Table of Contents

Climate Control Workbook

Initial Print Date: 10/07 Revision Date:

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Climate Control Workbook

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand A/C refrigerant circuit operation.
- Identify and locate refrigerant system components.
- Understand the operation of the Climate Control Systems.
- Identify the different components of the Climate Control Systems.
- Diagnose and service BMW Climate Control Systems.

Introduction

The purpose of the heating, ventilation and air conditioning system (HVAC) is to treat the air entering the passenger compartment in order to achieve and maintain a constantly comfortable environment for the occupants.

The modern automotive system that adds/removes heat, dehumidifies, ventilates and filters the air entering the passenger compartment is referred to as ***Climate Control.*** Climate Control describes a more complete and precise management of the basic HVAC system, where the climate of the vehicles is constantly varied and adjusted depending on the occupants desired and requested settings.

The Climate Control System must:

- Adjust the temperature of the passenger compartment, depending on the requirements of the driver / passenger and dictated by outside temperatures.
- Circulate air through out the vehicle.
- Remove moisture, assist in defogging of the windows and enhancing occupant comfort level.
- Filter the air to remove dust, allergens.

Climate Control can be divided into the following Sub-Systems:

- Heater
- Air Conditioning
- Air Management (blower, filters, vents)
- Computer Controls (inputs and outputs)

Heating System

The “heater” or heating system of a vehicle is typically dependent on the vehicles engine cooling system. To analyze one we must first discuss the other.

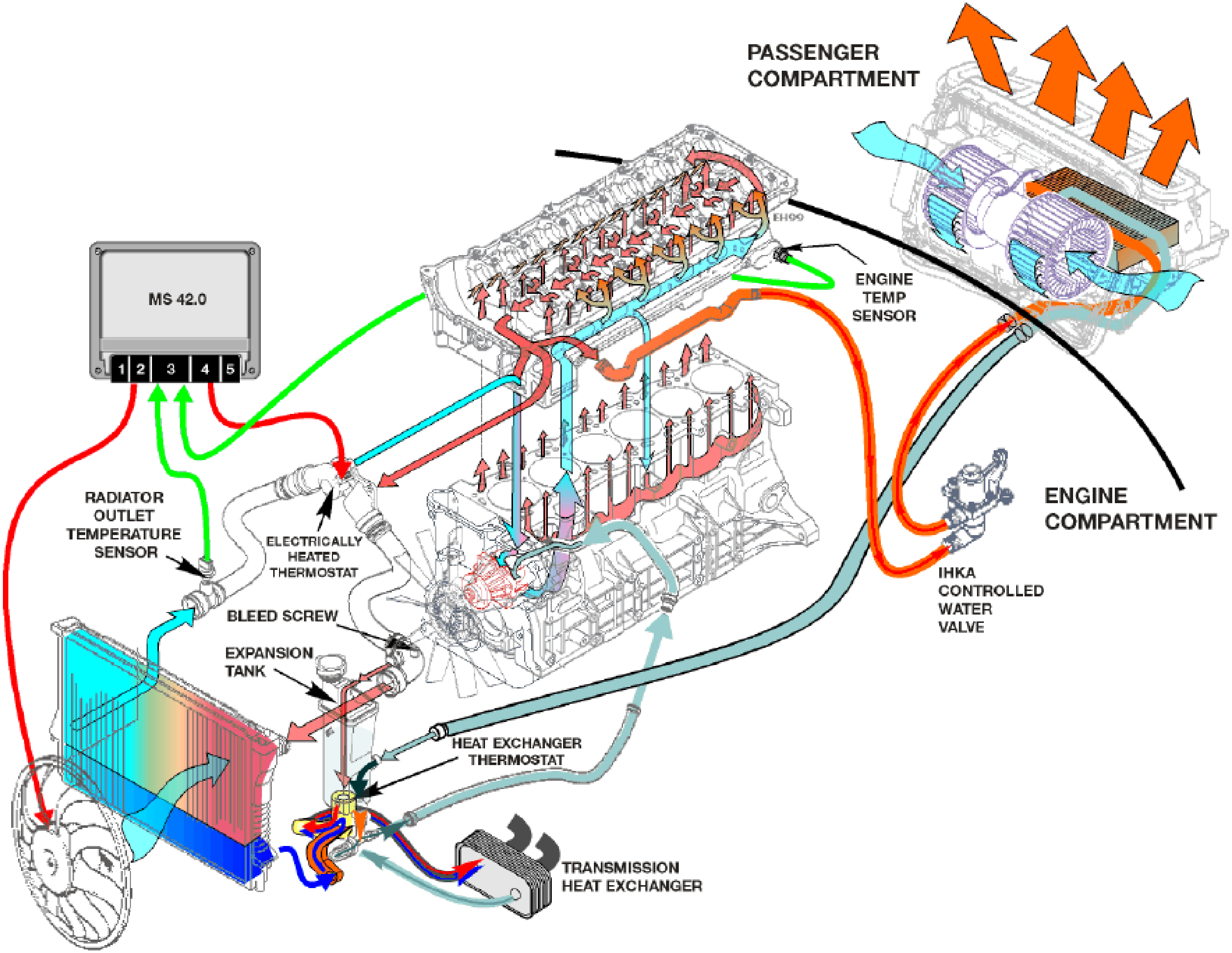
The engine cooling system is essentially responsible for the extraction and dissipation of the excess heat that results from the internal combustion process and friction forces associated with the normal operation of an engine.

Once the operating temperature has been reached the system dedicates most of its resources into controlling and maintaining this operation temperature. At the same time the surplus heat is diverted to the heater core inside of the vehicle where a blower motor fan is used to circulate heat through the passenger compartment.

Basic Heating System Components

- Coolant
- Radiator
- Radiator cooling fan
- Water pump (electric or mechanical)
- Thermostat (conventional or Data-Map)
- Coolant pipes and hoses
- Auxiliary water pump (optional)
- Coolant/water valve (optional)
- Heater core
- Blower motor/fan

Typical Cooling System Showing Heating System Components



Heat Management

The engine management DME (ECM) controls the coolant flow depending on the following conditions:

- Low output when cooling requirement is minimum and outside temperatures are low.
- High output when maximum cooling is required and outside temperatures are high.

The electric coolant pump may be completely switched off under certain conditions (to allow the coolant to heat up rapidly during the warm-up phase). However, this only occurs when no heating is required and the outside temperature is within the allowed range.

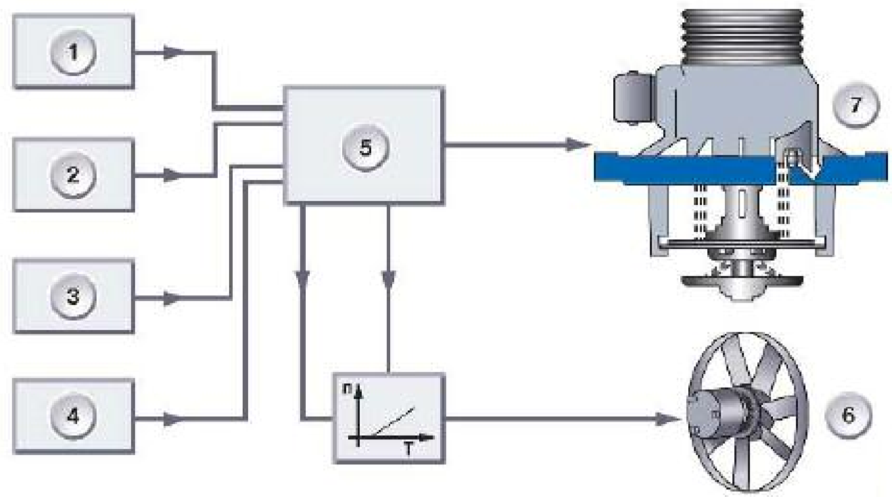
The electric pump also operates differently from conventional pumps when controlling the engine temperature. Previously, only the currently present temperature could be controlled by the thermostat. The software in the engine control module now features a calculation model that can take into account the progression of the cylinder head temperature based on load. In addition to data-map control of the thermostat, the heat management system makes it possible to use various data maps for the purpose of controlling the coolant pump. For instance, the DME can adapt the engine temperature to match the current driving situation.

This means that four different temperature ranges can be implemented:

- 111°C (232°F) ECO mode
- 105°C (221°F) Normal mode
- 95°C (203°F) High mode
- 80°C (176°F) High + data-map thermostat mode

If the engine management DME (ECM) selects ECO mode based on the current operating conditions, the system aims to bring about a higher cylinder head temperature of 111°C.

The engine is operated with relatively low fuel consumption in this temperature range as internal friction is reduced. An increase in temperature therefore favors lower fuel consumption in the low load range. In High and Data-map thermostat mode, the driver wishes to utilize the optimum power development of the engine. The cylinder head temperature is therefore reduced to 80°C. This results in improved volumetric efficiency, thus increasing engine torque. The DME (ECM) can then set an operating mode adapted to the particular driving situation. Consequently, it is possible to influence fuel consumption and power output by means of the cooling system.



Index	Explanation	Index	Explanation
1	Air-temperature data map	5	Chip
2	Load data map	6	Electric fan
3	Road-speed data map	7	Data-map thermostat
4	Coolant-temperature data map		

Intelligent Heat Management

The previous section explained the operating modes in which heat management was implemented. However, an electrically driven coolant pump makes even more options possible. For instance, it is now possible to warm up the engine without the coolant circulating, or to allow the pump to continue running after the engine is switched off in order to facilitate heat dissipation.

The advantages offered by this type of pump are listed below:

Fuel Consumption

- Faster warm-up as coolant is not circulated (stationary)
- Increased compression ratio through greater cooling capacity at full load compared to the predecessor engine

Exhaust Emissions

- Faster engine warm-up due to drastically reduced pump speed and the resulting minimal volumetric flow of coolant
- Reduced friction
- Reduced fuel consumption
- Reduced exhaust emissions

Power Output

- Component cooling independent of engine speed
- Demand-based coolant pump output
- Avoidance of energy loss

Comfort

- Optimum coolant volumetric flow.
  - Greater heater output when demanded.
  - Residual heat when engine is not running.

Component Protection

- Electric pump overrun achieves more effective heat dissipation after switching off engine when hot coolant at the rate determined by the engine speed.
- Only the circulated amount of coolant can be influenced by the mapped thermostat for temperature control purposes.
- The system switches between the small and large circuit, i.e. the circuit flowing via the radiator. This consequently means that the cooling capacity is dependent on the engine speed.
- If the heater core temperature exceeds safety parameters, the IHKA module will manipulate the thermostat settings to lower the overall heat in the system to protect the core from bursting.

Air Conditioning System

An air conditioning system does not produce cold air but rather it carries heat away from the vehicle interior to the outside. The closed system is filled with a refrigerant (R12 or R134a) which is circulated and provoked to change state from a liquid to a gas and back again.

The air conditioning system operates in accordance with the refrigerating principle. Circulating through this closed system, the refrigerant is compressed, heated, expanded and cooled as it extracts heat and humidity from the air of the passenger compartment.

E90 A/C System Components

Basic A/C System Components

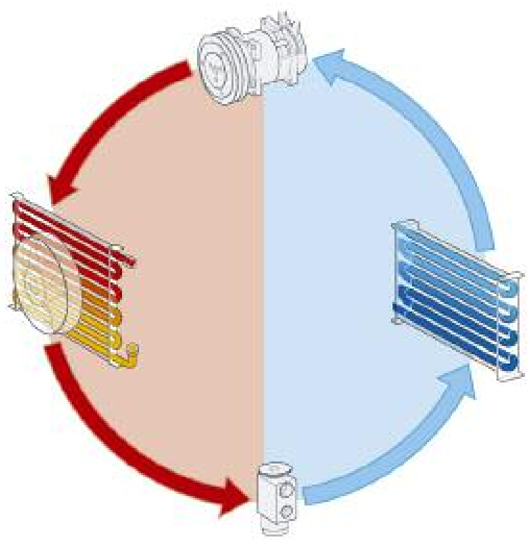
- Refrigerant
- Condenser
- Condenser fan
- Compressor
- Expansion valve
- Hoses and pipes
- Receiver Dryer/collector
- Evaporator
- Compressor Control Device
- Blower Fan

Additional components of the A/C system include:

- Compressor pulley (Clutch or Clutchless)
- Pressure switch/sensor
- Evaporator temperature sensor

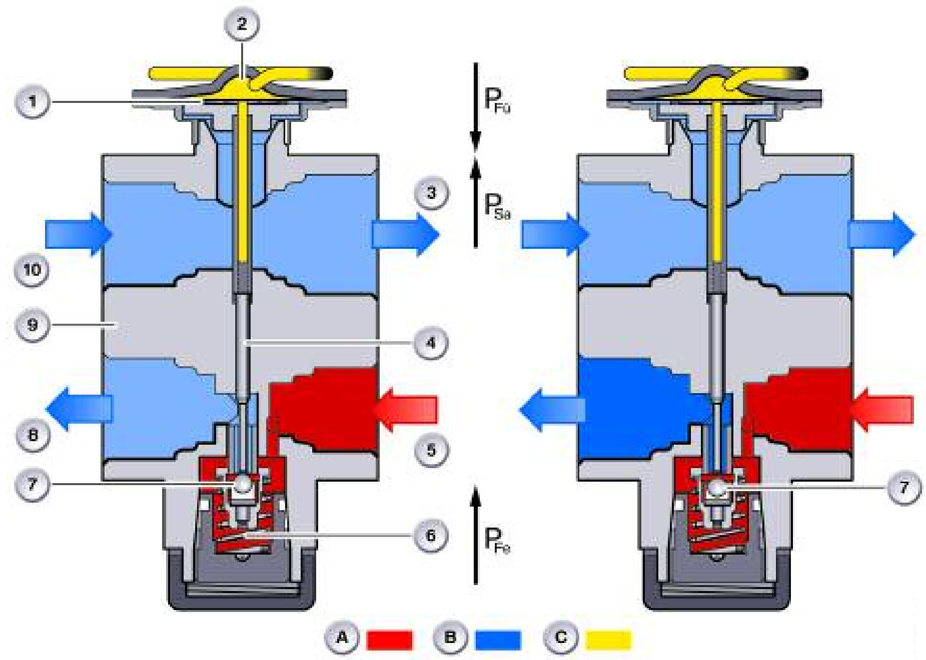
The Refrigerant Cycle

The refrigerant circuit is divided into a high pressure section (high side) and a low pressure section (low side). The high pressure side is comprised of the compressor, condenser, condenser fan, pressure sensor, receiver dryer and expansion valve. The low pressure side also involves the compressor and expansion valve along with the evaporator and blower fan.The expansion valve separates the high-pressure side of the system from the low-pressure side. Pressurized liquid refrigerant exits the receiver dryer and as it passes through the metered orifice of the expansion valve it decompresses and boils.



This change of state causes the refrigerant to absorb heat as it makes its way through the inside the evaporator. The amount of refrigerant released is controlled by the expansion valve based on evaporator temperature and pressure as well as the temperature of the air passing through the evaporator and proportional to the cooling demand. If too little refrigerant enters the evaporator, poor cooling results. If too much refrigerant enters, it might not completely boil away and liquid refrigerant might return to the compressor, causing damage to the system.

Typical Expansion Valve



Index	Explanation	Index	Explanation
1	Diaphragm	9	Housing
2	Sending gas	10	From evaporator
3	To compressor	A	High pressure
4	Valve needle	B	Low pressure
5	From condenser	C	Sensing gas pressure
6	Spring	Pfu	Pressure in sensor line (sensor fill)
7	Ball	Psa	Evaporator pressure (low pressure)
8	To evaporator	Pfe	Control spring force

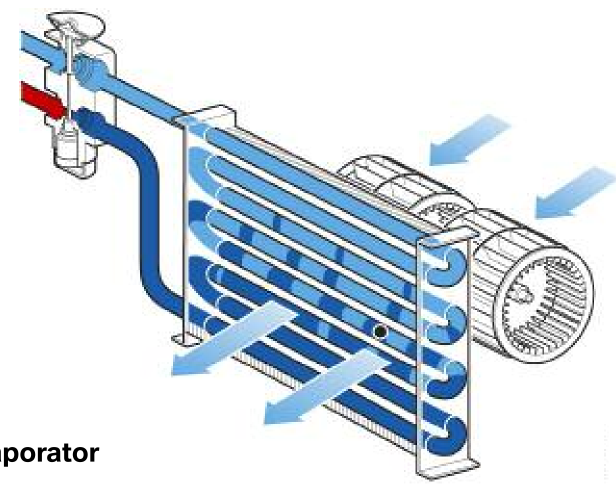
The pressure and temperature are measured by passing the refrigerant through the expansion valve at the outlet of the evaporator. The top section of the valve measures the temperature of the refrigerant intake and the refrigerant pressure acts on the underside of the diaphragm.

The valve needle is pressed down against a spring to open the valve, allowing liquid refrigerant to flow into the evaporator. The refrigerant evaporates, pressure and temperature drop.

The pressure and temperature of the gaseous refrigerant at the evaporator outlet are used to open and close the valve via a diaphragm.

When the air temperature at the evaporator outlet drops, the sensing gas in the diaphragm chamber contracts, this moves the valve needle upward and reduces the refrigerant flow rate to the evaporator.

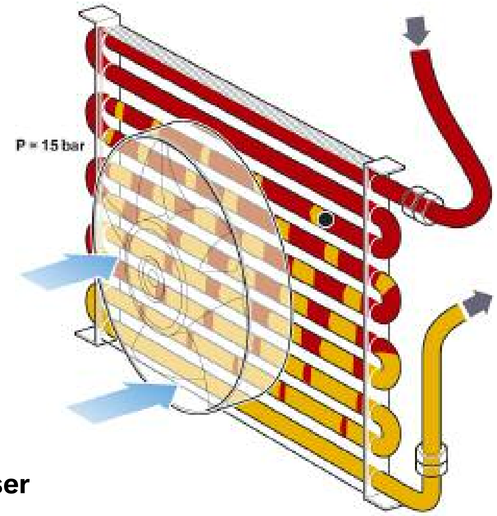
The flow rate is increased again when the air temperature at the evaporator output rises. Increasing pressure at the evaporator outlet assists the valve closing action. Decreasing pressure assists the valve opening action. This control procedure runs continuously for as long as the air conditioning system is in operation.



Typical Evaporator

Heat is extracted from the cabin air as it is circulated by the blower fan through the evaporator outer surface area. This transfers heat from the cabin air to the vaporizing refrigerant inside, reiterating that an air conditioning system operates by removing heat instead of adding cold.

An engine driven compressor extracts the, gaseous, low pressure refrigerant from the evaporator, compresses it and heats it. The now compressed and superheated gas is pumped through the condenser where it cools to a medium temperature, high pressure liquid as out side air is forced through the condenser fins via driving or the condenser cooling fan.



Typical Condenser

The refrigerant now in a subcooled liquid state flows from the condenser to a liquid reservoir (receiver dryer) where it is collected. Any moisture and impurities are removed by the desiccant in the receiver dryer. This high pressure liquid now flows back into the low pressure side of the system, where it is forced through the expansion valve metered orifice back into the evaporator on its way to complete the cycle once again.

A/C System Diagnosis

Refrigerant Pressure

Refrigerant pressure is directly proportional to its temperature so as the temperature goes up so does the pressure and vice versa.

Refrigerant in the A/C system is provoked to change state from a liquid to a gas and back again. During every change of state heat is either absorbed or given away in the process. This thermodynamic property is put to use in the Low Side and in the High Side of all A/C systems.

The low side pressure is a direct reading the evaporator temperature and its heat exchanging capabilities. Low side pressures should average +/- 2bar. (28 to 32psi) that means that actual pressure of a variable displacement compressor/TEV system can be between 1 to 3bar. or (15 to 45psi) at any given time.

The high side pressure is a direct reading of the condenser cooling efficiency. Although high side pressures may vary between 150 to 300psi. normally they should be about 2 to 2.5 times the ambient temperature. Depending on humidity, an outside temperature of 80°F should produce a pressure of 160 to 200psi on the High Side.

When the high side pressure is way above normal it may indicate that the condenser auxiliary cooling fan is not cooling the refrigerant sufficiently. Proper air flow across the condenser insures the efficiency of the entire system. The cooler the refrigerant leaving the condenser the lower its pressure; consequently the lower the temperature of the refrigerant entering the evaporator the more heat can be absorbed from the passenger compartment.

Pressure gauges are indispensable when diagnosing an A/C system BUT they are incapable of measuring the quantity or for that matter the type of refrigerant in the system.

The refrigerant capacity of an A/C system can be found on the A/C label under the hood and in the respective technical information relating the specific system.

E93 Under Hood Label

Note: For more information on quantity and type of refrigerant and refrigerant oil refer to the Operating Fluids Section (Group 64) on TIS.

Visual Inspection

It is important to understand the overall condition of the system. Some time between verifying the Customer Complaint and the A/C Efficiency Test, a Visual Inspection of the system should be performed.

This Visual Inspection may cover, but is not limited too:

- Compressor drive belt condition
- Compressor drive pulley type and condition
- Compressor engagement
- Condenser fan operation.
- Cooling system condition and operation
- Heater valve operation
- Blower fan operation
- Refrigerant system integrity (a/c hoses, connections and fittings)
- Electrical system malfunctions (Fuses/Relays)
- IHKA settings and controls
- Individual vehicle equipment options
- Ambient temperature
- Relative humidity
- Customer system expectations

E60 vent outlet temperature reading

A/C Quick Check

- Note ambient humidity
- Note ambient temperature
- Note refrigerant type (R-134a)
- Close all windows and doors.
- Engine Speed = 1500-2000 RPM.
- Blower Volume = Medium Speed
- Temperature Wheel = “Max Cold”
- “Snowflake” Button = A/C On
- Test conditions > 3 minutes
- Center vent discharge = 20°F less than the ambient temperature.

Service Information

Condenser Service

The procedure in the condenser is divided into three operations. In the first stage, the hot gaseous refrigerant at a temperature of about 60-120°C coming from the compressor at a pressure of 10 to 25 bar gives off its superheat to the outside air. The actual condensation takes place in the second phase where the refrigerant has lost so much energy that it becomes liquid. In the third phase, further energy is taken from the now liquid refrigerant. This state is referred to as refrigerant sub-cooling. This phase also makes sure that no gas bubbles can form on the refrigerant’s way to the expansion valve. The sub-cooling takes more heat away from the refrigerant than is necessary for actual condensation. The sub-cooled refrigerant in the evaporator can absorb a larger quantity of heat and thus increase the refrigerating capacity of the system. The auxiliary fan arranged directly before the condenser ensures an effective supply of cooling air. The refrigerant remains in the condenser at a high pressure of approx. 10-25 bar. Approx. 80-90% of the condenser is used in the actual condensation process where a temperature drop of 30 to 40°C occurs.

The following points must be observed when working on the condenser:

- The distance between the condenser and vehicle radiator must be as large as possible.
- The condenser fins must not be bent or dirty.
- Ensure the auxiliary fan is operating correctly.
- A soiled condenser results in poor condensation and unnecessarily high operating pressures.

Note: The sub-cooling of the refrigerant in the condenser enhances the efficiency of the air conditioning system.

Evaporator Service

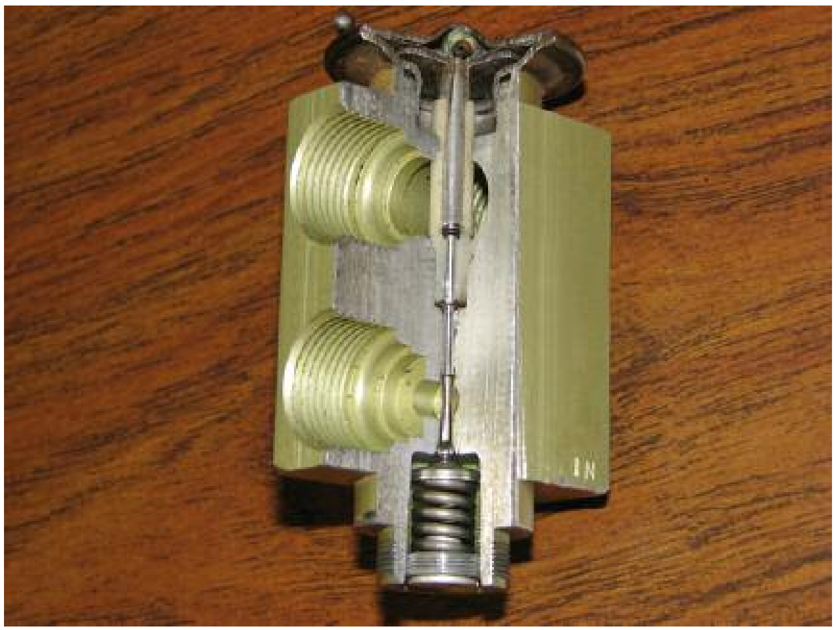
The evaporator functions as a heat exchanger in that thermal energy is taken externally from the air and given off internally to the refrigerant. The most important factor is the energy absorption by the refrigerant during the transition from the liquid to the gaseous state.This transition requires a great deal of energy in the form of heat which is taken from the air blown through the system of fins. The refrigerant cools down greatly while the injection procedure ensures the pressure drops from 10-20 bar. to about 2 bar. The refrigerant is evaporated at low pressure by the heat delivered from the passenger compartment with the use of a blower fan.
The following points must be observed when working on the evaporator:

- The evaporator fins must not be dirty or bent. This would result in the growth of bacteria and odor.
- The evaporator fins must not ice up. If the evaporator does ice up, the fault will be in the area of the evaporator temperature sensor. This situation may result in compressor damage.
- The micro filter change intervals must be maintained to insure adequate air flow.
- The condensation water drain must not be clogged and water must drain off freely.
- The evaporator temperature sensor must be installed correctly.

Note: To treat bacteria and odor complaints, a special cleaning and treatment procedures must be followed. SI 64 04 03 “A/C System Musty Odor” can be found in TIS.

Expansion Valve Service

A block-valve design of expansion valve is used on current BMW A/C systems. The refrigerant enters at the upper right inlet. At the left of the valve there is a capillary tube filled with an inert gas that senses the temperature of the air coming into the housing from the plenum.



When the air temperature in the plenum rises, the pressure in the capillary tube increases. This pushes down on a diaphragm and pushrod assembly, which increases the size of the orifice opening, allowing more refrigerant into the evaporator and providing more cooling.

When plenum temperature falls, the pressure in the capillary tube falls. The spring pushes up on the pushrod, making the orifice opening smaller; less refrigerant is allowed into the evaporator, allowing less cooling. Refrigerant from the outlet of the evaporator passes through the bottom left opening of the block valve.

When the pressure at the evaporator outlet is high, this increases the pressure needed by the capillary tube to open the valve. Less refrigerant is provided to the evaporator (to prevent the evaporator from being flooded).

When pressure at the outlet end of the evaporator is lower, less pressure is exerted on the bottom of the diaphragm. The diaphragm pushes down on the pushrod, allowing more refrigerant into the evaporator.

The following points must be observed when working on the expansion valve:

- Very little refrigerant flow through the evaporator will result in poor AC output.
- Too much refrigerant flow will flood the evaporator and cause possible compressor damage.
- The setting of the expansion valve must not be adjusted or varied (except for instructions in the Service Information).
- The expansion valve must not be repaired.
- Seals must be replaced every time the pipes and hoses are released.
- It is imperative that an A/C system being serviced be evacuated for a minimum of 30 minutes or more in order to remove any possible moisture trapped within.

Note: If moisture gets into this system, it may freeze and clog the expansion valve. The A/C system may operate normally for a while, then stop cooling. Then, as system temperature increases, the ice melts. The system works again for a while, until moisture freeze-up causes it to stop again.

Compressor Service
The function of the compressor is to pump the refrigerant along the system. As the gaseous refrigerant exits the evaporator, it is pulled into the compressor by suction where it is compressed and super-heater and then pumped along to the condenser. Liquid refrigerant in the compressor causes noise complaints and internal damage. There are currently three methods of compressor control and two types of compressors depending on the vehicle or equipment option. (See Compressor Operation)

Typical Compressor service points to remember:

- When troubleshooting a noisy compressor complaint, make sure the noise is present only when the clutch is engaged.
- If it is present when the clutch is not engaged, remove the compressor drive belt and check again.
- If the noise continues, it is not related to the compressor.
- If removing the drive belt reduces or eliminates the noise, check the torque of the compressor and bracket mounting bolts.
- Check the belt tension and condition, and tensioner pullies which can produce rattling noises that would sound like a defective compressor.
- A loose/slipping belt can cause noise.
- A belt that is too tight can damage the clutch/pulley bearings.
- If the compressor is noisy with the compressor clutch engaged, make sure the system is charged with the correct amount of refrigerant.
- An over-charged system can cause compressor noise.
- If the A/C system is overcharged with refrigerant, the liquid entering the compressor can damage it.
- When troubleshooting a noisy compressor complaint, recover the refrigerant and recharge the system with the correct amount.
- A failed compressor must be returned with the inlet and outlet ports sealed using the plastic caps from the replacement compressor. Otherwise the “failed” compressor will be damaged by moisture, and it will be impossible for Warranty to analyze it.

Compressors with plastic pullies:

- Avoid impact on the plastic pulley (through tools, contact with base)
- Send back damaged compressors only in original packaging.

Note: It is important to perform the following running-in procedure when operating a new compressor for the first time.

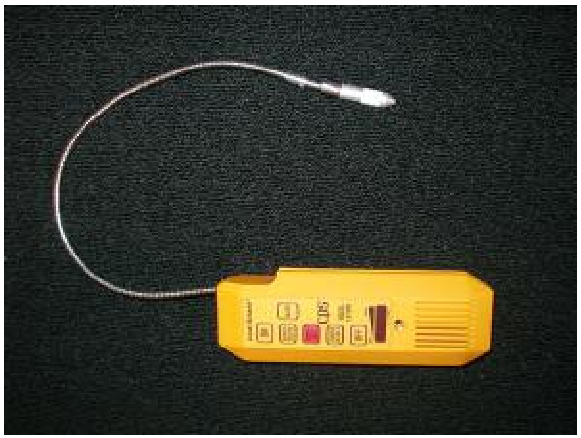
- Switch off air conditioning system
- Set all air outlet nozzles on the instrument panel to "OFF"
- Start engine and allow idle speed to stabilize
- Set blower capacity to min. 75% of the maximum blower capacity
- Switch on air conditioning and allow to run for at least 2 minutes at idle speed. Risk of damage at higher speed! (Refer to BMW Diagnostic Equipment Service Functions for more detailed instructions)

Note: When replacing a compressor you must follow the instructions on refilling the refrigerant oil. For details on compressor replacement and oil capacities are found in the Operating Fluids Information in TIS.

Leak Testing the A/C System

Always be aware of the safety measures associated with handling refrigerant as far as wearing eye protection, gloves and respiratory equipment. (Refer to Safety Section)

If the refrigerant leak was not identified during the evacuation, the system must be filled before it can be tested for leaks with either dye or the electronic leak detection device.



Typical Electronic Leak Detector

Using a leak detector like this takes experience and practice. Many times an oily black dust collects on or around leaking component. This evidence of escaping oil and refrigerant and is a very good place to start.

To check for a leak with dye, the dye has to be added to the system and then monitored using an ultraviolet lamp and special safety glasses. When the ultraviolet beam of light shines on the suspected component/area, it reflects a yellow glow as evidence of the refrigerant leak.

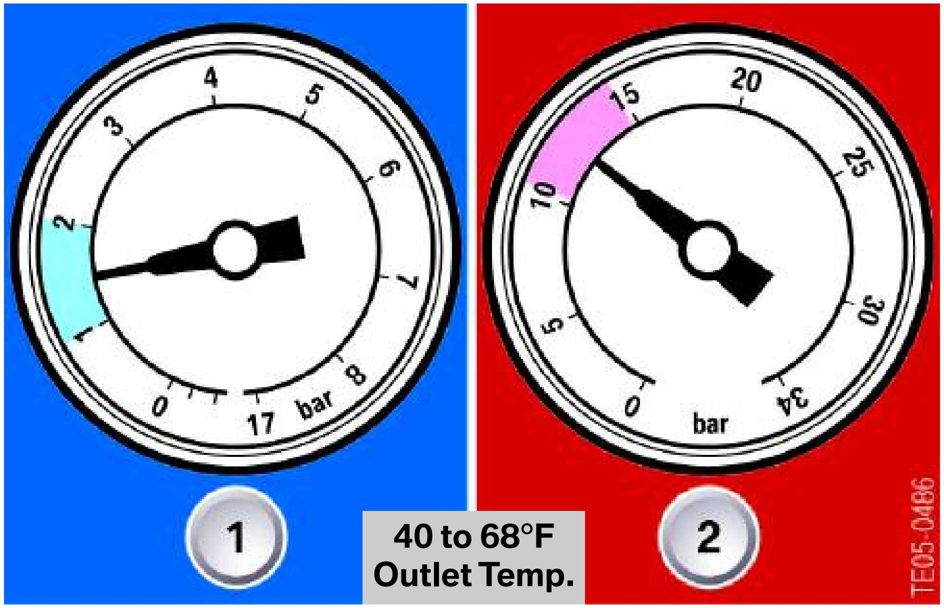
Typical Fluorescent Dye Leak Detector Kit

These are some helpful leak testing tips to keep in mind:

- It is better to check the Low Side for leaks with the A/C system off.
- The High Side is best checked for leaks with the A/C system on.
- Refrigerant is heavier than air. Therefore you must always test below the suspected lines, connections and components.
- Solvent fumes, wind and cooling fans may throw off your diagnosis.
- Remember that refrigerant dye stains and a leak inside the vehicle like an evaporator can damage the interior.
- Evaporator leaks are best diagnosed with an electronic leak detector at the outlet vents and at the condensation drain with the system off.

Note: Refer to SI B 04 14 04 "A/C Leak Detection Kit" R-134a A/C dye leak tester has been approved for use on BMW Group vehicles.

Normal Operation Pressure Readings



Index	Explanation
1	Low pressure - normal 1 to 2 bar (15 to 30psi)
2	High pressure - normal 10 to15 bar (150 to 225psi)

These pressures will vary depending on outside temperature and humidity. Readings that differ from above are not considered correct and may indicate a problem. Proper interpretation of these reading will allow you to make an accurate diagnosis of the system.

Although the typical outlet temperature for a properly operating system should be 20° lower than the current ambient temperature, outlet temperature may range between 40 to 68°F at any given time depending on outside temperature and humidity.

Note: Refer to S.I.B. # 641392 (3646) for nominal air conditioning system pressures R12/R134a.

Relative Humidity (%)	Outside Air Temp (°F)	R-12 Discharge Temp(°F)	R-12 Low Pressure (psi)	R-12 High Pressure (psi)	R-134a Discharge Temp (F)	R-134a Low Pressure (psi)	R-134a High Pressure (psi)
20	70	44	24	143	44	9	69
	80	44	31	192	44	24	85
	90	50	45	232	47	40	136
	100	59	47	270	53	50	231
	110	66	57	320	64	58	308
30	70	44	23	154	44	10	80
	80	44	35	203	44	28	110
	90	54	47	239	48	42	168
	100	63	50	283	59	54	253
	110	74	60	334	69	62	328
40	70	44	34	170	45	12	93
	80	50	40	216	50	32	149
	90	58	48	146	56	45	212
	100	67	53	291	64	57	264
	110	77	63	350	74	67	348
50	70	46	37	178	45	14	102
	80	55	43	223	51	36	164
	90	61	50	252	59	54	229
	100	71	58	312	70	67	229
	110	84	66	365	80	76	368
60	70	47	40	187	45	18	133
	80	55	49	230	53	39	191
	90	64	54	266	62	57	249
	100	75	60	318	72	72	310
	110	86	68	383	83	80	384
70	70	47	41	228	46	19	168
	80	56	50	257	56	42	215
	90	66	56	278	67	61	260
	100	78	63	333	77	75	321
	110	91	72	402	87	87	390
80	70	47	43	247	46	21	178
	80	57	53	268	57	47	218
	90	69	62	287	69	67	267
	100	82	70	340	78	80	331
	110	95	76	438	90	89	405
90	70	48	44	258	46	33	183
	80	60	55	286	59	54	223
	90	72	63	307	71	69	274
	100	85	72	350	84	84	345
	110	101	80	463	87	94	424

Low Pressure Readings

- A Low pressure reading in both High and Low gauges usually indicates Low refrigerant charge.
- Very low pressures on both sides, with even a vacuum reading on the low side will typically indicate:
  - A restriction on the receiver dryer (with auxiliary fan on)
  - Expansion valve restricted or not opening (with auxiliary fan on)
  - The low pressure on high side here indicates a restriction because as the refrigerant is trapped in the condenser (not circulating) the auxiliary fan continues to cool it and thus lowers its pressure.

High Pressure Readings

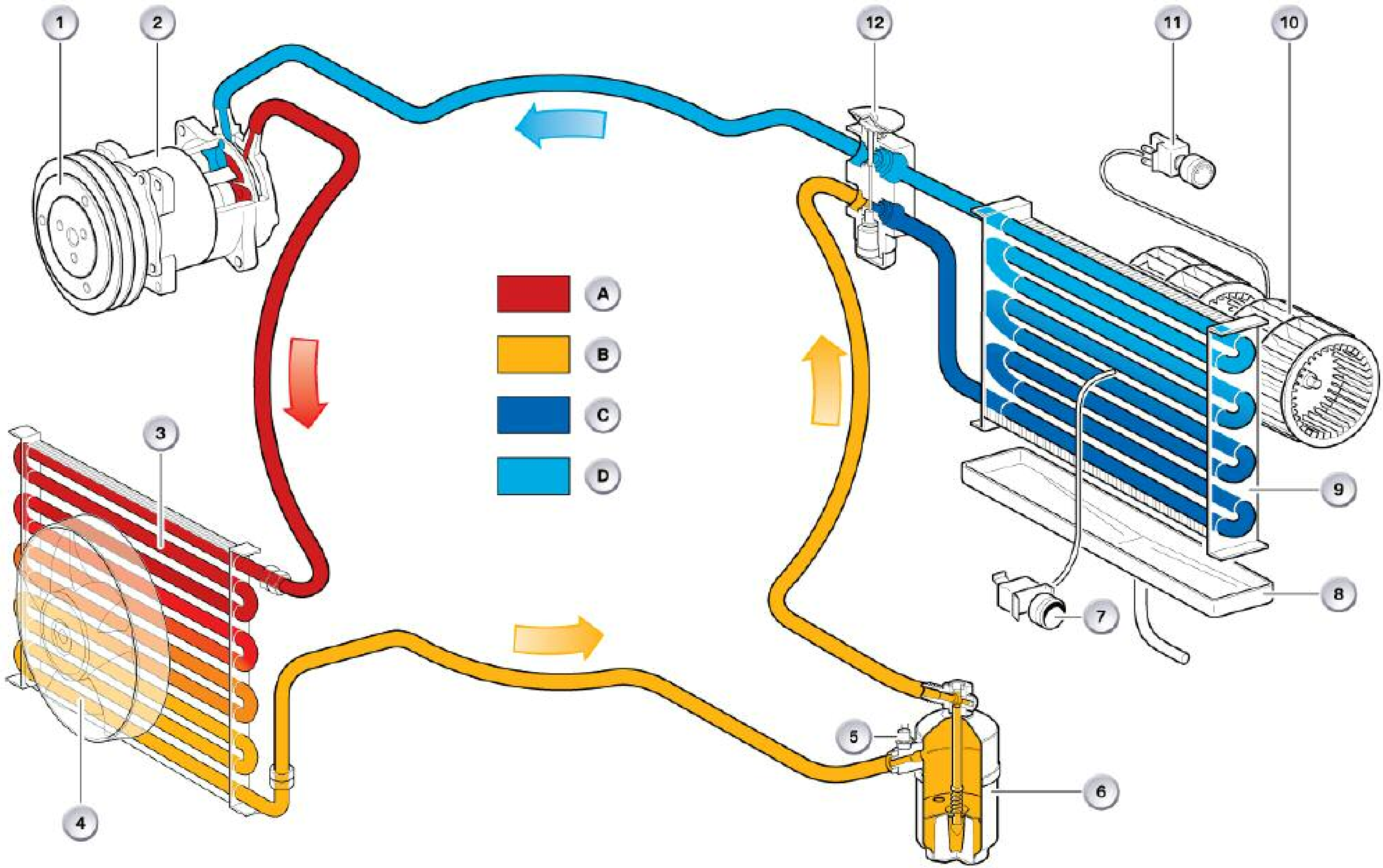
- A High pressure reading on the Low side typically indicates overcharging
- A high pressure on the Low side may indicate an open expansion valve.
- A high pressure reading on both high and Low side typically would indicate
  - Overcharging
  - Condenser cooling fan not working
  - Oil saturation of the system (condenser)
  - Expansion Valve Stuck Open (not closing)

Combined High and Low Pressures

- Low pressure high and high pressure low normally indicates:
  - Reduced Compressor output
  - Compressor belt slipping
  - Compressor clutch defective
  - Compressor control defective
  - Compressor control failure
- Low pressure low and high pressure normal to high.
  - Restriction in dryer (auxiliary fan NOT on)

Note: These examples are just for sole purpose of the explanation of the system operation. In service, system pressures may behave differently based on the conditions at the time of testing.

Typical Air Conditioning System



Classroom Exercise 1 - Review Questions

1. Which of these materials is used to absorb moisture?
Select the best possible answer.

a) Refrigerant
b) Desiccant
c) Lubricant
d) Catalyst

2. What happens to the refrigerant in the evaporator?
Select the best possible answer.

a) Absorbs heat
b) Boils
c) Expands
d) All of the above.

3. Which two major A/C components are combined in some current BMW A/C System?
Select the best possible answer.

a) Evaporator / Expansion Valve
b) Condenser / TEV
c) Dryer / Condenser
d) All of the above.

4. What does water on the carpet of the passenger compartment indicate?
Select the best possible answer.

a) Expansion valve open
b) Leak in Condensation Hose
c) Leaking Evaporator
d) Both C and B

5. What does a "musty odor" from the A/C system vents indicate?
Select the best possible answer.

a) Mold in the A/C System
b) Stuck open Expansion Valve
c) Leak in the Condenser
d) Leaking Heater Core

6. Fill in the following legend pertaining to the diagram in the opposite page.

Index	Explanation	Index	Explanation
1		9	
2		10	
3		11	
4		12	
5		A	
6		B	
7		C	
8		D	

Classroom Exercise 2 - Review Questions

1. Why do current vehicles use Map controlled thermostats?
Select the best possible answer.

a) Thermal Efficiency
b) Fuel Economy
c) Tailpipe Emissions
d) All of the above

2. Why is pulling a continuos vacuum on an empty A/C System imperative to it's efficiency?
Select the best possible answer.

a) To purge all air
b) To extract all the Refrigerant
c) To drain all the oil
d) To extract moisture

3. What are the two main functions of the evaporator?
Select the best possible answer.

a) Dry the air
b) Release heat
c) Absorb heat
d) Both A and C

4. What is the minimum amount of time we should pull a vacuum on a system before charging?
Select the best possible answer.

a) 1 hour
b) 30 sec.
c) 15 minutes
d) 30 minutes

5. Match the heating system component with it 's air conditioning counterpart.

Heating System	A/C System
Radiator	**Refrigerant**
Radiator fan	**Evaporator**
Water pump	**Condenser**
Map Thermostat	**Auxiliary fan**
Pipes and hoses	**Blower fan**
Expansion tank	**Compressor**
Coolant	**Expansion valve**
Coolant/water valve	**Lines and Hoses**
Heater core	**Receiver dryer**
Blower fan	**Compressor control (Valve/Clutch)**

Workshop Exercise - A/C Efficiency Test

Satisfy the following conditions before performing an A/C efficiency test.

- *Connect the BMW Diagnostic Equipment and check for faults (no faults in the fault memory).*
- *Use a thermometer with separate gauge.*
- *Perform the test in a suitable work bay with an ambient temperature between 20°C and 30°C (68° F and 86° F).*

1) Connect BMW Diagnostic Equipment to the vehicle and display evaporator temperature.

2) Position a (pocket) thermometer with a separate gauge about 5cm (2in) below the roof liner at the height of the B-pillar. Position the gauge facing outside of vehicle interior.

3) Heat up vehicle interior:

- *A/C button is not activated during heating up.*
- *Close all windows and doors.*
- *Set recirculated air mode.*
- *Select air distribution mode for footwell and defrosting.*
- *Maximum temperature setting.*
- *Maximum fan stage.*
- *Run engine at @ 2000 rpm until operating temperature is reached, then idle speed.*

4) Perform the A/C efficiency test and document below.

- *Turn on A/C compressor at a vehicle interior temperature of 50°C (122°F).*
- *After 3-4 minutes, the evaporator sensor temperature must be 15°C (59°F) or below.*

5) If this temperature is not reached:

- *Recycle the refrigerant from the A/C system.*
- *Measure amount of refrigerant collected.*

6) If the collected refrigerant quantity does not correspond to specified fill quantity:

- *Recharge with the correct amount of refrigerant and repeat the efficiency test.*

7) If fill quantity is correct:

- *Continue troubleshooting by refrigerant pressure readings.*

Workshop Exercise - Intro/Demo

Using the A/C Service Equipment and BMW Diagnostic Equipment demonstrate the following.

1. *Perform a visual inspection on the vehicle and list any findings below.*

2. *Pinpoint the location of all crusial components of the A/C System and check them off the list below.*

Expansion Valve	*Condenser W/integrated Dryer*
Compressor	*Receiver Dryer (stand alone)*
Compressor Clutch	*Water Valve*
Condenser	*Clutchless Pulley*
Refrigerant Pressure Switch	*Auxiliary Water Pump*
Low Side Service Port	*High Side Service Port*
IHKA Single Zone	*IHKA Dual Zone*

3. *Proceed to install the A/C Service equipment and demonstrate the proper procedure to Recycle refrigerant Evacuate and Recharge the A/C System.*

4. *Perform the cooling system bleeding procedure and list the steps below.*

5. *Perform the compressor run in procedure on your test vehicle and list the steps below.*

NOTES PAGE

Safety Precautions

The following safety precautions should be observed when working on an automotive refrigeration system:

- Always wear eye protection and gloves while handling refrigerant or servicing an air conditioning system.
- Avoid breathing R-134a vapor or mist; exposure may irritate eyes, nose, throat, and lungs.

- If refrigerant or compressor oil contacts the skin or eyes, rinse the affected area with warm water, administer first aid immediately, and consult a doctor.
- Use only, approved service equipment to discharge A/C systems.
- If an accidental discharge occurs, ventilate the work area.
- Store refrigerant service equipment and bulk supply containers in a cool, dry location away from direct sunlight and other heat sources (<113° F, (45° C).
- Do not expose refrigerant to an open flame, since burning refrigerant can produce poisonous gas. This includes open flames (such as in a propane leak detector), portable heaters, and lit cigarettes.
- Do not pressure-test service equipment or vehicle A/C systems with an air/R-134a mixture. Some mixtures of air and R-134a are combustible at elevated pressures. The use of compressed air for leak detection in an R-134a system could result in a fire or explosion.
- Never weld or steam-clean any part of the air conditioning system. Heating the refrigerant in a closed system could cause an explosion, due to the increased pressure.
- Always consider R-12 or R-134a to be under high pressure, whether in the automobile refrigeration system, service equipment, or refrigerant storage containers.
- R-134a should only be handled by competent, informed personnel using approved procedures and equipment. Failure to do so may result in serious injury and/or substantial equipment or vehicle damage.
- Removal of R-134a must be carried out using R-134a equipment that meets the requirements of SAE J2210.
- If accidental discharge occurs, ventilate the work area before resuming service.
- Exposure to high concentrations of refrigerant vapor can induce anesthetic effects such as weakness, dizziness, and nausea.
- Do not discharge refrigerant into the atmosphere; contain it.
- R134a is heavier than air; if discharged into the atmosphere, it can replace the air, causing suffocation.
- If R-12 is discharged into the air it damages the environment.

Note: Refer to repair instructions of group 64 for safety precautions when handling refrigerant oil (for refrigerant R 134a)

Workshop Exercise 1 - A/C System Diagnosis

*Using an instructor assigned vehicle, perform an **A/C Quick Check** on vehicle. Proceed to **Verify Customer Complaint** with diagnosis based on complaint listed below. Complete worksheet using proper format regarding, "Complaint/Cause and Correction".*

Vehicle: ____________ Chassis #: ____________ Production Date: ____________

Complaint: **AIR CONDITIONING INOPERATIVE**

Cause:

Correction:

Workshop Exercise 1 - A/C System Diagnosis

Turn vehicle on and set IHKA to max cool, allow system to stabilize. Check cabin/vent temperature and verify proper system performance based on ambient temperature and humidity.

What are the cabin and vent temperature readings and do they verify the customer complaint?

Hook-up the A/C service station or manifold gauges, then start the engine and set IHKA to max cool, allow system to stabilize while monitoring manifold gauges. Record the readings on the gauges provided below.

LOW Side ______ *psi.* *HIGH Side* ______ *psi.*

Vent ______ *F* *Ambient* ______ *F*

Turn off the engine and perform a visual inspection of controls, settings, belts, hoses and fittings looking for anything that may cause the customer complaint.

What should the correct pressures and vent temperatures be at the current outside temperatures and humidity?

Compare these to the normal gauge readings.
What do all these test result indicate?

What is your suggested plan of action to diagnose the problem?

Workshop Exercise 1 - A/C System Diagnosis

Turn vehicle on and set IHKA to max cool, allow system to stabilize. Check cabin/vent temperature and verify proper system performance based on ambient temperature and humidity.

Connect the BMW diagnostic equipment, perform Short Test and list any Fault codes below.

Are any of the recovered Fault Codes related to this problem?

Is there a symptom in the Symptoms Menu that applies to our customer's complaint?

If yes, follow the Test Plan to completion and list the main steps below.

What conclusions did you arrive to from following the test plan in the Symptom's Menu.

If you chose your own Test Plan, List your actions below.

Where do you think the problem is?

Based on instructor evaluation:
Return this vehicle to the condition you found it and move on to the next exercise or correct the problem and retest.

NOTES PAGE

Workshop Exercise 2 - A/C System Diagnosis

*Using an instructor assigned vehicle, perform an **A/C Quick Check** on vehicle. Proceed to **Verify Customer Complaint** with diagnosis based on complaint listed below. Complete worksheet using proper format regarding, "Complaint/Cause and Correction"*

Vehicle: ______________ Chassis #: ____________ Production Date: ______________

Complaint: **AIR CONDITIONING "COOL BUT NOT REALLY COLD"**

Cause:

Correction:

Workshop Exercise 2 - A/C System Diagnosis

Using an instructor assigned vehicle perform the A/C Quick Check.
*With the engine **off** perform a preliminary visual inspection. Connect the A/C service station or manifold gauge, run the engine and A/C on MAX and record pressure readings below.*

Analyze the system and record pressure readings ,vent and outside temperature.

LOW Side ______ *psi.* *HIGH Side* ______ *psi.*

Vent ______ *F* *Ambient* ______ *F*

Compare these to the normal gauge readings.
What may all these readings indicate?

____

____

____

According to these readings what should be done next?

____

____

Following the A/C service station's instructions perform the refrigerant recycle procedure.
Why is it important to note the amount, if any of refrigerant that is recovered at this stage?

____

____

____

Perform a complete evacuation of the system, observing that both gauges (high and low) register a steady and continuous vacuum reading for at least ______________ minutes.

Why is it important to note the amount, if any of refrigerant **OIL** that is recovered at this stage?

____

____

____

Why is it necessary to continue pulling a vacuum on the system even after it was fully evacuated and is now empty?

____

____

____

When would a longer evacuation time be necessary?

____

____

____

Workshop Exercise 2 - A/C System Diagnosis

Answer the following questions based on what you know up to now.

Make sure the system holds vacuum for at least 5 minutes.
Why is it imperative that the system hold vacuum for at least 5 minutes?

If the vacuum **holds**, can the system still be leaking?

If the vacuum does **not hold**, what is the necessary course of action?

What tools can we use to pinpoint this refrigerant leak.?

If the refrigerant leak is large enough, it may be detected during the visual inspection.
What are we looking for as visual evidence that a component is possibly leaking?

What is the procedure necessary to pinpoint a refrigerant leak that was not detected by visual inspection, the vacuum hold test or the electronic leak detector?

What pre-condition is best for detecting a suspected refrigerant leak in the liquid line of an A/C system?

Workshop Exercise 2 - A/C System Diagnosis

What pre-condition is best for detecting a suspected refrigerant leak in the Low side of an A/C system?

What tool is preferred when diagnosing an evaporator for refrigerant leaks and Why?

What characteristic of refrigerant we must keep in mind when diagnosing a refrigerant leak with an electronic leak tester?

Using the appropriate leak detection method pinpoint the refrigerant leak and state your findings below.

What procedure has been approved by BMW to TEST empty evaporators with out removing them from the vehicles?

Based on instructor evaluation:
Return this vehicle to the condition you found it and move on to the next exercise/vehicle or continue this exercise by:

1. *Follow the appropriate procedure to pinpoint the refrigerant leak.*
2. *Proceed to recharge the refrigerant system properly.*
3. *Re- test the system for leaks.*
4. *Evaluate system performance to make sure it is back to original working order.*

NOTES PAGE

Workshop Exercise 3 - A/C System Diagnosis

*Using an instructor assigned vehicle, perform an **A/C Quick Check** on vehicle. Proceed to **Verify Customer Complaint** with diagnosis based on complaint listed below. Complete worksheet using proper format regarding, "Complaint/ Cause and Correction"*

Vehicle: ______________ Chassis #: ____________ Production Date: ______________

Complaint: **"AIR CONDITIONING NOT COLD ENOUGH" (POOR PERFORMANCE)**

Cause:

Correction:

Workshop Exercise 3 - A/C System Diagnosis

Using an instructor assigned vehicle perform the A/C Quick Check and a preliminary visual inspection -
Connect the A/C service station or manifold gauge, run the engine and A/C on MAX to stabilize the system pressures.
Check the vent temperatures and refrigerant pressures and record them below.

Vent ________ *F* *Ambient* ______ *F*

LOW Side ______ *psi.* *HIGH Side* _____ *psi.*

Compare these to the normal gauge readings.

What may all these readings indicate?

____

____

Based on observations, describe what is happening in the system.

____

____

____

What is the recommended next step in this diagnosis?

____

____

Fill in the blanks.

Following the A/C service station's instructions:

Perform the procedure to _____________ the refrigerant.

How much refrigerant was in the system?

____

____

How much refrigerant does the system specify?

____

____

What is the difference between the specified refrigerant amount and the refrigerant recovered?

____

____

____

What did this test confirm?

____

____

Evacuate the system and note the amount of _______ recovered.

Why is this last step important?

____

____

____

Workshop Exercise 3 - A/C System Diagnosis

How much oil should you add to this system?

Based on the previous test results proceed to recharge the system properly.
How much refrigerant does the system call for?

Based on instructor evaluation:
Return this vehicle to the condition you found it and move on to the next exercise/vehicle or continue to next step.

Proceed to recharge the system with the correct amount of refrigerant.

Evaluate system performance to make sure it is back to original working order.

NOTES PAGE

Workshop Exercise4 - A/C System Diagnosis

*Using an instructor assigned vehicle, perform an **A/C Quick Check** on vehicle. Proceed to **Verify Customer Complaint** with diagnosis based on complaint listed below. Complete worksheet using proper format regarding, "Complaint/ Cause and Correction"*

Vehicle: ______________ Chassis #: ____________ Production Date: ______________

Complaint: **"POOR PERFORMANCE AFTER A SHORT DRIVE"**

Cause:

Correction:

Workshop Exercise 4 - A/C System Diagnosis “Poor A/C performance after a short drive”

Using an instructor assigned vehicle install A/C Manifold Gauges and BMW Diagnostic Equipment.

LOW Side ______ *psi.*   *HIGH Side* ______ *psi.*

Vent Temp. ______ *F*   *Ambient Temp.* ______ *F*

Interior Temp. ______ *F*   *Engine Temp.* ______ *F*

Analyze the system and record pressure, temperature readings.
What may these readings indicate?

____

____

____

Perform a short test on the vehicle.
List any faults related to the Customer Complaint.

____

____

____

CAUTION!!!

ENGINE MAY RUN HOT !!!

Select the symptoms path on the BMW Diagnostic Equipment.
Is there a symptom listed that applies to this customer complaint?

____

____

____

____

If “YES” follow Symptom test plan and list findings below.

____

____

____

____

If “NO” what course of action may all these readings indicate in other to correct the problem?

____

____

____

Correct the problem, retest if necessary then restore the vehicle to proper operating condition.

Workshop Exercise 5 - A/C System Diagnosis

Using an instructor assigned vehicle, install A/C Manifold Gauges and BMW Diagnostic Equipment.

Set the A/C to MAX cooling, allow the system to stabilize and verify the proper refrigerant pressures.

STOP THE ENGINE
Disconnect the cooling/condenser fan harness connector.
Restart the engine and set the A/C to MAX.
Pay close attention to engine temperature as you observe what happens and explain below.

____

____

____

____

Analyze the system and record pressure , temperature readings below.

LOW Side ______ *psi.* *HIGH Side* ______ *psi.*

Vent ______ *F* *Ambient* ______ *F*

Interior ______ *F* *Engine* ______ *F*

CAUTION!!!

DO NOT OVERHEAT THE ENGINE !!!!

Shut down the engine, connect the fan and answer the following questions.

What happened to the Low Side pressure? ____________________

How high did the High Side gauge go? ____________________

Why do you think this occurred?

____

____

____

Why did the High Side eventually come down?

____

____

____

At what pressure did the High Side go back up? ____________________

Why do you think this occurred?

____

____

____

Classroom Exercise - A/C Gauge Reading Diagnosis.

A/C cold initially but then turning warm again. Outlet temperature changes constantly between cold and warm.

Low Side, unsteady low to vacuum readings, High Side, high to very high unsteady readings with Icing on expansion valve.

What may the pressure readings above indicate?
Check the best possible answer.

Defective evaporator temp. sensor

Inoperative auxiliary fan

Over charged system

Based on the previous readings, what is the recommended next step in this diagnosis?
Check the best possible answer.

Check IHKA inputs/outputs

Recycle the refrigerant and recharge correctly

Check the auxiliary fan circuit

If a diagnostic check of IHKA inputs and outputs reveals no faults or problems what could the problem be?

____

____

____

____

____

Based on the previous statements and clues, which solution do you think may correct this vehicle's A/C problem?

Check the best possible answer.

- **Recycle the refrigerant**
- **Replace the Condenser**
- **Add the correct oil charge**
- **Recharge the system to specifications.**

- **Recycle the refrigerant**
- **Replace the Dryer**
- **Evacuate the system**
- **Add the correct oil charge**
- **Recharge the system to specs**

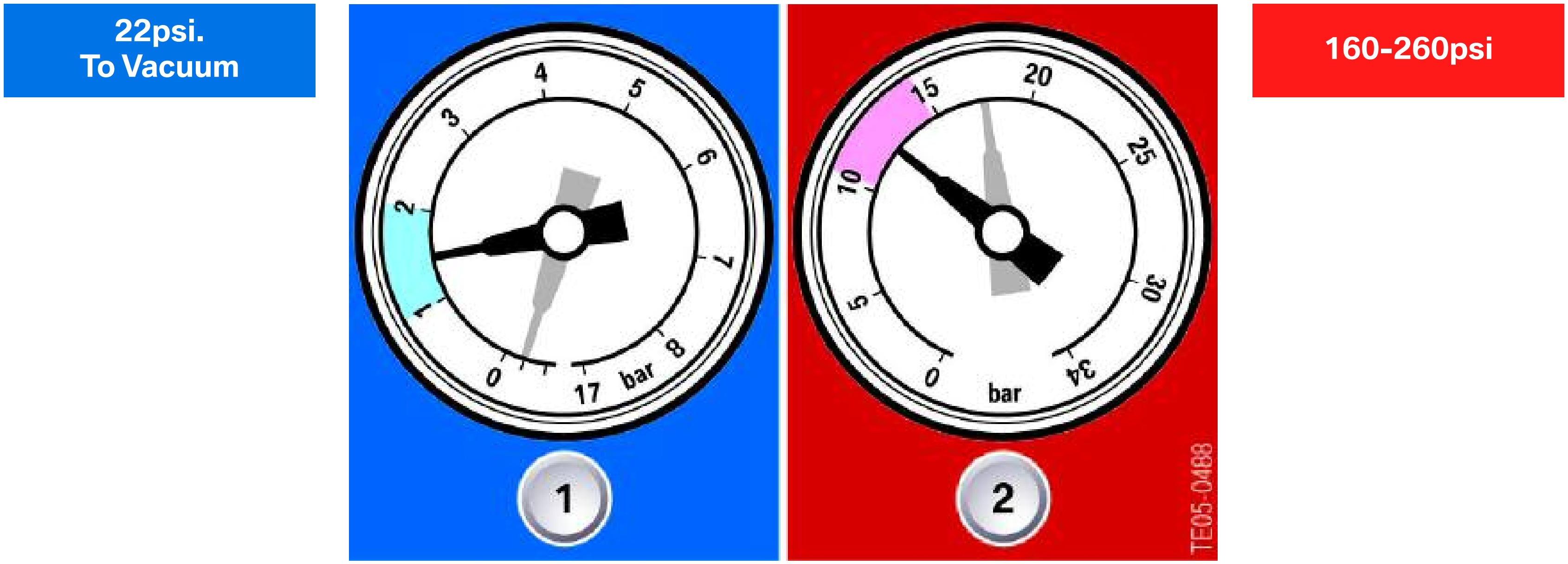
- **Recycle the refrigerant**
- **Replace the Evaporator Sensor**
- **Recharge to the correct amount**
- **Add the correct oil charge**

- **Recycle the refrigerant**
- **Flush the system**
- **Evacuate the system**
- **Recharge the system**
- **Add the correct oil charge**

NOTES PAGE

Typical Symptoms Complaint/Cause/Correction

Outlet Temperature Initially Cold then Warm

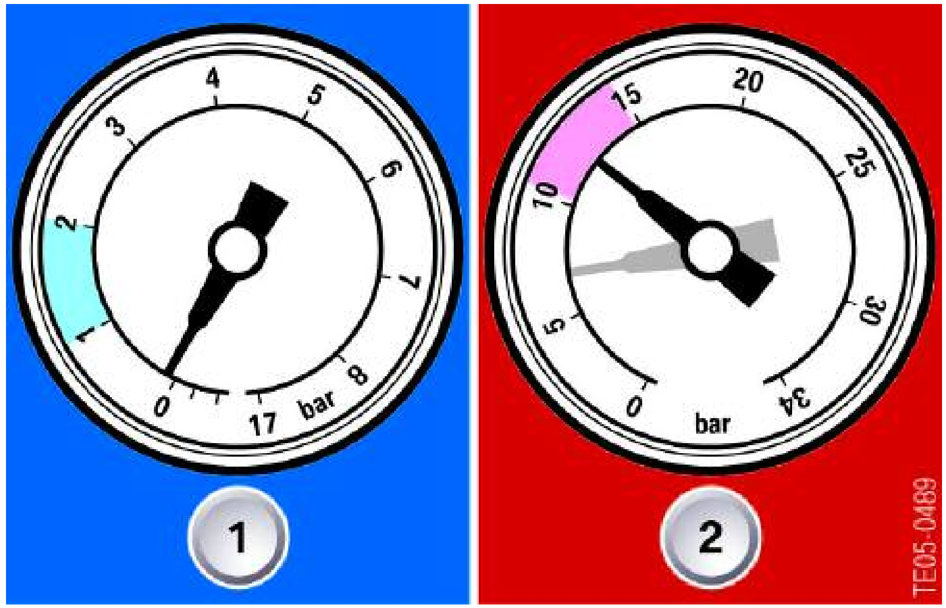


1 = Low pressure - normal to too low 2 = High pressure - normal to too high

Symptoms	Possible faults	Repair
• Outlet temperature is initially cold but then warm. • Evaporator/expansion valve partly ices up and then thaws again. • High pressure increases, low pressure drops to vacuum range. • Evaporator ices up before the compressor is switched off. • Slow compressor switching cycles.	Moisture in refrigerant circuit.	Recycle and Evacuate the system, replace the dryer and recharge.
	Temperature sensor for evaporator defective.	Check evaporator temperature sensor and replace if necessary.
	Faulty pressure sensor or signal.	

Outlet Temperature Not Cold at All

Low
To Zero psi.



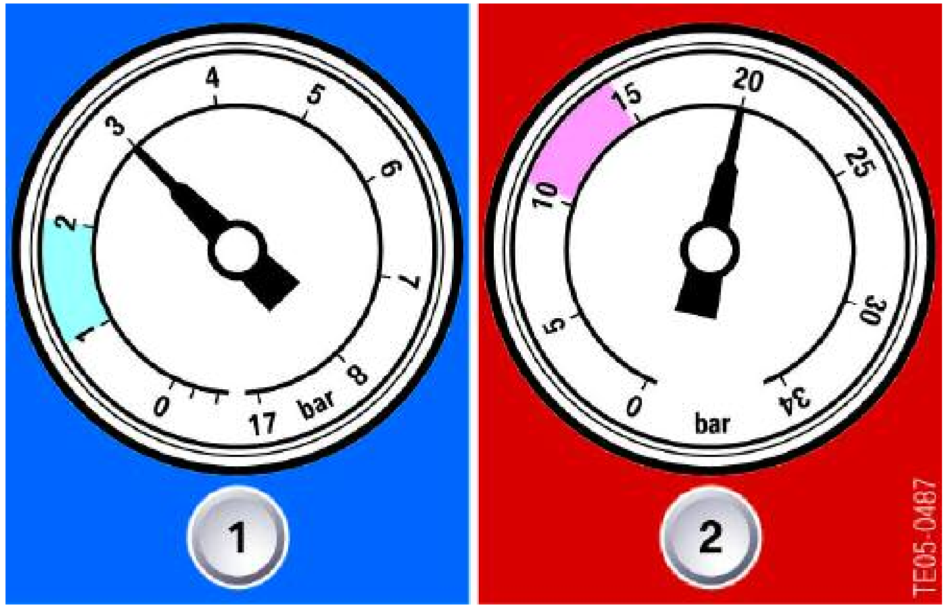
100-180psi.

1 = Low pressure - too low
2 = High pressure - normal to too low

Symptoms	Possible faults	Repair
• Outlet temperature not cold enough "only a little cool but not really cold".	Low refrigerant refrigerant in the system.	Evacuate system, compare amount of refrigerant removed to required system capacity. Check for leaks, correct and recycle and recharge refrigerant to specific level.
	System leaks.	Check for leaks and repair them, replace the component in question. Recycle, recharge the system to specifications and re-check.
	Failed expansion valve.	Replace expansion valve and dryer, recycle, evacuate and recharge the refrigerant to specifications and leak test.
	Defective compressor.	Replace the compressor, receiver dryer, evacuate, recharge to specifications and leak test.
	Partial blockage of the receiver dryer.	Recycle refrigerant, replace the dryer, evacuate the system, recharge to specification and leak test.

Outlet Temperature Cool but Not Cold

44psi.



295psi.

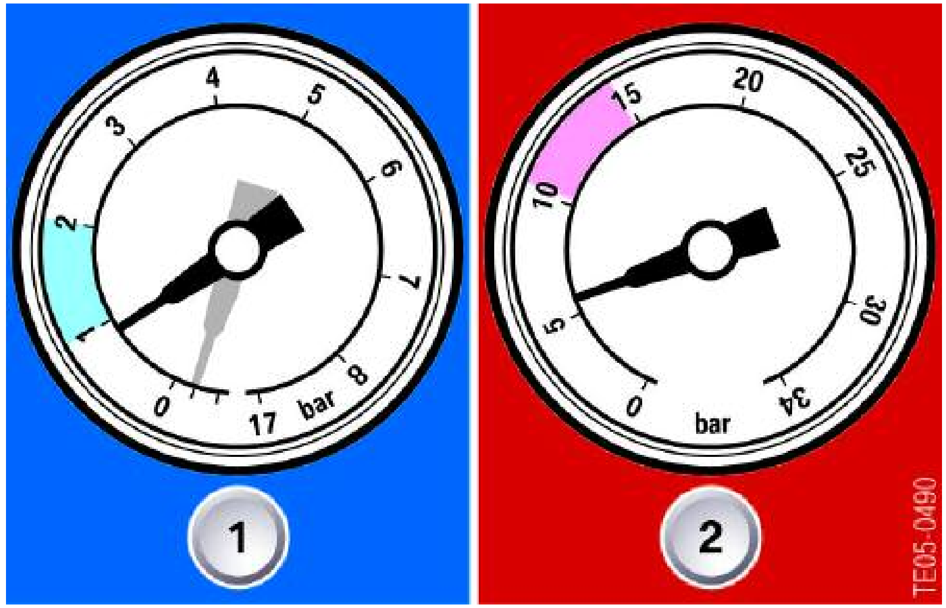
1 = Low pressure - too high

2 = High pressure - too high

Symptoms	Possible faults	Repair
• Outlet temperature cool but not cold. • Low side pipes hot to the touch.	Air in the system.	Leak test, replace dryer, evacuate, recharge to specifications and retest for leaks.
	Too much refrigerant in the system.	Recycle the refrigerant, evacuate the system and recharge to specifications.
	Condenser blockage/dirty fins.	Check condenser fins for debris or damage and correct.
	Condenser fan is not cooling.	Check operation of condenser fan (fuse, relay, wiring, motor, stiff movement) and correct.
	Expansion valve does not close.	Check installation and operation of temperature sensor, then replace expansion valve and dryer, Recycle, recharge and leak test.

Low Cooling Performance with Icing at TEV

**15psi.
To Vacuum**



80psi.

Note: Check valve for obstructions such as dryer granulate, or metal chips from the compressor. If found, flush the entire system, blow out with air and replace any suspected component.

1 = Low pressure - too low

2 = High pressure - too low

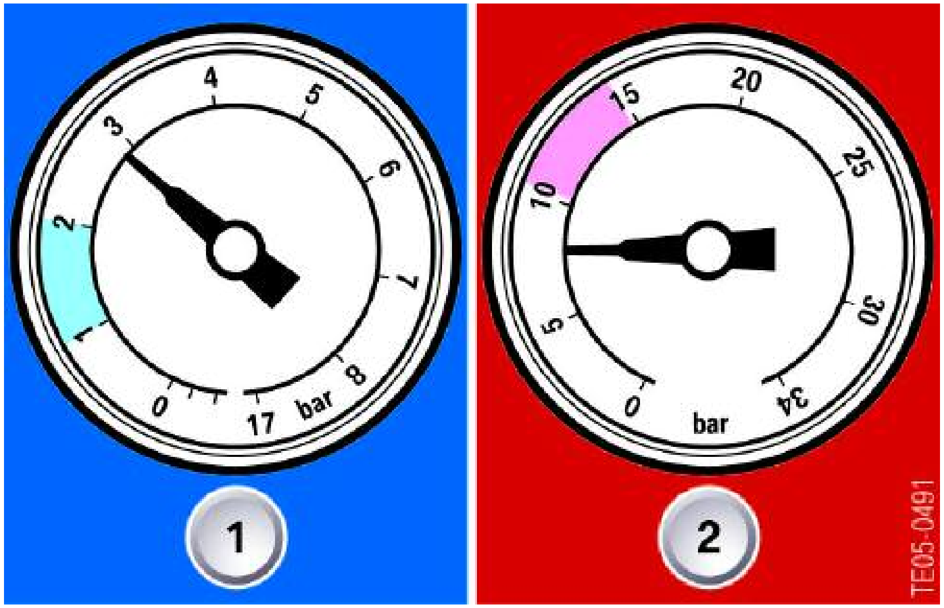
Symptoms	Possible faults	Repair
• Outlet temperature not cold enough "only a little cool and not really cold". • Low pressure may drop into vacuum range. • Visible icing on refrigerant lines from/to dryer.	Moisture in the system.	Leak test, recycle the refrigerant, replace dryer, evacuate, recharge and retest for leaks.
	Expansion valve blocked/does not open.	Check installation and operation of temperature sensor. Isolate blockage. Recycle refrigerant, replace expansion valve and or receiver dryer. Evacuate, recharge to specifications and leak test.
	Filter dryer clogged, acts as throttle, refrigerant expands in line before expansion valve.	

Not Cold with Loud Compressor Operation

44psi.

100psi.

Note: If metal chips are found, flush clean the entire system, replace the dryer, expansion valve and or any contaminated components, recharge and re-test.



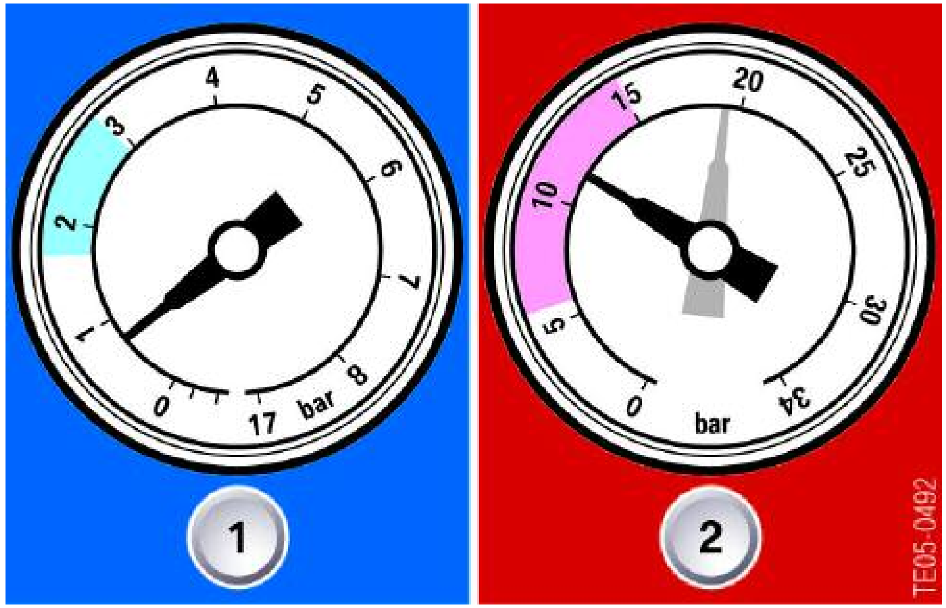
1 = Low pressure - too high

2 = High pressure - too low

Symptoms	Possible faults	Repair
• Outlet temperature insufficiently cold "not cold enough". • Compressor is loud. • Reduced compressor output.	Compressor drive belt slipping.	Check for correct tension of drive belt and replace belt if necessary.
	Magnetic clutch of compressor defective or incorrectly set air gap/clearance.	Check operation of magnetic clutch, temperature/pressure switches, wiring, fuse / relay, control unit), adjust air gap if necessary.
	Compressor may be mechanically defective.	Replace compressor, charge the system to specifications and check for proper operation.

Not Cold with Visible Icing Near Dryer

12-15psi.



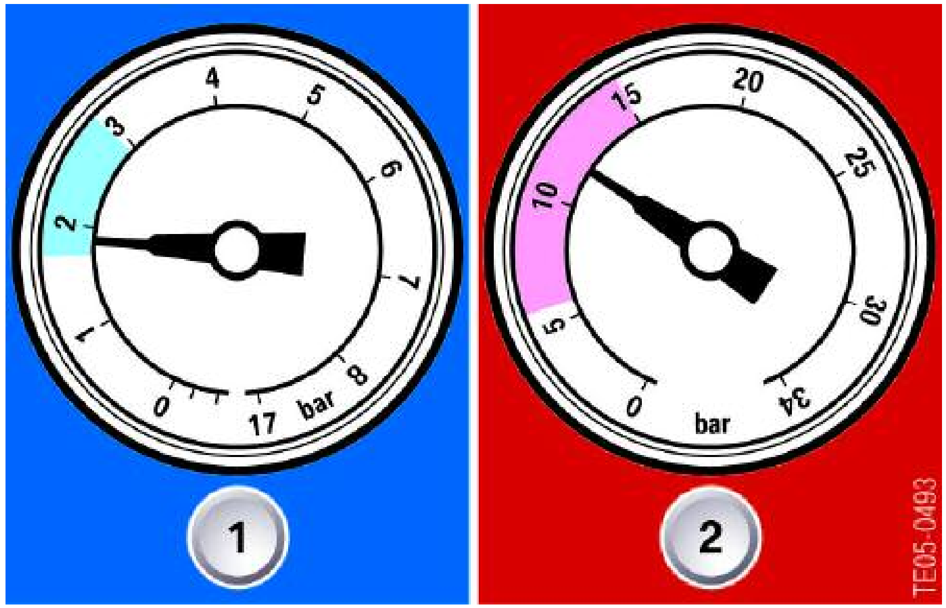
180-290psi.

1 = Low pressure -too low   2 = High pressure - normal to high

Symptoms	Possible faults	Repair
• Poor or no cooling performance. • Visible condensation or icing on lines or on component.	Blockage on high pressure side, generally in dryer.	Isolate the blockage, recycle the refrigerant. Locate and repair blockage, replace the dryer, recharge to specifications, check for leaks and verify systems operation.

Not Cold with Compressor Frequent Cycling

28psi.



180psi.

1 = Low pressure - low normal   2 = High pressure - normal

Symptoms	Possible faults	Repair
• Outlet temperature is not cold enough ("only a little cool but not cold enough"). • Frequent compressor switch-on cycles (short operation and short cut-out times).	Temperature sensor for evaporator is defective switches incorrectly.	Check evaporator temperature sensor. Verify electrical connection and replace if necessary.

Climate Control Systems

There are a few different types of BMW climate control systems. Most of the current US vehicles are equipped with fully automatic climate control systems (IHKA). Each climate control system has different features and functions depending upon the vehicle application.

IHKS

Translated from German, the acronym means “Integrated Heating and Air Conditioning Control. This system does not regulate the interior temperature of the passenger compartment automatically. IHKS is single zone system, controlled directly by the driver to achieve the desired level of comfort and was installed on the E36/5(318ti), E36/7(Z3) and the E52 Z8 as standard equipment.

IHKR

The IHKR system is a “semi-automatic” climate control system. Interior air temperature is controlled automatically, but air distribution and blower speed are controlled from the control panel by the driver. IHKR was used on the some early vehicles such as the E34 and E36 (up to 95). The most recent use of the IHKR system was on the E39 525, E53 X5 3.0, E46 325 and the E85 Z4 as standard equipment (IHKA was available as an option). IHKR is also a single zone system, with only one temperature control for the entire passenger cabin.

IHKA

This is a fully automatic climate control system. Air distribution, blower speed and temperature regulation are controlled automatically. The system is designed to maintain the driver desired temperature setting automatically by monitoring interior temperature. The IHKA system is a dual zone system, with 2 temperature controls with some exceptions (the E46, E85 and E83 X3 with basic single zone IHKA). IHKA was first installed on 7 and 8 series vehicles. The system was added to the 3 series (E36, E46), then to the 5 series E39, E53 and it is currently available on all US models.

FKA (E70)

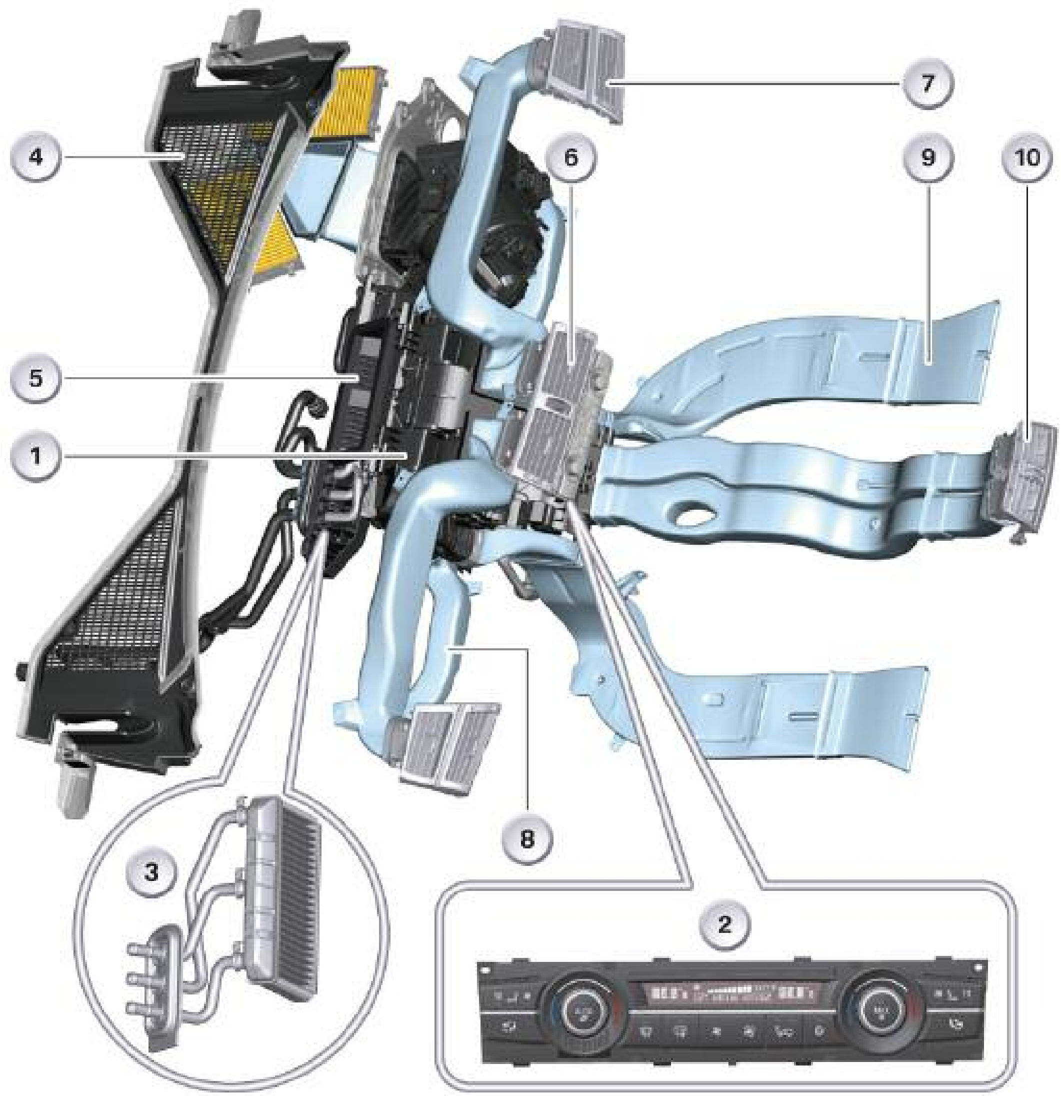
This is a rear climate control system that is available currently on the E70 X5. By combining IHKA with FKA the system is considered to be a true 4 zone system. Every passenger has the option to change the temperature of his sitting area independently with respect to the other occupants.

FKA (E66)

This is a Rear Compartment Air Conditioning system (FKA), available as an option on the E66. The rear compartment air conditioner is located in the front area of the luggage compartment. The control and integration of the rear compartment air conditioning system in the IHKA refrigerant circuit is designed so that independent operation is possible for either the front or rear unit.

Note: BMW Climate Control Systems may be Coolant (water) Temperature Regulated or Air Temperature Regulated depending on the model.

E70 Dual Zone IHKA



E70 Dual Zone IHKA

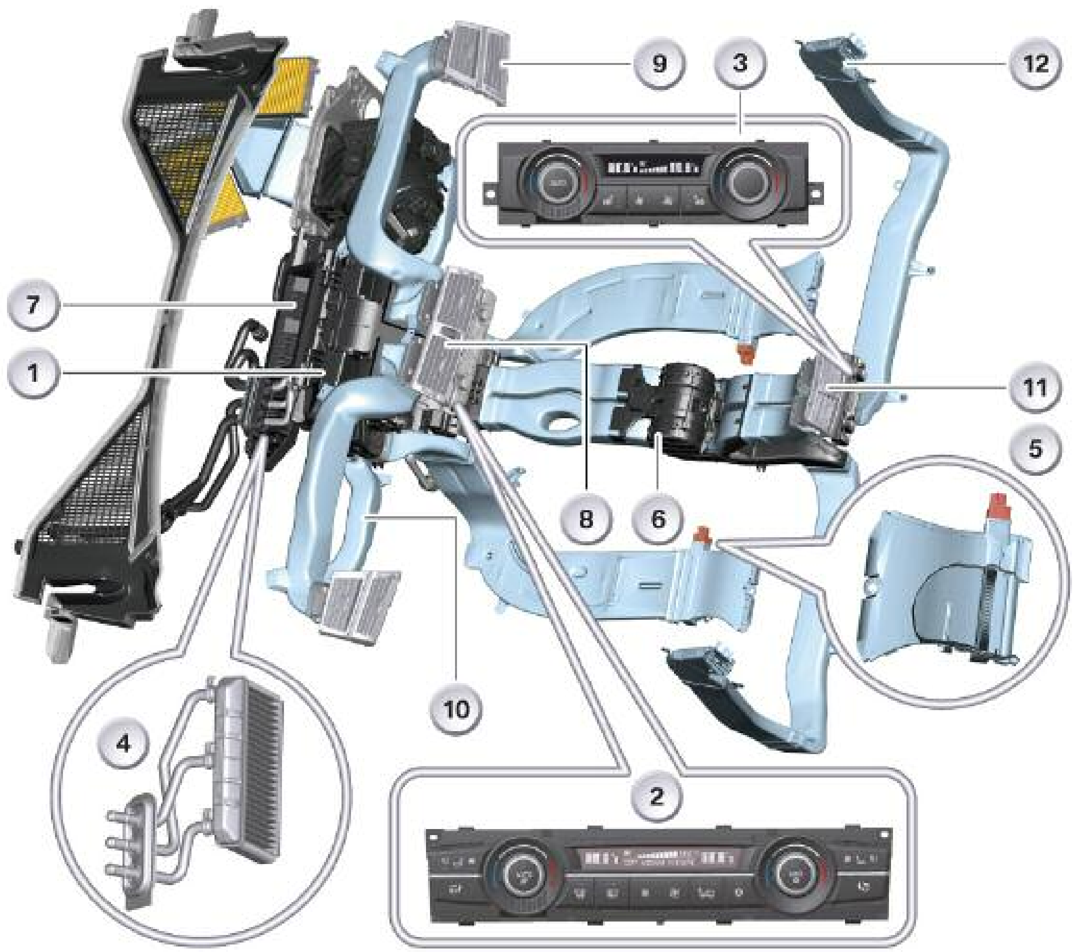
Fresh air or recirculated air can be routed directly to the air ducts via the evaporator and appropriate bypass, without being routed through the system's heater core. The air flow (fresh air or recirculated air) is first routed via the evaporator in the heating/ air-conditioning housing, provided that the A/C compressor has been activated, cooled and then heated to the required temperature via the heating system.

Due to its dual section heater core, the IHKA allows separate and individual 2- zone, right/left temperature control. This is achieved in part, through the use of left and right temperature sensors. The desired temperature is fine tuned via two water control valves (left/right). The water flow through the heater core is aided with the use of an auxiliary water pump in the case of vehicles with the N62 engine (the N52 engine has an electric water pump thus no auxiliary pump is needed)

Index	Explanation	Index	Explanation
1	IHKA, 2-zone	6	Ventilation air outlet, front center, left/right
2	IHKA operating unit with right & left temp. controls.	7	Ventilation air outlet, front left/right
3	Two inlet pipes to HWT, two water valves	8	Footwell air outlet, front left/right
4	Fresh air intake	9	Footwell air ducts, rear left/right
5	Defrost air outlet	10	Ventilation air outlet, rear left/right

Note : E70 Dual Zone IHKA uses ten actuator motors and flaps.

E70 IHKA 4-zone with FKA rear automatic A/C System



E70 Four Zone IHKA with FKA

The 4-zone climate control system consists of the standard 2-zone IHKA plus:

- Its own FKA controls
- Four additional outlet temperature sensors
- A separate rear blower
- Air ducts and outlets in the B-pillars
- Two separate PTC heating elements in the rear footwell air ducts
- Three additional actuator motors for air flap control of the system (IHKA with FKA, total of thirteen actuator motors)

Index	Explanation	Index	Explanation
1	IHKA with rear automatic A/C system, 4-zone.	7	Defrost air outlet
2	IHKA, dual front temperature controls	8	Ventilation air outlet, front left/right
3	FKA, dual rear temperature controls	9	Ventilation air outlet, front left/right
4	Two inlet pipes to HWT, two water valves	10	Footwell air outlet, front left/right
5	PTC heating element in footwell air ducts rear left/right	11	Rear ventilation air outlet, center, left/right
6	Rear blower (FKA)	12	Ventilation air outlet, B-pillar left/right

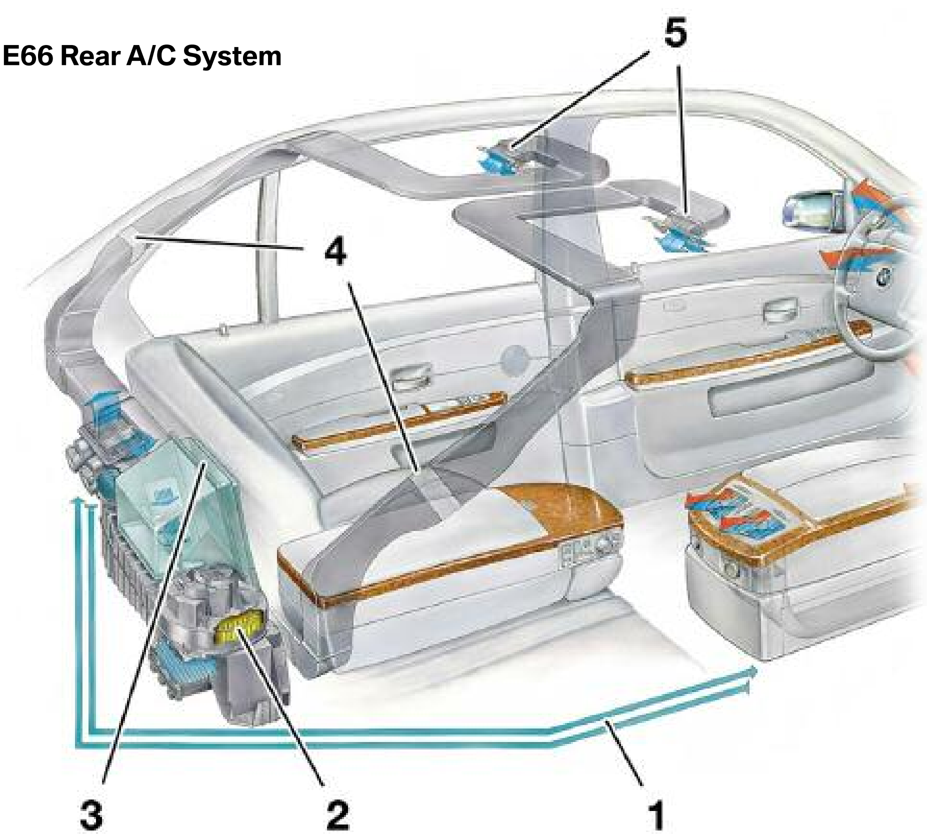
E66 Rear Air Conditioning FKA

From E66 series launch, a Rear Compartment Air Conditioning system (FKA) may be installed as an option. The rear compartment air conditioner is located in the front area of the luggage compartment and consequently reduces the volume of the luggage compartment by about 20 percent (incl. trim panels).

The control and integration of the rear compartment air conditioning system in the IHKA refrigerant circuit is designed so that independent operation is possible for either the front or rear unit.

The air required for rear compartment air conditioning is drawn in via a particle filter (recirculated air filter) from the luggage compartment with the use of a rear blower fan.

E66 Rear A/C System



The rear system shares some of the Main (front) A/C system's components like compressor, condenser and dryer and the operate independently from each other separated by two refrigerant shut off valves.

Operation of the rear air conditioning system from two separate control panels and takes place by means of push-buttons and rotary knobs, of which only those on the right are "intelligent." These two control panels must be matched with respect to each other; i.e. the right-hand control panel must be calibrated with the exact end stop values of the potentiometers of the left-hand control panel. (Refer to the relevant service information on TIS)

The rear compartment air conditioning system additionally supplies cold air to an integrated refrigerator box. This refrigerator box should not be confused with the electrically operated refrigerator box that is optionally available also for the E65.

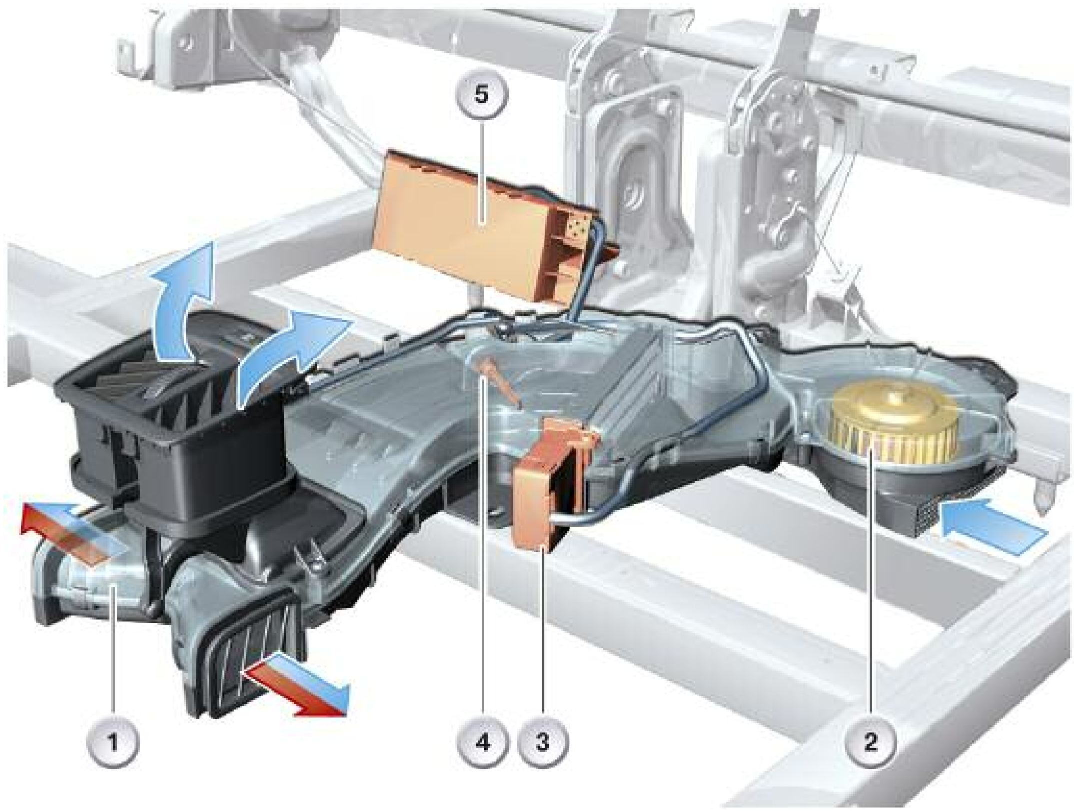
Index	Explanation
1	Pressure and suction refrigerant line.
2	Blower and recirculated air filter.
3	Rear compartment refrigerator box
4	Left/Right ducts to roof outlets.
5	Left/Right outlets in control units.

Note: Filling mode can be activated via the diagnosis interface for the rear compartment air conditioning system. In this mode, both refrigerant shut-off valves (front/rear) are opened, allowing complete recovery of the refrigerant charge.

E70 Third Row Heating/Ventilation

The E70 with 3rd row seats uses a heating and ventilation system referred to as HB3SR. The blower is switched on and off using the button near the center air outlet. The air distribution at the ventilation air vents in the third row seats is controlled using a knurled adjusting wheel with control flap. A PTC heating element is activated via the limit position switch operated by the knurled adjusting wheel.

E70 HB3SR System General View



E70 HB3SR Vent and control location

Index	Explanation
1	System unit for heating and ventilating the 3rd row of seats
2	Ventilation blower and heating for 3rd row of seats, recirculated air intake
3	PTC heating element
4	Auxiliary heating temperature sensor
5	HB3SR control unit

Note: HB3SR is NOT a rear air conditioning system and it operates independently from the IHKA and FKA Systems.The only link with the vehicle electronics is for power management.

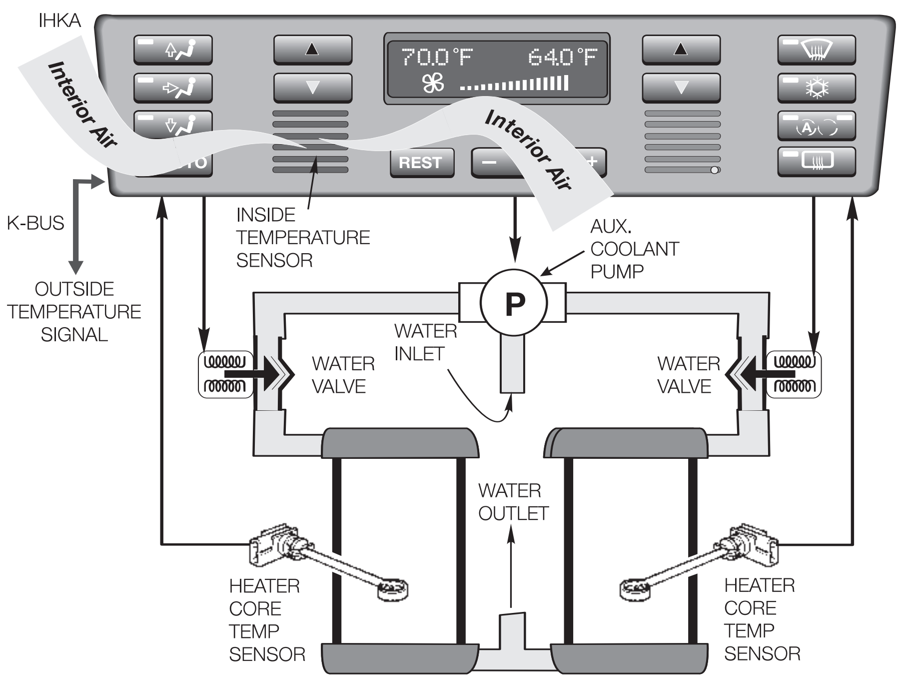
Water-based Temperature Controlled IHKA

Although IHKA is available in single and dual zone, most current BMW vehicles are dual zone systems.

Due to the split design of a dual section heater core, the dual zone IHKA allows for separate 2- zone right/left temperature control by varying the water temperature on either side of the system.

The heater core uses two temperature sensors and the temperature is controlled via two water valves (left/right) that regulate water flow through the system based on the requested Driver/Passenger temperature settings. These water valves are electrically pulsed and are typically sprung open when deactivated.

Typical Dual Zone Water Temperature Controlled System



The water are valves pulsed to regulate temperature based on the following inputs:

- Left/Right temperature settings
- Left/Right heater core temperatures
- Outside temperature
- Interior temperature
- "Y" factor

An auxiliary water pump is used to ensure the adequate volume of coolant through both sides of the heater core to comply with the system's requirements. This pump is Typically powered directly from the IHKA control module through a final stage output.

The auxiliary pump is used to supply coolant for the REST feature of the IHKA, although not all models use one. Some current vehicles use electric main water pumps and no longer need auxiliary water pumps.

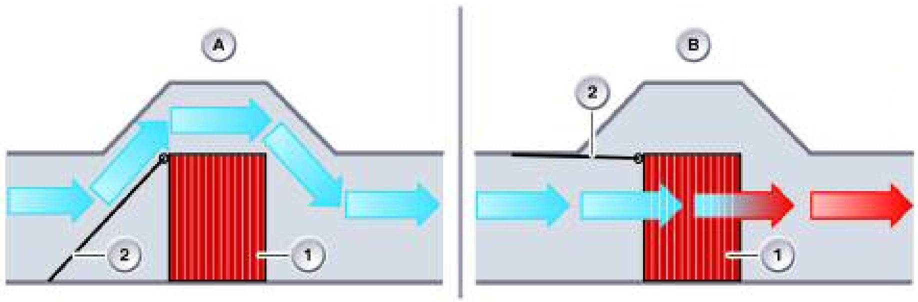
The air-mass flow (fresh air or re-circulated air) is first routed via the evaporator in the heating/air-conditioning housing (provided that the compressor has been activated) to be cooled, dried and then heated to the required temperature via the heating system heater core. The air is cooled and dried in the evaporator at the same time and the condensation is led away via the drains of the heater/AC air box.

Fresh air or re-circulated air can be routed directly to the air ducts via the evaporator and appropriate bypass, without being routed through the heating system heater core.

Note: Current vehicles that use Water-based Temperature are E53, E6X, E70, E83.

Air-based Temperature Controlled IHKA

The temperature for the best possible interior climate in an air controlled system is regulated with a mixer flap in this type of system. A water valve that controls the water flow rate through the heater core (as in the water base system) is not used in an air-based temperature control system. A temperature mixer flap is integrated in the heater/air box housing and is used for adjusting the requested temperature.

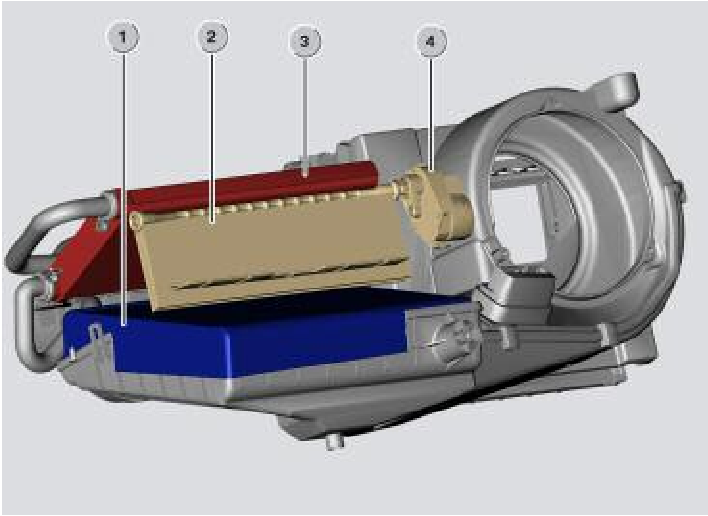


Index	Explanation	Index	Explanation
A	Heating off	1	Heat exchanger
B	Heating on	2	Temperature mixer flap

When the temperature mixer flap routes the fresh air or recycled air through the heater core completely, maximum heating capacity is realized. When it is not necessary to heat the air, the heater is covered off by the temperature mixer flap and the air is deflected away. A corresponding proportion of cold air to warm air is mixed with the flap in the intermediate positions, thus achieving and controlling the out let temperature in the vehicle based on the requested customer settings and calculated values. The temperature mixer flap is operated by a stepper motor which is controlled by the IHKA/IHKR control unit.

This type of temperature control is used on the E85 as a single zone as well as in the E9X vehicles as a dual zone.

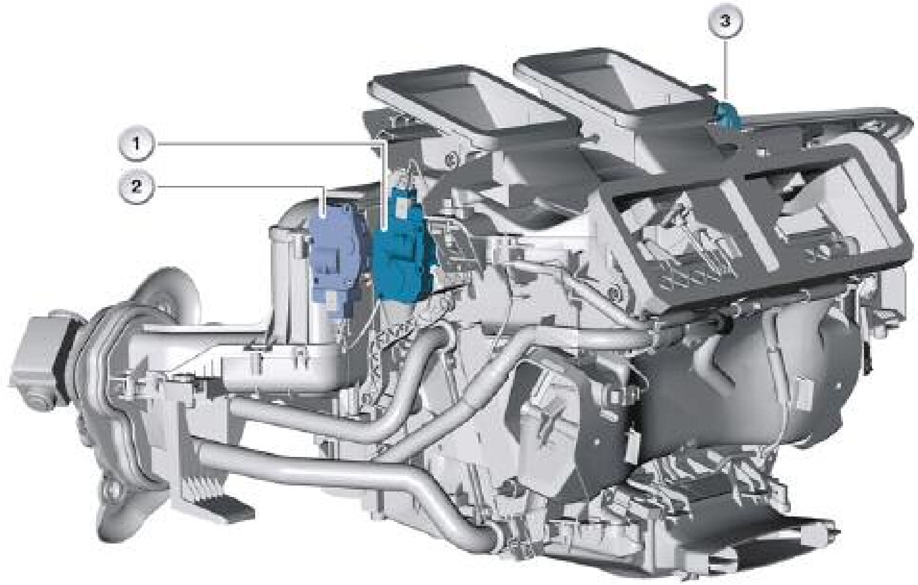
E85 IHKS Temperature Control Flap



Index	Explanation
1	Evaporator
2	Mixed air flap
3	Heater core
4	Stepper motor, mixed air flap

A disadvantage of this control system is the large package space it requires. In the case of complaints ("poor heating output" or residual heating in "cold" setting) particular care must be taken to ensure that the mixer flap rests snugly on the stops in the corresponding end positions.

As in the water-based temperature control system (signal for water valves), the control variable signal Y is calculated from the temperature set-point and the various temperature sensors (Y Factor). The respective position of the temperature mixer flap is derived from this signal. It also determines the position of the air distribution flaps as well as the automatic blower output control when the automatic button is pressed.



E90 Air Temperature Controlled System

Index	Explanation
1	Stepper motor, air mixing flap, left
2	Stepper motor, air blending, front
3	Stepper motor, air mixing flap, right

The temperature for the best possible interior climate in an air controlled system is regulated with a mixer flap in the heater/air conditioner.

Coolant flow is constant in the heater core as the mass air flow is fed through the evaporator. As this happens, the air is cooled and dried (providing the air-conditioning system is switched on). The mixer flap then feeds the air completely or in part over the heating system heater core, depending on the desired temperature value set at the IHKA control panel the air flow is subsequently mixed again. The air-mass is then fed through the ventilation flaps and into the vehicle interior.

The temperature inside the vehicle is controlled by means of a master controller. Control is based on the nominal values set and the calculated actual value (the nominal values are the requested temperature settings). The actual value is calculated from the temperatures measured by the interior temperature sensor and the footwell temperature sensor.

The lead parameter is calculated from the comparison between the actual value for the interior temperature and the corrected nominal value (calculated from temperature request, interior temperature and ambient temperature).

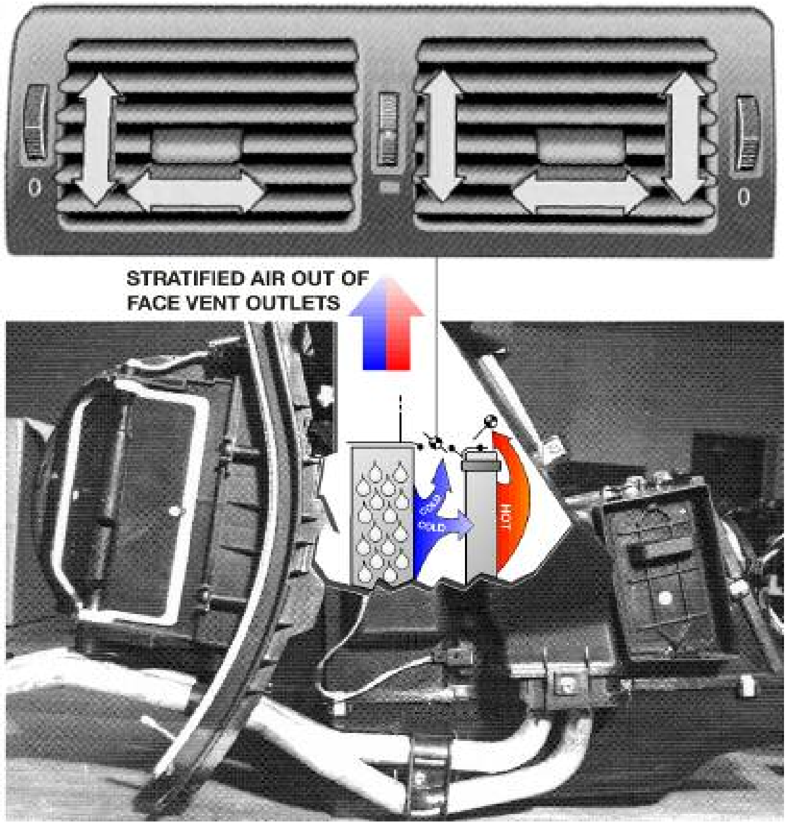
Compared to the set specification, the interior temperature is raised in the cold so that a comfortable level is achieved even at negative temperatures, despite the temperature setting being unchanged. A separate temperature setting for the driver's side and the front-passenger side makes 2 mixer flaps necessary for a dual zone system.

Vent Temperature Stratification

Stratification in the climate control system refers to the mixing of the air temperature at the outlet vents. Hot, warm or cold air can be adjusted as it comes out of the front or rear outlet vents no matter what main temperature setting was selected on the IHKA. This is realized by mixing hot and cold air with the use of blend air flap.

Front stratification refers to the components necessary to adjust the dash outlet vent temperature to the occupant’s preference. Rear stratification refers to the rear passenger compartment air delivery vents.

Thumbwheel adjusters on or near the vents are the typically connected to the mixing flaps mechanically (Bowden cable) or electronically (Potentiometers and stepper motors).



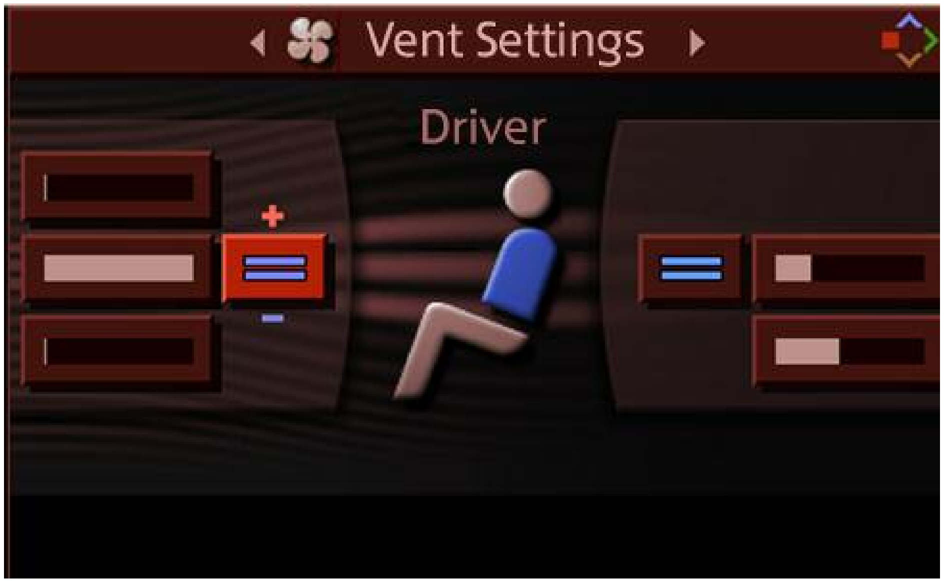
Typical Stratification Process

Stratification is realized mechanically and electronically:

- Mechanical stratification is through the use of a Bowden cable connected from the air mixing flap to a thumbwheel adjuster mounted on or near the vent.
- Electronic stratification adjusts the air mixing flaps with the use of stepper motors.

The adjustment is done by manipulating the air mixing flap depending on:

- Thumbwheel and Bowden cable position (mechanical)
- Vent outlet temperature sensor readings
- Occupant requested settings (Potentiometer position at the thumbwheel adjusters)
- Occupant selected settings on the I Drive CID screen under climate control menu.



E70 CID Vent Stratification Settings

Note: In vehicles with CID (E6X or E70) the air stratification can be adjusted through the I Drive and CID screen at the climate control settings.

The Y Factor

The reference variable Y Factor (in %) is derived from the comparison of the actual interior temperature value with the corrected target value = driver's choice + outside temperature application.

Although air temperature controlled systems work in similar manner, in a coolant temperature controlled system:

Y Factor of 0% = water valves closed = NO heating output.

Y Factor of 100% = water valves open = FULL heating output.

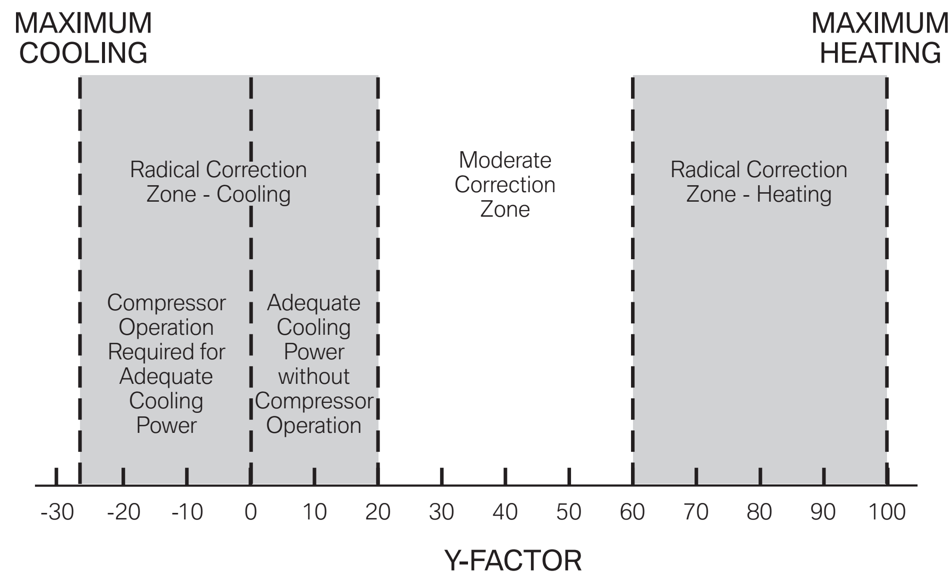
The master controller sends the signal to the two lower-ranking auxiliary controllers on the left and right. The auxiliary controller relieves the burden on the master controller in that it corrects interference such as air volume and water flow fluctuations or coolant and fresh air temperature variations that would otherwise be noticeable as variations in the temperature in the passenger compartment.

The opening time of the water valves is calculated from the difference of the auxiliary controller set point and the actual heat exchanger temperature. The water valves are activated pulse-width modulated with a period duration of 3600 ms.

This control variable Y represents the basis for further fundamental functions of the IHKA such as:

- Automatic blower output control in the automatic program
- Air distribution flap adjustment in the automatic program
- Auxiliary water pump operation ON/OFF
- Cold start interlock
- Compensation of solar sensor influence

Typical Y Factor Chart



The lower the Y-factor number, the harder the system is working to cool down the interior; the higher the number, the harder the system is working to warm up the interior. In the middle region, the system is working to maintain the existing interior temperature.

Note: It is not possible to view the Y-Factor parameter in all vehicles and the typical Y-range of 0 to100% temperature control has been extended from -200% to +300% to comply with current IHKA system functions.

Climate Control Components

Climate Control Panel/Module (E90 IHKA)

The control and operating module is the control center of the heating and air conditioning system. It is the point where all the necessary sensor data is processed and the required settings can be entered.

Since the E90 a new feature of the control module is that it no longer directly controls all functions and components like in other models but rather makes use of other control modules for this purpose (distributed functions).

The E90 IHKA panel is directly responsible for the following:

- SZM switch input
- Solar sensor input
- Receives the rear stratification knob (rheostat) signal
- Receives ventilation, footwell, and evaporator temperature sensor signals

  The IHKA panel indirectly receives

- Condensation sensor signal via the K-CAN.

  The signal path is: Condensation sensor => FZD => K-CAN =>IHKA

Digital Motor Electronics (DME) Control Module

The DME control unit performs the following functions:

- Actuates the Engine cooling fan for cooling of the condenser.
- Interfaces with the IHKA control unit via the bus network for the compressor release signal.
- Interfaces with the IHKA control unit for operation of the engine's electric water pump for the residual heat feature.

Junction Box (JB)

The junction box is extremely important to the IHKA system. It is responsible for the following functions:

- Output signal for seat heating.

  The signal path is: SZM => ribbon cable => IHKA => K-CAN=> JBE => SHM/SMFA

- Rear window defogger

  The signal path is: IHKA => K-CAN => JBE (relay) => Rear window defogger filters/grid

- Blower motor operating voltage

- Refrigerant control valve (in compressor)

  The signal path is: IHKA => K-CAN => JBE => Operating voltage for valve

- Gateway to the PT-CAN for bi-directional communication between the IHKA and DME.

  The signal path is: IHKA <=> K-CAN <=> JBE <=> PT-CAN <=> DME

- Receives the rear stratification knob (rheostat) signal

- Receives refrigerant pressure sensor signal

  The signal path is: Pressure sensor => JBE => K-CAN => IHKA

- Receives AUC sensor signal

  The signal path is: AUC sensor => JBE => K-CAN => IHKA

- Splice point for the ambient air temperature sensor

  The signal path is: Ambient air temperature sensor => hardwire => through JB => IKE

Roof Control Panel (FZD)

The roof control panel is used to relay the condensation sensor signal to the IHKA. It takes the signal from the condensation sensor and places it on the K-CAN.

Car Access System (CAS)

The CAS assigns a personal identification code to every remote control. The CAS transfers the personal identification code to the IHKA control unit via the K-CAN.

The ID code “Key-based settings” (Key Memory) are stored in the IHKA control unit.

When the vehicle is unlocked, the remote control unit used is recognized. The settings stored for this unit are called up and executed. While entering the sleep mode (run-down period), the current settings are stored for the remote control unit in use at that time.

Car Communication Computer (CCC)
If the vehicle is equipped with a navigation system, the signals from the controller for selecting the menus and sub-menu are processed in the CCC.

To actuate the CID (Central Information Display), the red-green-blue signals from the graphics processor are converted into Low Voltage Differential Signalling (LVDS) digital signals.

Central Information Display

The following control and display functions are selected and activated with the controller in the CID (Central Information Display):

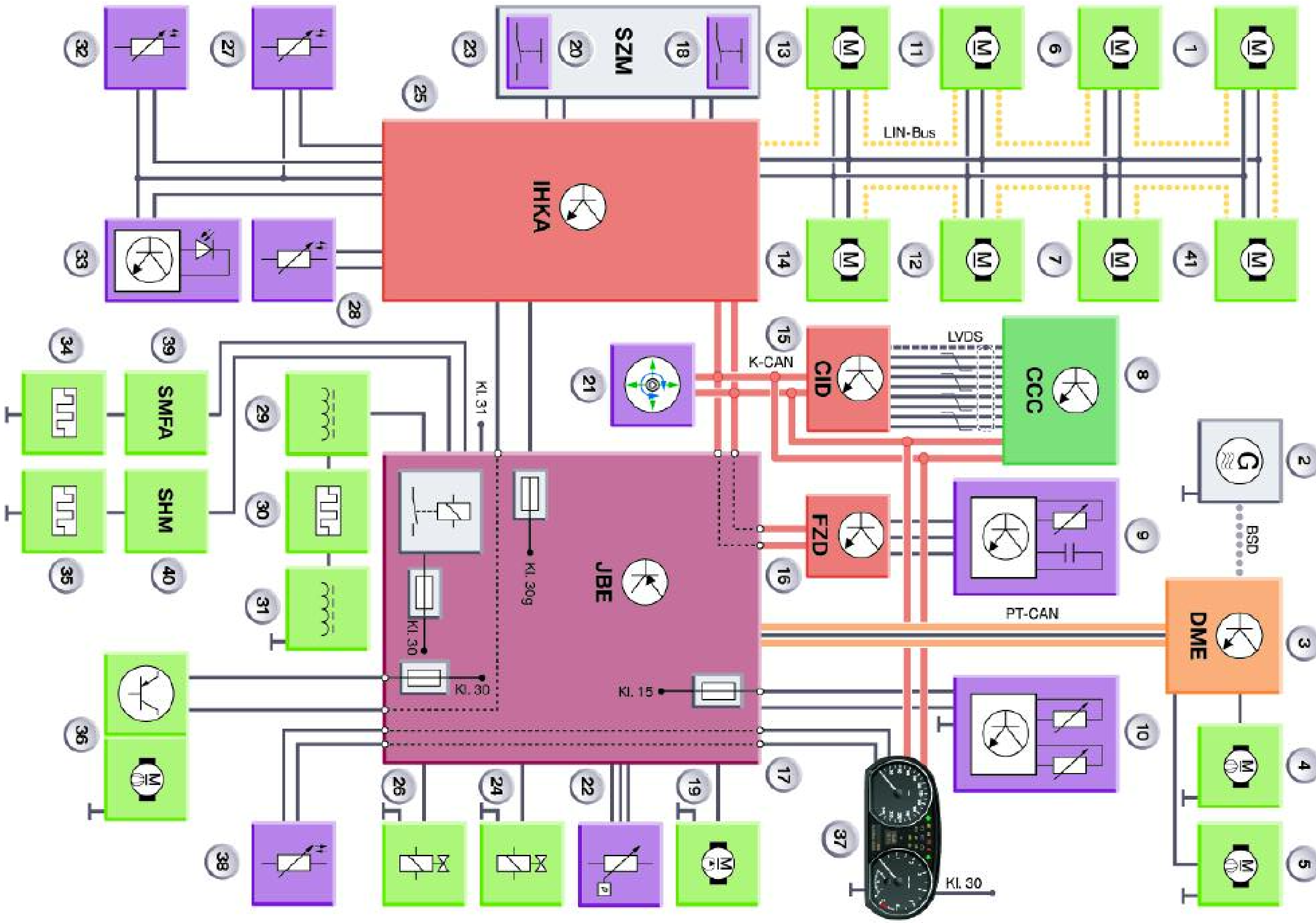
- Air distribution setting - The defrost flaps, ventilation flaps and footwell flaps can be individually set in the air distribution submenu.
- Automatic mode - The intensity of the IHKA can be set in the automatic mode submenu. In other words, the automatic influence of the climate conditions outside the vehicle on the air volume and the opening angle of the flaps can be set to one of three different settings (low, medium, high).

Center Console Switch Cluster (SZM)

The center console switch cluster (SZM) is connected by means of a 14-wire ribbon cable directly to the IHKA control module. The commands from the SZM are then transmitted via K-CAN to the corresponding systems.

The A/C control and operating unit is also responsible for activation of the LEDs for function and backlighting.

E90 IHKA Diagram



E90 IHKA Diagram Legend

Index	Explanation	Index	Explanation
1	Rear blend/stratification motor	22	Pressure sensor
2	Alternator	23	Center console switch cluster (SZM)
3	Digital motor electronics (DME)	24	Water valve
4	Electric water pump	25	Outside temperature sensor
5	Engine cooling fan	26	Auxiliary water pump (not for US)
6	Ventilation motor	27	Evaporator temperature sensor
7	Front blend/stratification motor	28	Footwell temperature sensor
8	Car communication computer (CCC)	29	Blocking circuit (filter)
9	Condensation sensor	30	Rear window defogger
10	AUC II sensor	31	Blocking circuit (filter)
11	Fresh air/recirculation motor	32	Ventilation temperature sensor
12	Mix air flap motor, left	33	Solar sensor (1-channel)
13	Defrost flap	34	Seat heating element, left
14	Footwell flap motor	35	Seat heating element, right
15	Central information display (CID)	36	Blower motor and final stage
16	Roof function center (FZD)	37	Instrument Cluster
17	Junction Box Electronics Control Module (JBE)	38	Outside temperature sensor
18	Seat heater button, left	39	Driver's seat module
19	A/C compressor valve	40	Seat heating module (passenger)
20	Seat heater button, right	41	Mix air flap motor, right
21	Controller		

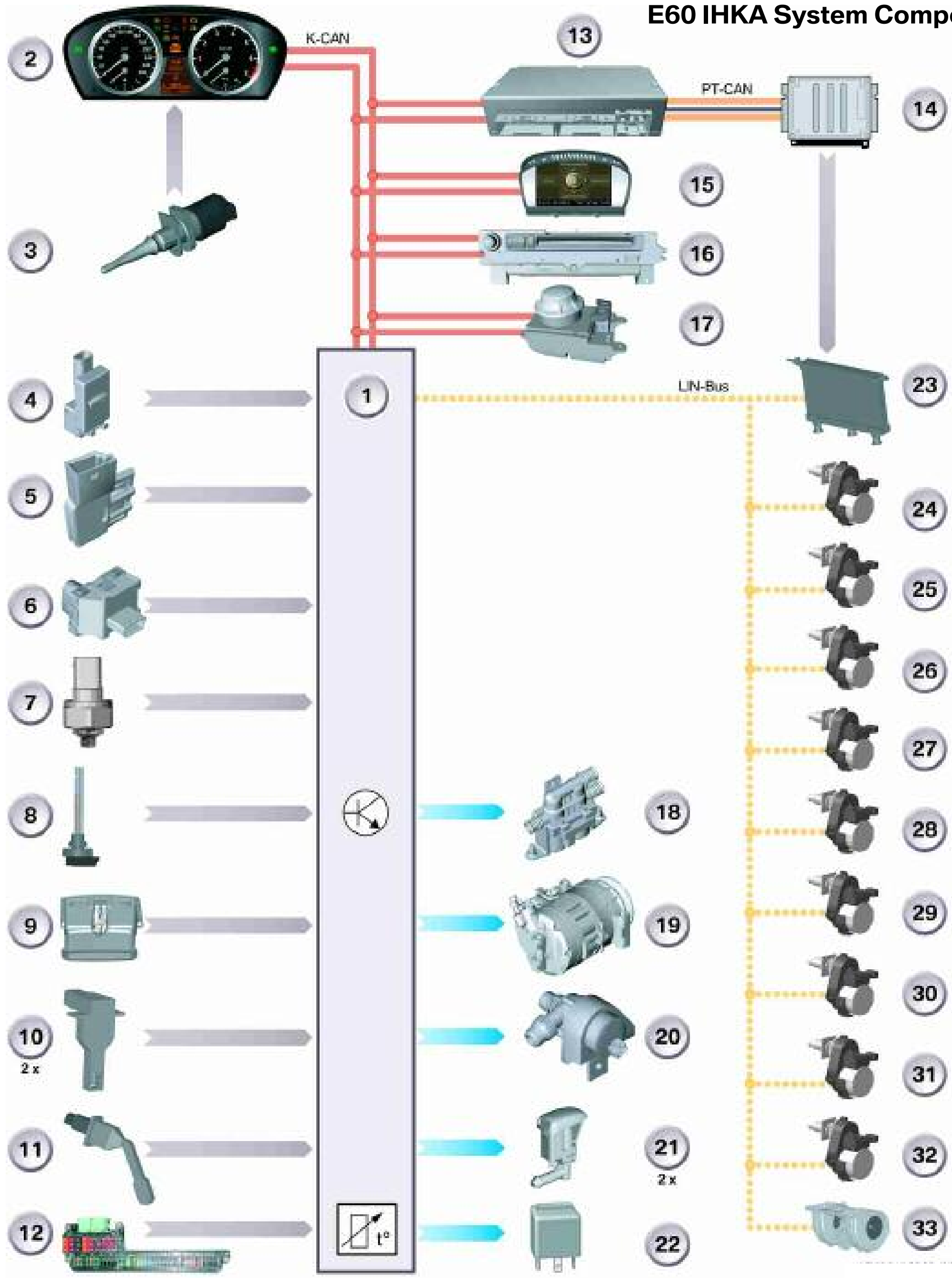
IHKA Inputs

IHKA system performance relies on a network of sensors that input information to the controller in order to compensate and adjust all the variables that are involved in the control of the climate, in the vehicles passenger compartment.

These sensors vary depending on equipment options but are generally the following:

- Interior Temperature Sensor
- AUC Sensor
- Solar Sensor
- Condensation Sensor
- Outlet Temperature Sensor
- Refrigerant High Low Pressure Sensor
- Evaporator Temperature Sensor
- Heater Core Temperature Sensors Left Right
- Ambient Outside Temperature

E60 IHKA System Components



E60 IHKA System Components

Index	Explanation	Index	Explanation
1	HKA controls / module with interior temperature sensor	19	A/C compressor
2	Instrument cluster (KOMBI)	20	Auxiliary water pump
3	Ambient temperature sensor	21	Heated washer jets , Left and Right
4	AUC sensor	22	Relay for heated rear window
5	Condensation sensor	23	Auxiliary Electric Heater (Not For US)l
6	Solar sensor	24	Fresh Air / air-recirculation flap motor Left
7	Refrigerant pressure sensor	25	Fresh Air / air-recirculation flap motor Right
8	Ventilation temperature sensor	26	Ventilation flap motor, Left
9	Potentiometers for rear compartment ventilation	27	Ventilation flap motor, Right
10	Heater core temperature sensors Left and Right	28	Cold air flap motor
11	Evaporator temperature sensor	29	Footwell flap motor, Left
12	Power distributor, front	30	Footwell flap motor, Right
13	Body Gateway Module (KGM)	31	Defroster flap motor
14	Digital Motor Electronics (DME)	32	Rear compartment flap motor (stratification)
15	Central Information Display (CID)	33	Blower with blower output stage
16	Multi-audio System Controller (M-Ask)	LIN-bus	Local interconnect network bus
17	Controller	PT-CAN	Powertrain CAN
18	Dual water valve	K-CAN	Body CAN

Interior Temperature Sensor

The interior temperature sensor is a NTC type thermistor, typically mounted in the IHKA panel. To promote adequate air flow across the sensing element a small puller type fan is used. Fan and sensor work together provide an interior cabin temperature input to the IHKA control module.

E60 IHKA Interior Temperature Sensor

AUC Sensor

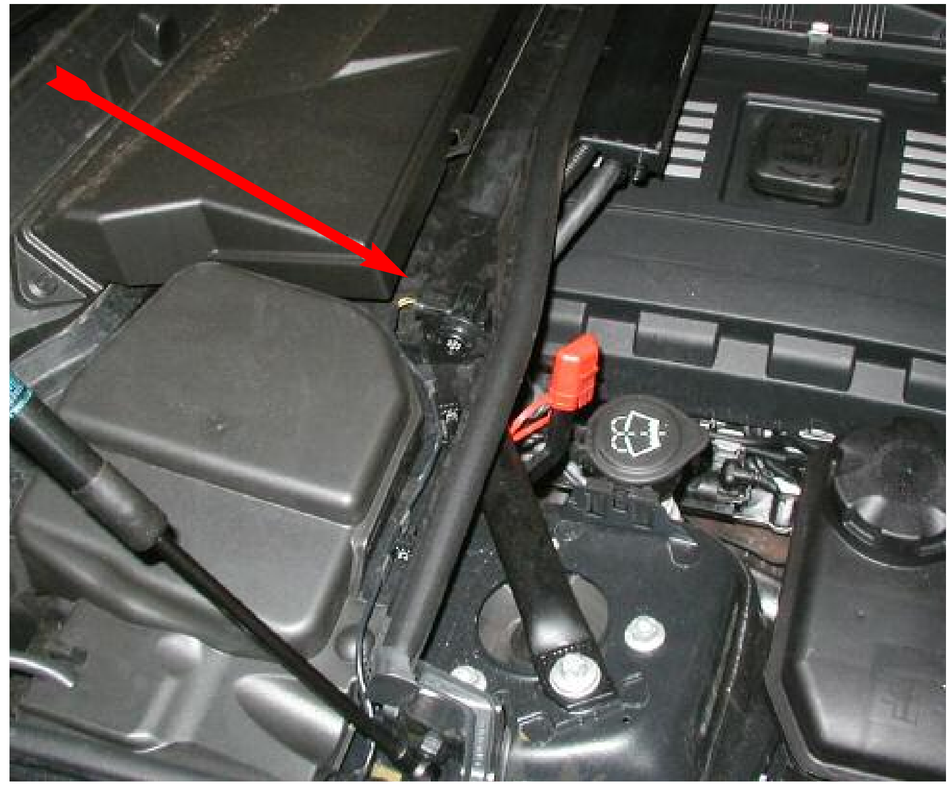
The AUC sensor, originally located in the lower right corner of the fan shroud, samples ambient air that has entered the engine compartment. The sensor contains a gas sensor, which measures the level of oxidizable gases in air. These include hydrocarbons, NOx, SOx and CO. The AUC sensor sends a voltage signal to the control panel/module according to the concentration of these pollutants.

If a high level of pollutants is detected, the control panel/module activates the recirculating air mode as follows:

- In heating mode, recirculating air is used for a maximum of 3 minutes.
- In cooling mode, recirculating air is used for a maximum of 10 minutes.

If the level of oxidizable gases drops to an acceptable point before the time limit is reached, the IHKA system switches back to fresh air intake. If air quality has not improved at the end of the time limit, the system switches to fresh air briefly and then back to recirculating mode for another 3 or 10 minute period.

E90 AUC Sensor Location



Note: Operating strategies of the AUC sensor may vary from model to model.

Solar Sensor

The solar sensor records the light intensity of the insolation to which the vehicle interior is being subjected separately for the right and left-hand sides. The influence of insolation on the temperature in the vehicle interior is compensated for in automatic mode by means of temperature specified value control intervention.

E60 Solar Sensor

Typically located in the center of the dashboard or integrated to the rain light sensor assembly like on E70. The solar sensor consists of a light sensitive diode that provides the IHKA module with inputs of sunlight intensity.

The input is used as a measure of the solar heating effect on vehicle occupants. The sensor signals will influence blower output, air stratification and ventilation flap operation.

Condensation Sensor

Introduced with the E60 model, this sensor varies its frequency out put in response to the presence of humidity and temperature in the windshield area. This information is sent to the IHKA control module via a digital signal with a varying frequency. This information is evaluated by the IHKA control module, which then implements a series of countermeasures to prevent windshield fogging.

On the current E60 the condensation sensor is mounted under the rain light sensor (RLS) on the mirror base. Other names for the condensation sensor are Mist, Fogging, and Humidity sensor.

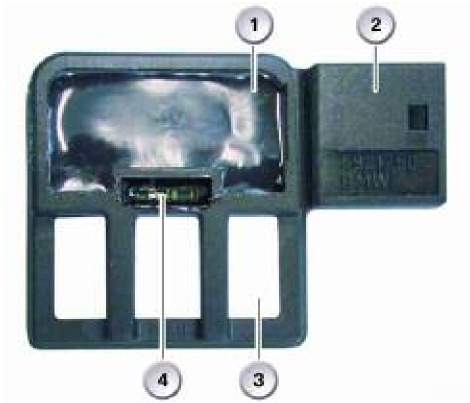
E60 Condensation Sensor

Index	Explanation
1	Rain-light sensor
2	Condensation sensor

The sensor is located beneath the RLS on the windshield below the cover for the base of the rear view mirror. A special locating tool is used to install the new sensor, this tool is supplied with the replacement sensor. The sensor is affixed to the windshield with an adhesive. If the sensor needs to be removed from the windshield it must be replaced.

Condensation/Mist Sensor

Index	Explanation
1	Sensor electronics
2	Pin connection
3	Moisture measuring cell
4	Well for laser adjusted resistors



When moisture is detected by the Condensation Sensor, the following occurs:

- Defroster Flaps open further
- Fresh Air Flaps open 100%
- Blower speed is increased
- Footwell Flaps are closed
- Temperature increases
- Evaporator Temperature threshold goes to minimum

These measures are implemented one after another until windshield fogging is eliminated. Further steps are initiated if one measure proves to be ineffective. After successfully eliminating windshield fogging, the measures are gradually cancelled in steps.

Rain/Driving Light Solar Sensor

The rain/driving light solar sensor RLSS of the E70 is clipped into a retaining ring beneath the windshield mirror base cover. The rain/driving light solar sensor separately records the insolation acting upon the vehicle occupants for the left and right halves of the vehicle. It generates two signals that are proportional to the insolation acting upon the vehicle occupants.

The temperature rise due to heat from sun radiation in the vehicle interior is compensated for in automatic mode by means of temperature specified value control intervention.

The sensor signal is read in by the FZD via the LIN bus and relayed to the IHKA via the K-CAN.

The signals are used by the IHKA to regulate the left and right air volume and ventilation temperature.

E70 RLSS Sensor

Outlet Temperature Sensor

NTC Sensors are installed in the air outlet vents in order to monitor air vent temperature delivered. This is a crucial parameter in the calculation of the ideal outlet temperature with regard to the requested temperature value.
Depending if the system is single, dual zone or four zones like E70, these sensors operate in the same manner and in all cases are located in the middle of the air delivery. In the case of a four zone system the driver, front passenger and rear seat passengers may have their own individual temperature settings. This is in part possible because of the use of these individual outlet vent temperature sensors and PTC heaters in the rear footwell vents.

E70 Rear Outlet Temperature Sensors

Index	Explanation
1	E70 FKA rear center ventilation outlet
2	Left/right rear ventilation temperature sensors
3	Left/right rear air stratification potentiometer
4	Left/right rear ventilation manual shut-off flap

The vent temperature is also adjusted locally at the dash face vents or the rear delivery vents by means of the stratification potentiometer thumbwheel adjusters. This is still done with a cable in some current vehicles like X3.

Refrigerant High/Low Pressure Sensor

The pressure sensor is mounted on the liquid reservoir and sends out a voltage signal depending on the pressure in the air conditioning system.

This signal is transferred in the form of a telegram to the digital motor electronics (DME). In turn, the DME outputs the control voltage for the output stage of the auxiliary fan, thus activating the corresponding fan stage (speed) or shutting down the compressor to prevent damage in response to very high pressures. Activation of the auxiliary fan is also influenced by an excessively high coolant temperature.

On vehicles equipped with a condenser module (filter dryer integrated in the condenser), the pressure sensor is installed in the high pressure line between the condenser and expansion valve. On various automatic transmission vehicles such as the E65 and E60, the auxiliary fan is also activated by excessively high transmission fluid temperature. The higher fan stage is then generated in this case.

Evaporator Temperature Sensor

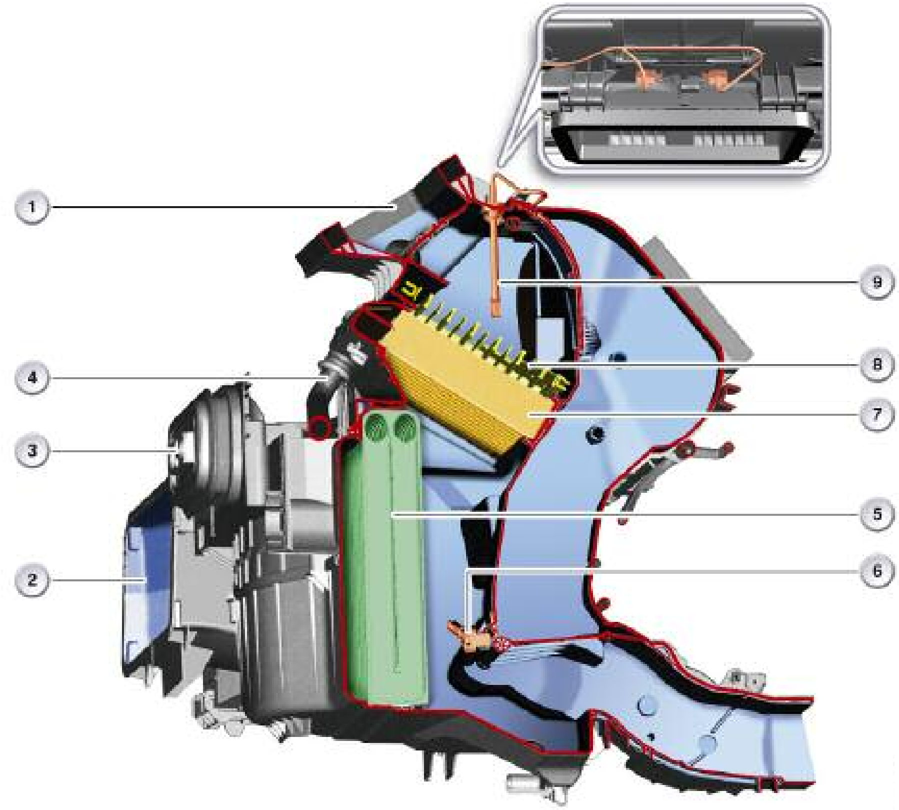
The sensor is installed between the evaporator fins or arranged behind the evaporator in the flow of cold air. Depending on the type of system in the vehicle, the temperature at the evaporator is monitored as the regulator switches the electromagnetic clutch of the compressor on and off or signals the compressor control valve (clutchless compressor) as required. This prevents the evaporator fins from icing up due to frozen condensed water.

Controlled via the IHKA control unit, the sensor generally switches off the compressor at a temperature of about. 1°C and on again at about. 3°C.

In connection with the output-controlled compressors with magnetic clutch, the sensor only serves as a protection function in the event that the temperature at the evaporator drops below 3°C. Consequently, the compressor remains switched on almost permanently. With the interior temperature set at comfortable levels, the compressor is generally switched off by the electromagnetic clutch only at outside temperatures below about. 6°C.

In the case of output-controlled compressors without an electromagnetic clutch, if there is a threat of the evaporator icing up, the IHKA will correspondingly change the pulse-width-modulated control signal via the electric control valve in the compressor. Consequently, the compressor output is reduced in the direction of zero. Icing of the evaporator can be recognized by decreasing air volume at the air outlet vents.

Note: Evaporator temperature sensor is shown by #6 in the illustration.



E70 IHKA Housing

Index	Explanation
1	IHKA housing
2	Fresh air intake
3	Expansion valve coolant connection
4	Heater core water connection
5	Evaporator
6	**Evaporator temperature sensor**
7	Heater core
8	Electric PTC auxiliary heater (not for US vehicles)
9	Heater heater core temperature sensor

Heater Core Temperature Sensors Left/Right

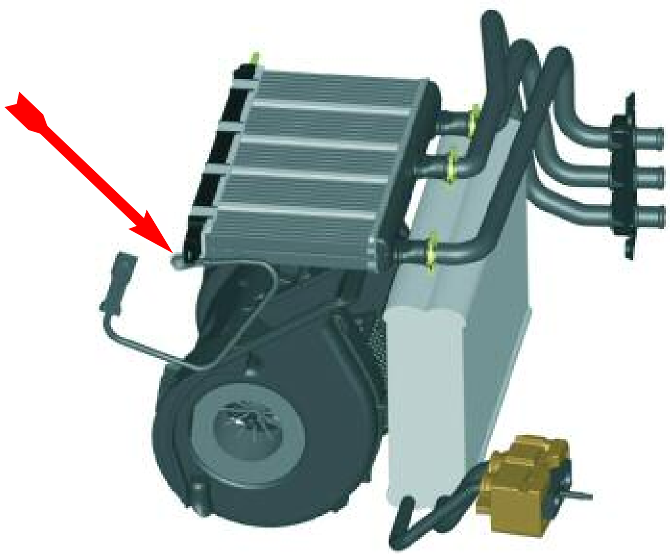
Heater core temperature is monitored to insure the correct desired temperature at the vents. Heater core temperature along with ambient, vent and evaporator temperatures are the main parameters utilized to calculate Y Factor. Thus we control the coolant flow though the heater core by varying the heater valve opening on a water based system.

The Air based System has no need for a water valve because it controls temperature by adjusting the air mixing flap.

As an added benefit we also monitor heater core temperature in other to maintain a safe range of operation and in case of over heating the heater valves can be shut off.

In IHKA the individual temperature readings are of crucial importance and necessary in other to be able to separately adjust the outlet temperature for the driver and the passenger. This calls for the installation of two heater core temperature sensors.

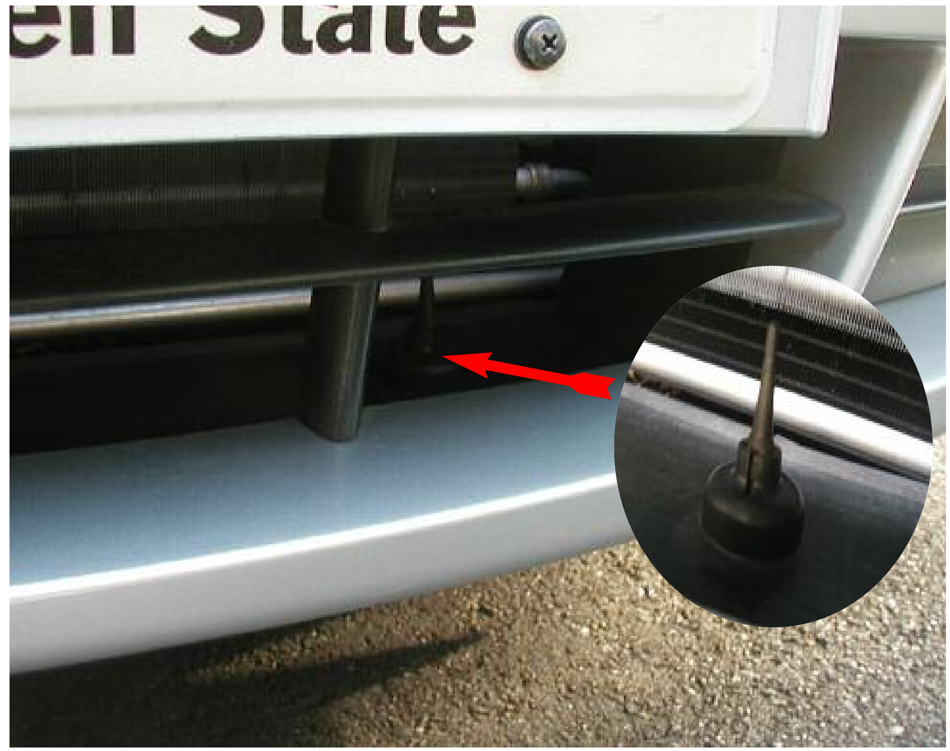
E60 Heater Core Temperature Sensor



Ambient Outside Temperature

The ambient temperature sensor is similar to interior, evaporator, heater core and outlet vent sensors in their operation. An NTC negative temperature coefficient sensor as temperature goes up resistance goes down.

The temperature sensor is located at the front end of the vehicle in front of the condenser and it is responsible for reporting ambient temperatures to all systems that require the reading.



E60 Ambient Temperature Sensor

Workshop Exercise - Climate Control Input Diagnosis

Using an Instructor assigned vehicle, hook-up the BMW Diagnostic Equipment and perform a complete short test. Hook-up the A/C service station, turn vehicle on and set IHKA to Auto. Allow system to stabilize while monitoring manifold gauges.

1. *Check cabin/vent temperature and verify proper system performance.*

2. *Access climate settings in the CID and modify Air Distribution and Automatic mode settings.*
   What changes did you observe?

3. *Access Diagnosis Request for front and rear vent temperature, adjust the stratified air potentiometers for both and observe vent temperature readings.*
   In what module did you locate vent temperature?

4. *Install a thermometer in the outlet being manipulated and answer the following questions.*
   What does the flap position at 100% produce at the rear vent outlet?

5. *Place the rear temp. flap position at 0%.* What temperature is registered at the rear vent outlet?

6. *Set the driver side temperature to the hottest setting on IHKA.* Which flap registered the change and what does it read?

7. *Set the passenger side temperature to the coldest setting.* Which flap registered the change and what does it read?

8. *Monitor what changed and register your findings.*

Workshop Exercise - Climate Control Input Diagnosis

Using the Instructor assigned vehicle, hook-up the BMW Diagnostic Equipment and perform a complete short test. Hook-up the A/C service station, turn vehicle on and set IHKA to Auto. Allow system to stabilize while monitoring manifold gauges.

9. *Access Diagnosis Request for the A/C pressure sensor and compare the displayed value to the manifold gauge readings.* What module monitors the pressure sensor and why?

10. Did the reading match the high side reading on the manifold gauge?

11. *Unhook the pressure sensor with the A/C working and observe changes in system operation.* Did the sensor value change?

12. How did the A/C system pressures respond?

13. What did the pressure reading on the BMW Diagnostic Equipment display?

14. *Complete a short test and note which modules stored a fault.* Which module(s) stored a fault for the pressure sensor and why?

15. *Restore the system to normal operating condition and clear any faults.*

Workshop Exercise - Climate Control Input Diagnosis

Using an Instructor assigned vehicle, hook-up the BMW Diagnostic Equipment and perform a complete short test. Hook-up the A/C service station, turn vehicle on and set IHKA to Auto. Allow system to stabilize while monitoring manifold gauges.

16. *Place the system in auto mode and set left and right temperature requests to 65 degrees. Access diagnosis request for the solar sensor.*
    What can you do to trick the Solar Sensor to react?

17. Did the sensor value change?

18. How did the system respond to solar variation?

19. In which module did you find solar sensor information and why?

20. *Leave the system in auto mode and access diagnosis request for the AUC II sensor.*
    What does the sensor value display?

21. In which module did you find the AUC sensor and why?

22. How can you trick the AUC sensor to react?

Workshop Exercise - Climate Control Input Diagnosis

Using an Instructor assigned vehicle, hook-up the BMW Diagnostic Equipment and perform a complete short test. Hook-up the A/C service station, turn vehicle on and set IHKA to Auto. Allow system to stabilize while monitoring manifold gauges.

23. *Manipulate the sensor and observe changes in sensor values and system operation.*
    What changes in the system operation did you observe?

24. *Access diagnosis request for the interior temperature sensor and note current values.*
    In which module did you find interior temperature and why?

25. *Restrict the air inlet to the interior temperature sensor and observe changes in sensor values and system operation.*
    What happened?

26. Could a build-up of dust/debris or a blockage at the fresh air inlet cause a system performance complaint?

27. Would such a condition set a fault? Why or why not?

28. *Carefully place a cup of warm water on the dash to fog up the windshield.*

29. Where is a good location to test the mist sensor signal?

30. What equipment and V Cable # can you use to monitor the mist sensor signal?

31. Monitor the Mist Sensor change. What type of signal did you get from the mist sensor?

NOTES PAGE

IHKA Outputs

Based on the feedback from the IHKA inputs the system calculates the Y factor and reacts to the desired requested temperature and or conditions detected to operate the following out put devices to deliver optimum performance.

Compressor clutch/Compressor control valve

Blower motor/Final stage

Water valves

Auxiliary water pumps

Electric water pump

Auxiliary fan

Stepper motors

Compressor Operation

The compressor control circuit varies between systems. There are three basic methods for compressor control.

- The compressor clutch coil receives power from the KL 87 terminal of a relay which is ground controlled by ECM (DME).
- The compressor clutch is powered directly by the climate control module. A final stage in the control module sends power directly to the compressor clutch. The relay and additional wiring are eliminated.
- Constantly engaged compressors are usually variable displacement units. The compressor has a swash plate that can vary the amount of compression on the refrigerant with the input from a control valve.

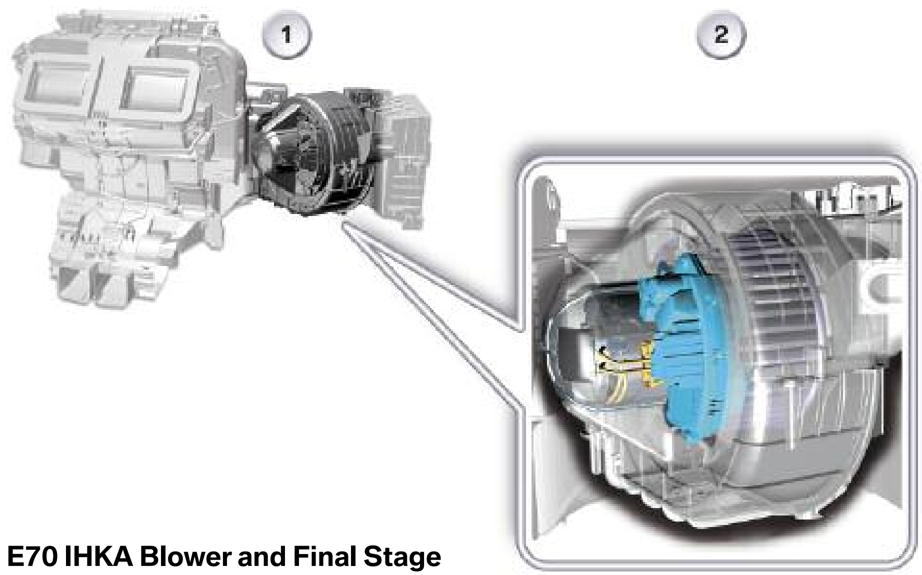
The compressor valve is controlled and powered by the junction box in most resent models but the command comes from the IHKA module.

Blower Motor/Final Stage

The fresh air/recirculated air blower is flange mounted to the right side of the IHKA housing. The specified voltage for the blower is provided by the IHKA (Master) as a defined control signal (PWM signal) via a single-wire interface of the blower output stage (Slave).

The blower motor is actuated by the blower output stage depending on this variable control signal. The line connections from the IHKA to the final stage are monitored by the IHKA.

The blower and the output stage can be replaced separately. See appropriate workshop systems documentation. The motor voltage is limited to 12.5V by the software. If an overload is detected at the output stage output or temperature protection is activated, the engine output is reduced.



E70 IHKA Blower and Final Stage

Index	Explanation
1	IHKA blower housing
2	blower output stage

Water Valves

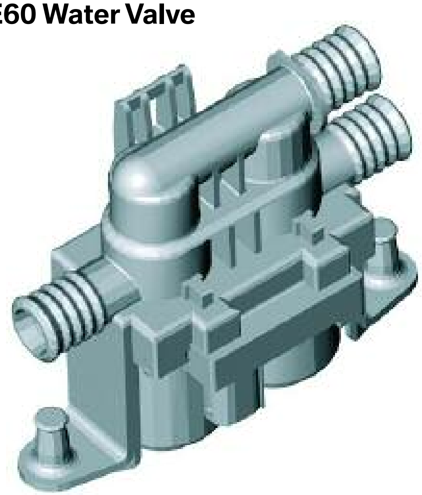
Temperature regulation on IHKA systems is accomplished by solenoid actuated water valve(s). The valve(s) are normally held open by spring pressure (fail safe), and are electrically pulse width modulated by the IHKA control module (B+) signal to regulate the flow of hot coolant through the heater core(s).

The water valve(s) are pulsed according to the Y-factor, which is calculated from the following inputs:

- Desired temperature request (left and right if equipped)
- Interior temperature
- Heater core temperature(s)
- Ambient air temperature
- Blower speed request

When the desired temperature calls for maximum heat, the water valve(s) do not receive pulses and are mechanically sprung open. Similarly, when maximum cooling is requested, the IHKA control module powers the water valve(s) completely closed. The water valves used on the water temperature controlled dual zone IHKA systems have one inlet and two outlets on a single valve.

E60 Water Valve



Water Valve (Air Temperature Control)

A water valve that controls the water flow rate through the downstream heater core is not used for setting the temperature in an air-based temperature control system but rather a temperature mixer flap is integrated in the heater/air conditioner.

A single water valve is typically used to control the amount of heat sent to the heater core on an Air Temperature Controlled Systems, although most current vehicles (E85, E9X) don't use one.

To control the temperature desired by the dual zone climate control system, air mixing flaps are used.

Auxiliary Water Pumps

Typically used on Water Regulated Systems. Electrically powered auxiliary coolant pump ensure that an adequate supply of hot coolant is always available to the heater core(s). The IHKA control module operates the pump directly or through a relay by supplying the ground circuit.

Some current vehicles use electric water pumps and don't need to use an auxiliary pump to maintain adequate coolant flow through the heater core.

E60 Auxiliary Water Pump

Electric Water Pumps

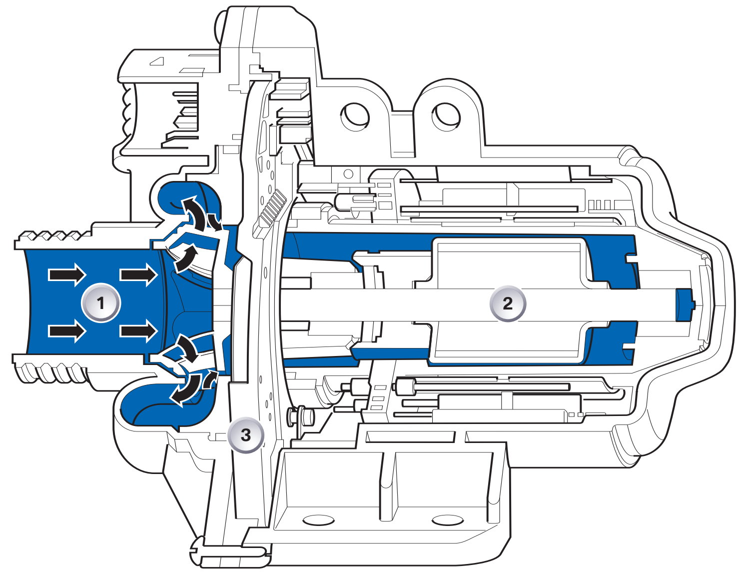
The current N52 and N54 engines are equipped with electronically controlled water pumps. Electric water pumps decreased warm up time while enhancing power output and fuel economy.

When the residual heat (REST) function is activated, the IHKA control unit interfaces with the DME control module to activate the electric water pump. The water pump allows hot/warm coolant to flow through the heater core and warm the passenger compartment.

The coolant pump of the N54 engine is an electrically driven centrifugal pump with a power output of 400W and a maximum flow rate of 9000 l/h. This represents a significant increase in power of the electric coolant pump used in the N52 engine, which has a power output of 200 W and a maximum flow rate of 7000 l/h.

The DME (ECM) uses the engine load, the operating mode and the data from the temperature sensors to calculate the required cooling output. Based on this data, the DME issues the corresponding command to the electric coolant pump.

The electric coolant pump regulates its speed in accordance with this command. The system coolant flows through the motor of the coolant pump, thus cooling both the motor as well as the electronic module. The coolant lubricates the bearings of the electric coolant pump.



Electric Water Pump

Note: The pump must be filled with coolant when removed for service to prevent any corrosion. Also, the pump impeller must be turned by hand before installation to ensure the pump is not seized.

Index	Explanation
1	Pump
2	Electric Motor
3	Electronics for coolant pump

Map Thermostat

In view of the fact that an intelligent heat management system has an influence on fuel consumption, exhaust emissions, performance and comfort according to engine temperature, this data-map thermostat was developed for use with such a system.

The data-map thermostat successfully integrates modern engine management electronics. That combination is achieved by placing an electrically heated resistor in the expanding element of the thermostat.

That data map is determined, for example, by the following parameters:

- Engine load
- Engine speed
- Vehicle speed
- Intake-air temperature
- Coolant temperature

Auxiliary Fan Control (from 99 MY)

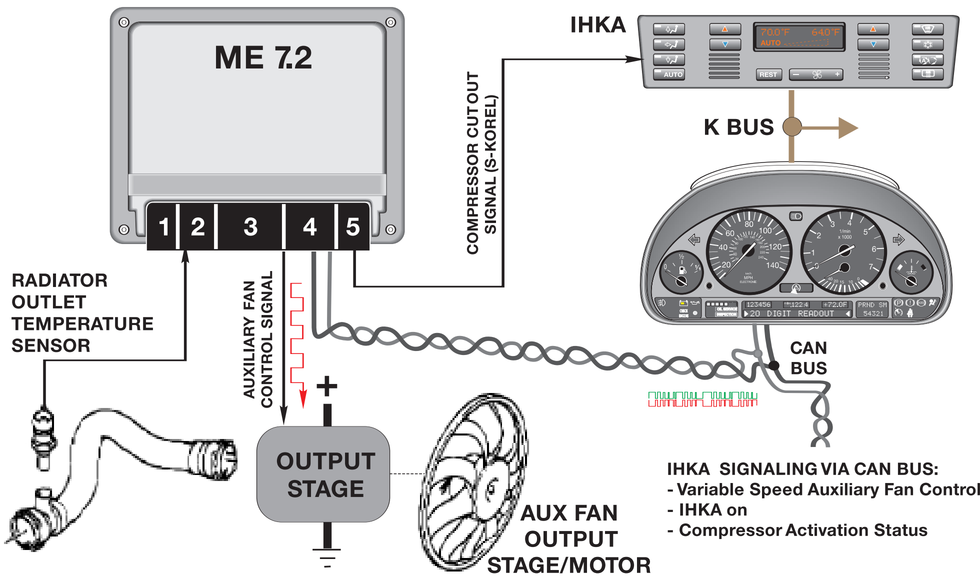
The auxiliary fan motor incorporates an output final stage that activates the fan motor at various speeds.

The auxiliary fan is controlled by the ECM. The motor output stage receives power and ground and activates the motor based on a PWM signal (10-100Hz) received from the ECM (DME).The fan is activated based on the following factors"

- Radiator outlet temperature input exceeds a preset temperature.
- IHKA signaled via K and CAN bus based on calculated refrigerant pressures.
- Vehicle Speed
- Battery Voltage Level

When the over-temperature light in the instrument cluster is on (120°C), the fan is run in the overrun function. This signal is provided to the ECM (DME) via the CAN bus. When this occurs, the fan is run at a frequency of 10Hz.

Typical Auxiliary Fan Control System



Stepper Motors

BMW IHKR and IHKA Climate Control Systems use 12 volt DC electric stepper motors to operate many of the air inlet, air distribution and temperature mixing flaps. While different types of stepper motors are used on different vehicles, they all share many desirable characteristics:

- Lower power consumption
- Operate in both directions
- They can be started and stopped in any position
- They provide quick movement
- They move in precise increments
- They do not require feedback potentiometers to determine position
- They remain in position when shut off
- They have long service life

Conventional Stepper Motors

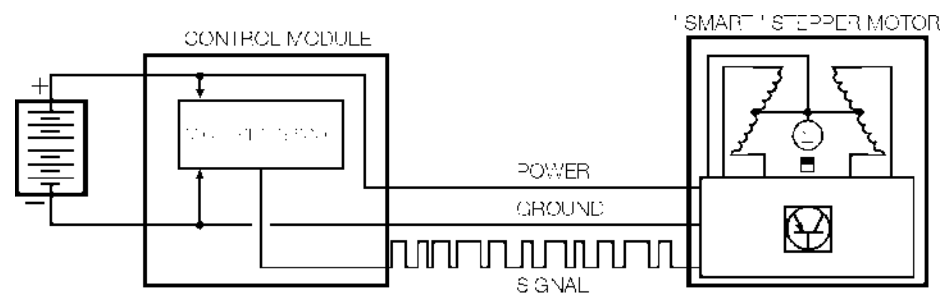
Until the E38 was introduced, the stepper motors used in IHKR and IHKA climate control systems did not contain electronic components, and only 3 part numbers were needed to service all the motor assemblies. These motors consisted of copper wire coils wrapped around iron cores (pole pieces), and permanent magnet rotors, all attached to a high-reduction mechanical gearbox. The system electronic control components were located inside the climate control module assembly.

There up to 4 sets of winding in these motors. This circuit arrangement requires from 5-6 wires between the control module and the stepper motor. These motors were used on early climate control systems and are still used on some vehicles for fresh air flap operation.

"Smart" Stepper Motors

Starting with the E38 climate control system, some of the control module electronics were moved into the stepper motors, making the E38 motors (except the fresh air flaps motor) substantially different from the "conventional" stepper motors we've already discussed.

These "Smart" stepper motors use only three wires for operation. There is a power, a ground and the third wire for the "M" bus signal. The "M" bus is used to send messages to the stepper motors. The commands or "messages" are sent by the climate control module. The stepper motors contain processors which will "interpret" the bus messages and actuate the stepper motors to the correct position.



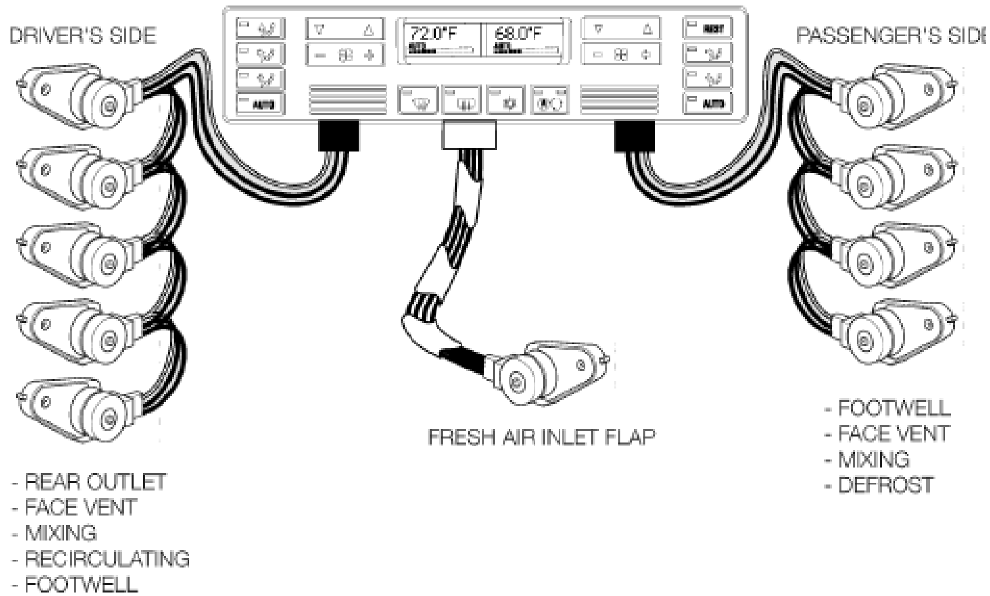
Typical M-bus Diagram

The M-bus stepper motors are different and have a different part number. They all feature a fixed programmed address and must therefore be installed in no other position than on the corresponding air flap, they cannot be interchanged and must be replaced with the same part number as was originally equipped.

The operating instructions issued to the smart stepper motors by the control module are much more sophisticated than with conventional stepper motors. The sequence of events appears below:

- The control module determines that a flap position must change
- It issues a “wake-up call” to alert the stepper motors that a command is coming
- It “names” the motor that is to respond to the command
- It issues the command signal, e.g. “move 15 steps clockwise”
- All the stepper motors “hear” the command
- Only the stepper motor that “hears its name” follows the command
- The “named” stepper motor then informs the control module that it has carried out the command

E38 M-bus Stepper Motors



E65 Stepper Motors

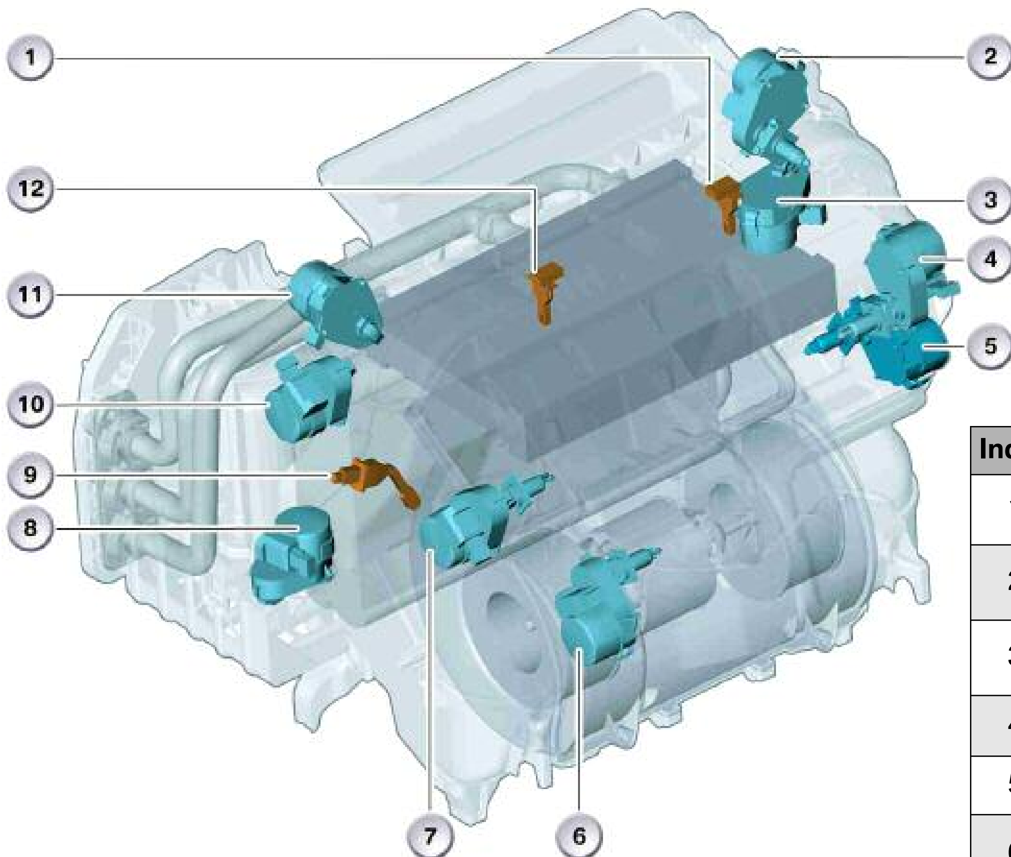
The E65 IHKA has a total of 11 stepper motors, 1 Rapid action motor for the fresh air flap and 10 “Smart” Stepper motors for all other flaps Each of these motors contains an integrated circuit (MUX- 4 chip) in the plug connection housing. This IC controls the winding of the motor and is linked by a M-Bus.

All stepper motor drives are controlled by the IHKA control module over the M-Bus.

Each drive has a permanent address (stored on the chip) which is a unique identifier for the individual motor (for bus communication). The stepper motors are all different and are not interchangeable.

Note: Faults (blockages) reported by the drives are stored in the IHKA control module, which responds by discontinuing control signals to the motor in question.

E60 Stepper Motors



E60 Stepper Motors

The E60 IHKA system uses 9, MUX5 motors (multiplex motor type 5). These stepper motors have different part numbers, are connected to the LIN Bus in parallel and are not interchangeable.

The LIN Bus replaced the M-Bus. This bus circuit consists of three wires, power (B+), ground and the LIN bus signal wire.

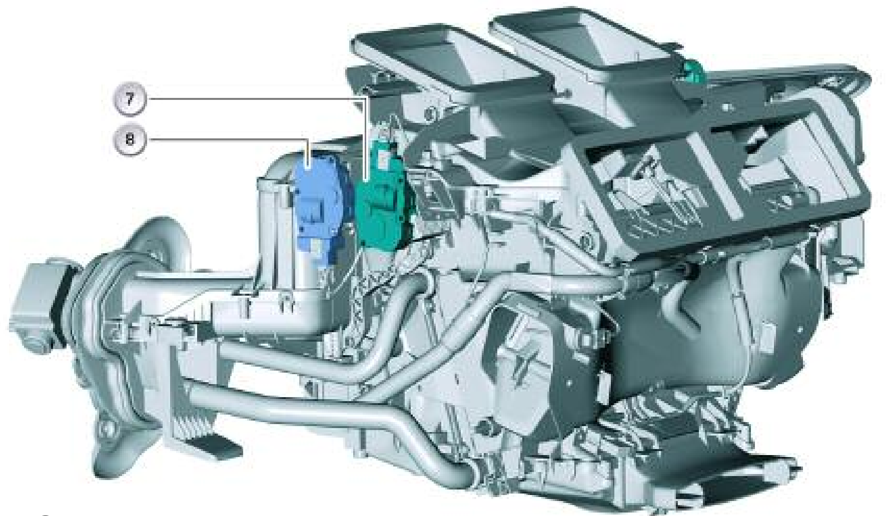
The stepper motors for the fresh air/recirculation air flaps are designed as high speed motors. This system does not use any bowden cables for flap actuation.

Index	Explanation	Index	Explanation
1	Heater Core Temperature Sensor (RH)	7	Stepper Motor, left side ventilation
2	Stepper Motor, right footwell	8	Stepper Motor, fresh air/re-circulated air (LH)
3	Stepper Motor, fresh air/re-circulated air (RH)	9	Evaporator Temperature Sensor
4	Stepper Motor, right side ventilation	10	Stepper Motor, defrost
5	Stepper Motor, air stratification	11	Stepper Motor, left footwell
6	Stepper Motor, rear compartment (center)	12	Heater Core Temperature Sensor (LH)

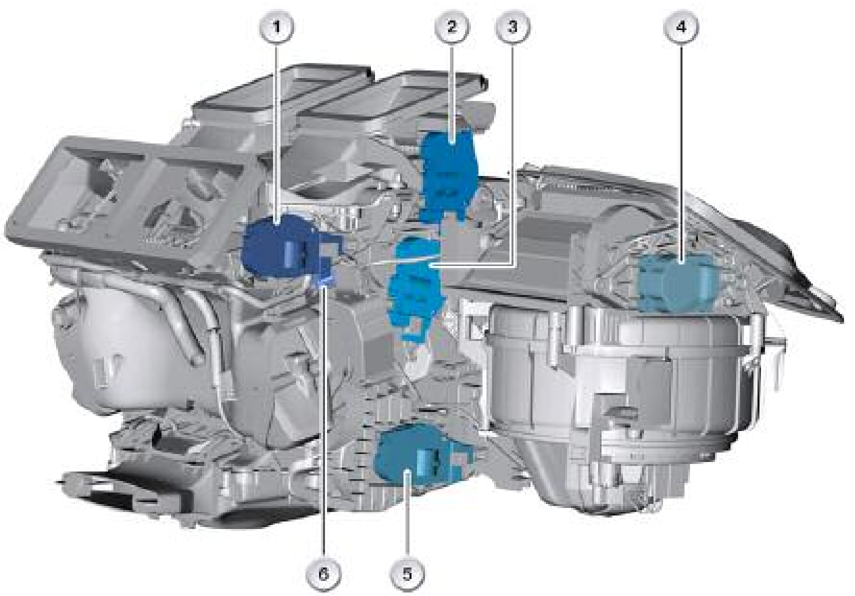
E9X Stepper Motors

The current E9X IHKA systems utilizes eight stepper motors that are wired in series for climate control operation. The IHKA control module also operates the stepper motors via the LIN-bus.

- All eight stepper motors can be replaced without removing the dashboard or A/C housing.
- Seven of the eight stepper motors used are identical (same part number).
- A different stepper motor is used only for the fresh air/recirculation motor. “See the Service Information section”.
- Flap motors are wired in series.
- Each flap motor has a measuring resistance of about 1 ohm.



E90 Stepper Motors LH



E90 Stepper Motors RH

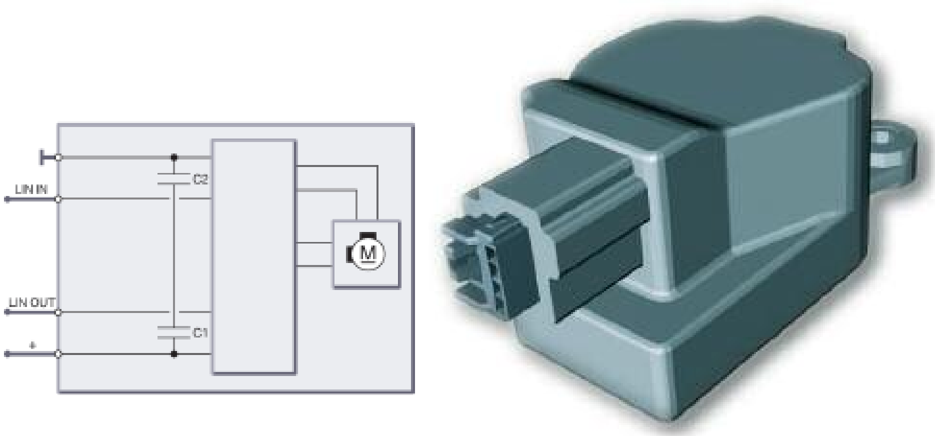
Index	Explanation	Index	Explanation
1	Stepper Motor, Ventilation Flap	5	Stepper Motor, Air Blending, Rear
2	Stepper Motor, Defroster Flap	6	Stepper Motor, Footwell
3	Stepper Motor Air Mixing Flap, Right	7	Stepper Motor, Air Mixing Flap, Left
4	Stepper Motor, Fresh / Recirculating Air	8	Stepper Motor, Air Blending, Front

Each flap motor is connected to its predecessor via this measuring resistance. For this reason, troubleshooting must be performed in the order stipulated in the schematic circuit diagram. A new generation of stepper motors is used in the E90/E91/E92/E93 systems as well as in the current E70.

These stepper motors feature two LIN bus connection lines (input/output). A motor has only one LIN-bus input on the wiring harness (foot-well motor). The motors are connected in series (the foot-well motor is the last motor in the series connection).
Also in this case there are two different stepper motor versions. The motor with the designation EFB with 1Ω resistor, is used for all air flaps except the fresh air flap as well as in IHR and IHKR for the central (mechanism) kinematics.

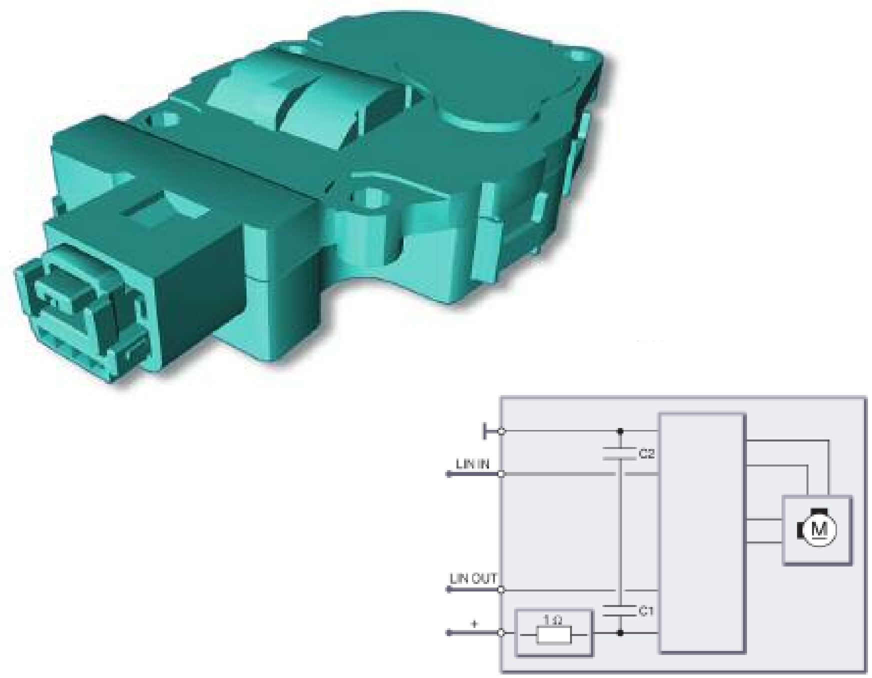
EAB Stepper Motor
The motor with the designation EAB is used for the fresh air flap and the central kinematics (Air Distribution Mechanisms). The EAB motor varies its speed corresponding to the force applied at the flap. Faster at a low load force and slower at a high load force (with no 1Ω resistor).

EAB Stepper Motor

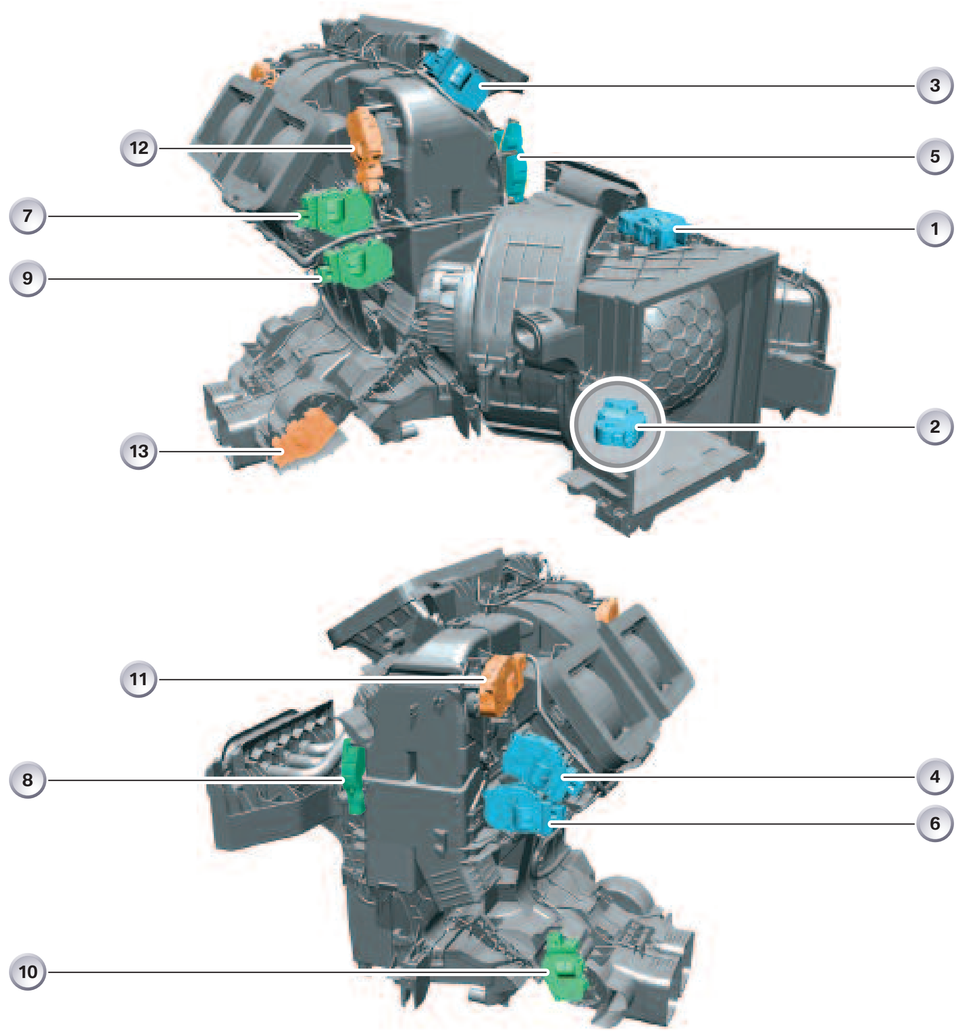


EFB Stepper Motor
The EFB motor has a constant displacement speed and a defined moment. The EFB motors are all identical and must therefore be programmed. The air flap motors are connected in series. A 1Ω measuring resistor is installed in each air flap motor. The following air flap motor is connected to the one before it via this measuring resistor or shunt through the LIN-bus. The motors must be connected only in the sequence as shown in the schematic circuit diagram and electronically addressed for proper system operation.

EFB Stepper Motor



E70 Stepper Motors



	Actuator motors	IHKA	IHKA w/ FKA
1	Fresh air/recirculated air, actuator motor	√	√
2	Dynamic pressure compensation, actuator motor	√	√
3	Defrost, actuator motor	√	√
4	Left/right front ventilation, actuator motor	√	√
5	Right/left front footwell, actuator motor	√	√
6	Right/left front air stratification, actuator motor	√	√
7	Right front ventilation, actuator motor	√	√
8	Left front footwell, actuator motor	√	√
9	Right front air stratification, actuator motor	√	√
10	Left/right rear air stratification, actuator motor	√	√
11	Left rear footwell, actuator motor	**Not used**	√
12	Right rear footwell, actuator motor	**Not used**	√
13	Right rear air stratification/shut-off, actuator motor	**Not used**	√

.

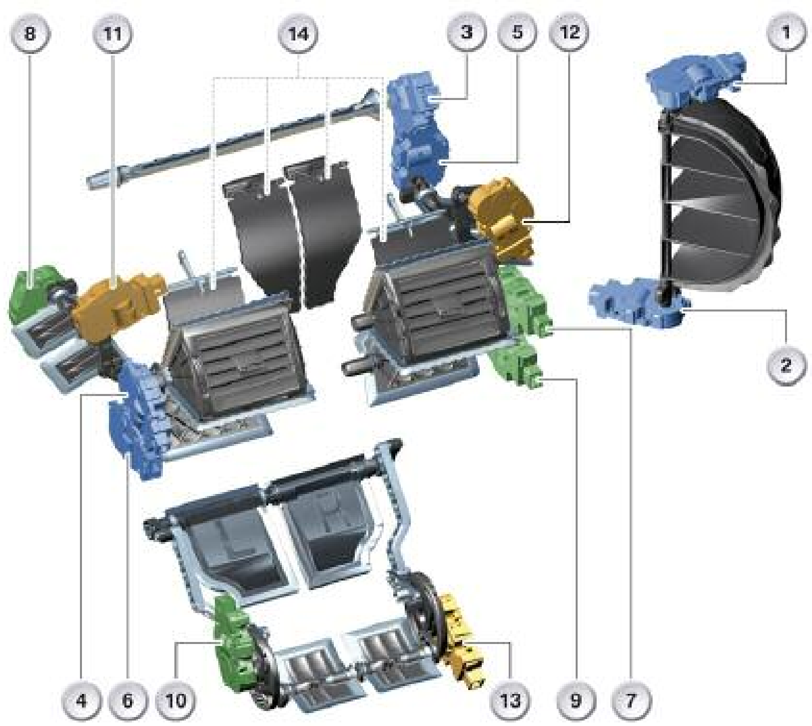
E70 Stepper Motors

The IHKA actuator stepper motors used on the E70 are the same as in the E9X. They are all designed as identical components and are actuated by the IHKA via the LIN bus.

When an actuator motor is being replaced it must be ensured that the correct plug is connected to the relevant motor from the wiring harness end. The plug order can be found in the wiring diagram.

Then an addressing run must be started using the BMW diagnostics system. The IHKA detects the actuators that are connected in series and assigns an address to the new motor if necessary.

The actuation of the addressing run is integrated in the diagnostics system in the service function (re-address body, heating/air conditioning functions, flap motors). A function test (reference run) is also integrated in the diagnostics system, with which the operational capability and the adjusting path of the motors can be tested.



Replacement of a Stepper Motor

After replacement, the stepper motor must be addressed. The addressing procedure is initiated with BMW Diagnostic Equipment.

The IHKR or IHKA control unit automatically assigns the address to the flap motor. The motor recognizes its assignment (address e.g. footwell motor) based on an addressing current.

This arrangement makes it possible to use a standard motor for all air distribution flaps. The motor must not be turned by hand as this would pose the risk of irreparably damaging the electronics or the gear mechanism.

IHKA with Rear Automatic Air Conditioning, 4-zone, Overview of Air Distribution Flaps

Index	Explanation
1	Actuator motor, fresh air/recirculating air
2	Actuator motor,dynamic pressure compensation
3	Actuator motor, defrost
4	Actuator motor, front left ventilation
5	Actuator motor, front right footwell
6	Actuator motor, front left air stratification
7	Actuator motor, right front ventilation
8	Actuator motor, left front footwell
9	Actuator motor, right front air stratification
10	Actuator motor, left rear air stratification
11	Actuator motor, left rear footwell
12	Actuator motor, right rear footwell
13	Actuator motor, right rear air stratification/shut-off
14	Housing internal non-return flaps

Workshop Exercise 1 - Climate Control Stepper Motor Diagnosis

Using an instructor assigned E9X or E70 vehicle, hook up BMW Diagnostic Equipment, with Key ***ON*** *and Engine and IHKA* ***OFF.*** *Following repair procedures, gain access to JB/JBE, Blower Motor and Final Stage, A/C Housing and Stepper Motors.*

1. *Unhook one stepper motors and complete a SHORT TEST.* List any fault/s set below?

2. *Go to Service Functions and Re-address the stepper motors to follow the test plan.*

3. *List the Stepper Motors in their correct order in the following chart.*

Explanation	pre.	post	Explanation	pre.	post

4. What pre-conditions must be observed when Re-addressing the stepper motors?

5. Are all displayed stepper motor position values from 0 to 100%?

6. *List the values displayed for each stepper on the* ***"Pre"*** *section of the chart.*

7. *Proceed with the Test Plan to test all the stepper motors until all fault codes are justified.*

8. What conclusion was determined by these tests?

Workshop Exercise 1 - Climate Control Stepper Motor Diagnosis

Student instructions: Using an E9X or E70 vehicle, hook up BMW Diagnostic Equipment **.**

9. Reconnect the stepper you disconnected and re-address them again.

10. Are all values displayed this time with in 0 and 100%?

*11. List the values for each stepper motor under "**Post**" on the chart provided.*

12. Why did the other stepper motors malfunction with just one stepper disconnected?

13. Where did you find the correct order that the steppers are supposed to be in?

14. *Re-assemble the vehicle, restore the system to normal operating condition and clear any faults.*

Workshop Exercise - Climate Control Output Diagnosis (BUG1)

Student instructions: Using an instructor assigned vehicle, hook up BMW Diagnostic Equipment.

1. *Perform a short test on the IHKA system and list any fault codes found below.*

2. *Verify the system operation and list your findings below.*

3. *Following repair procedures, gain access to JB/JBE, Blower Motor and Final Stage, A/C Housing and Stepper Motors.*

4. *Go to Function Selection and test temperature specification.*
   Is this function working properly?

5. *Perform an Air Distribution Test Plan next.*
   Is the Stepper Motor order correct?

6. *Work through the Test Plan to come to a conclusion to the problem.*

7. Did the Test Plan help your diagnosis and what do you think the problem is?

8. *Start the test plan for re-addressing the stepper motors.*

9. *Verify they are connected and positioned properly.*

10. *Re-address the stepper motors, Quick Delete and Short Test.*
    Is the system working properly?

Workshop Exercise - Climate Control Output Diagnosis (BUG2)

Student instructions: Using an instructor assigned vehicle, hook up BMW Diagnostic Equipment.

1. *Perform a short test on the IHKA system and list the fault codes found below.*

2. What do these fault codes indicate?

3. *Verify system operation and list your findings below.*

4. *Following repair procedures, gain access to JB/JBE, Blower Motor and Final Stage, A/C Housing and Stepper Motors.*

5. *Complete the test plan for re-addressing the stepper motors. List your findings below.*

6. How would you find and correct the problem? *List your actions below.*

7. *After fixing the problem re-addressing the stepper motors, erase fault codes and short test. List any new fault codes below.*

Workshop Exercise - Climate Control Output Diagnosis (BUG3)

Student instructions: Using an instructor assigned vehicle, hook up BMW Diagnostic Equipment.
Customer complaint is temperature regulation.

1. *Manipulate the IHKA to verify system operation.*
   What problem, if any was evident from your inspection?

2. *Perform a Short Test on the vehicle.*
   List any Fault Codes present in the system below.

3. *Manipulate the temperature settings at the IHKA and monitor both heater core temperature sensor signals.*
   What seems to be the problem with the system?

4. What type of Temperature Control System are you working on?

5. Is this valve Ground Controlled or Power Controlled on this vehicle?

6. Where is a good location to tap in to the water valve signal?

7. *Using the appropriate brake-out box and V cable connect the scope to verify the water valve is getting the correct signal.*

8. What type of signal did you get?

9. *Manipulate the IHKA settings and observe the water valve signal for change.*
   Is the problem electronic or mechanical?

10. Would such a condition set a fault? and Why?

11. *Based on instructor evaluation, repair and retest the vehicle or move on to the next exercise.*

NOTES PAGE

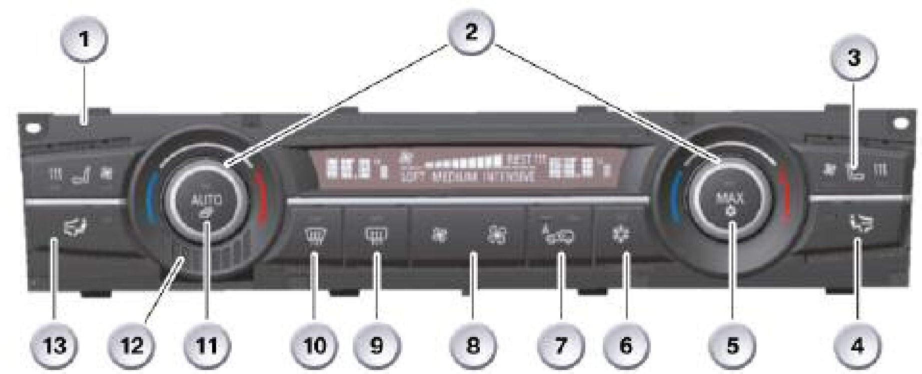
IHKA Functions and Features

BMW vehicles are equipped with various versions of climate control systems. Regardless of the version used, the objectives are basically the same. The climate control system is designed to perform the following functions:

- Remove heat from the passenger compartment when ambient temperatures are above the drivers comfort zone.
- Add heat from the passenger compartment when ambient temperatures are below the drivers comfort zone.
- Dehumidify the air entering the passenger compartment.
- Defrost front and rear windows for optimum vision and safety.
- Remove contaminants from incoming air (with microfilter-if equipped).

In addition to the above functions there are additional sub systems and additional features. These systems and features are not available on all models. These features include:

- Washer jet heating
- Windshield base heating
- “Rest” feature (residual heat)
- “Service Station” feature
- Parked car ventilation
- Automatic Air Recirculation (AUC)
- Cold start arrest
- Air pressure compensation



E70 IHKA Buttons

Index	Explanation	Index	Explanation
1	Driver seat heater and ventilation	8	Blower speed/REST Feature
2	Left and right temperature controls	9	Rear defog
3	Passenger seat heater and ventilation	10	front defrost
4	Passenger Air duct selection button	11	Automatic mode button
5	MAX AC Button	12	Interior temperature sensor
6	AC button	13	Driver Air duct selection button
7	AUC (Auto air recirculation)		

NOTES PAGE

E9X IHKA Functions

The IHKA used in the current E9X vehicles have the following functions:

- Temperature control
- Evaporator control
- Air distribution setting
- Airflow control
- Sunlight adaptation (solar sensor)
- MAX cooling
- Residual heat
- Defrost function
- AUTO function
- Heated rear window
- OFF
- Air recirculation mode
- Automatic air-recirculation control
- Condensation sensor program
- Convertible Mode (E93)

Temperature Control
The temperature for the best possible interior climate is regulated with a mixer flap in this (air based) heater/air conditioning system.

The air-mass flow is fed through the evaporator. As this happens, the air-mass flow is cooled and dried (providing the air-conditioning system is switched on). The mixer flap then feeds the air-mass flow completely or in part over the heating system heater core (depending on the desired temperature value set at the IHKA control panel). The air flow is subsequently mixed again. The air-mass flow is then fed through the ventilation flaps and into the vehicle interior.

The temperature inside the vehicle is controlled by means of a master controller. Temperature Control is based on the nominal values set and the calculated actual value (the nominal values are set with 2 temperature selector knobs).

The actual value is calculated from the temperatures measured by the interior temperature sensor and the footwell temperature sensor.

The lead parameter is calculated from the comparison between the actual value for the interior temperature and the corrected nominal value (calculated from temperature request, interior temperature and ambient temperature).

Compared to the set specification, the interior temperature is raised in the cold so that a comfortable level is achieved even at negative temperatures, despite the temperature setting being unchanged.

The ambient temperature is transmitted to the IHKA control unit via the K-CAN. The separate temperature setting for the driver's side and the front-passenger side makes 2 mixer flaps necessary.

Evaporator Control

The evaporator temperature is regulated by means of the evaporator temperature sensor and the expansion valve. The evaporator temperature is set to the predefined specification of 2°C (35.6°F). Lower temperatures are not possible due to the risk of icing.

If the function gradual evaporator control is encoded, the nominal value for the evaporator temperature will be calculated between 2°C and 7°C (35.6°F and 44.6°F). The specification depends on the ambient temperature, the ventilation temperature and the refrigerant pressure. A variable evaporator control reduces dehumidification. This enhances comfort for it reduces the risk of mucous membranes drying out.

Air Distribution Setting

For the best possible operation of the air distribution, it is important for the manually adjustable air vents to be open.

Occupants have the possibility of allowing the air distribution to be decided by the automatic program (AUTO button). Alternatively, individual, personal settings are possible through manual selection (defrost, ventilation, footwell).

If the vehicle is equipped with navigation/CCC, it is also possible to make a fine adjustment via the CID (Central Information Display) in the submenu Air distribution. Compared to manual selection, fine adjustment offers the additional possibility of further individualization of the air distribution.

Airflow Control

The airflow control is dependent on the following settings and control actions:

- Manual blower setting
- Automatic blower and flap setting - The automatic blower and flap functions are activated when the AUTO button is pressed.
- Dynamic pressure compensation - The air volume at the air inlet grills increases disproportionately with increasing road speed. This effect is compensated for by the opening angle of the fresh-air flap being reduced as speed increases (dynamic pressure compensation).

The opening angle is regulated according to the programming.

- Blower control - If necessary, the power management system will assign priority levels to reduce the blower output (via K-CAN).
- Effect of terminal 50 - When the engine is being started (terminal 50 ON), the blower is switched OFF to reduce the load on the vehicle battery.

Front Stratification Adjustment Thumbwheel

The front adjustment thumbwheel is part of the DSC/DTC/Hazard switch cluster.

The thumbwheel signal is wired directly to the IHKA control unit as an analog/varying voltage signal. The IHKA panel sends the specific position signal to the front mixing flap motor via the LIN bus.

Rear Stratification Adjustment Thumbwheel

The rear adjustment thumbwheels is located to the right of the rear center vent. The thumbwheel potentiometer signal is wired directly to the JBE control unit as an analog/varying voltage signal.

The JBE converts this signal into a digital signal over the K-CAN to the IHKA control unit which then sends the specific position signal to the rear mixing flap motor via the LIN bus.

Sunlight Adaptation (solar sensor)

How the solar sensor affects the IHKA regulation on the driver's side and on the front passenger side is not programmed separately. The following functions are modified when automatic mode is activated (depending on the intensity of sunlight):

- Blower output is increased or reduced
- Desired temperature value is increased or reduced

MAX Cooling

The MAX button makes it possible for the user to select maximum cooling with just one press of a button at the IHKA controls. When the MAX button is pressed, all functions, including the defrost function, are deactivated. The air conditioning function is activated (if it was not already activated) and defined settings are selected. (example: temperature control is deactivated, ventilation flaps are fully opened).

Residual Heat (REST)

The residual-heat function allows the heat from the engine to be used to heat up the vehicle interior when the engine is not running (e.g. during a stop at a level crossing).

The residual-heat function is only possible for a certain run-down period (15 minutes from terminal 15 OFF). The DME is signaled to activate the electric water pump via the bus system to circulate the coolant.

Switch-on Conditions:

- Terminal 15 OFF

  And
- Run-down period active (up to 15 minutes after terminal 15 OFF)

  And
- REST button in IHKA controls ON

  And
- Ambient temperature below 25°C

  And
- Engine temperature at some point above 60°C

  And
- On-board supply voltage over 11.4 volts

Conditions for Switching Off:

- Terminal 15 ON

  Or
- Residual heat ON (15 minutes) expired

  Or
- REST button in IHKA control panel OFF

  Or
- OFF condition activated with residual heat active (terminal R)

  Or
- Prompt from power management to switch off auxiliary consumers

  Or
- On-board supply voltage less than 11 volts

Defrost Function
When the defrost function is activated, the defroster flap (on the inside in front of the windshield) is opened fully. The fresh-air/air-recirculation flaps move to the fresh air position.

All other flaps are closed. The blower is run up to maximum output.

AUTO Function
When this button is pressed, all IHKA functions are set to automatic mode. If one or more automatically controlled functions are manually set, automatic control for the functions concerned will be cancelled.

Note: All other functions remain automatically controlled.

Heated Rear Window
The heated rear window is switched on when the button in the IHKA control panel is pressed. The function indicator lamp in the button lights up.

The heated rear window is switched off by pressing the button again or automatically after the heating time has expired.

Defrosting Phase (1st heating period)
When terminal 15 is switched ON, the first time the system is switched on, the time span for the heated rear window is defined as follows:

- Ambient temperature down to -15°C: Heating period: 10 minutes
- Ambient temperature below 15°C: Heating period: 17 minute

Pulsing
After the defrosting phase, the heating phase (25 minutes with pulsed heat output (on-off cycle: 40 seconds ON, 80 seconds OFF). The function indicator lamp in the button is off during pulsing. reversed step-by-step in reverse order.

2nd Heating Period
After the 1st heating period has expired, each subsequent time the button is pressed will cause the heated rear window to be switched on for a further 30 minutes (defrosting phase).After the 2nd heating period has expired, output is again pulsed.

OFF
The IHKA control panel is switched off when the blower speed is set to 0. (The control panel/control unit continues to run in the background.)

Air-recirculation Mode
In air-recirculation mode, the flow of outside air can be stopped to prevent pollution from entering the vehicle, e.g. in traffic congestion. Air inside the vehicle is continually re-circulated.
To make sure that there is a sufficient supply of fresh air, air-recirculation mode is only available for a limited time. (30 minutes air recirculation -> 30 seconds partial fresh air -> 30 minutes air recirculation -> etc.)

Automatic Air-recirculation Control

If the AUC II sensor detects an increased level of pollutants in the environment from spark-ignition and diesel engines, the IHKA control unit will automatically switch to air recirculation mode.

To make sure there is still an adequate supply of fresh air, air recirculation is only available for a limited time:

- At ambient temperatures less than 0°C: 2 minute re-circulated air mode -> 20 seconds fresh air mode -> 2 minute re-circulated air mode -> etc.
- At ambient temperatures from 0°C to 6°C: 3 minute re-circulated air mode -> 20 seconds fresh air mode -> 3 minute re-circulated air mode -> etc.
- Operation without a/c function at ambient temperatures greater than 6°C: 4 minute re-circulated air mode -> 20 seconds fresh air mode -> 4 minute re-circulated air mode -> etc.
- Operation with a/c function at ambient temperatures greater than 6°C: 12 minute re-circulated air mode -> 20 seconds fresh air mode -> 12 minute re-circulated air mode -> etc.

When the engine is started and the AUC function activated, fresh-air mode is always selected for about. 40 seconds due to the warming phase of the AUC sensor.

Condensation Sensor Program

The following conditions must be satisfied for the condensation sensor to operate:

- The engine must be running
- The IHKA must be in automatic mode

The IHKA control unit evaluates the condensation sensor signal (humidity). If condensation on the windshield is imminent, the following measures are initiated in sequence to prevent condensation from forming:

- Open defrost flaps further
- Switch from air-recirculation/AUC/automatic air-recirculation mode to partial fresh-air mode
- Switch from partially fresh air in air-recirculation/AUC/automatic air-recirculation mode to fresh air
- Increase blower air volume
- Reduce air volume for the footwell
- Increase desired temperature value

If one measure proves to be ineffective, the next measure is initiated. Once successful, the measures previously performed are reversed step-by-step in reverse order.

Convertible Mode (E93)

The E93 Convertible with its retractable hardtop combines two vehicles in one. It is a Coupe when closed and a Convertible when open, a fact taken into account by the automatic climate control to create pleasant and comfortable heating/ventilation conditions.

This characteristic makes it possible for an individual climate control program for both states. The software automatically initiates the automatic climate control program when it detects that the hardtop is down.

Trials and customer surveys have shown that the previous air conditioning systems set up for Sedans or Coupes were not ideal for a Convertible with the top down.

The temperature and blower output stage had to be constantly readjusted for the purpose of ensuring pleasant interior conditions.

All control parameters are adapted to the requirements of driving with the top down when the hardtop is lowered.

Convertible mode requires no additional sensors. The IHKA control unit was programmed with corresponding software that takes these specific parameters into account.

Convertible mode is activated by opening the retractable hardtop. The IHKA receives the corresponding information on the status of the hardtop from the Convertible top module (CTM).

Note: The E64 was also equipped with a convertible mode for the Climate Control.

Convertible mode is always active on vehicles with no central information display (CID). On vehicles with central information display, the Convertible Mode box in the "Automatic Program" menu must first be activated.

This activation is possibly only with the hardtop open and is set to active as part of initial programming.

E93 CID Climate Program selection screen

Note: If Convertible mode is not activated, the selected automatic program (soft, medium, intensive) is activated when the hardtop is opened.

Condition Based Service

Fresh Air/Recirculating Air Filters

The E9X is equipped with a carbon activated microfilter which is accessible from the engine compartment.

1. E90 Microfilter

Fresh air is drawn in via two filter elements in the intake area in front of the bulkhead. The recirculated air is drawn in at the side by the blower via separate recirculating air filters.

Fresh Air Filtering

A particulate filter or a micro/activated charcoal "combination filter" is also used on the E70 fresh air intake. The particulate filter (also referred to as a microfilter) removes dust, pollen, soot and other dirt from the fresh air that is needed to control the climate of the vehicle.

The adsorption filter (activated charcoal filter) has the job of removing the pollutants (hydrocarbons, acidic gasses) that mainly occur in high concentrations under smog conditions from the fresh air used the vehicle's IHKA system.

Recirculated Air Filtering

A new type of honeycomb filter is used in the recirculated air intake.

The versions for fresh air particulate filters can also be used for filtering recirculated air, but are used for cleaning the air in the passenger compartment.

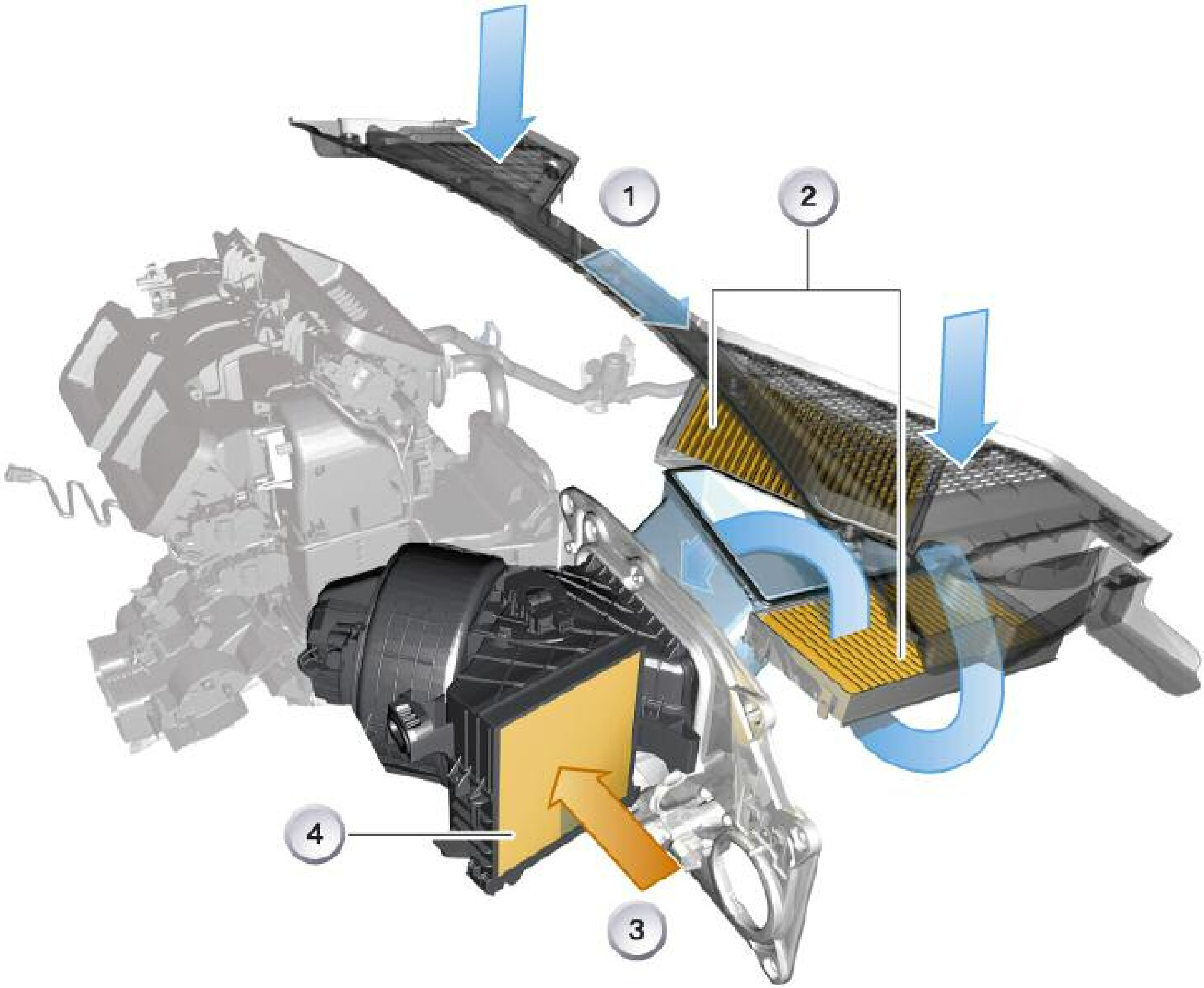
Filter types and equipment in the E70. All filters are electrostatically charged during manufacture and have the characteristic of attracting particles and holding them in, therefore cleaning the air.

The performance figures of an adsorption filter are initial pressure loss, particle separation, dust storage capacity, gas adsorption (such as n-butanes, sulphur dioxide, toluene) and are independent of the filter surface and the air-mass flow.

In order to be able to cope with customer specific filter usage and associated change interval increases and reductions, the filter change intervals of the E70 have not been stored in the CBS (Condition Based Service) system.

Note: The filter change intervals can be found in the relevant service literature.

E70 Air Filtering



Index	Explanation	Index	Explanation
1	IHKA fresh air intake	3	IHKA recirculated air intake
2	IHKA fresh air filter	4	IHKA recirculated air filter