SURFACE VEHICLE STANDARD

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(R) R-12 (CFC-12), R-134a (HFC-134a), R-1234yf (HFO-1234yf), R-744, and R-152a (HFC-152a) Technician Training for Service and Containment of Refrigerants Used in Mobile A/C Systems

RATIONALE

This SAE Standard is intended to identify the requirements for service technicians to be professionally trained when required to service MAC systems that use refrigerant. Updates are being made to add R-152a and revise some requirements for other refrigerants.

1. SCOPE

Mobile air conditioning (MAC) systems used in passenger cars and light duty trucks are covered by these SAE Standards when servicing the refrigerant system. Technician training is required to ensure that recommended procedures are used for service and repair of MAC systems using R-12, R-134a, R-1234yf, R-744, and R-152a refrigerants. Unique requirements for each refrigerant are detailed within this standard. Technicians may be trained in any or all refrigerants. The technician shall be trained to recognize which refrigerant is being handled and how to handle it safely, and be equipped with the essential information, proper equipment, and tools which are unique to these refrigerants. This standard outlines minimum content requirements for such training programs. Training programs designed in accordance with this standard are not intended to ensure or assess the technical skills of technicians regarding the diagnosis and repair of motor vehicle air conditioners. Rather, the goal of such programs is to provide information to technicians about safely handling refrigerants and control of emissions during service.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

2.1.1.1 System Design Guidelines

SAE J639 Safety and Design Standards for Motor vehicle Refrigerant Vapor Compression Systems

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2.1.1.2 System Components

SAE J2064 Coupled Automotive Refrigerant Air Conditioning Hose Assemblies

SAE J2196 Service Hose for Automotive Air Conditioning

SAE J2197 HFC-134a (R-134a) Service Hose Fittings for Automotive Air Conditioning Service Equipment

SAE J2842 R-1234yf and R744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements

SAE J3062 Automotive Refrigerant Air Conditioning Hose Requirements

2.1.1.3 Technician Service Procedures

SAE J1628 Technician Procedures for Refrigerant Leak Detection in Service of Mobile Air Conditioning Systems

SAE J1989 Recommended Service Procedure for the Containment of CFC-12 (R-12)

SAE J2211 Recommended Service Procedure for the Containment of HFC-134a (R-134a)

SAE J2298 Ultraviolet Leak Detection: Procedure for Use of Refrigerant Leak Detection Dyes for Service of Mobile Air Conditioning Systems

2.1.1.4 Service Equipment

SAE J1771 Criteria for Refrigerant Identification Equipment for Use with Mobile Air Conditioning Systems

SAE J2296 Retest of Refrigerant Container

SAE J2297 Ultraviolet Leak Detection: Stability and Compatibility Criteria of Fluorescent Refrigerant Leak Detection Dyes for Mobile R-134a and R-1234yf (HFO-1234yf) Air Conditioning Systems

SAE J2299 Ultraviolet Leak Detection: Performance Requirements for Fluorescent Refrigerant Leak Detection Dye Injection Equipment for Aftermarket Service of Mobile Air Conditioning Systems

SAE J2670 Stability and Compatibility Criteria for Additives and Flushing Materials Intended for Aftermarket Use in R-134a (HFC-134a) and R-1234yf (HFO-1234yf) Vehicle Air Conditioning Systems

SAE J2791 HFC-134a Refrigerant Electronic Leak Detectors, Minimum Performance Criteria

SAE J2888 R-1234yf Service Hose, Fittings, and Couplers for Mobile Refrigerant Systems Service Equipment

SAE J2912 Performance Requirements for R-134a and R-1234yf Refrigerant Diagnostic Identifiers (RDI) for Use with Mobile Air Coniditoning Sysystems

SAE J2913 R-1234yf [HFO-1234yf] Refrigerant Electronic Leak Detectors, Minimum Performance Criteria

SAE J2927 R-1234yf Refrigerant Identifier Installed in Recovery and Recycling Equipment for Use with Mobile A/C Systems

SAE J2970 Minimum Performance Requirements for Non-Refrigerant Tracer Gasses and Electronic Tracer Gas Leak Detectors

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2.1.1.5 Recovery/Recycle Equipment

SAE J1732 HFC-134a (R-134a) Refrigerant Recovery Equipment for Mobile Automotive Air Conditioning Systems

SAE J1990 Recovery and Recycle Equipment for Mobile Automotive Air Conditioning Systems

SAE J2209 CFC-12 (R-12) Refrigerant Recovery Equipment for Mobile Automotive Air Conditioning Systems

SAE J2788 HFC-134a (R-134a) Recovery/Recycle/Recharging Equipment for Mobile Air Conditioning Systems

SAE J2810 HFC-134a (R-134a) Refrigerant Recovery Equipment for Mobile Automotive Air Conditioning Systems

SAE J2843 R-1234yf (HFO-1234yf) Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air Conditioning Systems

SAE J2851 Recovery Equipment for Contaminated R-134a or R-1234yf Refrigerant from Mobile Automotive Air Conditioning Systems

SAE J3030 Automotive Refrigerant Recovery/Recycling/Recharging Equipment Intended for Use with Both R-1234yf and R-134a

2.1.1.6 Replacement Refrigerant Requirements

SAE J1657 Selection Criteria for Retrofit Refrigerants to Replace CFC-12 (R-12) in Mobile Air Conditioning Systems

SAE J1659 Vehicle Testing Requirements for Replacement Refrigerants for CFC-12 (R-12) Mobile Air Conditioning Systems

SAE J1991 Standard of Purity for Use in Mobile Air Conditioning Systems

SAE J2099 Standard of Purity for Recycled R-134a (HFC-134a) and R-1234yf (HFO-1234yf) for Use in Mobile Air Conditioning Systems

SAE J2683 Refrigerant Purity and Container Requirements for Carbon Dioxide (CO_2 R-744) Used in Mobile Air Conditioning Systems

SAE J2776 Refrigerant Purity and Container Requirements for New HFC-134a 1,1,1,2 - Tetrafluoroethane Refrigerant Used in Mobile Air Conditioning Systems

SAE J2844 R-1234yf (HFO-1234yf) New Refrigerant Purity and Container Requirements Used in Mobile Air Conditioning Systems

2.1.1.7 Publication Certification

SAE J2911 Procedure for Certification that Requirements for Mobile Air Conditioning System Components, Service Equipment, and Service Technician Training Meet SAE J Standards

2.1.2 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 13043 Road Vehicles - Refrigerant Systems Used in Mobile Air Conditioning Systems (MAC) - Safety Requirements

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2.1.2.1 ISO Standard 13043

States that technicians shall be trained in recommended practices as described in SAE J2845 for R-744 and R-1234yf:

- Seven design requirements for service and manufacturing.
- R -134a service equipment according to SAE J2788.
- R -1234yf service equipment according to SAE J2843.
- R -152a service equipment according to future SAE standards.

2.1.3 Other Publications

ASHRAE 34 Designations and Safety Classification of Refrigerants

"Certification Training Manual Including Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians and Best Service Practices," Mobile Air Conditioning Society, Lansdale, PA.

R-12 MSDS (available from the chemical suppliers)

R-744 MSDS (available from chemical suppliers)

R-1234yf MSDS (available from chemical suppliers)

R-152a MSDS (available from chemical suppliers)

R-134a MSDS (available from chemical suppliers)

3. TECHNICIAN TRAINING SHALL COVER THE FOLLOWING REGARDING REFRIGERANTS

3.1 Refrigerants may be referred to with a prefix denoting their specific class or their common class. For this standard, the following shall be considered interchangeable: CFC-12 = R-12, HFC-134a = R-134a, HFO-1234yf = R-1234yf, CO_2 = R-744, and HFC-152a = R-152a.

3.2 The U.S. EPA's Significant New Alternatives Policy (SNAP) program reviews and lists refrigerants as acceptable, subject to use conditions, or unacceptable for use in mobile air conditioning systems. In general, the use conditions may identify if specific design criteria are required for the system applications. These use conditions are in addition to the servicing requirements of MAC systems that identify refrigerants requiring non-venting and use of service procedures and equipment that is covered in this SAE J2845 document. These SAE Standards are based upon the U.S. EPA Section 609 mobile air conditioning systems and may be required by other international regulatory agencies.

3.3 Below are refrigerants that have been used internationally in MAC systems and refrigerants that EPA (SNAP) has listed as acceptable for use in MAC systems not requiring design use conditions.

3.3.1 CFC-12

3.3.1.1 Generally used in production vehicles prior to MY 1995.

3.3.1.1.1 If available, EPA SNAP allows R-12 to be used to service the original R-12 MAC systems.

3.3.1.1.2 R-134a has been used to retrofit R-12 systems.

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3.3.2 R-134a

3.3.2.1 Generally, first used in production vehicles in MY 1992.

3.4 Refrigerants the U.S. EPA has Listed Acceptable for Use in MAC Systems Requiring Design Use Conditions

3.4.1 R-1234yf

3.4.1.1 First used in production vehicles in MY 2012.

3.4.1.1.1 R-1234yf—after a 4-year SAE International Cooperative Research Project—identified it as a low global warming potential (GWP) refrigerant for use in MAC systems.

3.4.1.1.2 R-1234yf—currently in production MAC systems—cannot be used in R-12 or R-134a, direct expansion refrigerant systems, and shall meet the EPA's design use requirements. This is due to the ASHRAE 2L mildly flammable rating that requires system refrigerant circuit designs that are different than those that are used in R-134a MAC systems. Due to its mildly flammable status, there are special guidelines when servicing R-1234yf systems.

3.4.1.1.3 Due to its mildly flammable status, R-1234yf shall meet U.S. EPA system use design requirements.

3.4.2 R-152a

3.4.2.1 R-152a is not currently used in production vehicles in North America. This refrigerant, due to flammability (ASHRAE A2), shall not be used in a direct expansion MAC systems refrigerant system without meeting EPA design use requirements.

3.4.2.1.1 Based upon the EPA rule, it shall not be used as a replacement refrigerant in a production R-12, R-134a, or R-1234yf mobile air conditioning system.

3.4.2.1.2 Due to its A2 flammability classification, R-152a shall meet U.S. EPA's system use design requirements.

3.4.2.1.3 EPA suggests a secondary loop system design that uses a small R-152a refrigerant charge and coolant-based cooling circuit can comply with the EPA use conditions.

3.4.3 R744

3.4.3.1 R744 (carbon dioxide) is currently in a limited number of production MAC systems in Europe. In 1998, nine European partner organizations published the 3-year RACE study (Refrigeration and Automotive Climate Systems Under Environmental Aspects).

3.4.3.1.1 The U.S. EPA has listed R-744 as acceptable for use in MAC systems requiring design use conditions.

3.5 Refrigerants Not Acceptable for Use in MAC Systems (According to U.S. EPA SNAP Listing)

3.5.1 At this time, there are no other chemical replacements for use as a refrigerant in the U.S. for MAC systems.

3.5.2 Hydrocarbon products are highly flammable and are illegal to use as defined by the U.S. EPA and pose a safety concern, both for the service technician and the vehicle occupants.

3.5.3 Aftermarket products are sold to consumers under various names. These products are sold in aerosol applications and as a direct charging replacement refrigerant for R-12 and R-134a systems but have not been approved by EPA and/or vehicle manufacturers.

3.5.3.1 The containers can contain R-152a or hydrocarbons, including propane and butane, resulting in highly flammable products.

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3.5.4 Inspection of product safety data sheet may have danger hazard statements (GHS-US).

3.5.4.1 H220—Extremely flammable gas.

3.5.4.2 H280—Contains gas under pressure; may explode if heated.

3.5.5 Using other refrigerants in a MAC system can result in system cooling performance loss due to incorrect refrigerant control settings, such as TXV, pressure controls, and compressor failure due to incorrect lubricant.

4. MINIMUM GENERAL TECHNICAL AND SAFETY REQUIREMENTS TO BE COVERED IN TRAINING

4.1 Some of the practices, techniques, and procedures—as well as the information, tools, and equipment which have been commonly used in mobile air conditioning system diagnosis and service of R-12, R-134a, or other refrigerants—will be different for MAC systems using R-744, R-1234yf, or R-152a. Modifications and adjustments will have to be made based on the individual characteristics of each refrigerant. No technician may perform service or repair on a mobile air conditioning system using R-12, R134a, R-744, R-1234yf, or R-152a without being trained for the refrigerant being handled.

4.2 Service technicians shall be trained to always wear proper personal protective equipment while handling/servicing systems that contain any refrigerant.

4.3 Service technicians shall read and follow the appropriate material safety data sheets, which provide information on safety and the proper personal protective equipment to use. These include, but may not be limited to, the following items.

4.3.1 All contact with liquid or gaseous refrigerant shall be avoided.

4.3.2 Goggles with side protection and gloves (insulated against heat loss and impermeable to refrigerant) shall be worn while working with the refrigerant circuit.

4.3.3 Exposure of the skin to refrigerant may result in frostbite, in which case rub affected area with lukewarm water. A physician shall be consulted immediately regarding the affected skin areas.

4.3.4 A physician shall be consulted immediately in the event of complaints following exposure to high refrigerant concentrations. Complaint symptoms may include increased breathing rate, breathlessness, headache, accelerated pulse, and dizziness.

4.3.5 Avoid breathing A/C refrigerant and lubricant vapor or mist. To remove refrigerant from the A/C system, use service equipment designed for recovery of that refrigerant which is certified to meet the requirements of the appropriate SAE Standards.

4.3.6 Specific requirements for proper handling of flammable refrigerants to be covered in training.

4.4 Training shall include appropriate information regarding refrigerant cylinders.

4.4.1 All compressed gases in cylinders or portable tanks in motor vehicle service area shall be stored, handled, and transported in accordance with Compressed Gas Association Pamphlet P-1 or other regulatory bodies.

4.4.2 Storage of multiple containers of refrigerant may be subject to local, state, or federal rules or regulations.

4.4.3 In general, do not expose any compressed gas cylinders (R-134a, R-1234yf, CO_2, R-152a, etc.) to temperatures in excess of 52 °C (125 °F), as this may result in cylinders becoming liquid full. Excessive temperatures may cause cylinders to rupture and cause injuries to personnel and/or damage to property.

4.4.4 Refrigerant cylinders shall not be:

4.4.4.1 Exposed to direct sunlight or any other heat source.

4.4.4.2 Subject to mechanical stress (e.g., dropping, throwing).

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4.4.4.3 Stored in shafts (below ground surfaces/enclosed areas) or in front of cellar windows.

4.4.4.4 Filled in the workshop or by workshop personnel.

4.4.4.5 Filled with any refrigerant other than that for which it was originally intended.

4.4.4.6 Transported without being securely stowed.

4.5 Training shall discuss standard, hybrid electric and other commercialized alternative propulsion vehicles in the context of safety and performance of mobile A/C related issues (i.e., proper operation of the mobile air conditioning and cooling systems in a hybrid vehicle is important not only for passenger comfort, but for the optimal operation of on-board computers and battery packs). Training shall include coverage of plug-in hybrid or battery electric vehicles battery packs that use the A/C system in conjunction with a liquid cooling system for battery pack cooling. Chillers in a secondary loop should also be discussed, including service related to the coolant loop of these secondary loops. Due to the complexity of modern thermal system controls, training shall include exposure to the various types of control systems and how these systems can be used for diagnosis.

4.6 Technician training shall include:

4.6.1 Training shall discuss key differences between equipment and tools designed for each refrigerant and stress the use of proper equipment with designated refrigerant.

4.6.2 Differences between R-744, R-152a, and R-1234yf as compared to R-134a (see Appendix A).

4.6.3 Identification of unique fittings and labels for each refrigerant along with refrigerant tank requirements.

4.6.4 Instructions on how to use refrigerant identification equipment.

4.6.5 Instructions on how to use SAE-certified electronic leak detection equipment and/or fluorescent dyes to identify leaks with each refrigerant. Refer to SAE J1628.

4.6.6 Instructions on how to contain and limit the use of each refrigerant based on vehicle specifications to promote technician safety and minimize the environmental impact of mobile air conditioning by using the appropriate SAE-certified recovery, recycling, and charging equipment.

4.6.7 System servicing procedures as detailed in this standard and vehicle manufacture's specified procedures.

4.6.8 General safety best practices and specific safety best practices for each refrigerant. Technicians shall also have a good understanding of the safety requirements as defined in SAE J639.

4.7 Training shall incorporate pertinent information about equipment, tools, and procedures specific to each refrigerant.

4.8 Technicians shall be advised of specific issues related to hybrids and plug-in electric cars (BEVs) with high-voltage A/C systems. Training shall incorporate appropriate MAC procedures, including those related to safety, and the importance and general description of procedures for disabling a high-voltage system.

4.9 Training shall include pertinent information from the U.S. EPA regarding the retrofitting of refrigerants in vehicles including retrofitting that is permitted and retrofitting that is prohibited under the U.S. EPA guidelines.

4.9.1 Under EPA regulations R-12 MVAC systems can only be retrofitted by using R-134a refrigerant.

4.9.2 R-1234yf MVAC systems cannot retrofitted with any other refrigerant. The use of R-134a in a vehicle manufactured to use R-1234yf is a violation of Section 203 of the Clean Air Act.

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5. MINIMUM INFORMATION TO BE COVERED ON UNIQUE FITTINGS, LABELS, AND CYLINDERS

5.1 Technicians shall be informed that industry standards and government regulations require the use of unique service fittings, labels, and cylinders for each refrigerant and be able to identify those fittings and labels.

5.1.1 R-12 cylinder is white.

5.1.2 R-134a cylinder is light blue (PMS color 2975).

5.1.3 R-1234yf cylinder is white with red band to denote flammability.

5.1.4 R-744 cylinder is gray (PMS color 352).

5.1.5 R-152a cylinder external color for new refrigerant shall be white with a red band on the shoulder or top of the container to designate a Class IV flammable refrigerant. Cylinder color should not be used as the primary indicator of the contents of the cylinder.

5.1.5.1 Label R-152a, 1,1-difluoroethane; DOT Label Flammable gas CAS number 75-36-6.

5.2 Fitting information for each refrigerant is available in SAE J639.

5.3 The U.S. EPA's significant new alternatives policy (SNAP) requires that each refrigerant shall be used with a set of unique fittings to prevent the accidental mixing of refrigerants. These fittings are attachment points on the MAC system itself, on all recovery recycling equipment, on can taps and other charging equipment, and on all refrigerant containers. Unique fittings help protect consumers and technicians by ensuring that only one type of refrigerant is used in each MAC system. They also protect the purity of the recycled supply of refrigerant. More information regarding EPA SNAP may be found on the EPA website.

6. MINIMUM INFORMATION TO COVER ON REFRIGERANT IDENTIFICATION

6.1 Prior to servicing a MAC system, technicians shall be required to verify what refrigerant is in the system. This shall include checking the SAE J639 system label to get information about the type and quantity of refrigerant that should be in the A/C system and potential issues arising from accidental or intentional mixing of refrigerants.

NOTE: Technicians shall also be warned that fittings can be illegally defeated with adapters, labels might never be installed, and even properly affixed labels can fall off or become illegible; for these reasons, the use of an SAE-certified refrigerant identification device is required to prevent the spread of contaminated refrigerant to other vehicles and the refrigerant supply.

6.2 Even though the label may be adhered correctly, this does not necessarily ensure that the proper refrigerant is contained within the A/C system. MAC systems might contain R-12, R-152a, R-134a, R-1234yf, R-744, and any of a number of hydrochlorofluorocarbons (HCFCs) and/or blends, HCs, or a mixture of any of the above.

6.3 Mixtures of refrigerants shall be recognized so technicians can protect themselves from hazard and to protect the shop refrigerant supply, shop equipment, and MAC systems of customer vehicles from contamination.

6.4 Mixtures of refrigerants shall be identified to prevent improper recovery and the resulting further spread of the contaminated refrigerant, which could potentially damage other MAC systems and service equipment. Refrigerant recovery and recycling equipment is designed to process only one refrigerant for reuse. Recycling equipment will not segregate mixtures of refrigerants. Contaminated refrigerant (blend of more than one refrigerant or non-system refrigerant) in recovery/recycling equipment could lead to the potential contamination of more refrigerant. Technicians shall understand the use of recovery equipment to safely recover contaminated refrigerant and where to find approved reclamation/destruction facilities for contaminated refrigerant along with applicable regulations that cover this situation. For more information, refer to the EPA website.

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6.5 The technician shall understand that the use of a refrigerant identifier can provide an important safety warning that a hydrocarbon or other improper refrigerant has been charged into the system. Certain types of electronic leak detection devices (heated diode or corona discharge)—as well as motors, switches, and controls on recovery and recycling machines—could generate sparks that could serve as ignition sources, with the potential to result in a fire, in the presence of refrigerants classified as flammable (A2, A2L, or A3) by ASHRAE Standard 34.

6.6 Training programs shall address the possibility that the mixing of refrigerants in a MAC system can result in higher-than-expected system pressures, system and component damage, diagnostic errors, and/or other potential hazards to people and environment.

7. MINIMUM INFORMATION TO COVER ON ELECTRONIC LEAK DETECTION AND USE OF FLUORESCENT DYES

7.1 Training shall incorporate pertinent information about equipment, tools, and procedures specific to each refrigerant. Training shall incorporate pertinent references to SAE Standards for electronic leak detectors and trace dyes, as well as the technician procedure for using electronic refrigerant leak detectors, trace dyes, and other methods. This includes non-refrigerant tracer gases and electronic tracer gas leak detectors as identified in SAE J2970.

7.2 Training shall indicate that all electronic leak detectors are subject to some level of false triggering. A list of common false triggering chemicals can be found in both SAE J2791 and SAE J2913.

7.2.1 Training shall indicate that users should consult all manufacturers operating instructions for additional information.

7.2.2 Training shall indicate that, when using an ELD (electronic leak detector) to check for a leaking port leak, it is normal to find refrigerant in the space between the valve core and the sealing cap immediately after opening the cap. Therefore, the service port and cap assembly must first be checked as an assembly prior to opening the cap.

7.2.3 Training shall indicate that before opening the sealing cap, inspect around the cap seal. If no leak is found, the valve core is not likely to be a major leak source.

7.2.4 Training shall indicate that if a leak can be detected around the sealing cap, remove the cap and wait 30 seconds. Waft air across the service port to remove residual refrigerant that may have built up below the cap, then inspect for a leak with an ELD. If air is not moved across the service port, a false leak indication may occur.

7.2.5 Training shall inform users to not place the electronic leak detector's probe tip down inside the service port, as it may damage the valve core pin. Only pass the probe tip around the upper edge of the service port.

7.2.6 Training shall indicate that the service port cap is the primary seal for the service port. Contrary to popular belief, it is not the valve core that is down inside the port; therefore, missing or damaged caps should always be replaced to minimize refrigerant loss.

7.2.7 Training shall include the proper method of inspecting hose coupling connections at the crimping areas, seals, and connections for leaks using an electronic refrigerant leak detector.

7.3 Training shall include the following regarding R-12 performance criteria for electronic refrigerant leak detectors.

7.3.1 Shall have a label which states "Design Certified by (Certifying Agent) to Meet SAE J1627."

7.4 Training shall include the following regarding R-134a performance criteria for electronic refrigerant leak detectors.

7.4.1 Shall have a label which states "Design Certified by (Certifying Agent) to Meet SAE J2791."

7.4.2 Leak detectors certified to SAE J2970 may also be used to detect leaks in R-134a systems.

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7.5 Training shall include the following regarding R-1234yf performance criteria for electronic refrigerant leak detectors.

7.5.1 Shall have a label which states “Design Certified by (Certifying Agent) to Meet SAE J2913.”

7.5.2 Technicians shall be informed that certain leak detection devices (heated diode or corona discharge) that are not certified to SAE J2913 could serve as ignition sources in the presence of hydrocarbons or other flammable refrigerants.

7.5.3 Leak detectors certified to SAE J2970 may also be used to detect leaks in R-134a systems.

7.6 Training shall include the following regarding R-744 carbon dioxide.

7.6.1 Leak detection for this refrigerant presents a unique challenge. R-744 (CO_2) exists naturally and artificially in the atmosphere and could trigger detection devices when there is no system leak.

7.6.2 Use SAE J2970 if no other alternative is available.

7.7 Training shall include the following regarding R-152a performance criteria for electronic refrigerant leak detectors.

7.7.1 Shall have a label which states “Design Certified by (Certifying Agent) to Meet (future SAE standards).”

7.7.2 Technicians shall be informed that certain leak detection devices (heated diode or corona discharge) that are not certified to future SAE standards could serve as ignition sources in the presence of hydrocarbons or other flammable refrigerants.

7.7.3 Leak detectors certified to SAE J2970 may also be used to detect leaks in R-152a systems.

8. MINIMUM INFORMATION TO COVER ON RECOVERY, RECYCLING, AND RECHARGING EQUIPMENT, AND RECOVERY ONLY EQUIPMENT

8.1 U.S. EPA regulations currently require recovery of all MAC refrigerants. Refrigerant oil shall be collected and disposed of in accordance with federal, state and local requirements.

8.2 R-12

8.2.1 Training shall reference SAE J2209.

8.3 R-134a

8.3.1 Training shall reference SAE J2788.

8.3.2 Training shall reference SAE J2810.

8.4 R-1234yf

8.4.1 Training shall reference SAE J2843.

8.4.2 If a refrigerant system with R-1234yf is overcharged and a leak into the passenger compartment occurs, the concentration in the passenger compartment could exceed the lower flammability limit. Should a significant ignition source occur within the area—with this high concentration in the passenger compartment—it could result in ignition of the refrigerant potentially resulting in a fire.

8.4.3 Motors, switches, battery cables, connections, and controls on some recovery and recycling equipment could serve as ignition sources in the presence of flammable refrigerants. Only electrical devices (with anti-arcing designed) as specified in SAE J2843 are permitted.

8.4.4 Technicians shall also be warned and told how to avoid other possible high amperage discharges, which might ignite certain refrigerant mixtures.

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8.4.5 Technician training shall incorporate pertinent elements of SAE J2843 for refrigerant recovery, recycling and recharging equipment.

8.4.6 Technicians shall be informed that recharge equipment (and procedures) will be different from those used for current MAC systems. Automatic refrigerant recharge requirements will be included in certified recovery and recycling equipment:

8.4.7 Because R-1234yf is flammable, the following procedures are essential to avoid a potential hazard.

8.4.7.1 For example, before delivering a full system charge, equipment used to recharge R-1234yf systems will first place the system under a minimum vacuum of -0.09 MPa gauge (26.9 in Hg). The machine will then monitor the applied vacuum and note if it decays. If the slope of the vacuum decay exceeds 51 mm Hg/min (2.0 in Hg/min) in 5 minutes, then a leak is indicated and the machine will not permit the recharge process to continue. The technician shall locate and repair the leak(s) before again attempting to recharge the system.

8.4.7.2 If the system passes the vacuum decay check, the machine shall instruct the user to turn the vehicle's HVAC blower motor on low (A/C off), with air distribution mode set to "floor," to run the blower for 1 to 2 minutes to clear any residual contamination and to place an operating SAE J2913-compliant leak detector's probe with the unit set for maximum sensitivity in the center of a floor ducts outlet.

8.4.7.3 The machine shall ask user to verify the leak detector is in place and blower motor is on low. If "no," the machine shall not allow user to continue.

8.4.7.4 If "yes," the machine shall initiate a gross leak test by charging 15% of the refrigerant system charge specified on the SAE J639 vehicle label on both high and low sides of the system. The user will be required to monitor the SAE J2913 leak detector for 5 minutes for indication of a leak.

8.4.7.5 The machine shall ask the user to verify if a leak is detected or not.

8.4.7.6 If leak is detected, the equipment shall continue to hold for further external leak checking and shall lock out all operations except recovery and/or re-evacuation.

8.4.7.7 If vacuum decay and pressurized leak checks are passed, then the balance of the programmed amount shall be charged.

8.4.7.8 Extra care shall be taken to avoid significant over-charging of the refrigerant system.

8.5 R-744 Carbon Dioxide

8.5.1 The proper recovery of CO_2 from high-pressure systems is necessary to ensure a harmless depressurization and avoid technician exposure to unacceptable concentrations of CO_2 in the work area. Similar considerations will apply to recharging the system.

8.5.2 At this time, an SAE Standard does not exist for R-744 service equipment.

8.5.3 The technician shall be informed that R-744 systems operate at much higher (five to ten times) pressures than current systems.

8.5.4 If a refrigerant system with CO_2 is overcharged, it can lead to high-pressure build-up in the system and the technician needs to be made aware of potential pressure differences.

8.5.5 If a refrigerant system with CO_2 is overcharged and a leak into the passenger compartment occurs, the concentration in the passenger compartment could exceed the occupant, health-based, limit for CO_2.

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8.6 R-152a

8.6.1 Training shall reference future SAE standards.

8.6.2 If a refrigerant system with R-152a is overcharged and leaks from the system, a local concentration could exceed the lower flammability limit. Should a significant ignition source occur within this same local area, it could result in ignition of the refrigerant.

8.6.3 Motors, switches, battery cables, connections, and controls on some recovery and recycling equipment could serve as ignition sources in the presence of flammable refrigerants potentially resulting in a fire. Only electrical devices (with anti-arcing designed) as specified in future SAE standards are permitted.

8.6.4 Technicians shall also be warned and told how to avoid other possible high amperage discharges which might ignite flammable refrigerant mixtures.

8.6.5 Technician training shall incorporate pertinent elements of future SAE standards for refrigerant recovery, recycling, and recharging equipment.

8.6.6 Technicians shall be informed that recharge equipment (and procedures) will be different from those used for current MAC systems. Automatic refrigerant recharge requirements will be included in certified recovery and recycling equipment:

8.6.7 Because R-152a is flammable, the following procedures are essential to avoid a potential hazard.

8.6.7.1 For example, before delivering a full system charge, equipment used to recharge R-152a systems will first place the system under a minimum vacuum of -0.09 MPa gauge (26.9 in Hg). The machine will then monitor the applied vacuum and note if it decays. If the slope of the vacuum decay exceeds 51 mm Hg/min (2.0 in Hg/min) in 5 minutes, a leak is indicated and the machine will not permit the recharge process to continue. The technician shall locate and repair the leak(s) before again attempting to recharge the system.

8.6.7.2 If the system passes the vacuum decay check, the machine shall instruct the user to turn the vehicle's HVAC blower motor on low (A/C off), with air distribution mode set to "floor," to run the blower for 1 to 2 minutes to clear any residual contamination and to place an operating future SAE standards-compliant leak detector's probe with the unit set for maximum sensitivity in the center of a floor ducts outlet.

8.6.7.3 The machine shall require user to verify leak detector is in place and blower motor is on low. If "no," the machine shall not allow user to continue.

8.6.7.4 If "yes," the machine shall charge 15% of the refrigerant system charge specified on the SAE J639 vehicle label on both high and low sides of the system. The user will be required to monitor the future SAE standards leak detector for 5 minutes for indication of a leak.

8.6.7.5 The machine shall require user verification if a leak is detected or not.

8.6.7.6 If leak is detected, the equipment shall continue to hold for further external leak checking and shall lock out all operations except recovery and/or re-evacuation.

8.6.7.7 If vacuum decay and pressurized leak checks are passed, then the balance of the programmed amount shall be charged.

8.6.7.8 Extra care shall be taken to avoid significant over-charging of the refrigerant system.

9. MINIMUM SYSTEM SERVICING PROCEDURES TO BE COVERED IN TRAINING

9.1 Training shall incorporate pertinent information about service procedures specific to each refrigerant. Training shall incorporate pertinent references from SAE J2211, detailing recommended service procedures for containment of refrigerants.

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9.2 Technicians shall be advised to clean all dirt, grease, and debris from and around connection joints before servicing and disassembly of refrigerant connections.

9.3 Technicians shall be advised to carefully inspect refrigerant connections, joint seals, and seal surfaces for signs of wear, deformation, contamination, or damage after disassembly. Prior to disassembly, look for presence of refrigerant oil on adjacent surfaces that could be sign of a leak. Due to lower oil charges and lower compressor oil retention in some newer models, an absence of oil or dye residue may not be an indication that there is no oil leaking from the compressor. Service ports and hoses shall be inspected for signs of leakage.

9.3.1 Technicians shall be advised that after removal of the quick release service charge couplers from the high and low side service fitting ports they shall be checked for refrigerant leakage after system service.

9.3.2 The replaceable valve core in the service port fitting can be a source of refrigerant leakage. MAC systems shall have fitting caps that provide a covering to minimize dirt/dust from entering the service fittings and a device, such as a tether, that assures the cap cannot easily be misplaced during service. MAC systems using R-134a, R-152a, or R-1234yf shall use a sealed service-fitting cap. Caps for R-744 fittings shall have a vent so that refrigerant cannot become trapped under the cap posing a safety concern when removed (potential for cap to become a projectile and/or create a potentially harmful spray of refrigerant).

9.3.3 Refrigerant leakage from the core valve can be due to age, temperature, or the seal surface taking a compression set, then—after being opened improperly—re-sealing. Damage to the core pin can occur from the installation of quick release service charge couplers.

9.3.4 Technicians shall be advised that damaged valve cores shall be replaced with parts specifically designed for the appropriate refrigerant and application.

9.4 Technicians shall be advised that seals, gaskets, and O-rings shall never be reused but replaced with all new parts.

9.5 Technicians shall be advised to ensure proper alignment of male/female portions and seal so there is no misalignment and stress on the fitting connection.

9.6 Technicians shall be advised that refrigerant connection shall be tightened to correct bolt/nut torque value specified by manufacturer.

9.7 Technicians shall be informed of the importance of maintaining good ventilation in the work area.

9.8 Technicians shall be advised to open vehicle windows and doors when charging a MAC system to prevent an accumulation of refrigerant in case of a major refrigerant leak. If a major leak inside of the vehicle passenger compartment is detected, technicians shall vacate the vehicle and ventilate the area.

9.9 Technicians shall be informed that refrigerants are heavier than air and, in general, low lying areas such as workshop pits, shafts, or cellar exits are areas where released refrigerant can pool in the absence of ventilation. Work areas shall be adequately ventilated to prevent an excessive buildup of refrigerants.

9.10 R-12

9.10.1 Technician training shall incorporate pertinent information for servicing R-12 mobile air conditioning systems.

9.11 R-134a

9.11.1 Technician training shall incorporate pertinent information for servicing R-134a mobile air conditioning systems.

9.12 R-1234yf

9.12.1 Technicians shall be advised of the following general service procedures.

9.12.1.1 Work areas shall be adequately ventilated to prevent R-1234yf plus air mixtures from reaching the flammability range of 6.2 to 12.3% by volume.

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9.12.1.2 For example, NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas 2008 Edition and/or NFPA 69 may be used for reference to understand and monitor vapor-air concentrations for flammable refrigerants.

9.12.2 Technicians shall be advised, for safety reasons, that evaporators in vehicles equipped with R-1234yf refrigerant systems shall never be repaired or replaced with one removed from another or salvage vehicle, and that new replacement MAC evaporators shall meet the appropriate SAE J2842 and any labeling requirements.

9.13 R-744

9.13.1 Technician training shall incorporate pertinent information for servicing of R-744 mobile air conditioning systems

9.13.2 Technicians shall be advised, for safety reasons, that evaporators in vehicles equipped with R-744 refrigerant systems shall never be repaired or replaced with one removed from another or salvage vehicle, and that new replacement MAC evaporators shall meet the appropriate SAE J2842 and any labeling requirements.

9.14 R-152a

9.14.1 Technicians shall be advised that with R-152a in a secondary loop, no refrigerant heat exchangers are located within the passenger cabin. However, replacement of defective system heat exchangers with only new components is required.

9.14.2 Technicians shall be advised of the following general service procedures.

9.14.2.1 In general, low lying areas, such as workshop pits, shafts, or cellar exits are areas where released refrigerant can pool in the absence of ventilation. Work areas shall be adequately ventilated to prevent R-152a plus air mixtures from reaching the flammability range of 3.7 to 18% by volume.

9.14.2.2 For example, NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas 2008 Edition and/or NFPA 69 may be used for reference to understand and monitor vapor-air concentrations for flammable refrigerants.

9.14.3 Technicians shall be made aware of the potential for leakage of R-152a from the cabin cooling coil to the coolant heat exchanger.

10. GENERAL AND SPECIFIC SAFETY PRACTICES

10.1 Training shall address the unique characteristics of each refrigerant and incorporate information to promote recommended practices in the work environment. Technicians shall be advised to review the MSDS and all related safety information for each refrigerant.

10.2 R-1234yf Specific Requirements

10.2.1 Although design features are integrated into systems and R-1234yf is a mildly flammable refrigerant as classified by ASHRAE 34, various precautions shall be observed.

10.2.2 R-1234yf minimum technician training shall incorporate information addressing the following key areas.

10.2.2.1 Service technicians shall not smoke or have an open flame while working on and/or servicing systems which contain R-1234yf.

10.2.2.2 Technicians shall avoid R-1234yf coming in contact with open flames and hot surfaces, sparks, and high-energy ignition sources as ignition may occur.

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10.2.2.3 Technicians shall be aware of the importance of using tools and service equipment designed to SAE Standards for R-1234yf, including, but not limited to, leak detectors, recovery/recycling/recharging equipment, and MAC system components (such as evaporators, on-car refrigerant leak detection devices, etc.) required for use with R-1234yf systems.

10.3 R-744 Specific Requirements

10.3.1 At a minimum, technician training shall incorporate information addressing the following key areas:

10.3.1.1 R-744 cylinders have a higher pressure than technician is used to dealing with R-134a and R-1234yf refrigerants. Technician shall be made aware of increased pressure and the exposure limits for their personnel safety with the different refrigerants.

10.4 R-152a Specific Safety Requirements

10.4.1 Although design features are integrated into systems, R-152a is a flammable refrigerant as classified by ASHRAE 34 and various precautions shall be observed.

10.4.2 R-152a minimum technician training shall incorporate information addressing the following key areas.

10.4.2.1 Service technicians shall not smoke or have an open flame while working on and/or servicing systems which contain R-152a.

10.4.2.2 Technicians shall avoid R-152a coming in contact with open flames and hot surfaces, sparks and high-energy ignition sources as ignition may occur.

10.4.2.3 Technicians shall be aware of the importance of using tools and service equipment designed for R-152a, including, but not limited to, leak detectors, recovery/recycling/recharging equipment, vacuum pumps, and MAC system components (such as evaporators, on-car refrigerant leak detection devices, etc.). All service tools shall be properly rated for use with flammable refrigerants.

11. TECHNICIAN TRAINING AND CERTIFICATION

11.1 EPA requires that technicians, working for any form of compensation, shall be trained and certified to service motor vehicle air conditioning systems regardless of the refrigerant used. All EPA-approved technician certification programs shall meet the following requirements.

11.2 Training

11.2.1 Each program shall provide adequate training, through one or more of the following means: training through self-study of instructional material, or on-site training involving instructors, videos, or a hands-on demonstration.

11.3 Test Subject Material

11.3.1 Certification tests shall adequately cover the standards established for the service and repair of MAC systems, including recommended service procedures for the containment of refrigerant, proper use of recovery equipment and/or recovery and recycling equipment, best service practices, safety, and applicable rules and regulations. Subject matter shall also include anticipated future technological developments and the environmental consequences of refrigerant release.

11.4 Test Administration

11.4.1 Completed tests shall be graded by an entity or individual who receives no benefit based on the outcome of testing; a fee may be charged for grading. Technicians are required to sign a statement certifying that they have taken the certification test without assistance. Each test shall provide a means of verifying the identity of the individual taking the test.

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11.5 Proof of Certification

11.5.1 Each certification program shall offer individual proof of certification, such as a certificate, wallet-sized card, or display card, upon successful completion of the test. Each certification program shall provide a unique number for each certified technician.

11.6 Technical Revisions

11.6.1 Directors of approved certification programs shall conduct periodic reviews of test subject material and update the material based upon the latest technological developments in motor vehicle air conditioner service and repair. Other international regulatory authorities may have service technician certification requirements that are similar.

12. EXAMPLE OF MAC SYSTEMS TRAINING PROGRAM CONTENT

12.1 "Certification Training Manual including Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians and Best Service Practices," published in 2008 by the Mobile Air Conditioning Society in Lansdale, PA, incorporates training material which has evolved from the service industry's experience with the transition from R-12 to R-134a, and which is now mandated by the U.S. EPA for all Section 609 certification programs.

12.2 For example, the indices from this program (below) identify many of the key subject areas that shall be addressed in technician training programs for any refrigerant. While not every subject area may apply to every refrigerant, they identify many areas, which shall be addressed.

12.3 The MAC SYSTEMS 2008 certification manual (table of contents) can be found in Appendix B as an example of subjects to be considered.

13. NOTES

13.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE INTERIOR CLIMATE CONTROL SERVICE COMMITTEE

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APPENDIX A - COMPARISON OF R-134a, R-1234yf, R-744, AND R-152a

Table A1

Basic Physical Properties	R-134a	R-1234yf	R-744	R-152a
Boiling point, Tb	-26 °C	-29 °C	-78.5 °C	-25 °C
Critical point, Tc	102 °C	95 °C	31 °C	113 °C
Pvap, MPa (25 °C)	0.665	0.677	6.4	0.596
P„ap MPa (80 °C)	2.63	2.44	Super Critical	2.34
Liquid density, kg/m^3 (25 °C)	1207	1094	711	900
Vapor density, kg/m^3 (25 °C)	32.4	37.6	243	18.4
Flammability	No	Yes	No	Yes
Lower flammability limit	N/A	6.20%	N/A	3.70%
Upper flammability limit	N/A	12.30%	N/A	18.00%
AC system				
AC type	Vapor compression	Vapor compression	Super critical fluid	Vapor compression
AC components	Can use either an R-134a evaporator or 2842 evaporator	Use only evaporators which meet SAE J2842	Use only evaporators which meet SAE J2842	No in-cabin evaporator; refrigerant chiller added
Storage and handling				
Container type	Light blue container (PMS color 2975)	White container with red band (CAS 754-12-1)	Gray container (PMS color 352)	White container with red band (CAS 75-37-6)
Product storage	Do not expose to open flames, red hot surfaces, or temps in excess of 52 °C	Do not expose to open flames, red hot surfaces, or temps in excess of 52 °C	Do not expose to open flames, red hot surfaces, or temps in excess of 52 °C	Do not expose to open flames, red hot surfaces, or temps in excess of 52 °C
Personal protective equipment	Gloves, goggles	Gloves, goggles	Gloves, goggles	Gloves, goggles
Equipment				
Recovery, recycling, recharge equipment	Meets SAE J2210, superseded by SAE J2788	Only use equipment that meets SAE J2843 or SAE J3030 for use with R-1234yf	N/A	Only use equipment that meets future SAE standards for use with R-152a
Recovery only	Only use equipment that meets SAE J1732, superseded by SAE J2810	Only use equipment that meets SAE J2851 for use with R-1234yf	N/A	Only use equipment that meets future SAE Standards for use with R-152a
Leak detectors	Only use equipment that meets SAE J1627, superseded by SAE J2791	Only use equipment that meets SAE J2913 for use with R-1234yf	N/A	Only use equipment that meets future SAE standards for use with R-152a

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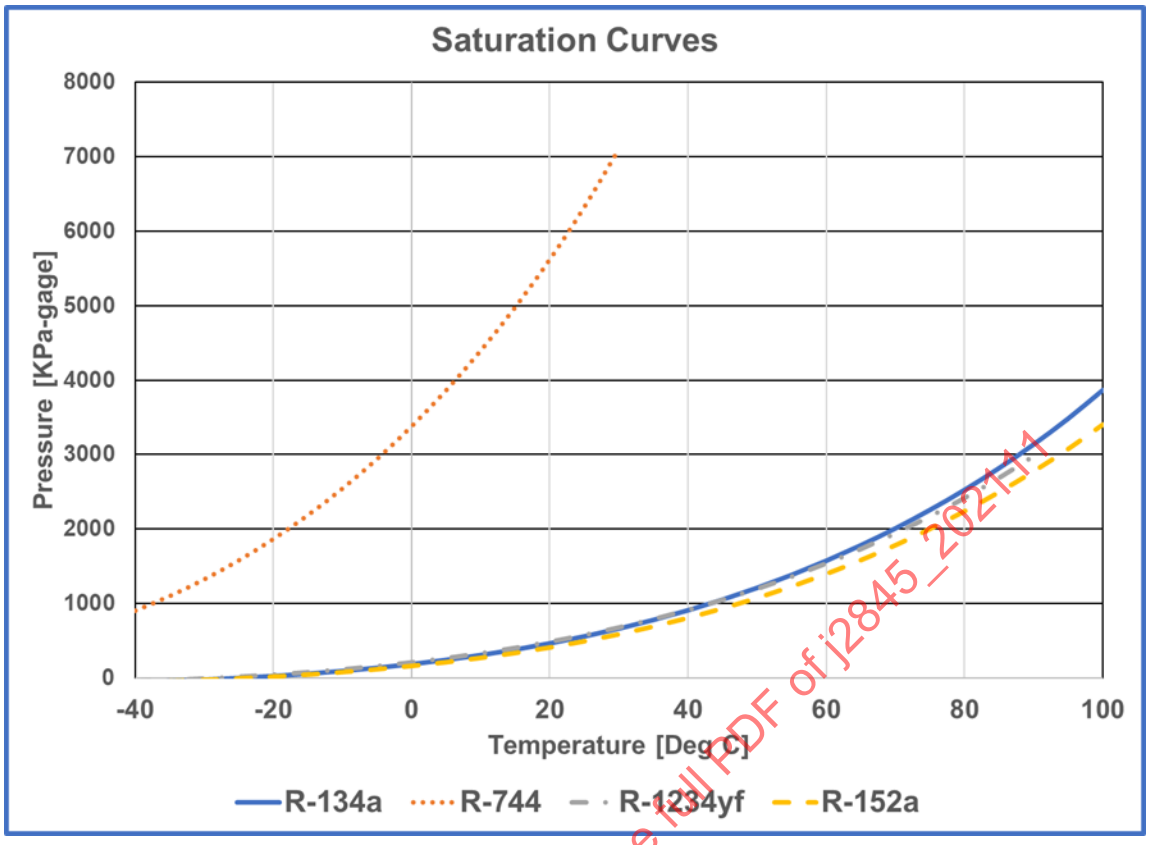

Figure A1

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