



# SURFACE VEHICLE STANDARD

**SAE**

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R-1234yf [HFO-1234yf] and R-744 Technician Training for Service and Containment of Refrigerants Used in Mobile A/C Systems

## RATIONALE

This standard is required to identify the requirements for technician to be professionally trained when required to service MAC systems that use R-1234yf and/or R-744 refrigerants. Updates are included in this version from the February 2011 publication.

### 1. SCOPE

Technician training is required to ensure that recommended procedures are used for service and repair of Mobile Air Conditioning (MAC) systems using R-744 and/or R-1234yf. Unique requirements for each refrigerant are detailed within this standard. Technicians may be trained in either or both refrigerants. The technician shall be trained to recognize which refrigerant is being handled, 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.

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## 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 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE J639	Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems
SAE J1628	Technician Procedures for Refrigerant Leak Detection in Service of Mobile Air Conditioning Systems
SAE J2064	R-134a and R-1234yf Refrigerant Automotive Air-Conditioning Hose and Assemblies
SAE J2099	Standard of Purity for Recycled HFC-134a (R-134a) and HFO-1234yf (R-1234yf) for Use in Mobile Air-conditioning Systems
SAE J2211	Recommended Service Procedure for the Containment of R-134a
SAE J2842	R-1234yf and R744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements
SAE J2843	R-1234yf Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems
SAE J2844	R-1234yf New Refrigerant Purity and Container Requirements Used in Mobile Air-Conditioning Systems
SAE J2851	R-1234yf Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems
SAE J2888	R-1234yf Service Hose, Fittings and Couplers for Mobile Refrigerant Systems Service Equipment
SAE J2911	Certification Requirements for Mobile Air Conditioning System Components, Service Equipment, and Service Technicians to Meet SAE J Standards
SAE J2912	R-1234yf Refrigerant Identification Equipment for Use with Mobile Air Conditioning Systems
SAE J2913	R-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

#### 2.1.2 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-744 MSDS (available from chemical suppliers)

R-1234yf MSDS (available from chemical suppliers)

### 3. TECHNICAL REQUIREMENTS

- 3.1 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 and R-134a will be different for MAC systems using R-744 and/or R-1234yf. 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-744 and/or R-1234yf without being trained for the refrigerant being handled.
- 3.2 Service technicians shall be trained to always wear proper personal protective equipment while handling/servicing systems that contain any refrigerant.
- 3.3 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:
- All contact with liquid or gaseous refrigerant shall be avoided.
  - Goggles with side protection and gloves (insulated against heat loss and impermeable to refrigerant) shall be worn while working with the refrigerant circuit.
  - 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.
  - 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, dizziness.
  - 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.
- 3.4 Training shall discuss key differences between equipment and tools designed for each refrigerant and stress the use of proper equipment with designated refrigerant.
- 3.5 Training shall discuss standard, hybrid 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).
- 3.6 Technician training shall include:
1. Differences between R-744 as compared to R-134a and/or R-1234yf as compared to R-134a (see Appendix A).
  2. Identification of unique fittings and labels for each refrigerant along with tank identification.
  3. Instructions on how to use refrigerant identification equipment.
  4. Instructions on how to use leak detection equipment and/or fluorescent dyes to identify leaks with each refrigerant.
  5. Instructions on how to contain and limit 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.
  6. System servicing procedures as detailed in this standard.
  7. 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. UNIQUE FITTINGS AND LABELS

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

- R-134a tank is light blue (PMS Color 2975).
- R-1234yf tank is white with red band to denote flammability.
- R-744 tank is gray (PMS Color 352).

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

The U.S. EPA's Significant New Alternatives Policy (SNAP) requires that each refrigerant shall be used with a unique set of fittings to prevent the accidental mixing of refrigerants. These fittings are attachment points on the MAC system itself, on all recovery and 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 help protect purity of the recycled supply of refrigerant. More information regarding EPA SNAP may be found at <http://www.epa.gov/ozone/snap/refrigerants/fittlist.htm>.

#### 5. REFRIGERANT IDENTIFICATION AND POTENTIAL CONTAMINATION

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.

Technicians shall also be warned that fittings can be defeated with adapters, labels might never be installed, and even properly affixed labels can fall off or become illegible, and 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.

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-134a, R-1234yf, R-744 and any of a number of hydrochlorofluorocarbons (HCFCs) and/or R-containing blends, HCs, or a mixture of any of the above.

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.

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 how 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 see <http://www.epa.gov/ozone/title6/608/reclamation/reclist.html>.

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 in the presence of refrigerants classified as flammable (A2, A2L or A3) by ASHRAE standard 34 2010.

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.

## 6. ELECTRONIC LEAK DETECTION AND USE OF FLUORESCENT DYES

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.

### 6.1 R-744

Leak detection for this refrigerant presents a unique challenge. R-744 (CO<sub>2</sub>) exists naturally and artificially in the atmosphere and could trigger detection devices when there is no system leak.

### 6.2 R-1234yf

Technicians shall be informed to use leak detection devices certified to SAE J2913 for use with R-1234yf. Certain leak detection devices (heated diode or corona discharge) could serve as ignition sources in the presence of hydrocarbons or other flammable refrigerants.

## 7. RECOVERY, RECYCLING AND CHARGING EQUIPMENT

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

### 7.1 R-744

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. The proper recovery of CO<sub>2</sub> from high-pressure systems is necessary to ensure a harmless depressurization and avoid technician exposure to unacceptable concentrations of CO<sub>2</sub> in the work area. Similar considerations will apply to recharging the system.

The technician shall be informed that R-744 systems operate at much higher pressures than current systems. They must be aware that release and rapid expansion of CO<sub>2</sub> can cause serious injury and asphyxiation by displacing air.

### 7.2 R-1234yf

Motors, switches, battery cables, connections and controls on some recovery and recycling equipment could serve as ignition sources in the presence of flammable refrigerants.

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

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

7.2.3 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:

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 of mercury). The machine will then monitor the applied vacuum, and note if it decays. If the slope of the vacuum decay exceeds 51mm Hg/min (2.0 in HG/min) in five 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

Requirements shall be consistent with SAE J2843.

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

The machine shall require user to verify leak detector is in place and blower motor is on high. If “No” the machine shall not allow user to continue.

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 J2913 leak detector for 5 min for indication of a leak.

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

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.

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

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

#### 7.2.3.1 CO<sub>2</sub>

If a refrigerant system with CO<sub>2</sub> 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. If a refrigerant system with CO<sub>2</sub> is overcharged and a leak into the passenger compartment occurs, the concentration in the passenger compartment could exceed the health based limit for CO<sub>2</sub>.

#### 7.2.3.2 R-1234yf

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, this could result in ignition of the refrigerant.

### 8. SYSTEM SERVICING PROCEDURES

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.

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-1234yf plus air mixtures from reaching the flammability range of 6.2 to 12.3 % by volume.

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.

#### 8.1 R-744

Technician training shall incorporate pertinent information for servicing of future CO<sub>2</sub> mobile air conditioning systems.

## 8.2 R-1234yf

Technicians shall be advised of the following general service procedures:

- 8.2.1 Shall be informed of the importance of maintaining good ventilation in the work area.
- 8.2.2 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.
- 8.2.3 Shall be advised to clean all dirt, grease and debris from and around connection joints before servicing and disassembly of refrigerant connections.
- 8.2.4 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.
- 8.2.5 Shall be advised that seals/O-rings shall never be reused, but replaced with all new parts.
- 8.2.6 Shall be advised to ensure proper alignment of male/female portions and seal so there is no misalignment and stress on the fitting connection.
- 8.2.7 Shall be advised that refrigerant connection shall be tightened to correct bolt/nut torque value specified by manufacturer.
- 8.3 Shall be advised that evaporators in vehicles equipped with R-744 or 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 Standard J2842 and any labeling requirements.
- 8.4 Shall be advised of specific issues related to hybrids and plug-in electric cars 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.

## 9. GENERAL AND SPECIFIC SAFETY PRACTICES

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. (Note MSDS's are attached in this standard and available on the internet.)

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.

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

In general do not expose any compressed gas cylinders (R-134a, R-1234yf, CO<sub>2</sub>, etc.) to temperatures in excess of 52 °C (125 °F), as this will result in cylinders becoming liquid full.

Refrigerant cylinders shall not be

- Exposed to direct sunlight or any other heat source.
- Subject to mechanical stress (e.g., dropping, throwing).
- Stored in shafts (below ground surfaces/enclosed areas) or in front of cellar windows.
- Filled in the workshop or by workshop personnel.
- Filled with another refrigerant.
- Transported without being securely stowed.

#### 9.1 R-744

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

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.

#### 9.2 R-1234yf

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.

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

- Service technicians shall not smoke or have an open flame while working on and/or servicing systems which contain R-1234yf.
- Technicians shall avoid R-1234yf coming in contact with open flames and hot surfaces, sparks and high-energy ignition sources as ignition may occur.
- Technicians shall be aware of the importance of using tools and service equipment designed 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. TECHNICIAN TRAINING AND CERTIFICATION

EPA requires that technicians 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:

Training - 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.

Test subject material - Certification tests shall adequately cover the standards established for the service and repair of MACs, 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.

Test administration - 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.

Proof of certification - 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.

Technical revisions - 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.

#### Training Program Content

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, 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.

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.

The MACS 2008 Certification Manual (Table of contents) can be found in Appendix B as an example of subjects to be considered.

## 11. NOTES

### 11.1 Marginal Indicia

A change bar (I) 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.

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

	HFC-134a	HFO-1234yf	CO2
<b>Basic Physical Properties</b>			
Boiling Point, T <sub>b</sub>	-26°C	-29°C	-78.5C
Critical Point, T <sub>c</sub>	102°C	95°C	31C
P <sub>vap</sub> , MPa (25°C)	0.665	0.677	6.4
P <sub>vap</sub> , MPa (80°C)	2.63	2.44	
Liquid Density, kg/m <sup>3</sup> (25°C)	1207	1094	711
Vapor Density, kg/m <sup>3</sup> (25°C)	32.4	37.6	243
<b>Flammability</b>			
Flammability	No	Yes	No
Lower Flammability Level	N/A	6.2%	N/A
Upper Flammability Level	N/A	12.3%	N/A
<b>AC System</b>			
AC Type	Vapor Compression	Vapor Compression	Super Critical Fluid
AC Components	Can use either R-134a evaporator or J2842 evaporator	Use only evaporators which meet J2842	Use only evaporators which meet J2842
<b>Storage, Handling</b>			
Container Type	Light Blue Container, PMS Color 2975	White Container with Red Band	Gray Container, PMS Color 352
Product Storage	Do not expose to open flames, red hot surfaces, or temps in excess of 52C	Do not expose to open flames, red hot surfaces, or temps in excess of 52C	Do not expose to open flames, red hot surfaces, or temps in excess of 52C
Personal Protective Equipment	gloves, goggles	gloves, goggles	gloves, goggles
<b>Equipment</b>			
Recovery/Recycling Equipment	Only use equipment that meets J2210, superseded by J2788 and is for use with R-134a	Only use equipment that meets J2843 and is for use with HFO-1234yf	N/A
Recovery Only	Only use equipment that meets J1732, superseded by J2810 and is for use with R-134a	Only use equipment that meets J2851 and is for use with HFO-1234yf recovery for reclaim or destruction.	N/A

FIGURE A1

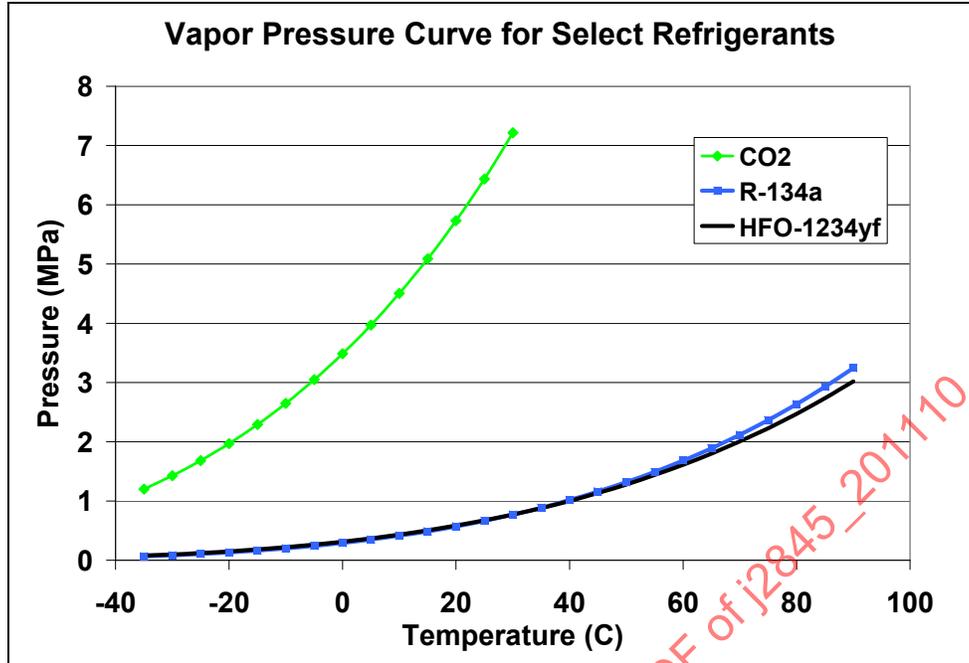


FIGURE A2

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