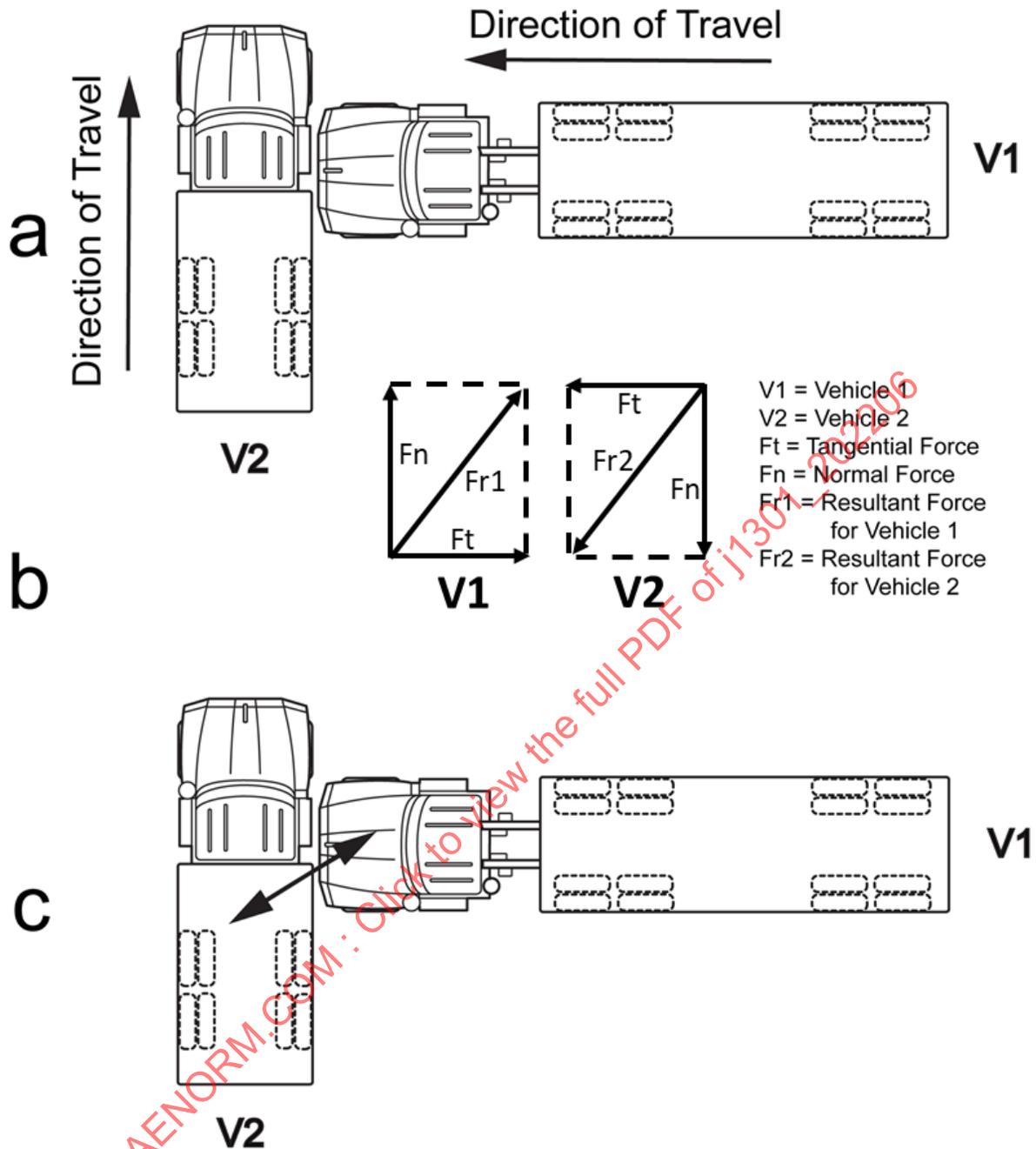


Figure A1 - Vector analysis

Application—It is difficult to compute accelerations during vehicle field inspections or if all the accident-involved vehicles are not available. Resultant directions of force are therefore assigned to each vehicle on the basis of subjective evaluations. The investigator, however, should examine all available input to assure the highest possible accuracy for force assignments. Indicators of the principal force direction are available in each area of investigation in the following respects:

- a. Human—Occupants respond to the resultant direction of principal force acting on the vehicle. Documentation of occupant trajectories therefore allows assessment of the relative principal force direction (i.e., 180 degrees opposing to the occupant path of travel). Caution is required when determining the effects of post-impact vehicle rotation. It is possible the vehicle may have rotated before the occupant struck an interior surface, or was arrested by the occupant restraints.