

AHRI Standard 740
(formerly ARI Standard 740)

1998 Standard for
**Refrigerant Recover/Recycling
Equipment**

AHRI Air-Conditioning, Heating,
and Refrigeration Institute

2111 Wilson Boulevard, Suite 500
Arlington, VA 22201, USA
www.ahrinet.org

PH 703.524.8800
FX 703.562.1942

IMPORTANT

SAFETY RECOMMENDATIONS

It is strongly recommended that the product be designed, constructed, assembled and installed in accordance with nationally recognized safety requirements appropriate for products covered by this standard.

ARI, as a manufacturers' trade association, uses its best efforts to develop standards employing state-of-the-art and accepted industry practices. However, ARI does not certify or guarantee safety of any products, components or systems designed, tested, rated, installed or operated in accordance with these standards or that any tests conducted under its standards will be non-hazardous or free from risk.

ARI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The Certification Program includes recovery, recovery/recycle and recycle equipment including System Dependent Equipment.

Certified Ratings

The following Certified Ratings are verified by tests at rating conditions specified in Section 4:

1. Liquid Recovery Rate (kg/min)
2. Vapor Recovery Rate (kg/min)
3. Final Recovery Vacuum Level (kPa)
4. Recycle Flow Rate (kg/min)
5. Moisture (PPM by wt.)
6. Acid (PPM by wt.)
7. Non-Condensables (% by vol.)
8. High Temperature Vapor Recovery Rate (kg/min)
9. Residual Trapped Refrigerant (kg)
10. Quantity of Refrigerant Processed at Rated Conditions (kg)
11. High Boiling Residue (% by vol.)

Note:

This standard supersedes ARI Standard 740-95.

TABLE OF CONTENTS

SECTION		PAGE
Section 1.	Purpose	1
Section 2.	Scope	1
Section 3.	Definitions	1
Section 4.	Test Requirements	2
Section 5.	Rating Requirements	2
Section 6.	Minimum Data Requirements for Published Ratings.....	3
Section 7.	Operating Requirements.....	3
Section 8.	Marking and Nameplate Data.....	3
Section 9.	Voluntary Conformance	4

TABLES

Table 1.	Standard Contaminated Refrigerant Samples.....	5
Table 2.	Performance.....	7
Table 3.	Contaminants.....	7
Table 4.	ARI Categories of Refrigerants	8

FIGURES

Figure C1.	Test Apparatus for Self-Contained Equipment	11
Figure C2.	System Dependent Equipment Test Apparatus	12

TABLE OF CONTENTS (CONTINUED)

APPENDICES

SECTION	PAGE
Appendix A. References - Normative	9
Appendix B. References - Informative	9
Appendix C. Methods of Testing for Rating Refrigerant Recovery/Recycling Equipment - Normative.....	10
C1. Purpose.....	10
C2. Scope.....	10
C3. Definitions.....	10
C4. Test Apparatus and Instrumentation	10
C5. Performance Test Procedures.....	10
C6. Sampling and Chemical Analysis Methods	15
C7. Performance Calculations for Ratings	15
Appendix D. Particulate Used In Standard Contaminated Refrigerant Sample - Normative	17

REFRIGERANT RECOVERY/RECYCLING EQUIPMENT

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish for refrigerant recovery/recycling equipment: definitions; test requirements, rating requirements, minimum data requirements for published ratings, operating requirements, marking and nameplate data; and conformance conditions. It establishes methods of testing for rating and evaluating the performance of refrigerant recovery/recycling equipment for contaminant or purity levels, capacity, speed, purge loss to minimize emission into the atmosphere of designated refrigerants and to assure that recycling equipment meets the minimum purity requirements for refrigerants established in the Industry Recycling Guide (IRG-2).

1.1.1 Intent. This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 Review and Amendment. This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 Scope. This standard applies to equipment for recovering and/or recycling single refrigerants, azeotropes, zeotropic blends, and their normal contaminants from refrigerant systems. This standard defines the test apparatus, test gas mixtures, sampling procedures and analytical techniques that will be used to determine the performance of refrigerant recovery and/or recycling equipment (hereinafter, "equipment").

2.1.1 Equipment shall be as defined in 3.3.1 and 3.3.2.

2.1.2 Refrigerants used to evaluate equipment shall be pure halogenated hydrocarbons, azeotropes and blends containing halogenated hydrocarbons.

Section 3. Definitions

3.1 Definitions. All terms in this document will follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, and Refrigeration* unless otherwise defined in this section.

3.2 Clearing Refrigerant. Procedures used to remove trapped refrigerant from air conditioning and refrigeration equipment before switching from one refrigerant to another.

3.3 Equipment Classification.

3.3.1 Self-Contained Equipment. A refrigerant recovery or recycling system which is capable of refrigerant extraction without the assistance of components contained within an air-conditioning or refrigeration system.

3.3.2 System Dependent Equipment. Refrigerant recovery equipment which requires for its operation the assistance of components contained in an air-conditioning or refrigeration system.

3.4 High Temperature Vapor Recovery Rate. For equipment having at least one designated refrigerant (see 8.2) with a boiling point in the range of -50 to +10°C, the rate will be measured for R-22, or the lowest boiling point refrigerant if R-22 is not a designated refrigerant.

3.5 Published Ratings. A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term "published rating" includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.

3.5.1 Standard Rating. A rating based on tests performed at Standard Rating Conditions.

3.5.2 Application Rating. A rating based on tests performed at Application Rating Conditions (other than Standard Rating Conditions).

3.6 Push/Pull Method. The push/pull refrigerant recovery method is defined as the process of transferring liquid refrigerant from a refrigeration system to a receiving vessel by lowering the pressure in the vessel and raising the pressure in the system, and by connecting a separate line between the system liquid port and the receiving vessel.

3.7 Rating Conditions. Any set of operating conditions under which a single level of performance results, and which causes only that level of performance to occur.

3.7.1 Standard Rating Conditions. Rating conditions used as the basis of comparison of performance characteristics.

3.8 Reclaim. To process used refrigerant to new product specifications. Chemical analysis of the refrigerant shall be required to determine that appropriate specifications are met. The identification of contaminants and required chemical analysis shall be specified by reference to national or international standards for new product specifications.

3.9 Recover. To remove refrigerant in any condition from a system and store it in an external container.

3.10 Recycle. To reduce contaminants in used refrigerants by separating oil, removing non-condensables and reducing moisture, acidity and particulate matter to the levels prescribed in Industry Recycling Guide (IRG-2).

3.11 Recycle Equipment. Equipment that recycles and whose type of equipment is "Recovery/Recycle" or "Recycle."

3.12 Recycle Flow Rate The amount of refrigerant processed divided by the time elapsed in the recycling mode. For equipment which uses a separate recycling sequence, the recycle rate does not include the recovery rate (or elapsed time). For equipment which does not use a separate recycling sequence, the recycle rate is a rate based solely on the higher of the liquid or vapor recovery rate, by which the contaminant levels were measured.

3.13 Residual Trapped Refrigerant. Refrigerant remaining in equipment after clearing.

3.14 "Shall," "Should," "Recommended" or "It is Recommended." "Shall," "should," "recommended" or "it is recommended" shall be interpreted as follows:

3.14.1 Shall. Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.14.2 Should, Recommended or It is Recommended. "Should," "recommended" or "it is recommended" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.15 Standard Contaminated Refrigerant Sample. A mixture of new or reclaimed refrigerant and specified quantities of identified contaminants which constitute the mixture to be Representative test refrigerants other than those designated in the third column of Table 4 may be selected for test purposes to form multiple individual refrigerants within a chosen category. If the representative test refrigerant is replacing a normally designated representative test refrigerant per Table

processed by the equipment under test. These contaminant levels are expected only from severe service conditions.

3.16 Trapped Refrigerant. The amount of refrigerant remaining in the equipment after recovery or recovery/recycling operation before clearing.

3.17 Vapor Recovery Rate. The average rate that refrigerant is withdrawn from the mixing chamber between two pressures as vapor recovery rate is changing depending on the pressure. (The initial condition is vapor only at saturation pressure and temperature at either 24°C or at the boiling point 100 kPa, whichever is higher. The final pressure condition is 10% of the initial pressure, but not lower than the equipment final recovery vacuum and not higher than 100 kPa.)

Section 4. Test Requirements

4.1 Testing Requirements. All standard ratings shall be verified by tests conducted in accordance with the provisions set forth in Appendix C to this standard.

4.1.1 Equipment. Equipment shall be tested using all components as recommended by the manufacturer.

4.1.2 Electrical Conditions. Tests shall be made at the electrical characteristics specified on the unit nameplate.

Section 5. Rating Requirements

5.1 Standard Rating Conditions. Published Ratings shall include all of the standard ratings as shown in Tables 2 and 3, for each refrigerant designated by the manufacturer. The standard contaminated refrigerant sample shall have the characteristics specified in Table 1, except that recovery equipment not rated for any specific contaminant shall be tested with new or reclaimed refrigerant. Testing shall be conducted at an ambient temperature of 24°C ±1°C except high temperature vapor recovery shall be 40°C ±1°C.

For purposes of characterized performance, refrigerants have been categorized as shown in Table 4. Representative test refrigerant(s) have been selected within each category for test and rating purposes as shown in Table 4. Designated individual refrigerants may be selected for testing and rating.

4, then the refrigerant with the highest vapor pressure within the category is used as the representative test refrigerant.

5.2 Tolerances. Performance related parameters shall be equal to or better than the published ratings.

Section 6. Minimum Data Requirements for Published Ratings

6.1 Minimum Data Requirements for Published Ratings. Published Ratings shall include all of the Standard Ratings as shown in Tables 2 and 3 for each refrigerant designated by the manufacturer.

Section 7. Operating Requirements

7.1 Equipment Information. The equipment manufacturer shall provide operating instructions, necessary maintenance procedures and source information for replacement parts and repair.

7.2 Filter Replacement for Recycle Equipment. The equipment shall indicate when any filter/drier(s) needs replacement. This requirement can be met by use of a moisture transducer and indicator light, by use of a sight glass/moisture indicator or by some measurement of the amount of refrigerant processed such as a flow meter or hour meter. Manufacturer must provide maximum quantity recycled or filter change interval in their written instructions.

7.3 Purge of Non-Condensable. If non-condensables are purged, the equipment shall either automatically purge non-condensables or provide an indicating means to guide the purge process. Recycle equipment must provide purge means.

7.4 Purge Loss. The total refrigerant loss due to purging non-condensables, draining oil and clearing refrigerant (see C7.5) shall be less than 3% (by weight) of total processed refrigerant.

7.5 Permeation Rate. High pressure hose assemblies 16 mm nominal and smaller shall not exceed a permeation rate of 3.9 g/cm²/yr (internal surface) at a temperature of 48.8°C. Hose assemblies which have been UL recognized as having passed ANSI/UL 1963 requirements shall be accepted without testing. See C5.1.4.

8.2 Data for Designated Refrigerants. For each refrigerant category designated, the manufacturer shall include all the

7.6 Clearing Trapped Refrigerant. For equipment rated for more than one refrigerant, the manufacturer shall provide a method and instructions which will accomplish connections and clearing within 15 minutes. Special equipment, other than a vacuum pump or manifold gauge set shall be furnished.

The clearing procedure shall not rely upon the storage cylinder below saturated pressure conditions at ambient temperature.

7.7 Temperature. The equipment shall be evaluated at 24°C with additional limited evaluation at 40°C. Normal operating conditions range from 10°C to 40°C.

7.8 Purity Requirements. Recycle equipment must meet the purity requirements prescribed in the Industry Recycling Guide (IRG-2).

7.9 Exemptions. Equipment intended for recovery only shall be exempt from 7.2, 7.3 and 7.8.

Section 8. Marking and Nameplate Data

8.1 Marking and Nameplate Data. The nameplate shall display the manufacturer's name, model designation, type of equipment, designated refrigerant(s) and electrical characteristics where applicable.

Recommended nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltages shown in Table 1 of ARI Standard 110. Recommended nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publication 38.

8.1.1 Type of Equipment.

- a. Recovery, Recovery/Recycle, or Recycle
- b. Self-Contained or System Dependent

8.1.2 Designated Refrigerants.

- a. *Category(ies).* If rating for all refrigerants within a category.
- b. *Refrigerant(s)* If rating for designated individual refrigerants.

following that are applicable per Table 2 for all refrigerants per Section C5.1.2.

- a. Liquid Recovery Rate (kg/min)
- b. Vapor Recovery Rate (kg/min)
- c. High Temperature Vapor Recovery Rate (kg/min)
- d. Final Recovery Vacuum (kPa)
- e. Recycle Flow Rate (kg/min)
- f. Residual Trapped Refrigerant (kg)
- g. Quantity of Refrigerant processed at rated conditions (kg)
- h. Refrigerant Loss (kg)

Section 9. Voluntary Conformance

9.1 Conformance. While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its *Purpose* (Section 1) and *Scope* (Section 2) unless such claims meet all of the requirements of this standard.

Table 1. Standard Contaminated Refrigerant Samples

	Refrigerant Type													
	R11	R12	R13	R22	R113	R114	R123	R134a	R500	R502	R503	R401A	R401B	R401C
Contaminants														
ppm by refrigerant	100	80	30	200	100	85	200	200	200	200	30	200	200	200
ppm by refrigerant ¹	80	80	N/A	80	80	80	80	80	80	80	N/A	80	80	80
by Weight ²	500	100	N/A	500	400	200	500	100	100	100	N/A	200	200	200
% by refrigerant	20	5	N/A	5	20	20	20	5	5	5	N/A	5	5	5
	300/ MO	150/ MO	N/A	300/ MO	300/ MO	300/ MO	300/ MO	150/ POE	150/ MO	150/ MO	N/A	150/ AB	150/ AB	150/ AB
Gases / Volume	N/A	3	3	3	N/A	3	N/A	3	3	3	3	3	3	3

Contaminant shall consist of inert materials and shall comply with particulate requirements in Appendix D.
 of 60% oleic acid and 40% hydrochloric acid on a total number basis.
 ter, AB = Alkylbenzene, MO = Mineral Oil.

le.

Table 1. Standard Contaminated Refrigerant Samples (Continued)

Units	Refrigerant Type														
	R404A	R406A	R407A	R407B	R407C	R407D	R408A	R409A	R410A	R411A	R411B	R412A	R23	R507	R50
ppm by refrigerant	200	200	200	200	200	200	200	200	200	200	200	200	30	200	200
ppm by refrigerant ¹	80	80	80	80	80	80	80	80	80	80	80	80	N/A	80	N/A
mg by Weight	500	200	500	500	500	500	200	200	500	200	200	200	N/A	100	N/A
% by refrigerant	5	5	5	5	5	5	5	5	5	5	5	5	N/A	5	N/A
	150/ POE	150/ AB	150/ POE	150/ POE	150/ POE	150/ POE	150/ MO	150/ MO	150/ POE	150/ MO	150/ MO	150/ AB	N/A	150/ POE	N/A
Number of Bases	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

contaminant shall consist of inert materials and shall comply with particulate requirements in Appendix D.
 composed of 60% oleic acid and 40% hydrochloric acid on a total number basis.
 POE = Polyolefin Ester, AB = Alkylbenzene, MO = Mineral Oil.

le.

Table 2. Performance				
Parameter	Type of Equipment			
	Recovery	Recovery/Recycle	Recycle	System Dependent Equipment
Liquid Refrigerant Recovery Rate (kg/min)	X ¹	X ¹	N/A	N/A
Vapor Refrigerant Recovery Rate (kg/min)	X ¹	X ¹	N/A	N/A
High Temp. Vapor Recovery Rate (kg/min)	X ¹	X ¹	N/A	N/A
Final Recovery Vacuum (kPa)	X	X	N/A	X
Recycle Flow Rate (kg/min)	N/A	X	X	N/A
Refrigerant Loss (kg)	X ³	X	X	X ³
Residual Trapped Refrigerant (kg)	X ²	X ²	X ²	X ²
Refrigerant Processed At Rated Conditions (kg)	N/A	X	X	N/A

If not rated use N/A, "Not Applicable."
X Mandatory rating or equipment requirements.

Superscripts:
1 For a recovery or recovery/recycle unit, one must rate either liquid refrigerant recovery rate or vapor refrigerant recovery rate or one can rate for both. If rating only the one, the other shall be indicated by N/A, "not applicable."
2 Mandatory rating for equipment tested for multiple refrigerants.
3 Mandatory rating if multiple refrigerants, oil separation or non-condensable purge are rated.

Table 3. Contaminants				
Contaminant	Type of Equipment			
	Recovery	Recovery/Recycle	Recycle	System Dependent Equipment
Moisture Content (PPM by weight)	*	X	X	N/A
Chloride Ions (pass/fail)	*	X	X	N/A
Acidity (PPM by weight)	*	X	X	N/A
High Boiling Residue (% by volume)	*	X	X	N/A
Particulates (pass/fail)	*	X	X	N/A
Non-Condensables (% by volume)	*	X	X	N/A

* For recovery equipment, these parameters are optional. If not rated, use N/A, "not applicable."
X Mandatory rating.

Table 4. ARI Categories of Refrigerants		
Category Number	Refrigerant Number	Representative Test Refrigerants (Designated Category Refrigerants)
Low Pressure		
I	R-113 R-123 R-11	R-11 and R-123
Medium Pressure - Low Moisture		
II	R-114	R-114
Medium Pressure		
III	R-12 R-134a R-401C R-406A R-500	R-134a
Medium High Pressure		
IV	R-401A R-409A R-401B R-412A R-411A R-407D R-22 R-411B R-502 R-407C R-402B R-408A R-509	R-22 and R-407C
High Pressure		
V	R-407A R-404A R-402A R-507 R-407B R-410A	R-410A
Very High Pressure - High Moisture		
VI	R-13 R-23 R-508A R-503 R-508B	R-508A

APPENDIX A. REFERENCES-NORMATIVE

A1 Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of this standard.

A1.1 ANSI/UL Standard 1963, *Refrigerant Recovery/Recycling Equipment*, First Edition, 1991 American National Standards Institute/Underwriters Laboratories, Inc., 11 West 42nd Street, New York, New York 10036, U.S.A./333 Pfingsten Road, Northbrook, Illinois, 60062, U.S.A.

A1.2 AHRI Standard 110-97 (formerly ARI Standard 110-97), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, Air-Conditioning, Heating, and Refrigeration Institute, AHRI, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.

A1.3 AHRI Standard 700-95 (formerly ARI Standard 700-95), *Specifications for Fluorocarbon and Other Refrigerants*, 1995, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, Virginia, 22201, U.S.A.

A1.4 Appendix C to ARI Standard 700-95, *Analytical Procedures for ARI Standard 700-95*, 1995, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, Virginia, U.S.A.

A1.5 Addendum 700-1 to Appendix C to ARI Standard 700-95, Air-Conditioning and Refrigeration Institute, 4301 North Fairfax Drive, Suite 425, Arlington, Virginia, U.S.A.

A1.6 ASHRAE *Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., ASHRAE, 1791 Tullie Circle, N.E., Atlanta, Georgia, 30329, U.S.A.

A1.7 Industry Recycling Guide (IRG-2), December 1994, *Handling and Reuse of Refrigerants in the United States*, developed by The Ad-Hoc Committee for the Use of Recycled Refrigerants - comprised of representatives of equipment manufacturers, contractors, refrigerant manufacturers and the General Services Administration of the U.S. Government.

A1.8 IEC Standard Publication 38, *IEC Standard Voltages*, 1983, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES-INFORMATIVE

None.

APPENDIX C. METHODS OF TESTING FOR RATING REFRIGERANT RECOVERY/RECYCLING EQUIPMENT - NORMATIVE

C1 Purpose. The purpose of this appendix is to specify methods of testing for rating refrigerant recovery/recycling equipment. Specified are: test apparatus and instrumentation, performance test procedures, sampling and chemical analysis methods, and performance calculations for ratings.

C2 Scope. This appendix applies to refrigerant recovery/recycling equipment as defined in Section 3 of this Standard.

C3 Definitions. Definitions for this appendix are identical with those in Section 3 of this standard.

C4 Test Apparatus and Instrumentation.

C4.1 General Recommendations. The recommended test apparatus is described in the following paragraphs. If alternate test apparatus are employed, the user shall be able to demonstrate that they produce results equivalent to the specified referee apparatus.

C4.2 Self-Contained Equipment Test Apparatus. The apparatus, shown in Figure C1, shall consist of:

C4.2.1 Mixing Chamber. A mixing chamber consisting of a tank with a conical-shaped bottom, a bottom port and piping for delivering refrigerant to the equipment, various ports and valves for adding refrigerant to the chamber and stirring means for mixing.

C4.2.2 Filling Storage Cylinder. The storage cylinder to be filled by the refrigerant transferred shall be cleaned and at the pressure of the recovered refrigerant at the beginning of the test. It will not be filled over 80%, by volume.

C4.2.3 Vapor Feed. Vapor refrigerant feed consisting of evaporator, control valves and piping to create a 3.0°C superheat condition at an evaporating temperature of 21°C ± 2°C.

C4.2.4 Alternative Vapor Feed. An alternative method for vapor feed shall be to pass the refrigerant through a boiler and then through an automatic pressure regulating valve set at different saturation pressures, moving from saturated pressure at 24°C to final pressure of recovery.

C4.2.5 Liquid Feed. Liquid refrigerant feed consisting of control valves, sampling port and piping.

C4.2.6 Instrumentation. Instrumentation capable of measuring weight, temperature, pressure and refrigerant loss, as required.

C4.2.7 Size. The size of the mixing chamber shall be a minimum of 0.09 m³. The bottom port and the refrigerant feed shall depend on the size of the equipment. Typically, the mixing valves and piping shall be 9.5 mm. For large equipment to be used on chillers, the minimum inside diameter of ports, valves and piping shall be the smaller of the manufacturer's recommendation or 37 mm.

C4.3 System Dependent Equipment Test Apparatus. This test apparatus is to be used for final recovery vacuum rating of all system dependent equipment.

C4.3.1 Test Setup. The test apparatus shown in Figure C2 consists of a complete refrigeration system. The manufacturer shall identify the refrigerants to be tested. The test apparatus can be modified to facilitate operation or testing of the system dependent equipment if the modifications to the apparatus are specifically described within the manufacturer's literature. (see Figure C2.) A 6.3 mm balance line shall be connected across the test apparatus between the high and low pressure sides, with an isolation valve located at the connection to the compressor high side. A 6.3 mm access port with a valve core shall be located in the balance line for the purpose of measuring final recovery vacuum at the conclusion of the test.

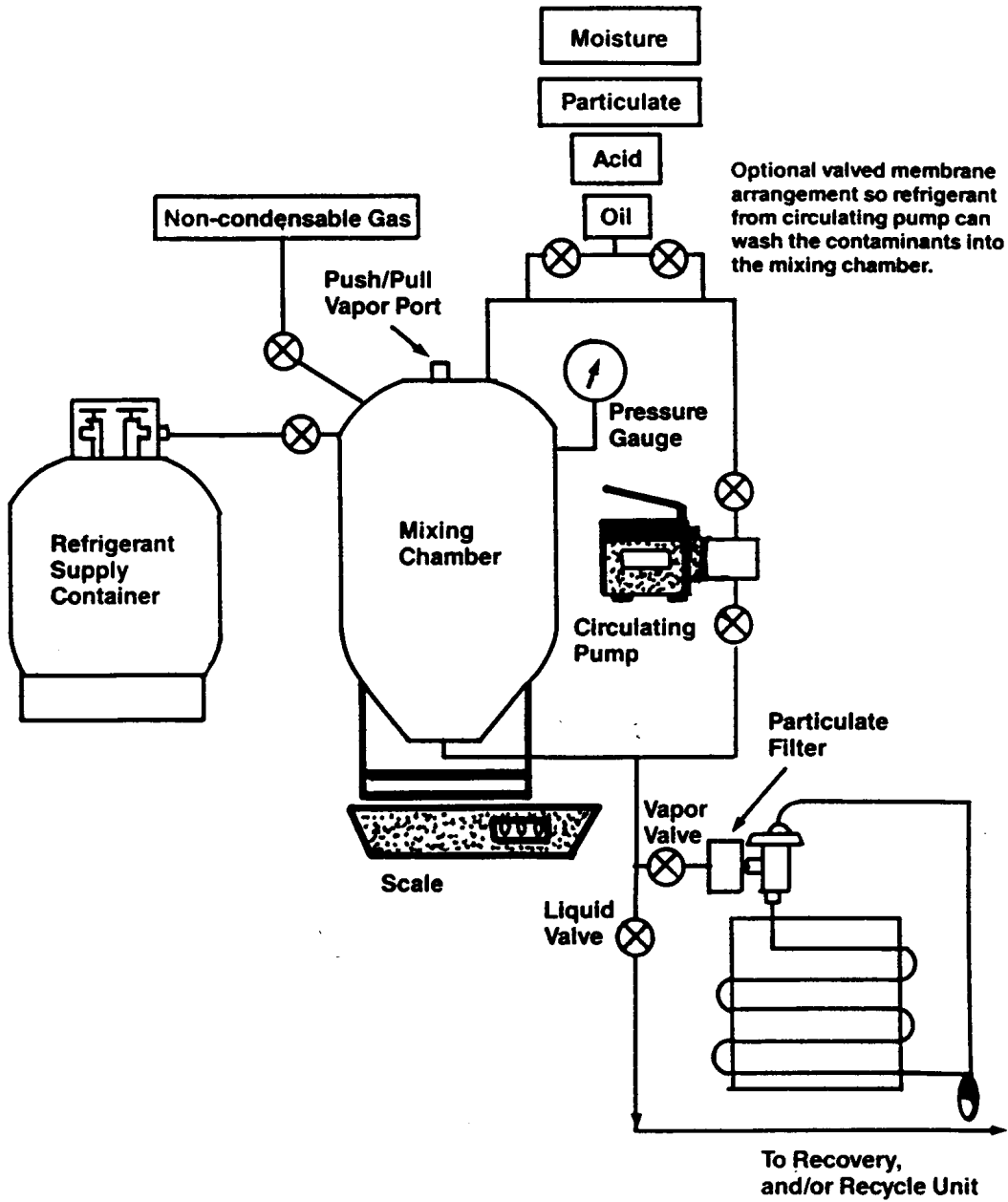


Figure C1. Test Apparatus for Self-Contained Equipment

of standard air conditioning
system for use as a test apparatus

Configuration
or refrigeration s

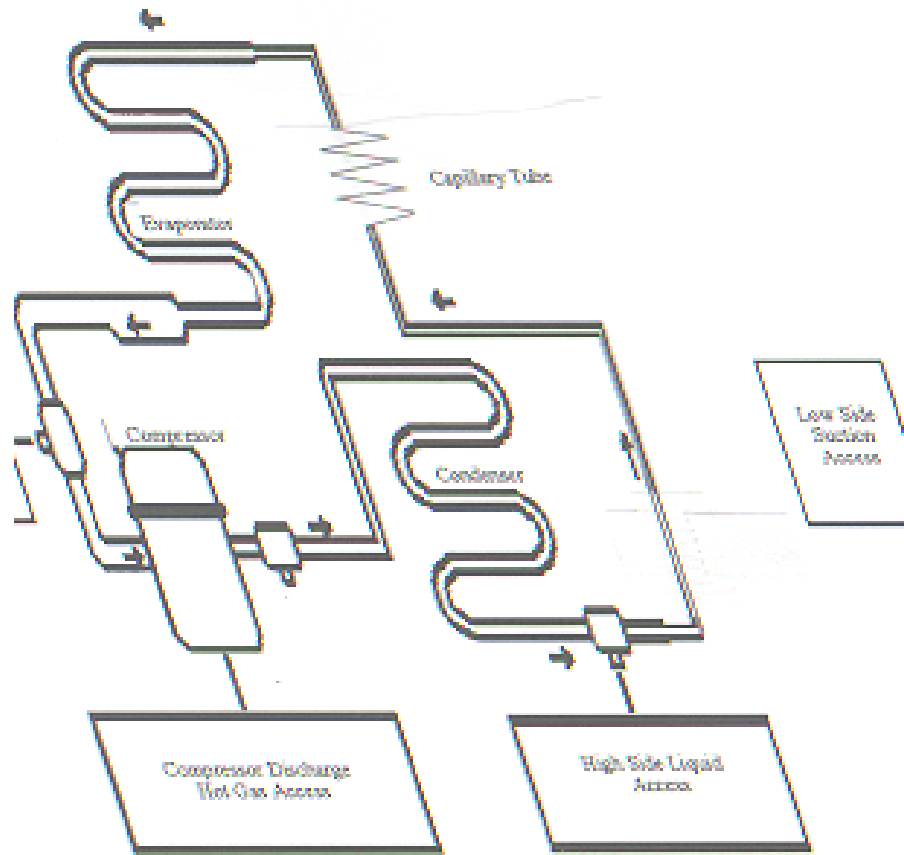


Figure C2. System Dependent Equipment Test Apparatus

C5 Performance Testing Procedures.

C5.1 General Testing.

C5.1.1 Temperatures. Testing shall be conducted at an ambient temperature of $24^{\circ}\text{C} \pm 1^{\circ}\text{C}$ except high temperature vapor recovery shall be at $40^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The evaporator conditions of C4.2.3 shall be maintained as long as liquid refrigerant remains in the mixing chamber.

C5.1.2 Refrigerants. The equipment shall be tested for all representative test refrigerants in designated refrigerant categories or designated individual refrigerants. All tests in Section C5 shall be completed for each refrigerant before proceeding with the next refrigerant.

C5.1.2.1 Refrigerant Categories. For purposes of characterized performance, refrigerants have been categorized as shown in Table 4.

C5.1.2.1.1 Representative test refrigerant(s) have been selected within each category for test and rating purposes as shown in Table 4.

C5.1.2.2 Designated individual refrigerants may be selected for testing and rating.

C5.1.2.2.1 Representative test refrigerants other than those designated in the third column of Table 4 may be selected for test purposes to form multiple individual refrigerants within a chosen category. If the representative test refrigerant is replacing a normally designated representative test refrigerant per Table 4, then the refrigerant with the highest vapor pressure (at 40°C) within the category is used as the representative test refrigerant.

C5.1.3 Selected Refrigerants. An individual refrigerant may be selected for rating by a manufacturer; he may not imply compliance with the category requirements.

C5.1.4 Hose Assemblies. For the purpose of limiting refrigerant emissions to the atmosphere,

C5.6.1.1 Liquid Refrigerant Recovery Rate. If elected, the recovery rate using the liquid refrigerant feed means (see C4.2.5) shall be determined. After the equipment reaches stabilized conditions of condensing

hose assemblies shall be tested for permeation according to ANSI/UL Standard 1963, Section 40.10.

C5.2 Equipment Preparation and Operation. The equipment shall be prepared and operated per the operating instructions.

C5.3 Contaminated Refrigerants. The standard contaminated refrigerant sample shall have the characteristics specified in Table 1, except as provided in C5.4

C5.4 Recovery-Only Testing. Recovery equipment not rated for any specific contaminant shall be tested with new or reclaimed refrigerant.

C5.5 Test Batch. The test batch consisting of refrigerant sample (see Section C5.3) of the test refrigerant shall be prepared and thoroughly mixed. Continued mixing or stirring shall be required during the test while liquid refrigerant remains in the mixing chamber. The mixing chamber shall be filled to 80% level by volume.

C5.5.1 Control Test Batch. Prior to starting the test for the first batch for each refrigerant, a liquid sample will be drawn from the mixing chamber and analyzed per Section C6 to assure that contaminant levels match Table 1 within ± 10 ppm for moisture, ± 20 ppm for oleic acid and $\pm 0.5\%$ for oil.

C5.6 Recovery Tests (Recovery and Recovery/Recycle Equipment).

C5.6.1 Determining Recovery Rates. The liquid and vapor refrigerant recovery rates shall be measured during the first test batch for each refrigerant (see C7.1, C7.2 and C7.4). Equipment preparation and recovery cylinder changeover shall not be included in elapsed time measurements for determining vapor recovery rate and liquid refrigerant recovery rate. Operations such as subcooling the recovery cylinder shall be included. Recovery cylinder shall be the same size as normally furnished by the equipment manufacturer. Oversized tanks shall not be permitted.

temperature and/or recovery cylinder pressure, the recovery process shall be stopped and an initial weight shall be taken of the mixing chamber (see C7.2). The recovery process shall be continued for a period of time

sufficient to achieve the accuracy in C7.4. The recovery process shall be stopped and a final weight shall be taken of the mixing chamber.

C5.6.1.2 Vapor Refrigerant Recovery Rate. If elected, the average vapor flow rate shall be measured to accuracy requirements in clause C7.4 under conditions with no liquid refrigerant in the mixing chamber. The liquid recovery feed means shall be used. At initial conditions of saturated vapor at the higher of 24°C or the boiling temperature (100 kPa), the weight of the mixing chamber and the pressure shall be recorded. At final conditions representing pressure in the mixing chamber of 10% of the initial condition, but not less than the final recovery vacuum (see C7.6) nor more than 100 kPa, measure the weight of the mixing chamber and the elapsed time. At initial conditions, the recovery cylinder shall be at saturation pressure at ambient conditions.

C5.6.1.3 High Temperature Vapor Recovery Rate. Applicable for equipment having at least one designated refrigerant (see 8.2) with a boiling point between -50°C and +10°C. Measure the rate for R-22, or the refrigerant with the lowest boiling point if R-22 is not a designated refrigerant. Repeat the test in C5.6.1.2 at saturated conditions at 40°C and continue to operate equipment to assure it will achieve the final recovery vacuum (see C5.6.3). At initial conditions the recovery cylinder shall be at saturated pressure at 40°C.

C5.6.2 Recovery Operation. This test is for determining the final recovery vacuum and the ability to remove contaminants as appropriate. If equipment is rated for liquid recovery (see C5.6.1.3), liquid recovery feed means described in C4.2.5 shall be used. If not, vapor recovery means described in C4.2.3 or C4.2.4 shall be used. Continue recovery operation until all liquid is removed from the test apparatus and vapor is removed to the point where equipment shuts down by automatic means or is manually shut off per operating instructions.

C5.7.1.1 Recycle Flow Rate. While recycling the first recovery cylinder for each refrigerant, determine the recycling flow rate

C5.6.2.1 Oil Draining. Capture oil from the equipment at intervals as required in the instructions. Record the weight of the container. Completely remove refrigerant from oil by evacuation or other appropriate means. The weight difference shall be used in C.5.7.2.

C5.6.3 Final Recovery Vacuum. At the end of the first test batch for each refrigerant, the liquid valve and vapor valve of the apparatus shall be closed. After waiting 1 minute, the mixing chamber pressure shall be recorded (see C7.6).

C5.6.4 Residual Refrigerant. This test will measure the mass of remaining refrigerant in the equipment after clearing and therefore the potential for mixing refrigerants (see 7.6).

C5.6.4.1 Initial Conditions. At the end of the last test for each batch for each refrigerant, the equipment shall be disconnected from the test apparatus (Figure C1). Recycle per C5.7, if appropriate. Perform refrigerant clearing operations as called for in the instruction manual. Capture and record the weight of any refrigerant which would have been emitted to the atmosphere during the clearing process for use in C7.5. If two loops are used for recycling, trapped refrigerant shall be measured for both.

C5.6.4.2 Residual Trapped Refrigerant. Evacuate an empty test cylinder to 1.0 kPa. Record the empty weight of the test cylinder. Open all valves to the equipment so as to provide access to all trapped refrigerant. Connect the equipment to the test cylinder and operate valves to recover the residual refrigerant. Record the weight of the test cylinder using a recovery cylinder pressure no less than specified in C4.2.2. Place the test cylinder in liquid nitrogen for a period of 30 minutes or until a vacuum of 1000 microns is reached, whichever occurs first.

C5.7 Recycling Tests (Recovery/Recycle Equipment).

C5.7.1 Recycling Operation. As each recovery cylinder is filled in C5.6.2, recycle according to operating instructions. There will not necessarily be a separate recycling sequence. Note non-condensable purge measurement in C7.5.

by appropriate means (see C7.3) to achieve the accuracy required in C7.4.

C5.7.2 Non-Condensable Sample. After completing C5.6.3, prepare a second test batch (C5.5). Recover per C5.6.2 until the current recovery cylinder is filled to 80% level by volume. Recycle per C5.7.1. Mark this cylinder and set aside for taking the vapor sample. For equipment having both an internal tank of at least 3 kg refrigerant capacity and an external recovery cylinder, two recovery cylinders shall be marked and set aside. The first is the cylinder described above. The second cylinder is the final recovery cylinder after filling it to 80% level by volume and recycling.

C5.7.3 Liquid Sample for Analysis. Repeat steps C5.5, C5.6.2 and C5.7.1 with further test batches until indication means in 7.2 show the filter/drier(s) need replacing.

C5.7.3.1 Multiple Pass. For equipment with a separate recycling circuit (multiple pass), set aside the current cylinder and draw the liquid sample (see C5.6) from the previous cylinder.

C5.7.3.2 Single Pass. For equipment with the single pass recycling circuit, draw the liquid sample (see C5.6) from the current cylinder.

C5.8 Measuring Refrigerant Loss. Refrigerant loss due to non-condensables shall be determined by appropriate means (see C7.5.1). The loss could occur in C5.6.1, C5.6.2 and C5.7.1.

C6 Sampling and Chemical Analysis Methods.

C.6.1 Chemical Analysis. Chemical analysis methods shall be specified in appropriate standards such as ARI Standard 700, Appendix-C to ARI Standard 700 and Addendum 700-1 to Appendix C. If alternate test methods are employed, the laboratory must be able to demonstrate that they produce results equivalent to the specified referee method.

C6.1.1 Water Content. The water content in refrigerant shall be measured by Karl Fischer Coulometric Titration Techniques. Report the moisture level in parts per million by weight.

C6.1.2 Chloride Ions. Chloride ions shall be measured by turbidity tests. At this time, quantitative results have not been defined. Report chloride content as "pass" or "fail." In the future,

C7.3.1 For equipment using multi-pass recycling or a separate sequence, the recycle rate

when quantitative results are possible, report chloride content as parts per million by weight.

C6.1.3 Acidity. The acidity test uses the titration principle. Report the acidity in parts per million by weight (mg KOH/kg) of sample.

C6.1.4 High Boiling Residue. High boiling residues shall use measurement of the volume of residue after evaporating a standard volume of refrigerant. Using weight measurement and converting to volumetric units is acceptable. Report high boiling residues as percent by volume.

C6.1.5 Particulates/Solids. The particulates/solids measurement employs visual examination. Report results as "pass" or "fail."

C6.1.6 Non-condensables. The level of contamination by non-condensable gases in the base refrigerant being recycled shall be determined by gas chromatography. Report results as percent by volume.

C7 Performance Calculations for Ratings.

C7.1 Vapor Refrigerant Recovery Rate. This rate shall be measured by weight change of the mixing chamber divided by elapsed time (see C5.6.1.2). The units shall be kg/min and the accuracy shall be per C7.4.

C7.1.1 High Temperature Vapor Recovery Rate. This rate shall be measured by weight change of the mixing chamber divided by elapsed time (see C5.6.1.3). The units shall be kg/min and the accuracy shall be per C7.4.

C7.2 Liquid Refrigerant Recovery Rate. This rate shall be measured by weight change of the mixing chamber divided by elapsed time (see C5.6.1.3). The units shall be kg/min and the accuracy shall be per C7.4.

C7.3 Recycle Flow Rate. The recycle flow rate shall be as defined in 3.11, expressed in kg/min, and the accuracy shall be per C7.4.

shall be determined by dividing the net weight, W of the refrigerant to be recycled by the actual time

T required to recycle. Any set-up or operator interruptions shall not be included in the time, T.

C7.3.2 If no separate recycling sequence is used, the recycle rate shall be the higher of the vapor refrigerant recovery rate or the liquid refrigerant recovery rate. The recycle rate shall match a process which leads to contaminant levels in C7.9. Specifically, a recovery rate determined from bypassing a contaminant removal device cannot be used as a recycle rate when the contaminant levels in C7.9 are determined by passing the refrigerant through the contaminant removal device.

C7.4 Accuracy of Flow Rates. The accuracy of test measurements in C7.1, C7.2 and C7.3 shall be ± 0.008 kg/min for flow rates up to 0.42 kg/min and $\pm 2.0\%$ for flow rates larger than 0.42 kg/min. Ratings shall be expressed to the nearest 0.02 kg/min.

C7.5 Refrigerant Loss. This calculation will be based upon the net loss of refrigerant which would have been eliminated in the non-condensable purge process (see C5.7.1), the oil draining process (see C5.6.2.1) and the refrigerant clearing process (see C5.6.4.1), all divided by the net refrigerant content of the test batches. The refrigerant loss shall not exceed 3% by weight.

C7.5.1 Non-Condensable Purge. Evacuate an empty container to 2 kPa. Record the empty weight of the container. Place the container in a dry ice bath. Connect the equipment purge connection to the container and operate purge according to operating instructions so as to capture the non-condensables and lost refrigerant. Weigh the cylinder after the recycling is complete. Equivalent means are permissible.

For units which either recycle or list non-condensable removal, non-condensable gases are purged, operating the recycle device per the manufacturer's instructions through an evaporator pressure regulator (EPR) valve into a liquid nitrogen-chilled cylinder. This combination will simulate the atmosphere while allowing the capture of purge gases. The cylinder is weighed before and after the purge procedure.

C7.5.2 Oil Draining. Refrigerant removed from the oil after draining shall be collected and measured in accordance with C5.6.2.1.

C7.5.3 Clearing Unit. Refrigerant captured during the clearing process shall be measured in accordance with C5.6.4.1

C7.6 Final Recovery Vacuum. The final recovery vacuum shall be the mixing chamber pressure in C5.6.3, expressed in kPa. The accuracy of the measurement shall be within 0.33 kPa.

C7.7 Residual Trapped Refrigerant. The amount of residual trapped refrigerant shall be the final weight minus the initial weight of the test cylinder in C5.6.4.2, expressed in kg. The accuracy shall be ± 0.02 kg and reported to the nearest 0.05 kg.

C7.8 Refrigerant Processed. The amount of refrigerant processed before changing filters (see C5.7.3) shall be expressed in kg to an accuracy of $\pm 1\%$.

C7.9 Contaminant Levels. The contaminant levels remaining after testing shall be published as follows:

- Moisture content, ppm by weight
- Chloride ions, pass/fail
- Acidity, ppm by weight
- High boiling residue, % (by volume)
- Particulates-solid, pass/fail (visual examination)
- Non-condensables, % (by volume)

APPENDIX D. PARTICULATE USED IN STANDARD CONTAMINATED REFRIGERANT SAMPLE - NORMATIVE

D1 *Particulate Specification.*

D1.1 The particulate material (pm) will be a blend of 50% coarse air cleaner dust as received, and 50% retained on a 200-mesh screen. A source for the coarse air cleaner dust is:

AC Spark Plug Division
General Motors Corporation
Flint, Michigan

D1.2 *Preparation of Particulate Materials.* To prepare the blend of contaminant, first wet screen a quantity of coarse air cleaner dust on a 200-mesh screen (particle retention 74 pm).

This is done by placing a portion of the dust on a 200-mesh screen and running water through the screen while stirring the dust with the fingers. The fine contaminant particles passing through the screen are discarded. The larger than 200-mesh particles collected on the screen are removed and dried for one hour at 110°C. The blend of standard contaminant is prepared by mixing 50% by weight of coarse air cleaner dust as received (after drying for one hour at 110°C) with 50% by weight of the >200-mesh screened dust.

D1.3 *Particle Size Analysis.* The coarse air cleaner dust as received and the blend used as the standard contaminant have the following approximate particle size analysis:

Wt. % in various size ranges, pm.

Size Range	As Received	Blend
0-5	12	6
5-10	12	6
10-20	14	7
20-40	23	11
40-80	30	32
80-200	9	38