APTA STANDARDS DEVELOPMENT PROGRAM
RECOMMENDED PRACTICE
American Public Transportation Association
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APTA Bus Maintenance Training Working Group

Training Syllabus to Instruct/Prepare for the ASE Transit Bus Steering and Suspension Test

Abstract: This *Recommended Practice* provides guidelines for establishing a standardized bus maintenance training program related to the ASE certification syllabus for transit bus and coach suspension and steering maintenance.

Keywords: Automotive Service Excellence (ASE) H6, bus, certification, steering, suspension, tires, training, transit, wheel alignment, wheels

Summary: This *Recommended Practice* provides transit bus maintenance training and transit bus maintenance departments with typical information to evaluate, develop or enhance current training programs for the diagnosis, repair and maintenance of transit bus steering and suspension systems. In addition, this document allows departments to instruct/prepare transit bus technicians and mechanics for the H6 National Automotive Service Excellence (ASE) Transit Bus Suspension and Steering Test. Individual operating agencies should modify these guidelines to accommodate their specific equipment and mode of operation.

Scope and purpose: This *Recommended Practice* reflects the consensus of the APTA Bus Standards Program members in conjunction with transit labor organizations, including ATU and TWU, on the subject material, manuals, textbooks, test equipment, methods and procedures that have provided the best performance record based on the experiences of those present and participating in meetings of the program task forces and working groups. APTA recommends the use of this document by organizations that have a training department or conduct training for the maintenance of transit buses, organizations that contract with others for transit bus maintenance training, and organizations that influence how training for transit bus maintenance is conducted.

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Training Syllabus to Instruct/Prepare for the ASE Transit Bus Steering and Suspension Test

1. Learning environment

For best application of this *Recommended Practice*, a combination of classroom lectures, mentoring, practical training and practice tests should be included in the training program.

2. Computer skills

Basic computer skills are now a standard for transit bus technicians. Basic skills and knowledge in the operation of a computer in a Microsoft Windows environment is essential.

3. Course learning objectives

The learning objectives listed below have been developed through a labor-management committee of subject matter experts (SMEs). The learning objective levels represent 100 (introductory), 200 (intermediate) and 300 (advanced). Within each level, the learning objectives are organized in the recommended order of instruction. When a transit bus mechanic demonstrates proficiency in the learning objectives, he or she should be capable of attaining ASE Transit Bus Technician Certification. Objectives are also organized into transit bus subsystems that follow the organization of the questions in the ASE test.

- **Module I: Steering System Diagnosis and Repair:** The objective of these courses is to provide the employee with knowledge and hands-on practice of proper procedures for inspecting and maintaining transit bus steering systems, including steering column and shaft, power steering system, steering arms, connecting arm, drag link center link and tie-rod ends. Emphasis will be placed on properly identifying problems, determining necessary repairs and properly performing routine preventive maintenance.
- **Module II: Suspension Systems Diagnosis and Repair:** The objective of these courses is to provide the employee with knowledge and hands-on practice of proper procedures for inspecting and maintaining transit bus suspension systems and their components and subsystems, including the independent front suspensions, rear suspensions and straight/I-beam axles. Emphasis will be placed on properly identifying problems, determining necessary repairs and properly performing routine preventive maintenance.
- **Module III: Wheel Alignment Diagnosis, Adjustment and Repair:** The objective of these courses is to provide the employee with knowledge and hands-on practice of proper procedures for wheel alignment of transit buses, including diagnosing need for alignment and making all necessary adjustments and repairs. Emphasis will be placed on understanding the theory of alignment, properly identifying problems, determining necessary repairs and working with alignment equipment.
- **Module IV: Wheels and Tires Diagnosis and Repair:** The objective of these courses is to provide the employee with knowledge and hands-on practice of proper procedures for inspecting and maintaining transit bus wheels and tires, including diagnosing tire wear patterns and wheel/tire

vibration problems. Emphasis will be placed on properly identifying problems, determining necessary repairs and properly performing routine preventive maintenance.

4. Exam requirements

The minimum acceptable grade to pass the course and all practical tests is 75 percent. Students must pass written tests with a minimum grade of 80 percent.

5. ASE test content summary

TABLE 1

Specifications for Transit Bus Suspension and Steering Test

Content Area	Questions in Test	Percent of Test
A. Steering System Diagnosis and Repair	12	27%
B. Suspension System Diagnosis and Repair 1. Independent Front Suspension (4) 2. Straight Beam Axle Front Suspension (6) 3. Rear Suspension (6) 4. Aux. Suspension System and Controls (7)	23	51%
C. Wheel Alignment Diagnosis, Adjustment and Repair	6	13%
D. Wheels and Tires Diagnosis and Repair	4	9%
Total	**45**	**100%**

Please see Appendix B for the full list of ASE course tasks that should be covered during the training course.

NOTE: Source for test structure data: ASE website, 10/19/2012.

Related APTA standards

None.

References

National Institute for Automotive Service Excellence (ASE) website. http://www.ase.com/

Definitions

None.

Abbreviations and acronyms

ADA Americans with Disabilities Act
ASE Automotive Service Excellence
ATU Amalgamated Transit Union
EDSI Educational Data System Inc.
KPI kingpin inclination
NATSA North American Transportation Services Association
OJT on-the-job training
OSHA Occupational Safety and Health Administration
SAI steering axis inclination
TLC Transportation Learning Center
TWU Transit Workers Union

Summary of document changes

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	5/15/13	7/7/16	9/6/16	9/30/16	10/6/16
First revision					
Second revision					

Appendix A: Transit suspension and steering learning objectives

101 THEORY & UNDERSTANDING	
Learning Objectives	**ASE Task Reference**
Describe the basics of steering and axle alignment	C2, C3, C4, C7
Describe the terms “steering axis inclination (SAI)” and “kingpin inclination (KPI)”	C4
Describe the difference between camber measures and Ackerman angles	C2, C6
Describe thrust line, centerline and tracking	C7
Describe caster	C3
Explain basic hydraulic system principles	A6
Describe different tire wear patterns and how they occur	D1
Identify the procedures for removing air from a power steering system	A5
Describe radial and lateral runout	D5
Describe and demonstrate safety procedures while performing suspension repairs	B1(6), B2(5), B3(4), B3(7)
Explain steering shaft configurations, including tilt, telescopic and U-joint phasing	A1, A2
Describe proper ride height and its effect on the bus	B2(6)
Explain OSHA requirements related to tire maintenance	D1, D2, D3, D4, D5, D6, D7

101 TOOL USAGE	
Learning Objectives	**ASE Task Reference**
Demonstrate proper use of a belt tension gauge	A3
Demonstrate proper use of a dial indicator	A3, A14, A15, A16

101 PROCEDURES, INSPECTIONS AND TESTING	
Learning Objectives	**ASE Task Reference**
Fill vehicle suspension system with air and check for leaks	B1(6), B2(5), B3(4)
Align tires properly for checking inside tire pressure	D2
Check component play and wear	B1(8), B3(5), B2(6)
Check condition of ball joint boots	B1(3)
Check power steering fluid level and condition	A3, A4
Check condition of bushing, bracket and mounting hardware	B1(8), B2(4), B3(3)
Check for wear and cracks	B1(2), B1(8), , B2(2), B2(4), B3(2), B3(3)
Check front axle mounting hardware and components for movement and/or rust and corrosion	B2(2)
Inspect for loose/bent components	D3
Check hardware and components	B1(2), B3(2), B2(2), B3(2)
Check hardware and linkage for wear	B1(8), B3(5), B2(7)
Check lubrication; lubricate as necessary	B1(2), B1(3), B1(8), B3(2), B3(5), B2(2), B2(3), B2(7)

Learning Objectives	ASE Task Reference
Check shock absorbers	C1
Check tire pressures and sizes	B2(1), C1, D2, D7
Inspect lines and clearances	B1(6), B2(5), B3(4)
Inspect seals for leaks	B2(3)
Inspect steering component wear	C1
Inspect tire tread depth, sidewall damage, recap condition, broken belts	D2, D6
Adjust tire pressure to specs	B2(1)
Visually inspect rims, spacers, studs and nuts	D4
Replace tire	D5
Tighten fasteners to recommended torque values	A2
Visually check for dog tracking, wandering	C1

102 THEORY & UNDERSTANDING

Learning Objectives	ASE Task Reference
Describe different types of steering control links (boomerang, differential lever, strut)	A3
Explain gear/miter box operation	A3

102 TOOL USAGE

Learning Objectives	ASE Task Reference
Demonstrate proper use of a steering wheel puller	A1, A2

102 PROCEDURES, INSPECTIONS AND TESTING

Learning Objectives	ASE Task Reference
Attach mounting hardware	A14, A15, A16
Check for damaged/deteriorated frame components (cracks, breaks, distortion)	C1
Check for U-bolt movement, rust and corrosion	B3(2)
Check greased components for proper lubrication	A3
Check operation of kneeling indicator lamp and alarm	B1(7), B2(6)
Check play, wear and positioning of clamps and retainers	A14, A15, A16
Check Steering shaft slip-yoke and u-joints for play and wear	A1,
Compare wheel and tire runout to manufacturer specifications	D5
Inspect for lubrication, play and wear	A14, A15, A16
Inspect condition of valve stem, cap, core and seal	D2
Match tires on axle by diameter or circumference	D7
Match tires to rims by selecting/measuring correct tire diameter	D7

Learning Objectives	ASE Task Reference
Visually inspect hydraulic lines, fans, hoses, fittings, check valves	A11
Torque to manufacturer's specifications	D4
Demonstrate ability to interpret readings from automatic tire pressure monitoring system (if applicable)	B1(1), B2(1), B3(1)

103 THEORY & UNDERSTANDING

Learning Objectives	ASE Task Reference
Explain function of valves and air flow through suspension system	B3(6)
Explain power steering and hydraulic system circuit tests	A6
Describe problems associated with underfilling, overfilling, contamination and improper hydraulic fluid	A4
Explain suspension airbag safety	A1

103 PROCEDURES, INSPECTIONS AND TESTING

Learning Objectives	ASE Task Reference
Test for correct operation of kneeling and interlock system	B1(7), B2(6)
Check ride height, bearing play and tire pressures	C1
Check steering wheel placement/alignment	A1, C1
Determine that vibration is not drivetrain or suspension related	D3
Visually inspect components (center link, drag link, tie rods, tie rod ends, steering damper) and check for proper lubrication	A14, A15, A16
Visually inspect tire wear and pressure, suspension components	B1(1), B2(1), B3(1)

201 THEORY & UNDERSTANDING

Learning Objectives	ASE Task Reference
Explain ADA requirements for kneeling system	B1(7), B2(6)
Explain manufacturer's procedures for removing air from a power steering system	A5
Explain how the balance machine operates	D6
Explain possible causes for drivability issues	C1
Explain torque specifications for Pitman arm	A13
Explain toe-in and toe-out	C5

201 TOOL USAGE

Learning Objectives	ASE Task Reference
Demonstrate use of dial indicator to perform runout measurements on mounted tire/wheel and compare to manufacturer's specifications	D5
Demonstrate use of gauge to measure toe	C2

201 PROCEDURES, INSPECTIONS AND TESTING	
Learning Objectives	**ASE Task Reference**
Adjust ride height at the front and rear leveling valves	B1(5), B2(6), B3(4)
Adjust wheel stop bolts to produce specified turning radius	A17, A18
Check air systems and note/repair air leaks	B3(6)
Check belt alignment and tension	A8
Check bolts on lateral rod	B2(7)
Check condition of brackets and fasteners	A1, A3
Check condition of leveling valve links	B1(5), B3(4)
Check for axle wheel bearing play and wear	C8
Check for contaminated fluid, and change as required	A7
Check for cracks and/or leaks in the housing	B3(2)
Check for leaks; repair as needed	A4
Check for leaks in articulated joint (if applicable)	A17
Check for proper torque specifications	B1(2), B1 (8), B2(2), B3(2), B3(5), D5
Check for shock absorber leaks	B1(8), B2(4), B3(3)
Check for wear and play in kingpins/ball joints	B1(3), B2(3)
Check grease seals and seal condition (if present)	A13
Check hardware and for loose/damaged linkage	B1(8) , B3(5)
Check manufacturer specifications on allowable bushing or shim play	B1(3), B2(3)
Check manufacturer-recommended fluid type	A4
Check power steering/hydraulic fluid in cooling system operation	A3
Check pressure relief valves	A12
Check power steering pump mounting holes for wear	A9
Check shifting of rear axle; check driveshaft alignment and phasing	B3(1)
Check steering box mounting condition	A3
Check steering linkage, kingpins and kingpin bearings for excessive play or binding	A3
Check stop-to-stop range in steering box	A12
Check that grease fittings are in proper alignment; lubricate fittings properly	A2
Check the condition of belt, pulley and tensioners	A8
Check U-bolts on lateral rod	B2(6)
Correctly align Pitman arm on installation	A13
Demonstrate ability to diagnose specific wheel/tire problems	D3
Demonstrate ability to diagnose steering column noises	A1
Demonstrate ability to differentiate between brake pull and steering wander	C1
Ensure that play is not wheel bearing related	B1(4)
Fill and bleed system	A7

Learning Objectives	ASE Task Reference
Follow manufacturers' procedures for removing air from a power steering system	A5
Identify an out-of-spec turning radius	A17, A18
Inspect air bags for wear	B1(6), B2(5), B3(4)
Inspect belt and pulley condition	A3
Inspect kneeling system	B2(6)
Inspect leveling valves	B1(6), B3(4)
Inspect linkage	B1(6), B3(4)
Inspect mountings and brackets	A10
Inspect power steering pump	A10
Inspect reservoir for leaks or damage	A7
Inspect spindle for damage	B1(4)
Inspect/lube slip yoke	A2
Measure and adjust ride height	B2(5)
Measure caster and determine if within specification	C3
Measure camber and determine if within specification	C2
Measure toe and determine if within specification	C5
Perform road test to check for excessive bounce or sway	B1(8), B2(4), B3(3)
Note sequence and timing of operation for different manufacturers	B1(7), B2(6)
Perform road test and note articulated alarms, sway of back end of articulation and bus tracking	A17
Perform road test and note rough ride, looseness, body sway	B1(1), B2(1), B3(1)
Perform road test to check for shimmy, wander and pull	A14, A15, A16
Perform road test to diagnose component failures	A13, B1(3), B2(3), C1, D13
Perform static balance tests; add weights as necessary to rebalance assembly	D6
Demonstrate ability to refer to manufacturer's specifications for front, rear and side-to-side ride height	B1(5), B2(6), B3(4)
Remove and replace filter	A7
Repair or replace electrical, hydraulic or mechanical components	A17
Replace reservoir	A7
Replace seals and covers as required	B2(3)
Replace shock absorbers; adjust if required	B1(8), B2(4), B3(3)
Service rim and wheel as needed	D5
Tighten belts to the recommended tension	A3
Tighten steering wheel to proper torque	A2
Torque mounting bolts to manufacturer's specifications	B2(6)
Unload and inspect axle	C8
Unload front end	B1(3), B2(3), C8

Learning Objectives	ASE Task Reference
Visually check for wear and play in kingpins	B2(3)
Visually inspect tie rod hole (for Pitman arm)	A13
Refer to manufacturer specifications; adjust if needed	C2, C3, C4, C5, C6, C7
Torque to manufacturer specifications	B2(2), D4, D5

202 THEORY & UNDERSTANDING

Learning Objectives	ASE Task Reference
Explain the relationship of wheel stops and steering box pressure relief valves	A17, A18

202 TOOL USAGE

Learning Objectives	ASE Task Reference
Demonstrate ability to use a dial indicator to check for wear and straightness	A14, A15, A16
Demonstrate ability to use a ball joint press	B1(3)
Demonstrate ability to use a dial indicator to check that play and loading are within manufacturer's specifications	C8
Demonstrate ability to use a Pitman arm puller tool	A13
Demonstrate ability to use a tie rod puller/separator	A14, A15, A16

202 PROCEDURES, INSPECTIONS AND TESTING

Learning Objectives	ASE Task Reference
Adjust components as needed	A14, A15, A16
Adjust rear axle alignment as needed	C7
Adjust steering wheel with drag link	A14, A15, A16
Check bushings, hardware and control arm components	B1(2)
Check for excessive steering wheel play	A1
Check phasing of U-joints and proper hardware	A2
Check rear axle against thrust line/center line	C7
Check steering column bearings	A1
Measure Ackerman angle and check if within specifications	C6
Measure steering axis inclination and kingpin inclination and check if within specifications	C4
Perform balance tests, and balance as needed	D3, D6
Place vehicle on alignment machine	C2, C3, C4, C5, C6, C7
Remove pump to inspect gear and coupling	A9
Replace air bags, valves, linkage, lines or brackets as necessary	B1(6), B2(5), B3(4)
Replace ball joints/kingpins as necessary	B1(3), B2(3)
Replace components and torque to proper specifications	B1(8), B3(2), B3(5), D4
Replace gaskets, seals and O-rings as needed	A9

Learning Objectives	ASE Task Reference
Replace lines, fans, hoses, fittings, check valves as needed	A11
Replace mountings and brackets	A10
Replace power steering pump	A10
Demonstrate ability to follow recommended procedures for inspecting and replacing bushings, bearings and seals	A2

203 TOOL USAGE

Learning Objectives	ASE Task Reference
Demonstrate ability to use dial indicator to inspect kingpins and compare with wear specifications	B1(3), B2(3)

203 PROCEDURES, INSPECTIONS AND TESTING

Learning Objectives	ASE Task Reference
Adjust bearings as needed	C8
Adjust pressure relief valve settings	A12
Adjust stop-to-stop range in steering box	A12
Adjust to manufacturer's specifications	C2, C3, C4, C5
Centerline/realign steering wheel back to square during installation	A2
Check for interference caused by incorrect routing	A1
Check leakage and aeration in the hydraulic system	A3
Check condition of teeth on drive gear	A9
Demonstrate ability to determine whether power steering problem is mechanical or hydraulic	A3
Install bushings and use reamer when necessary	B1(3)
Replace faulty belt system components	A8

301 THEORY & UNDERSTANDING

Learning Objectives	ASE Task Reference
Describe the correlation between the kneeling and interlock systems	B2(6)

301 TOOL USAGE

Learning Objectives	ASE Task Reference
Demonstrate ability to use laptop to adjust angle sensor	A19
Demonstrate ability to use laptop to check pressures on the accumulators	A19
Connect flow meter and pressure gauge to ensure that flow and pressure are within the manufacturer's specifications	A3, A6
Demonstrate ability to use laptop or handheld diagnostic device to identify faults	A19

301 PROCEDURES, INSPECTIONS AND TESTING	
Learning Objectives	**ASE Task Reference**
Adjust pressure relief settings to produce specified turning radius	A17, A18
Check adjustment of steering box relief valves	A3
Check alignment after replacement of components	A14, A15, A16
Check axle alignment	B2(7)
Demonstrate ability to diagnose power steering temperature sensor and wiring for sensor and fan motors	A11
Disable airbag/safety restraints in steering column where applicable	A1
Remove steering knuckle bushings	B2(3)

302 TOOL USAGE	
Learning Objectives	**ASE Task Reference**
Demonstrate ability to use laptop to check for dog tracking and wandering	C1
Demonstrate ability to use bushing reamer tool	B2(3)
Demonstrate ability to use heating and cutting equipment to remove shock mounting hardware	B2(4)

302 PROCEDURES, INSPECTIONS AND TESTING	
Learning Objectives	**ASE Task Reference**
Check condition of steering knuckle bushings	B2(3)
Install and adjust shims	B2(3)
Install steering knuckle bushings	B2(3)
Remove and replace wedge pins with kingpins	B1(3), B2(3)

303 TOOL USAGE	
Learning Objectives	**ASE Task Reference**
Demonstrate ability to use kingpin press	B1(3), B2(3)

Appendix B: ASE Transit Bus Suspension and Steering Test (H-5) task list

A. Steering system diagnosis and repair

1. Diagnose steering column (tilt, telescoping or fixed) shaft noise, looseness and binding problems; determine needed repairs.
2. Inspect and replace steering shaft U-joint(s), slip joint(s), bearings, bushings and seals; phase steering shaft U-joints.
3. Diagnose power steering system noises, steering binding, uneven turning effort, looseness, hard steering, overheating, fluid leakage and fluid aeration problems; determine needed repairs.
4. Inspect power steering fluid level and condition; determine fluid type and needed service.
5. Purge air from the power steering system.
6. Perform power steering system pressure and flow tests; determine needed repairs.
7. Inspect, service or replace power steering reservoir, including filter, seals and gaskets.
8. Inspect, adjust, align or replace power steering pump belt(s), pulley(s) and tensioner(s).
9. Inspect power steering pump drive gear and coupling; replace as required.
10. Inspect, adjust or repair power steering pump, mountings and brackets; replace as required.
11. Inspect power steering system cooler, lines, hoses and fittings; replace as required.
12. Inspect and adjust integral-type power steering gear; replace as required.
13. Inspect and replace Pitman arm; center steering linkage.
14. Inspect, adjust/service or replace drag link/center link, tie rods and tie rod ends; position adjusting sleeves, clamps and retainers.
15. Inspect idler arm; replace as required.
16. Inspect steering and Ackerman (tie rod) arms; replace as required.
17. Check and adjust steering linkage or wheel stops (axle stops).
18. Check and adjust steering gear poppet/relief valves.
19. Diagnose problems in the articulation system electronic controls and mechanical and hydraulic components; determine needed repairs.

B. Suspension systems diagnosis and repair

1. Independent front suspensions

1. Diagnose front suspension system noises, looseness, body sway and rough ride; determine needed repairs.
2. Inspect upper and lower control arms, strut rods/radius arms, bushings, shafts, and rebound/jounce bumpers on short and long arm (SLA) suspension systems; replace as required.
3. Inspect upper and lower ball joints and/or kingpins; replace as required.
4. Inspect steering knuckle/spindle assemblies; replace as required.
5. Measure and adjust ride height.
6. Inspect front suspension system air bags; replace as required.
7. Inspect operation of kneeling system; perform necessary repairs.
8. Inspect stabilizer bar (sway bar) bushings, brackets and links; replace as required.
9. Inspect shock absorbers, bushings, brackets and mounts; replace as required.

2. Straight/I-beam axle diagnosis and repair

1. Diagnose front suspension system noises, looseness, body sway, and rough ride; determine needed repairs.
2. Inspect front axle, U-bolts and nuts; service or replace as required.
3. Inspect kingpins, steering knuckle bushings, locks, bearings, shims, seals and covers; service or replace as required.
4. Inspect shock absorbers, bushings, brackets and mounts; replace as required.
5. Inspect front suspension air bags; replace as required.
6. Measure vehicle ride height; determine needed adjustments or repairs.
7. Inspect, repair and/or replace radius rods, lateral/torque rods, stabilizer bar (sway bar), bushings, brackets and mounts, and air/walking beams; adjust as necessary.
8. Inspect operation of kneeling system; perform necessary repairs.

3. Rear suspensions

1. Diagnose suspension system noises, looseness, rough ride and body sway problems; determine needed repairs.
2. Inspect rear axle housing, U-bolts and nuts; service or replace as required.
3. Inspect shock absorbers, bushings, brackets and mounts; replace as required.
4. Measure vehicle ride height; determine needed adjustments or repairs.
5. Inspect and adjust rear axle aligning devices such as radius rods, lateral rods, torque rods, stabilizer bars, and related bushings, mounts, shims, and links; replace as required.
6. Inspect, test, adjust or repair air suspension pressure regulator, pressure protection valve(s), height control valve(s), lines, hoses and fittings; replace as required.
7. Inspect, test or repair air bags, mounting plates, suspension arms and bushings; replace as required.

C. Wheel alignment diagnosis, adjustment and repair

1. Diagnose vehicle wandering, pulling, shimmy, bump steer and steering effort problems; determine needed adjustments or repairs.
2. Check and adjust camber; determine needed repairs.
3. Check and adjust caster; determine needed repairs.
4. Check SAI/KPI and included angle; determine needed repairs.
5. Check and adjust toe.
6. Diagnose toe-out-on-turn (Ackerman angle) problems; determine needed repairs.
7. Check rear axle alignment (thrust line/centerline) and tracking; adjust or determine needed repairs.
8. Check and adjust steering and/or drive axle wheel bearings.

D. Wheels and tires diagnosis and repair

1. Diagnose tire wear patterns; determine needed repairs.
2. Inspect, repair or replace tires, valve stems and caps; check and adjust air pressure.
3. Diagnose wheel/tire vibration and shimmy problems; determine needed repairs.
4. Inspect and replace wheels (rims), wheel spacers, studs and nuts.
5. Measure wheel and tire radial and lateral runout; determine needed repairs.
6. Balance wheel and tire assembly.
7. Measure tire diameter and/or circumference; match tires and rims.

E. Frame service and repair

1. Inspect frame and frame members for cracks, breaks, distortion, elongated holes, looseness and damage; determine needed repairs.
2. Inspect, install or repair cradle and cradle mounts, brackets and crossmembers in accordance with manufacturers' recommended procedures.
3. Inspect bulkheads for cracks and rust; determine needed repairs.

Appendix C: Sample curriculum

Steering and Suspension Systems
Module I: Steering System Diagnosis and Repair

Goal: Participants should understand the basics of steering system components and operation, be able to perform common maintenance procedures and efficiently diagnose and repair steering system problems.

Objectives:
Upon completion of this course, participants should be able to:

- identify the components and operating principles of the steering system;
- diagnose steering systems and determine repair needs;
- identify and replace defective steering linkage components;
- diagnose and repair steering columns; and
- describe wheel alignment angles and corrections.

Course description: Participants are provided with an introduction to the basics of steering and suspension systems. This instruction is both hands-on and classroom from a qualified instructor, who will introduce the basics of steering system and suspension components and operation, including pertinent physics, component identification, safety issues, applicable tools/equipment and proper usage. Participants should leave the course with a basic understanding of steering and suspension system operations, maintenance, diagnosis and repair.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands-on, online, lab): Hands-on and classroom

Course duration: 24 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or whiteboard (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, PowerPoint, homework assignment

- MICHELIN® Truck Tire Service Manual
- Specific bus manufacturers' maintenance repair manuals
- Specific steering gear repair manual
- Michelin "Tire Wear Fundamentals" video
- PowerPoints

Course developer: Brian Lester, EDSI

Subject matter experts: Mike Joyce, Metro Transit; Dan Engelkes, Rockford Mass Transit

Revision dates: 5/14/2013

Follow-up: To be determined based on ASE revision schedule

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Job tasks/learning objectives/OJT checklist: These are the concrete tasks that can be performed to apply the knowledge taught in this course and reinforce the content of the Steering section of the ASE H-6 Exam:

101	
Learning Objectives	**ASE Task Reference**
Explain basic hydraulic system principles	A6
Identify the procedures for removing air from a power steering system	A5
Explain steering shaft configurations, including tilt, telescopic and U-joint phasing	A1, A2
Demonstrate proper use of a belt tension gauge	A3
Demonstrate proper use of dial indicator	A3, A14, A15, A16
Check power steering fluid level and condition	A3, A4
Tighten fasteners to recommended torque values	A2

102	
Learning Objectives	**ASE Task Reference**
Describe different types of steering control links (boomerang, differential lever, strut)	A3
Explain gear/miter box operation	A3
Demonstrate proper use of a steering wheel puller	A1, A2
Attach mounting hardware	A14, A15, A16
Check greased components for proper lubrication	A3
Check play, wear and positioning of clamps and retainers	A14, A15, A16
Check steering U-joints	A1, A14, A15, A16
Inspect for lubrication, play and wear	A14, A15, A16
Visually inspect lines, fans, hoses, fittings, check valves	A11

103	
Learning Objectives	**ASE Task Reference**
Explain power steering and hydraulic system circuit tests	A6
Describe problems associated with underfilling, overfilling, contamination and improper hydraulic fluid	A4
Explain suspension airbag safety	A1
Check steering wheel placement/alignment	A1, C1
Visually inspect components (center link, drag link, tie rods, tie rod ends, steering damper) and check for proper lubrication	A14, A15, A16

201	
Learning Objectives	**ASE Task Reference**
Explain manufacturers' procedures for removing air from a power steering system	A5
Explain torque specifications for Pitman arm	A13
Adjust wheel stop bolts to produce specified turning radius	A17, A18
Check belt alignment and tension	A8
Check condition of brackets and fasteners	A1, A3
Check for contaminated fluid and change as required	A7
Check for leaks; repair as needed	A4
Check for leaks in articulated joint (if applicable)	A17
Check grease seals and seal condition (if present)	A13
Check manufacturer recommended fluid type	A4
Check power steering/hydraulic fluid in cooling system	A3
Check pressure relief valves	A12
Check power steering pump mounting holes for wear	A9
Check steering box mounting condition	A3
Check steering linkage, kingpins and kingpin bearings for excessive play or binding	A3
Check stop-to-stop range in steering box	A12
Check that grease fittings are in proper alignment; lubricate fittings properly	A2
Check the condition of belt, pulley and tensioners	A8
Correctly align Pitman arm on installation	A13
Demonstrate ability to diagnose steering column noises	A1
Fill and bleed system	A7
Follow manufacturers' procedures for removing air from a power steering system	A5
Identify an out-of-spec turning radius	A17, A18
Inspect belt and pulley condition	A3
Inspect mountings and brackets	A10
Inspect power steering pump	A10
Inspect reservoir for leaks or damage	A7
Inspect/lube slip joint	A2
Perform road test and note articulated alarms, sway of back end of articulation and bus tracking	A17
Perform road test to check for shimmy, wander and pull	A14, A15, A16
Perform road test to diagnose component failures	A13, B1(3), B2(3), C1, D13
Remove and replace filter	A7
Repair or replace electrical, hydraulic or mechanical components	A17
Replace reservoir	A7

Learning Objectives	ASE Task Reference
Tighten belts to the recommended tension	A3
Tighten steering wheel to proper torque	A2
Visually inspect tie rod hole (for Pitman arm)	A13

202

Learning Objectives	ASE Task Reference
Explain the relationship of wheel stops and steering box pressure relief valves	A17, A18
Demonstrate ability to use a dial indicator to check for wear and straightness	A14, A15, A16
Demonstrate ability to use a Pitman arm puller tool	A13
Demonstrate ability to use a tie rod puller/separator	A14, A15, A16
Adjust components as needed	A14, A15, A16
Adjust steering wheel with drag link	A14, A15, A16
Check for excessive steering wheel play	A1
Check phasing of U-joints and proper hardware	A2
Check steering column bearings	A1
Remove pump to inspect gear and coupling	A9
Replace gaskets, seals and O-rings as needed	A9
Replace lines, fans, hoses, fittings, check valves as needed	A11
Replace mountings and brackets	A10
Replace power steering pump	A10
Demonstrate ability to follow recommended procedures for inspecting and replacing bushings, bearings and seals	A2

203

Learning Objectives	ASE Task Reference
Adjust pressure relief valve settings	A12
Adjust stop-to-stop range in steering box	A12
Centerline/realign steering wheel back to square during installation	A2
Check for interference caused by incorrect routing	A1
Check leakage and aeration in the hydraulic system	A3
Check condition of teeth on drive gear	A9
Demonstrate ability to determine whether power steering problem is mechanical or hydraulic	A3
Replace faulty belt system components	A8

301	
Learning Objectives	**ASE Task Reference**
Demonstrate ability to use laptop to adjust angle sensor	A19
Demonstrate ability to use laptop to check pressures on the accumulators	A19
Connect flow meter and pressure gauge to ensure that flow and pressure are within the manufacturer's specifications	A3, A6
Demonstrate ability to use laptop or handheld diagnostic device to identify faults	A19
Adjust pressure relief settings to produce specified turning radius	A17, A18
Check adjustment of steering box relief valves	A3
Check alignment after replacement of components	A14, A15, A16
Demonstrate ability to diagnose power steering temperature sensor and wiring for sensor and fan motors	A11
Disable airbag/safety restraints in steering column where applicable	A1

Steering and Suspension Systems, Module II

Suspension Systems Diagnosis & Repair

Goal: Participants should understand the basics of steering system components and operation, be able to perform common maintenance procedures, and efficiently diagnose and repair steering system problems

Objectives:
Upon completion of this course, participants should be able to:

- identify and replace defective suspension components.

Course description: Participants will receive classroom instruction in which a qualified instructor will go over the basics of suspension system components and operation, including pertinent physics, component identification, safety issues, applicable tools/equipment and proper usage. Participants should leave the course with a basic understanding of suspension systems operations, maintenance, diagnosis and repair.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands-on, online, lab): Hands-on and classroom

Course duration: 24 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or whiteboard (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, PowerPoint, homework assignment

- Meritor Bus and Coach Front Axles Maintenance Manual 23
- MAN Axle Maintenance and Repair Manual
- MICHELIN® Truck Tire Service Manual
- Specific bus manufacturer's maintenance repair manual
- PowerPoints

Course developer: Brian Lester, EDSI

Subject matter experts: Mike Joyce, Metro Transit; Dan Engelkes, Rockford Mass Transit

Revision dates: 5/15/13

Follow-up: To be determined based on ASE revision schedule

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Job tasks/learning objectives/OJT checklist: These are the concrete tasks that can be performed to apply the knowledge taught in this course and to reinforce the content of the Suspension section of the ASE H-6 Exam:

101	
Learning Objectives	**ASE Task Reference**
Describe and demonstrate safety procedures while performing suspension repairs	B1(6), B2(5), B3(4), B3(7)
Describe proper ride height and its effect on the bus	B2(6)
Fill vehicle suspension system with air and check for leaks	B1(6), B2(5), B3(4)
Check component play and wear	B1(8), B3(5), B2(6)
Check condition of ball joint boots	B1(3)
Check condition of bushing, bracket and mounting hardware	B1(8), B2(4), B3(3)
Check for wear and cracks	B1(2), B1(8), , B2(2), B2(4), B3(2), B3(3)
Check front axle mounting hardware and components for movement and/or rust	B2(2)
Check hardware and components	B1(2), B3(2), B2(2), B3(2)
Check hardware and linkage for wear	B1(8), B3(5), B2(7)
Check lubrication; lubricate as necessary	B1(2), B1(3), B1(8), B3(2), B3(5), B2(2), B2(3), B2(7)
Check tire pressures and sizes	B2(1), C1, D2, D7
Inspect lines and clearances	B1(6), B2(5), B3(4)
Inspect seals for leaks	B2(3)
Adjust tire pressure to specs	B2(1)

102	
Learning Objectives	**ASE Task Reference**
Check for U-bolt movement, rust and corrosion	B3(2)
Check operation of kneeling indicator lamp and alarm	B1(7), B2(6)
Demonstrate ability to interpret readings from automatic tire pressure monitoring system (if applicable)	B1(1), B2(1), B3(1)

103	
Learning Objectives	**ASE Task Reference**
Explain function of valves and air flow through suspension system	B3(6)
Test for correct operation of kneeling and interlock system	B1(7), B2(6)
Visually inspect tire wear and pressure, and suspension components	B1(1), B2(1), B3(1)

201	
Learning Objectives	**ASE Task Reference**
Explain ADA requirements for kneeling system	B1(7), B2(6)
Adjust ride height at the front and rear leveling valves	B1(5), B2(6), B3(4)
Check air systems and note/repair air leaks	B3(6)
Check bolts on lateral rod	B2(7)
Check condition of leveling valve links	B1(5), B3(4)
Check for cracks and/or leaks in the housing	B3(2)
Check for proper torque specifications	B1(2), B1 (8), B2(2), B3(2), B3(5), D5
Check for shock absorber leaks	B1(8), B2(4), B3(3)
Check for wear and play in kingpins/ball joints	B1(3), B2(3)
Check hardware for loose/damaged linkage	B1(8) , B3(5)
Check manufacturer specifications on allowable bushing or shim play	B1(3), B2(3)
Check shifting of rear axle; check driveshaft alignment and phasing	B3(1)
Check U-bolts on lateral rod	B2(6)
Ensure that play is not wheel bearing related	B1(4)
Inspect air bags for wear	B1(6), B2(5), B3(4)
Inspect kneeling system	B2(6)
Inspect leveling valves	B1(6), B3(4)
Inspect linkage	B1(6), B3(4)
Inspect spindle for damage	B1(4)
Measure and adjust ride height	B2(5)
Perform road test to test excessive bounce or sway	B1(8), B2(4), B3(3)
Note sequence and timing of operation for different manufacturers	B1(7), B2(6)
Perform road test and note rough ride, looseness, body sway	B1(1), B2(1), B3(1)
Perform road test to diagnose component failures	A13, B1(3), B2(3), C1, D13
Demonstrate ability to refer to manufacturer specifications for front, rear and side-to-side ride height	B1(5), B2(6), B3(4)
Replace seals and covers as required	B2(3)
Replace shock absorbers; adjust if required	B1(8), B2(4), B3(3)
Torque mounting bolts to manufacturer’s specifications	B2(6)

Learning Objectives	ASE Task Reference
Unload front end	B1(3), B2(3), C8
Visually check for wear and play in kingpins	B2(3)
Torque to manufacturer's specifications	B2(2), D4, D5

202

Learning Objectives	ASE Task Reference
Demonstrate ability to use a ball joint press	B1(3)
Check bushings, hardware and control arm components	B1(2)
Replace air bags, valves, linkage, lines or brackets as necessary	B1(6), B2(5), B3(4)
Replace ball joints/kingpins as necessary	B1(3), B2(3)
Replace components and torque to proper specifications	B1(8), B3(2), B3(5), D4

203

Learning Objectives	ASE Task Reference
Demonstrate ability to use dial indicator to inspect kingpins and compare to wear specifications	B1(3), B2(3)
Install bushings and use reamer when necessary	B1(3)

301

Learning Objectives	ASE Task Reference
Describe the correlation between the kneeling and interlock systems	B2(6)
Check axle alignment	B2(7)
Remove steering knuckle bushings	B2(3)

302

Learning Objectives	ASE Task Reference
Demonstrate ability to use bushing reamer tool	B2(3)
Demonstrate ability to use heating and cutting equipment to remove shock mounting hardware	B2(4)
Check condition of steering knuckle bushings	B2(3)
Install and adjust shims	B2(3)
Install steering knuckle bushings	B2(3)
Remove and replace wedge pins with kingpins	B1(3), B2(3)

303

Learning Objectives	ASE Task Reference
Demonstrate ability to use kingpin press	B1(3), B2(3)

Steering and Suspension Systems, Module III

Wheel Alignment Diagnosis, Adjustment and Repair

Goal: Participants should understand the basics of steering system components and operation, be able to perform common maintenance procedures, and efficiently diagnose and repair steering system problems.

Objectives:
Upon completion of this course, participants should be able to:

- diagnose wheel alignment problems;
- explain alignment concepts and adjustments;
- perform proper wheel alignment; and
- demonstrate ability to use a laptop.

Course description: Participants will receive classroom instruction in which a qualified instructor will go over the basics of wheel alignment adjustment and repairs, including pertinent physics, component identification, safety issues, applicable tools/equipment and proper usage. Participants should leave the course with a basic understanding of wheel alignment theory, practice and related repairs and diagnosis.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands-on, online, lab): Hands-on and classroom

Course duration:

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or whiteboard (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, PowerPoint, homework assignment

- Michelin “Wheel End Safety” video
- Koni Shock Technicians Guide Handout
- Specific bus manufacturer’s maintenance repair manual

Course developer: Brian Lester, EDSI

Subject matter experts: Mike Joyce, Metro Transit; Dan Engelkes, Rockford Mass Transit

Revision dates: 5/15/13

Follow-up: To be determined based on ASE revision schedule

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Job tasks/learning objectives/OJT checklist: These are the concrete tasks that can be performed to apply the knowledge taught in this course and reinforce the content of the Wheel Alignment section of the ASE H-6 Exam:

101	
Learning Objectives	**ASE Task Reference**
Describe the basics of steering and axle alignment	C2, C3, C4, C7
Describe the terms “steering axis inclination (SAI)” and “kingpin inclination (KPI)”	C4
Describe the difference between camber measures and Ackerman angles	C2, C6
Describe thrust line, centerline and tracking	C7
Describe caster	C3
Check shock absorbers	C1
Check tire pressures and sizes	B2(1), C1, D2, D7
Inspect steering component wear	C1
Visually check for dog tracking, wandering	C1

102	
Learning Objectives	**ASE Task Reference**
Check for damaged/deteriorated frame components (cracks, breaks, distortion)	C1

103	
Learning Objectives	**ASE Task Reference**
Check ride height, bearing play and tire pressures	C1
Check steering wheel placement/alignment	A1, C1

201	
Learning Objectives	**ASE Task Reference**
Explain possible causes for drivability issues	C1
Explain toe-in and toe-out	C5
Demonstrate use of gauge to measure toe	C2
Check for axle wheel bearing play and wear	C8
Demonstrate ability to differentiate between brake pull and steering wander	C1
Measure camber and determine if within specification	C2, C3
Measure toe and determine if within specification	C5
Perform road test to diagnose component failures	A13, B1(3), B2(3), C1, D13
Unload and inspect axle	C8
Unload front end	B1(3), B2(3), C8
Refer to manufacturer’s specifications; adjust if needed	C2, C3, C4, C5, C6, C7

202	
Learning Objectives	**ASE Task Reference**
Demonstrate ability to use a dial indicator to check that play and loading are within manufacturer's specifications	C8
Adjust rear axle alignment as needed	C7
Check rear axle against thrust line/centerline	C7
Measure Ackerman angle and check if within specifications	C6
Measure steering axis inclination and kingpin inclination and check if within specifications	C4
Place vehicle on alignment machine	C2, C3, C4, C5, C6, C7

203	
Learning Objectives	**ASE Task Reference**
Adjust bearings as needed	C8
Adjust to manufacturer specifications	C2, C3, C4, C5
Demonstrate ability to use laptop to check for dog tracking and wandering	C1

Steering and Suspension Systems, Module IV

Wheels and Tires Diagnosis and Repair

Goal: Participants should understand the basics of steering system components and operation, be able to perform common maintenance procedures, and efficiently diagnose and repair steering system problems.

Objectives:
Upon completion of this course, participants should be able to:

- understand OSHA regulation Standard 29 CFR Part 1910.177 ("Servicing Multi-Piece and Single Piece Rim/Wheels");
- demonstrate safe tire and wheel work practices;
- describe tire wear patterns and how they occur;
- explain general tire terminology; and
- explain wheel and tire service.

Course description: Participants will receive classroom instruction in which a qualified instructor will go over the basics of wheel and tire components and operation, including pertinent physics, component identification, safety issues, applicable tools/equipment and proper usage. Participants should leave the course with a basic understanding of transit bus wheel and tire maintenance, diagnosis and repair.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands-on, online, lab): Hands-on and classroom

Course duration: 24 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or whiteboard (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: An in-line valve with a pressure gauge or a pre-settable regulator, and sufficient length of hose between the clip-on chuck and the in-line valve (if one is used) to allow the employee to stand outside the trajectory; tire inflation safety cage; wheel balancer; 500 ft-lb torque wrench; dial indicator with roller; 1 in. drive tire gun; T-45 tire bar; tire circumference gauge; wheel dolly

- OSHA Standard 29 CFR Part 1910.177 ("Servicing Multi-Piece and Single Piece Rim/Wheels")
- Goodyear Truck Tire and Retread Service Manual
- Accuride Wheels, Rim/Wheel Safety and Service Manual
- Michelin in-shop safety video
- Specific bus manufacturer's maintenance repair manual

Course developer: Brian Lester, EDSI

Subject matter experts: Mike Joyce, Metro Transit; Dan Engelkes, Rockford Mass Transit

Revision dates: 5/15/13

Follow-up: To be determined based on ASE revision schedule

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Job tasks/learning objectives/OJT checklist: These are the concrete tasks that can be performed to apply the knowledge taught in this course and reinforce the content of the Wheels and Tires section of the ASE H-6 Exam:

101	
Learning Objectives	**ASE Task Reference**
Describe different tire wear patterns and how they occur	D1
Describe radial and lateral runout	D5
Explain OSHA requirements related to tire maintenance	D1, D2, D3, D4, D5, D6, D7
Align tires properly for checking inside tire pressure	D2
Inspect for loose/bent components	D3
Check tire pressures and sizes	B2(1), C1, D2, D7
Inspect tire tread depth, sidewall damage, recap condition, broken belts	D2, D6
Visually inspect rims, spacers, studs and nuts	D4
Replace tire	D5

102	
Learning Objectives	**ASE Task Reference**
Compare wheel and tire runout to manufacturer specifications	D5
Inspect condition of valve stem, cap, core and seal	D2
Match tires on axle by diameter or circumference	D7
Match tires to rims by selecting/measuring correct tire diameter	D7
Torque to manufacturer's specifications	D4

103	
Learning Objectives	**ASE Task Reference**
Determine that vibration is not drivetrain or suspension related	D3

201	
Learning Objectives	**ASE Task Reference**
Explain how the balance machine operates	D6
Demonstrate use of dial indicator to perform runout measurements on mounted tire/wheel and compare to manufacturer's specifications	D5
Check for proper torque specifications	B1(2), B1 (8), B2(2), B3(2), B3(5), D5
Demonstrate ability to diagnose specific wheel/tire problems	D3
Perform road test to diagnose component failures	A13, B1(3), B2(3), C1, D13
Perform static balance tests; add weights as necessary to rebalance assembly	D6
Service rim and wheel as needed	D5
Torque to manufacturer's specifications	B2(2), D4, D5

202	
Learning Objectives	**ASE Task Reference**
Perform balance tests, and balance as needed	D3, D6
Replace components and torque to proper specifications	B1(8), B3(2), B3(5), D4