MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 1–Point-To-Point Measuring

A-2

Types of measurements commonly used to measure vehicles include:

- _____, which references length, height, and width.
- point-to-point, which is the distance between two points.

A-4

A tape measure:

- is often used for making point-to-point measurements.
- should have the end ground down to fit reference holes.
- must lay _____ between points.

A-5

A tram gauge:

- is a telescoping measuring device with adjustable pointers on each end. It is used for making point-to-point measurements.
- may require a _____ _____to measure between the pointers.

A-8

When using tram gauges to make point-to-point measurements:

- set pointers at _____ heights when using the tram gauge scale. This is important since pointers set at different heights _____ _____ provide the same reading on the tram gauge as pointers set at the same height.
- insert the pointers securely into reference holes or on top of fasteners. When measuring to or between fasteners, measure from the _____ of the fastener head.

A-9

If pointers are set at different heights to avoid an obstruction, a tape measure should be used to measure between the tips of the tram gauge extensions.

Tram gauge pointers set at different heights to make datum measurements generally does not provide accurate results since it is difficult to determine if the gauge is exactly parallel to the datum plane.

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B-1

Point-to-point measurements for:

- holes of the same size are made either_____-to-_____ or center-to-center.
- fasteners will typically be center-to-center.

B-3

Diagonal measurements can measure to proper specification even if the body structure is out of alignment. This can be a problem if other dimensions are not referenced during point-to-point measuring. Measuring _____ and _____ in addition to the diagonal measurement will help ensure that the section is square.

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MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 2–Three-Dimensional Measuring

A-3

Vehicles are generally comprised of three sections – _____, _____, and _____.

A-4

The center section:

- is the _____ of measuring.
- is generally measured _____.
- if undamaged, provides a reference for all other measurements.

_____ undamaged measuring points are required to establish a foundation for measuring.

B-1

Three-dimensional measuring systems measure each reference point for length, height, and width simultaneously. Length is measured from a zero plane, height is measured from a datum plane, and width is measured from a centerline plane.

B-2

A datum plane:

- is an imaginary surface or plane positioned beneath the vehicle that is _____ to the vehicle underbody.
- is used by measuring systems as a starting point from which _____ is measured to various reference points on the vehicle.
- distance from the bottom of the vehicle varies according to the maker of the measuring system or dimension guide.

B-3

Centerline plane is:

- an imaginary plane that cuts the vehicle in half from the floor to the roof, running from front to rear.
- used by measuring systems as a starting point from which _____ is measured.
- used to establish a width position for vehicle reference points.

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B-4

Zero plane is:

- used by measuring systems as a starting point from which _____ is measured.
- an imaginary plane that extends across the width of the vehicle.
- projected at different locations depending on the maker of the dimension guide.

B-5

Length measurements:

- may be identified by referencing a dimension guide or identified on a computerized measuring system.
- may be made _____ or _____ of the zero plane.
- are made on the upperbody and underbody.

C-1

When making three-dimensional measurements:

- height is measured _____ to the datum plane.
- length is measured _____ to the centerline and datum plane.
- width is measured perpendicular to the _____ and parallel to the datum plane.

C-2

Point-to-point measurements are _____ than three-dimensional measurements when the two points being measured are not equal distances from datum, centerline, or zero plane.

C-3

Self-centering gauges:

- are used to identify _____ misalignment.
- are used to identify datum misalignment.
- have adjustable vertical scales for setting the centering gauge at the correct datum height.

C-4

Centering gauges are:

- installed in sets of four or five.
- viewed from the front or rear of the vehicle.
- viewed against other gauges, not the floor or rack.

Datum misalignment is indicated by the front or rear section gauges being higher or lower compared to the two gauges in the center section of the vehicle.

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C-8

Self-centering gauges are not designed to measure a vehicle's _____. This requires length to be measured with a tape measure or tram gauge.

C-11

A universal mechanical measuring system:

- uses a _____ or _____ positioned under the vehicle to measure length.
- measures width using the scale on the width gauge.
- measures height using the scale on the height tube.

C-14

A universal laser measuring system:

- uses a laser beam and measuring scales or _____ in place of mechanical pointers.
- may be a single laser unit using measuring bars, gauges, and/or transparent targets.
- may use a beam splitter to target multiple gauges and bars simultaneously.

C-18

An electromechanical measuring system:

- uses a _____ _____ with a pointer located under the vehicle that slides along a bridge or ladder positioned centrally beneath a vehicle.
- has adapters for the arm for different types and sizes of reference points.
- uses a computer program to receive the data sent to the computer from the mechanical arm.
- can be used to make continual measurements by leaving the pointer at the reference point while making pulls.

C-21

A computerized laser measuring system:

- has _____ hung at reference points that reflect light back to a hub (sensor) in the laser unit.
- has adapters for hanging targets at different types and sizes of reference points.

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C-24

Ultrasonic measuring systems:

- have _____ hung at reference points that produce ultrasonic signals that are received by the measuring beam. The beam processes and converts information into measurements.
- use a computer program to receive the data sent to the computer from the measuring beam.
- have adapters for hanging probes on different types and sizes of reference points.

C-27

A fixture system uses _____ beams, or transverse beams:

- bolted to the bench at locations listed on a fixture diagram.
- that have reference marks to accurately position fixtures.
- to mount fixtures at a specific location.

Fixture systems:

- have vehicle-specific reference manuals that provide exact locations for mounting fixtures to the bench.
- use a two-post hoist to load the vehicle on to the bench.

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MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 3–Vehicle Dimension Data

A-4

Specifications that show the width measurement in relation to centerline may be added together to get a _____ measurement.

A-5

Items shown on a dimension sheet for the underhood area may include measurements that are:

- point-to-point.
- referencing centerline.

Upperbody measurements listed in dimension manuals:

- are generally point-to-point.
- may use reference points such as _____ _____ and/or seams.

A-6

Dimensions are:

- shown from either the _____ looking down or the bottom looking up.
- provided in _____.
- symmetrical or asymmetrical.

A-7

Symmetrical measurements are the same on each side of the vehicle. Asymmetrical vehicles may have:

- _____ _____ from the left to right side.
- reference points that are in different locations.

A-10

If a vehicle is mounted in pinchweld clamps or lifted on a hoist, the front and rear of the vehicle may sag if the weight is removed from the vehicle's suspension; therefore, measurements may be listed as loaded or unloaded. A _____ measurement is taken with the drivetrain installed. An _____ measurement is taken with the drivetrain removed. A removed drivetrain reduces the amount of sag in the vehicle when it is not resting on its suspension.

A-11

_____ measurements may also be listed with the suspension loaded or unloaded. This affects the measurements to movable parts such as ball joints.

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B-3

The location of the zero plane and datum are provided in the manual. It is written as a specific distance and point. For example, datum may be listed as 300 mm below the rocker panel lower flange edge.

D-1

Comparative measurements:

- allow _____ measurements to be made.
- may be taken side-to-side.
- are used with a vehicle that is _____.
- may be point-to-point.
- may be taken using three-dimensional measuring equipment.

D-2

Measurements may be taken from an identical undamaged vehicle. Generally, these are limited to _____ measurements.

E-1

Vehicle repair tolerance:

- is generally ±_____ mm for unibody vehicles.
- is generally ±_____ mm for body-over-frame vehicles.
- may be less for proper panel fit and suspension and drivetrain alignment.

E-2

Tolerance applies to individual measurements or covers a span of measurements. It cannot, however, be added to each measurement taken between two points. For example, five measurements are made between a point in the front of the vehicle and a point in the rear of the vehicle. Each measurement is off by 3 mm. While each individual measurement is off by 3 mm (within tolerance), the overall misalignment is 15 mm. This number is not within tolerance.

E-3

Tolerances of ±3 mm for unibody and ±5 mm for body-over-frame vehicles apply to specifications in each _____.

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MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 4–Types Of Damage Conditions

A-3

Diamond is damage that occurs in the center section where one side is moved _____ or _____, causing the center section of the frame to be out of square, taking on a diamond-like appearance.

A-4

Diamond:

- may be determined by cross-checking diagonal dimensions of the center section in addition to making length, height, and width measurements.
- is commonly associated with full frames.

A-5

Twist is damage that occurs to the vehicle center section in which one or both ends of the center section are _____ _____ _____ with each other.

A-6

Sag is a condition where the front or rear sections of the vehicle have _____ measurements that are out of specification. Sag may also be a condition where the front or rear of the vehicle appear out of level.

A-7

Mash, also called collapse or short rail, is a condition where any section or frame member is _____ than factory specification.

A-8

Sway occurs when collision energy forces a part of the vehicle to one side or the other. This condition is a width misalignment.

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MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 5–Preparing To Measure A Vehicle

A-2

Points used to measure vehicles are reference points. These points may be any particular area on a vehicle that the technician uses to make a measurement.

A-4

Measuring for damage analysis:

- is done to locate _____ and _____ structural damage.
- is done to locate hidden damage.
- helps determine the repair plan.

A-5

Equipment used for damage analysis should allow quick measurement of the vehicle to locate damage. Some measuring systems have special equipment designed to work with lifts to create quick measurements. This eliminates the need to mount a vehicle to a bench or rack to obtain vehicle dimensions.

A-6

A second type of measuring is measuring for vehicle repair. Measuring for repair:

- helps create a _____ _____ _____.
- allows monitoring _____ during straightening operations.
- requires the vehicle to be anchored to a bench, rack, or floor to hold the vehicle in place during straightening operations.

B-1

A worksheet with illustrations:

- is helpful when using a system that does not provide an electronic readout of vehicle measurements.
- helps to visualize the _____ and _____ of the damage.

B-2

A worksheet with illustrations:

- helps develop an _____ and _____ plan.
- assists the technician in monitoring the straightening progress.

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B-3

A worksheet with illustrations may be used if:

- there are measurements that need to be taken and no dimension specifications exist.
- measurements must be taken to movable points.

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MEASURING PROGRAM 1–OBJECTIVES WORKSHEET
Module 6–Vehicle Measuring

A-3

To determine center section alignment, dimensions that must be measured include:

- diagonal.
- length.
- height.
- width.

The established center section determines the zero line, width, and datum from which all other measurements will be based.

A-4

Measuring the center section generally requires measuring the _____ corners of the center section. For electronic measuring systems, this establishes the centerline plane, datum plane, and zero plane from which all other measurements are based.

A-5

To prevent interference when accessing reference points, proper anchoring locations may be identified on _____ _____. Anchoring may or may not be necessary for damage analysis depending on the type of measuring system being used.

When anchoring vehicles:

- remove _____ and _____from the pinchweld flanges and clamp jaws before installation.
- make sure that fuel and brake lines, cables, hoses, or wires will not be crushed when installing pinchweld clamps.

A-6

If the center section is damaged, it may be necessary to work from an undamaged section of the vehicle and work into the damaged area.

However, depending on the measuring system, only _____ or _____ undamaged points are required to make measurements. This may require some preliminary pulls to align the center section.

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B-2

When determining the basic reference points to be measured:

- identify _____ _____ in each of the vehicle's three sections.
- measure areas of obvious _____ and _____ damage.

B-4

Special adapters are often required to measure a vehicle's _____. Some systems use devices similar to strut tower gauges that project upperbody damage below the vehicle.

C-3

Steering axis is the imaginary line that projects from the _____ pivot point through the _____ pivot point on a wheel that is steered. This axis is critical to the performance of the suspension system.

The upper pivot point on a:

- MacPherson strut system is the strut bearing at the strut tower and the lower pivot point is the lower ball joint.
- short arm/long arm system is the upper control arm ball joint and the lower pivot point is the lower ball joint.
- solid axle system is the upper ball joint and the lower pivot point is the lower ball joint.

C-5

Another angle that is affected by SAI is camber. Camber is the _____ and _____ tilt of the tire at the top compared to true vertical when viewed from the front of the vehicle.

The line of the upper and lower pivot point when viewed from the side is called _____. The pivot point positions are verified by length measurements from zero plane. Generally these measurements are comparison measurements only.

C-6

Points measured to determine proper caster angles include the:

- upper strut pivot point to the _____ plane for the right and left side.
- lower ball joint to the _____ plane for the right and left side.

These measurements may be comparative or have specifications depending on the measuring system or reference material being used.

C-7

To determine SAI angles, measure:

- the _____ pivot point to the vehicle centerline for the right and left side.
- from the _____ _____ to the vehicle to centerline for the right and left side.

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C-8

Measurements may be made to verify correct position of steering rack, rear axle, engine cradle, etc.

D-1

Systems that use upper strut tower gauges may also use these gauges to make comparative measurements on both the vehicle center section and the deck lid area. Hanging the gauges at specified areas on the vehicle will determine if the areas are symmetrical from side-to-side.

D-2

Upperbody door opening measurements:

- are generally point-to-point measurements.
- are provided in dimension manuals.
- may be comparative from side-to-side.

D-4

Additional upperbody measurements:

- are generally point-to-point measurements.
- may include any upperbody point on a vehicle as long as it is a _____ point.
- may be provided in dimension guides.
- may be comparative readings from side-to-side.

E-1

Determine if the readings are consistent with the collision damage. If the readings are not consistent, determine where the discrepancies exist.

E-2

Compare the measuring results against the _____ damage. This verifies that the damage is consistent with the readings.

E-3

To determine if the readings made with a computerized measuring system are correct, compare point-to-point measurements with measurements taken with a _____ _____ or tape measure.

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