### Exhaust System

#### Section 6A - Exhaust System

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Exhaust System

Special Tools

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<th>Kent-Moore Oxygen Sensor Socket</th>
<th>KN-46577</th>
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<tr>
<td>Kent-Moore socket (or equivalent 7/8 in. automotive oxygen sensor socket)</td>
<td>Aids in the removal and installation of oxygen sensors on products equipped with Emissions Control.</td>
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**Exhaust System**

**Important Information**

**NOTICE**

Improperly designing, installing, or modifying the engine’s exhaust system can introduce seawater or water from condensation into the combustion chambers, damaging the engine. The installing dealer or boat builder is responsible for proper installation of the exhaust system as explained in the installation instructions for the product. Engine damage resulting from water ingestion is not covered by the product warranty, unless the damage is the result of a defective part supplied by the engine manufacturer.

The exhaust system must be installed in accordance with the specifications contained in this section. Special care must be taken as the custom designed exhaust systems used can create a tuning effect that can cause water to be forced back into the engine. The instructions in **Checking for Water Intrusion** must be performed to ensure that water intrusion is not occurring. It is the boat manufacturer's responsibility for ensuring that water intrusion does not exist with their unique exhaust system.

**WARNING**

Installing the exhaust system incorrectly can lead to serious injury or death. When installing or designing exhaust systems, follow all federal, state, and local boating and safety standards for the market in which the boat will be sold.

Exhaust system design and installation can affect:

- Noise level.
- Performance.
- Water Intrusion.
- Carbon monoxide levels.
- Component longevity.

**GLOSSARY**

**Water lift muffler**—A muffler that exhausts above the inlet in order to muffle by lifting a column of water.

**Inline muffler**—A muffler that has an outlet that is parallel and level with the inlet.

**Collector**—A collection device that joins two exhaust banks into a perpendicular chamber without providing any noise reduction.
Carbon Monoxide Poisoning

IMPORTANT: The following important information is covered in the owner's operation, maintenance and warranty manuals. You may also want to include this information in the boat owner's manual.

Carbon monoxide is present in the exhaust fumes of all internal combustion engines including the outboards, sterndrives, and inboard engines that propel boats, as well as the generators that power various boat accessories. Carbon monoxide is a deadly gas that is odorless, colorless, and tasteless.

Early symptoms of carbon monoxide poisoning, which should not be confused with seasickness or intoxication, include headache, dizziness, drowsiness, and nausea.

**WARNING**

Carbon monoxide poisoning can lead to unconsciousness, brain damage, or death. Keep the boat well ventilated while at rest or underway and avoid prolonged exposure to carbon monoxide.

GOOD VENTILATION

Ventilate passenger area, open side curtains, or forward hatches to remove fumes.

1. Example of desired air flow through the boat.

   ![mc79553-1](image)

POOR VENTILATION

Under certain conditions, permanently enclosed or canvas enclosed cabins or cockpits with insufficient ventilation may draw in carbon monoxide. Install 1 or more carbon monoxide detectors in your boat.

Although the occurrence is rare, on a very calm day, swimmers and passengers in an open area of a stationary boat that contains or is near an operating engine may be exposed to a hazardous level of carbon monoxide.

1. Examples of poor ventilation while a boat is stationary:

   ![mc79554-1](image)

   - Operating the engine when the boat is moored in a confined space.
   - Mooring close to another boat with its engine operating.

2. Examples of poor ventilation while a boat is moving:

   ![mc79556-1](image)

   - Operating the boat with the trim angle of the bow too high.
   - Operating the boat with no forward hatches open (station wagon effect).
Exhaust Connections

**NOTICE**

Hot spots in exhaust hoses can damage hoses and cause leaks. Ensure that discharge water from the exhaust elbow flows without restriction through all hoses and fittings.

To avoid hot spots that can burn exhaust hoses, install the exhaust hoses at the angle shown below. Install hoses on exhaust elbow outlets so discharge water from the exhaust elbow flows around the entire inside diameter of the hose.

- **a** - Maximum misalignment +/- 5 degrees
- **b** - Exhaust outlet centerline (14° vs. crankshaft centerline)
- **c** - Exhaust hose centerline
- **d** - Angle vs. horizontal
- **e** - Horizontal (level surface)
8.1 exhaust connection

a - Maximum misalignment +/- 5 degrees
b - Exhaust outlet centerline (14 degrees vs. crankshaft centerline)
c - Exhaust hose centerline
d - See chart for angle vs. horizontal
e - Horizontal (level surface)

IMPORTANT: The exhaust system supplied by Mercury MerCruiser is compliant with the ABYC Standard P-1. If components are used in any portion of the exhaust system that modify the design of the supplied system, it is the boat builder's responsibility to ensure that the new system complies with the ABYC Standards. Exhaust system connections to components other than those supplied by Mercury MerCruiser must use two stainless steel clamps with a minimum width of 13 mm (1/2 in.) at each joint.

Secure all exhaust connections, including those at the exhaust elbow, with two hose clamps. Do not use spring tension clamps.

Exhaust Connections with Emissions Control

NOTICE
Hot spots in exhaust hoses can damage hoses and cause leaks. Ensure that discharge water from the exhaust elbow flows without restriction through all hoses and fittings.
To avoid hot spots that can burn exhaust hoses, install the exhaust hoses at the angle shown below. Install hoses on exhaust elbow outlets so discharge water from the exhaust elbow flows around the entire inside diameter of the hose.

**Correct**

**Incorrect**

**a** - Exhaust outlet centerline  
**b** - Parallel with crankshaft centerline  
**c** - Exhaust angle 14° ± 5°

**IMPORTANT:** The exhaust system supplied by Mercury MerCruiser is compliant with the ABYC Standard P-1. If components are used in any portion of the exhaust system that modify the design of the supplied system, it is the boat builder's responsibility to ensure that the new system complies with the ABYC Standards. Exhaust system connections to components other than those supplied by Mercury MerCruiser must use two stainless steel clamps with a minimum width of 13 mm (1/2 in.) at each joint.

Secure all exhaust connections, including those at the exhaust elbow, with two hose clamps. Do not use spring tension clamps.
Exhaust Through-Hull Fittings

Exhaust fittings (flanges, outlets) must be equipped with an internal shutter and external flapper to prevent water intrusion problems. This is a requirement on all applications except water lift mufflers, where it is still recommended. A variety of fittings is available through Mercury Precision Parts and Accessories.

NOTE: For exhaust accessories, refer to Section 10 — Miscellaneous Accessories.

Exhaust Resonators

The design of the exhaust pipe and muffler system can cause a tuning effect that can contribute to a water intrusion problem. This tuning effect can be caused by a combination of factors, including but not limited to:

- Configuration of the exhaust outlets.
- Design and size of the muffler (if applicable).
- Length of exhaust hoses.
- Amount of back pressure in the system.

The interactive nature of these factors makes it difficult to predict which exhaust system designs will be susceptible to the tuning effect. To address this situation, Mercury MerCruiser has developed exhaust resonators that are installed aft of the exhaust elbow outlets, which help to break up the reverse pulsations without affecting engine performance.

Mercury MerCruiser recommends using resonators on all models that have water present after water intrusion testing, and the exhaust system is confirmed to meet all specifications, as outlined in this manual. Resonators are typically more beneficial for large engines, but can be used on other models. The kit is available through Mercury Precision Parts and Accessories.

Resonators are installed as shown. Because of the critical nature of the placement of the resonator, Mercury MerCruiser will free-license this technology to allow the resonator to be built into your muffler. Contact your product application engineer for details.

The exhaust resonator is positioned with the inside flat surface at the preferred distance of 43 cm (17 in.) from the front edge of the exhaust hose. You can reduce the 43 cm (17 in.) dimension can to a minimum of 33 cm (13 in.), if necessary. This dimension must be the same on both exhaust outlets. The boat builders must test to find the optimum resonator placement for each type of exhaust system.

IMPORTANT: Complete the water intrusion test to ensure that the resonators are installed properly.
FOR PRODUCTS WITHOUT EMISSIONS CONTROL

**Exhaust resonator**

**Exhaust hose**

**Dimension to inside flat surface of resonator 33–43 cm (13–17 in.)**

**No less than 51 mm (2 in.) between resonator and exhaust outlet or closest fitting**

**Hose clamp positioned around center of resonator for retention**

**Exhaust outlet**

**Exhaust elbow**
**FOR PRODUCTS WITH EMISSIONS CONTROL**

- **a** - Exhaust elbow
- **b** - Dimension to inside flat surface of resonator 33–43 cm (13–17 in.)
- **c** - Exhaust resonator
- **d** - Exhaust outlet
- **e** - No less than 51 mm (2 in.) between resonator and exhaust outlet or closest fitting
- **f** - Hose clamp positioned around center of resonator for retention
- **g** - No less than 51 mm (2 in.) between resonator and exhaust outlet or closest fitting

**Emissions Control Systems Overview**

**Combustion**

Combustion is a rapid chemical reaction, called oxidation, in which fuel chemically combines with oxygen to produce heat energy. Among other elements, air contains oxygen and nitrogen, and gasoline contains hydrogen and carbon. These four primary elements combine chemically during combustion to form new chemical compounds.
If combustion were complete, the oxidation of air and gasoline would result in water, carbon dioxide, and nitrogen, which are not harmful to the environment. For combustion to be complete, it needs to occur at a specific air-to-fuel ratio called the stoichiometric ratio (14.7:1 for gasoline). Although this ratio is ideal for reducing hydrocarbons (HC) and carbon monoxide (CO), it is a lean mixture that can be difficult or slow to ignite, reducing engine power and efficiency.

**Emissions**

Since combustion is usually incomplete, not all of the exhaust gases burn, causing emissions. All marine engines must reduce the exhaust emission of certain pollutants and harmful gases to conform with standards legislated by the Environmental Protection Agency (EPA). All engines sold in the state of California must also comply with the standards legislated by the California Air Resources Board (CARB). In accordance with these standards, and in preparation of future standards, Mercury Marine is working to reduce the following: carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NOx).

**CARBON MONOXIDE (CO)**

Carbon monoxide (CO) is a poisonous gas created by incomplete combustion of gasoline. If combustion occurs in an oxygen-deficient environment, the limited amount of oxygen allows only one oxygen (O) atom to bond with a carbon (C) atom, creating CO from partially burned fuel. Richer air-to-fuel ratios create more CO than lean ratios.

**HYDROCARBONS (HC)**

Hydrocarbon (HC) emissions are caused by incomplete combustion of gasoline and other hydrocarbon-based fuels. When gasoline burns, oxidation occurs; however, some hydrocarbons do not oxidize. Lower engine temperatures make it harder for the hydrocarbons to oxidize. Therefore, some hydrogen and carbon atoms remain bonded and pass through the exhaust system as HC gases from unburned fuel.

**OXIDES OF NITROGEN (NOx)**

Oxides of nitrogen (NOx) is a generic term for a group of chemical compounds that contain nitrogen (N) and oxygen (O) in varying amounts (x). NOx is created by overheated hydrogen and oxygen. At extremely high temperatures, N atoms can combine with O atoms to create NOx. Unlike CO and HC, which form when combustion temperatures are too low, NOx forms when combustion temperatures are too high. NOx itself is not harmful. However, when exposed to sunlight, NOx combines with unburned hydrocarbons to create the visible air pollutant called smog.

**Controlling Emissions With Catalysts**

**CATALYST COMPONENTS**

A catalyst, or catalytic converter, is a device installed into the engine's exhaust system that reduces the toxicity of emissions. Mercury MerCruiser engines use three-way catalysts with the following components:

- **Substrate**—The substrate is a metallic foil core that provides a large surface area for the washcoat.
- **Washcoat**—The washcoat is applied to the substrate to act as a carrier for the catalyst. This washcoat creates an irregular, porous surface, providing more surface area for the precious metal of the catalyst.
- **Catalyst**—The catalyst is a combination of precious metals applied to the porous structure of the washcoat. The heated chemical reaction of exhaust gases and precious metals of the catalyst reduce emissions. This catalyst assembly is then housed in the mantle.
• Mantle—The mantle is the tube that contains the catalyst. The mantle is installed in the engine's exhaust manifold housing.
• Oxygen sensors—Multiple oxygen sensors transmit emissions data to the propulsion control module (PCM) to control emissions.
• Propulsion control module (PCM)—Models with Emissions Control use a PCM09 controller to manage fuel delivery to the engine and maintain CARB emissions standards.

CATALYST OPERATION
Mercury MerCruiser's engines with Emissions Control meet the CARB requirements for exhaust emissions levels effective January 2008 in the state of California. These engines feature three-way catalysts, which use a combination of platinum, palladium, and rhodium to convert harmful emissions to safe levels. A three-way catalyst reduces emissions in the following ways:
• It reduces nitrogen oxides to nitrogen and oxygen ($2\text{NO}_x \rightarrow x\text{O}_2 + \text{N}_2$).
• It oxidizes carbon monoxide into carbon dioxide ($2\text{CO} + \text{O}_2 \rightarrow \text{CO}_2$).
• It oxidizes unburnt hydrocarbons to carbon dioxide and water ($\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$).
Oxygen Sensors

The Vazer 100 and 3.0 MPI have one catalyst and two oxygen sensors. All others have two catalysts and four oxygen sensors. The oxygen sensors send oxygen information to the PCM before and after the catalysts in the exhaust system. This dual-sensor system provides a closed-loop monitoring system, ensuring required air-to-fuel ratios and emissions.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Action</th>
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<tbody>
<tr>
<td>1</td>
<td>PCM calculates air-fuel ratio.</td>
</tr>
<tr>
<td>2</td>
<td>Fuel system delivers the required air/fuel ratio to the combustion chamber.</td>
</tr>
<tr>
<td>3</td>
<td>Combustion occurs (power stroke).</td>
</tr>
<tr>
<td>4</td>
<td>Exhaust gases enter the exhaust manifold (exhaust stroke).</td>
</tr>
<tr>
<td>5</td>
<td>The first oxygen sensor sends a signal to the PCM, delivering pre-catalyst oxygen information.</td>
</tr>
<tr>
<td>6</td>
<td>The exhaust gases pass through the catalyst. Catalyst reactions oxidize hydrocarbons (HC) and carbon monoxide (CO) and reduce oxides of nitrogen (NOx).</td>
</tr>
<tr>
<td>7</td>
<td>The second oxygen sensor sends a signal to the PCM, delivering post-catalyst oxygen information.</td>
</tr>
</tbody>
</table>

**NOTE:** Each oxygen sensor is protected by a 5 amp fuse.

**NOTE:** Mercury MerCruiser engines do not depend on closed-loop control to calculate air-f-to-fuel ratios at all times. During some operating situations, closed-loop control is off, and the PCM relies on its default programming to make these calculations.

Kent-Moore Oxygen Sensor Socket | KN-46577