

SUBJECT: EB 13-002 e-Stroke Users Guide for Disc and Drum Brakes

SECTION 1: INTRODUCTION

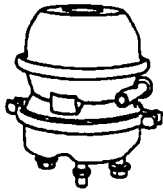
The purpose of the e-Stroke Brake Monitoring System is to enhance the operational safety of commercial vehicles. The e-Stroke System accomplishes this by providing a simple and objective means for monitoring the operation and adjustment of each brake, allowing the operator to perform the necessary inspections quicker and more accurately; plus gives maintenance personnel enhanced brake inspection and diagnostic capabilities.

Additionally, by providing continuous, real-time monitoring of brake actuator stroke and air pressure, e-Stroke can detect anomalies in brake function during dynamic, real world operation that may not be detected during routine maintenance and inspections.

Whether the vehicle is undergoing daily brake inspections, or driving down the road, e-Stroke has the ability to detect defects that include: inoperative brakes, out of adjustment brakes, dragging brakes, and other brake related problems affecting brake stroke. By identifying precisely where the problem is located, troubleshooting and repairs can be done much more efficiently.

Air disc brake systems present additional challenges for commercial vehicle operators. Traditional visual adjustment inspections are not possible. The e-Stroke Brake Monitoring System provides brake check capability without having to remove wheels for inspection. In addition, the e-Stroke system can detect over-adjusted caliper linings which may lead to premature wear or more serious conditions.

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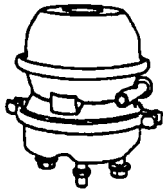
WARNING:

THIS MANUAL IS INTENDED TO PROVIDE A GENERAL OVERVIEW OF POTENTIAL BRAKE ISSUES, NOT A SPECIFIC ANALYSIS. IT IS THE CUSTOMER'S RESPONSIBILITY TO FOLLOW AND PERFORM ALL PREVENTATIVE AND / OR SCHEDULED BRAKE MAINTENANCE AS SPECIFIED BY THE VEHICLE OEM.

e-STROKE IS INTENDED TO PROVIDE A MONITORING FUNCTION WHICH WILL ALERT THE OPERATOR OR TECHNICIAN OF A POTENTIAL BRAKING ISSUE. MECHANICAL AND VISUAL INSPECTIONS OF THE BRAKING SYSTEM ARE PERIODICALLY REQUIRED TO VERIFY e-STROKE FAULT INDICATIONS OR CONFIRM THAT THE BRAKING SYSTEM IS PROPERLY FUNCTIONING.

CUSTOMER (NOT MGM BRAKES) IS SOLELY LIABLE FOR CUSTOMER'S FAILURE TO PROPERLY MAINTAIN / INSPECT VEHICLE BRAKES.

WHILE THE MGM BRAKES e-STROKE ELECTRONIC BRAKE MONITORING SYSTEM HAS BEEN DESIGNED AND TESTED TO PROVIDE EARLY WARNING OF ABNORMAL BRAKE CONDITIONS, EXTERNAL FAILURE OF CRITICAL SEALING COMPONENTS IN THE DISC BRAKE CALIPER - ACTUATOR SYSTEM CAN AFFECT THE e-STROKE SYSTEMS' ABILITY TO ACCURATELY DETECT AND REPORT A DRAGGING BRAKE CONDITION DUE TO A FROZEN OR LOCKED CALIPER LEVER ARM. THIS CAN OCCUR IF THE CALIPER - ACTUATOR SEALING SYSTEM IS COMPROMISED, AND THE VEHICLE IS PARKED AND UNUSED FOR A PERIOD OF TIME, ALLOWING CORROSIVE AGENTS TO ATTACK THE INTERNAL CALIPER MECHANISM AND PATENTED MGM CALIPER LEVER ARM DETECTION SYSTEM. ANY VEHICLE WHICH IS PARKED AND PLACED OUT OF SERVICE FOR A PERIOD OF TIME SHOULD BE CAREFULLY INSPECTED FOR PROPER BRAKE SYSTEM OPERATION BEFORE PLACING THE VEHICLE BACK INTO SERVICE, ESPECIALLY IF THERE IS A POSSIBILITY OR CONCERN THAT THE CALIPER SEALING SYSTEM MAY BE COMPROMISED.



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SECTION 2: SYSTEM COMPONENTS

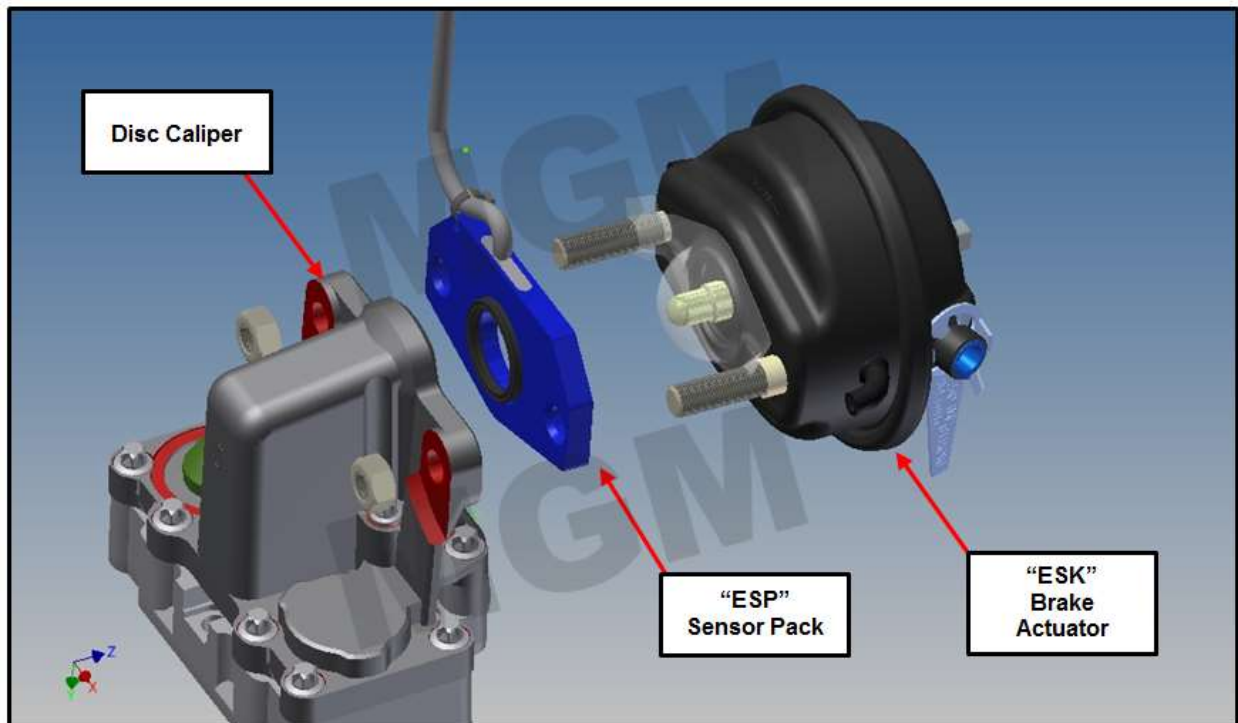
2.1: Disc Brake Actuators

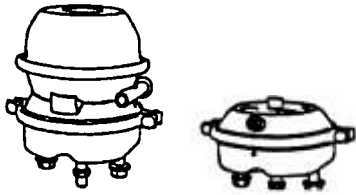
MGM Brakes e-Stroke disc brake actuators are denoted by an “ESK” suffix on the part number. Each “ESK” assembly includes the e-Stroke disc actuator and external sensor pack spacer or “ESP”.

The “ESK” actuator is assembled with a specified ESP sensor angle orientation, similar to the port and clamp band angle of a standard actuator and is calibrated at an MGM Brakes manufacturing facility to ensure accuracy. Proper specification of the sensor angle should orient the ESP harness away from the centerline of the disc brake rotor. e-Stroke disc actuator components are not serviceable. *DO NOT attempt to rotate the ESP orientation on the actuator mounting studs.*

Refer to the MGM Service Manual EB 13-006 for additional Disc Actuator Service Information.

ESK Actuator and ESP Sensor Assembly:





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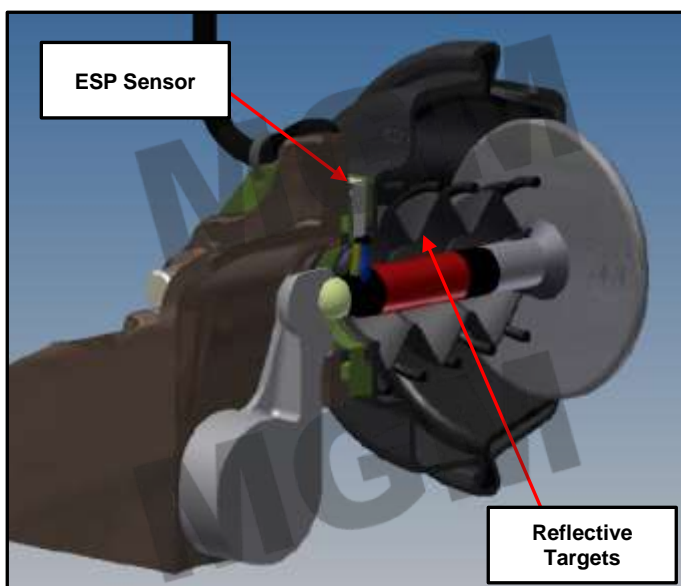
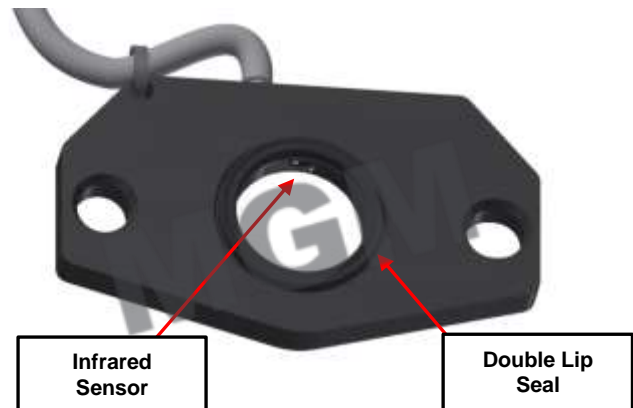
2.2: External Sensor Pack for Disc Brake Actuators

The e-Stroke disc external sensor pack or “ESP” is an environmentally sealed spacer assembly that provides the e-Stroke disc actuator stroke measurement to the ECU (CCM). These stroke measurement ranges are monitored with the brake application pressure reading to determine if a fault condition is present. The e-Stroke ESP uses infrared sensing technology to detect reflective material on the actuator piston rod.

The ESP is a non-serviceable component that may be replaced as a separate service part. No adjustment or calibration is required when replacing an e-Stroke ESK actuator assembly. Care must be taken during installation to ensure the caliper sealing surface is clean from dirt and corrosion. Failure to clean the caliper mounting surface may result in caliper assembly leakage and potential functional issues with the foundation brake components.

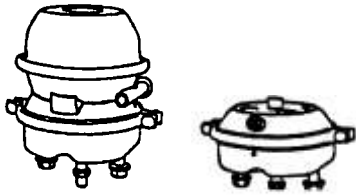
Ensure the actuator and ESP seal height is a minimum of 3mm from the mounting surface if components are to be reused after removal.

Care should be taken to ensure no caliper/ball end grease accidentally gets on the sensor lenses or piston rod reflective targets.



- *Reflective Targets on Piston Rod indicate Stroke Position*
 - 1st Black – Normal Release
 - Red – Normal Apply
 - 2nd Black – Over-Stroke
- *Keep reflective targets clean and free from damage.*
- *Do not use solvents to clean the reflective targets.*
- *Spring Loaded Ball End Detects Caliper Drag*

Reference EB 13-001 for additional e-Stroke Sensor & Harness information.



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2.3: Drum Brake Actuator

MGM Brakes e-Stroke drum brake actuators are denoted by an “ESH” suffix on the part number. Each actuator is assembled with a specified sensor angle orientation, similar to the port and clamp band angle of a standard actuator, and is calibrated at an MGM Brakes manufacturing facility to ensure accuracy. Proper specification of the sensor angle should orient the sensor pigtail toward the centerline of the vehicle, away from the wheel end.

e-Stroke drum actuator components are not field serviceable, with the exception of single/piggy-back or service diaphragm replacement. For service information, refer to the MGM Service Manual relating to the actuator to be serviced. *DO NOT attempt to rotate, slide or otherwise adjust the magnetic sleeve, sleeve clamp, or the sensor stone shield.*

A stainless steel strain relief bracket (P/N 8090039) is included with the actuator assembly to provide a means for securing the sensor pigtail, preventing the sensor from being inadvertently pulled out of the actuator during normal vehicle operation. The strain relief bracket should be installed on the upper mounting stud of the actuator facing toward the centerline of the vehicle.



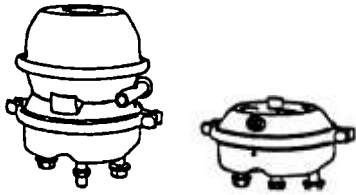
2.4: Drum Brake Sensor



The e-Stroke drum brake Sensor (P/N 8290120) provides the e-Stroke Actuator stroke measurement to the ECU. This stroke measurement is monitored with the brake application pressure reading to determine if a fault condition is present.

The sensor is a non-serviceable component, which may be replaced separate from the brake actuator assembly if required. No adjustment or calibration is required when replacing an e-Stroke sensor. Care must be taken during installation to insert the sensor into the actuator sensor port with the proper alignment, parallel to the piston rod. The sensor must be fully seated in order to ensure complete system accuracy.

Reference EB 08-006 for additional e-Stroke Sensor & Harness information.



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2.5: Pressure Transducer

The pressure transducer (P/N 8090550) provides the e-Stroke ECU with information about the pressure that the driver is applying to the brake system. A brake fault will be indicated when the actuator stroke is not in proportion to air pressure applied by the brake system. For example, if the driver applies the brake treadle and an actuator does not move from the fully retracted position, the e-Stroke system will determine that brake is “non-functional”. e-Stroke brake pressure data is available on the SAE J1939 network.



2.6: Chassis Communication Module (ECU)

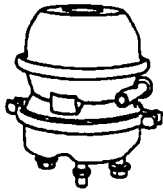
The GEN 3 Chassis Communication Module (CCM or ECU, P/N 8291XXX) is the “brains” of the e-Stroke system and capable of monitoring up to 8 wheel ends. The ECU provides regulated power to the actuator sensors and the pressure transducer. The actuator sensor and pressure transducer inputs are continuously monitored by the ECU to determine whether the stroke of each of the actuators is in proportion to the air pressure applied by the brake system.



ECU operation requires 9 to 32 V DC ignition switched power. Multiple alarm outputs are available which will energize an external warning light or alarm device during active brake fault conditions. Separate alarm outputs are provided for Tractor / Truck / Bus Brake Monitoring and lining wear as well as Trailer Brake Monitoring. The ECU alarm output is commonly connected to vehicle I/O systems to illuminate integrated dash warning lights. *Consult vehicle OEM or installer for specific e-Stroke warning light or dash display operation when connected to an I/O system.*

SAE J1939 connection is required for complete system functionality. The SAE J1939 connection is primarily used to monitor vehicle speed and transmit fault codes as fault conditions occur. The e-Stroke GEN 3 system is compatible with SAE J1939 250kbs and 500kbs networks. The e-Stroke Diagnostic Tools communicate with the ECU over the SAE J1939 / J1708 circuits. *Reference EB 08-025 for e-Stroke Published SAE J1939 / J1708 Fault Codes.*

Brake fault history is recorded in the ECU memory for up to 126 counts per fault per wheel. The fault history may be viewed and cleared using the available diagnostic tools. *See Section 4 for more diagnostic information.*



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SECTION 3: SYSTEM OPERATION

3.1: Continuous Brake Monitoring

Upon initial power-up, the ECU will “Bulb Check” or “Blink” the alarm output twice which allows the operator to verify the Warning Light function. *Consult vehicle OEM or installer for specific e-Stroke warning light or dash display operation when connected to an I/O system.*

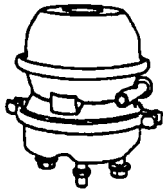
During operation of the vehicle, the e-Stroke system continuously monitors the stroke of each actuator to ensure it is appropriate for the current brake application pressure. If any actuator is determined to be Over-Stroke, Dragging, Non-Functioning, or the disc caliper linings are over-adjusted the following actions will occur while the fault condition is active:

- The Warning Light will illuminate (Where Applicable). *See Section 7 for Warning Light Interpretation.*
- *The Dash Display will indicate the fault condition (Where Applicable). Consult vehicle OEM for specific operation.*
- The ECU will record (count) the fault occurrence in the memory.
- The appropriate SAE J1939 / J1708 fault code is transmitted over the diagnostic network to a diagnostic tool or AVM type reporting system while the fault is active.

In addition to the above brake fault conditions; the following conditions will also activate the appropriate ECU alarm output:

- J1939 communication error
- The e-Stroke system failing to start up / run
- e-Stroke Sensor Fault
- Pressure Transducer Fault
- Lining Wear Fault (Where Applicable)

Note: *While the e-Stroke system can detect brake adjustment issues during real time operation; Over-Stroke and Non-Functioning conditions should be verified during a Stationary Vehicle Inspection. See section 3.2.*



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3.2: e-Stroke System Functional Test

Note: *Always follow the CVSA recommended procedures when conducting a Stationary Vehicle Inspection to verify proper brake adjustment.*

The following steps can be used to test the e-Stroke system for proper function and verify general brake system condition.

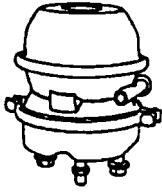
1. Park the vehicle and allow the brakes to cool.
2. Properly chock the wheels and release the parking brake.
3. Adjust the Air-Reservoirs to between 90 and 100 psi (as indicated by the dash gauges) by allowing the compressor to build pressure or cycling the brakes to reduce system pressure.
4. Turn OFF the ignition and engine to maintain the recommended testing pressure at the air reservoirs (90-100psi).
5. Switch the ignition back ON to the run position without starting the engine. Wait 30 seconds to allow the e-Stroke system to start up and bulb check.
6. Fully depress the Brake Pedal / Treadle for approximately 10 seconds and release for 10 seconds. Repeat the 10 second apply and release brake application 5 times. During this time monitor the brake function by watching the Warning Light or using the e-DT Diagnostic Tool.
7. If the Warning Light illuminates or the e-Stroke Diagnostic Tool indicates a fault condition, follow the steps in section 4 to determine the cause of the issue.

Note: *The e-Stroke functional test procedure will detect Over-Stroke and Non-Functioning brake conditions; however Dragging brake conditions can only be detected while the vehicle is moving at speeds over 5mph.*

Note: *e-Stroke Disc Brake Over-Stroke detection is limited to 15 – 50psi brake application range. Over-Stroke faults are suppressed with brake applications above 50psi and only displayed upon brake release for disc brake configurations only. CVSA recommended procedures should be followed to verify proper brake adjustment. The e-Stroke system provides a warning that brakes may be out of adjustment.*

Note: *Three brake applications (within an ignition power cycle) resulting in a non-functioning condition is required before the non-functioning fault will be displayed by the e-Stroke system.*

Note: *Consult vehicle OEM for specific dash display operation. Some dash displays will not indicate fault condition unless two brake related issues are detected at the same time.*



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SECTION 4: SYSTEM DIAGNOSTICS & TROUBLESHOOTING

Note: *It is the responsibility of the end user to determine how the e-Stroke system will be used. Drivers and Technicians should be instructed on how to respond to an e-Stroke warning as determined appropriate by the end user.*

4.1: Active Faults (Warning Light ON)

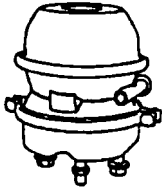
Brake faults may be caused by many different conditions. When investigating an e-Stroke displayed fault condition, such as a Non-Functioning or Dragging brake, it is necessary to first confirm whether the brake condition is true.

If an active fault condition has alerted the Driver or Technician to a brake issue, the following steps should be taken to identify the cause of the issue:

1. If the fault condition is active (Warning Light ON) then the current status of the e-Stroke system should be checked using one of the diagnostic methods in Section 4.3. The e-Stroke system will output a wheel specific description of the active fault condition.
2. The vehicle foundation brakes should then be inspected for proper operation. Drum brake systems can be visually inspected for push rod and lining movement. Disc brake calipers are sealed assemblies which do not allow for visual inspection of the pushrod movement. The lining running clearance or gap should be inspected for proper clearance and brake application movement. Check the caliper manufacturers' clearance specification to confirm the caliper is adjusted properly. If lining movement does not correspond with the brake application pressure then the actuator should be removed from the caliper for further inspection of the foundation brake.
3. If no issue is found with the brake system, then follow the instructions in Section 4.4, 4.5 to inspect the e-Stroke system.

If the vehicle braking system has been inspected and found to be working properly, then the e-Stroke Troubleshooting Guide (Section 4.5) should be followed to continue the fault analysis.

4. **Always** clear the ECU history upon completion of brake or e-Stroke system service. *The ECU fault history can be cleared by pressing and holding the ECU Red Push Button for 5 seconds or using one of the available e-Stroke diagnostic tools.*



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4.2: In-Active Faults (Warning Light OFF)

If the vehicle has been reported to have a brake problem, but the Warning Light is OFF during inspection then the ECU fault history should be checked with the following steps:

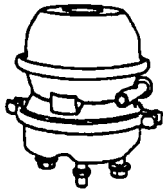
1. If the fault condition is In-Active (Warning Light OFF) then the fault history of the e-Stroke ECU should be checked using one of the diagnostic methods in Section 4.3.
2. The ECU records fault history with a simple counter; date and time of the occurrences are not available. Fault counters will increment once per occurrence as faults occur. The ECU history can also be cleared at any time using one of the diagnostic tools or by pressing and holding the ECU Red Push Button for 5 seconds. If the red push button method is used, the warning light will blink 10 consecutive times to confirm the fault history has been deleted.

It is necessary to take the time period in which the fault history was recorded into account when reviewing the data. If it is unknown when the ECU history was cleared last, then it is possible that many of the faults recorded may not be recent.

3. Review the fault history looking for wheel ends which have fault counts recorded.
4. The brake system should then be inspected to confirm the fault condition(s) reported by the e-Stroke system and repaired accordingly.
5. If no issue is found, then the ECU fault history should be cleared and the brake system can then be cycled or the vehicle driven to try to duplicate the fault condition. Use one of the available diagnostic tools (Section 4.3) to monitor the e-Stroke system for brake faults during this test.

Note: In some cases, a fault may be present for a period of time but then goes away. An example of this is if the pad clearance on a disc brake was not properly reset after a relining. The brake would over-stroke for a period of time before the self-adjusting mechanism in the caliper brought the running clearance into specification. In this case, the ECU would show over-strokes in the fault history but no issue may be present by the time a mechanic inspects it. See Step 7 below for more details.

6. If no issue is found with the foundation brake, then follow the instructions in Section 4.4, 4.5 to repair the e-Stroke system.
7. The e-Stroke system may detect fault conditions if the brake is not properly adjusted after service. Apply 25-30 brake applications after brake service to allow the slack or caliper adjuster to operate. Always verify that the lining clearance meets caliper manufacturer specifications.



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8. Always clear the ECU history upon completion of brake or e-Stroke system service. *The ECU fault history can be cleared by pressing and holding the ECU Red Push Button for 5 seconds or using one of the available e-Stroke diagnostic tools.*

4.3: e-Stroke ECU Memory Retrieval

4.3.1: e-Stroke GEN 3 Blink Code Retrieval

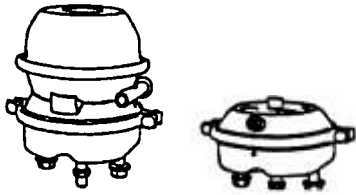
The e-Stroke GEN 3 system is capable of displaying both Active and In-Active (stored) fault information using a series of simple blink codes and the system warning lights.

Only blink codes for Active faults will be displayed when an Active fault is occurring (Warning Light ON). The Active fault will need to be repaired and the warning light will need to be OFF before In-Active stored faults can be retrieved with this blink code method. If the blink code sequence is initiated when the warning light is OFF then stored fault codes will be displayed.

Blink Code Retrieval Operation:

- Press the Red Push Button on the front of the ECU for 1 second to initiate the warning light fault code blink sequence. The warning light(s) will then respond with a series of blink codes.
- A blink code of 1-1 (1 blink 1.5 second pause followed by 1 blink) indicates that no stored fault codes are present within the ECU.
- Reference the e-Stroke Warning Light Blink Code Definition Table (Section 4.3.2 Below) to determine the system condition.
- Press and hold the Red Push Button on the front of the ECU for 5 seconds to clear the fault history.



Reference the e-Stroke GEN 3 Blink Code Operation Guide (MGM Bulletin EB 08-011) for additional instruction on blink code retrieval.



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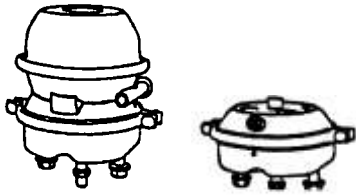
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4.3.2: e-Stroke Warning Light Blink Code Definition Table

e-s3™ Warning Light Blink Code Operation			
<i>Applies to ECUs with P/N 8291xxx Prefix.</i>		<i>Reference EB 08-011</i>	
ECU Push Button Operation:			
Press ECU Button for 1 second to begin e-Stroke fault blink code sequence			
Press ECU Button for 5 seconds to clear e-Stroke stored fault blink codes			
Blink Code Timing:			
0.5 seconds	Lamp On		
0.1 seconds	Lamp Off		
1.5 seconds	Pause In-Between Digits		
4 seconds	Pause In-Between Faults		
			
e-s3™ Warning Light Blink Code Definitions			
First Digit	Type of Fault	Second Digit	Location of Fault
1	No Fault	1	No Fault (Only with First Digit = 1)
2	Non-Functioning Brake	1	Axle 1 - Left
3	Over-Stroke Brake	2	Axle 1 - Right
4	Dragging Brake	3	Axle 2 - Left
5	e-Stroke Sensor Fault	4	Axle 2 - Right
6	Lining Wear Warning	5	Axle 3 - Left
8	Low Running Clearance	6	Axle 3 - Right
		7	Axle 4 - Left
		8	Axle 4 - Right
7	e-Stroke System Fault	1	Pressure Transducer
		2	SAE J1708 / J1939 Communication
10	e-Stroke Fault Codes Cleared		
			

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4.3.3: e-Stroke Laptop Diagnostic Program

The e-Stroke Diagnostic Program may be used to acquire the following information from the e-Stroke GEN 3 ECU:

- Current Wheel Specific Brake & Lining Status (Active Faults)
- Stored Fault History (In-Active Faults)
- e-Stroke System & Diagnostic Status
- ECU Information: Software Version, Configuration, Serial Number.

P/N 9090109 Kit connects the ECU to a standard laptop computer (Customer Supplied with Windows Operating System) via an RS-232 connection.

P/N 9090111 Kit connects the laptop computer to the e-Stroke system via a standard SAE J1939 250 kbs 9-pin diagnostic connection.

Note: The P/N 9090111 kit is not compatible with SAE J1939 500kbs networks. Use the P/N 9090109 or P/N 9090110 diagnostic kits for SAE J1939 500 kbs support.

Reference the e-Stroke GEN 3 RS-232 Program Users Guide (MGM Bulletin EB 11-001) for additional instruction.

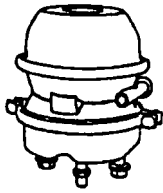
4.3.4: e-DT Diagnostic Tool

The e-DT is a diagnostic tool which is designed to work with e-Stroke systems. The e-DT kit (P/N 9090110) can be easily used as a hand held tool with the supplied Diagnostic Harness which connect to a 9-pin diagnostic port (OBD) connector. The e-DT display can also be permanently mounted in the vehicle for onboard diagnostic support. When connected to the vehicles SAE J1939 network the e-DT will automatically turn ON and establish communication with the e-Stroke System. This kit is compatible with SAE J1939 250 kbs and 500kbs networks.



The e-DT displays real time e-Stroke system status, Active brake fault conditions, and lining wear status (if applicable). In addition the brake fault history (In-Active faults) can be acquired from e-Stroke GEN 3 Systems using the e-DT. Vehicle speed and brake application pressure are also available for diagnostic purposes using the e-DT.

Reference the e-DT Diagnostic Tool Users Guide (MGM Bulletin EB 08-013) for additional instruction.



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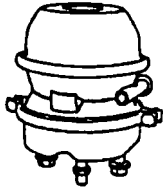
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4.4: System Wiring Troubleshooting

As with all electrical systems on vehicles, damaged or incorrectly installed wiring can cause issues with the functionality of the system. If the system is displaying a brake fault condition and it has been verified that the actuator and vehicle braking system is working and adjusted properly, then it is advisable to check the system wiring and verify that:

- All connectors are completely plugged together.
- No wires are being pulled, or pinched.
- Check connections for corrosion, missing seals or bent terminals.
- No wires are cut or broken, the cable jacket and insulation is intact and no wire crimp connections are loose.
- An adequate amount of slack in the wires is provided around steering and suspension components to prevent tension in the wire.
- The power harness is connected securely to the vehicle power source.
- The sensor and pressure transducer supply power can be verified at the end of each wire harness by unplugging the sensor at the wire harness and measuring voltage between connector terminals A (Red wire, +5 VDC) and B (Black Wire, Ground).

Note: If the e-Stroke sensors or harnesses are suspected to be faulty, that wheel should be considered un-monitored by e-Stroke.



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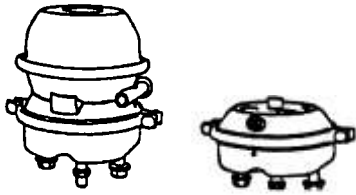
SUBJECT: EB 13-002 e-Stroke Users Guide for Disc and Drum Brakes

4.5: System Trouble Shooting Guide

- *Reference EB 13-003 e-Stroke GEN 3 Disc Trouble Shooting Guide for additional Troubleshooting information.*
- *Reference EB 08-016 e-Stroke GEN 3 Drum Trouble Shooting Guide for additional Troubleshooting information.*
- *Reference MGM Drawing 9230103 for a generic e-Stroke GEN 3 system schematic. Consult Vehicle OEM for vehicle specific wiring schematics.*
- *All e-Stroke technical documents are available on www.mgmbrakes.com.*

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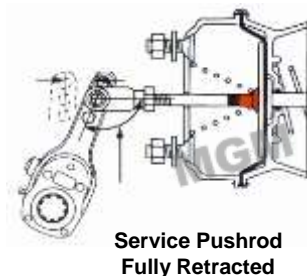
SECTION 5: UNDERSTANDING BRAKE DIAGNOSTICS

In order to simplify the fundamental logic used to determine brake faults, the actuator sensors should be considered as a method to determine whether the actuator pushrod is fully retracted, within the normal operating stroke range, or beyond the SAE J1953 adjustment indication threshold. At the same time, the pressure transducer provides an indication as to what region of stroke the actuator should be within. For a single actuator the resulting logic can be expressed in the table below.

Fault Description	Service Brake Air Pressure	Pushrod Stroke Position
Dragging Brake	No Pressure	Pushrod not fully returned while vehicle is moving
Non-Functioning Brake	Service Pressure Applied	Pushrod remains fully returned after three brake applications
Over-Stroke	Service Pressure Applied	Pushrod beyond acceptable stroke limit
Disc Caliper Low Running Clearance	Lining clearance is below caliper manufacturers' specification	

5.1: Absolute vs. Relative Stroke for Drum Brake Actuators

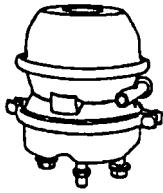
When following up on an e-Stroke fault indication with a brake inspection, it is important to understand that the e-Stroke system monitors absolute stroke of the actuator pushrod. Absolute stroke is measured from the absolute minimum stroke: i.e. actuator pushrod has fully retracted to zero stroke. It is possible to incorrectly set-up drum brake actuators and slack adjusters so that the actuator pushrod is not capable of retracting to zero stroke. In this case, the actuator pushrod will be pre-stroked an indeterminate amount.



When measuring stroke in this condition, the inspector will observe only the relative difference between the non pressurized and applied positions. This is known as relative stroke. It is important to consider that the travel limit on a brake actuator is based on absolute stroke, not relative stroke.

For example, a drum brake actuator pushrod may be pre-stroked 1/2 in. from absolute zero stroke when the actuator is not pressurized. With the brakes applied, an inspector may observe a 1-3/4 in. relative travel and incorrectly conclude that the brake is within adjustment limits for a 2-1/2 in. stroke actuator. However, the e-Stroke system will observe 2-1/4 in. of absolute stroke and correctly indicate a brake out of adjustment.

To avoid this scenario, it is critical to rule out the influence of pre-stroked drum brake actuators. By removing the clevis pin, an inspector can confidently determine if an actuator



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has been properly set-up to return to absolute zero stroke if the rod moves further into the chamber when the pin is removed.

Note: CAUTION MUST BE USED WHEN REMOVING THE CLEVIS PIN. ACTUATOR PUSHROD MOVEMENT MAY OCCUR. ENSURE THAT THE POWER SPRING IS PROPERLY CAGED IF SO EQUIPPED.

5.2: Dragging Indication

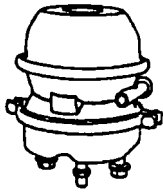
The ECU indicates a dragging brake if a drum actuator is stroked beyond the first 3/8 in. of absolute stroke or 1/4 in. for a disc actuator, the Pressure Transducer indicates that the operator has released the brakes AND the vehicle is moving faster than 5mph.

The dragging brake indication is intended to alert the operator of a potentially hazardous braking issue (a dragging brake may cause a thermal event). e-Stroke is able to determine if the push rod has properly returned but does not discriminate due to cause.

Real world causes are numerous and require a qualified technician to inspect the brake system to determine the root cause. This includes but is not limited to:

- Hanging brake shoes or linings
- Malfunctioning pneumatic valves that allow pressure to build in actuator
- Water or ice contamination in the air system
- Seized disc caliper internal components
- Mechanical set-up issues
- Malfunctioning slack adjuster or caliper adjuster
- Worn foundation brake components
- Spring brake engagement due to low parking brake system pressure
- Broken parking brake spring preventing actuator from fully retracting

Note: Door interlock systems (which apply the service brakes) and parking brake applications are common examples where an actuator will be stroked into the operating region without pressure in the service circuit. The e-Stroke system monitors vehicle speed via J1939 / J1708 and will not indicate a dragging fault condition while the vehicle is at rest with the parking brakes or the interlocks applied. When the vehicle exceeds 5mph a dragging brake fault would be indicated if the parking or service brake fails to release. The dragging brake fault logic includes a short delay before activating to allow for slow release brake conditions. Consult the vehicle OEM for specific interlock functionality.



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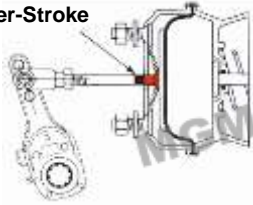
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5.3: Drum Brake Over-stroke Indication

Over-Stroke



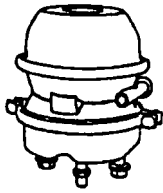
An over-stroke fault indicates the actuator has stroked beyond the SAE J1953 adjustment indicator threshold. By design this is only applicable during brake applications. If an actuator would stroke beyond the threshold without pressure in the service circuit, the situation is still regarded as a “dragging” brake.

While an over-stroke fault from the e-Stroke system indicates that the brake may likely be out of adjustment and further investigation is warranted, it should be noted that there are certain conditions when an over-stroke fault can occur on a brake that is not out of adjustment per CVSA criteria. Current published CVSA and FMCSA criteria must be reviewed prior to determining whether an out of adjustment condition is present.

Brake adjustment limits established by state and federal regulations (DOT and CVSA) are based on measuring actuator stroke with the vehicle stationary, the system air pressure (reservoir) is 90 to 100 psi and the brakes relatively cool. If brake stroke is measured outside of these “standard” conditions it may change. Wheel rotation, increased brake pressure and increased brake temperature will increase stroke. On a moving vehicle with hot brakes, a high pressure brake application can produce strokes that exceed the published adjustment limits even though the brake is properly adjusted.

If the e-Stroke system indicates an over-stroke condition on any brake, the brake adjustment should be verified using the CVSA test conditions (stationary vehicle, air reservoirs at 90 to 100 psi and cool brake). If there are no over-stroke indications during the proper stationary adjustment test, the e-Stroke system confirms the actuators comply with the CVSA adjustment guidelines. However, over-stroke indications observed using the proper stationary adjustment test, should be verified with physical measurements to determine if the stroke explicitly exceeds the CVSA limits.

Note: *When pushrod travel (actuator stroke) on a brake with an automatic adjuster is at or exceeds the readjustment limits, the need for repairs to the automatic adjuster or other foundation / caliper brake components are indicated. Adjustment of automatic brake adjusters, except as required at installation, is a dangerous practice as it gives the driver a false sense of security since the adjusters are likely to go out of adjustment again in the future, unless additional repairs are performed.*



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5.4: Disc Brake Over-stroke Indication

Visual measurement of the air disc actuator piston rod stroke is not possible given the fully enclosed and sealed caliper assembly. Due to this fact, the traditional SAE J1953 brake adjustment inspection method cannot be conducted on air disc brake assemblies with enclosed push rods. Disc actuators typically do not include the traditional “orange stripe” out of adjustment indicator on the piston rod.

Note: It is possible for over-stroke brake faults to occur after recent foundation brake work, especially on air disc applications where the user may forget to set the running clearance on the caliper. If the over-stroke conditions do not stop after sufficient brake applications (enough to allot the automatic adjuster to bring the running clearance into an acceptable range) then the brakes should be further inspected.

The e-Stroke disc system is however designed to detect out of adjustment actuator stroke at 2.1 in. with brake application pressures not exceeding 50psi.

5.5: Non-Functioning Indication

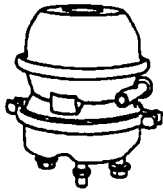
A non-functioning brake fault occurs when a drum actuator is not stroked beyond the first 3/8 in. of absolute stroke or 1/4 in. for a disc actuator AND the operator has applied sufficient service pressure to the unit. Disc brake non-functioning detection requires three occurrences within an ignition power cycle before an active fault will be displayed. A brake inspection should be performed by a qualified technician to determine the root cause.

Typical issues include but are not limited to:

- Pinched, crimped, or broken air lines
- Defective air valves
- Water or ice contamination in the air system
- Lack of system pressure
- Over-Adjusted Lining, Slack or Caliper
- Leaking actuator diaphragm
- Removal of e-Stroke drum sensor from actuator

5.6: Disc Caliper Low Running Clearance Indication

A low lining running clearance fault occurs when an air disc caliper lining is below the manufacture’s recommended running clearance. This may occur if the lining clearance is misadjusted manually or automatically over-adjusted due to a malfunctioning caliper mechanism. Reference caliper manufacture recommendations for lining clearance inspection method and allowable running clearance.



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5.7: Actuator Sensor Fault Indication

An actuator drum or disc sensor fault and pressure transducer fault indicates the sensor is no longer providing appropriate data to the ECU. A technician should inspect the wiring harness specific to this sensor.

Typical Issues include but are not limited to:

- Damaged or defective sensor
- Chaffed or cut wiring, loose or corroded connections

5.8: Determining Control System vs. Foundation Brake Issue

Similar faults reported on the right and left sides of the same axle are likely caused by an air control system issue rather than a mechanical issue with the foundation brake.

Faults reported on a single wheel only are likely due to a mechanical foundation brake issue or electrical issue with that specific wheel end.

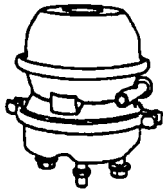
When e-Stroke faults appear consistent across an axle, the troubleshooting approach should start with vehicle components/systems that control both wheel ends rather than a brake component that is specific to only one wheel end.

Possible causes for an air control system issue includes:

- Defective or malfunctioning valves
- Incorrect operation of the interlocks
- Air system contamination

5.9: Inspections & Maintenance

Section 5 of this document is intended to provide a general overview of potential brake issues, not a specific analysis. It is the customer's responsibility to follow and perform all preventative and / or scheduled brake maintenance as specified by the vehicle OEM. The e-Stroke system is intended to provide a monitoring function which will alert the operator or technician of a potential braking issue. Visual inspections of the braking system are required to verify e-Stroke fault indications or confirm that the braking system is properly functioning.



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SECTION 6: AVM REPORT INTERPRETATION

Automatic Vehicle Monitoring (AVM) Systems are commercially available for many commercial vehicle and transit applications. This type of system is configurable allowing the user to monitor vehicle systems by recording SAE J1708 and J1939 fault code activity. Fault reports can be automatically generated summarizing selected system activity on specific vehicles in service.

The e-Stroke Brake Monitoring System transmits SAE J1708 and J1939 fault codes as fault conditions occur during braking activity. These fault codes can be recorded and summarized in AVM reports as described in this section.

Note: *This section is intended to provide an overview of e-Stroke related AVM reports, not an analysis of brake related issues or specific AVM System operation. Visual verification of reported faults should always be conducted to ensure that potential issues are not overlooked resulting in unsafe vehicle conditions.*

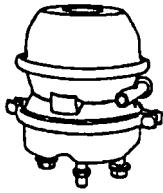
Further, if the e-Stroke sensors or harnesses are suspected to be faulty, that wheel should be considered unmonitored by e-Stroke.

Consult the Vehicle OEM or AVM System Provider for specific AVM System Operation.

6.1: AVM Report Overview

AVM reports are typically user configurable, allowing data to be displayed as desired in multiple formats. Figures 1 and 2 illustrate two different AVM report formats showing the same fault occurrences.

- **Figure 1 - Summary Report:** Each fault occurrence is counted over the course of the reporting period, typically 24hrs. Each fault is listed with the occurrence count and date & time stamp of the last fault occurrence at the end of the reporting period.
- **Figure 2 - Detailed Report:** Each occurrence will be listed individually with a date & time stamp as each fault occurred. Detailed reports may also include a duration time for each fault.



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Figure 1: Example of Summary Report

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/03/09 07:20 PM	2	Brakes	Brake Stroke - Axle 2 Left - Dragging Brake
⚠ 08/03/09 07:20 PM	2	Brakes	Brake Stroke - Axle 2 Right - Dragging Brake

Figure 2: Example of Detailed Report

Bus #123			
Occurred On	Component	Description	Duration
⚠ 08/03/09 19:20:03	Brakes	Brake Stroke - Axle 2 Left - Dragging Brake	01s
⚠ 08/03/09 19:20:03	Brakes	Brake Stroke - Axle 2 Right - Dragging Brake	01s
⚠ 08/03/09 17:55:23	Brakes	Brake Stroke - Axle 2 Left - Dragging Brake	02s
⚠ 08/03/09 17:55:23	Brakes	Brake Stroke - Axle 2 Right - Dragging Brake	02s

6.2: e-Stroke Fault Occurrences

6.2.1: Low Occurrence Faults

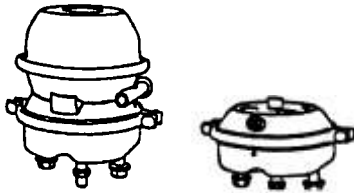
Figure 3 shows a Dragging Brake occurrence which may have occurred during normal operation of the vehicle.

- The faults occurred only once in this reporting period (24hr).
- The faults occurred as a pair on Axle 2 Left and Right Wheels.
- The faults occurred at the same time during operation.

Figure 3: Typical One Time Fault Occurrence

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/03/09 07:31 PM	1	Brakes	Tractor Brake Stroke - Axle 2 Left - Dragging brake: the brake rod has not returned after a braking operation.
⚠ 08/03/09 07:31 PM	1	Brakes	Tractor Brake Stroke - Axle 2 Right - Dragging brake: the brake rod has not returned after a braking operation.

Note: While all brake faults detected by the e-Stroke system require timely evaluation by maintenance, it should be noted that a Dragging Brake condition can lead to a hazardous situation such as a thermal event with only one occurrence. Therefore it is up to the user to properly monitor the warning light function per Section 7.



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6.2.2: Increasing Severity Faults

Figure 4, 5 and 6 shows an Over-Stroke Fault on Axle 1 Left increasing in severity over the course of 5 days.

- Day 1 accumulated 5 faults which may prompt a Technician to either inspect or watch this vehicle for the next few days.
- Day 2 accumulated 30 faults which may indicate an over-stroke issue is present. It is advisable to inspect the vehicle braking condition.
- Day 5 accumulated 581 faults which indicates that this bus has a sever over-stroke issue and should be inspected and repaired.

Figure 4: Example of a Brake Issue Increasing in Severity – Day 1

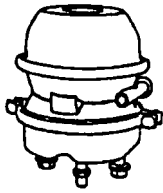
Bus #123			
Last Occurred	Count	Component	Description
⚠ 07/31/09 05:16 PM	5	Brakes	Tractor Brake Stroke - Axle 1 Left - Brake overstroke: the brake rod has overstroked during a braking operation.

Figure 5: Example of a Brake Issue Increasing in Severity – Day 2

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/01/09 04:28 PM	30	Brakes	Tractor Brake Stroke - Axle 1 Left - Brake overstroke: the brake rod has overstroked during a braking operation.
⚠ 08/01/09 11:09 AM	2	Brakes	Tractor Brake Stroke - Axle 1 Left - Non-functioning brake actuator: the brake rod has not actuated during a braking operation.

Figure 6: Example of a Brake Issue Increasing in Severity – Day 5

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/04/09 01:11 AM	581	Brakes	Tractor Brake Stroke - Axle 1 Left - Brake overstroke: the brake rod has overstroked during a braking operation.
⚠ 08/03/09 02:57 PM	2	Brakes	Tractor Brake Stroke - Axle 1 Left - Non-functioning brake actuator: the brake rod has not actuated during a braking operation.



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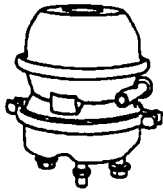
6.2.3: Sensor & Harness Fault Conditions

e-Stroke is designed to self-diagnose sensor issues. Unfortunately unavoidable harness issues and corrosion can occur which may lead to inconsequential faults reported. Figures 7, 8 and 9 illustrate patterns in fault reporting which may be interpreted as a sensor or harness issue rather than an actual brake fault.

Note: *Reported fault patterns as shown below should always be inspected to verify that a faulty braking condition is not present.*

- Figure 7: Axle 2 Right has a significant amount of sensor faults reported. This is typically indicative of a true sensor issue.
- Figure 8: Axle 2 Left has a random mixture of faults reported including sensor fault. In many cases when a sensor or harness develops a functional issue random faults may be reported.
- Figure 9: Axle 1 Left has a random mixture of faults reported, but not a sensor fault. It is unlikely that the same wheel will have a mechanical issue which results in a Dragging, Non-Functioning, and Over-Stroke condition during the same day.

Note: *After the braking system is inspected and verified to be working properly the sensor and harnesses should be inspected and repaired as required.*



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Figure 7: Typical Sensor or Harness Fault Condition

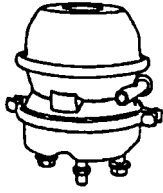
Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/04/09 12:33 AM	827	Brakes	Tractor Brake Stroke - Axle 2 Right - Actuator sensor fault: the sensor is not connected, damaged, or otherwise responding incorrectly.
⚠ 08/03/09 11:59 PM	8	Brakes	Tractor Brake Stroke - Axle 2 Right - Brake overstroke: the brake rod has overstroked during a braking operation.
⚠ 08/03/09 08:27 PM	1	Brakes	Tractor Brake Stroke - Axle 2 Right - Dragging brake: the brake rod has not returned after a braking operation.

Figure 8: Typical Sensor or Harness Fault Condition

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/03/09 10:29 PM	7	Brakes	Tractor Brake Stroke - Axle 2 Left - Actuator sensor fault: the sensor is not connected, damaged, or otherwise responding incorrectly.
⚠ 08/03/09 09:32 AM	2	Brakes	Tractor Brake Stroke - Axle 2 Left - Brake overstroke: the brake rod has overstroked during a braking operation.
⚠ 08/03/09 09:48 AM	20	Brakes	Tractor Brake Stroke - Axle 2 Left - Dragging brake: the brake rod has not returned after a braking operation.
⚠ 08/03/09 09:28 AM	1	Brakes	Tractor Brake Stroke - Axle 2 Left - Non-functioning brake actuator: the brake rod has not actuated during a braking operation.

Figure 9: Typical Sensor or Harness Fault Condition

Bus #123			
Last Occurred	Count	Component	Description
⚠ 08/02/09 03:15 PM	1	Brakes	Tractor Brake Stroke - Axle 1 Left - Brake overstroke: the brake rod has overstroked during a braking operation.
⚠ 08/02/09 06:30 PM	3	Brakes	Tractor Brake Stroke - Axle 1 Left - Dragging brake: the brake rod has not returned after a braking operation.
⚠ 08/02/09 07:03 PM	26	Brakes	Tractor Brake Stroke - Axle 1 Left - Non-functioning brake actuator: the brake rod has not actuated during a braking operation.



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6.3: Inoperable System Conditions

If the AVM system is unable to communicate with the e-Stroke system a “Roll Call Timeout” Fault or similar fault may be produced depending on the AVM configuration. A “Roll Call Timeout” Fault is typically associated with the following issues:

- **The e-Stroke System is not receiving power or the power harness is disconnected.**

Unfortunately, in some cases power is intentionally disconnected from the e-Stroke ECU in efforts to deactivate the warning light without fixing the condition which is activating the alarm output.

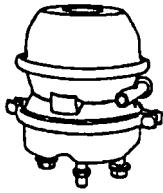
Note: *Deactivating the e-Stroke system will result in the vehicle brakes not being monitored. Unsafe brake conditions will not be reported with the e-Stroke system inoperable.*

- **SAE J1708 or SAE J1939 is not functioning properly.**

The AVM system may not be communicating properly with the e-Stroke system. The ECU diagnostic connections and vehicle diagnostic circuit should be checked.

Figure 10: e-Stroke J1708 or J1939 Communication Issue

Bus #123			
Last Occurred	Count	Component	Description
08/03/09 03:41 PM	2	Brakes	Roll Call Timeout - Brake Monitor



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SECTION 7: e-STROKE WARNING LIGHT INTERPRETATION

The e-Stroke system alarm output will activate during active fault conditions. The following section describes Warning Light operation and some simple checks which may be conducted to determine the nature of the fault condition without diagnostic tools.

Section 7 may be referenced by Maintenance, Dispatch, or Roadside Assistance personnel. It is the responsibility of the e-Stroke system end user to determine the appropriate action which must be taken when a driver reports that the Brake Monitor Warning Light is ON.

The Brake Monitor Warning Light operation must be verified by the start-up bulb check every time the vehicle ignition is switched ON. This will ensure that the Warning Light is operational and will illuminate with a brake fault condition.

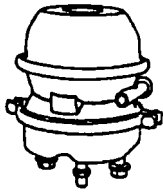
Note: *It is important to verify the vehicle specific Warning Light designation, location, and operation with the vehicle OEM or system installer prior to reference of this section.*

Some vehicles OEMs use a text display in place of a traditional warning light. In this case there is not a warning light connected to the e-Stroke system to display the blink code sequence. Consult the vehicle OEM for specific text display operation.

7.1: Warning Light Condition 1

The Brake Monitor Warning Light is ON while driving at speeds OVER 5 MPH, and driver is NOT applying the service brakes.

- If YES, Apply the service brakes. Does the Warning Light turn OFF as soon as the brakes are applied or the vehicle decelerates under 5 MPH?
- If YES, then the vehicle has a potential Dragging Brake condition. Continued operation of the vehicle is not recommended as further operation could result in a hazardous situation or thermal event. Call for roadside assistance.



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7.2: Warning Light Condition 2

The Brake Monitor Warning Light is ON when the driver APPLIES the service brakes ONLY (The Warning Light is OFF when the service brakes are NOT applied.).

- The vehicle has a potential Non-Functioning or Out-of-Adjustment Brake condition.
- Contact Road Side Assistance or Dispatch to determine if vehicle operation should be continued.

7.3: Warning Light Condition 3

The Brake Monitor Warning Light is ON continuously with the service brakes APPLIED and RELEASED.

- The e-Stroke system may have detected a caliper low running clearance condition or a sensor fault or functionality issue.
- A sensor fault or functionality issue will result in the vehicle brake condition NOT being monitored. Contact Road Side Assistance or Dispatch to determine if vehicle operation should be continued.

Note: Section 7 includes only recommended field warning light interpretation guidelines and MGM Brakes is not responsible for any liability associated with these recommendations. Each user must determine if a vehicle should be taken from service on a case by case basis.

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