U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL ACCIDENT SAMPLING SYSTEM

FIELD TECHNIQUES

IV
CRASH MEASUREMENTS

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PREFACE

This manual and its accompanying slide-tape package are part of a self-instructional training program. The purpose of the program is to introduce the user to the fundamentals of motor vehicle accident investigation. The program content emphasizes basic principles and techniques that underlie or are required for the conduct of field case studies in the National Accident Sampling System (NASS) of the National Highway Traffic Safety Administration, U.S. Department of Transportation.

The NASS program contains an extensive schedule of formal training. The present self-study system, however, is intended to be used by new or replacement personnel who join the program at times when the formal training cycle is not scheduled. The system is also useful for skill enhancement by existing NASS field researchers, and as an overview for middle and upper level management personnel.

These training modules are administered as deemed appropriate by NHTSA and the NASS Zone Centers which provide field training, quality control, and middle echelon management for the NASS program.

DIRECTION OF PRINCIPAL FORCE

27 The o'clock direction of principal force (DPF)* occupies the first two columns of the CDC. The CRASH program converts o'clock DPFs to degrees of angle from the longitudinal axis of the vehicle. In addition, there is a provision in the program for a more precise estimate of the direction of principal force.

O'CLOCK AND DEGREE MEASURES OF DPF

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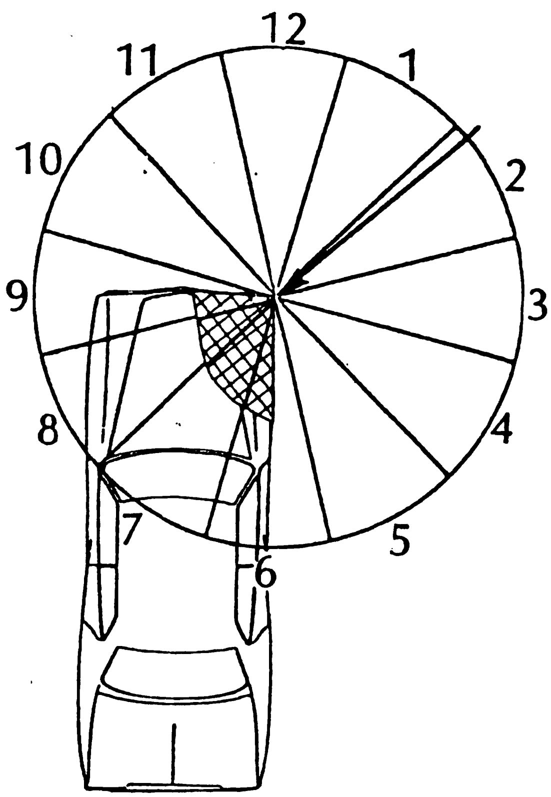

FIGURE 3: Clockface and DPF arrow on vehicle with right front damage

When we speak of the principal force, we are talking about the resultant sum of the major impact forces. In the CDC, the direction of that resultant force is specified in reference to the face of a clock. In Figure 3, we see a diagram of a vehicle with deformation to the right

*Sometimes abbreviated PDQF (principal direction of force) or *DOPF* (direction of principal force).

front corner. We have placed a clock face over the deformation. Twelve o'clock on the clock face is oriented toward the front of the vehicle. The center of the clock face is placed at the point of the application of the impact force. The DPF arrow points to the center of the clock face. The force is from the 2 o'clock sector of the clock face. The code for Columns 1 and 2 of the CDC would be 02.

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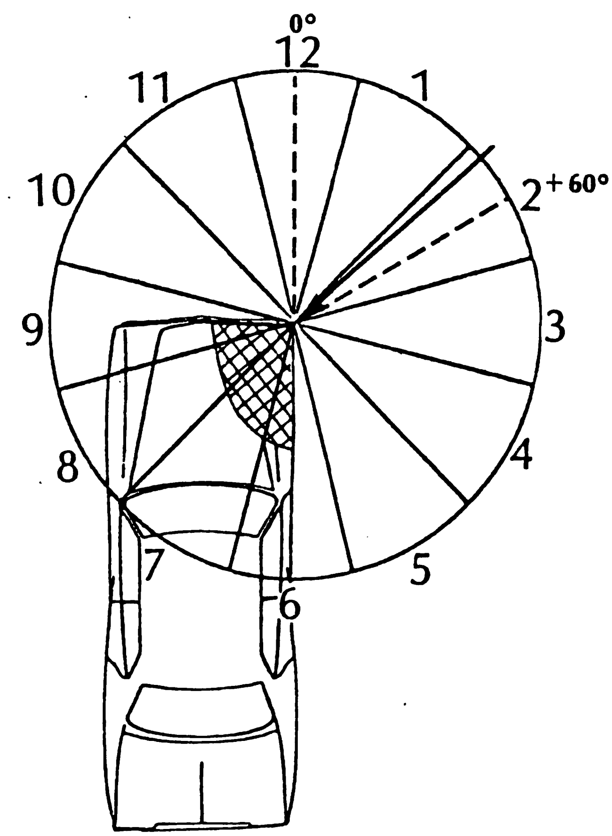

FIGURE 4: Vehicle and clockface with mid-point of 2 o'clock sector indicated

The CRASH program automatically converts the o'clock direction of principal force to a degree value. Our 2 o'clock DPF from the CDC would be converted to +60°. Any DPF within the 2 o'clock sector would be converted to the degree equivalent of the mid-point of the sector. The mid-point of the 2 o'clock sector is +60° from straight ahead.

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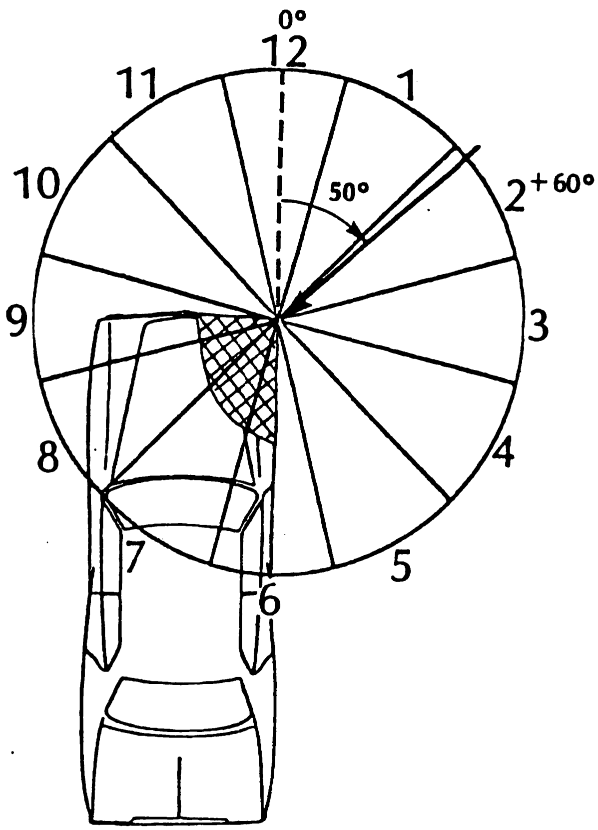

FIGURE 5: DPF angle measured to be 50°

There is also a provision for entering a more precise estimate of the DPF. Here our DPF is actually about +50° from straight ahead. We can enter +50° as an improved force direction.

You won't always be able to specify the DPF this accurately. If you can specify only the o'clock DPF, the CRASH program will convert the o'clock DPF to the degree equivalent of the mid-point of that sector. In this case, the 2 o'clock DPF would be converted to +60°. If you can specify the DPF more precisely, you can enter the improved DPF — in this case +50° — into the program.

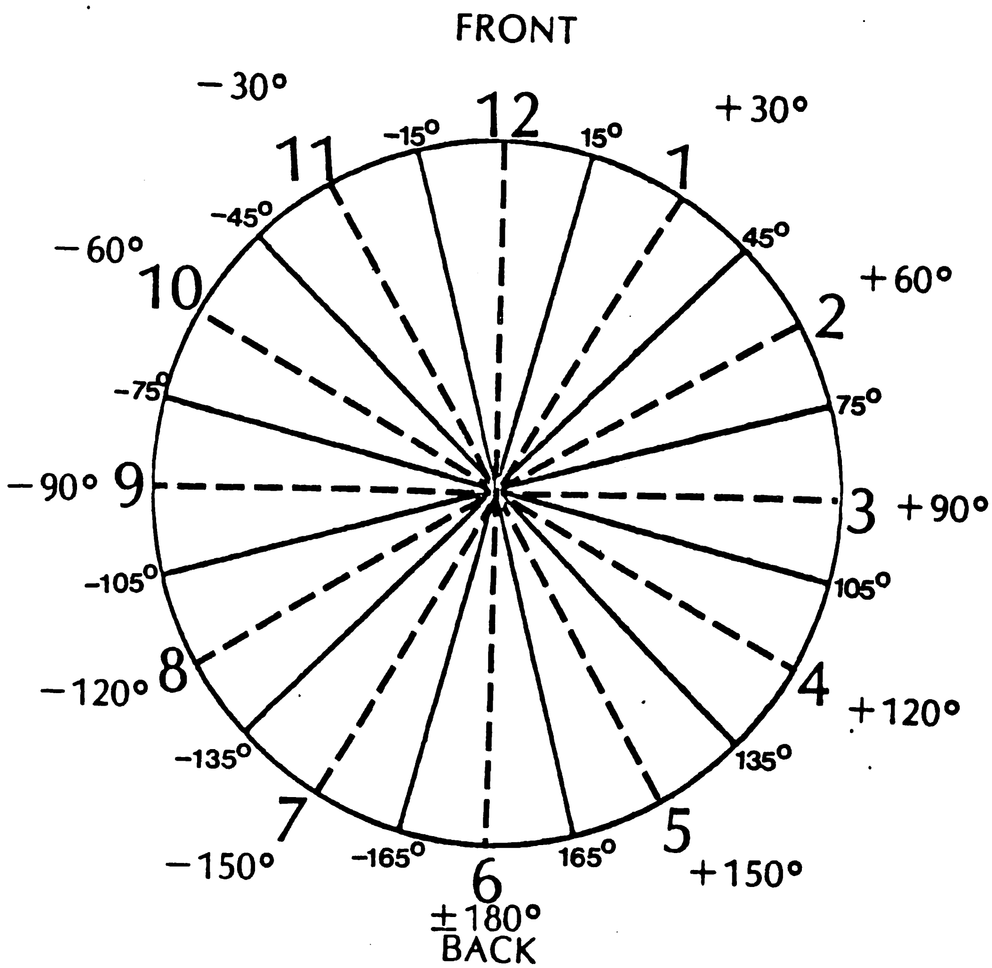

FIGURE 6: Clockface with degree equivalents of mid-points of 12 sectors

There are 360^{o} in a circle and 12 hours on the clock face. 360 divided by 12 is 30. Thus, the hours are spaced at 30^{o} intervals around the clock face. If we think of the mid-point of 12 o'clock as 0^{o}, we can convert the other o'clock DPF values into degrees of angle from 12 o'clock. Hours on the right side of the clock face are given positive values up to $+180^{o}$. Hours on the left side of the clock face are given negative values up to -180^{o}. Note that the mid-point of 6 o'clock can be expressed as either $+180^{o}$ or -180^{o}.

MEASURING THE IMPROVED DPF

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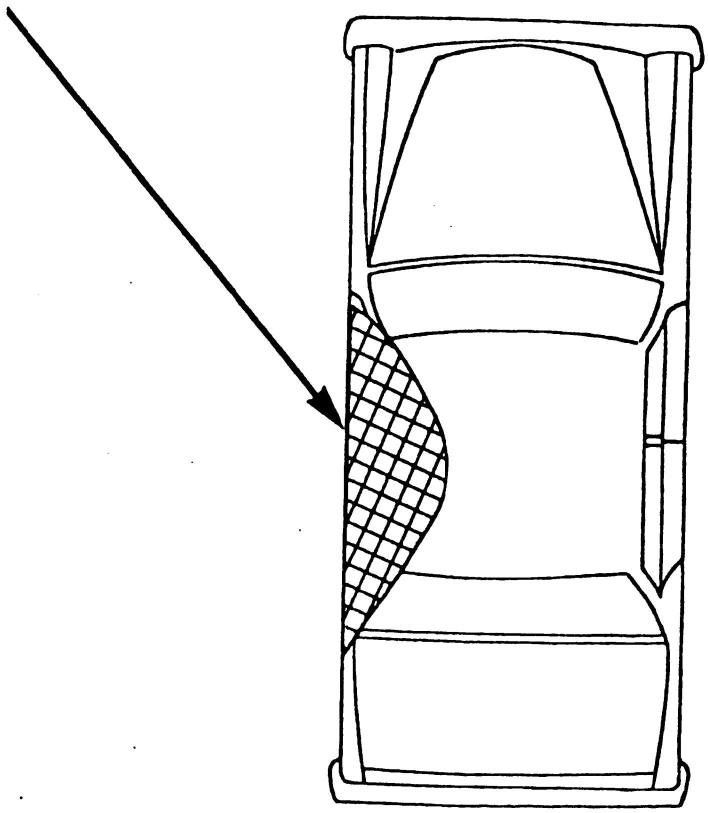

FIGURE 7: Left side damage to vehicle; DPF arrow in 11 o'clock sector

Measuring the o'clock DPF was covered in detail in Module III of this series, Collision Deformation Classification. Here we are concentrating on measuring the improved DPF — the DPF in degrees from straight ahead. The direction of principal force arrow shown in Figure 7 is in the 11 o'clock sector, but we wish to specify a more accurate DPF in degrees.

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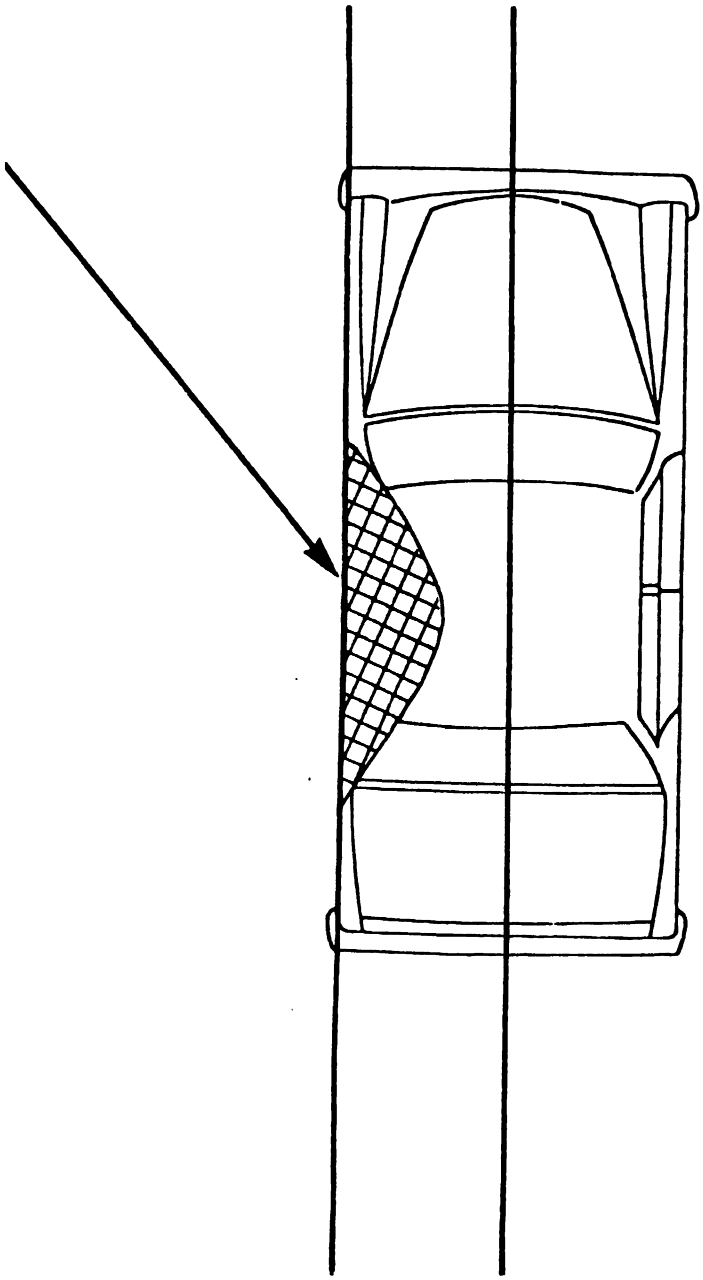

FIGURE 8: Vehicle, DPF arrow, parallel lines for long axis and left side parallel

We are interested in the angle with respect to the front end of the longitudinal (or long) axis of the vehicle. The long axis and a parallel line along the left side of the vehicle are shown here.

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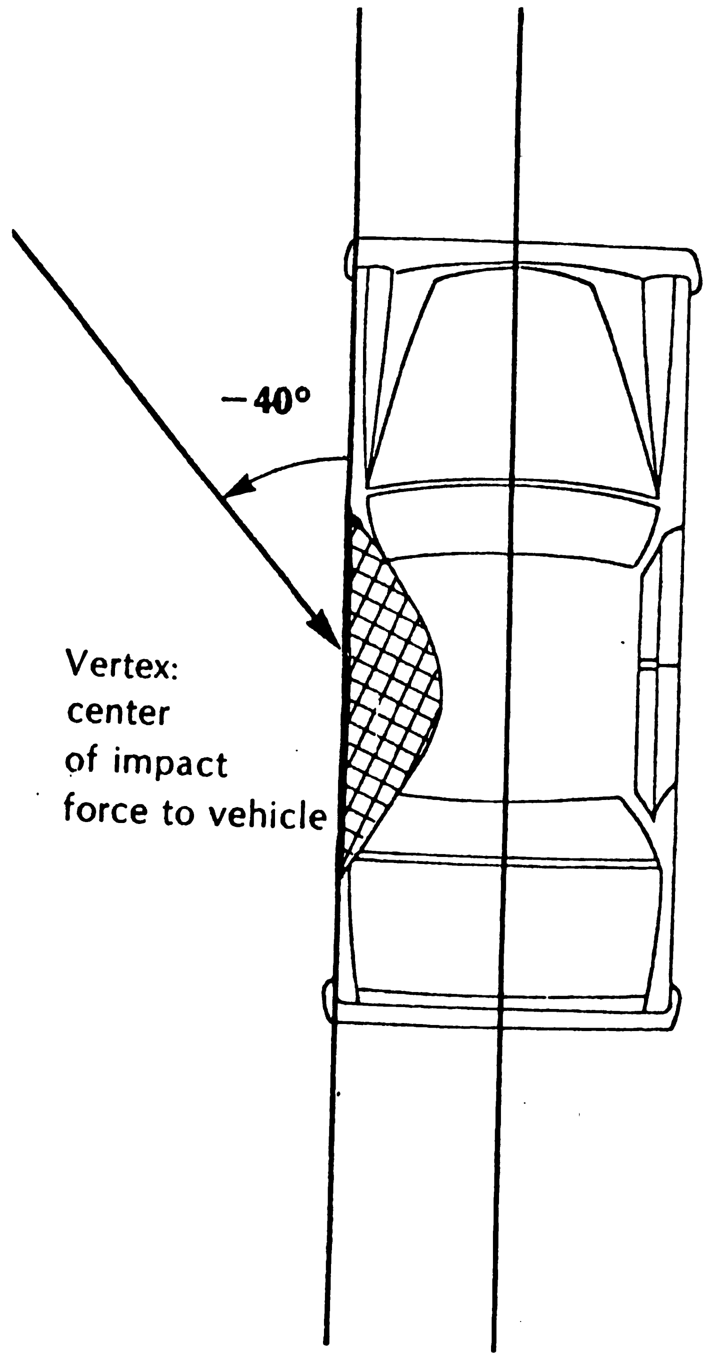

FIGURE 9: Degree measure of DPF arrow (-40°)

We measure the improved DPF from the line parallel to the long axis. The vertex of the angle is the point where the center of the impact force was applied to the vehicle. The angle here is -40°; that is, 40° counterclockwise from the front end of the longitudinal axis of the vehicle.

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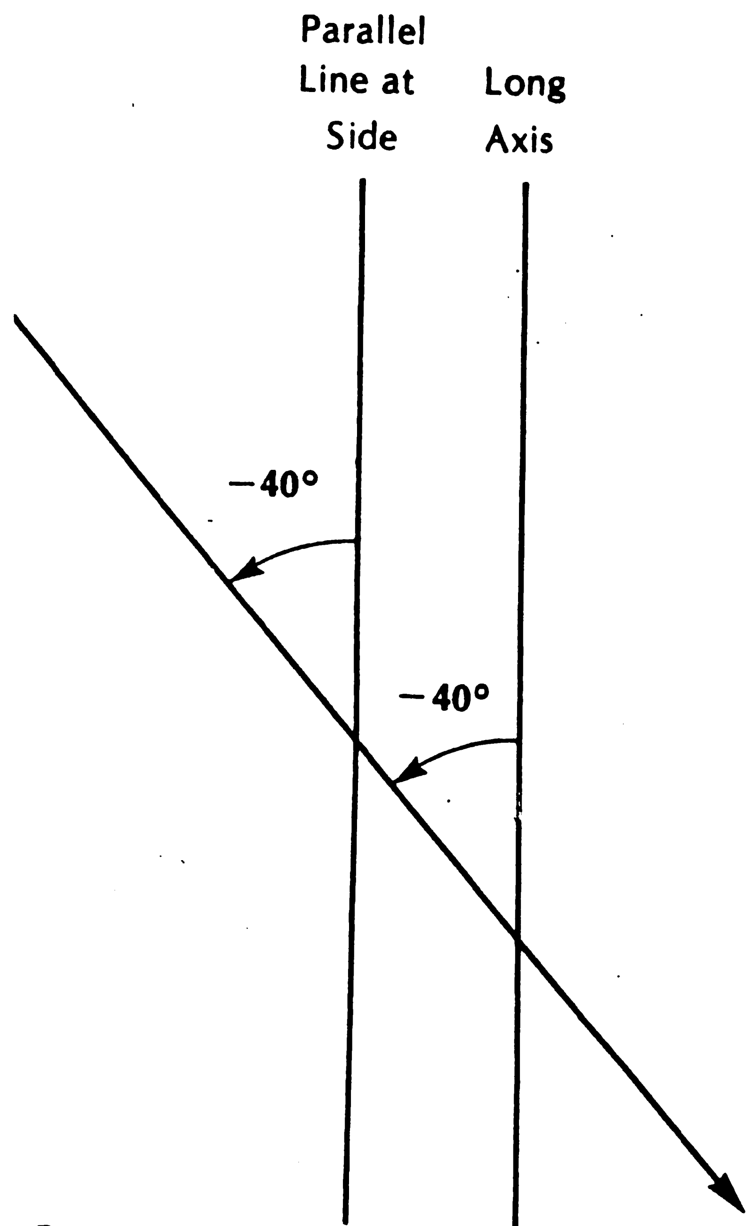

FIGURE 10: Two parallel lines with crossing line at 40° angle with each

Here are the two parallel lines representing the long axis of the vehicle and a parallel line at the left side. The arrow representing our impact force crosses both these parallel lines and forms an angle with each. A basic law of geometry states that the angles formed by the crossing line with each of the two parallel lines will be equal. In this case, both angles are 40°. For the CRASH program they are designated as -40°, since the force is from the left of the long axis.

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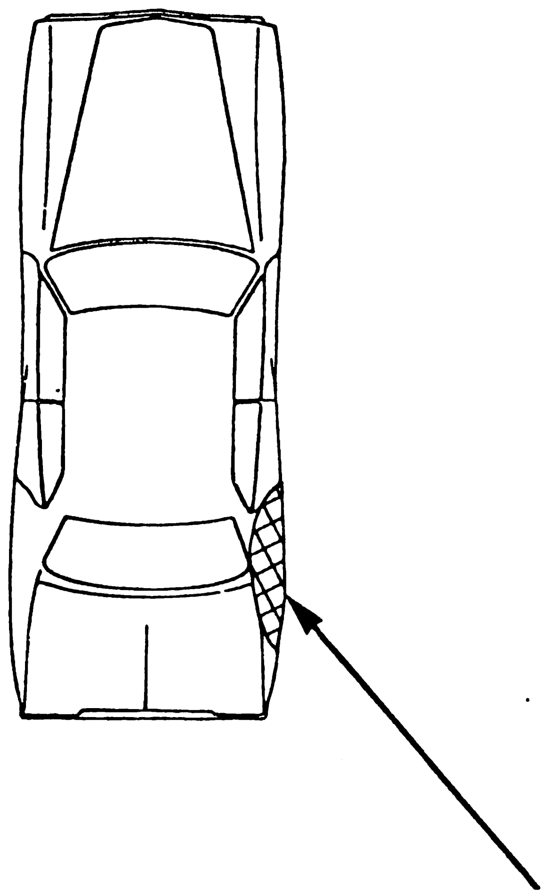

FIGURE 11: Non-rectangular vehicle with DPF arrow

You may be in error if you simply measure the angle of the force with respect to the side of the car. Not all vehicles are rectangular. Thus the sides of vehicles are not always parallel to the long axis.

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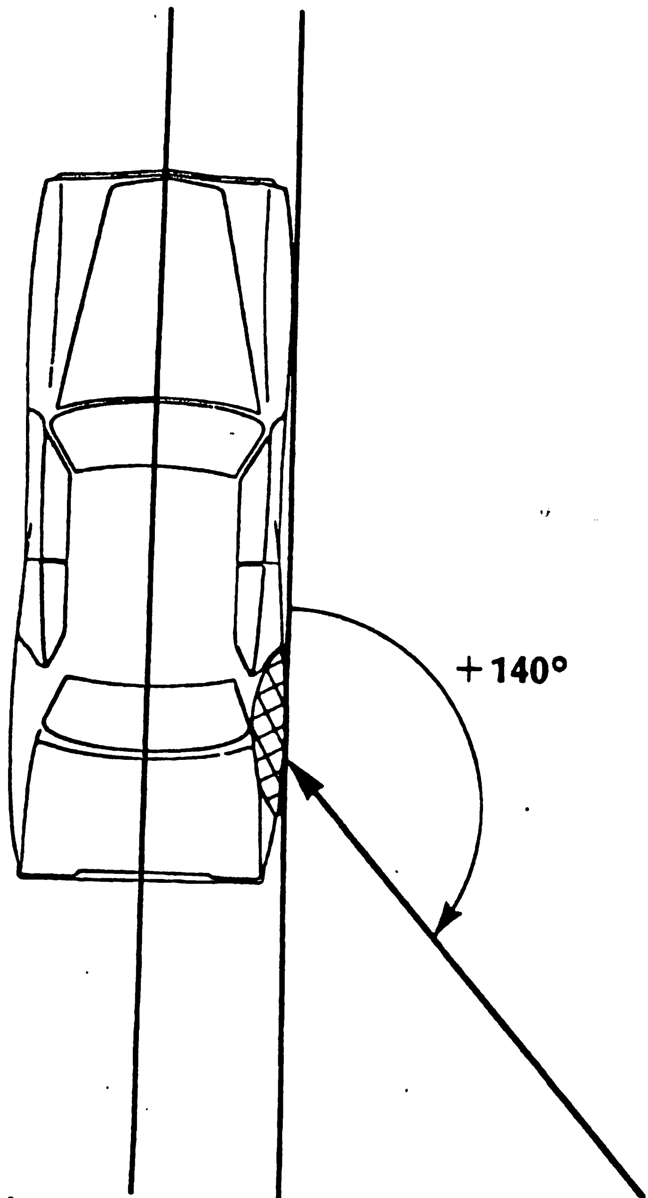

FIGURE 12: Non-rectangular vehicle with measured DPF arrow (+140°)

The correct procedure is to measure with respect to a line parallel to the long axis. The DPF here is +140°. Since the side of the car is not parallel to the long axis, you would be somewhat in error if you simply measured the angle from the side of the car.

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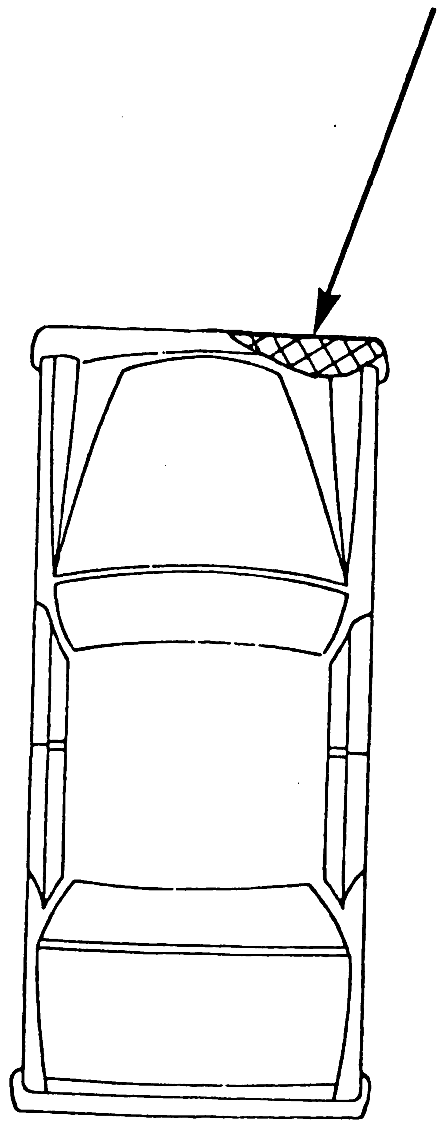

FIGURE 13: Vehicle with DPF arrow

For front or rear impacts, the concept is the same. The DPF is the angle between the impact force and a line parallel to the long axis of the vehicle. The vertex of the angle is the point of application of the impact force to the vehicle.

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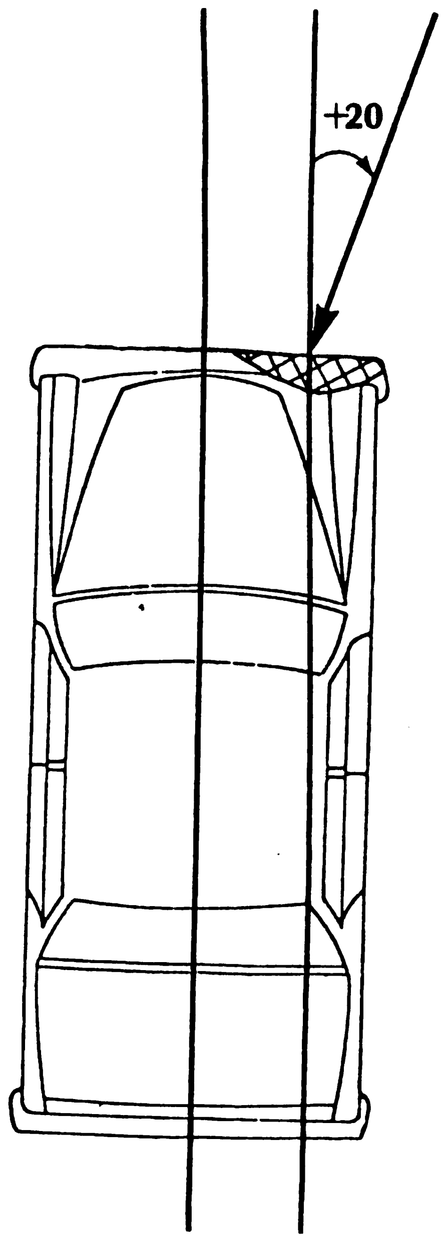

FIGURE 14: Measured DPF arrow (+20°)

Figure 14 illustrates the measured angle, +20°.

On pages 37 and 38 are direction of principal force exercises. For each vehicle, draw the long axis of the vehicle, construct any necessary parallel line, and measure the DPF in degrees. Then, assign an o'clock DPF to each.

STOP TAPE.

DIRECTION OF PRINCIPAL FORCE EXERCISES:

Note: In doing these exercises it may be helpful to refer back to Figure 6 on page 28.

1.

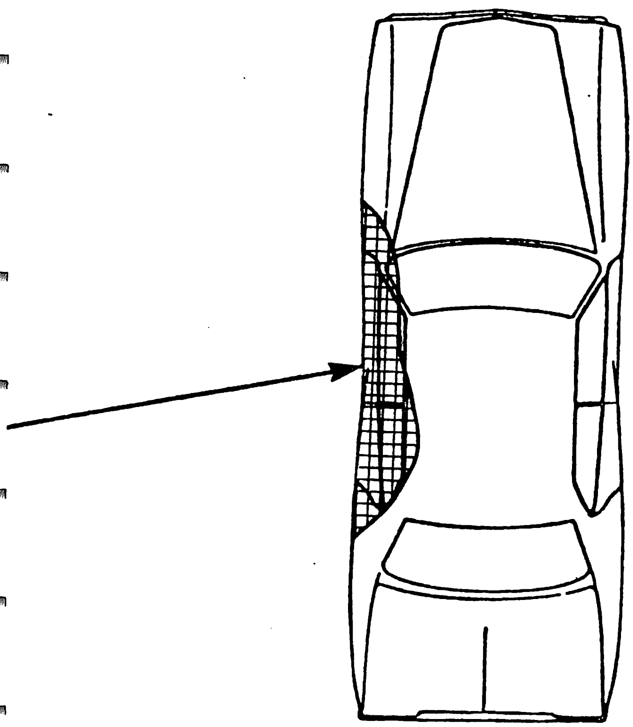

FIGURE 15

DPF in degrees: ____

O'clock DPF: ____

2.

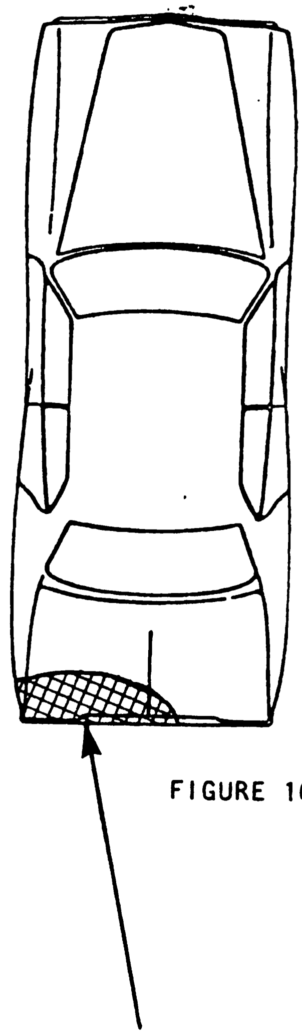

FIGURE 16

DPF in degrees: ____

O'clock DPF: ____

3.

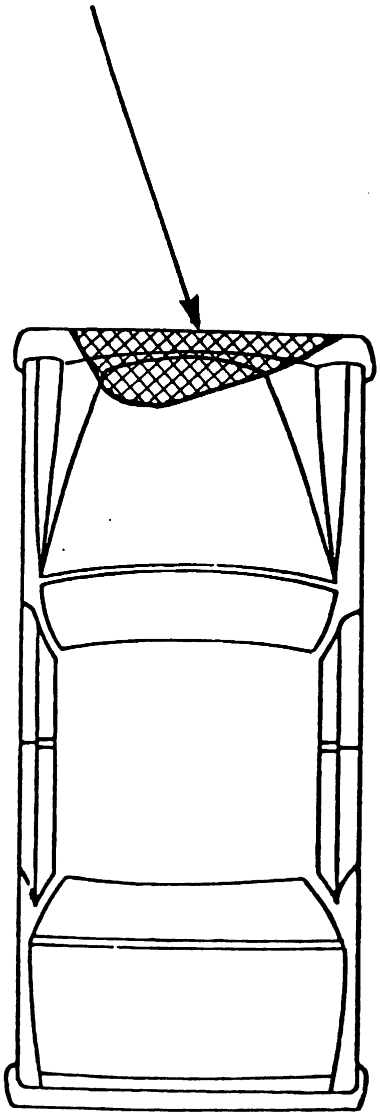

FIGURE 17

DPF in degrees: ______

O'clock DPF: ______

4.

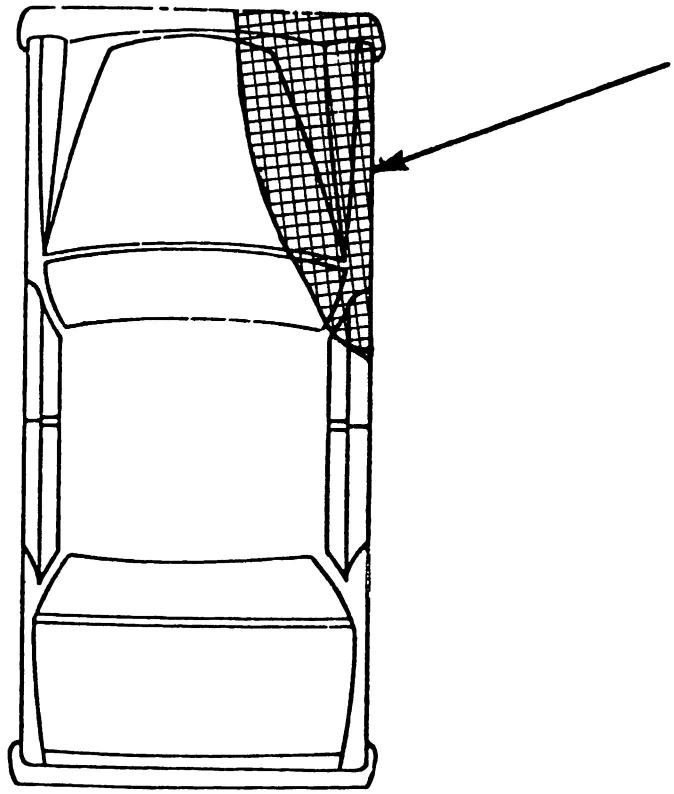

FIGURE 18

DPF in degrees: ______

O'clock DPF: ______

When finished, turn to page 131 of Appendix A for the correct answers. Then restart your tape.

DETERMINING THE DPF IN THE FIELD

40 The direction of principal force is defined geometrically. In our exercises and diagrams, we have depicted the impact force as an arrow pointing to the vehicle. We have measured the angle of this arrow with respect to the longitudinal axis of the car. In the field, however, there are no arrows to tell you the direction of principal force. You must estimate the direction combining several different kinds of data. The Collision Deformation Classification module of this series explained the field determination of the DPF in some detail. Nevertheless, let us now briefly review the three major classes of evidence to be considered in assigning the DPF.

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Consider these factors to ascertain the DPF:

(1) VEHICLE: (a) Deformation "Flow"
(b) Vehicle Weights and Impact Speeds.

(2) ENVIRONMENT: Pre- and Post-Impact Trajectories

(3) HUMAN: Occupant Kinematics.

There are three major types of evidence to be weighed: vehicle evidence, environmental evidence, and human evidence. The most important source of information is vehicle inspection. Inspection of the "flow" of the sheet metal crush usually allows you to estimate the DPF. The vehicle deformation is the primary information source, but there are several other factors to be considered. The relative vehicle weights are important, as are relative impact speeds (if known).* The environmental factors are the collision trajectories: the heading angles at impact and the post-impact paths of travel. The human factor is occupant kinematics. Although there are many complicating factors (such as vehicle rotation), occupants generally move in a direction opposite to the direction of the impact force. The vehicle deformation pattern is the single most important factor, but you should consider all of these factors before making your final estimate.

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*The DPF can be determined accurately through vector analysis. The principal force acting between the vehicles is a vector sum of the individual impact and resistive forces. Force is the algebraic product of mass x acceleration. A simplified method involves vector analysis using momentum vectors. Momentum equals weight x speed. Estimation of the DPF through momentum vector analysis is not perfectly accurate, since momentum and force are two different quantities. Nevertheless, the momentum vector method is probably more accurate than subjective estimation. More information on momentum vectors is provided in the Physics and Measurement module of this series, and in the NASS Procedures Manual.

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Try to estimate the DPF to the nearest 10°. Enter your degree estimate into CRASH as an improved DPF.
Then convert your degree DPF estimate to an o'clock DPF for Columns 1 and 2 of the CDC.

None of the factors just listed — vehicle evidence, environmental evidence, or human evidence — leads to an exact measure of DPF. In the field, there are no arrows showing you the DPF. Often your best estimate will be an o'clock DPF.

But, when possible, follow this procedure: Estimate the DPF to the nearest 10°. DPF estimates will range from -180° to $+180^\circ$.* Enter your degree estimate into CRASH as an improved DPF. Then convert your degree estimate to an o'clock DPF for the CDC code.

*CRASH will accept improved DPF with positive angles up to 360°. Thus, an entry of $+270^\circ$ would be equivalent to an entry of -90°.

Colinearity

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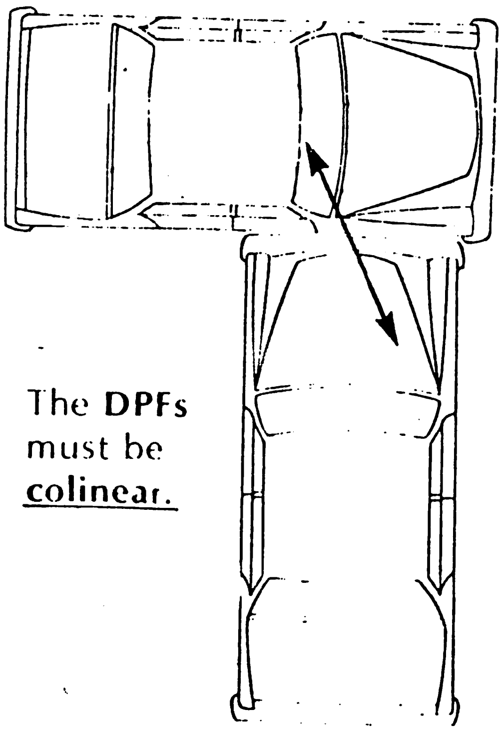

FIGURE 19: Colinearity in two-vehicle collision

You will recall that many different directions of principal force are possible for any given heading angle at impact. The major factors are the relative weights and speeds of the vehicles at impact. Whatever the DPFs for the two vehicles are, they must be colinear.* That is, the direction of the force to one vehicle must be opposite to the direction of the force to the other vehicle. We can depict the two forces as a single two-headed arrow between the vehicles. This is simply an illustration of Newton's third law of motion: For every action, there is an equal and opposite reaction.

*Certain tire-ground forces, neglected in CRASH, can make the DPFs slightly non-collinear. Nevertheless, colinear DPF should always be entered into CRASH.

For a two-vehicle collision, the CRASH 3 program automatically checks to ensure that the two DPFs are colinear. If there is a discrepancy of 15^o or less, the program adjusts the entered DPF's to make them collinear. If the discrepancy is more than 15^o, the program is stopped. You must then correct the entered DPFs and restart the program. CRASH 2 does not have this internal collinearity check; you must double check for colinearity before entering the DPFs.