AUTO-1450: AUTOMOTIVE BRAKING SYSTEMS

Cuyahoga Community College

Viewing: AUTO-1450 : Automotive Braking Systems

Board of Trustees:
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Academic Term:
Fall 2022

Subject Code
AUTO - Automotive Technology

Course Number:
1450

Title:
Automotive Braking Systems

Catalog Description:
Designed to provide student with foundation in theory and operation of automotive braking systems. Includes hydraulic brake principles, machining operations, and troubleshooting and repair of disc and drum brake assemblies. Operation and diagnosis of anti-lock braking systems included.

Credit Hour(s):
3

Lecture Hour(s):
2

Lab Hour(s):
3

Other Hour(s):
0

Requisites

Prerequisite and Corequisite
None.

Outcomes

Course Outcome(s):
Diagnose brake systems.

Essential Learning Outcome Mapping:
Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):
1. Identify and interpret brake system concerns; determine necessary action.
2. Research vehicle service information including fluid type, vehicle service history, service precautions, and technical service bulletins.
3. Describe procedure for performing a road test to check brake system operation; including an anti-lock brake system (ABS).
4. Install wheel and torque lug nuts.

Course Outcome(s):
Diagnose and repair hydraulic brake systems.

Objective(s):

1. Diagnose poor stopping, pulling or dragging concerns caused by malfunctions in the hydraulic system; determine necessary action.
2. Inspect brake lines, flexible hoses, and fittings for leaks, dents, kinks, rust, cracks, bulging, wear; and loose fittings/supports; determine needed action.
3. Replace brake lines, hoses, fittings, and supports.
4. Fabricate brake lines using proper material and flaring procedures (double flare and ISO types).
5. Select, handle, store, and fill brake fluids to proper level; use proper fluid type per manufacturer specification.
6. Identify components of hydraulic brake warning light system.
7. Identify components of brake warning light system.
8. Bleed and/or flush brake system.
9. Test brake fluid for contamination.
10. Diagnose pressure concerns in the brake system using hydraulic principles (Pascal's Law).
11. Measure brake pedal height, travel, and free play (as applicable); determine necessary action.
12. Check master cylinder for internal/external leaks and proper operation; determine necessary action.
13. Remove, bench bleed, and reinstall master cylinder.

Course Outcome(s):

Diagnose and repair drum brakes.

Objective(s):

1. Diagnose poor stopping, noise, vibration, pulling, grabbing, dragging or pedal pulsation concerns; determine necessary action.
2. Remove, clean, and inspect brake drum; measure brake drum diameter; determine serviceability.
3. Refinish brake drum and measure final drum diameter; compare with specifications.
4. Remove, clean, inspect, and/or replace brake shoes, springs, pins, clips, levers, adjusters/self-adjusters, other related brake hardware, and backing support plates; lubricate and reassemble.
5. Inspect wheel cylinders for leaks and proper operation; remove and replace as needed.
6. Pre-adjust brake shoes and parking brake; install brake drums or drum/hub assemblies and wheel bearings; perform final checks and adjustments.

Course Outcome(s):

Diagnose and repair disc brakes.

Objective(s):

1. Diagnose poor stopping, noise, vibration, pulling, grabbing, dragging, or pulsation concerns; determine necessary action.
2. Remove and clean caliper assembly; inspect for leaks, damage, and wear; determine needed action.
3. Inspect caliper mounting and slides/pins for proper operation, wear, and damage; determine needed action.
4. Remove, inspect, and/or replace brake pads and retaining hardware; determine needed action.
5. Lubricate and reinstall caliper, brake pads, and related hardware; seat brake pads; inspect for leaks.
6. Clean and inspect rotor and mounting surface; measure rotor thickness, thickness variation, and lateral runout; determine needed action.
7. Remove and reinstall/replace rotor.
8. Refinish rotor on vehicle; measure final rotor thickness and compare with specifications.
9. Refinish rotor off vehicle; measure final rotor thickness and compare with specifications.
10. Retract and re-adjust caliper piston on an integrated parking brake system.
11. Check brake pad wear indicator; determine necessary action.
12. Describe importance of operating vehicle to burnish/break-in replacement brake pads according to manufacturer's recommendations.

Course Outcome(s):

Diagnose and repair power-assisted brake systems.

Objective(s):

1. Check brake pedal travel with, and without, engine running to verify proper power booster operation.
2. Identify components of the brake power assist system (vacuum and hydraulic); check vacuum supply (manifold or auxiliary pump) to vacuum- type power booster.
2. Check vacuum supply (manifold or auxiliary pump) to vacuum-type power booster.
3. Inspect vacuum-type power booster unit for leaks; inspect the check-valve for proper operation; determine necessary action.
4. Inspect and test hydraulically-assisted power brake system for leaks and proper operation; determine necessary action.
5. Measure and adjust master cylinder pushrod length.

Course Outcome(s):

Diagnose and repair miscellaneous related brake components and systems (wheel bearings, parking brakes, electrical components).

Objective(s):

1. Diagnose wheel bearing noises, wheel shimmy, and vibration concerns; determine necessary action.
2. Remove, clean, inspect, repack, and install wheel bearings; replace seals; install hub and adjust bearings.
3. Check parking brake system and components for wear, binding, and corrosion; clean, lubricate, adjust and/or replace as needed.
4. Check parking brake operation and parking brake indicator light system operation; determine necessary action.
5. Check operation of brake stop light system.
6. Replace wheel bearing and race.
7. Remove, reinstall, and/or replace sealed wheel bearing assembly.

Course Outcome(s):

Diagnose and repair electronic brake, traction and stability control components, and systems.

Objective(s):

1. Identify and inspect electronic brake control system components; determine necessary action.
2. Identify traction control/vehicle stability control system components.
3. Describe the operation of a regenerative braking system.
4. Diagnose poor stopping, wheel lock-up, abnormal pedal feel, unwanted application, and noise concerns associated with the electronic brake control system; determine necessary action.
5. Diagnose electronic brake control system electronic control(s) and components by retrieving diagnostic trouble codes, and/or using recommended test equipment; determine necessary action.
6. Identify and inspect electronic brake control system components (ABS, TCS, ESC); determine needed action.
7. Bleed the electronic brake control system hydraulic circuits.
8. Test, diagnose, and service electronic brake control system speed sensors (digital and analog), toothed ring (tone wheel), and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO) (includes output signal, resistance, shorts to voltage/ground, and frequency data).
9. Diagnose electronic brake control system braking concerns caused by vehicle modifications (tire size, curb height, final drive ratio, etc.).
10. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.
11. Demonstrate knowledge of electrical/electronic series, parallel, and series-parallel circuits using principles of electricity (Ohm's Law).
12. Demonstrate proper use of a digital multimeter (DMM) when measuring source voltage, voltage drop (including grounds), current flow and resistance.
13. Demonstrate knowledge of the causes and effects from shorts, grounds, opens, and resistance problems in electrical/electronic circuits.
14. Check operation of electrical circuits with a test light.
15. Check operation of electrical circuits with fused jumper wires.
16. Use wiring diagrams during the diagnosis (troubleshooting) of electrical/electronic circuit problems.
17. Diagnose the cause(s) of excessive key-off battery drain (parasitic draw); determine necessary action.
18. Inspect and test fusible links, circuit breakers, and fuses; determine necessary action.
19. Inspect and test switches, connectors, relays, solenoid solid state devices, and wires of electrical/electronic circuits; determine necessary action.
20. Replace electrical connectors and terminal ends
21. Repair wiring harness.
22. Perform solder repair of electrical wiring.
23. Check electrical/electronic circuit waveforms; interpret readings and determine needed repairs.
24. Repair CAN/BUS wiring harness.

Course Outcome(s):

Shop and personal safety is a primary and ongoing concern while in the repair environment for automotive braking systems; including using tools and equipment, working around supplemental restraint(SRS) or high voltage circuits, wearing personal protection equipment, awareness of personal clothing, adornments and body, and knowledge of fire safety and evacuation routes.

Objective(s):

1. For every outcome and/or supporting objective in AUTO-1450 Automotive Braking Systems the following safety requirements must be strictly enforced: Comply with personal and environmental safety practices associated with clothing; eye protection; hand tools; power equipment; proper ventilation; and the handling, storage, and disposal of chemicals/materials in accordance with local, state, and federal safety and environmental regulations.

Methods of Evaluation:

1. Participation and discussion
2. Observation

3. Written assignments
4. Exams
5. Quizzes
6. Lab tasks
7. Classroom recitations

Course Content Outline:

- Early brake designs
- Automotive brake designs
  a. External contracting-band brakes
  b. Internal expanding-band brakes
  c. Internal expanding-shoe brakes
  d. Disc brakes
- Brake system operation
- Service brakes
  a. Pedal assembly
  b. Power booster
  c. Master cylinder
  d. Hydraulic lines and hoses
  e. Hydraulic switches and valve
  f. Brake power assist system
- Wheel friction assemblies
  a. Drum brakes
  b. Disc brakes
- Parking brakes
  a. Parking brake friction assemblies
- Methods of brake actuation
  a. Mechanical actuation
  b. Hydraulic actuation
  c. Pneumatic actuation
  d. Electric actuation
- Brakes and the law
- Federal brake standards
  a. FMVSS 105 brake test
- Brake repair and the law
- Brakes and health
- Asbestos exposure
  a. Sources of asbestos exposure
  b. Effects of asbestos exposure
    i. asbestosis
    ii. cancer
- Asbestos precautions
- Asbestos waste disposal
- Chemical poisoning
  a. Sources of chemical poisoning
  b. Effects of chemical poisoning
- Chemical precautions
- Health care rights
- Energy principles
- Kinetic energy
  a. Weight and speed effects
  b. Kinetic energy and brake design
- Inertia
  a. Weight transfer and bias
- Mechanical principles
- Hydraulic principles
  a. Non-compressibility of liquids
  b. Constancy of pressure
  c. Hydraulic pressure and piston size

    d. Application force and piston size
    e. Piston size versus piston travel
    f. Hydraulic principles and brake design
- Friction principles
    a. Coefficient of friction
        i. surface finish effects
        ii. friction material effects
        iii. heat effects
    b. Friction contact area
    c. Static and kinetic friction
- Friction and heat
    a. Brake fade
- Brake fluid
- Brake fluid specifications
    a. Boiling point
    b. Dry and wet boiling points
    c. Temperature compatibility
    d. Mechanical compatibility
    e. Fluid compatibility
- Brake fluid types
    a. Polyglycol brake fluid
    b. Silicone brake fluid
    c. Hydraulic system mineral oil (HMSO)
- Brake fluid storage and handling
- Brake bleeding
    a. Manual bleeding
    b. Pressure bleeding
    c. Vacuum bleeding
- Brake fluid changes
    a. Silicone brake fluid changes
- Brake lines
    a. Brake tubing
    b. Brake hoses
- Brake line fittings
- Compression fittings
    a. flare fittings
        i. SAE flare fittings
        ii. ISO flare fittings
- Brake line routing
- Pedal assemblies
    a. Frame-mounted brake pedals
    b. Suspended brake pedals
    c. Brake pedal ratio
    d. Brake pedal freeplay
        i. freeplay adjustment
- Master cylinder construction
    a. Brake fluid reservior
        i. reservoir covers
    b. Master cylinder body
    c. Master cylinder pistons
    d. Piston seals
- Master cylinder operation
- Single piston master cylinder
    a. Brakes not applied
    b. Brake application
    c. Brake release
    d. Brake pumping
- Dual-circuit brake systems
- Standard dual-piston master cylinder

    a. Brakes not applied
    b. Brake application
        i. primary circuit failure
        ii. secondary circuit failure
    c. Brake release and brake pumping
- Quick-take-up master cylinder
    a. Brakes not applied
    b. Brake application
    c. Brake release
- Hydraulic valves
- Residual pressure check valve
    a. Residual check valve operation
    b. Systems without residual check valves
- Metering valve
    a. Metering valve operation
    b. Systems without metering valvees
    c. Metering valves and brake bleeding
- Proportioning valve
    a. Proportioning valve operation
    b. Height-sensing proportioning valve
- Combination valves
- Brake system switches
    a. Pressure differential switch
    b. Pressure differential switch operation
- Fluid level switch
- Stoplight switch
- Wheel cylinders
    a. Wheel cylinder body
    b. Wheel cylinder pistons and seals
        i. cup expanders
    c. Wheel cylinder dust boots
    d. Wheel cylinder designs
    e. Wheel cylinder operation
- Brake calipers
    a. Brake caliper body
        i. piston bores
            1. brake fluid routing
    b. Brake caliper pistons
        i. piston heat transfer
    c. Caliper piston materials
        i. aluminum pistons
        ii. cast iron and steel pistons
        iii. phenolic pistons
    d. Caliper piston seals
        i. stroking piston seals
        ii. fixed piston seals
            1. seal flex and piston retraction
        iii. low drag caliper seals
    e. Brake caliper dust boots
    f. Brake caliper operation
- Drum brake advantages
    a. Self-energizing and servo action
    b. Parking brake service
- Drum brake disadvantages
    a. Brake fade
        i. mechanical fade
        ii. lining fade
        iii. gas fade
        iv. water fade

- b. Adjusting mechanism
- c. Brake pull

- Drum brake construction
  - a. Backing plate
    - i. shoe anchors
    - ii. piston stops
    - iii. shoe contact pads
    - iv. wheel cylinders
  - b. Brake shoes
  - c. Brake shoe return springs
  - d. Brake shoe holddowns
  - e. Parking brake linkage
  - f. Brake drum
- Drum brake design
  - a. Non-servo brakes
    - i. self energizing action
    - ii. specific non servo brakes
    - iii. double trailing brake
    - iv. leading trailing brake
    - v. double leading brake
    - vi. non-directional
  - b. Dual-servo brakes
    - i. dual-servo brake construction
      1. adjusting link
      2. Primary and secondary brake shoes
    - ii. dual-servo brake operation
      1. servo action
    - iii. other dual-servo brakes
  - c. Uni-servo brake
  - d. Brake adjusters
    - i. manual brake adjusters
      1. starwheel manual adjusters
      2. cam manual adjusters
      3. wedge manual adjuster
      4. anchor manual adjusters
    - ii. automatic brake adjusters
      1. servo brake starwheel automatic adjusters
      2. non-servo starwheel automatic adjusters
      3. lever-latch automatic adjuster
      4. strut-rod automatic adjusters
      5. strut quadrant automatic adjuster
- Disc brake advantages
  - a. Fade resistance
    - i. swept area
    - ii. mechanical fade
    - iii. lining fade
    - iv. gas fade
    - v. water fade
  - b. Self-adjusting ability
  - c. Freedom from pull
- Disc brake disadvantages
  - a. No self-energizing or servo action
  - b. Brake noise
  - c. Poor parking brake performance
- Disc brake construction
  - a. Caliper
  - b. Splash shield
  - c. Brake pads
  - d. Brake rotor

- Disc brake design
  a. Fixed caliper design
     i. fixed caliper advantages
     ii. fixed caliper disadvantages
  b. Floating and sliding caliper design
     i. floating and sliding caliper advantages
     ii. floating and sliding caliper disadvantages
  c. Rear disc brakes
     i. rear disc parking brakes
     ii. four-wheel-disc hydraulic systems
  d. Inboard disc brakes
- Drum brake shoe construction
  a. Primary and secondary brake shoes
- Disc brake pad construction
  a. Pad wear indicators
- Shoe and pad friction materials
  a. Organic brake linings
     i. high temperature organic linings
     ii. "autobahn formula" organic linings
  b. Metallic brake linings
  c. Semi-metallic brake linings
     i. semi-metallic brake linings and rotor wear
     ii. semi-metallic lining applications
  d. Synthetic brake linings
     i. fiberglass brake linings
     ii. aramid brake linings
     iii. ceramic brake linings
  e. Lining material coefficient of friction
     i. edgebranding
     ii. hard and soft brake linings
  f. Lining assembly methods
     i. riveting
     ii. bonding
     iii. mold bonding
     iv. fusing and brazing
  g. Brake shoe to drum fit
     i. brake shoe arcing
        1. cam grinding
        2. undersize grinding
        3. fixed anchor grinding
     ii. shoe arcing and modern brake service
- Brake drum and rotor construction
  a. Solid drums
  b. Composite drums
  c. Steel and iron composite drums
  d. Aluminum and iron composite drums
  e. Solid and vented rotors
  f. Uni-directional vented rotors
  g. Drilled and slotted rotors
- Drum and rotor mounting methods
  a. Fixed drums and rotors
  b. Floating drums and rotors
- Brake drum and rotor wear and damage
  a. Drum taper wear
  b. Drum barrel wear
  c. Rotor taper variation
  d. Scoring
  e. Cracking

    f. Heat checking
    g. Hard or chill spots
- Brake drum and rotor distortion
    a. Drum distortion
        i. bellmouth drums
        ii. out-of-round drums
        iii. eccentric drums
    b. Rotor distortion
        i. rotor lateral runout
        ii. rotor lack of parallelism
- Drum and rotor refinishing
    a. Drum and rotor turning
    b. Drum grinding
    c. Rotor resurfacing
    d. Drum and rotor metal removal limits
        i. drum discard diameter
        ii. rotor discard dimension
    e. Special drum refinishing considerations
    f. Special rotor refinishing considerations
        i. special rotor metal removal limits
            1. rotor inner surface stock removal limit
        ii. rotor surface finish
            1. determining rotor surface finish
- Pedals, levers and handles
    a. Parking brake controls
        i. automatic parking brake release
    b. Parking brake levers
    c. Parking brake handles
    d. Electric parking brake switches
- Parking brake types
    - Electric
    - Mechanical/cable
- Parking brake linkages
    a. Linkage rods
    b. Linkage cables
    c. Linkage levers
    d. Linkage equalizers
    e. Electric actuators
    f. Linkage design
        i. single-cable linkages
        ii. dual-cable linkages
        iii. multiple-cable linkages
    g. Parking brake linkage adjustment
- Drum parking brakes
    a. Integral drum parking brakes
    b. Rear disc auxiliary drum parking brakes
    c. Driveline auxiliary drum parking brakes
        i. external contracting band driveline auxiliary drum parking brakes
        ii. internal expanding shoe driveline auxiliary drum parking brakes
- Caliper-actuated disc parking brakes
    a. Ball and ramp actuation
    b. Screw, nut and cone actuation
    c. Eccentric shaft and rod actuation
    d. Auxiliary disc parking brakes
- Ways to increase braking power
    a. Pedal force
    b. Mechanical advantage
    c. Hydraulic advantage
    d. Vacuum advantage
- Power boosters

    a. Vacuum booster theory
        i. air pressure - high and low
            1. meaeasuring vacuum
            2. booster vacuum supply
        ii. vacuum booster suspension
            1. atmospheric-suspended power chambers
            2. vacuum-suspended power chambers
        iii. vacuum check valves
            1. vacuum supply line filters
    b. Integral vacuum booster operation
        i. brakes not applied
        ii. brake application
        iii. brakes holding
        iv. brakes fully applied
        v. brake release
        vi. brake pedal feel
            1. pedal feel with reaction disc
            2. pedal feel with reaction plate and levers
    c. Multiplier vacuum boosters
    d. Hydraulic boosters
    e. Mechanical-hydraulic boosters
    f. Electro-hydraulic boosters
    g. Dual-power brake systems
- ABS characteristics
    a. ABS and tire traction
        i. tire slip and braking distance
        ii. tire slip and vehicle stability
    b. ABS is only an add-on
    c. ABS limitations
        i. antilock system limitations
        ii. antilock system physical limitations
- ABS operation
- System configurations
    a. Four-channel ABS
    b. Three-channel ABS
    c. Single-channel ABS
    d. Integral and non-integral
- ABS components
    a. Wheel speed sensors
    b. ABS control module
    c. ABS warning lamp
    d. Hydraulic modulator assembly
    e. Pump motor and accumulator
- Traction control
    a. Traction control operation
        i. traction active lamp
        ii. traction control strategies
        iii. traction deactivation switch
- Various ABS
- Brake shrouding
- Suspension and braking
    a. Suspension wear and damage
    b. Wheel alignment
    c. Wheel bearings and braking
- Shop safety and practices
    a. Lifts and hoists
    b. Jacks and safety stands
- Cleaning tools

   a. Brake vacuums
   b. Brake washers
   c. Brushes and scrapers
   d. Parts washers
   e. Air compressors
- Chemical cleaners
   a. Non-petroleum based solvents
   b. Alcohol
   c. Detergents
- Brake tools
   a. Adjusting tools
      i. special wrenches
         1. bleeder screw
         2. flare nut
         3. torque wrenches
   b. Tubing tools
      i. tubing cutters
      ii. tubing benders
      iii. flaring tools
   c. Assembly/disassembly tools
      i. holddown spring tools
      ii. return spring tools
      iii. wheel cylinder removal tools
      iv. caliper piston removers
      v. disc brake pad spreaders
      vi. wheel cylinder clamps
      vii. parking brake spring tools
      viii. dust boot tools
         1. drivers
         2. rings
         3. pliers
      ix. c-clamps
      x. swaging removal tools
   d. Measuring tools
      i. feeler gauges
      ii. micrometers
      iii. dial indicators
      iv. shoe setting calipers
      v. drum micrometers
      vi. cylinder bore go/no go gauges
      vii. pedal effort gauge
      viii. Tapley brake testing meter
   e. Cylinder and caliper refinishing tools
      i. drill motors
      ii. hone
   f. Friction component refinishing tools
      i. brake lathes
      ii. drum grinders
      iii. rotor resurfacer
   g. Hydraulic service tools
      i. brake fluid syringe
      ii. pressure bleeder
- Brake system diagnosis
   a. Talking to the customer
   b. Brake system road testing
   c. Road test procedure
      i. driveline vibration test
      ii. brake vibration test
      iii. braking power

    iv. braking stability
    v. brake pedal travel and feel test
    vi. brake noise
  d. Brake inspection
  e. Brake system diagnostic charts
    i. pedal symptoms
    ii. wheel brake symptoms
    iii. brake performance
    iv. brake noise
- Fluid related brake service
  a. Fluid level checking
    i. brake fluid inspection
    ii. brake fluid selection
    iii. specific brake fluid level checks
      1. conventional brake system
      2. ABS
  b. Brake bleeding
    i. bleeding sequences
    ii. master cylinder bench bleeding
      1. manual bench bleeding
      2. basic bench bleeding
      3. reverse bench bleeding
    iii. master cylinder on-car bleeding
      1. with bleeder screws
      2. without bleeder screws
    iv. bleeding the wheel brakes
      1. manual bleeding
      2. vacuum bleeding
      3. gravity bleeding
      4. pressure bleeding
      5. surge bleeding
    v. bleeding ABS
  c. Fluid changing
  d. Recentering pressure differential switches
    i. single piston switch without centering springs
    ii. single piston switch with centering springs
    iii. two-piston switch with centering springs
- Brake line, hydraulic valve and electrical component service
  a. Brake line inspection
    i. hoses
    ii. tubing
  b. Brake hose replacement
    i. removal
    ii. installation
  c. Brake tubing replacement
  d. Brake tubing fabrication
    i. cutting
    ii. bending
    iii. flaring
      1. SAE
      2. ISO
  e. Hydraulic control valve service
    i. metering valve tests
      1. pressure bleeder test
      2. pressure gauge test
    ii. proportioning valve tests
    iii. metering and proportioning valve replacement
    iv. proportioning valve adjustment
  f. Brake electrical component service

        i. electrical troubleshooting tools
        ii. stoplight circuit tests
            1. lights always on
            2. lights never on
        iii. mechanical stoplight switch adjustment
        iv. stoplight switch replacement
        v. warning light circuit tests
            1. warning light bulb tests
            2. parking brake switch test
        vi. failure warning system switch tests
            1. pressure differential switch test
            2. fluid level switch tests
- Pedal assembly, master cylinder, and wheel cylinder service
    a. Brake pedal assembly service
        i. pedal linkage inspection
        ii. pedal freeplay adjustment
    b. Master cylinder inspection and testing
        i. inspection
        ii. testing
            1. quick-take-up valve test
            2. compensating port test
            3. external leak test
            4. internal leak test
    c. Wheel cylinder inspection
    d. Master cylinder replacement
    e. Wheel cylinder replacement
    f. Hydraulic cylinder
- Overhaul
    a. i. overhaul kits
        ii. cylinder internal inspection
        iii. bleeder screw removal
        iv. cylinder honing
        v. cylinder bore measurement
    b. Master and wheel cylinder overhaul procedures
        i. Ford cast-iron dual master cylinder
        ii. General Motors aluminum QTU master cylinder
        iii. Two-piston wheel cylinder
- Drum Brake service
    a. Brake drum removal
        i. fixed drums
        ii. floating drums
    b. Drum brake inspection
        i. linings
        ii. wheel cylinder and axle
        iii. hardware
    c. Brake adjusting
        i. pedal travel test
        ii. parking brake caution
        iii. adjusting procedure
        iv. problem adjustments
        v. specific brake adjusters
            1. starwheel brake adjustment
            2. cam brake adjustment
            3. wedge brake adjustment
            4. eccentric anchor
            5. slotted anchor
    d. Brake shoe replacement

    i. disassembly
    ii. inspection
    iii. assembly
  e. Initial brake adjustment
    i. starwheel adjusters
    ii. drum installed
  f. Brake shoe burnish-in
  g. Shoe replacement procedures
    i. leading-trailing brake
    ii. dual-servo with cable type starwheel adjuster
    iii. dual-servo with lever-type starwheel adjuster
    iv. leading-trailing brake with strut-quadrant adjuster
- Disc brake service
  a. Brake pad inspection
    i. on-car
    ii. off-car
  b. Brake pad replacement
    i. pad removal
    ii. pad installation
  c. Brake pad burnish-in
  d. Brake caliper external inspection
    i. Brake caliper overhaul bleeder screw removal
    ii. brake caliper piston removal
      1. mechanical
      2. compressed air
      3. hydraulic
      4. hydraulic service bench
    iii. dust boot and piston seal removal
    iv. caliper internal inspection
      1. piston
      2. caliper honing
      3. bore measurement
    v. sleeved brake calipers
    vi. caliper assembly
      1. piston seal installation
      2. piston and dust boot installation
      3. press fit dust boot installation
      4. retaining ring dust boot installation
      5. lip/groove dust boot installation
  e. Brake pad replacement and caliper overhaul procedures
    i. single piston floating
    ii. single piston sliding
    iii. four piston fixed
    iv. single piston rear
    v. single piston rear
- Brake drum and rotor machining
  a. Drum and rotor service
  b. Visual drum and rotor inspection
  c. Brake drum measurement
    i. inside diameter
    ii. taper wear, barrel wear, and bellmouth distortion
    iii. out-of-round
    iv. eccentric distortion
  d. Brake rotor measurement
    i. thickness
    ii. taper variation
    iii. lateral runout
    iv. lack of parallelism
    v. inner friction surface

- measurement
  a. Drum replacement
  b. Drum and rotor refinishing
     i. metal removal considerations
     ii. maching new drums and rotors
  c. Brake lathe operation
     i. lathe care
     ii. mounting drums and rotors
     iii. centering drums and rotors
     iv. lathe settings
  d. Turning a brake drum
  e. Drum grinding procedure
  f. Rotor turning procedure
     i. turning a brake rotor off the car
     ii. turning a rotor on the car
     iii. Resurfacing a brake rotor
- Parking brake service
  a. Parking brake testing
     i. brake pedal travel test
        1. drum brakes
        2. disc brakes
     ii. parking brake control test
     iii. release test
     iv. performance test
  b. Parking brake adjustment
     i. shoe adjustment
     ii. cable adjustment
        1. cable adjusters
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