

# EXHAUST SYSTEM

1747-01/2423-00/2423-02/2423-03/2423-04/2423-05/

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## EXHAUST SYSTEM

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# دیجیتال خودرو

شرکت دیجیتال خودرو سامانه (مسئولیت محدود)

اولین سامانه دیجیتال تعمیرکاران خودرو در ایران



**EXHAUST SYSTEM****1747-01****GENERAL INFORMATION****1. SPECIFICATIONS**

Category	Specifications	Remarks
Exhaust manifold type	Integrated with MCC (4-2-1 type)	-
Catalyst	MCC+UCC	
Exhaust muffler	Front exhaust pipe + Center muffler + Rear muffler	

**Ultra low emission vehicle in compliance with enhanced emissions standards**

KULEV is an emission control regulation.

- Regulated emissions are carbon monoxide (CO), hydrocarbon (HC) and nitrogen oxides (NOx) at higher level compared with the previous regulation (KLEV).

Item	Application time point	Regulation limit (g/km) - based on manufactured vehicle		
		HC	CO	NOx
KULEV	2006	0.034	1.31	0.044

**2. PRECAUTIONS**

- Do not park the vehicle on flammable materials, such as grass, leaves and carpet.
- Do not touch the catalyst or the exhaust gas ignition system when the engine is running.
- If a misfire occurs in the combustion chamber or the emissions of pollutant exceeds the specified level, the catalyst can be damaged.
- When servicing or replacing components of the exhaust system, make sure that the components have certain spaces from all other parts of the under body.
- Be careful not to damage the exhaust system when lifting the vehicle from its side.
- All components and body parts of the engine exhaust system should be inspected for cracks, damage, air hole, part loss and incorrect mounting locations. Also check for any deformation which can result in exhaust gas drawn into the vehicle.
- Make sure that the exhaust pipe has been cooled down sufficiently before working because it is very hot right after the engine has been stopped.
- Wear protective gloves when removing the exhaust pipe.

Modification basis	
Application basis	
Approval basis	

EXHAUST SYSTEM

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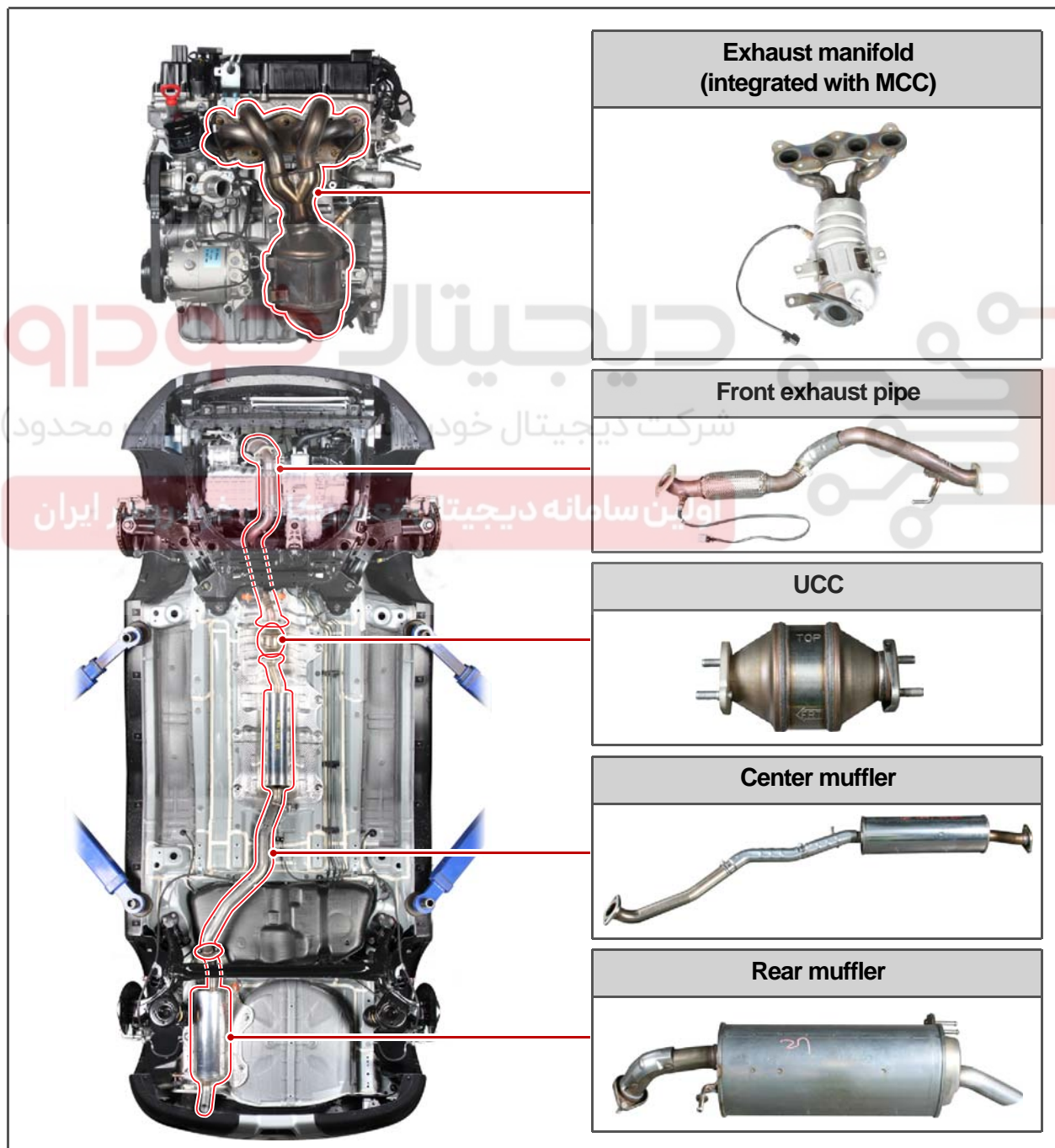
## OVERVIEW AND OPERATING PROCESS

### 1. OVERVIEW

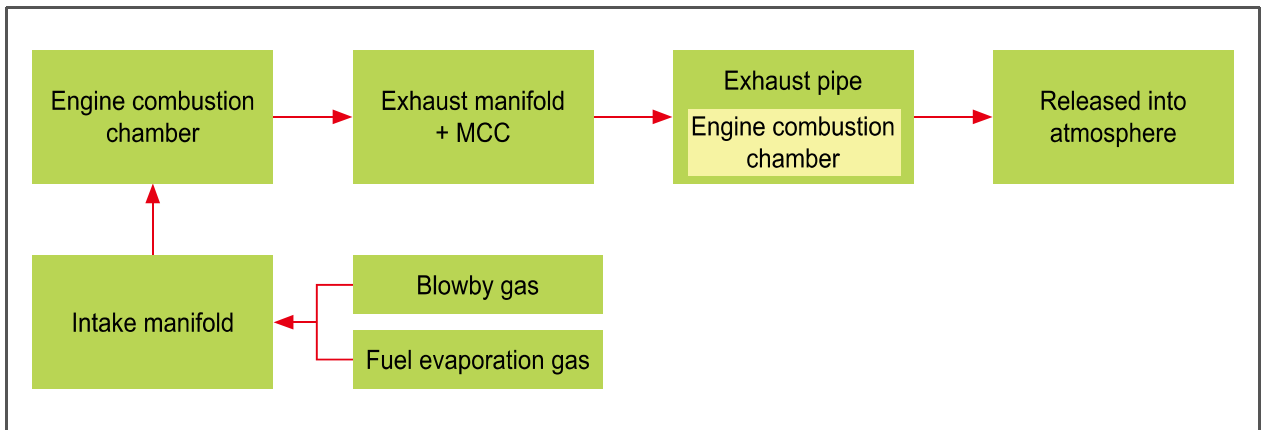
This system purifies the exhaust gas generated by the combustion in the engine to reduce the pollutants and noise during that arise during combustion.

Harmful materials produced in the combustion process are treated and reduced in the exhaust system to reduce emission levels.

### 2. COMPONENTS



### 3. SYSTEM DIAGRAM



#### ► Hazardous emissions

a. In relation to stoichiometric air-fuel-ratio

Category	Lean	Slightly lean	Rich
Emissions	Increased HC	Increased NOx	Increased CO, HC
	Reduced CO, NOx	Reduced CO, HC	Reduced NOx

b. In relation to engine temperature

Category	Low temperature	High temperature
Emissions	Increased CO, HC	Increased NOx
	Reduced NOx	Reduced CO, HC

c. In relation to driving conditions

Category	Idling	Accelerating	Decelerating
Emissions	Increased CO, HC	Increased CO, HC, NOx	Increased CO, HC
	Reduced NOx	-	Reduced NOx

Modification basis	
Application basis	
Effective date	



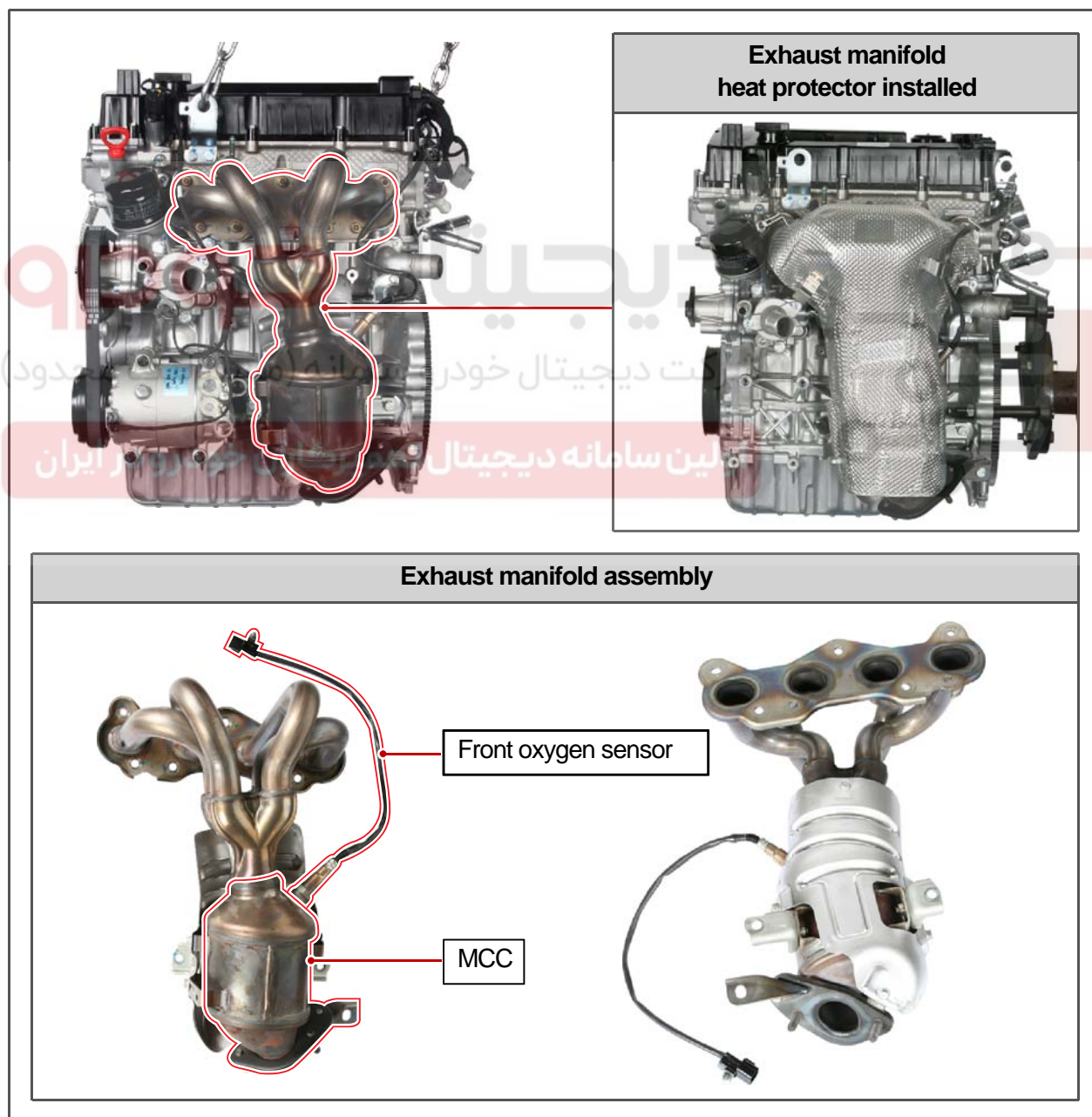
## CONFIGURATION AND FUNCTIONS

### 1747-01 EXHAUST MANIFOLD ASSEMBLY

#### 1) Overview

The exhaust manifold assembly is integrated with manifold catalytic converter (MCC). It is connected to the cylinder and delivers high temperature, high-pressure vapor generated from the engine to the MCC. The pulsation and inertia effects of the exhaust manifold are taken into consideration in the 4-2-1 type runner design.

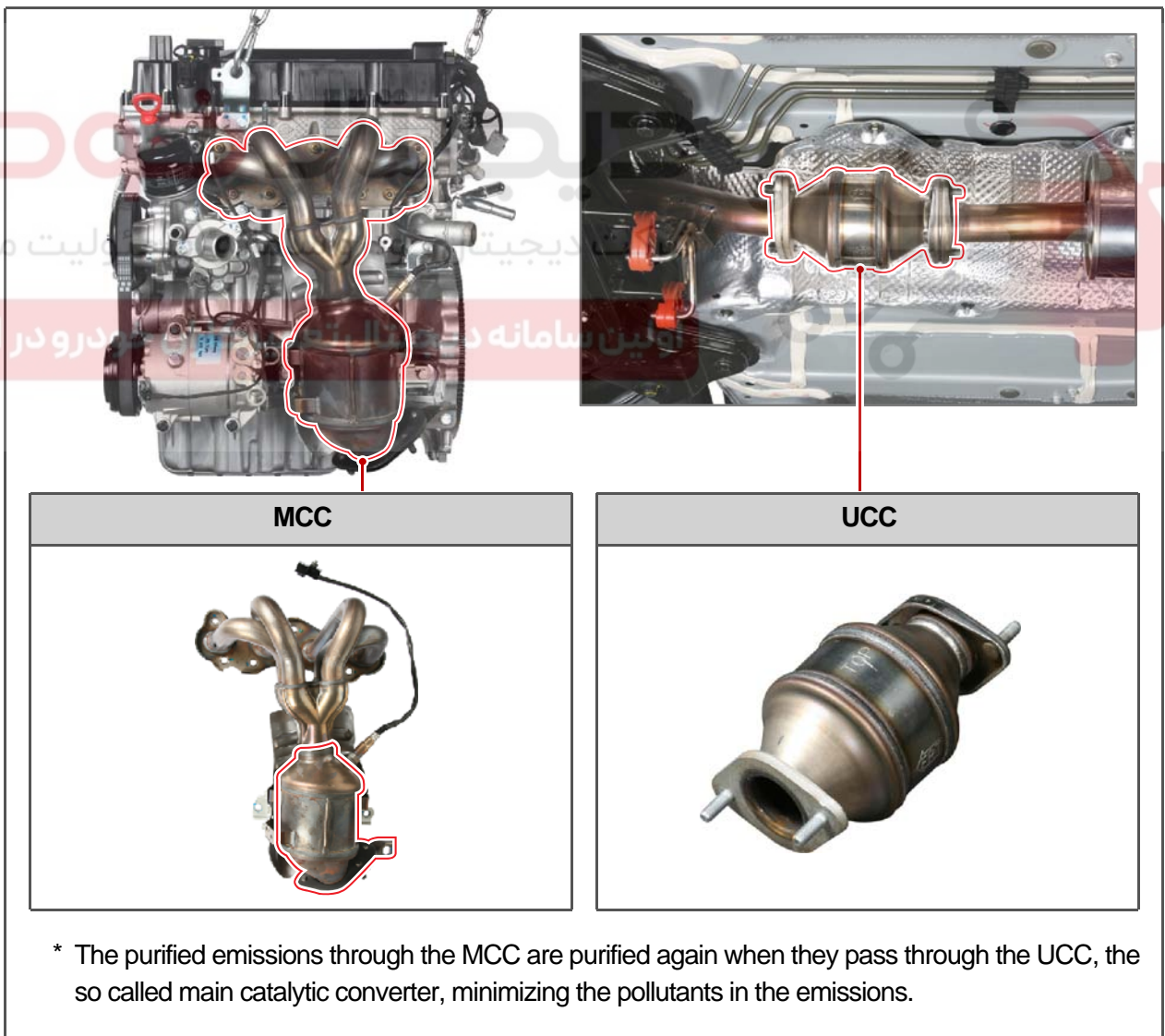
#### 2) Mounting Location and Components



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**2423-03 CATALYTIC CONVERTER****1) Overview**

Manifold catalytic converter (MCC) and underfloor catalytic converter (UCC) are installed to the system in accordance with Korea ultra low emission vehicle (KULEV) & OBD(EU6) to convert hazardous substances in the emissions such as CO, HC, NOx to into harmless substances. KULEV is legislation regarding ultra low emission vehicles in compliance with enhanced emissions standards. In general, one catalytic converter is installed to the bottom of the vehicle floor. But this system has an additional catalytic converter. To distinguish between the 2 catalytic converters, each catalytic converter name includes the location information. Normal operating temperature of catalytic converter is 400 to 800°C. The MCC reaches to this temperature and begins to function faster than the UCC does, because the MCC is adjacent to the exhaust manifold.

**2) Mounting Location and Components**

\* The purified emissions through the MCC are purified again when they pass through the UCC, the so called main catalytic converter, minimizing the pollutants in the emissions.

Modification basis	
Application basis	
Approval basis	

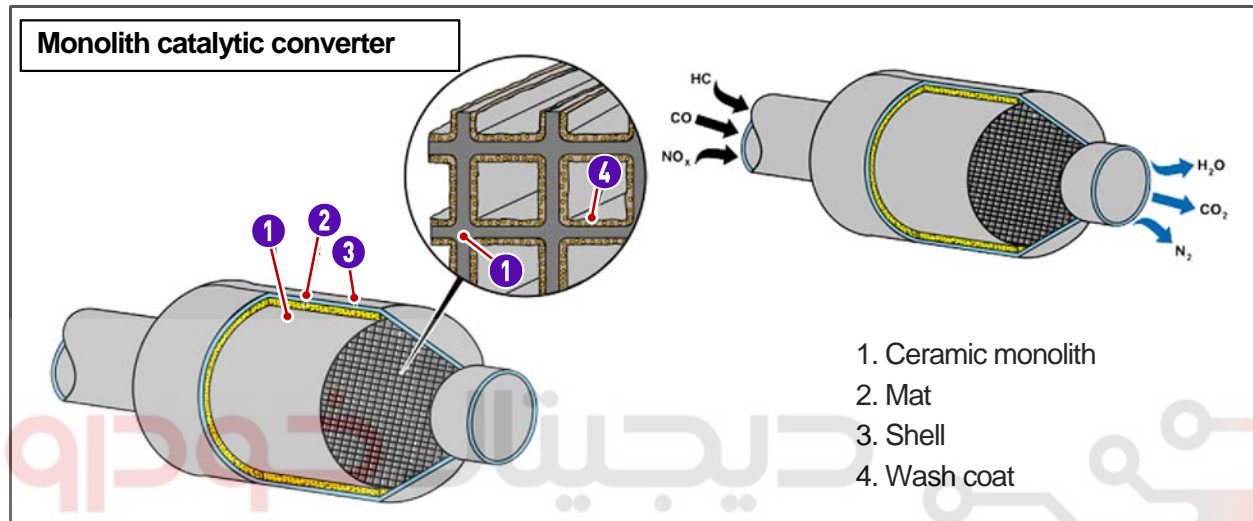
EXHAUST SYSTEM

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### 3) Configuration

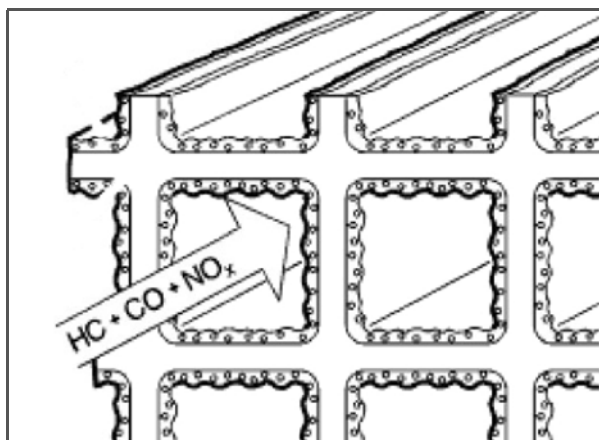
#### ► Monolith catalytic converter

The monolith catalytic converter consists of 2 metal substrates which is made of Cordierite. The main component of the converter is alumina or oxidized serum which is applied to ceramic monolith. The wash coat is applied to the ceramic body and then the catalytic metal substances (Pt, Pd, Rh) are applied to the wash coat. The weight of monolith type is lighter than that of other types. This type of converter is easy to manufacture and quickly reaches to the operating temperature.



The wash coat is to make a contact surface with exhaust gas bigger than its original by adhering closely to the fine holes of inner layer. If a lead compound or phosphorus adheres to the surface or the temperature rises, the surface area will be decreased. In general, alumina ( $Al_2O_3$ ) is used as a raw material and its 7 transitional phases including gamma-, delta-, theta-alumina features big surface area and high stability for the temperature. Nowadays gamma-alumina is typically used.

#### ► Monolith catalytic converter



##### A. Internal

- Substrate (basis): basic structure to maintain exhaust gas flow
- Middle layer: has approx. 700 small holes on the surface of substrate
- Catalyst: Pt, Rh, Pd
  - Pt: oxidation catalyst for HC and CO
  - Rh: reduction reaction catalyst for NOx

B. Mat: assembled between substrate and CAN to seal and secure substrate.

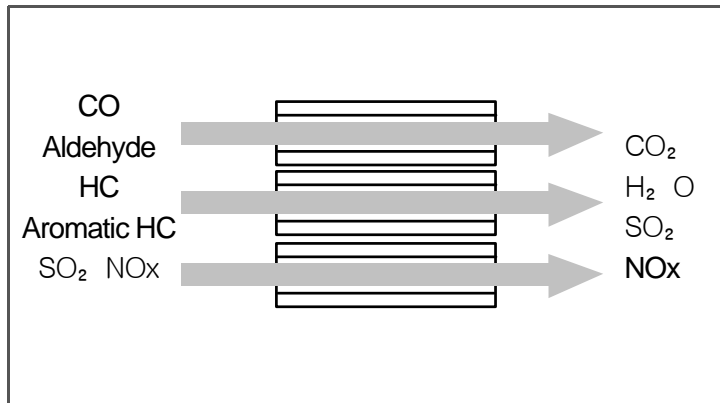
C. CAN: a container (houses substrate and mat)



## 4) Functions

### ► Purification

The 3-way catalyst reduces CO and HC by oxidation reaction and NOx by reduction reaction as follows:



- Oxidization reaction of CO  

$$\text{CO} + 1/2\text{O}_2 \leftrightarrow \text{CO}_2$$

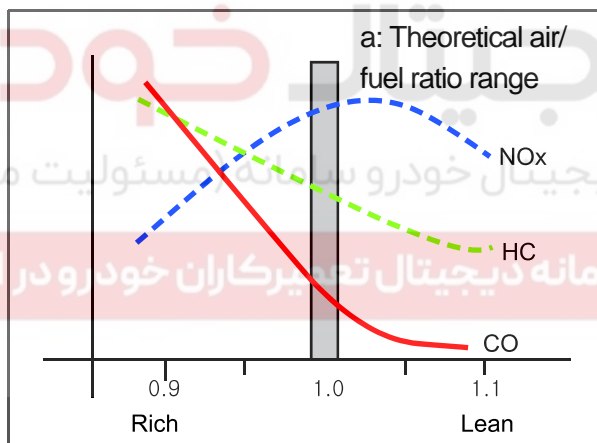
$$\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{CO}_2 + \text{H}_2$$
- Oxidization reaction of HC  

$$\text{HnCm} + 2m\text{H}_2\text{O} \leftrightarrow m\text{CO}_2 + (n/2 + 2m)\text{H}_2\text{O}$$
- Reduction reaction of NOx  

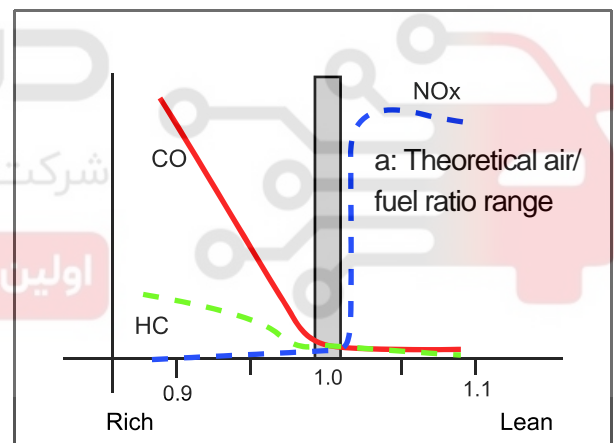
$$\text{NOx} + \text{CO} \leftrightarrow 1/2\text{N}_2 + \text{CO}_2$$

$$\text{NOx} + \text{H}_2 \leftrightarrow 1/2\text{N}_2 + \text{H}_2\text{O}$$

### ► Catalytic converter in relation to air-fuel ratio



<A: Characteristic of exhaust gas without 3-way catalyst>



<B: Characteristic of exhaust gas with 3-way catalyst>

$\lambda$  indicates fuel/air mixture ratio.

$\lambda < 1$ : rich mixture ratio,  $\lambda > 1$ : lean mixture ratio

$\lambda = 1$ : perfect combustion ( $\lambda = 1$  indicates mass ratio for air/fuel ratio of 14.7:1)

The graph A shows characteristics of exhaust gas when the catalyst is not operated, while the graph B shows characteristics when the catalyst is operated. As shown in the graph A, lean air/fuel ratio leads to excessive oxygen in the exhaust gas. CO and HC react to  $\text{O}_2$  and are purified as they are changed into  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . On the other hand, NOx does not react to  $\text{O}_2$  due to lack of its oxidizability and is discharged as it is. Also, NOx does not react if the exhaust gas temperature is low. On the other hand,  $\text{O}_2$  is decreased and CO and HC are increased if the mixture ratio is rich. In this case, NOx is reduced to  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and  $\text{N}_2$ , and HC and CO are discharged as they are.

Modification basis	
Application basis	
Effectiveness	

In the graph B, the theoretical air/fuel ratio should be maintained since oxidization and reduction occur in another section. Consequently, combustion should be performed at the theoretical air/fuel ratio (14.7:1) to obtain maximum effect of the 3-way catalyst. Also,  $O_2$  is decisive of purification rate of hazardous materials and it is determined by air/fuel ratio feedback control of the oxygen sensor.

Category	Lean	Rich
Amount of $O_2$	Abundant	Insufficient
HC/CO	HC and CO are oxidized	NOx reduction takes place

#### ► Catalytic converter in relation to temperature

Normal operating temperature is critical to the catalytic converter like the oxygen sensor. The catalytic converter cannot perform its function until its temperature reaches approx. 250°C. Therefore, when the cold engine is started, the engine ECU controls the ignition timing and idling speed so that the catalytic converter can reach its normal operating temperature quickly.

The ideal temperature for the 3-way catalyst converter is 400 to 800°C. In this temperature range, purification rate of the exhaust gas is maximized and service life of the converter is extended.

If engine disorder, such as misfire, occurs, the converter may be overheated over 1,400°C and the ceramic substrate can be damaged due to thermal aging, resulting in no effect of the catalytic converter.

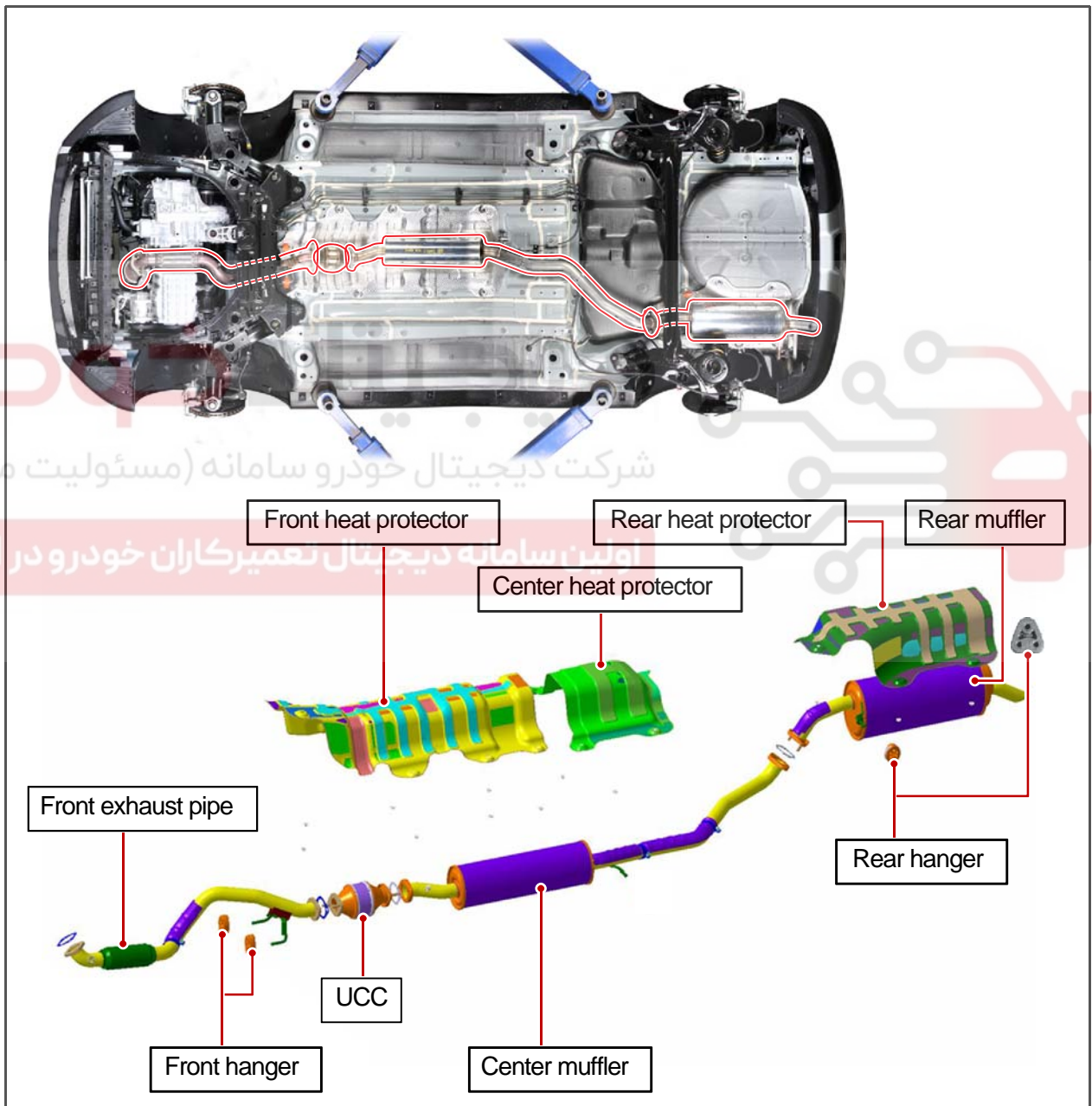
Consequently, unleaded gasoline should be used, and the factors which can overheat the catalytic converter, such as abrupt acceleration at idling and misfire, should be avoided to extend the service life of the catalytic converter and enhance its purification performance.

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**2423-00 EXHAUST MUFFLER ASSEMBLY****1) Overview**

The exhaust muffler suppresses the negative pressure and sound waves of exhaust gases passing the silencer before they are emitted into the air.

**2) Mounting Location and Components**

Modification basis	
Application basis	
Approval	

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#### ► Front exhaust pipe

- Protects the exhaust system from being deformed because of the relative movements between the engine and the exhaust system. It also absorbs and dampens the vibration energy.
- Prevents the deformation of the exhaust system caused by vibration on a rough road.
- Compensates the thermal expansion and shrinkage of the exhaust system.



#### ► Center muffler

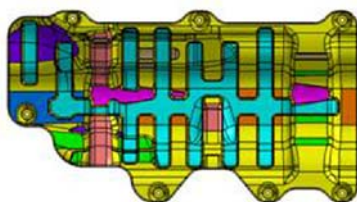
- The major function of this muffler is to reduce the noise, but it also functions as an auxiliary subunit of the primary silencer. The difference between these two silencers is the size. There are three types of sub silencer based on the internal structure: Expansion type, Resonator type or Absorption type.



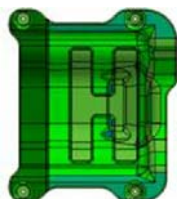
#### ► Rear muffler

- Reduces most of the noise and cools down the hot exhaust gas.

Front heat protector



Center heat protector



Rear heat protector



Front exhaust pipe hanger mounting



Rear muffler hanger mounting



## ► Heat protector

- Prevents the heat in the exhaust system from being transferred to the vehicle body.

## ► Hanger mounting

- A way to mount the exhaust system to the vehicle body. It also minimizes the vibration transmitted to the interior of the vehicle.

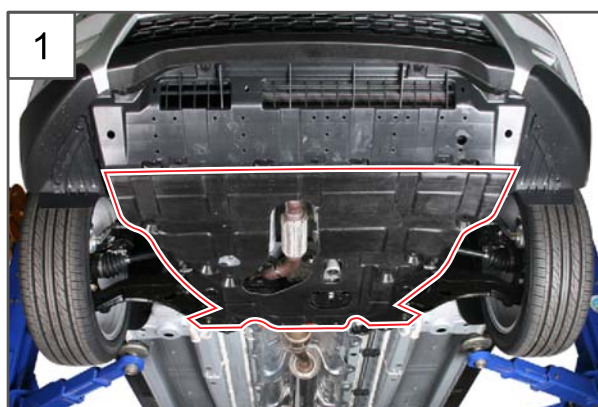
Modification basis	
Application basis	
Approval basis	



## REMOVAL AND INSTALLATION

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## 1747-01 EXHAUST MANIFOLD ASSEMBLY

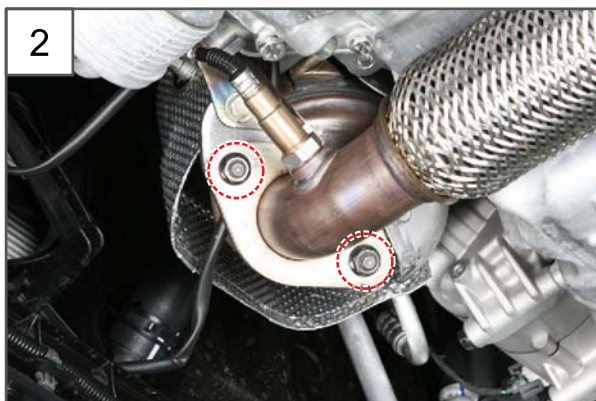


1. Remove the rear under cover under the vehicle.

**Tightening torque 13.8 to 17.6 Nm****CAUTION**

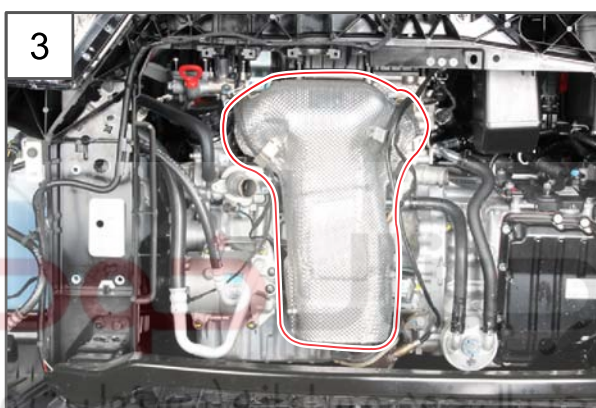
Tighten the mounting bolt to the specified torque. Excessive tightening torque can cause damage to the rear under cover.

Modification basis	
Application basis	
Affected VIN	021 62 99 92 92



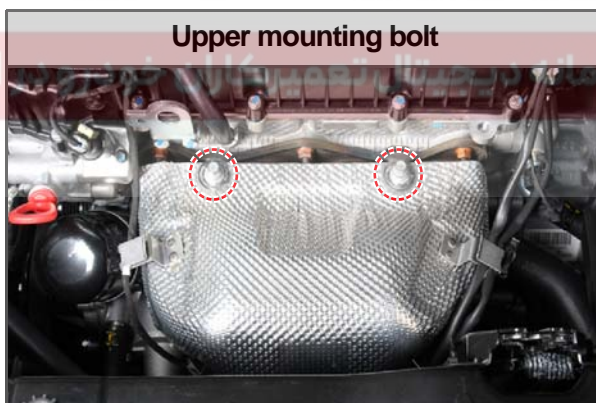
2. Unscrew the 2 mounting bolts (14 mm) securing the exhaust manifold and front exhaust pipe.

**Tightening torque** 34 to 37 Nm

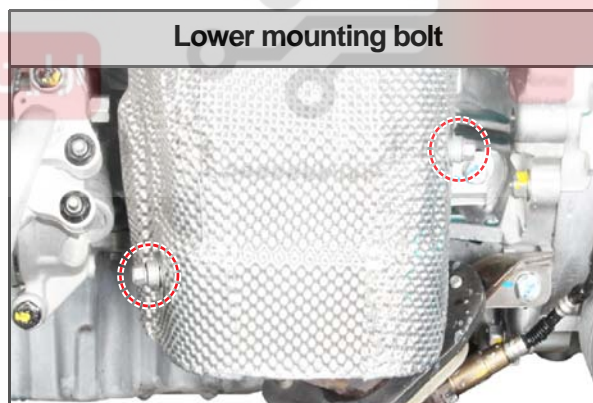


3. Unscrew the 4 mounting bolts (10 mm) for the exhaust manifold heat protector.

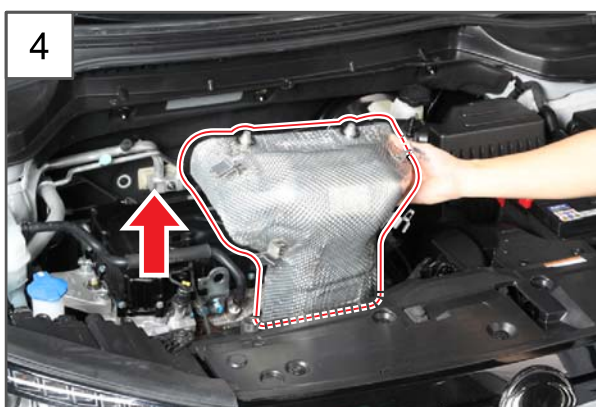
**Tightening torque**  $10 \pm 1.0$  Nm



Upper mounting bolt



Lower mounting bolt



4. Remove the exhaust manifold heat protector.

Modification basis	
Application basis	
Approval basis	

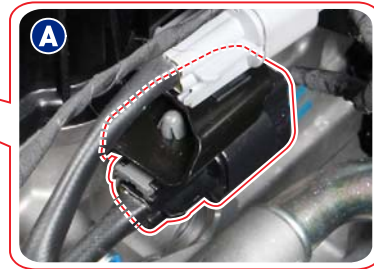
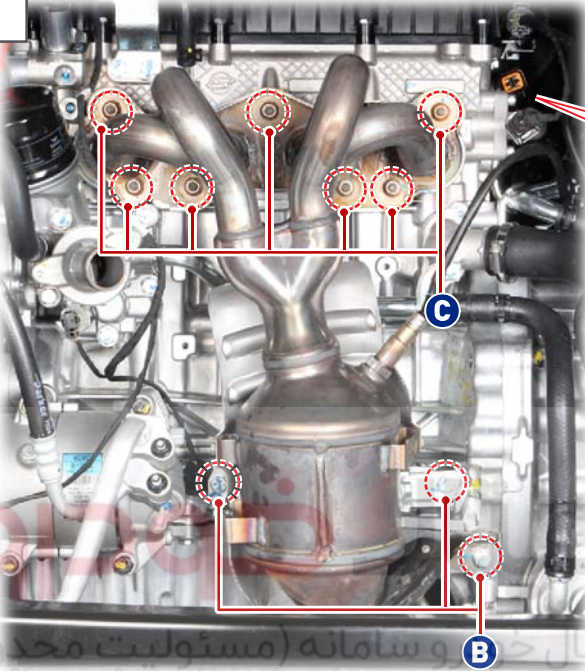
EXHAUST SYSTEM

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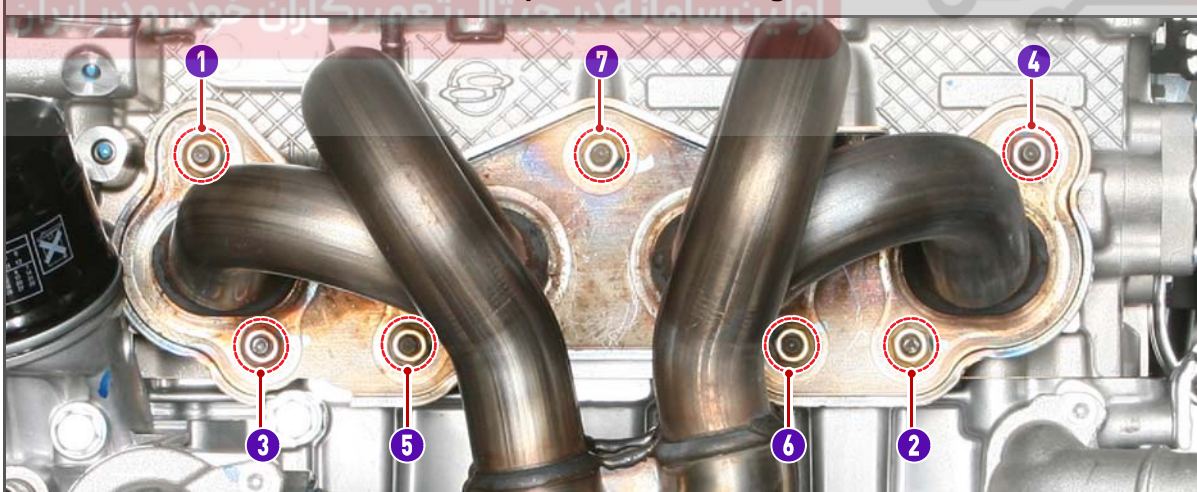
5. Disconnect the front oxygen sensor connector (A) and unscrew the 3 mounting bolts (B, 13 mm) for the exhaust manifold bracket and 7 mounting nuts (C, 12 mm) for the exhaust manifold in the sequence specified below.

5



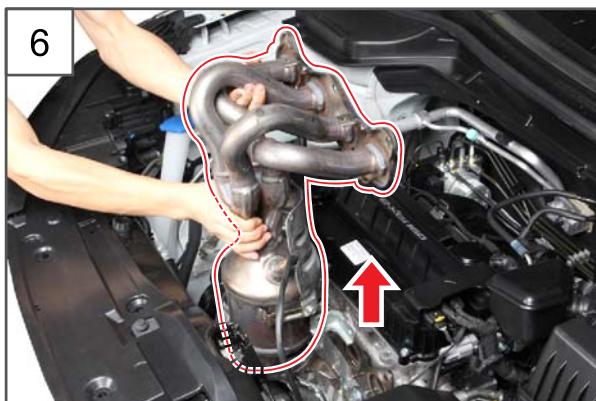
**Tightening torque** (B)  $25 \pm 2.5$  Nm  
(C)  $40 \pm 5.0$  Nm

#### Removal sequence for mounting nuts



#### ⚠ CAUTION

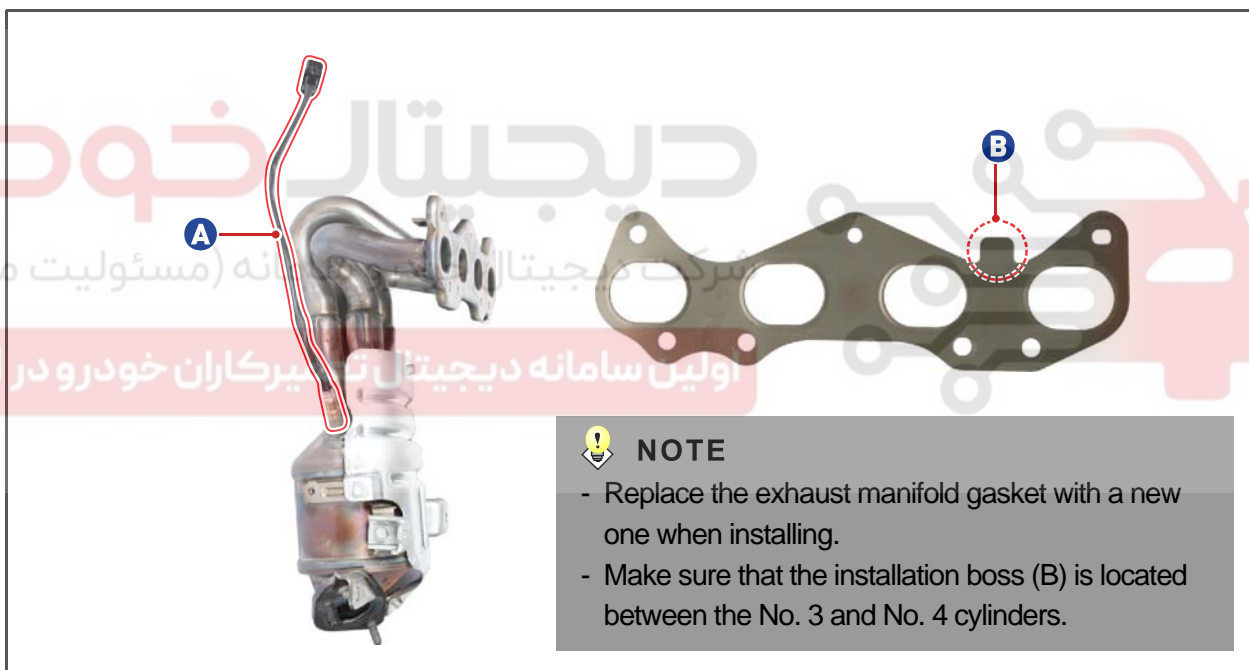
- Unscrew the mounting nuts slowly in two or more stages to prevent distortion of the exhaust manifold and cylinder head.
- Replace the mounting nuts with new ones when installing the exhaust manifold. Tighten the nuts in the reverse of unscrewing.



6. Remove the exhaust manifold assembly.

7. Remove the front oxygen sensor (A) from the removed exhaust manifold assembly.

8. Install in the reverse order of removal.



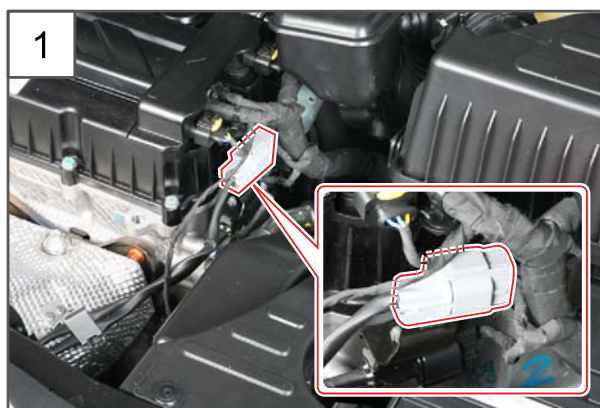
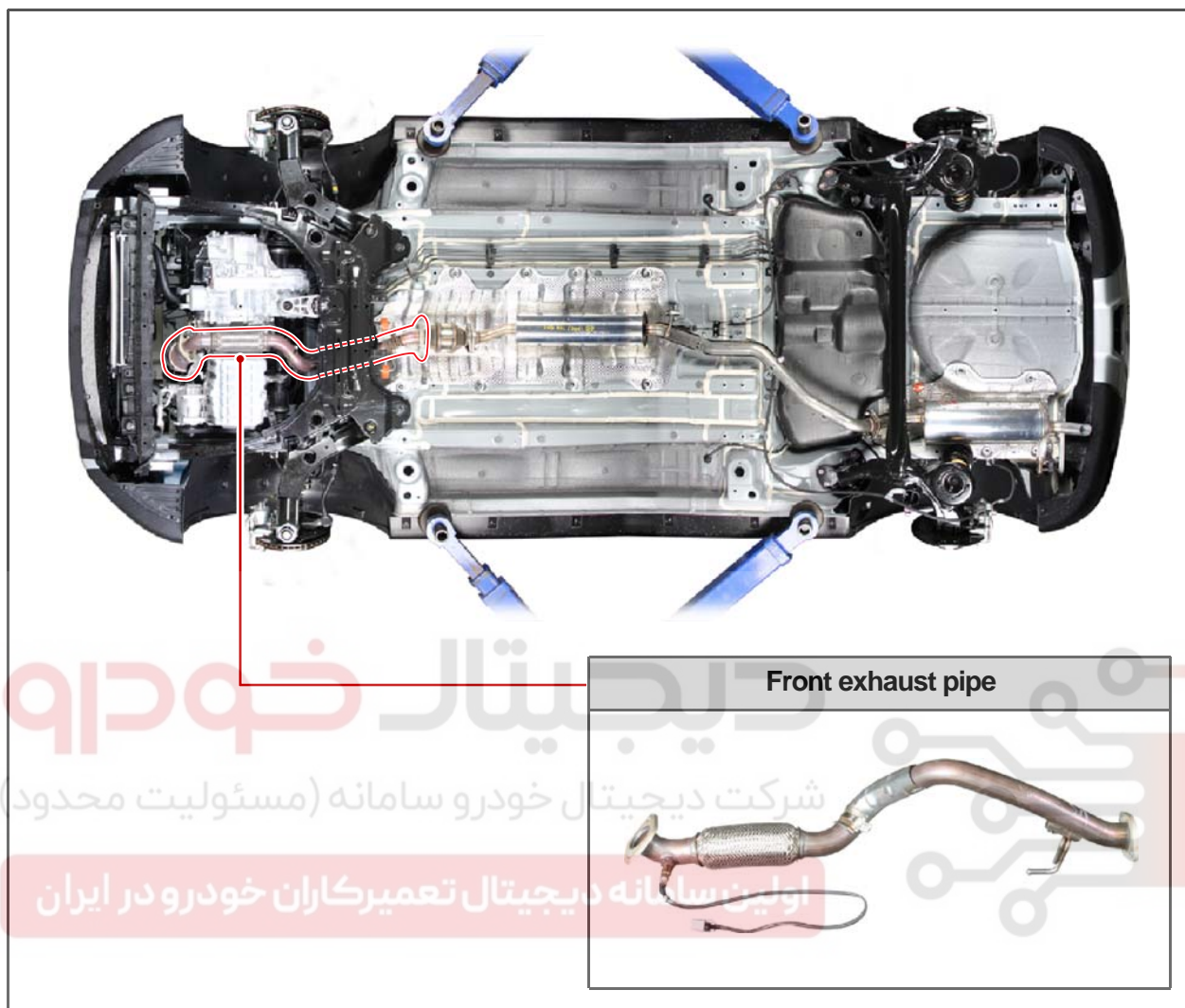
Modification basis	
Application basis	
Approved by	

EXHAUST SYSTEM

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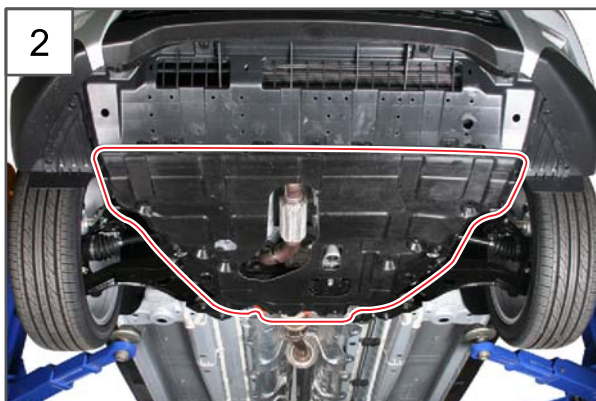
S.G.N.

## 2423-02 FRONT EXHAUST PIPE



1. Disconnect the rear oxygen sensor connector in the engine compartment.





2. Remove the rear under cover under the vehicle.

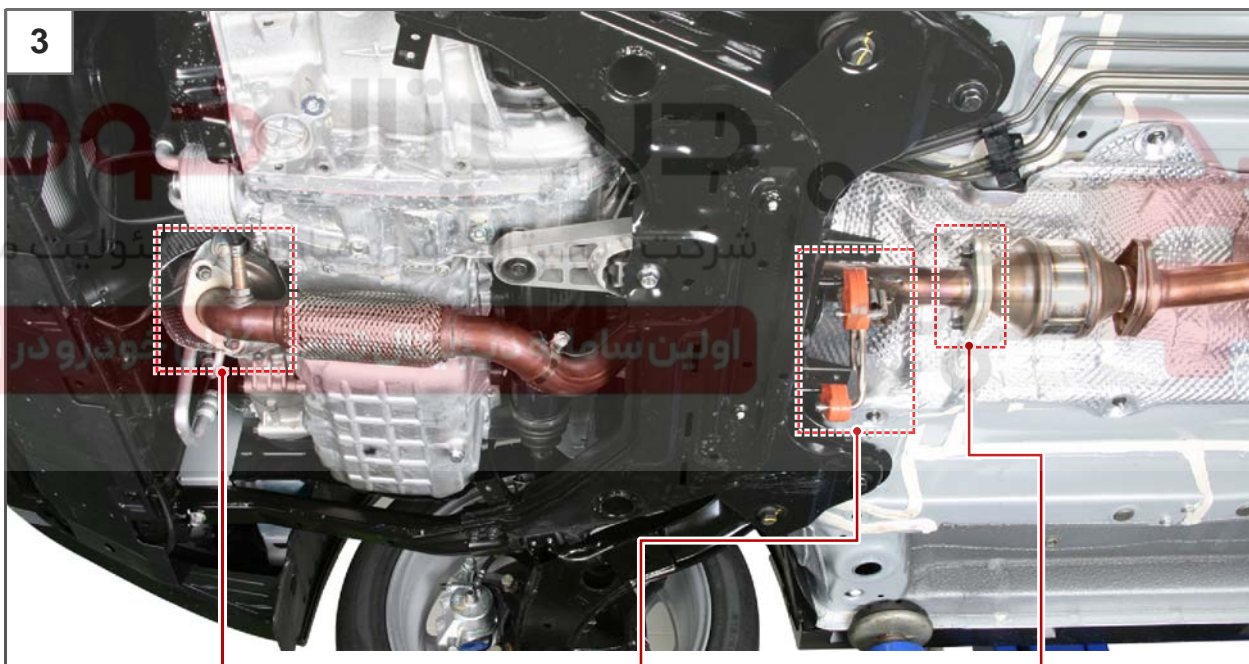
**Tightening torque** 13.8 to 17.6 Nm

**CAUTION**

Tighten the mounting bolt to the specified torque. Excessive tightening torque can cause damage to the rear under cover.

3. Unscrew the mounting bolts for the front exhaust pipe to remove the hanger mountings.

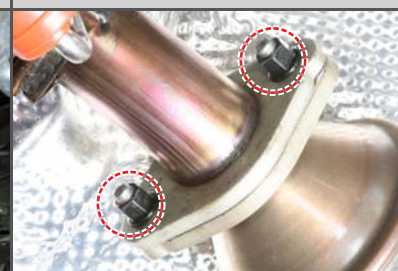
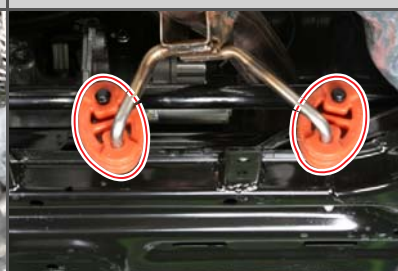
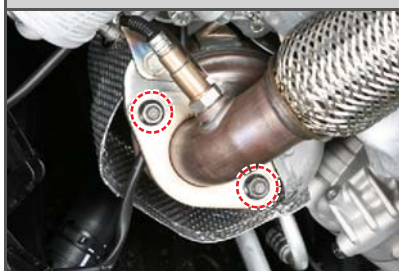
**Tightening torque** 34 to 37 Nm



**Mounting bolts  
securing exhaust  
manifold(14 mm, 2 off)**

**Front exhaust pipe  
hanger mounting**

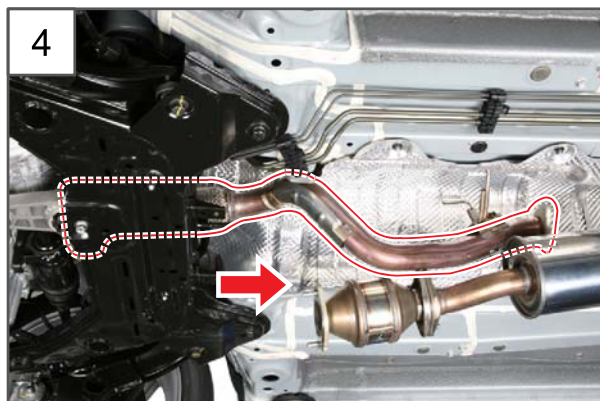
**Mounting bolts  
securing UCC  
(14 mm, 2 off)**



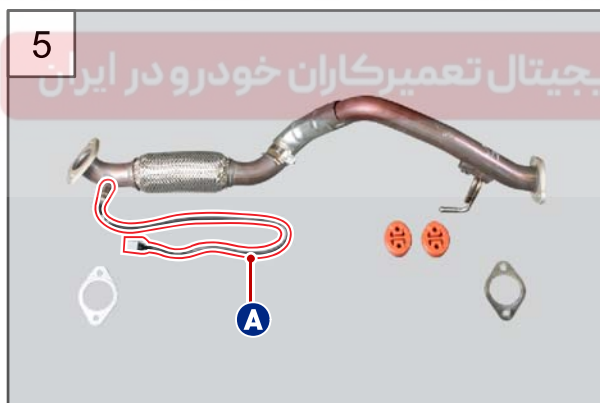
Modification basis	
Application basis	
Effective date	

EXHAUST SYSTEM

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4. Remove the front exhaust pipe in the direction shown in the picture (to the rear side of the front subframe).



5. Remove the rear oxygen sensor (A) from the removed front exhaust pipe.  
6. Install in the reverse order of removal.



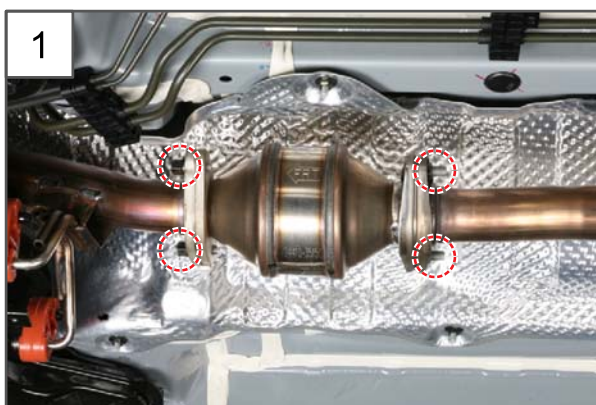
Replace the exhaust pipe gasket with a new one.



S.G.N.

2423-03

## UNDERFLOOR CATALYTIC CONVERTER



1. Unscrew the 4 UCC mounting bolts (14 mm).

**Tightening torque 34 to 37 Nm**

Modification basis	
Application basis	
Accessories	

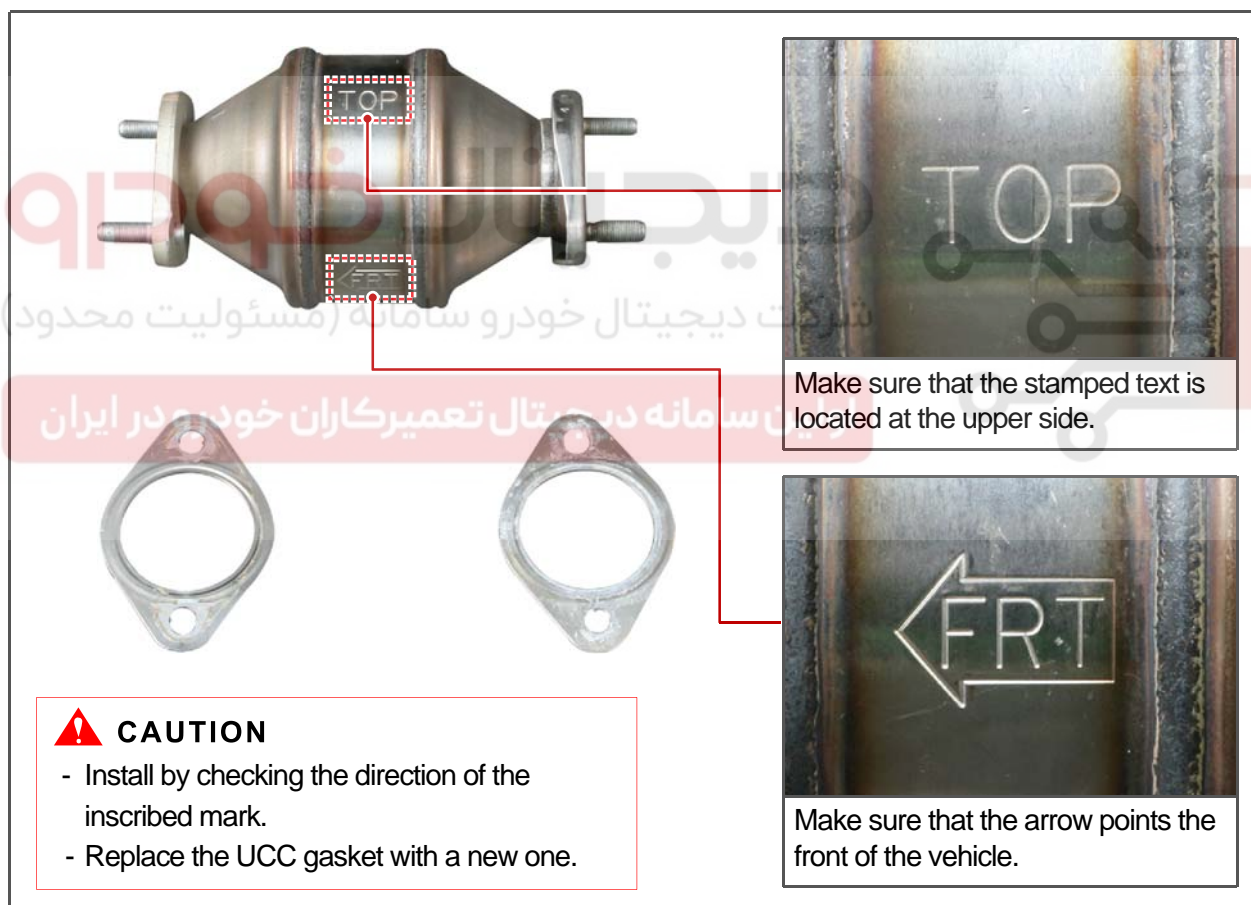
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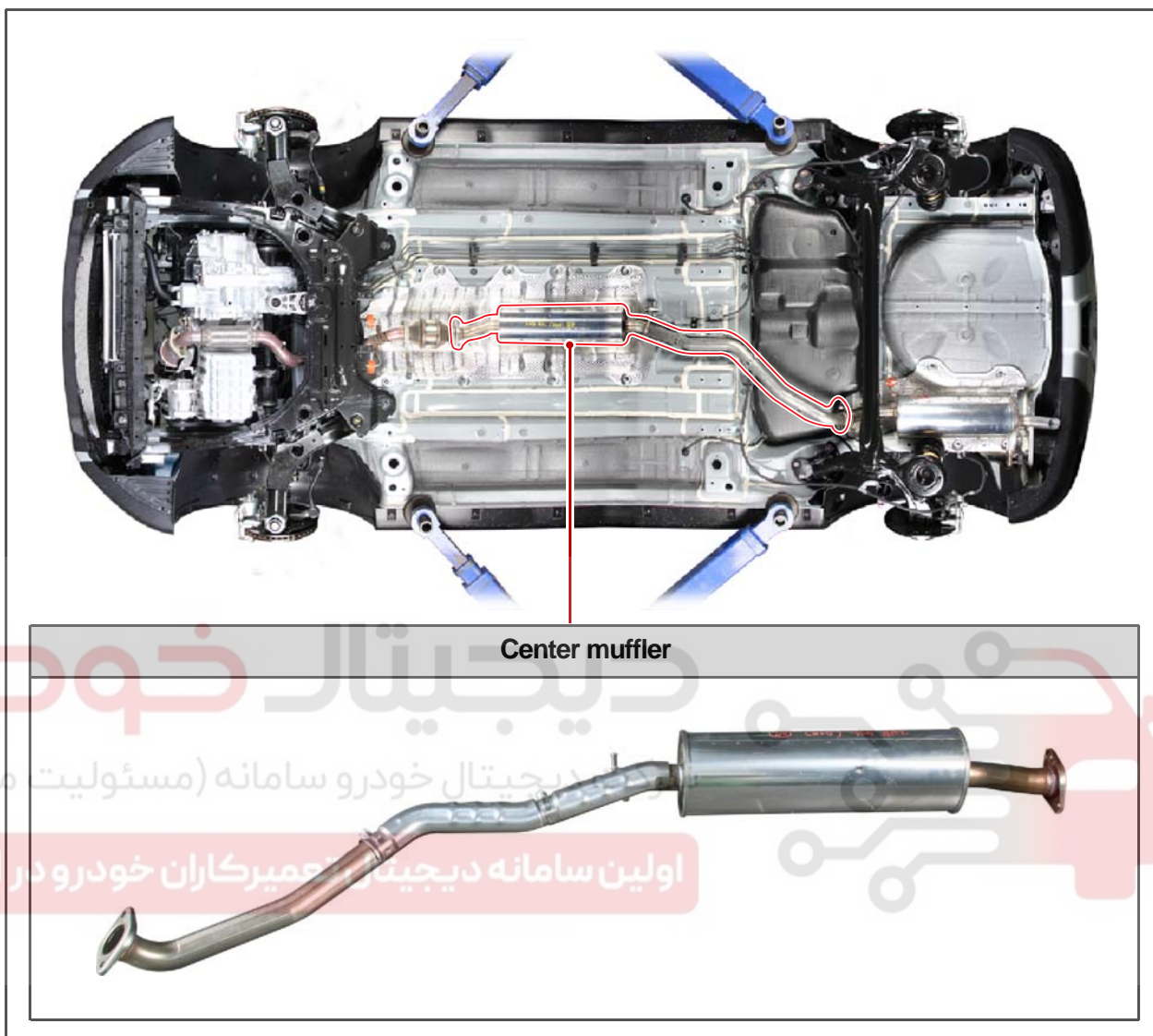
2. Remove the UCC from the vehicle.

3. Install in the reverse order of removal.



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## 2423-04 CENTER MUFFLER

ENGINE  
GENERALENGINE  
ASSEMBLFUEL  
SYSTEMIGNITION  
SYSTEMINTAKE  
SYSTEMEXHAUST  
SYSTEMLUBRICA  
TIONCOOLING  
SYSTEMCHARGE  
GSTARTIN  
GCRUISE  
CONTROENGINE  
CONTRO

E E M

Modification basis	
Application basis	
Life cycle	

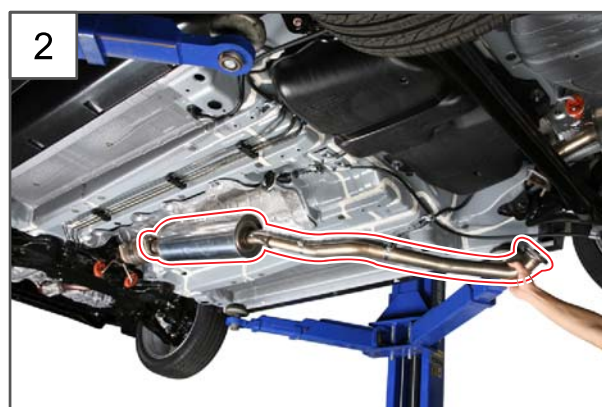
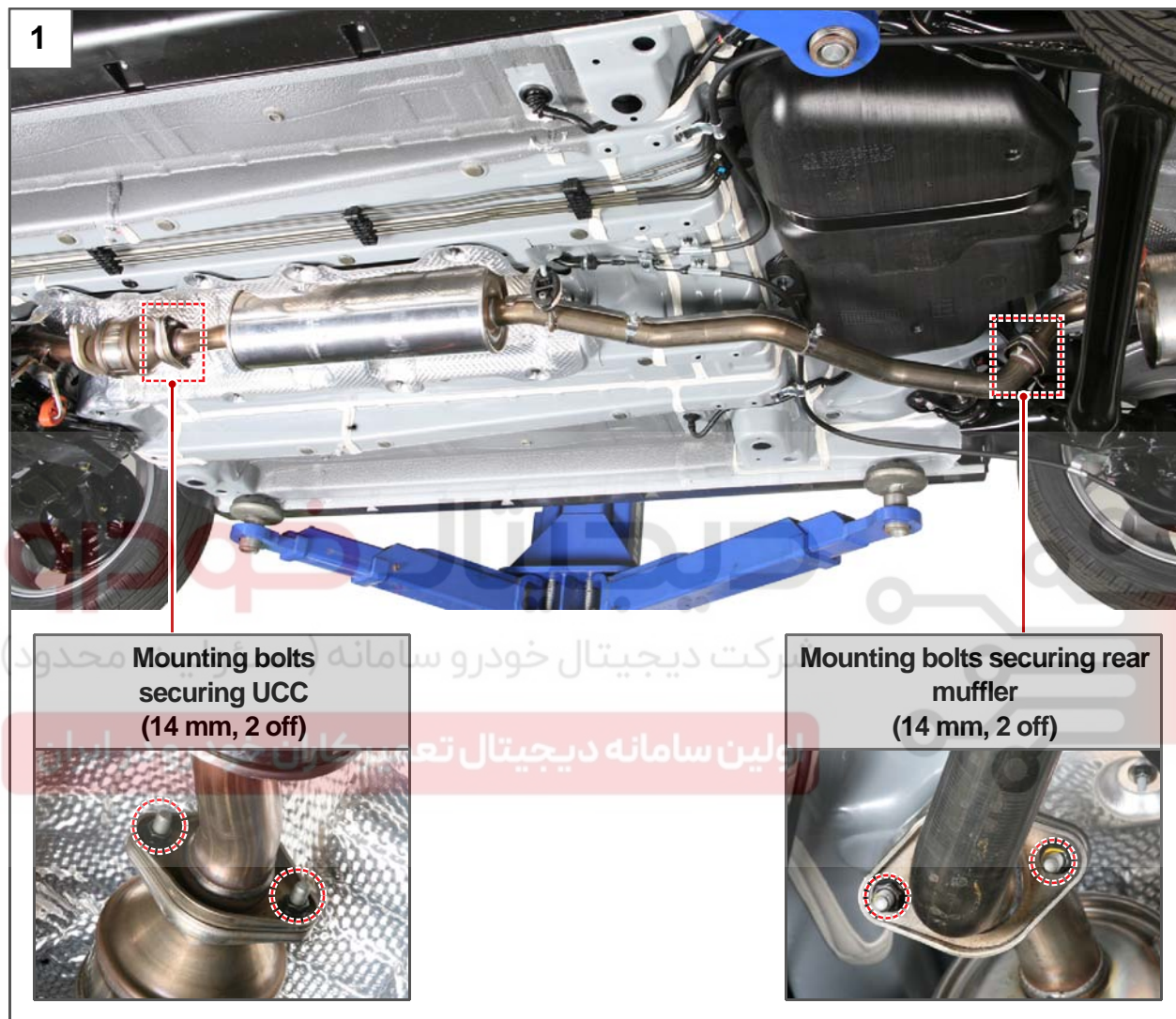
EXHAUST SYSTEM

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1. Unscrew the mounting bolts for the center muffler to remove the hanger mounting.

**Tightening torque 34 to 37 Nm**



2. Remove the center muffler from the vehicle.

3. Install in the reverse order of removal.



#### NOTE

Replace the center muffler gasket with a new one.

ENGINE  
GENERALENGINE  
ASSEMBLYFUEL  
SYSTEMIGNITION  
SYSTEMINTAKE  
SYSTEMEXHAUST  
SYSTEMLUBRICA  
TIONCOOLING  
SYSTEMCHARGE  
GSTARTIN  
GCRUISE  
CONTROLENGINE  
CONTROL

E E M

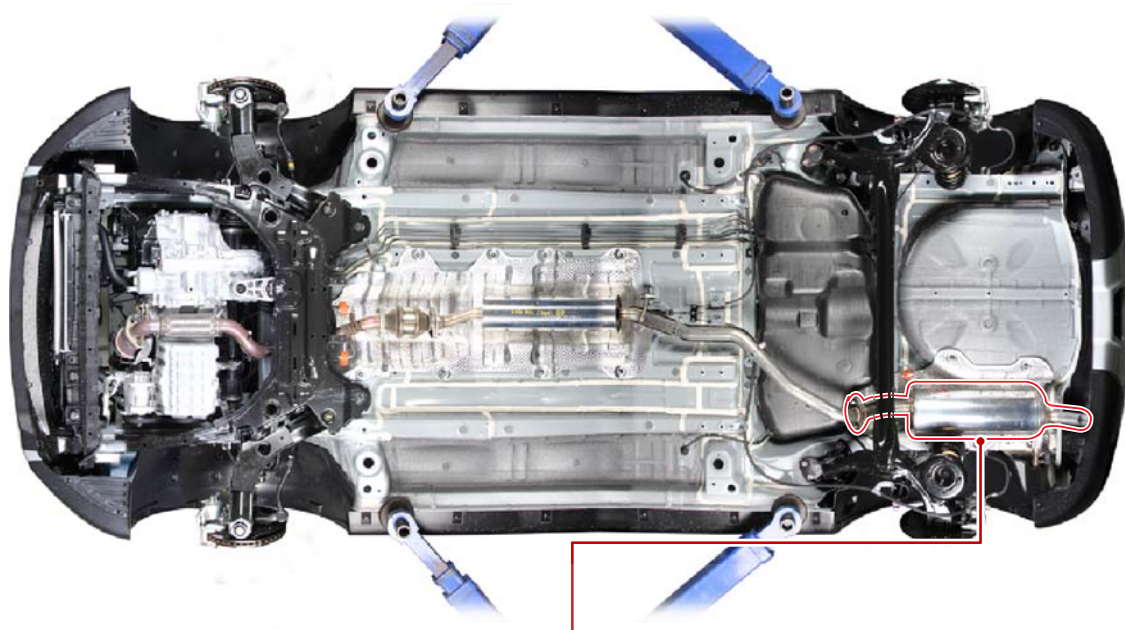
Modification basis	
Application basis	
Effective date	

EXHAUST SYSTEM

TIVOLI 2015.03

S.G.N.

## 2423-05 REAR MUFFLER



Rear muffler



EXHAUST SYSTEM

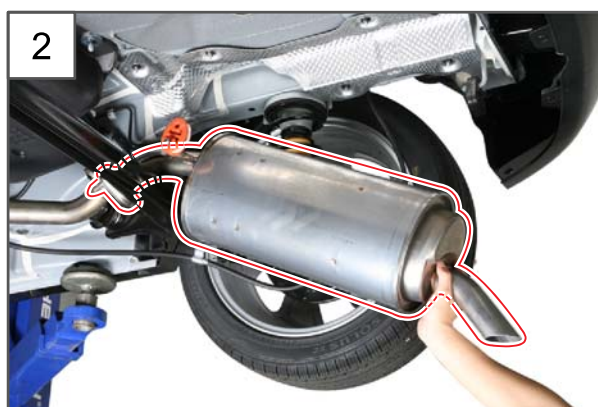
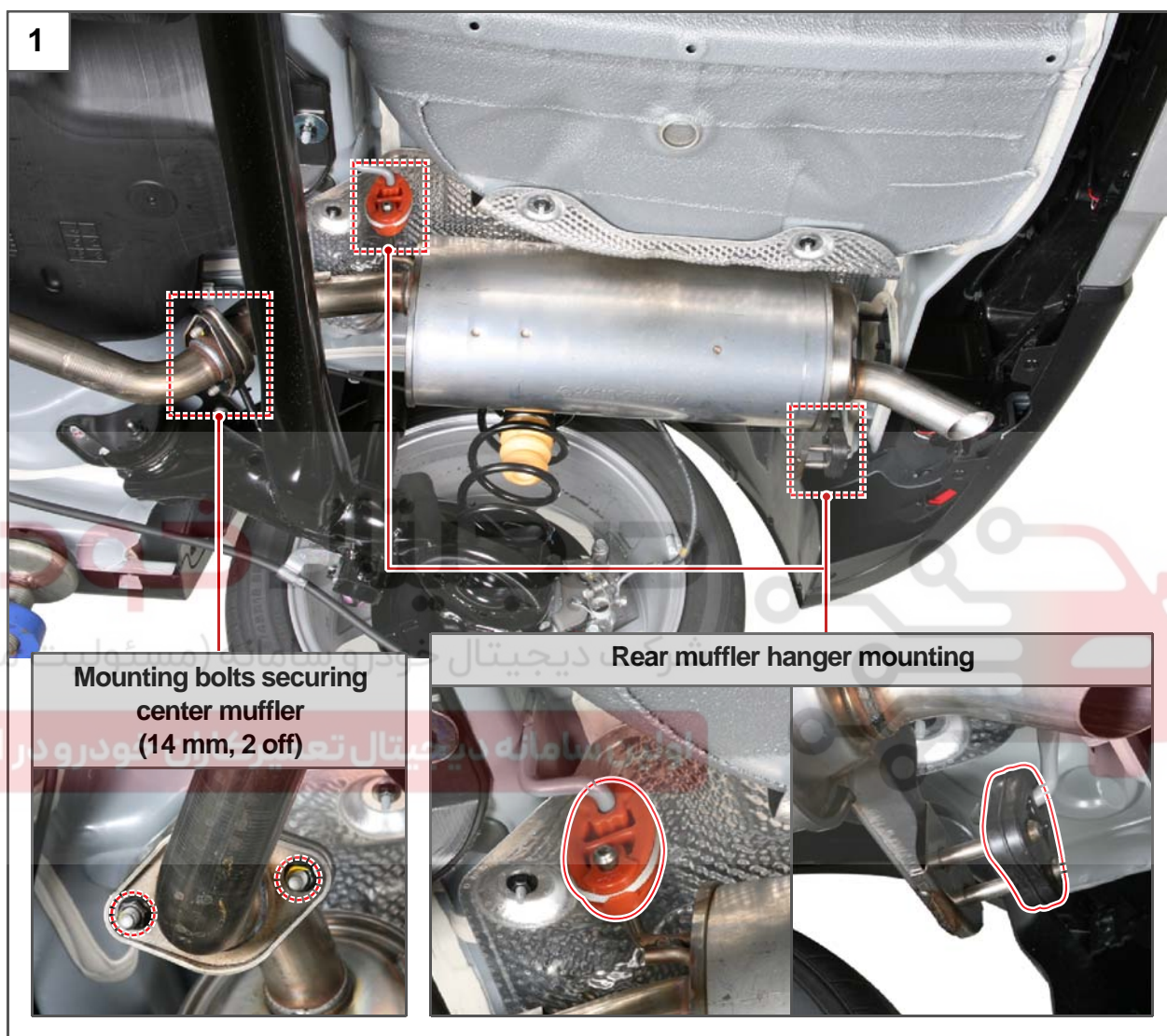
TIVOLI 2015.03

Modification basis	
Application basis	
Affected VIN	021 62 99 92 92



1. Unscrew the mounting bolts for the rear muffler to remove the hanger mountings.

**Tightening torque** 34 to 37 Nm



2. Remove the rear muffler from the vehicle.

Modification basis	
Application basis	
Approval basis	

EXHAUST SYSTEM

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3. Install in the reverse order of removal.



#### NOTE

Replace the rear muffler gasket with a new one.