EPA-HQ-OAR-2003-0118

SEP 19 2006

USA UNITED SUPPLIERS OF AMERICA, INC.

SUBMISSION TO ASHRAE SSPC 34 COMMITTEE

R-424A (RS-44 new formulation)

Request for Refrigerant Number Designation and Safety Classification
for
Refrigerant Blend R-125/134a/600a/600/601a (50.5, 47.0, 0.9, 1.0, 0.6)

March 15, 2005

Submitted on behalf of
USA United Suppliers of America, Inc.
by
Safety Consulting Engineers, Inc.
Schaumburg, IL 60173
(847) 925 8100

Cover

1. Applicant:

USA United Suppliers of America, Inc.
303 Rosevelt Avenue
Spring Valley, NJ 10977
Phone # 800 270-3080
Fax # 877 774-5528
Attn: James Burke

2. Primary Contact:

Dan Etzold
USA United Suppliers of America, Inc.
303 Rosevelt Avenue
Spring Valley, NJ 10977
Phone # 800 270-3080
Fax # 877 774-5528
Voice mail # 800 992-0730
E-mail detzold@ptd.net

3. Refrigerant:

R-125/134a/600a/600/601a

4. Requested Actions:

Refrigerant Number	Composition (Weight %)	Safety Group	Composition Tolerances (%)	Remark
	R-125/134a/600a/600/601a (50.5, 47.0, 0.9, 1.0, 0.6)	A1	(±1.0, ±1.0, +0.1(-0.2), +0.1(-0.2), +0.1(-0.2))	Zeotrope

Administrative Information

1. Applicant Identification:

- Applicant:

USA United Suppliers of America Inc.
303 Rosevelt Avenue
Spring Valley, NJ 10977
Phone # 800 270-3080
Fax # 877 774-5528

- Primary Contact

Dan Etzold
USA United Suppliers of America Inc.
303 Rosevelt Avenue
Spring Valley, NJ 10977
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- Applicant's Interest:

USA United Suppliers of America, Inc. is the master distributor of the subject refrigerant originally developed by Refrigerant Solutions, Ltd., Cheshire, UK.

2. Data Certification

I/We certify that the information provided in this application (including its appendices) is true and accurate to the best of my/our knowledge and that no information that would affect classification of toxicity or flammability safety is being withheld. I/We further certify that I/we have reviewed ANSI/ASHRAE Standard 34-2004 (including al published addenda thereto) and that the information provided in this application is consistent with the requirements of that standard.

Applicant:
James R. Burke

_____ Date _____
Corporate Secretary
USA United Suppliers of America, Inc.

Primary Contact:
Dan Etzold

_____ Date _____
Refrigerant Specialist
USA United Suppliers of America, Inc.

3. Designation and Classification Certification

I/We understand that designations and safety classifications recommended for public review approval or publication are not assigned and may be revised or disapproved until actually published in an addendum or revision to Standard 34.

Applicant:
James R. Burke

_____ Date _____
Corporate Secretary
USA United Suppliers of America, Inc.

Primary Contact:
Dan Etzold

_____ Date _____
Refrigerant Specialist
USA United Suppliers of America, Inc.

Designation Information

1. Refrigerant Identification:

R-125/134a/600a/600/601a (50.5, 47.0, 0.9, 1.0, 0.6)
Refrigerant Blend
Zeotrope

2. Refrigerant Data:

A. Individual Component of R125/R134a/R600a/R600/R601a

Property	R125	R134a	R600a	R600	R601a
Chemical Name	pentafluoroethane	1,1,1,2-tetrafluoroethane	isobutane (2-methylpropane)	n-butane	isopentane (2-methylbutane)
Chemical Formula	CHF_2CF_3	CH_2FCF_3	$CH_3(CH_3)CHCH_3$	$CH_3CH_2CH_2CH_3$	$(CH_3)_2CHCH_2CH_3$
Chemical Abstract Service Registry Number	354-33-6	811-97-2	78-28-5	106-97-8	78-78-4
Molecular Mass	120.02 g/mol	102.03 g/mol	58.12 g/mol	58.12 g/mol	72.15 g/mol
Freezing Point	-100.6°C (-149.1 °F)	-103.3 °C (-153.9)	-159.6°C (-255.28°F)	-138.3 °C (-216.9 °F)	-160.0 °C (-256.0 °F)
Normal Boiling Point	-48.1°C (-54.7 °F)	-26.1°C (-14.9°F)	-11.61°C (11.10°F)	-0.5°C (31.0°F)	28.0 °C (82.0 °F)
Saturated Vapor Pressure At 20°C(68°F) At 60°C(140°F)	1204.5 kPa 3167.0 kPa	571.5 kPa 1682.0 kPa	301.8 kPa 868.3 kPa	208.1 kPa 639.0 kPa	77.0 kPa 273.0 kPa
Temperature at the Critical Point	66.2°C (151.1°F)	101.1°C (213.9°F)	134.7 °C (274.5 °F)	152 °C (305.6°F)	187.4 °C (369. 2 °F)

USA United Suppliers of America, Inc. Application to ASHRAE/ANSI Standard 34, March 07, 2005

Property	R125	R134a	R600a	R600	R601a
Specific Volume at the Critical Point	1.75 L/kg	1.95 L/kg	4.46 L/kg	4.38 L/kg	4.24 L/kg
Use and Typical Application Temperatures Evaporating Range Condensing Range	Blend component for alternatives like 402A, 402B, 404A, 407A, 407B, 407C, 407D, 408A, 410A, 410B, 507A. Sterilant, fire suppressant.	Domestic and commercial refrigeration, primary alternative for R12 and R500, blend component for 404A, 407A, 407B, 407C, 407D, 413A, 416A. Aerosol propellant. Evaporating temp typically –20 °C to +20°C, condensing between 30°C to 50°C	Originally used for small refrigeration systems (1920-30) Now used as a blend component for refrigerants and aerosol propellants..	Blend component of alternatives to R12 and R500 (for example R416A). Primary uses as a fuel, aerosol propellant and a base material for solvents, rubbers, and plastics. Evaporating range –40 °C to 15 °C, condensing range 30 °C to 70 °C	Used only as a blend component to increase lubrication properties.

B. Refrigerant Blend of R125/134a/600a/600/601a

Property	Blend
(a) Formulation	R125/134a/600a/600/601a (50.5, 47.0, 0.9, 1.0, 0.6)
(b) Molecular Mass as Formulated	108.4 g/mol
(c) Molecular Mass of the Vapor at 60°C (140°F)	110.4 g/mol
(d) Temperature at 14.7 psia (101 kPa) Saturated liquid (Boiling Point) Saturated vapor (Dew point)	 -39.1°C -33.3°C
(e) Maximum temperature glide At the normal boiling point At 20°C(68°F)	 5.8 °C 4.3 °C
(f) Vapor Composition for the as formulated saturated liquid At normal boiling point At 20°C(68°F)	 73.27, 25.22, 0.95, 0.48, 0.08 64.69, 33.76, 0.82, 0.57, 0.16
(g) Dew Point Vapor Pressure At 20°C(68°F) At 60°C(140°F)	 752.9 kPa 2154.0 kPa
(h) Latent Heat of Vaporization At 60°C(140°F)	 105.1 J/kg
(i) Specific Heat Ratio of Vapor At 60°C(140°F)	 1.68
(j) Temperature at the Critical Point	87.5°C
(k) Specific Volume at the Critical Point	1.97 L/kg
(l) Pressure at the Critical Point	3845.3 kPa
(m) Heat of Combustion (calculated for nominal blend) (calculated for WCF)	 2425.16 kJ/kg 2613.35 kJ/kg
(n) Use and Typical Application Temperatures Evaporating Range Condensing Range	R22 replacement -30°C to 15°C 20°C to 70°C
(m) Proposed composition tolerances for classification	R125=49.5-51.5 %wt. R134a=46.0-48.0 %wt. R600a=1.0-0.7 %wt. R600=1.1-0.8 %wt. R601a=0.7-0.4 %wt.
(o) Worst case formulation (WCF) of the blend	R125/134a/600a/600/601a (49.5, 47.7, 1.0, 1.1, 0.7)
(p) Worst case fractionated formulation (WCFF) of the blend WCFF1 WCFF2	 R125/134a/600a/600/601a (14.37, 82.4, 0.31, 0.58, 2.34) (27.49, 69.1, 0.67, 0.98, 1.76)

NIST program Refprop 6.01 was used to calculate properties of the blend.

MSDS for the Blend and Individual Components

MSDS for the Blend R-125/134a/600a/600/601a
MSDS for R125
MSDS for R134a
MSDS for R600a (isobutane)
MSDS for R600 (butane)
MSDS for R601a (isopentane)

Refrigerant Solutions Limited
8 Muriestion Road
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Altrincham
Cheshire, WA15 9ST
Tel: +44 (0) 161 926 9876
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E-mail: rs@refsols.com
www.refsols.com

October 2001

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

1.1 Identification of the preparation: RS-44, liquefied refrigerant blend

1.2 Company

Refrigerant Solutions Limited
8 Muriestion Road
Hale
Altrincham
Cheshire, WA15 9ST
Tel: +44 (0) 161 926 9876
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13 Emergency telephone number (Outside USA) +44 (0) 161 926 9876
Emergency telephone number (USA) 800 270 3080

14 E-mail: rs@refsols.com
Web site: www.refsols.com

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No	Weight %
Pentafluoroethane	354-33-6	50.5
1, 1, 1,2--tetrafluoroethane	811-97-2	47.0
Isobutane	78-28-5	0.9
Butane	106-97-8	1.0
Isopentane	78-78-4	0.6

3. HAZARDS IDENTIFICATION

Liquefied gas: May cause frostbite to skin and eyes.

4. FIRST-AID MEASURES

Eyes: If substance has got into the eyes immediately wash out with plenty of water for at least 15 minutes. Keep eye wide open while rinsing.

Skin: May cause frostbite. Wash frost-bitten area immediately with plenty of water. Do not remove clothing. Wash affected skin with warm water. If skin irritation persists, call a physician.

Inhalation: Move to fresh air in case of accidental inhalation of vapours. Oxygen or artificial respiration if needed. Do not apply artificial respiration if patient is breathing. Consult a physician after significant exposure. Do not give adrenaline or similar drugs.

Ingestion: Do not induce vomiting without medical advice. Call a physician immediately. Do not give drugs from adrenaline-ephedrine group.

General advice: Consult a physician for severe cases.

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

5. FIRE-FIGHTING MEASURES

5.1 Suitable extinguishing media:

The product itself does not bum. Extinguish with carbon dioxide, dry chemical, foam or water spray, as appropriate for surrounding area.

5.2 Extinguishing media which must not be used for safety reasons

None

5.3 Specific hazards:

Possibility of generating hazardous reactions during a fire due to the presence of F groups. Fire or intense heat may cause violent rupture of packages

5.4 Special protection equipment for fire fighters:

In the event of fire, wear self-contained breathing apparatus. Suitable protective clothing

5.5 Specific methods:

Standard procedure for chemical fires. In the event of fire, cool exposed containers with water spray.

6 ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions:

Use Personal protective equipment Evacuate personnel to safe areas. Ensure adequate ventilation. Avoid contact with skin, eyes and inhalation of vapour.

6.2 Methods for clearing up:

Shut off leaks if without risk. Let the liquid evaporate. Ensure adequate ventilation.

7. HANDLING AND STORAGE

7.1 Handling: Provide sufficient air exchange and/or exhaust in work rooms. Do not puncture or drop container.

7.2 Storage: Keep containers tightly closed in a cool, dry well-ventilated place away from direct sunlight. Keep away from heat and sources of ignition.

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Engineering measures:	Ensure adequate ventilation, especially in confined areas.
8.2 Personal protection equipment:	
Respiratory protection:	In case of insufficient ventilation wear suitable respiratory equipment, preferably a compressed airline breathing apparatus.
Hand protection:	Impervious gloves (butyl rubber).
Eye protection:	Wear as appropriate: safety glasses, goggles. Wear face-shield and protective suit for abnormal processing problems.
Skin and body protection:	Chemical resistant apron, long sleeved clothing, safety shoes.
8.3 Exposure limit:	Occupational Exposure Limit 1000 ppm (TWA).

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Appearance:	Compressed liquefied gas
9.2 Colour:	Colourless
9.3 Odour:	Very faint ether-like
9.4 Boiling point/range:	-39.1°C
9.5 Critical temperature:	87.5 °C
9.6 Critical pressure:	3845.3 kPa

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

Cont.

9.7	Vapour pressure:	982.2 kPa at 25^0C
9.8	Liquid density:	1173 kg/m^3 at 25^0C
9.9	Water solubility:	Insoluble
9.10	Flash point:	Not applicable
9.11	Flammability:	Non-flammable
9.12	Explosion limit	Not applicable
9.13	Auto-ignition temperature:	Not determined

10. STABILITY AND REACTIVITY

10.1	Stability:	Stable at normal conditions. No decomposition if stored and applied as directed.
10.2	Conditions to avoid.	Fire/sources of heat.
10.3	Materials to avoid:	Strong oxidizing. agents, alkali metals, alkaline earth metals, finely divided aluminum.
10.4	Hazardous decornposition products:	Hydrogen fluoride by thermal decomposition and hydrolysis.

11. TOXICOLOGICAL INFORMATION

11.1 Acute toxicity:

HFC 125 : LC 50 inhalation (Rat)/4h:>769,000 ppm
HFC 134a: LC 50 inhalation (Rat)/4h:>359,300 ppm
Isopentane: LC50 inhalation (Rat)/4h, 434,564 ppm
Butane: LC50 inhalation (Rat)/4h, 272,000 ppm
Isobutane: LC50 inhalation (Rat)/4h, 142,500 ppm

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

Cont.

11.2 Irritation:

- Skin: slightly irritating, may cause frostbite
- Eyes: slightly irritating

12 ECOLOGICAL INFORMATION

Behaviour in the environment:

Mobility: Product is volatile when not under pressure.

Persistence/degradability: All the components decompose comparatively rapidly in the lower atmosphere and all have relatively short atmospheric lifetimes demonstrated below:

HFC 134a	14.6 years
HFC 125	32.6 years
Isopentane	approximately 10 years
Butane	approximately 10 years
Isobutane	approximately 10 years

Bioaccumulation: Not bioaccumulable.

Destination of the product:

Effects on the aquatic environment:

Discharge of the product will enter the atmosphere. No long term aqueous contamination due to low solubility.

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

13. DISPOSAL CONSIDERATIONS

Waste treatment: Refrigerant Products Limited will take back product for reclamation provided RS-44 has not been mixed with any other products. If RS-44 is mixed with other refrigerants, the mixture can be destroyed by high temperature incineration in an approved facility capable of absorbing and neutralizing the by-products.

14. TRANSPORT INFORMATION

14.1 International regulations: UN number: 3163

- Rail/road (RID/ADR): Class: 2
  Item number: 2A
  Hazard identification number: 20
  Labeling: 2
- Sea (IMO/IMDG): Class: 2.2
  Labeling: Gas comprime flammable
  Not classified as a marine pollutant
- Air (ICAO-IATA): Class: 2.2
  Labeling: Non-flammable gas

14.2 United Kingdom: Rail/road. Substance Identification number: 3163

14.3 Note: Given the possible evolution of transport regulations for hazardous materials, it is recommended to check their validity

15 REGULATORY INFORMATION

Classification according to European Directive on classification of hazardous preparations 88/379/EEC. Not classified as dangerous. The product does not need to be labeled in accordance with EC directives.

PRODUCT SAFETY DATA SHEET

PRODUCT: RS-44

Cont.

R-phrase(s): No R-phrases

S-phrase(s):

S7/9 - Keep container tightly closed in a well-ventilated place
S24/25 - Avoid contact with skin and eyes
S47- Keep at temperature not exceeding 500C
S51- Use only in well ventilated areas
S61- Avoid release to the environment

16. OTHER INFORMATION

The information provided in this Product Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process unless specified in the text.

MSDS

1.0 FRACTIONATION ANALYSIS

Fractionation simulations and testing have been conducted for the original refrigerant blend: R-125/134a/600a/600/601a defined as follows:

Component	%w/w	Tolerances
Pentafluoroethane (R125)	50.5	±1%
1,1,1,2-tetrafluoroethane (R134a)	47.0	±1%
Isobutane (R600a)	0.9	+0.1%, -0.2%
n-butane (R600)	1.0	+0.1%, -0.2%
Isopentane (R601a)	0.6	+0.1%, -0.2%

The purpose of the fractionation analysis is to identify the composition changes affecting flammability of the refrigerant's worst case manufacturing mixture during an isothermal vapor leak. The worst case manufacturing mixture (**WCF**) composition is defined for this blend as the composition containing the highest amount (percentage) of flammable components within the manufacturing tolerance range (+0.1%, -0.2 % for R600a, R600 and R601a) and the lowest amount of R125 (because of its flame suppressant properties). The worst case manufacturing composition (**WCF**) for the above original mixture is then defined as:

Component	%w/w
Pentafluoroethane (R125)	49.5
1,1,1,2-tetrafluoroethane (R134a)	47.7
Isobutane (R600a)	1.0
n-butane (R600)	1.1
Isopentane (R601a)	0.7

The simulations include:

- Leakage of the refrigerant worst case manufacturing mixture (**WCF**) at different temperatures and liquid loading of the cylinder evaluated by computer simulation and testing.

- Leakage and recharge of the refrigerant worst case manufacturing mixture at room temperature of the cylinder evaluated by computer simulation and testing.

2.0 FRACTIONATION SIMULATIONS

2.1

2.1 Computer simulation

The theoretical fractionation was performed by computer simulation using NIST developed program REFLEAK ver. 2.1.

Seven simulations were carried out for isothermal vapor leak process for the worst case manufacturing mixture:

(a) 90% liquid filled tank at 54.4°C (130°F)

(b) 90% liquid filled tank at 23°C (73.4°F)

(c) 73% liquid filled tank at –28.9°C (-20.2 °F) (BP of the WCF + 10°C)

(the program refused to run at 90% loading)

(d) 15% liquid filled tank at 60°C (140°F)

(e) 15% liquid filled tank at 23°C (73.4°F)

(f) 15% liquid filled tank at –28.9°C (-20.2 °F) (BP of the WCF + 10°C)

Another simulation was conducted for isothermal leak refill process at:

(a) 15% liquid filled tank at 23°C (73.4°F)

2.2 Fractionation (Depletion) Test and Composition Measurements

An isothermal vapor depletion of the worst-case formulation was carried out first at 23°C (73.4°F) and 90% loading configuration resulting in the final worst-case fractionated formulation obtained with the computer simulation. The results of the test didn't verify the computer model for one component. The isopentane concentration didn't increase at the end of the test as much as model predicted. **The isopentane concentration at 95% depletion from the model was ~400% higher then the experimental value**. The predicted concentration values for

all the remaining four components (R125, R134a, R600a, and R600) were in good agreement with test. In order to establish a credible concentration values for isopentane and find out a worst case fractionated formulation (**WCFF**) all seven depletion tests have been conducted. The WCFFs found in this analysis are based on test data, while simulation data was retain on the graphs to verify the depletion of the other four components (R125, R134a, R600a, and R600).

2.2.1 Setup

The apparatus consisted of a 1000-ml Stainless Steel cylinder equipped with a dip tube, needle valves with sampling ports, a 25-liter isolated and cooled tank (cooling bath), immersion cooler and a circulator, Teflon high pressure hose, and an electronic gas mass flow meter. A GX 6000 scale and a stopwatch completed the setup. The high-pressure hose was used to connect the cylinder sample port to the flow meter.

2.1.2 Procedure

The 1000-ml cylinder was filled at 90% or 15% liquid with the final worst-case formulation blend and was conditioned at its test temperature in the cooling bath (or worm bath) overnight.

Once the composition of the initial vapor and liquid samples were measured, the cylinder was placed on a balance and gross weight was recorded. The cylinder was then placed in the appropriate bath (at the corresponding depletion temperature) in the upright position (for vapor depletion) and the cylinder needle valve opened slowly until the vapor flow out of the cylinder was 2% mass/hour.

After 2% of the initial weight of the refrigerant leaked out from the cylinder, the needle valve was closed to stop the leak. Liquid and vapor samples were taken and analyzed by Gas Chromatography. This procedure was repeated at 10%, 20%...90% loss increments. The last sample if possible was taken at 95% of mass loss. The test stopped if there was no more liquid in the tank, or no more vapor coming out of tank.

A Hewlett-Packard GC with thermal conductivity detector (TCD) and a Haysep D 80/100 column with helium as a carrier gas was used to determine the concentration of the gases at different fractionation levels. The oven temperature was 100°C for 8 min, ramped to 160°C and kept for 16 min.

A vapor sample was taken directly from a vapor port on the tank; the liquid sample was trapped into pre-vacuumed small cylinder and 1 ml of it was then injected into GC.

Final fractionation test data is reported in Figure 1 through 14 and Table 2 through 9. The resulting test data points for vapor and liquid phase are superimposed on the computer simulation data.

2.3 Results

Comparison of the simulation data to the test data indicates that the computer model is satisfactory in predicting the fractionation behavior of the four components of the blend (R125, R134a, R600a and R600), **but is not acceptable in predicting concentration values of isopentane (R601a)**. Therefore all the flammable component concentrations were derived from the experimental data.

The Figures 1 through 14 contain both simulation and test data. The continuous lines represent computer-modeling data; the points refer to experimental data. Because the R600a, R600 and R601a amounts are very small comparing to R125 and 134a and they don't really show well on the graphs containing all five components (full range), the part of the graph containing flammables (low range) was expanded to show better their behavior. The candidate WCFFs resulting from this analysis are shown in Table 1.

TABLE 1. WCFF SELECTION

Loading	Temperature	Total % wt. of flammables	Phase	Corresponding R125 %wt.	Mass Loss
90%	54.4 °C	3.41	liquid	27.49	90% (end)
90%	23 °C	3.23	liquid	14.37	95% (end)
90%	-28.9 °C	3.36	vapor	68.50	2% (initial)
15%	60 °C	3.01	liquid	41.50	20% (end of liquid)
15%	23 °C	2.75	liquid	32.24	70% (end of liquid)
15%	-28.9 °C	3.24	vapor	48.06	2% (initial)
15% Leak&refill	23 °C	2.77	liquid	37.17	20% (end of 5th refill)

The highest ratio of total flammables to R125 was found for 90% loading at 23°C in liquid phase at the end of depletion.

The highest amount of flammables was found for 90% loading at 54.4°C in liquid phase at the end of depletion.

Therefore **WCFFs** are defined as :

WCFFs	**R125**	**R134a**	**R600a**	**R600**	**R601a**
WCFF1	**14.37**	**82.4**	**0.31**	**0.58**	**2.34**
WCFF2	**27.49**	**69.1**	**0.67**	**0.98**	**1.76**

TABLE 2
FRACTIONATION TEST RESULTS FOR 90% FILLED TANK @54.4°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	49.66	47.52	1.00	1.11	0.71	59.05	38.46	1.10	1.01	0.38	2.82	2.49
2	49.32	47.86	0.99	1.11	0.72	58.79	38.71	1.10	1.01	0.39	2.82	2.50
10	47.96	49.21	0.99	1.1	0.74	57.75	39.72	1.08	1.02	0.43	2.83	2.53
20	47.91	49.3	0.97	1.08	0.75	57.44	40.03	1.05	1.01	0.46	2.8	2.52
30	46.81	50.36	0.96	1.08	0.79	56.91	40.6	1.03	1.02	0.44	2.83	2.49
40	44.88	52.27	0.95	1.09	0.82	55.19	42.35	1.02	1	0.44	2.86	2.46
50	42.78	54.36	0.89	1.07	0.9	53.28	44.22	0.99	1.02	0.49	2.86	2.5
60	40.75	56.36	0.88	1.05	0.96	51.31	46.1	0.98	1.06	0.56	2.89	2.6
70	39.19	57.81	0.86	1.08	1.06	48.2	49.16	0.95	1.07	0.63	3	2.65
80	33.3	63.52	0.78	1.04	1.35	43.76	53.61	0.88	1.01	0.74	3.17	2.63
90	27.49	69.1	0.67	0.98	1.76	36.65	60.49	0.81	1	1.05	3.41	2.86

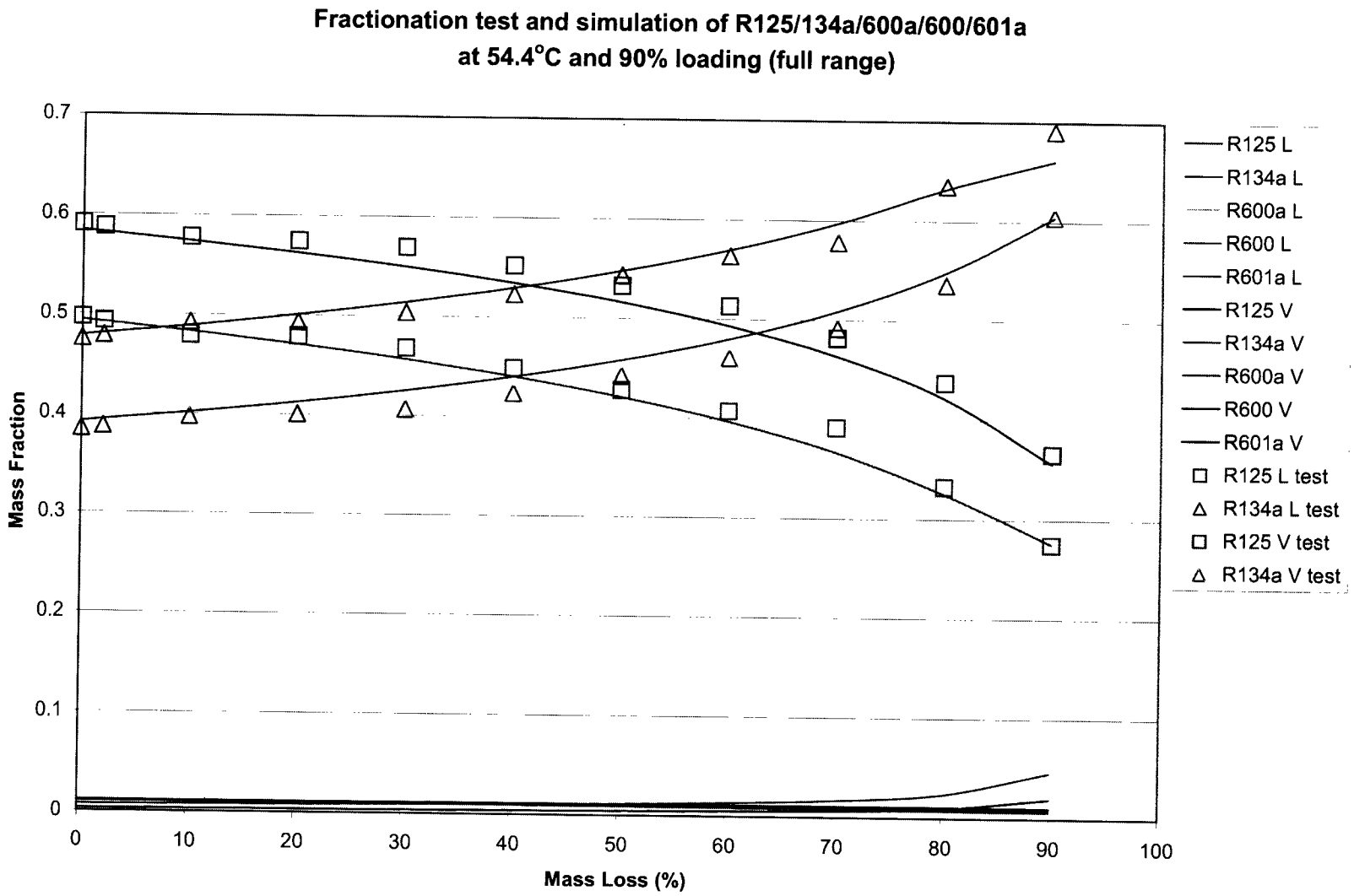

Figure 1. 90% loading at 54.4°C (full range)

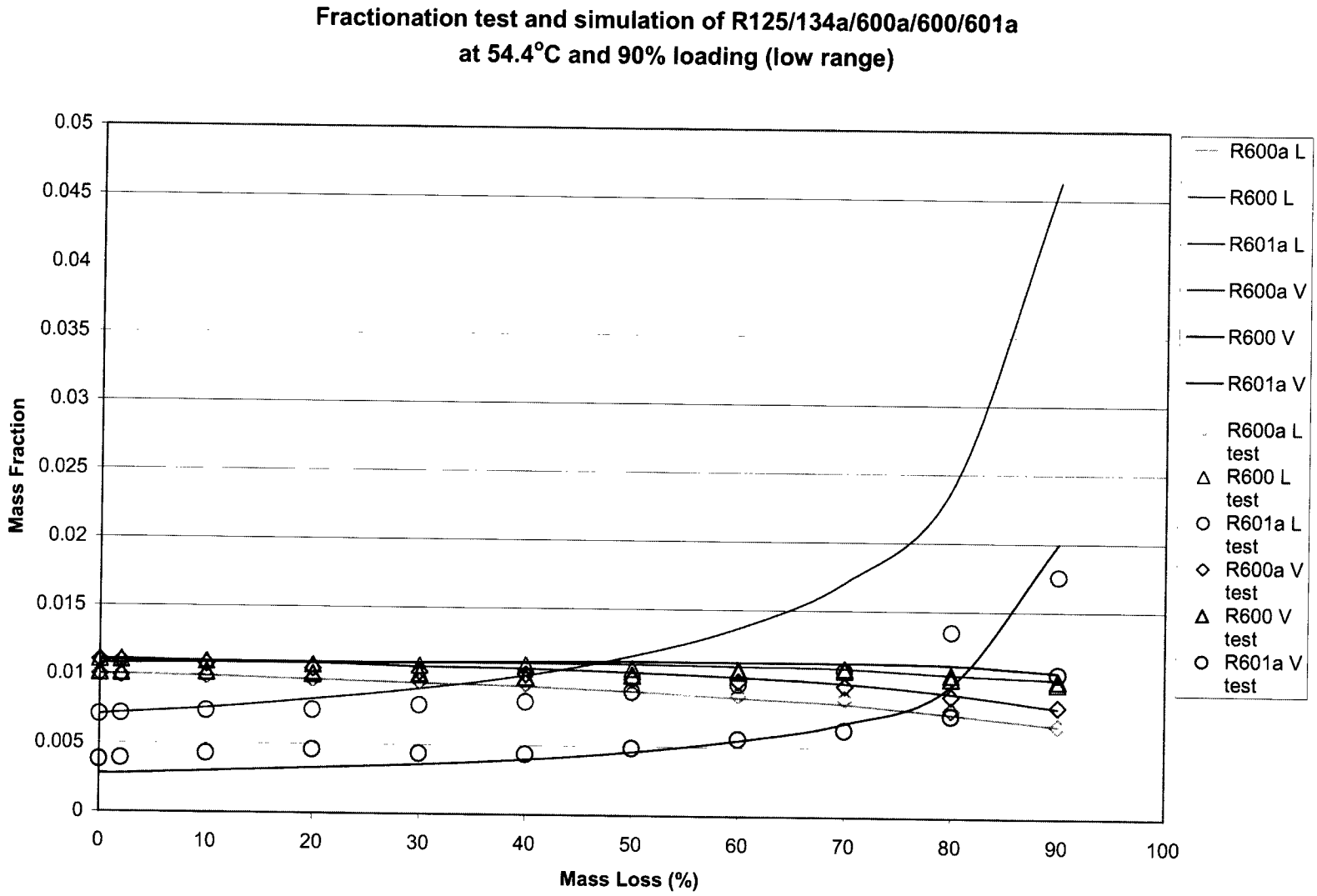

Figure 2. 90% loading at 54.4°C (low range)

TABLE 3
FRACTIONATION TEST RESULTS
FOR 90% FILLED TANK @-28.9°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	50.33	46.88	1.03	1.10	0.65	68.66	28.00	1.67	1.33	0.34	2.78	3.34
2	50.06	47.20	0.98	1.08	0.66	68.50	28.14	1.71	1.33	0.32	2.72	3.36
10	48.68	48.68	0.96	1.04	0.66	67.36	29.34	1.61	1.35	0.34	2.65	3.30
20	45.80	51.66	0.84	1.00	0.71	65.16	31.65	1.50	1.31	0.36	2.54	3.18
30	44.54	52.96	0.80	0.97	0.74	62.90	34.04	1.37	1.28	0.41	2.50	3.06
40	42.11	55.48	0.71	0.92	0.80	59.63	37.45	1.20	1.25	0.48	2.42	2.93
50	36.25	61.51	0.56	0.81	0.88	54.74	42.48	1.01	1.18	0.58	2.24	2.77
60	29.44	68.59	0.36	0.62	0.98	48.96	48.45	0.85	1.05	0.68	1.96	2.58
70	23.69	74.52	0.23	0.48	1.09	40.41	57.41	0.52	0.83	0.83	1.80	2.18
80	14.22	84.32	0.07	0.25	1.14	26.19	72.01	0.22	0.53	1.03	1.46	1.78
84.47	8.26	90.30	0.05	0.15	1.24	18.58	79.79	0.12	0.34	1.17	1.44	1.63

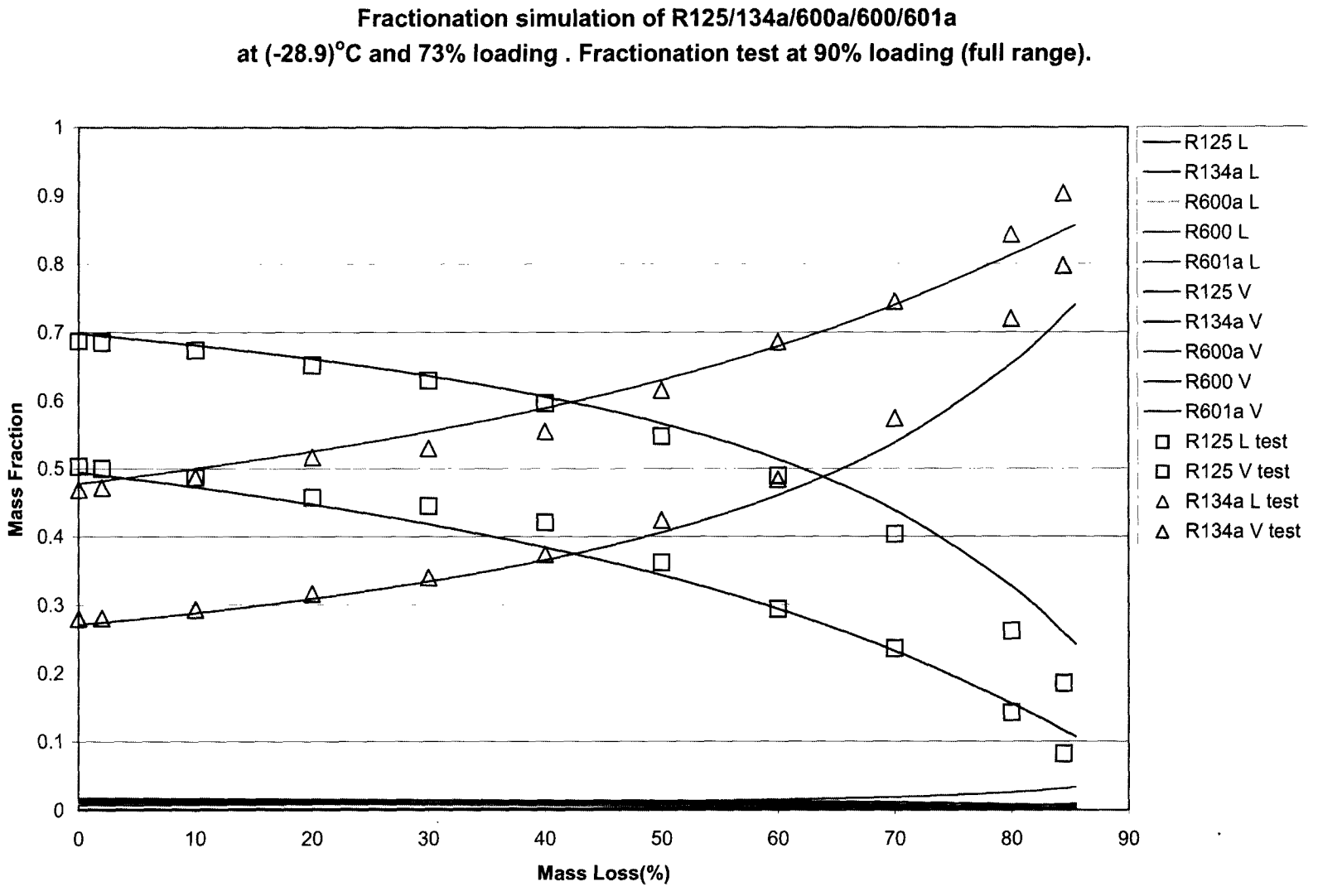

Figure 3. Test for 90% loading at (-28.9)°C. Simulation at 73% loading and (-28.9)°C (full range)

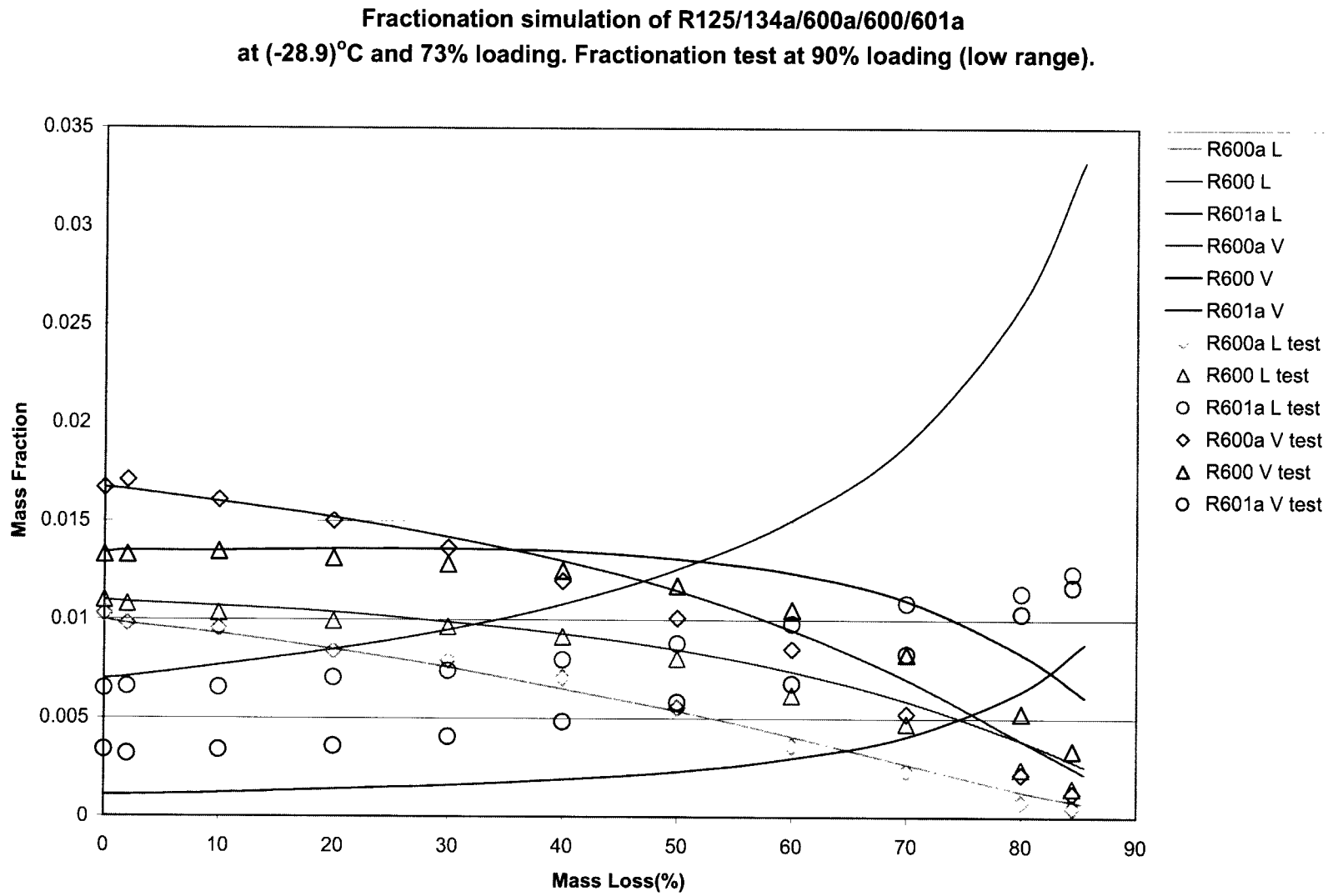

Figure 4. Test for 90% loading at (-28.9)°C. Simulation at 73% loading and (-28.9)°C (low range)

TABLE 4
FRACTIONATION COMPUTER SIMULATION RESULTS
FOR 90% FILLED TANK @23°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	49.43	47.76	1	1.1	0.7	62.76	34.68	1.24	1.13	0.19	2.8	2.56
2	49.15	48.04	0.99	1.1	0.71	62.52	34.93	1.24	1.13	0.19	2.8	2.56
10	47.95	49.22	0.97	1.1	0.76	61.46	35.98	1.22	1.14	0.2	2.83	2.56
20	46.28	50.86	0.94	1.09	0.83	59.96	37.47	1.2	1.15	0.23	2.86	2.58
30	44.35	52.74	0.9	1.08	0.92	58.21	39.21	1.17	1.15	0.25	2.9	2.57
40	42.11	54.92	0.86	1.07	1.04	56.12	41.3	1.14	1.16	0.29	2.97	2.59
50	39.45	57.5	0.81	1.04	1.2	53.56	43.85	1.09	1.16	0.34	3.05	2.59
60	36.19	60.64	0.74	1.01	1.42	50.32	47.08	1.03	1.16	0.41	3.17	2.6
70	32.04	64.57	0.65	0.96	1.78	46	51.39	0.95	1.14	0.52	3.39	2.61
80	26.48	69.68	0.54	0.87	2.44	39.79	57.56	0.82	1.09	0.74	3.85	2.65
90	18.29	76.35	0.37	0.72	4.27	29.68	67.41	0.6	0.94	1.37	5.36	2.91
95	12.36	78.55	0.27	0.6	8.22	21.57	74.61	0.43	0.78	2.61	9.09	3.82
97.48	8.85	69.28	0.26	0.66	20.95	16.62	76.4	0.34	0.69	5.95	21.87	6.98

TABLE 5
FRACTIONATION TEST RESULTS
FOR 90% FILLED TANK @23°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	50.27	46.93	1.04	1.07	0.7	62.79	34.48	1.27	1.09	0.37	2.81	2.73
2	49.67	47.47	1.01	1.08	0.76	62.78	34.37	1.36	1.08	0.4	2.85	2.84
10	48.48	48.66	1	1.07	0.79	61.94	35.18	1.33	1.12	0.42	2.86	2.87
20	46.76	50.41	0.97	1.06	0.8	60.56	36.65	1.23	1.13	0.43	2.83	2.79
30	45.04	52.05	0.94	1.06	0.92	58.88	38.39	1.19	1.1	0.44	2.92	2.73
40	43.54	53.59	0.9	1.03	0.93	56.96	40.2	1.18	1.15	0.51	2.86	2.84
50	40.3	56.89	0.84	1.01	0.97	54.67	42.56	1.11	1.1	0.53	2.82	2.74
60	37.69	59.46	0.79	0.99	1.08	51.83	45.3	1.09	1.13	0.64	2.86	2.86
70	33.43	63.68	0.7	0.94	1.24	48.02	49.14	1	1.09	0.75	2.88	2.84
80	28.3	68.78	0.59	0.86	1.47	42.01	55.14	0.89	1.07	0.9	2.92	2.86
90	18.79	78.22	0.38	0.68	1.93	32.85	64.39	0.63	0.92	1.21	2.99	2.76
95	14.37	82.4	0.31	0.58	2.34	23.79	73.31	0.51	0.8	1.6	3.23	2.91

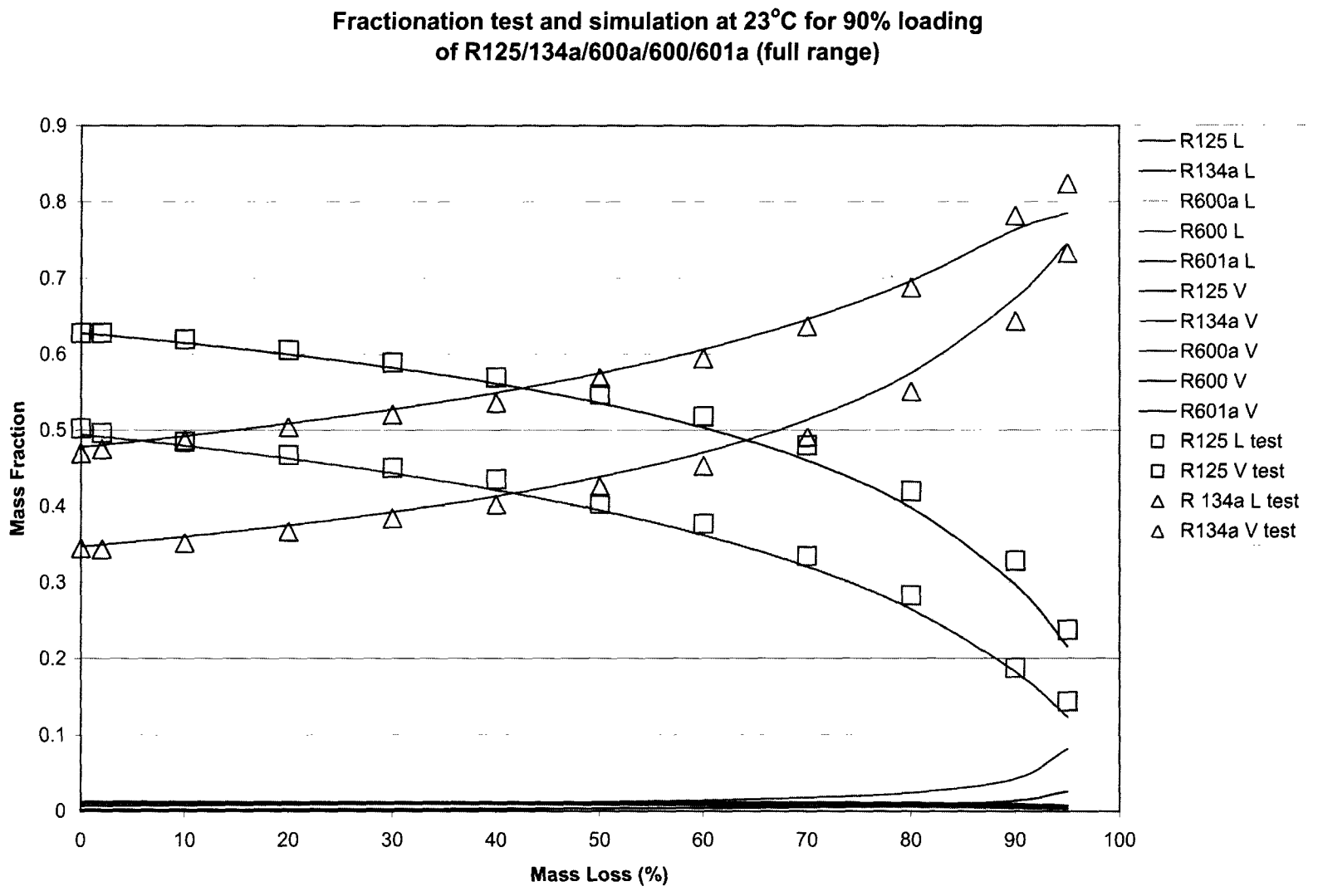

Figure 5. 90% loading at 23°C (full range).

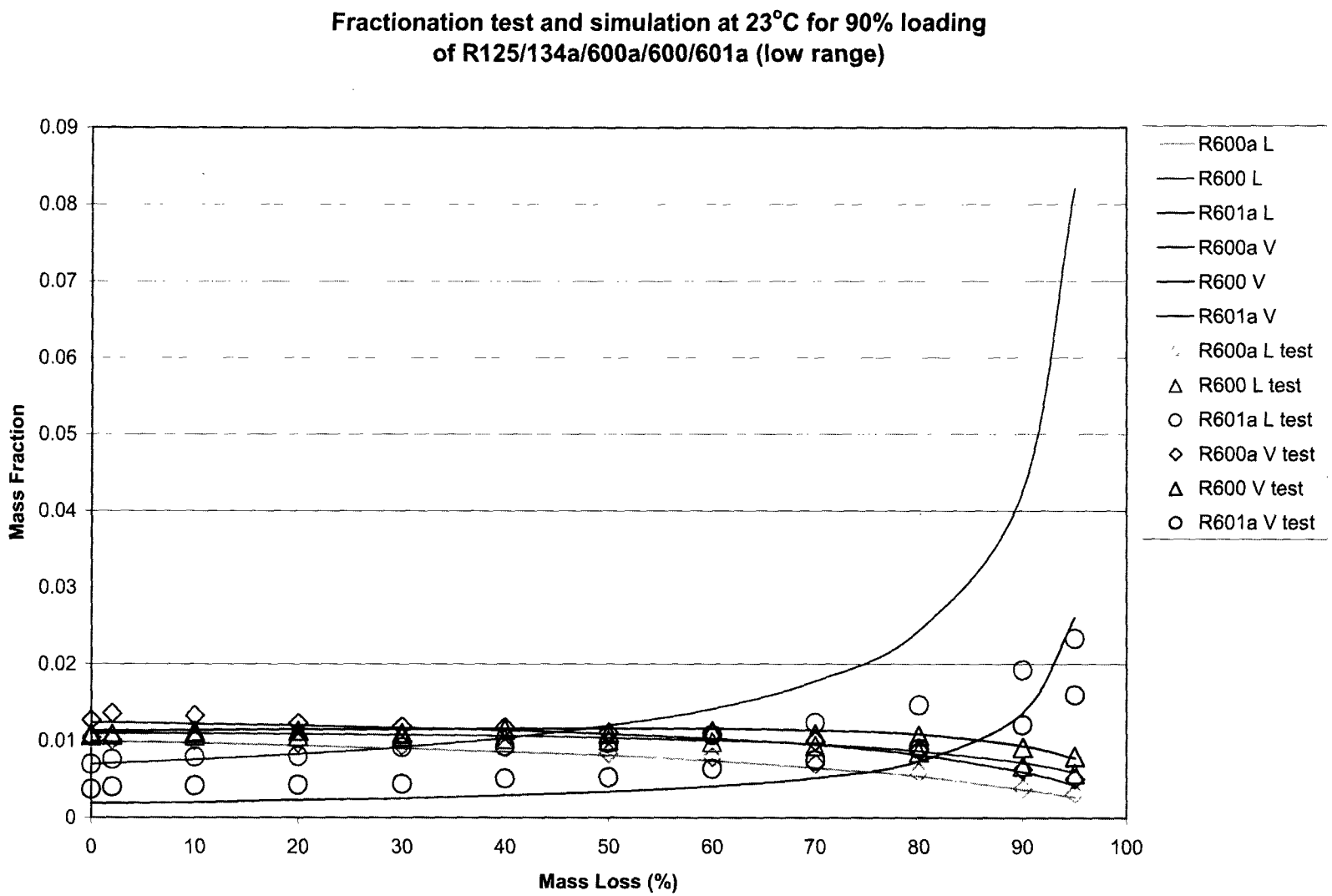

Figure 6. 90% loading at 23°C (low range).

TABLE 6
FRACTIONATION TEST RESULTS
FOR 15% FILLED TANK @60°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	44.05	53.01	0.94	1.08	0.91	52.99	44.38	1.07	1.05	0.52	2.93	2.64
2	43.27	53.76	0.96	1.09	0.92	52.35	44.98	1.06	1.06	0.55	2.97	2.67
10	42.63	54.41	0.95	1.07	0.94	51.7	45.67	1.04	1.04	0.55	2.96	2.63
20	41.55	55.44	0.94	1.06	1.01	50.76	46.61	1.02	1.03	0.57	3.01	2.62
30	42.62	54.44	0.91	1.04	0.98	50.82	46.46	1.02	1.05	0.65	282	266
40	48.88	48.29	1.01	1.07	0.74	49.52	47.81	0.99	1.03	0.64	2.82	2.66
50	49.08	48.15	1.03	1.07	0.67	49.37	47.49	1	1.01	0.66	2.77	2.67

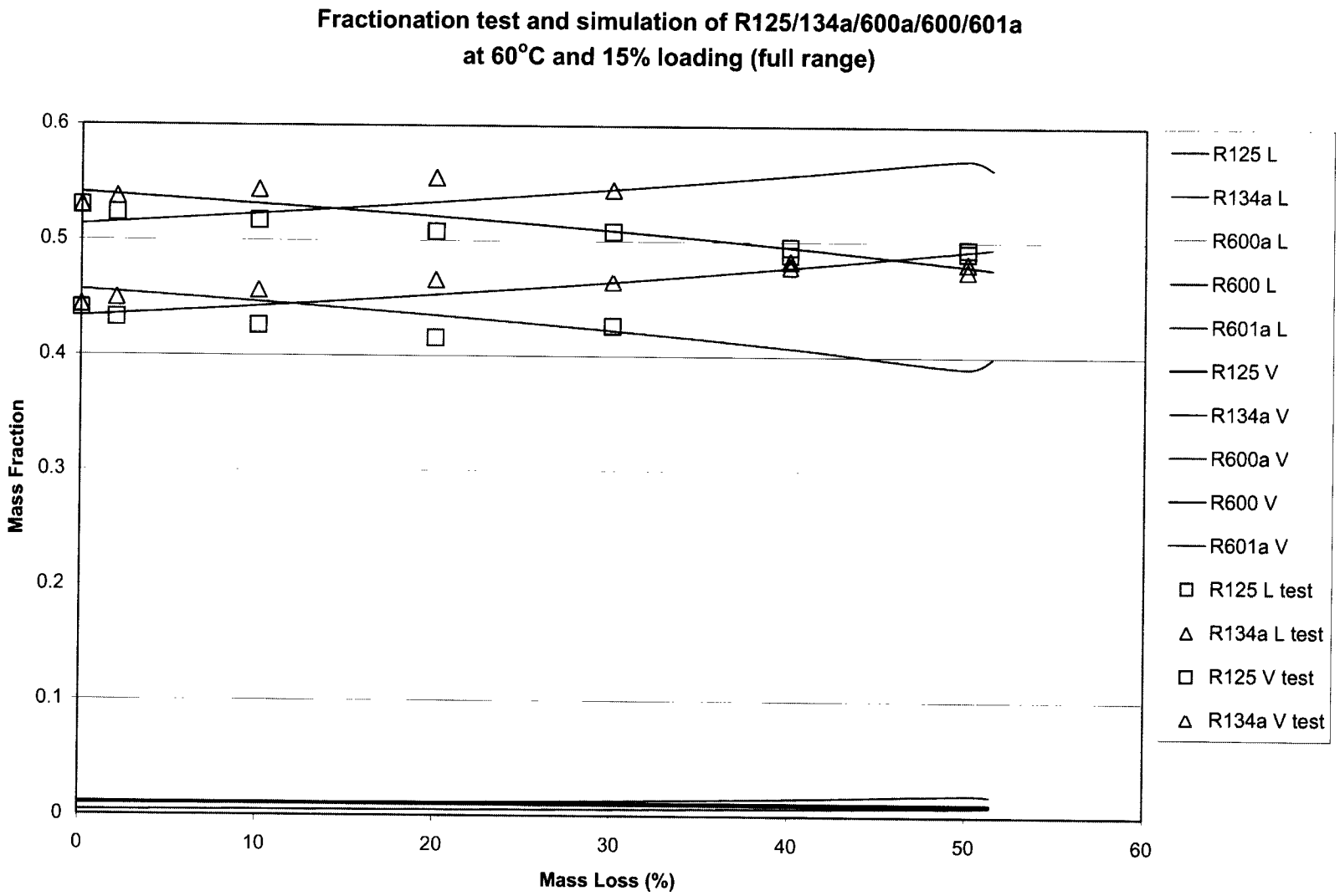

Figure 7. 15% loading at 60°C (full range)

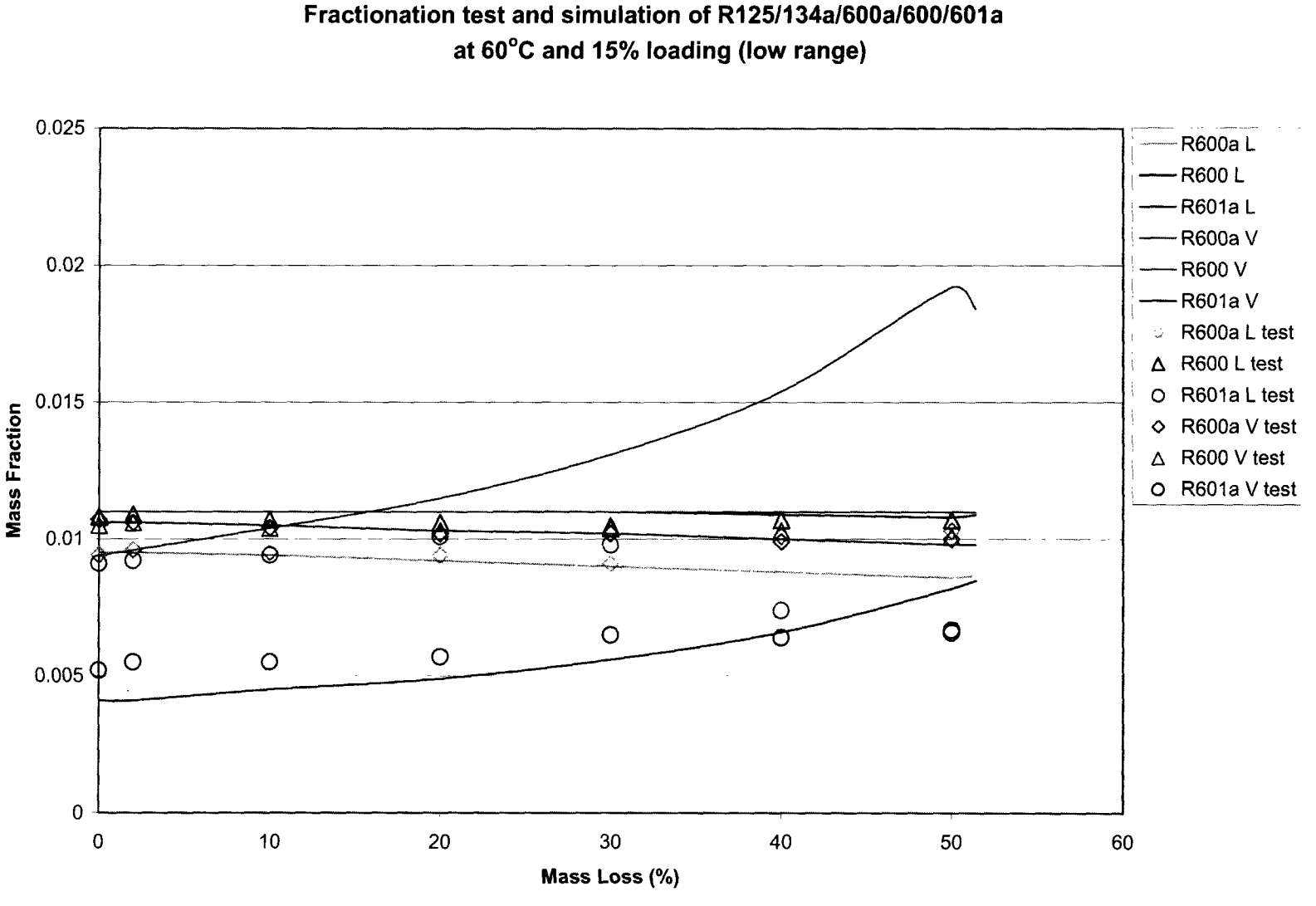

Figure 8. 15% loading at 60°C (low range)

TABLE 7
FRACTIONATION TEST RESULTS
FOR 15% FILLED TANK @-28.9°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	49.44	47.82	1.03	1.07	0.64	68.73	28.04	1.63	1.30	0.30	2.74	3.23
2	49.35	48.06	0.96	1.01	0.61	68.28	28.47	1.70	1.26	0.28	2.58	3.24
10	47.21	50.25	0.91	0.97	0.66	66.83	30.08	1.51	1.24	0.34	2.54	3.09
20	44.49	53.13	0.80	0.92	0.67	64.06	32.88	1.42	1.26	0.38	2.39	3.06
30	41.61	56.09	0.71	0.87	0.71	61.14	35.80	1.39	1.24	0.42	2.29	3.05
40	38.42	59.44	0.56	0.82	0.76	57.86	39.26	1.22	1.18	0.47	2.14	2.88
50	33.25	64.61	0.51	0.77	0.86	55.51	41.73	1.08	1.15	0.53	2.14	2.76
60	28.21	69.70	0.46	0.68	0.95	51.72	45.68	0.91	1.03	0.66	2.08	2.60
70	23.28	75.07	0.24	0.43	0.98	43.50	54.18	0.65	0.87	0.80	1.65	2.32
80	17.40	81.11	0.16	0.32	1.01	32.94	65.03	0.36	0.64	1.03	1.49	2.03

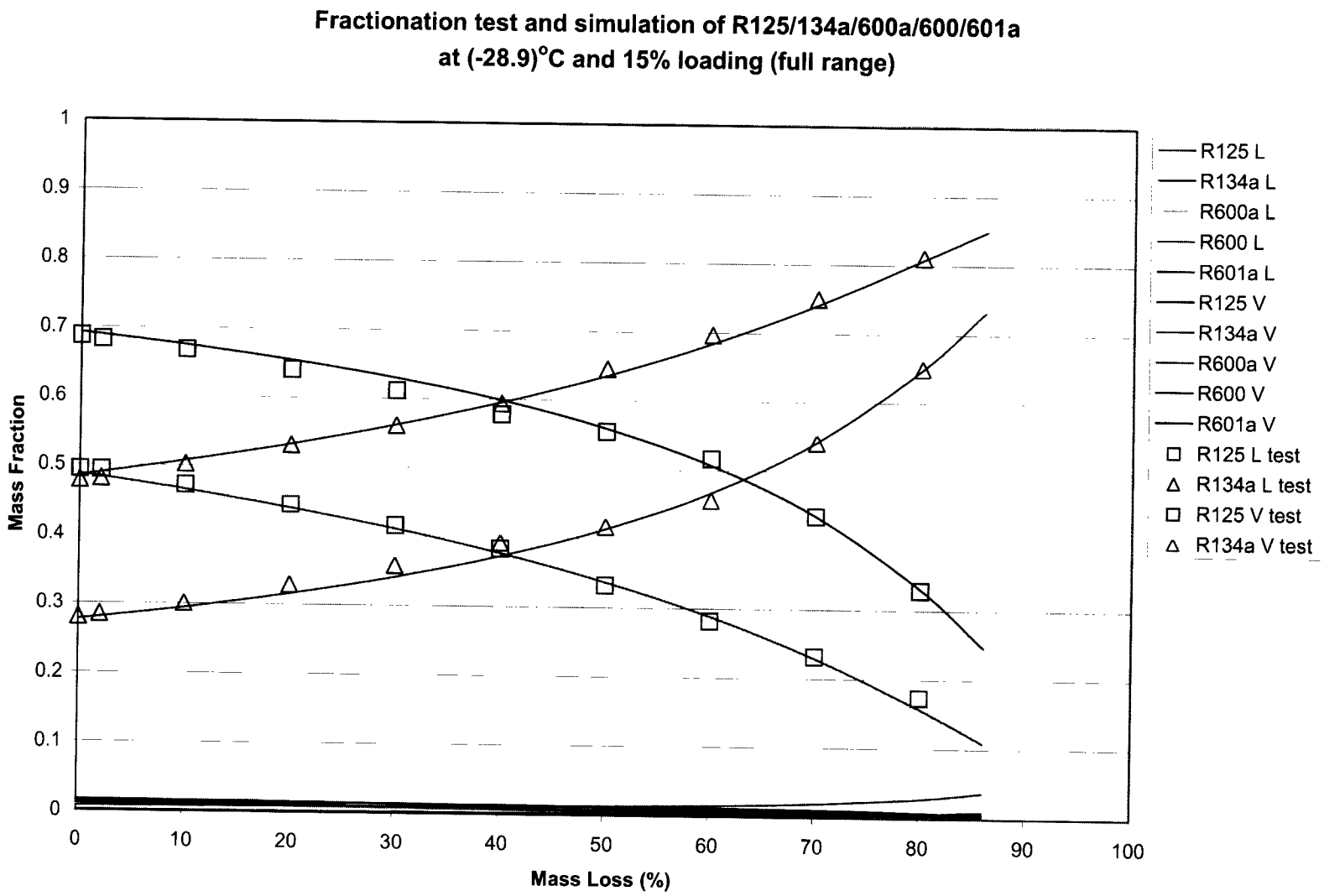

Figure 9. 15% loading at (-28.9) °C (full range)

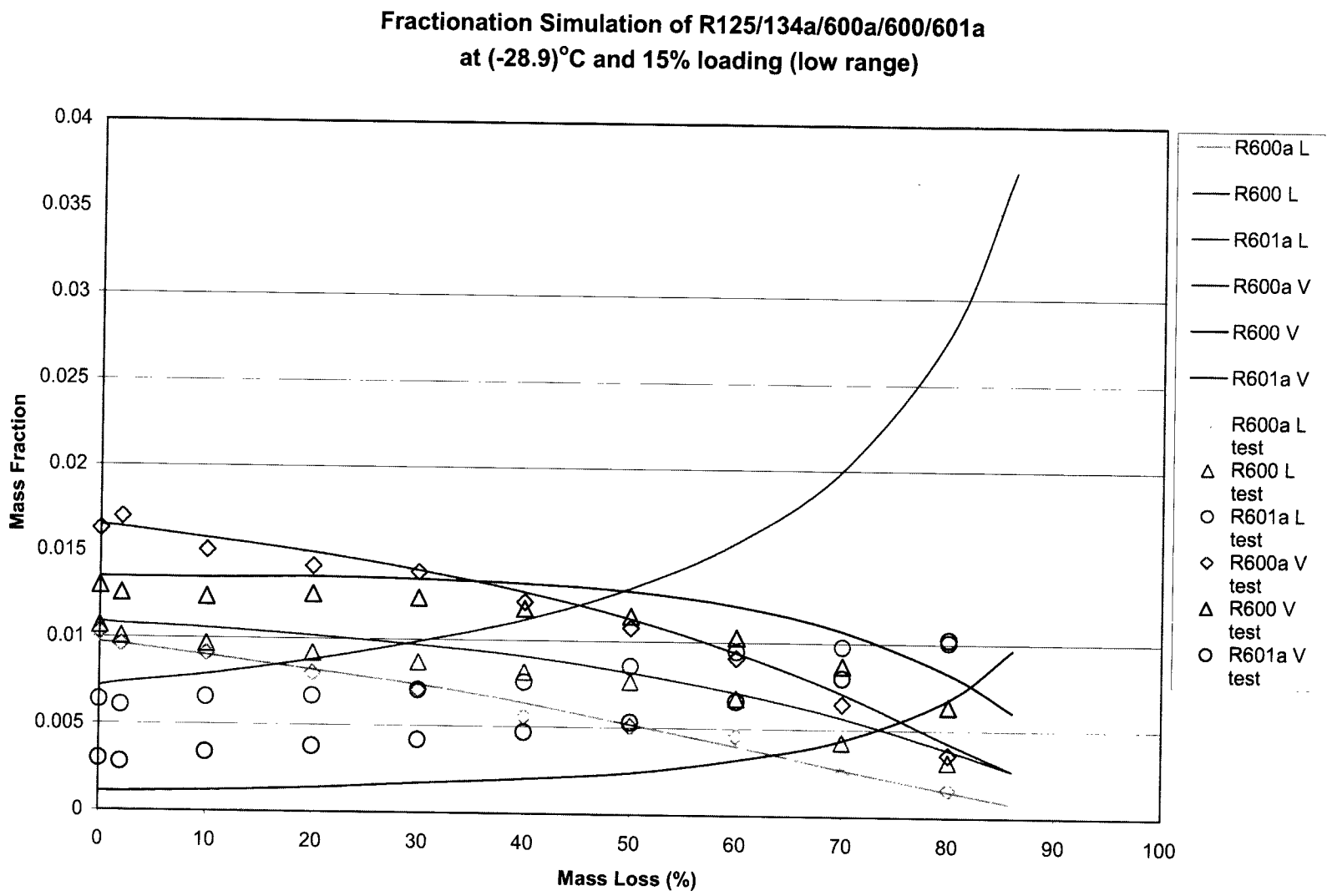

Figure 10. 15% loading at (-28.9) °C (low range)

TABLE 8
FRACTIONATION TEST RESULTS
FOR 15% FILLED TANK @23°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	46.93	50.27	0.99	1.08	0.72	59.82	37.44	1.24	1.13	0.38	2.79	2.75
2	46.32	50.95	0.97	1.06	0.69	59.76	37.44	1.27	1.14	0.38	2.72	2.79
10	45.05	52.26	0.93	1.05	0.71	59.50	37.73	1.22	1.17	0.38	2.69	2.77
20	43.21	54.06	0.92	1.03	0.78	58.07	39.13	1.23	1.15	0.42	2.73	2.80
30	42.16	55.12	0.87	1.02	0.83	56.28	40.87	1.20	1.16	0.48	2.72	2.84
40	39.86	57.28	0.87	1.04	0.95	54.82	42.42	1.16	1.15	0.46	2.86	2.77
50	37.89	59.40	0.80	0.97	0.94	53.00	44.31	1.10	1.09	0.49	2.71	2.68
61	34.41	62.87	0.73	0.93	1.06	49.31	48.06	1.01	1.04	0.58	2.72	2.63
70	32.24	65.01	0.68	0.89	1.18	46.25	51.15	0.94	1.01	0.64	2.75	2.59
80	44.30	52.97	0.91	1.03	0.79	44.48	52.87	0.92	1.01	0.73	2.73	2.66

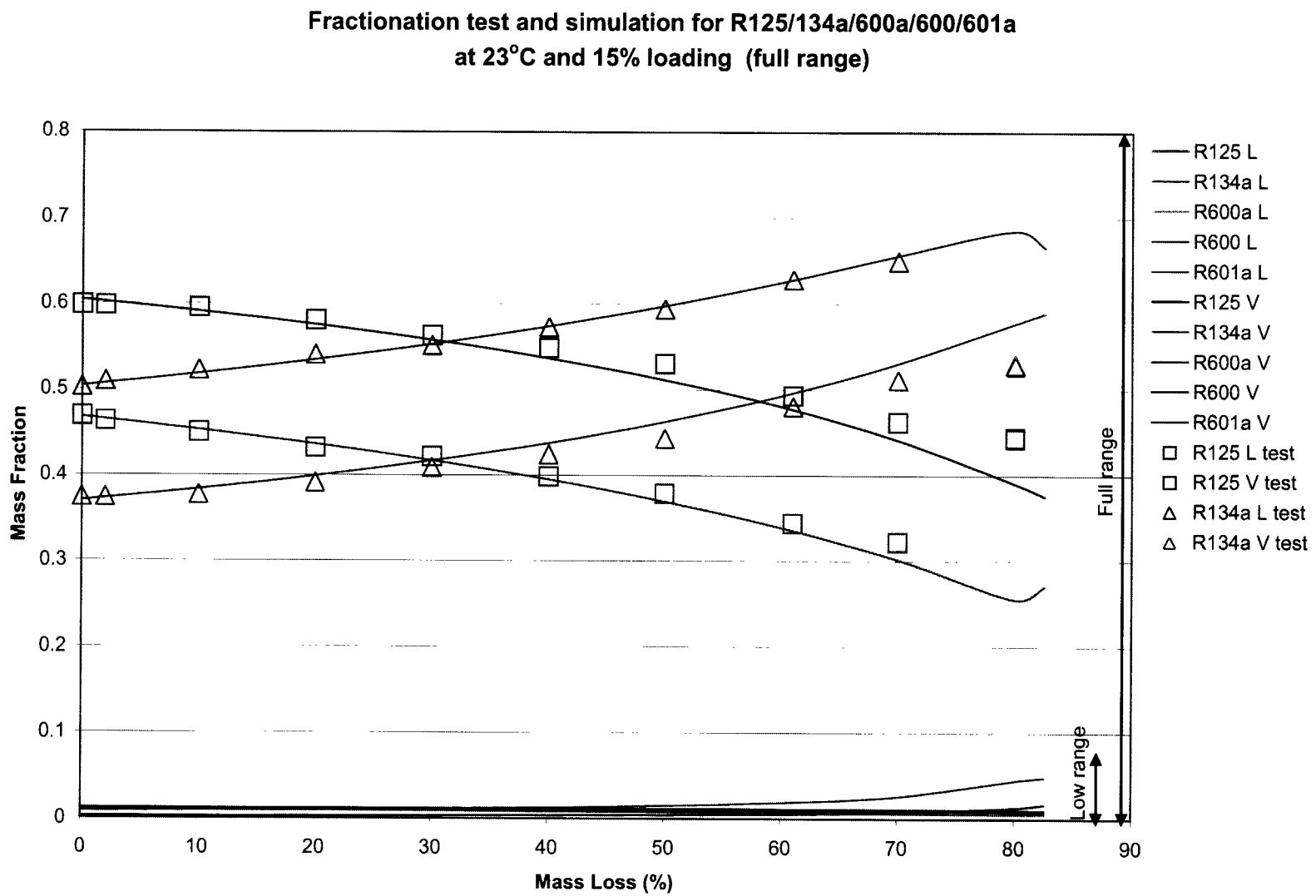

Figure 11. 15% loading at 23°C (full range)

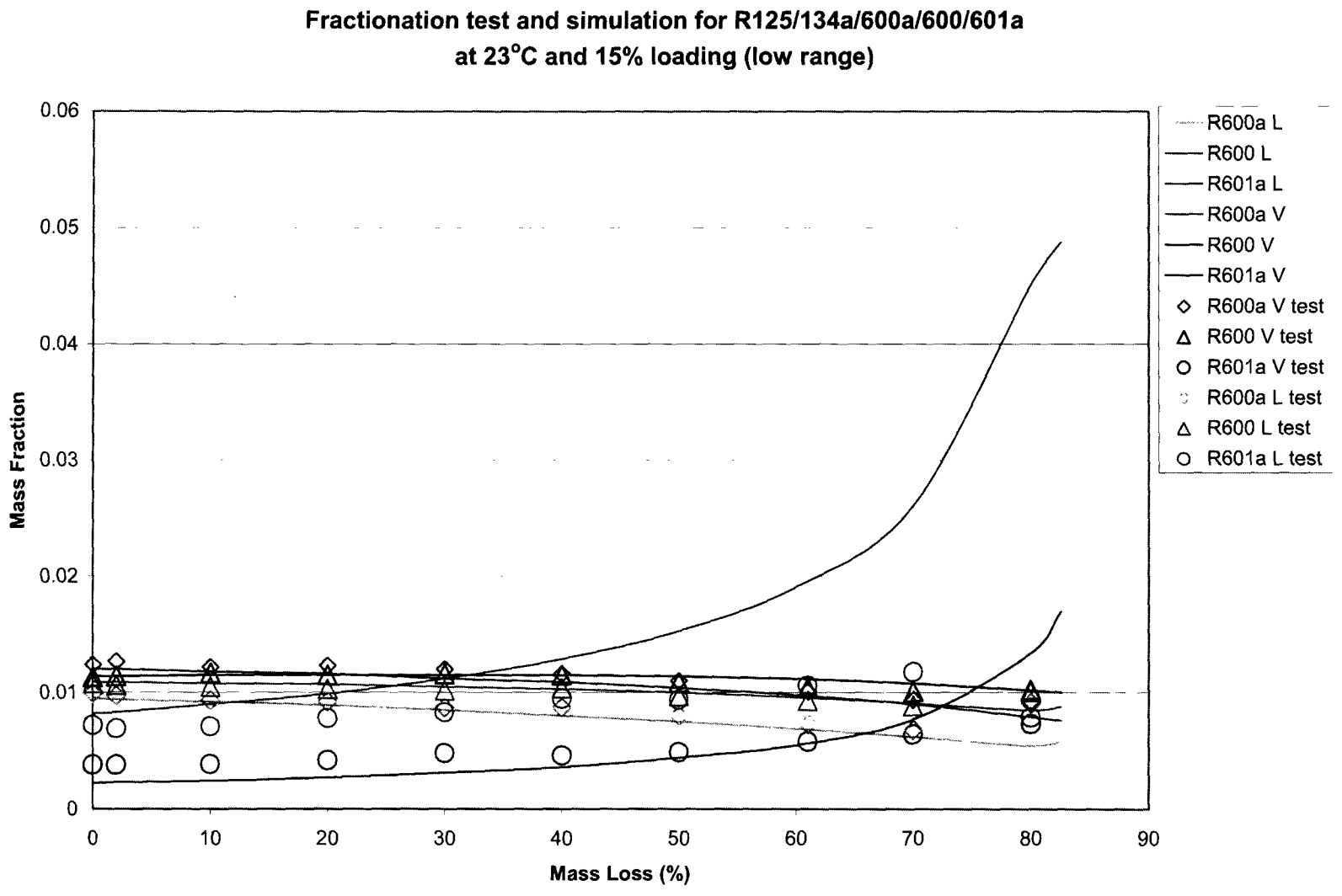

Figure 12. 15% loading at 23°C (low range)

TABLE 9
FRACTIONATION TEST RESULTS
FOR LEAK AND REFILL OF 15% FILLED TANK @23°C

Leaked Mass %wt	R125 L %wt	R134a L %wt	R 600a L %wt	R600 L %wt	R601a L %wt	R125 V %wt	R134a V %wt	R 600a %wt	R600 V %wt	R601a V %wt	Total Flamm. In liquid	Total Flamm. In vapor
0	46.11	51.12	0.99	1.04	0.75	60.01	37.48	1.19	1.00	0.32	2.78	2.51
10	44.55	52.70	0.94	1.02	0.79	58.89	38.47	1.21	1.03	0.40	2.75	2.64
20	42.66	54.56	0.92	1.01	0.85	57.42	39.91	1.19	1.06	0.43	2.78	2.68
0	44.17	53.05	0.95	1.03	0.80	58.44	38.90	1.21	1.06	0.39	2.78	2.66
10	42.34	54.89	0.92	0.99	0.86	57.09	40.24	1.17	1.05	0.45	2.77	2.67
20	41.12	56.15	0.88	0.96	0.90	55.41	41.89	1.11	1.02	0.57	2.74	2.70
0	42.84	54.36	0.92	1.03	0.84	57.09	40.34	1.15	1.00	0.42	2.79	2.57
10	41.12	56.14	0.86	0.98	0.90	55.66	41.67	1.14	1.06	0.47	2.74	2.67
20	39.30	57.99	0.81	0.97	0.93	54.14	43.16	1.11	1.04	0.55	2.71	2.70
0	41.25	56.08	0.84	0.97	0.86	56.01	41.29	1.16	1.07	0.47	2.67	2.70
10	40.59	56.73	0.84	0.95	0.90	54.69	42.63	1.14	1.06	0.48	2.69	2.68
20	38.69	58.55	0.82	0.97	0.96	53.06	44.25	1.10	1.05	0.55	2.75	2.70
0	41.41	55.86	0.86	0.98	0.89	55.41	41.87	1.15	1.08	0.49	2.73	2.72
10	39.70	57.65	0.79	0.94	0.92	53.92	43.46	1.08	1.04	0.50	2.65	2.62
20	37.99	59.31	0.78	0.94	0.98	52.29	45.09	1.06	1.01	0.55	2.70	2.62
0	40.38	56.90	0.81	0.97	0.94	54.57	42.75	1.12	1.06	0.51	2.72	2.69
10	38.67	58.56	0.80	0.97	1.00	52.98	44.34	1.08	1.04	0.56	2.77	2.68
20	37.17	60.06	0.78	0.96	1.03	51.63	45.72	1.04	1.04	0.57	2.77	2.65

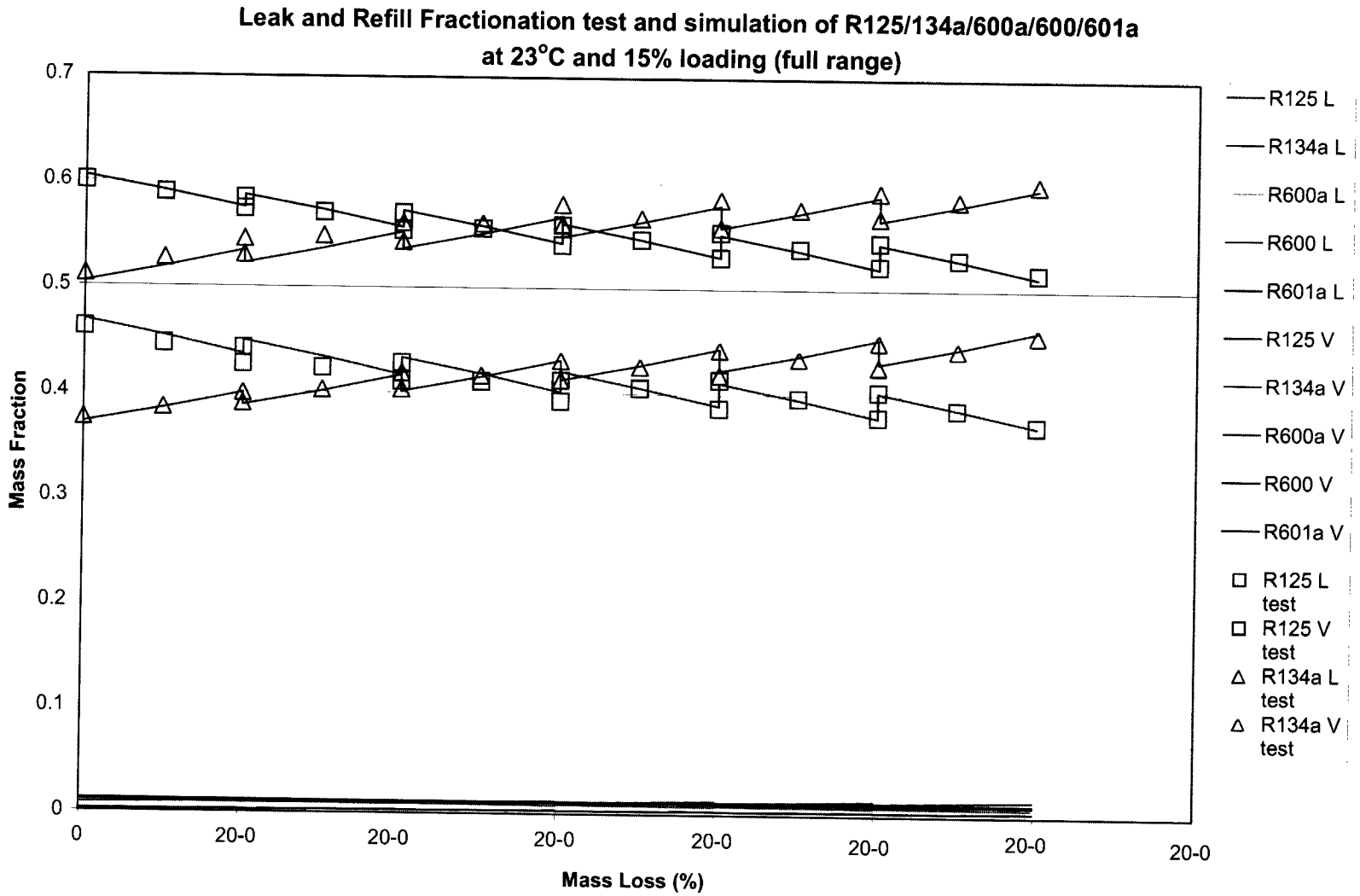

Figure 13. Leak and refill 15% loading at 23°C (full range)

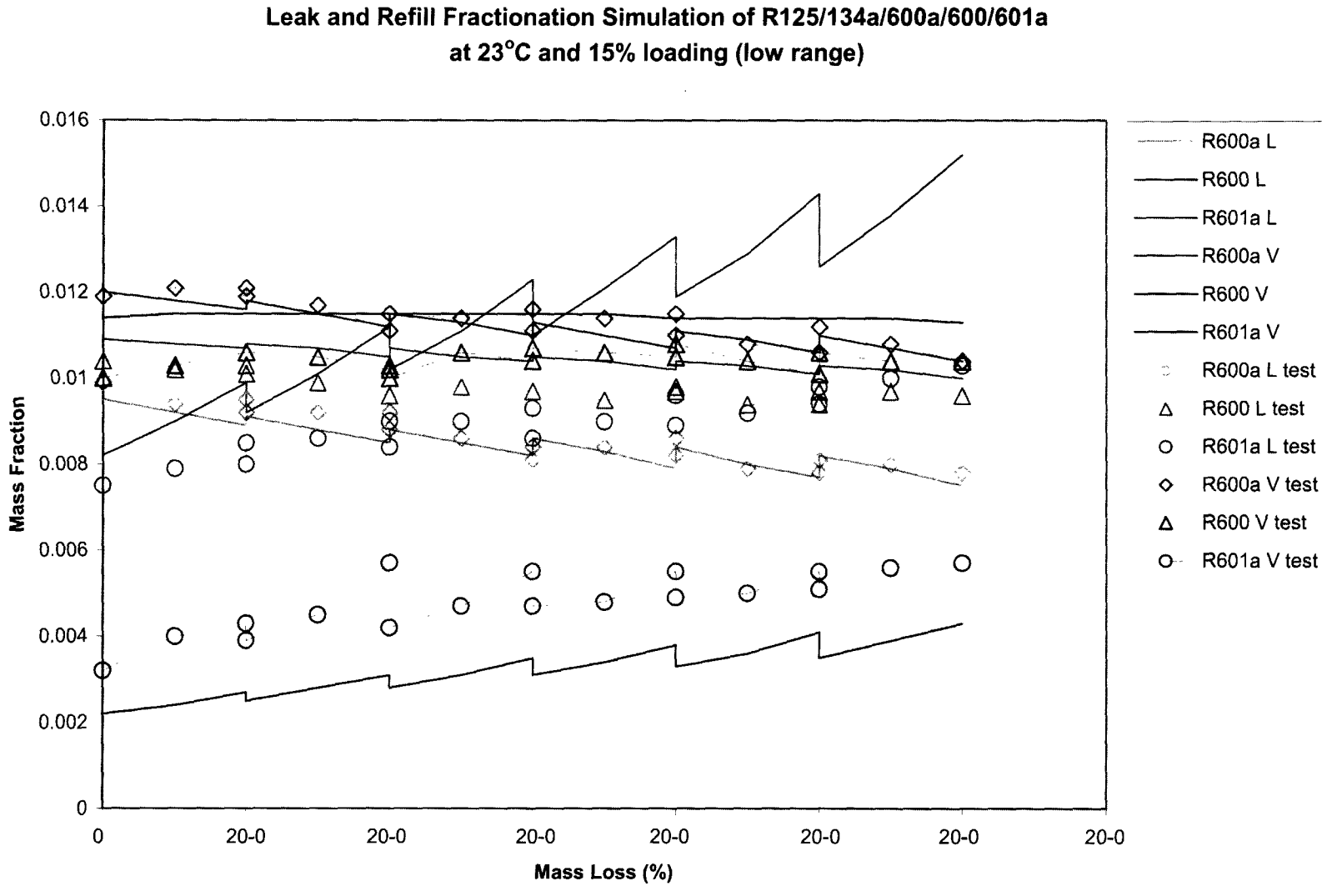

Figure 14. Leak and refill 15% loading at 23°C (low range)

Flammability Information

1.0 Flame Propagation

Flammability criteria tests have been conducted on the worst case manufactured (WCF) and worst case fractionated compositions (WCFFs) of the original refrigerant mixture R-125/134a/600a/600/601a (50.5, 47.0, 0.9, 1.0, 0.6). Emphasis was placed on identifying the shift of the flammable range of the refrigerant's worst case manufacturing (if any) due to a change in the overall mixture composition after an isothermal leak (fractionation) from the refrigerant system. Series of flammability tests were performed at both the worst case manufactured and worst case fractionated mixtures:

- WCF; R-125/134a/600a/600/601a (**49.5, 47.7, 1.0, 1.1, 0.7**) at 100°C
- WCFF1; R-125/134a/600a/600/601a (**14.37, 82.4, 0.31, 0.58, 2.34**) at 60°C
- WCFF2; R-125/134a/600a/600/601a (**27.49, 69.1, 0.67, 0.98, 1.76**) at 60°C

2.0 Flammability of Worst Case Manufactured and Fractionated Compositions

2.1 Test Setup and Procedure

The tests were performed using a 12-liter flask per ASHRAE standards. Tests were conducted at 100°C for WCF, at 60°C for WCFF and at atmospheric pressure. Refer to Figure 1 for the setup.

The flask consists of a one-necked glass test vessel. A stirrer was also used to mix the gases (air/refrigerant) in the glass flask. For the test, a liquid quantity of the blend mixture was injected and vaporized into a pre-vacuumed cylinder. A measured amount of gas is then introduced into the flask (by partial pressure), the flask is then brought back to atmospheric pressure using 50% relative humidity air. The stirrer was turned on to obtain complete mixing and attainment of thermal equilibrium. After five minutes of mixing, the stirrer was then turned off. An electric spark (15,000V, 30 mA) was created to ignite the gas mixture inside the flask. Visual observation of the flame propagation beyond a 90° fan from the tip of the electrodes to the vessel was considered as a reaction.

The flask was purged with dry compressed air to clean out residue after each trial. The quantity of the blend sample in air was varied between trials until the composition, which could just sustain propagation of the flame was determined.

2.2 Test Results

The flammability test results for WCF; R-125/134a/600a/600/601a (**49.5, 47.7, 1.0, 1.1, 0.7**) performed at 100°C are shown in Table 1.

The results for WCFF1; R-125/134a/600a/600/601a (**14.37, 82.4, 0.31, 0.58, 2.34**) at 60°C are shown in Table 2.

The results for WCFF2; R-125/134a/600a/600/601a (**27.49, 69.1, 0.67, 0.98, 1.76**) at 60°C are shown in Table 3.

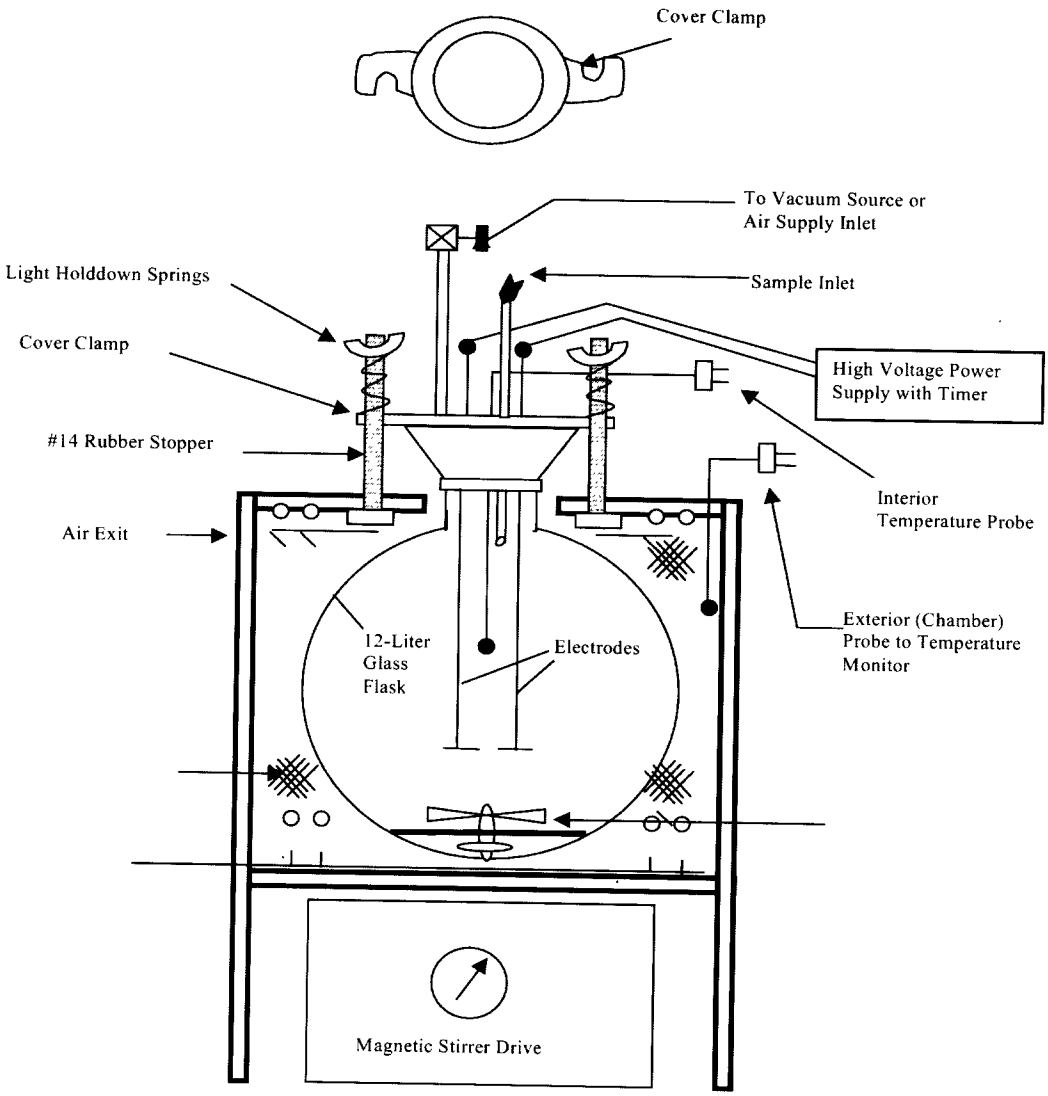

Figure 1. Flammability chamber setup

TABLE 1
FLAMMABILITY RESULTS FOR WCF
R-125/134a/600a/600/601a (49.5, 47.7, 1.0, 1.1, 0.7)

Flask Volume: 12-liter Air Relative: 50%

Test Temperature: 100°C (0.0086 gm $_{H2O}$)/gm$_{air}$

CONCENTRATION (% by volume)	RESULTS	
	GO	NO GO
2		X
3		X
4		X
5		X
6		X
7		X
8		X
9		X
10		X
11		X
12		X
13		X
14		X
15		X
16		X
17		X
18		X
19		X
20		X
22		X
24		X
26		X
28		X
30		X

TABLE 2
FLAMMABILITY TEST RESULTS FOR WCFF1
R-125/134a/600a/600/601a (14.37, 82.4, 0.31, 0.58, 2.34)

Flask Volume: 12-liter Air Relative: 50%

Test Temperature: 60°C (0.0086 gm $_{H2O}$)/gm$_{air}$

CONCENTRATION (% by volume)	RESULTS	
	GO	NO GO
2		X
3		X
4		X
5		X
6		X
7		X
8		X
9		X
10		X
11		X
12		X
13		X
14		X
15		X
16		X
17		X
18		X
19		X
20		X
22		X
24		X
26		X
28		X
30		X

TABLE 2
FLAMMABILITY TEST RESULTS FOR WCFF2
R-125/134a/600a/600/601a (27.49, 69.1, 0.67, 0.98, 1.76)

Flask Volume: 12-liter Air Relative: 50%

Test Temperature: 60°C $(0.0086\ gm_{H2O})/gm_{air}$

CONCENTRATION (% by volume)	RESULTS	
	GO	NO GO
2		X
3		X
4		X
5		X
6		X
7		X
8		X
9		X
10		X
11		X
12		X
13		X
14		X
15		X
16		X
17		X
18		X
19		X
20		X
22		X
24		X
26		X
28		X
30		X

WCF, and both WCFF1 and WCFF2 of the blend were nonflammable.