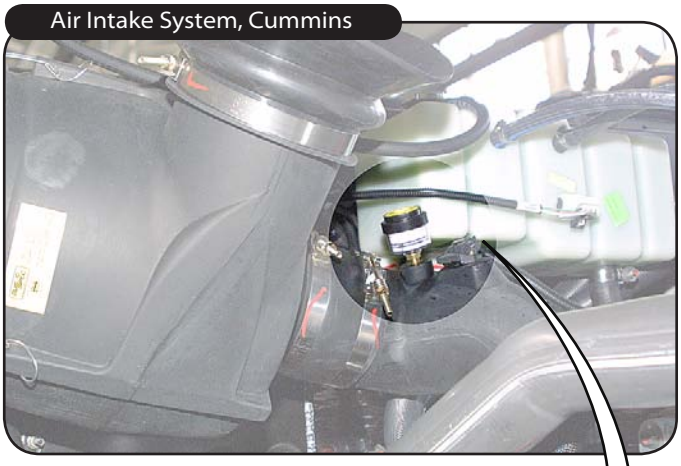
Intake System

Clean air is necessary for efficient fuel combustion and for normal engine life on any engine, and even more so for turbocharged engines like the Caterpillar C7 and Cummins ISB. Because intake air is forced into the intake manifold under pressure, both the volume and velocity of air flow is greater than in a naturally aspirated engine. Any opportunity for airborne contaminants to enter the intake flow represents a potential for serious damage to engine life. Therefore, careful inspection of the entire intake tract should be a part of regularly scheduled maintenance, and any signs of dust or debris entrace must be repaired immediately.

Air Intake System, Caterpillar

Air Intake System, Cummins



Fresh air enters the intake duct through vents built into the engine hood. The air enters a canister-type air filter mounted on top of the engine's right side, immediately above the engine's turbocharger. The filter element is of dry pleated fiber type and is easily accessible for replacement without tools, and without removal of any other chassis components or brackets. The element must be replaced when dirty, not cleaned and re-used.

After passing through the filter element, fresh air enters the turbocharger though a short plastic duct on the left side of the filter cansiter. A pressure-sensing restriction indicator mounted on this duct provides a visual alert in the case of restriction of the air flow entering the turbocharger.

The turbocharger compresses and forces the air through a metal pipe with rubber seal joints at each end into the Charge AIr Cooler mounted to the front of the engine's radiator. The air leaves the Charge Air Cooler through a similar piping arrangement on the left side of the engine, which directs it into the intake manifold.

Air Restriction Indicator (Cummins shown)

Normal reading. Some fluctuation while the engine is running is acceptable.

At a vaccuum of 25 inches H_2O, the red piston locks, indicating that the air intake tract is too restricted.

Air Restriction Indicator

The Air Restriction Indicator is visible from the right side of the bus when the engine compartment hood is raised. During engine operation, the indicator monitors vaccuum pressure inside the air filter elbow. As vaccuum increases, the indicator's red piston becomes visible through the clear portion of the housing indicating that air flow is being restricted by a clogged filter, debris, or other obstruction. The Air Restriction Indicator is variable until the monitored vaccuum increases to a measure of 25 inches H_2O. At that measure, the red piston fills the clear portion, and locks in its position. The indicator must then be manually reset by pressing the reset button after the restrictive condition has been corrected.

CAUTION ***The Air Restriction Indicator activates only when an air flow restriction has occured. A normal reading (no red showing) must not be misunderstood as an indication that the air filter is clean, and does not preclude the need for other inspection and maintenance. For example, a leak in the intake will allow damaging debris to enter, but will not be indicated by the Air Restriction Indicator.***

Filter restriction and proper operation of the indicator may be verified by pressing the reset button on the top of the indicator. If restriction is occurring, the red indictor will move when the engine is under load. The indicator will lock in position if the monitored vaccuum increases to 25 inches H_2O.

It is important to understand that the Air Restriction Indicator does not detect leaks, and will not properly indicate restrictions in a leaking intake system. Check for leaks in all inlet hoses, tubes and connections. If a leak is found, correct it immediately, using original replacement parts and torqing all clamps.

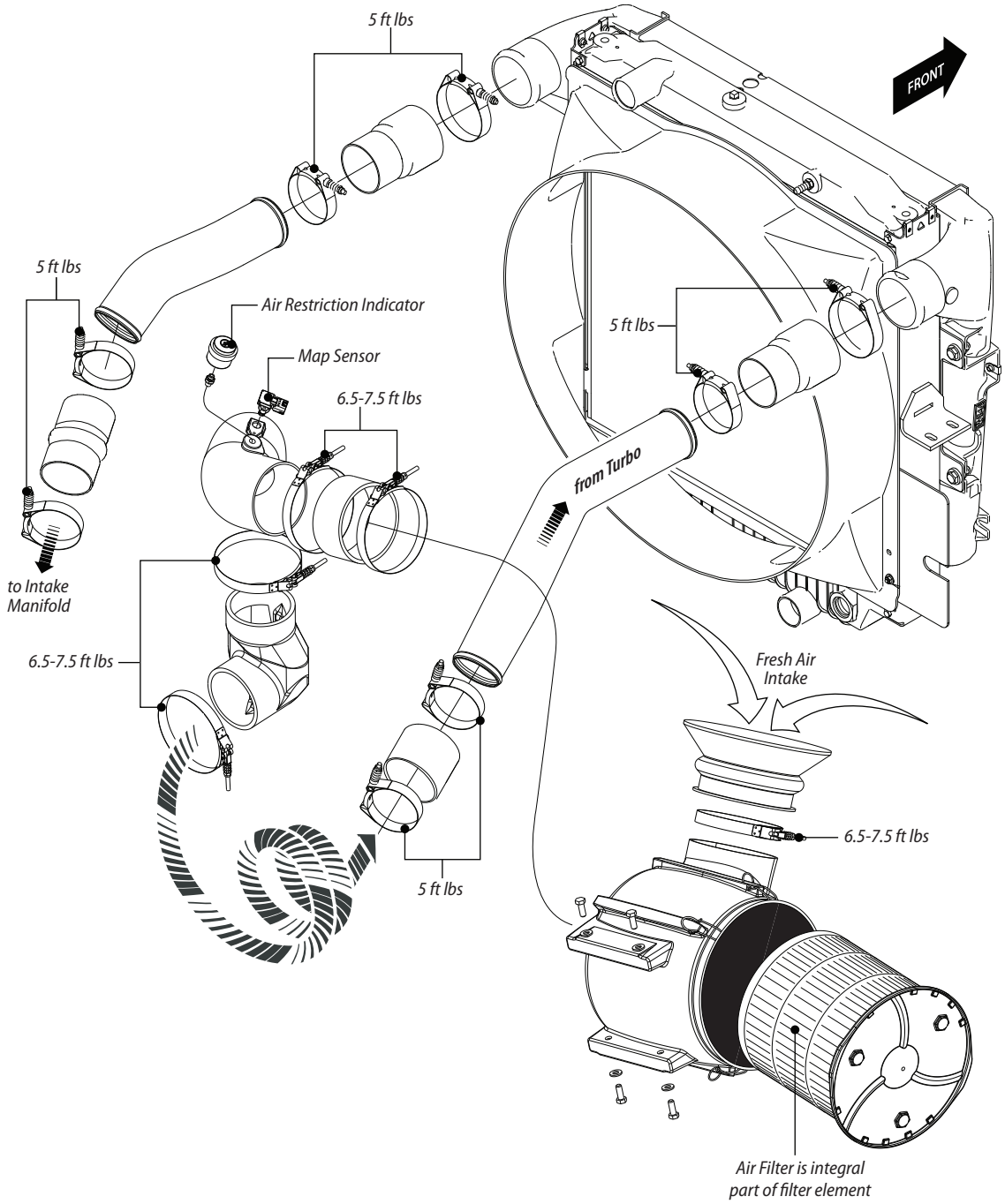
The Air Restriction Indicator can also be tested using a calibrated vacuum gauge and vacuum pump. Check the full range of the indicator, and verify that the red indicator locks into position at 25 inches H_2O. The Air Restriction Indicator is not repairable, and should be replaced if found to be operating incorrectly.

Charge Air System

The turbocharger of the engine uses the heat energy in the exhaust gases to compress the intake tract's filtered air on its way to the intake manifold, thereby delivering a denser charge of air into the combustion chambers, improving combustion and increasing horsepower.

Immediately after leaving the exhaust manifold, and before continuing on to the exhaust system, exhaust gases pass through the turbine chamber of a turbocharger unit mounted on the right side of the engine. The spinning turbine shaft passes through a seal into the impeller chamber, where it drives the impeller vanes. The turbine and impeller sides of the turbocharger are sealed, preventing exhaust gasses from mixing with fresh intake air. The impeller draws fresh air which has passed through the air filter, and compresses it. The compressed air leaves the impeller chamber and is routed through sealed tubing to the Charge Air Cooler, mounted immediately in front of the engine radiator. The Charge Air Cooler is a separate radiator which allows the heat of the compressed air to dissipate to the atmosphere. The compressed and now cooled air proceeds from the Charge Air Cooler through tubing to the left side of the engine where it enters the intake manifold.

Air Intake System



Intake System Maintenance

Although it is a simple system, dilligent maintenance and inspection of the air intake tract is critical to not only proper performance, but also to engine life and warranty compliance. Any leak along the various tubings and clamped joints of the intake tract, including the charge air track, is an opportunity for the engine to ingest abrasive dirt or contamination into the valves and combustion chambers under pressure. Never run the engine with the air cleaner or its filter element removed. Use only original replacement parts to avoid poor fit and consequent air leakage. Visually inspect the intake tract whenever working in the engine compartment. and follow the scheduled maintenance guidelines in the Specs & Maintenance chapter of this manual as a minimum.

CAUTION ***The intake system inspection and maintenance intervals indicated below are guidelines which assume normal operating conditions. Appropriate service intervals vary according to operating conditions. In dusty or high humidity environments, more frequent service may be required.***

General Inspection

Under normal operating conditions, inspect the Air Restriction Indicator daily (more frequently in dusty high humidity conditions). Inspect the air intake system every 3 months or 5000 miles. Inspect the system for:

- Air Restriction Indicator. If red indicator is visible, replace the air cleaner element, and check the system for debris and other restrictions.
- Clamps. Tighten loose clamps and check for proper fit and seal. Replace if corroded, broken or otherwise damaged.
- Ducts and piping. Inspect for wear, damage, or abrasion.
- Air cleaner element. Replace if soiled, wet, torn, or otherwise damaged. Ensure proper installation and seal.
- Mounting brackets. Check for loose or damaged mounts.
- Charged air system piping. Tighten loose clamps. Check for wear spots and holes in the piping.
- Air compressor inlet lines. Tighten. Check for wear or other damage.

Clamps should be tightened to the following specifications:

Spring-loaded clamps. ***Tighten to near full spring compression.***

T-Bolt clamps. ***Tighten to 50 in. lbs. (5.6 Nm).***

Worm gear clamps. ***Tighten to 38–42 in. lbs. (4.2–4.7 Nm).***

Hose clamps already in service. ***Tighten to 10 in. lbs. (1.1 Nm).***

Air Filter Element Replacement

Replace the air filter element at least once a year, and whenever the Air Restriction Indicator has been activated (shows red). Other indicators of a dirty air cleaner element include loss of power or excessive exhaust smoke. To replace the air cleaner element:

Air Cleaner Element

Unlatch the four clips and lift out the filter element. The lid is an integral part of the element.

1. Unlatch the four quick release latch clamps holding the lid to the top of the air filter housing.

2. Remove the lid to expose the air cleaner element.

3. Pull the air cleaner element straight out of the filter housing. A rotating or rocking motion may help unseat the element.

4. Before replacing the element, inspect all clamps, hoses, piping and seals.

   - Inspect inside the intake elbow for signs of dust or debris finding its way into the system through leaks. Replace any damaged components allowing the leak, and clean the debris inside the elbow and ducts before installing a new element.

   - If evidence of leaks is found, check the tube between the charged air cooler and the engine intake for contamination. If contamination is found, the charged air cooler should be replaced.

5. Install a new air cleaner element, fully seating its bottom seal.

6. Assemble removed parts in reverse order of disassembly.

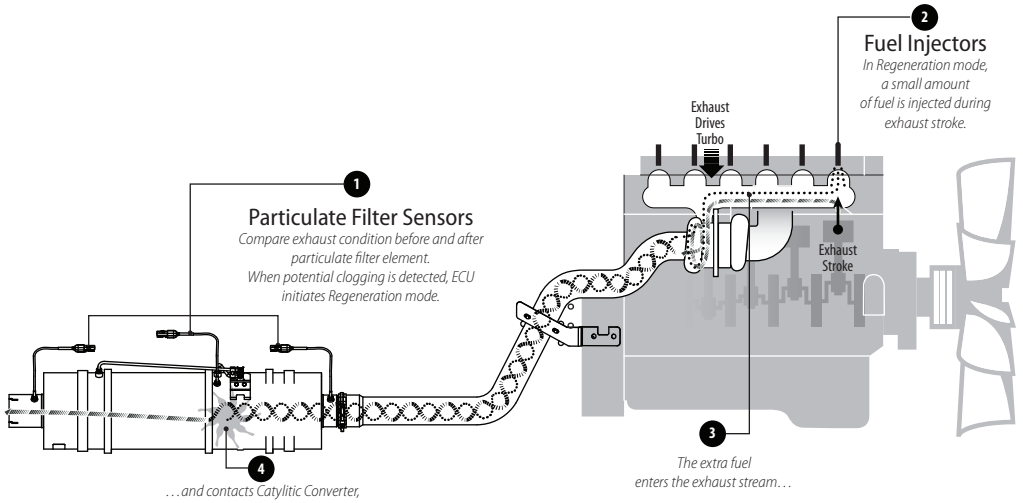
7. Replace the filter housing top. Ensure it is properly seated, and secure with the four quick release clamps. If necessary, a clamp's tension may be tightened by using pliers to carefully shorten its curve.

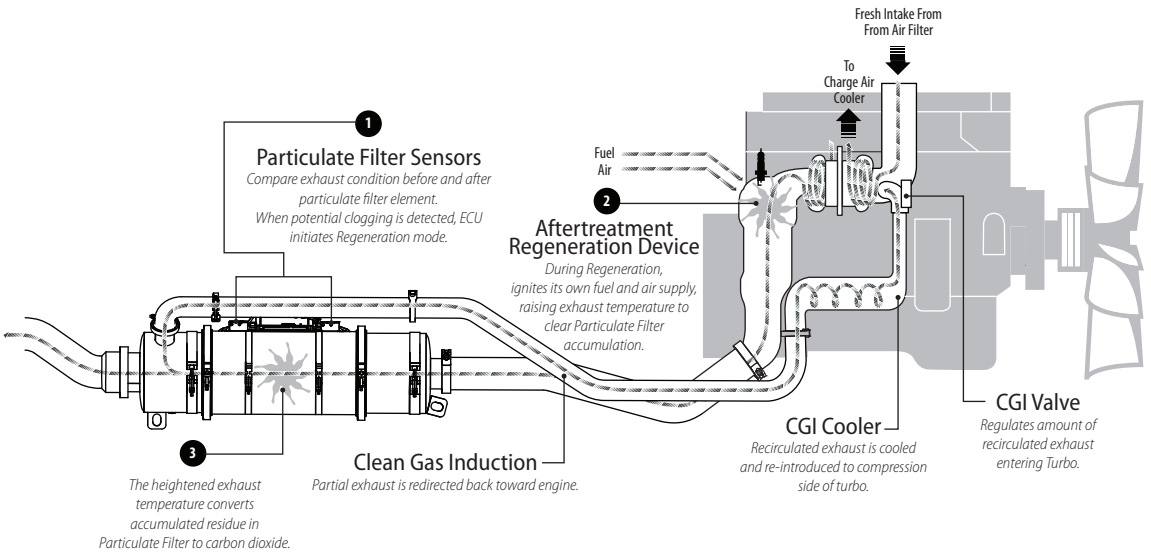
8. Reset the Air Restriction Indicator by pushing the reset button. This will allow the indicator to monitor the newly installed components.

The element fits snuggly around its bottom seal. A gentle rocking or rotating motion will help unseat it.

With the element removed, check the inside of the elbow for any sign of contamination due to leaks before replacing the element..

Cummins Regeneration





Caterpillar Regeneration

Exhaust System

New federally mandated emission standards affect all buses equipped with 2007 or newer diesel engines. The exhaust systems of both Caterpillar and Cummins engines in Blue Bird buses are *aftertreatment* systems which incorporate *Diesel Particulate Filters* (DPF) instead of ordinary mufflers. These sophisticated exhaust systems reduce emissions by trapping exhaust-borne particulates (soot) in a filter built into the DPF.

Over time, the trapped soot accumulates in the DPF, and must be removed by a process referred to as *regeneration*. Regeneration is conceptually similar to the cleaning mode of a self-cleaning oven in that heat is required to remove the soot. Regeneration converts most of the accumulated soot to carbon dioxide, and leaves behind a small amount of ash. Because of the higher operating temperatures involved, the exhaust system components are now more insulated from other chassis components than in previous years.

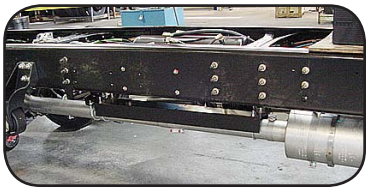
The rate at which the soot accumulates is dependent upon multiple conditions including the quality of the diesel fuel, type of engine oil, ambient temperature, engine load, and other factors. Regeneration occurs in three ways:

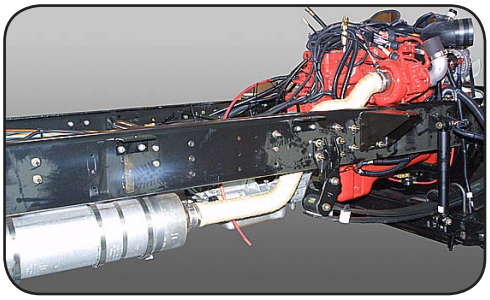
- Some regeneration occurs "naturally" whenever operating conditions (speed, engine load, etc.) result in exhaust system temperatures high enough to oxidize accumulated soot. Terminology differs between engine manufacturers, but this unassisted regeneration mode can generically be referred to as "passive" regeneration.
- Regeneration can be caused by raising the temperature of the exhaust system. A set of sensors mounted on the DPF assembly enable the Engine Control Module (ECM) to monitor the buildup. The ECM then automatically activates and de-activates a system designed to increase exhaust temperature when the ECM senses that regeneration is needed, and when certain requirements, including a minimum travel speed, are met. Although the specific mechanisms differ, both Caterpillar and Cummins engines are equipped with such systems. This automatic "heat assisted" mode can be generically referred to as "active" regeneration.
- Regeneration can be manually activated by means of a switch. This procedure is generically referred to as "stationary" regeneration, and should only be performed by or under the direction of a qualified service technician, and in a controlled environment to avoid the potential for human injury or fire hazards.

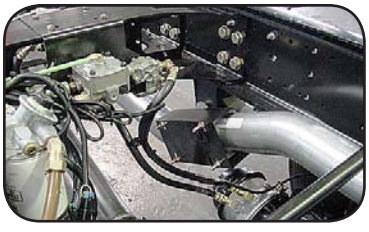
The ECM communicates the need for regeneration to the driver by a set of visual and audible signals in the instrument panel. An additional alert, the High Exhaust System Temperature (HEST) indicator, notifies the driver whenever exhaust system temperature is high due to recent regeneration.

Periodically, the normal ash accumulation which results from the regeneration process must be removed from the DPF, using equipment designed for the purpose at qualified engine service facilities. Refer to the engine manufacturer's documentation for these service intervals.

CAUTION ***In 2007 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications.***
In Caterpillar, use oils meeting API CJ-4 or Caterpillar ECF-3 compliant. See Caterpillar Operation and Maintenance Manual SEBU8083-08 for details.
In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.







The exhaust systems of 2007 and newer engines incorporate engine-specific Diesel Particulate Filters, which operate at higher temperatures during their Regeneration cycles. The front exhaust pipes are insulated, and heat shields are installed at locations along the exhaust tubing. (Cummins shown)

Engine-Specific Technologies

Although the purpose and general principles of aftertreatment exhaust systems are similar, both the terminology and the mechanisms to perform "active" regeneration differ among engine manufacturers.

Caterpillar and Cummins have also each developed their own technologies for accomplishing and controlling the active regeneration process. The engine-specific ECMs which control the process are different. Differences also exist between engine manufacturers in the construction of the DPF units, the exhaust flow paths, and other related components. It is for these reasons that the service technician must now regard that portion of the exhaust system from the engine to the outlet port of the DPF as part of the engine package itself.

This chapter provides separate conceptual explanations of the Caterpillar and Cummins systems. *However, the service technician must refer to the engine manufacturer's operators' manual and service literature regarding service and maintenance of the 2007 and newer exhaust systems.*

Regeneration Process In Caterpillar Engines

2007 emissions standards-compliant Caterpillar engines incorporate the Caterpillar Regeneration System (CRS). Exhaust leaving the turbo flows through an Aftertreatment Regeneration Device (ARD) mounted on the right side of the engine. The ARD is a chamber equipped with its own fuel injector, air intake, and spark plug.

Caterpillar Passive Regeneration

As the engine runs, exhaust merely passes through the ARD on its way to the exhaust pipe and into the DPF. If the engine's duty cycle generates sufficient heat, some of the soot accumulation is removed, even though the ARD is not activated. This unassisted regeneration mode is called *Passive Regeneration*.

At moderate and continuous speeds or engine load conditions, normal exhaust temperatures may be maintained at a high enough level for Passive Regeneration to "hold its own" against additional accumulation. Under frequent or prolonged moderate-to-heavy operating conditions, Passive Regeneration may even "gain ground" against the accumulation.

Caterpillar Active Regeneration

Accumulation occurs most at low speeds and relatively low temperatures. Frequent stop-and-go and continual low-speed operation typical of some school bus routes may not generate sufficient heat for Passive Regeneration to keep the DPF clear.

Sensors monitor the pressure differential before and after the DPF, and also monitor temperature. The pressure and temperature data is communicated to the ECM. When the readings indicate that the particulate filter is beginning to become restricted, the ECM may signal the system to enter *Active Regeneration* mode.

During Active Regeneration, a small amount of fuel and air is injected into the ARD, and is ignited by its spark plug. This combustion within the ARD raises the temperature of the exhaust flow sufficiently to remove the residue downstream in the DPF. This process occurs automatically and as-needed during normal operation.

Active Regeneration only occurs if DPF accumulation has reached a certain level, *and* if the bus is moving above a preset speed threshold (20 mph). If the bus is operated long enough (typically 20-30 minutes) at a speed above the Active Regeneration speed threshold, the accumulation clears and Active Regeneration mode stops. If the bus is slowed to below a certain speed threshold while in Active Regeneration mode, the Active Regeneration stops, even if the cleaning process has not completed. If the bus slows or stops while the exhaust system temperature is still high due to recent Active Regeneration, the HEST indicator appears on the driver's instrument panel to notify the driver that the system is hot.

Caterpillar Stationary Regeneration

Active Regeneration removes the accumulation at an increased rate. However, each time the bus slows to below the Active threshold, and each time exhaust temperature drops below that at which Passive Regeneration occurs, accumulation has opportunity to increase.

Therefore, depending upon the operating conditions, there may not be sufficient opportunity or duration for either Passive or Active Regeneration to keep the filter clear, and a *Stationary Regeneration* must eventually be performed.

During Stationary Regeneration, temperatures inside the exhaust can exceed 1200°F. Stationary Regeneration must be performed only in a controlled environment where all reasonable precautions are taken to avoid any hazard that might result from the elevated temperatures. Blue Bird strongly recommends that Stationary Regeneration be performed only by, or under the supervision of, a qualified service technician. Read carefully the section titled **Stationary Regeneration Precautions.**

Stationary Regeneration is initiated by means of a momentary toggle switch. Operating the switch starts a Stationary Regeneration only if certain conditions are true: The ECM must have indicated that regeneration is needed (as indicated by the appearance of the DPF indicator); the bus must be stopped with parking brake on; the engine must be running; and the transmission must be in Neutral.

During a Stationary Regeneration procedure, the process is monitored and controlled by the ECM and CRS. The Stationary Regeneration process continues until the filter is clean, and then stops. The bus may then be returned to normal service. (For more information, see **DPF Regeneration In Blue Bird Buses**.)

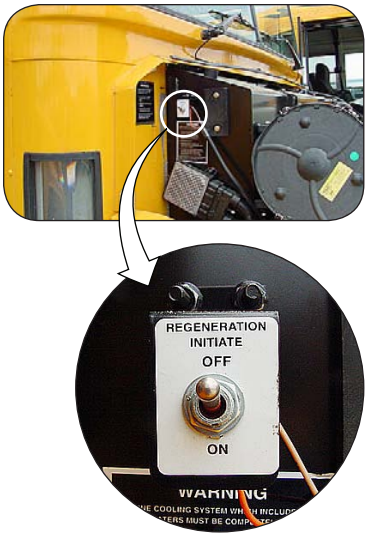
Clean Gas Induction in Caterpillar Engines

The exhaust system of the Caterpillar C7 engine also utilizes Clean Gas Induction (CGI). A portion of the exhaust is "recycled" through the engine to help control emissions. Just before the DPF outlet, a portion of the exhaust gases is re-directed back toward the engine through a 2 ½" tube. This inert exhaust enters a CGI Cooler, located on the right side of the engine, below the turbo and forward of the ARD. Enveloped in the engine coolant circuit, the CGI Cooler lowers the temperature of the incoming exhaust. The cooled exhaust flow then re-enters the compressor side of the turbocharger through an electrically-controlled, hydraulically-actuated mixing valve, and is re-introduced into the intake flow.

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.***

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.



Regeneration switch for use by Service Technicians performing Stationary Regeneration only in a controlled, fire-hazard-free environment.

Regeneration Process In Cummins Engines

2007 emissions standards-compliant Cummins engines incorporate the Cummins Aftertreatment System. When elevation of exhaust temperature is needed to facilitate regeneration, this system utilizes the engine's fuel injectors to inject a small measure of fuel during the exhaust strokes of the engine's cycle.

Cummins Passive Regeneration

When driving at high speeds or with heavy loads, the exhaust system is hot enough to turn soot accumulation inside the DPF into carbon dioxide. Temperatures generated in this mode are comparable to those of pre-2007-standards engines.

At moderate and continuous speeds or engine load conditions, normal exhaust temperatures may be maintained at a high enough level for normal operation to "hold its own" against additional accumulation. At moderate-to-heavy operating conditions, normal exhaust heat may even "gain ground" against the accumulation.

Cummins Active Regeneration

Accumulation occurs most at low speeds and relatively low temperatures. Frequent stop-and-go and continually low-speed operation typical of some school bus routes may not always generate sufficient heat for normal running to keep the particulate filter clear.

Sensors monitor the pressure differential before and after the DPF, and also monitor temperature. The pressure and temperature data is communicated to the ECM. When the pressure / temperature readings indicate that the particulate filter is beginning to become restricted, the ECM may signal the system to enter *Active Regeneration* mode.

During Active Regeneration, a small amount of fuel is injected into the exhaust stream by the engine's fuel injectors during the engine's exhaust stroke. This fuel reacts with the catalytic converter in the DPF, raising the temperature of the exhaust flow sufficiently to remove the residue. This process activates and deactivates automatically and as-needed during normal operation.

Active Regeneration begins only if DPF accumulation has reached a certain level, *and* if the bus is moving above a preset speed threshold (approximately 40 mph). If the bus is operated above the speed threshold long enough, the accumulation clears and Active Regeneration mode stops.

If the bus is slowed to below a certain speed threshold while in Active Regeneration mode, the Active Regeneration stops, even if the cleaning process has not completed. If the bus slows or stops while the exhaust system temperature is still high due to recent Active Regeneration, the HEST indicator appears on the driver's instrument panel to notify the driver that the system is hot.

Cummins Stationary Regeneration

Active Regeneration removes the accumulation at an increased rate. However, each time the bus slows to below the cut-off threshold, and each time exhaust temperature drops to levels insufficient for soot to be cleared, accumulation has opportunity to increase.

Depending upon the operating conditions, there may not be sufficient opportunity or duration for either normal running or Active Regeneration to keep the filter clear, and a Stationary Regeneration must eventually be performed.

During Stationary Regeneration, temperatures inside the exhaust can exceed 1300°F. Stationary Regeneration must be performed in a controlled environment where precautions are taken to avoid any hazard that might result from the elevated temperatures. Blue Bird strongly recommends that Stationary Regeneration be performed only by, or under the supervision of, a qualified service technician. Read carefully the section titled **Stationary Regeneration Precautions.**

Stationary Regeneration is initiated by means of a momentary toggle switch. Operating the switch starts a Stationary Regeneration only if certain conditions are true: The ECM must have indicated that Regeneration is needed (as indicated by appearance of the DPF indicator); the bus must be stopped with parking brake on; the engine must be running; and the transmission must be in Neutral. During a Stationary Regeneration procedure, the process is monitored and controlled by the ECM. Depending upon the severity of the restriction, the engine may or may not raise its idle speed. The Regeneration process continues until the filter is clean, and then stops. The bus may then be returned to normal service. (For more information, see **DPF Regeneration In Blue Bird Buses**.)

Cummins Exhaust Gas Recirculation

In the Cummins ISB engine, a portion of the exhaust is "recycled" through the engine to help control emissions. A device on the engine exhaust system routes a small amount of the exhaust stream through a cooler, mixes it with fresh air, and re-introduces it into the intake stream. This helps lower the temperature during combustion, which reduces the formation of Nitrous Oxides.

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.***

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.

Regeneration switch for use by Service Technicians performing Stationary Regeneration only in a controlled, fire-hazard-free environment.

DPF Regeneration In Blue Bird Buses

As with most new mechanical processes, the introduction of more sophisticated exhaust systems in 2007 emission standards-compliant engines has generated some degree of initial confusion. Engine manufacturers have designed their own methods to accomplish the regeneration (cleaning) of the DPF, and therefore describe the process in somewhat differing terms.

Whether your Blue Bird bus is equipped with a Caterpillar or Cummins engine, neither system is complicated. Nor should the regeneration process be regarded with alarm. Both Drivers and service technicians should be at least conceptually familiar with the regeneration process.

As soot builds up in the DPF filter, the driver is notified in several stages by visual and audible alerts. The alert system is designed to provide reasonable and comfortable fore-warning and adequate opportunity for the needed regeneration. As the need for regeneration becomes more severe, the alerts become increasingly imperative; and the penalty for postponing the needed regeneration also increases.

When the earliest alerts occur, there is typically ample time to complete a route and then have a Stationary Regeneration procedure performed at a proper facility. If early alerts are ignored, and the condition is allowed to worsen, the engine will eventually de-rate automatically, and performance will reduce noticeably. If the condition is allowed to become severe, a Stationary Regeneration may not be possible, and the DPF may require removal and treatment using specialized equipment. Therefore, to minimize disruption of your bus operation, the regeneration-related alerts should be heeded and responded to at their early stages as a matter of routine.

Aftertreatment Terms

The following summarizes some of the terms associated with the exhaust systems of Blue Bird buses equipped with 2007 emission standards compliant engines. Both the driver and technician should become familiar with the following terms:

Aftertreatment. The process of highly filtering engine exhaust in order to reduce emissions, and of purging the exhaust system of accumulated exhaust residue.

DPF (Diesel Particulate Filter). A component in the exhaust system which takes the place of a traditional muffler. A DPF contains a special dissimilar metals filter which traps particulate accumulation (soot), which is then converted to carbon dioxide by the aftertreatment process. The Cummins DPF also contains a catalytic converter.

Regeneration. The process of cleaning accumulated soot from the filtering components inside the DPF. Regeneration occurs at high exhaust system temperatures to turn the soot into carbon dioxide gas. Regeneration can be thought of as conceptually similar to the clean cycle of a self-cleaning oven.

ARD (Aftertreatment Regeneration Device). A component of the Caterpillar Regeneration System, located on the right side of the engine, at the outlet of the turbocharger. The ARD is controlled by the engine's ECM and is activated when regenera-

WARNING ***Postponing regeneration beyond the early indications may result in the engine being automatically de-rated, and reduction of power while driving.***

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.***

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.

tion needs to occur and the necessary conditions are met. When not in regeneration mode, the ARD is simply a chamber through which the exhaust flows. During regeneration, a charge of fuel and air is ignited in the ARD, and the resulting combustion creates additional heat to facilitate regeneration.

HEST Indicator (High Exhaust System Temperature). An instrument panel indicator which appears when the exhaust temperature is unusually high due to recent regeneration. This is a normal behavior of the aftertreatment system, intended to notify the driver and technician that the exhaust system temperature is high and that caution should be observed around the exhaust system.

DPF Indicator. An instrument panel indicator which displays when particulate accumulation has reached a preset level in the DPF, and regeneration is needed. The bus should either be operated with a more demanding duty cycle until the indicator goes off, or it should be scheduled for a Stationary Regeneration at a service facility.

Levels of Notification

Regeneration—the process which clears soot accumulation in the DPF—occurs automatically as the bus is operated, as long as certain operating conditions (such as minimum speed thresholds) are met. When bus operating conditions do not provide adequate opportunity for the regeneration system to keep the DPF clear, soot begins to accumulate. A system of driver alerts keeps the driver informed of when the exhaust system is in need of regeneration, and of high exhaust temperature associated with regeneration. Several levels of regeneration alerts occur in sequence, each indicating a more imperative warning.

High Exhaust Temperature Notification

The High Exhaust System Temperature (HEST) indicator appears to alert the driver when exhaust temperature is unusually high and that prudent judgement should be applied regarding the proximity of people or combustibles to the exhaust system. For example, the bus should not be parked on a surface of grass or weeds. The conditions under which the HEST indicator appears differ between Caterpillar- and Cummins-equipped buses:

With Caterpillar engine, the HEST indicator appears whenever the exhaust temperature is high (842°F or above), and the bus is either stopped or moving at a slow speed (approximately 5 MPH).

With Cummins engine, the HEST indicator appears whenever the exhaust temperature is high (752°F or above), regardless of moving speed.

The driver should be familiar with and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when the HEST indicator is on.

HEST Notification

The HEST alert appears in the DID status window.

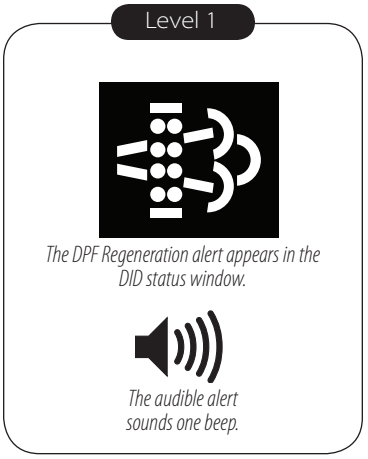
The audible alert sounds one beep.

- The HEST alert appears in the instrument panel.
- The audible alarm sounds one beep.

Level 1 Regeneration Notification: DPF Indicator Appears

In low-demand operating conditions, it is possible that the regeneration system does not have sufficient opportunity to prevent particulate build-up in the DPF. The ECM senses that accumulation is occurring and that regeneration is needed. The driver is notified as follows:

- The DPF Regeneration alert activates.
- The audible alert sounds one beep.



The above indicates that regeneration of the DPF is needed at the earliest convenience. The regeneration can be accomplished in either of two ways: If practical, the bus could simply be operated for a while at a speed above the automatic regeneration threshold; or the bus could be taken to a suitable location to have a Stationary Regeneration procedure performed.

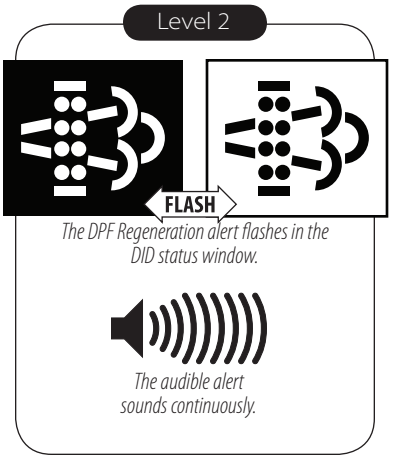
If the bus is operated at a minimum highway driving speed (20 mph Caterpillar; 40 mph Cummins), the automatic regeneration system will activate. If minimum speed is maintained long enough (usually 20-30 minutes), the automatic regeneration mode can likely reduce the soot sufficiently to cause the DPF Icon to go off.

Therefore, the first appearance of the DPF icon should be perceived by the driver as a normal notification of action that needs to be taken, but not as an emergency situation. Typically, even if the bus route does not afford immediate opportunity for higher-speed operation, there is sufficient time to finish the bus route and return to the bus maintenance shop before the higher level of notification occurs. Exactly how much "warning time" the first appearance of the DPF indicator represents is dependant upon specific operating conditions. However, current data from Cummins suggest that, at this level of notification, the DPF needs to undergo regeneration within the next two to six hours of bus operation. If regeneration does not begin, a more imperative notification will activate.

Level 2 Notification: DPF Indicator Blinks

If the bus continues to be operated without taking the measures indicated by a Level 1 Notification (described above), particulate accumulation continues, and a more imperative notification occurs:

- The DPF Regeneration alert begins to flash.
- The audible alarm sounds continuously.
- The engine may be automatically de-rated.



The above indications should be interpreted as a more imperative alert that the exhaust system is in need of regeneration soon. As soon as practical, the bus should be operated at or above the minimum speed needed to allow automatic regeneration to activate, or a Stationary Regeneration must be performed. Again, situation-specific variables apply. Current data from Cummins suggest that at this level of notification, the DPF needs to be regenerated within the next one to two hours of bus operation. Otherwise, the third level of notification will occur.

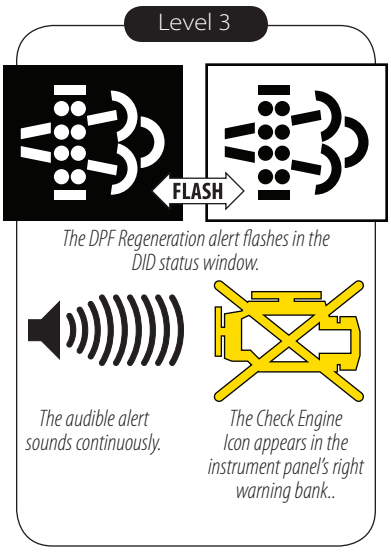
Level 3 Notification: Check Engine Indicator Appears

If the bus continues to be operated without taking the measures indicated by a Level 2 Notification, particulate accumulation worsens. These indicators are activated:

- The DPF Regeneration alert continues to flash.
- The audible alert sounds continuously.
- The engine is automatically de-rated.
- The Check Engine alert appears.

The above indicates that a Manual Regeneration must be performed as soon as possible. Because the engine is automatically de-rated it may not be possible to drive at sufficient speed to cause active regeneration to occur.

With Cummins engine, depending upon the severity of the accumulation, the regeneration switch may not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.



Level 4 Notification: Stop Engine Indicator Appears

If the bus continues to be operated without taking the measures indicated by a Level 3 Notification, particulate accumulation reaches a critical level. Engine power is automatically *further* de-rated by the ECM. The indicators differ slightly between Caterpillar- and Cummins-equipped buses:

Cummins:

- The DPF Regeneration alert deactivates.
- The audible alert sounds continuously.
- The engine is further de-rated.
- The Check Engine alert deactivates.
- The red Stop Engine alert appears.

Caterpillar:

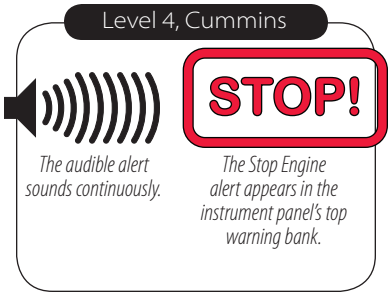
- The DPF Regeneration alert continues to flash.
- The audible alert sounds continuously.
- The engine is further de-rated.
- The Check Engine alert remains on.
- The red Stop Engine alert appears.

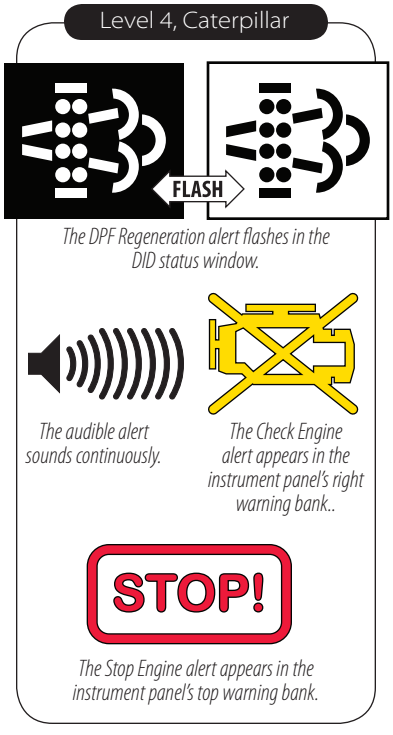
The above indicates that accumulation has progressed to critical levels and the bus should be stopped with the engine off as soon as it is safe to do so. The bus should remain shut down until the aftertreatment system has been serviced.

With Cummins engine, the regeneration switch will not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.

With Caterpillar engine, depending upon the severity of the accumulation, the regeneration switch may not be allowed to initiate a regeneration without the use of Caterpillar's PC-based diagnostic software, Electronic Technician.

With either Caterpillar or Cummins engine, removal and cleaning of the DPF using specialized equipment may be required.





Stationary Regeneration Precautions

During active regeneration, the exhaust system can reach extremely high temperatures. Automatic active regeneration, which occurs while driving the bus, is programmed to occur only when the bus is moving at a minimum speed, and it stops when the vehicle slows or stops.

With Caterpillar engine, if the exhaust is still unusually hot from recent regeneration when the bus slows or stops, the HEST indicator appears to remind the driver of the high temperature condition.

With Cummins engine, the HEST indicator appears whenever the high temperature condition exists.

When performing a Stationary Regeneration, the entire process occurs for an extended period while the bus is stopped. It is therefore critical that prudent human safety and fire hazard precautions are followed. Those precautions include:

- Read, understand, and abide by all the precautions pertaining to regeneration procedures in the engine manufacturer's Operator's Manual.

- If at all possible, the Stationary Regeneration procedure should be conducted at a service facility by trained technicians.

- The Driver's first priority is the safety of the passengers. If a Stationary Regeneration must unavoidably be done by the Driver under a qualified technician's direction, alternate transportation should be arranged first, or passengers should be removed under proper supervision to a location away from the bus.

- Select an appropriate location to park the vehicle.

    - Choose a surface that will not burn or melt under high temperature, such as clean concrete or gravel, *not grass or asphalt*.

    - Ensure that nothing that can burn, melt, or explode (gasoline, wood, paper, plastics, fabric, compressed gas containers, hydraulic lines) is near the exhaust outlet. Abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when performing a Stationary Regeneration.

- Park the bus securely.

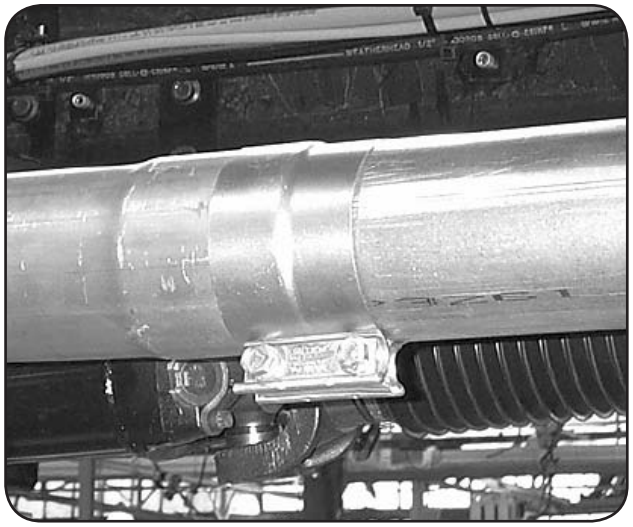
    - Set the parking brake. Put the transmission in Neutral. Chock the wheels.

- Secure the exhaust area.
    - If bystanders might enter the area, set up barriers to keep people safely away from the exhaust outlet.
    - If the procedure is performed indoors at a service facility, attach an exhaust discharge pipe rated for at least 1500°F.
    - Keep a fire extinguisher nearby.
- Check exhaust system surfaces to confirm that no tools, rags, grease, debris or any other objects are on or near the exhaust system.
- Start the engine.
- Operate the Regeneration Switch to begin the regeneration process.
- Monitor the process. If any unsafe condition occurs, shut off the engine immediately. During the regeneration process, the engine may change speed, and the turbocharger may whistle. When the process is complete, the engine will return to normal idle speed. Exhaust gas and exhaust surface temperatures will remain elevated until they have had time to cool to normal levels.

Exhaust Piping

The exhaust system beyond the DPF is designed to move hot exhaust gases from the engine, underneath and toward the rear of the bus, while preventing contamination of the passenger area. All pipes and connections must be inspected for leaks at least monthly to provide continued safe transport of passengers.

CAUTION ***Never work under a bus with the engine running. Never work under a bus until the wheels are chocked, to prevent movement in either direction.***



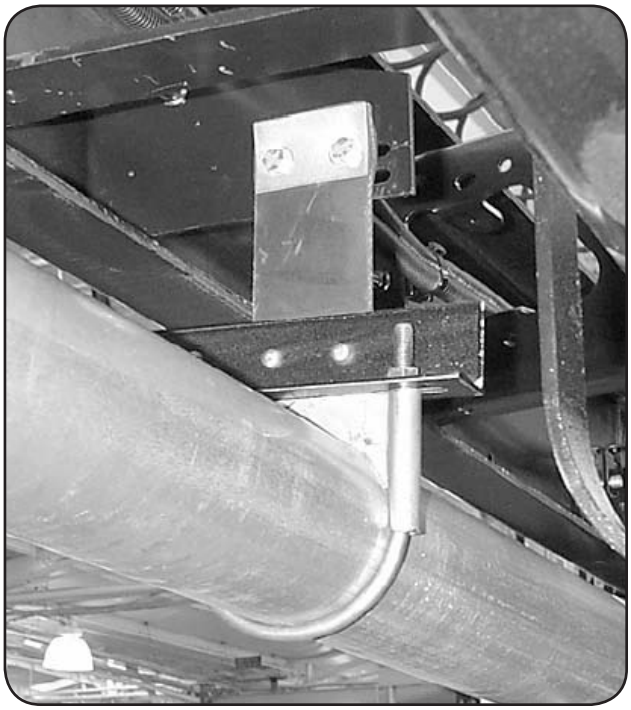
Typical Exhaust Clamp

Although the exact configuration of exhaust pipe and tailpipe sections is dependent upon the wheelbase and body length of the particular bus, the pipe sections, joint clamps and suspension hangers from the DPF / muffler assembly are similar. As a general rule, to remove the exhaust system, or any part of it, start at the rear most hanger and work forward.

Typical Exhaust Hanger

DPF / Muffler Removal

This general procedure applies to all wheelbases.



1. Start at the rear bumper and loosen all the sections forward until you reach the DPF / muffler.
2. Remove the clamp securing the tailpipe onto the DPF / muffler.
3. With the slack produced by loosening the section clamps rearward, remove the tailpipe section nearest the DPF / muffler.
4. Loosen the nuts at the straps securing the DPF / muffler.
5. Support the DPF / muffler and remove the strap from the hanger.

If it is necessary to continue removing exhaust pipe sections, proceed from the DPF / muffler toward the engine as far as necessary.

DPF / Muffler Reinstallation

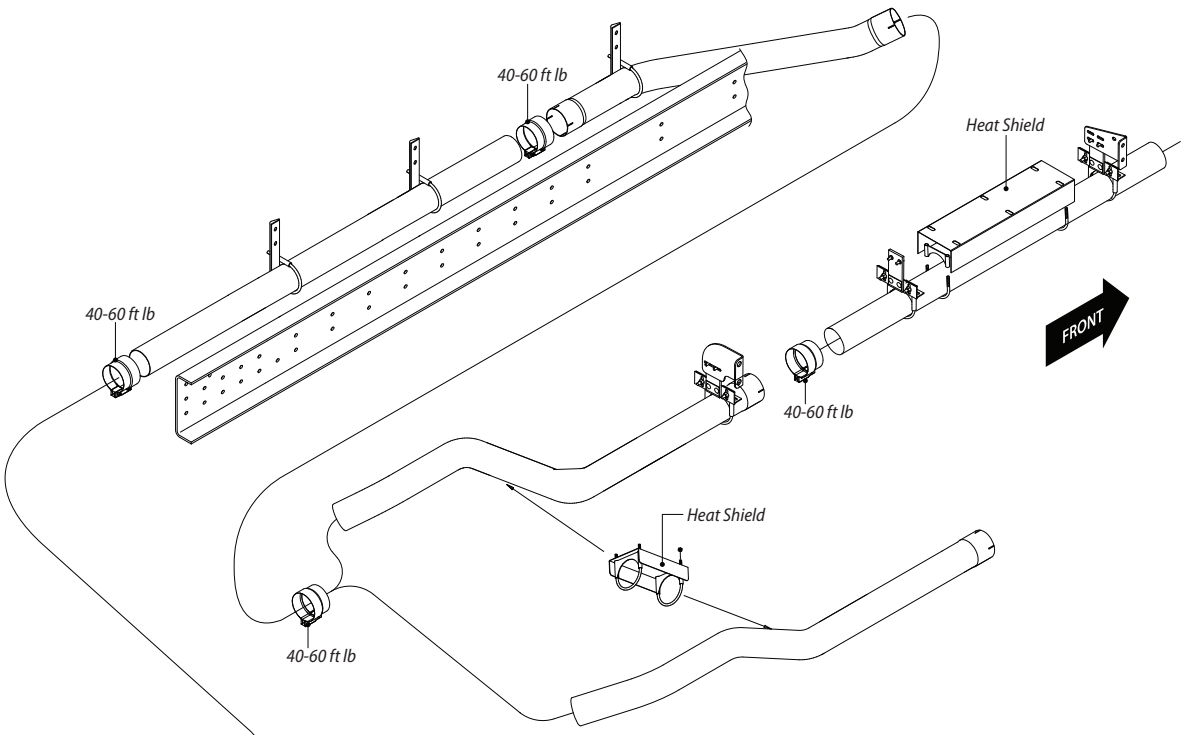
When assembling the exhaust system, start at the forward most section and work toward the rear of the bus. Always use new clamps and hardware.

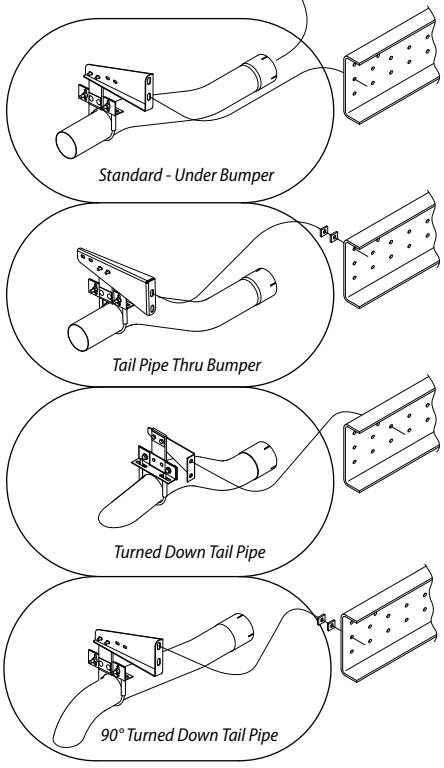
1. Assemble the exhaust pipe to the DPF / muffler. Leave all connectors loose for final adjustment.

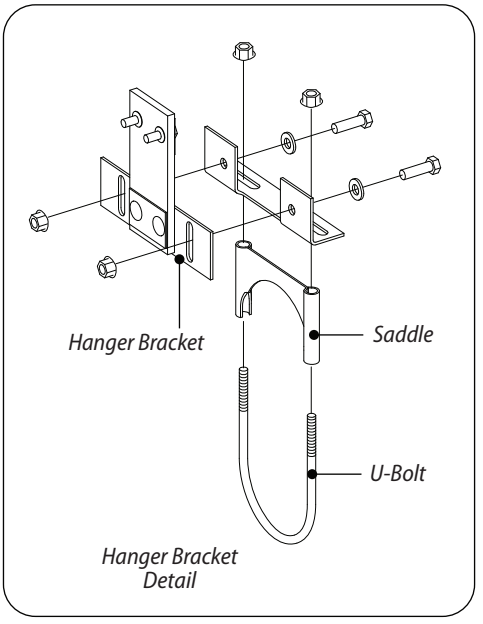
2 Use new wideband clamps and hardware.

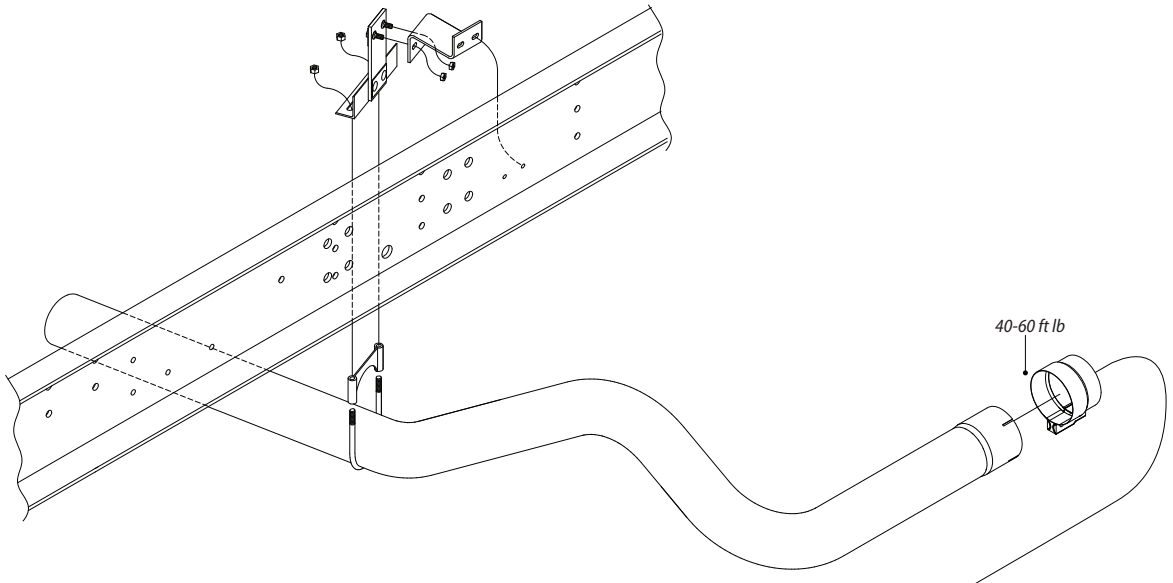
3. Tighten the strap holding the DPF / muffler.

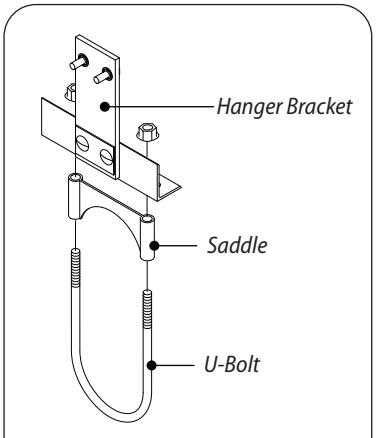
4. Continue working toward the rear of the vehicle. Leave all joints loose until the entire tailpipe assembly is in the correct position, and then tighten all the clamps.


40-60 ft lb
Heat Shield
40-60 ft lb
FRONT
40-60 ft lb
Heat Shield
40-60 ft lb

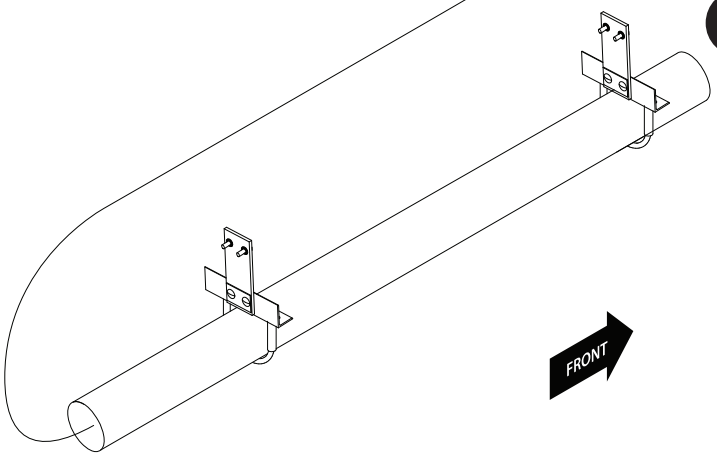

Standard - Under Bumper
Tail Pipe Thru Bumper
Turned Down Tail Pipe
90° Turned Down Tail Pipe


Hanger Bracket
Saddle
U-Bolt
Hanger Bracket Detail





Hanger Bracket Detail



Exhaust Piping