

# **Developing Procedures And Standards For Mobile Air Conditioning Systems**

**SAE Alternate Refrigerant Symposium**

**June/July 2004**

**Ward Atkinson**

# Industry Guidelines Standards

- **System Design Requirements**
  - Refrigerant Lines and Hoses
  - Pressure Relief Devices [5 to 10 times higher]
  - Service Fittings
  - Controls For Refrigerant Safety Mitigation
- **Service Sector Requirements**
  - Technician Training Certification
  - Refrigerant Removal Charging Equipment
  - Refrigerant Leak Detection Equipment
  - Service Tools

# **SAE J639 Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems [UNDER REVISION]**

- Refrigerant vapor compression systems providing cooling and/or heating
- Design standards for refrigerant containment and safety
  - Included are cautionary statements to alert service technicians to the inadvisability and the possible health and safety effects associated with venting refrigerant during service.
- The document addresses only CFC-12, HFC-134a, HFC152a a flammable gas and carbon dioxide refrigerants.
- To prevent system contamination all refrigerants used in mobile air conditioning vapor compression systems require unique service fittings. The unique service fittings minimize the potential for system refrigerant contamination during service activity.

# SAE J639 Pressure Relief Devices



**Overcharged  
System?**



# SAE J639 Pressure Relief Devices



**Overcharge?**

**Wrong Refrigerant?**



# SAE J639 Pressure Relief Devices



Oil Separator [CO<sub>2</sub>]

No pressure device



# **SAE J2064 R134a Refrigerant Automotive Air-Conditioning Hose**

**This SAE Standard covers hose and hose assemblies intended for conducting liquid and gaseous R134a refrigerant in automotive air-conditioning systems. The hose shall be designed to minimize permeation of R134a refrigerant, contamination of the system, and to be functional over a temperature range of – 30 to 125 °C. Specific construction details are to be agreed upon between user and supplier. A hose marked “J2064” signifies that it has been coupled, tested, and has met the requirements of SAE J2064..**

# New SAE J Documents

- New Standard for System Refrigerant Connections [Design]
  - Refrigerant Tube/pipe Connections
    - Fittings/joints
- Service Equipment and Technician Standards for new refrigerants [Service]
- Refrigerant Leak Detection [Design]
  - New standard for HFC-152a and R744
  - New standard for HFC-134a reduced emission systems



# **Procedure For Determining HFC-134a System Leakage**

**[New J-standard to be developed]**

# Assumptions for R134a Leakage Chart Spreadsheet

- Industry standards do not exist for determining refrigerant system emissions from mobile air conditioning systems.
- Test procedures are not common between production component suppliers in establishing leakage values.
- The following System “Leakage Chart” has been developed from industry experience of expected refrigerant leakage change from system design changes.

# Assumptions for R134a Leakage Chart Spreadsheet

- **It allows a comparison and rating value of various technologies that are currently available.**
  - Not all leak paths can be determined with a high level of accuracy for real world conditions due to
    - Assembly Variation
    - Wear & Degradation
    - Affects of vibration and localized temperatures

# Assumptions for R134a Leakage Chart Spreadsheet

- **Included In Assumptions**

- Rigid pipe connections are tube and pipe assemblies
- Flexible hose assemblies include tube, hose and crimping
- Compressor major permeation paths are shaft seal and housing seals
- Heat exchangers are considered as robust and the Leakage Chart assigns a value of 1 for their emissions.

System Component Connection							Calculated Value
<b>Fittings</b>							
Rigid Pipe Connections and Flexible Hose Connections	Single O-ring	Single Captured O-ring	Multiple O-ring	Seal Washer	Seal Washer with O-ring	Metal Gasket	Do Not Enter Data
<b>Total Emissions</b>	125	75	50	10	5	1	
Number of fittings:	9	1		2			1220
<b>High Side service port</b>							
<b>Total Emissions</b>	60	60	40	10	5	1	
Number of fittings:	1						60
<b>Low-Side service port</b>							
<b>Total Emissions</b>	40	40	25	10	10	1	
Number of fittings:	1						40
<b>PRV, Switches, Transducers</b>							
<b>Total Emissions</b>	40	40	25	10	10	1	
Number of fittings:	2	1					120
						Fittings Total	1440
<b>Flexible Hose</b>							
			Calculated Value	Type of Hose			
Includes Hose and Hose Coupling Crimps [End Connections included in Component Connection]	Length [mm]	Diameter [mm]	Surface Area Do Not Enter Data	All Rubber Hose	Standard Barrier or Veneer Hose*	Ultra-low Perm Barrier or Veneer Hose*	Do Not Enter Data
High pressure line 1	650	10	20420		1		231
High pressure line 2			0				0
High pressure line 3			0				0
High pressure line 4			0				0
Low pressure line 1	650	16	32673	1			1470
Low pressure line 2			0				0
Low pressure line 3			0				0
Low pressure line 4			0				0
TOTAL	[place a "1" in the appropriate cell]			[place a "1" in the appropriate cell]		Hose Total	1701
<b>Heat Exchangers</b>							
Assumpiton = 0.5						Heat Exchange Total	1
	[heat exchanger value pre-set value 1]				[heat exchanger value pre-set value 1]		
<b>Compressor</b>							
				Type of seal			
	Single Lip+ Body O-rings	Single Lip+Body Gaskets	Multiple Lip and Body O-rings	Multiple Lip + Gaskets			Do Not Enter Data
<b>Total Emissions</b>	2500	2000	1200	700			
Compressor	1					Compressor Total	2500
			[place a "1" in the appropriate cell]				

12 Fittings  
Service Ports  
Switches

Flexible  
Hoses

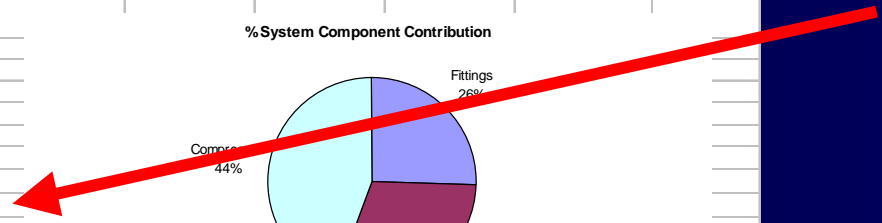
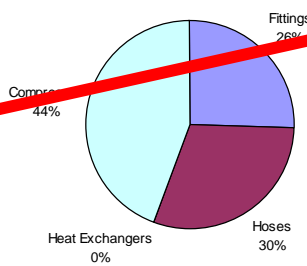
Heat  
Exchangers

Compressor

**Total Rating**

Summary	% Contribution
Fittings	25.5%
Hoses	30.2%
Heat Exchangers	0.0%
Compressor	44.3%
	100.0%
<b>RatingTOTAL</b>	
<b>5642</b>	

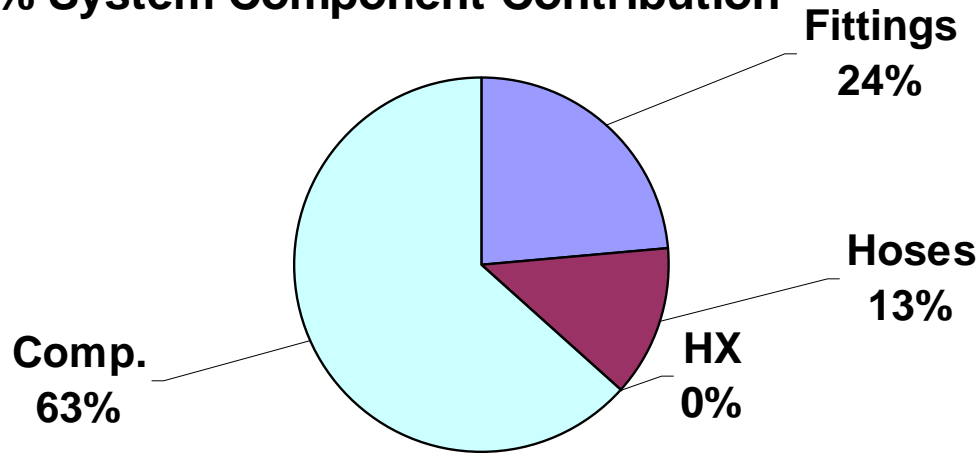
% System Component Contribution





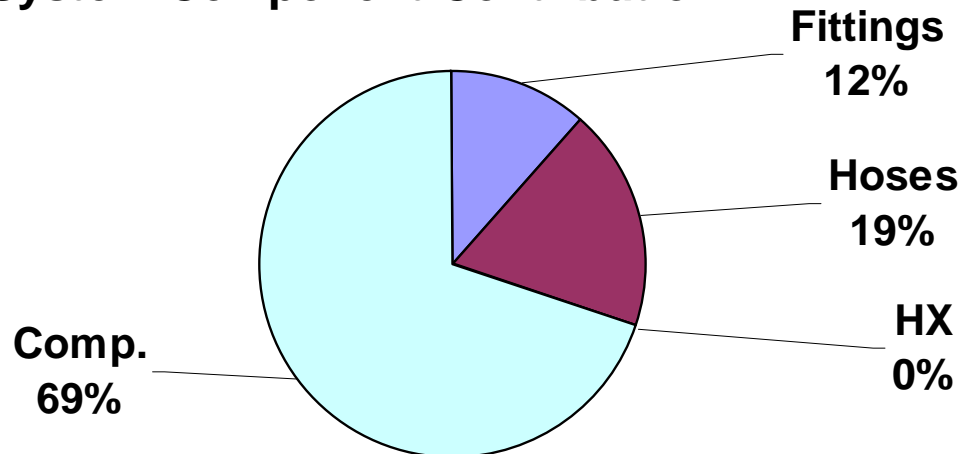
# Assumptions for R134a Leakage Chart Spreadsheet

**% System Component Contribution**



**Reducing  
hose/fitting  
emissions Total  
System Emissions  
are lower resulting  
in changing  
component  
contribution**

**% System Component Contribution**



# **Benefits Of Reducing HFC-134a Leakage**

- **Lower Direct GHG Emissions**
- **More Reliable Systems**
- **Less Maintenance and Cost**
- **Demonstrates HFC-134a Competitive In Climate Protection**

# **Goals For New Refrigerant System Leakage Standard**

**Improving Consumer Satisfaction**

# System Design Goals

- **Current R134a Systems Provide 4-7 Years Of Operation Before Requiring Refrigerant Recharging**
- **New Refrigerant Systems Must Provide Improved Operational Period**
- **VDA Working Group At Phoenix 2003 Meeting Stated Goal For R744 Systems**
  - **“This means at least 5 years maintenance free operation in Phoenix.”**

# **Use And Handling New Refrigerants**

**HFC152a**

**R744 Carbon Dioxide**



# Use And Handling New Refrigerants



## Think Safety

1. Assess the risk.
2. Analyze how to reduce risk.
3. Act to ensure safe operations.

# Handling of Refrigerants

- **Considerations in developing new SAE J-standards**
  - **EPA Activities**
    - Caley Johnson principal contact and investigator [Contact: johnson.caley@epa.gov](mailto:johnson.caley@epa.gov) 1.202.343.9234
      - packaging, distribution, and storage of HFC-152a and CO<sub>2</sub> refrigerants
    - HFC-152a
      - Containers and transportation
    - R744
      - Containers and transportation
  - **JAMA Presentation**

# Considerations For Service Equipment and Handling

- HFC-152a Current US Regulations
  - Classifies as dangerous goods under 49 C.F.R 172.700 -172.704 when shipped by air.
  - Environmental Protection Agency has found it is *not* a Volatile Organic Compound (VOC),
  - Has an LEL (lower explosive limit) of 3.9 volume percent in air and it does not give a flame extension or flashback in the standard test used to measure the flammability of aerosol products.
  - Toxicological evaluations have demonstrated that has a very low order of acute and chronic inhalation toxicity. Is not a mutagen, teratogen or carcinogen.
  - Workplace exposure limit (AEL) is 1000 ppm.

# Considerations For Service Equipment and Handling

## R744 Current US Regulations

- Based upon published MSDS
  - **IS HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION**
  - **Carbon Dioxide is covered under specific State regulations in 16 states**
- **HAZARDOUS MATERIAL INFORMATION SYSTEM**
  - **CARBON DIOXIDE GAS**
  - **HEALTH 1 (BLUE) moderate acute or significant chronic exposure hazard**
  - **CARBON DIOXIDE LIQUEFIED**
  - **HEALTH 3 (BLUE) severe acute exposure hazard; one time overexposure can result in permanent injury and may be fatal**

# SAE Documents [J2683]

- **R744 Purity**
  - Established J Spec
- **Need To Establish Requirement For Safe charging of the system**
  - Liquid State or Vapor State
  - Do containers require liquid pick up tubes?
    - Not currently standard
  - Safe Container Size/Amount
  - Concern for Safety when Transferring Between Containers



# Existing CO<sub>2</sub> Tank Fitting

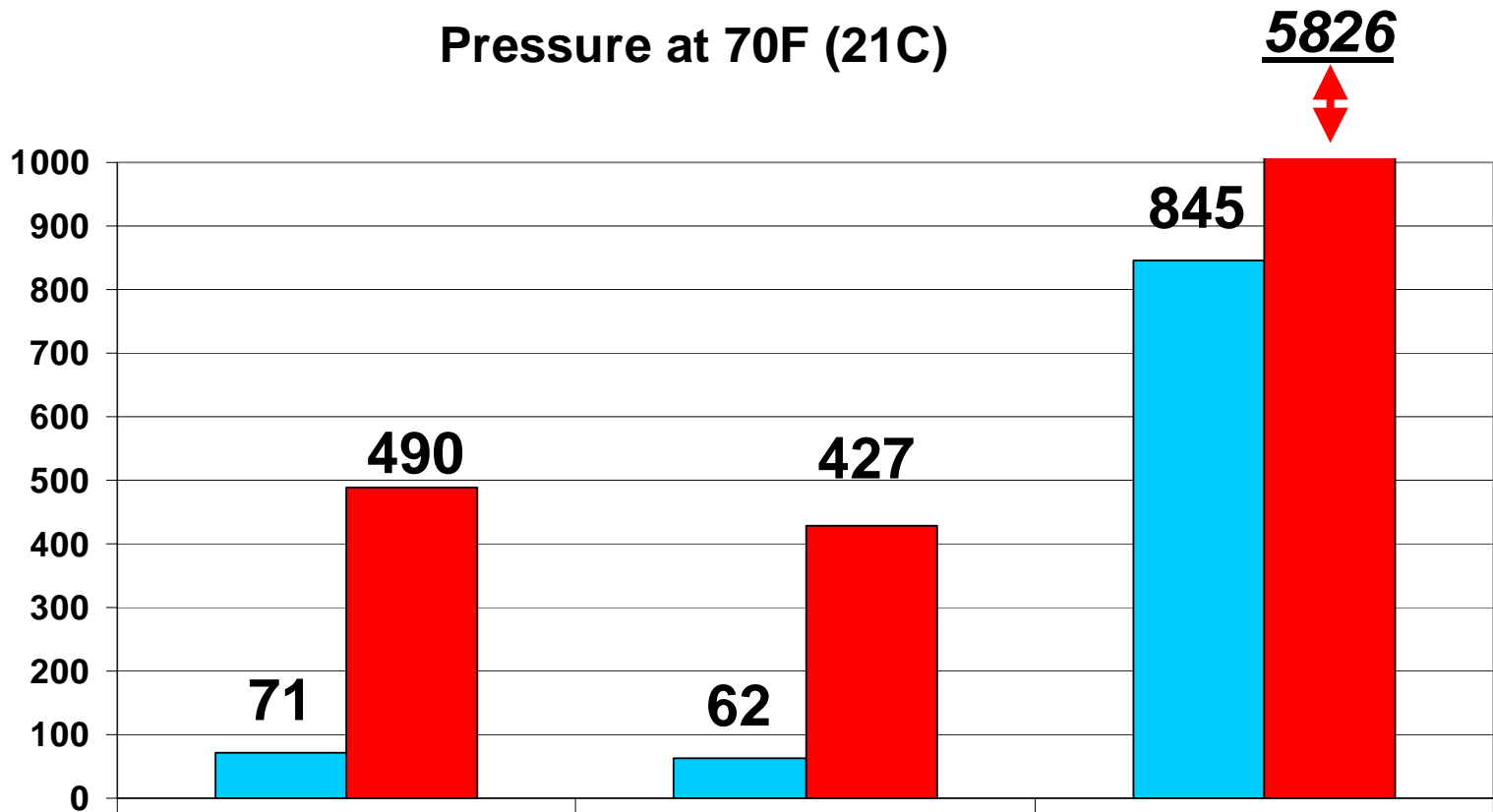
US Market



J2683



# Refrigerant Tank Pressure

Pressure at 70F (21C)



5826



 PSIG	71	62	845
 kPa	490	427	5826

# CO<sub>2</sub> Material Compatibility

Aluminum	A
Brass	A
Monel	A
Copper	A
Carbon Steel	A
316 Stainless Steel	A
Buna-n	C
Butyl	D
Kel-F	A
Neoprene	B
Nylon	D
Polycarbonate	A
Polyethylene	B
PVC	A
Teflon	A
Viton	A

**Materials Currently Used in  
Systems and Service Equipment**

Legend	
A	Good
B	Fair
C	Poor
D	Insufficient Data

# Refrigerant Handling

- **R744 (Carbon dioxide)**
  - Proper Cylinder Movement & Storage



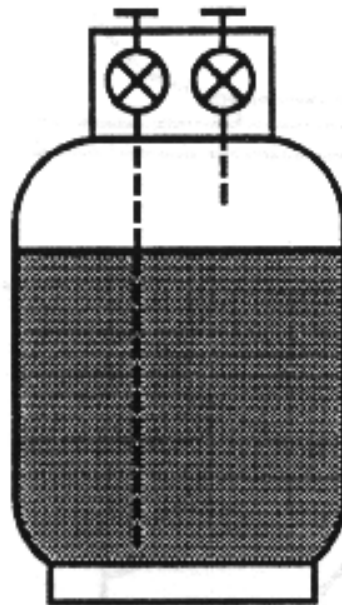
**One Cylinder**

(Defective pressure blow out disc)

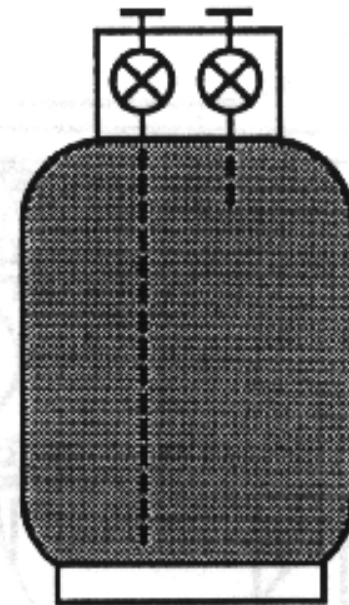


# Equipment Charge Standards R134a R152a

## R134a Requirements



80% Full at  
70°F (21°C)



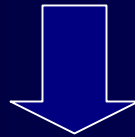
Expands to 100%  
Full at 158°F (70°C)

# Japan Strategy towards Exemption of the High Pressure Gas Safety Law

# High Pressure Japan Gas Safety Law and Refrigerant

## High Pressure Gas Safety Law Article 2

- Compressed gas of 1.0MPa or more at the working temperature
- Liquefied gas of 0.2MPa or more at the working temperature use



Since R134a and R152a gas exceed 0.2MPa at ordinary temp. ,and CO2 gas exceeds 1.0MPa, they are defined as high pressure gases.

# Servicing Infrastructure: Japan

High pressure gas safety:  
Registration required for stockpiling of CO2 gas cylinder, charging and sales etc.

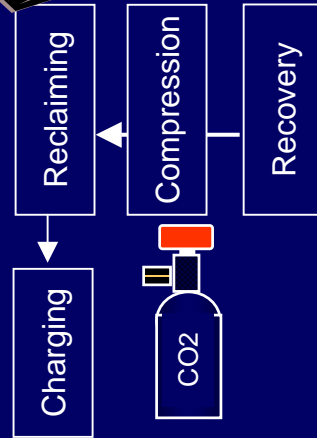
Documents should be sent to self-government office

Recycling of CO2 cylinder

Regular inspection  
(1times/5yrs by KHK)

CO2 Gas Maker (ex. Showa-tansan)

Chemical plant



Distribution of CO2 cylinder

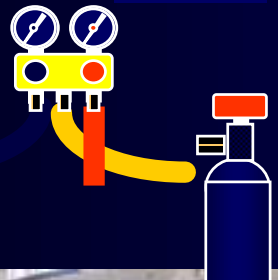
Refrigerant Vessel maker



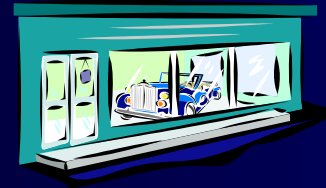
Certification of cylinder by KHK

Dealer

Charging and selling



Stocks of CO2 cylinder



Restrictions of "HIGH PRESSURE

SAFETY LAW"KHK: Certification agent in Japan



# Liquefied gas to be exempted from the High Pressure Gas Safety Law (Japanese Government Ordinance Related Notification Article 4)

Item	Contents
Type of gas	Liquefied gas except for poisonous gas of 0.8MPa or less at 35 °C.
Volume of vessel	Inner volume 1 liter or less
Charge quantity	V/C or less V: inner volume (liter) C: 1.27 in the case of R152a
Vessel material	Steel or light metals
Strength of vessel	1.The vessel shall not be deformed by 1.5 times the pressure at 50 °C nor burst at 1.8 times such pressure. 2. No gas shall leak at 48 °C.
Vessel construction, etc.	1.Those vessels which may have a projecting valve shall be provided with a means of protecting the valve. 2.The name of the gas shall be indicated on the outside surface of the vessel.

As in the case of R134a, R152a in a service can may be exempt from the High Pressure Gas Safety Law.

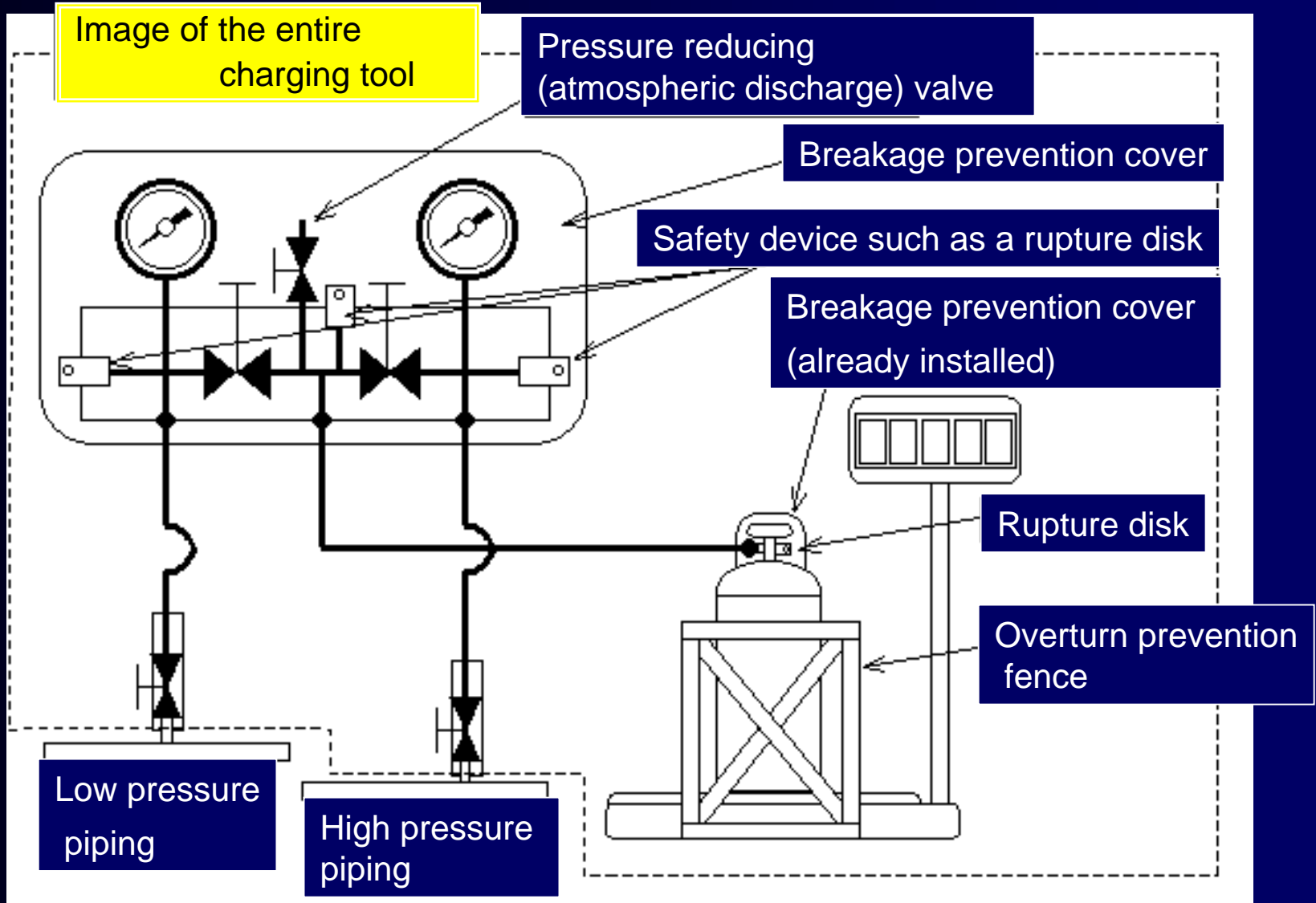
# Japan CO2 refrigerant vessel safety requirements

On the basis of a fluorocarbon can and CO2 vessel (Vessel Safety Regulations), study the safety requirements of CO2 refrigerant vessels taking into consideration “it is the same inert gas but the pressure is high.”

Item	Safety requirements
Material	1. The material shall be of steel or light metal. The carbon content of the carbon steel shall be 0.35% or less, and 0.40% or less in the manganese steel
Pressure proof strength	2. CO2 refrigerant vessel shall not be deformed when 26.7MPa or more pressure is applied, nor burst when <b>32MPa</b> or more pressure is applied.
Inner volume	<b>3. <u>Shall be 1 liter or less.</u></b>
Charge	<p>4. The gas charge shall be the G value or less obtained by the below equation.</p> <p style="margin-left: 40px;"><math>G = V/1.5</math>     G: the numerical value of gas mass (unit kilogram)</p> <p style="margin-left: 80px;">V: the numerical value of the inner volume of vessel (unit liter)</p> <p>5. For the charged vessel, do not use one which has been charged with gas other than CO2.</p> <p>6. Those vessels which may have aged 5 years after being subjected to a vessel inspection or re-inspection or may have been damaged, shall be the ones which have been subjected to a vessel re-inspection, passed and provided with a stamped notice.</p>

Item	Safety requirements
<b>Stamping</b>	<p>10. The accessory of the CO2 refrigerant vessel shall be provided with a clearly and indelibly stamped notice, at an easy-to-see location on the thick-wall area, with the following items in order.</p> <ul style="list-style-type: none"> <li>a. The date when the accessory passed the accessory inspection</li> <li>b. The code of the name of the person who conducted the inspection</li> <li>c. Name or code of the accessory maker</li> <li>d. Symbol and No. of the accessory</li> <li>e. Mass of the accessory (Symbol: W, Unit: kilogram)</li> <li>f. Pressure in the pressure proof test (Symbol: TP, Unit: MPa)</li> <li>g. Type of vessel on which the accessory is mounted (Liquefied gas: Symbol: LG)</li> </ul>
<b>Indication</b>	<p>11. CO2 refrigerant vessel shall have the following items indicated at an easy-to-see location.</p> <ul style="list-style-type: none"> <li>a. One half or more of the surface area of the vessel shall be coated green.</li> <li>b. Type of gas which can be charged</li> </ul>

# CO2 Charging Tool



# New Refrigerants

- **Many Unanswered Questions**
  - For Vehicle Manufacturing
  - For Vehicle Service Sector
- **New Service Equipment required**
- **Extensive New Technician Training and Certification Programs required**
- **Requires New SAE J Documents**