

# REFRIGERANT EMISSIONS

## ALONG THE MAC SYSTEM LIFETIME

### Session 1

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# EU MAC R-134a actual technology

## Emission optimistic scenario

Nominal refrigerant charge		750g
		Total emissions (g R-134a)
Emissions at manufacture	Capacity heels	7,5
	Filling of the system	2
Emissions during life time	Regular emissions	690
	Accidents	170
End of life	Emissions during servicing	198
	Emissions at End Of Life	67,5
		1 135g

## **Leak rates data collection**

- **The main issue: DATA QUALITY**
- **Component by component approach :  
Leak tightness measurement**
- **Fleets monitoring : garage survey and  
weighing residual charge in  
representative panels of vehicles**

# Emissions along the refrigerant distribution

## Heels in a refrigerant container



# Summary of emissions of refrigerant capacity handling and MAC manufacturing process

- Capacity heels (CH)
  - $7.5 < CH < 45\text{g/lifetime}$
- Emissions when filling the MAC system
  - $0 < \text{Emissions} < 2\text{g/lifetime}$

# Emissions during the AC system manufacturing process

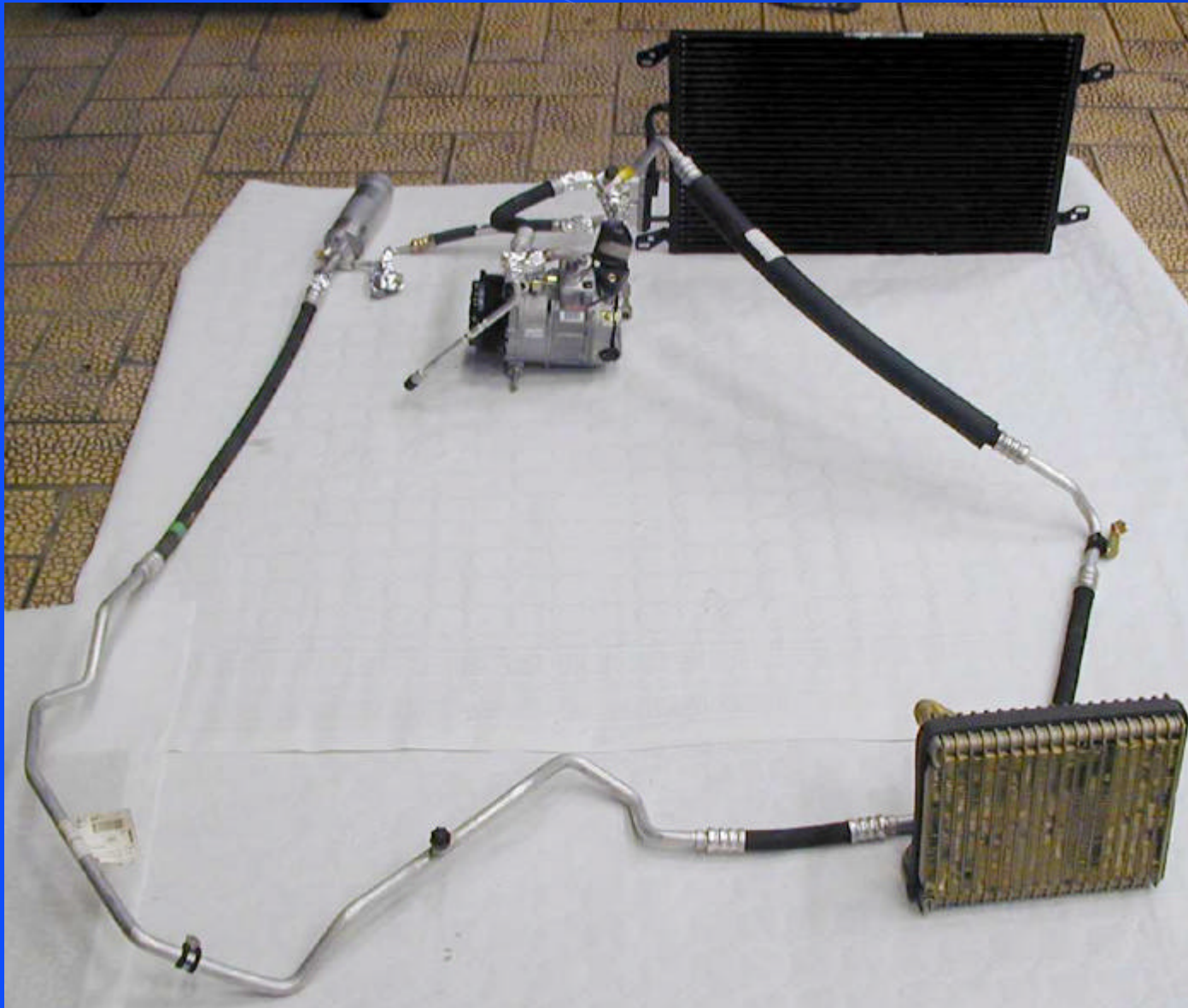
- Refrigerant charge
  - connection and disconnection of the AC system and the charge machine  
 $0 < \text{emission} < 2 \text{ g /yr}$

# Emissions during the AC system manufacturing process

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## Where emissions are coming from ?

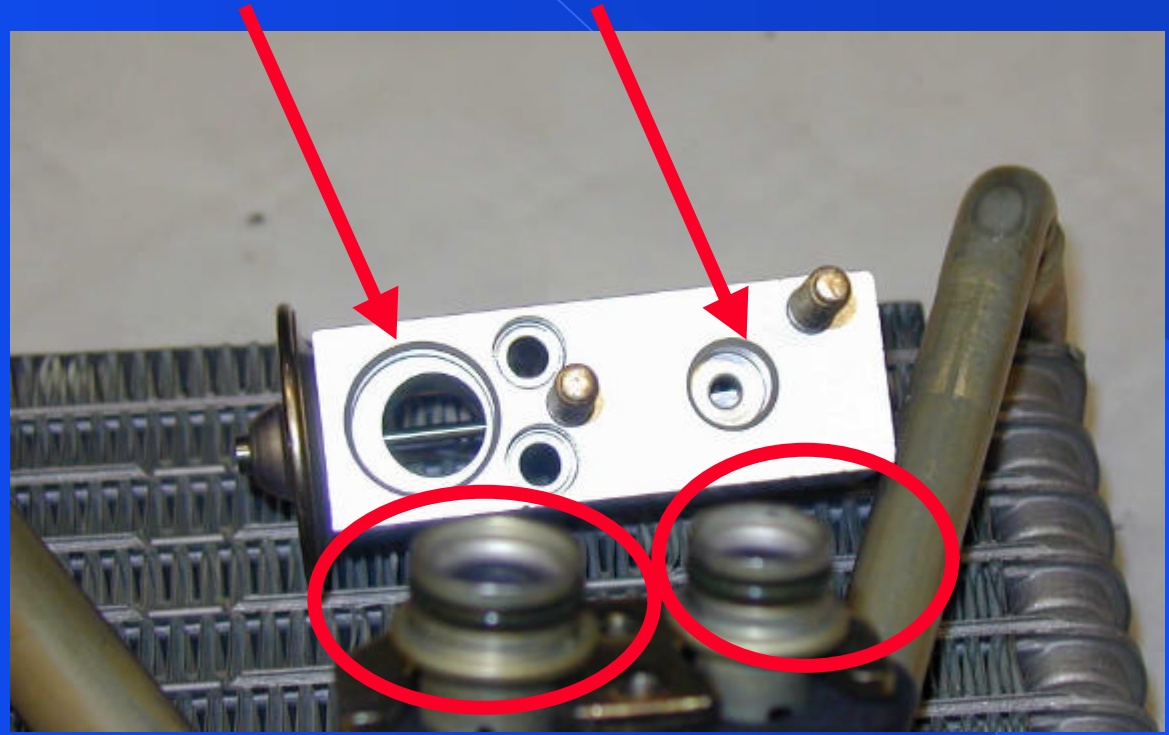




## Evaporator connections

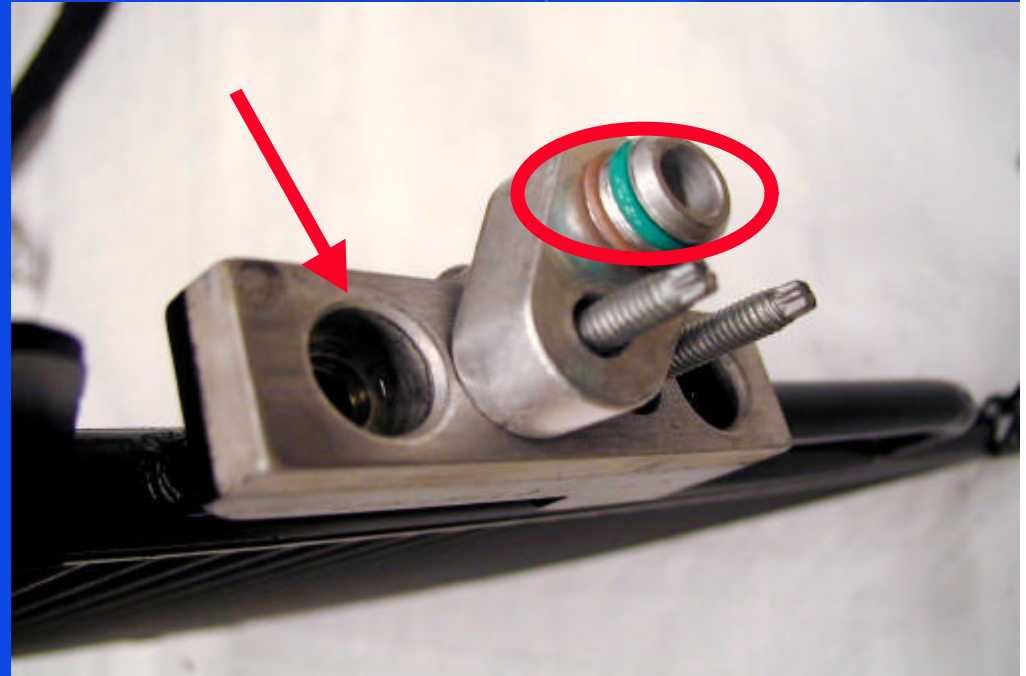
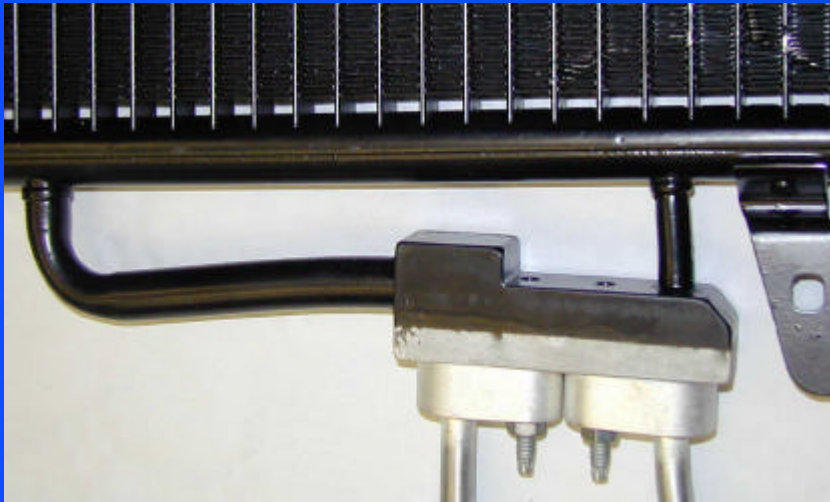
Evaporator connections (2):  $0.5 < LR < 3\text{g/yr}$

TXV connections (2 ):  $0.5 < LR < 3\text{g/yr}$

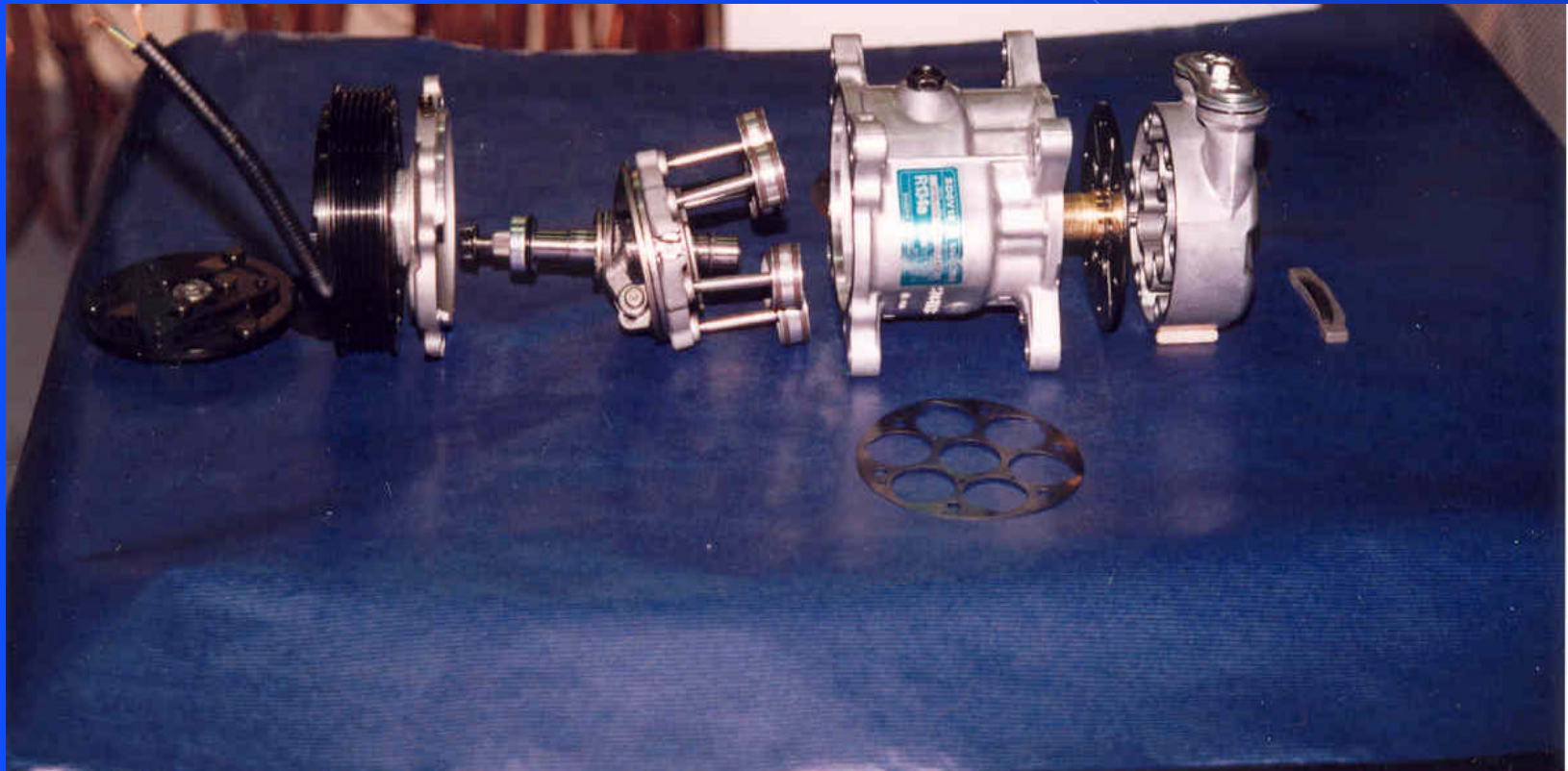


# Condenser connections

Condenser connections (2):  $0.5 < LR < 3\text{g/yr}$



# Compressor spare parts

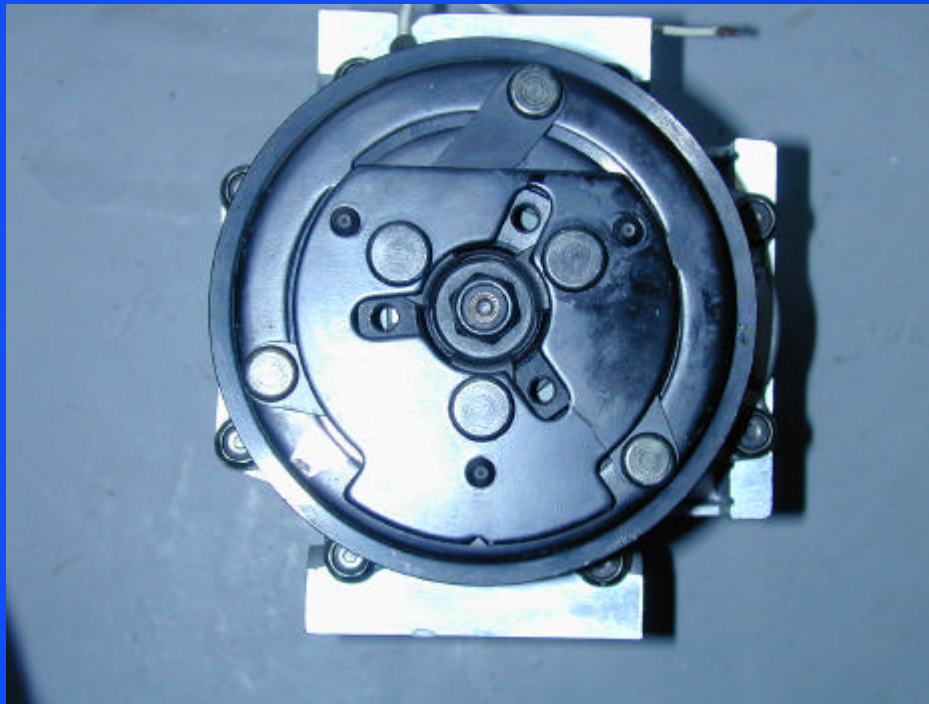




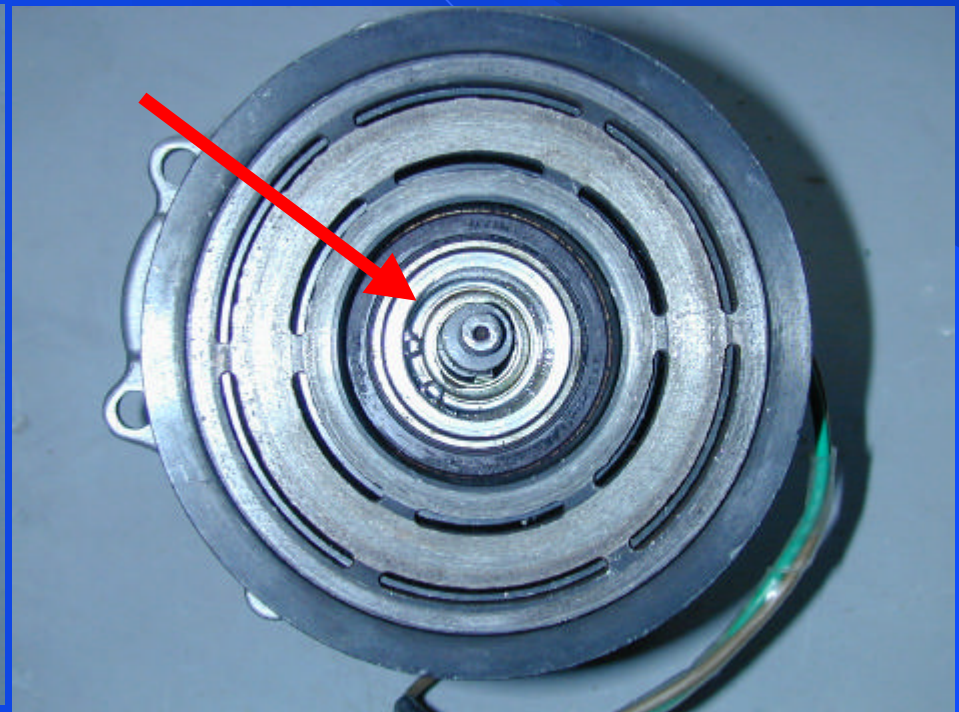
## Compressor shaft seal

Compressor shaft seal (1):  $10 < \text{LR} < 20 \text{ g/yr}$

Face view



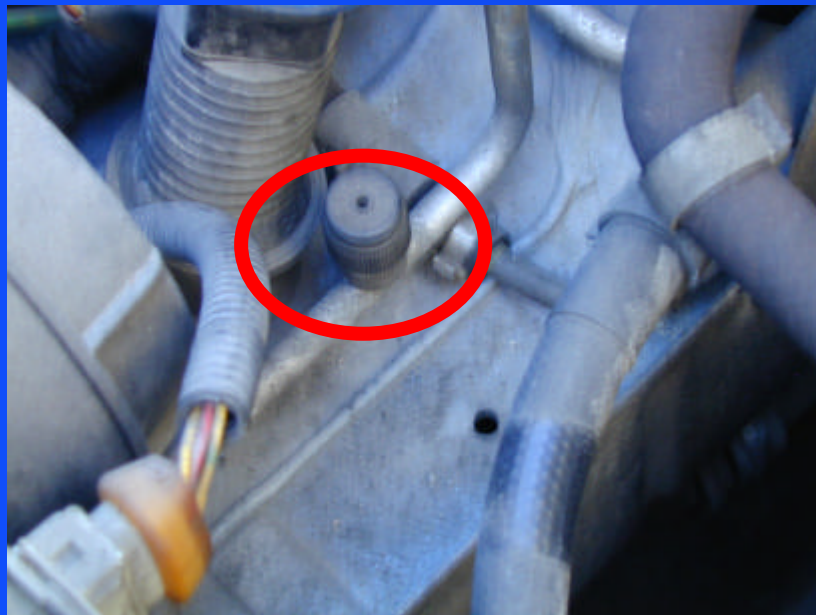
Shaft seal



# The service valves

- The Schrader valves and their caps

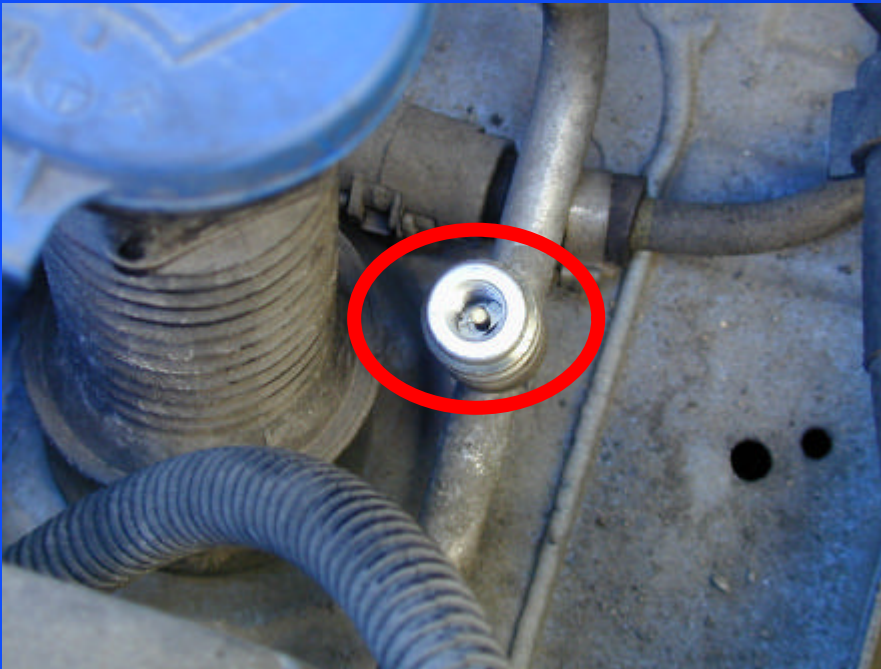
Schraders with caps



## The service valves

- The Schrader valves (and their caps)

Schraders without their caps





## Summary of emissions from service valves

- For Brand new cars (if well fitted):  $LR < 1\text{g/yr}$
- After 1<sup>st</sup> opening, with cap and O-ring:  $LR < 1\text{g/yr}$
- After 1<sup>st</sup> opening (**without cap**):  $3 < LR < 15\text{g/yr}$
- After multiple openings (**without cap**):  $5 < LR < 25\text{g/yr}$



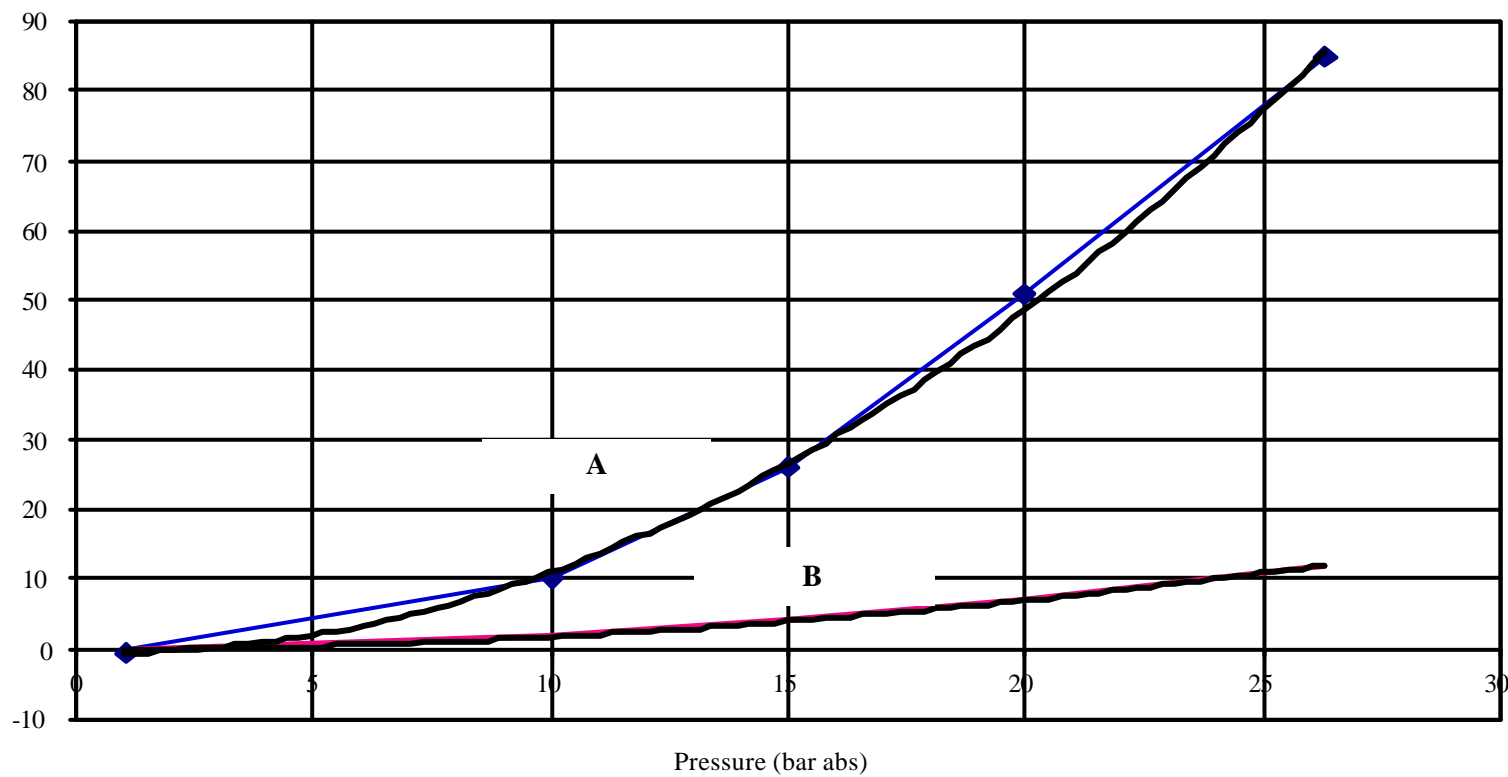
# Emissions from hoses

Rubber and elastomer parts of the hose



## Two permeation rates of rubber hoses

The permeation rate:  $P_r$  in g/yr depending on the pressure.



# Summary of controlled emissions

Technology	m(g/yr)			Total
	Hoses	Fittings	Crimps	g/yr
Usual technology	12.8	4.25	1.3	18.35
Best available technology	1.15	0.9	0.3	2.35

## Summary of total emissions

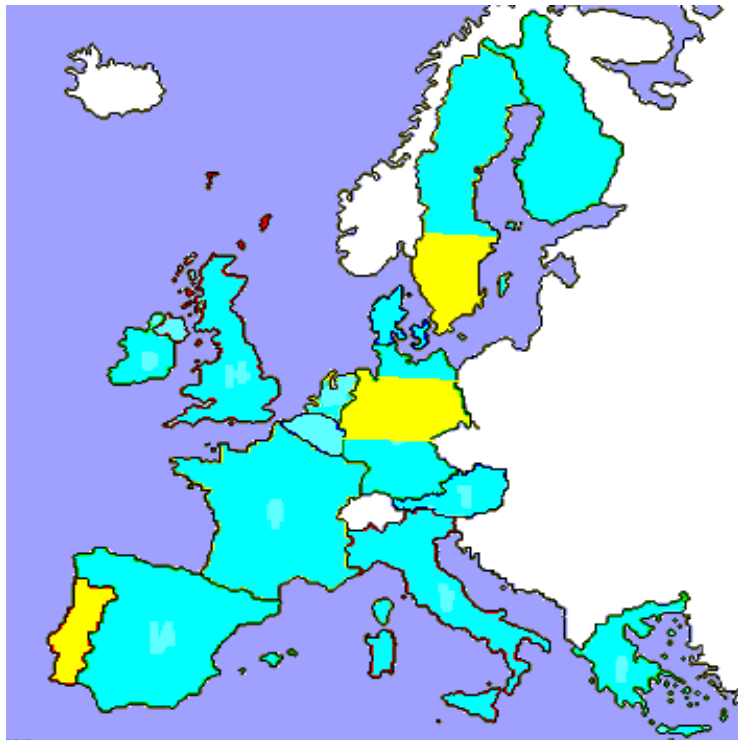
<b>Estimates (g/yr)</b>	<b>Hoses and fittings</b>	<b>Compressor shaft seal</b>	<b>Service valves</b>	<b>Total</b>
<b>High estimate</b>	<b>18.3</b>	<b>20</b>	<b>2</b>	<b>40.3</b>
<b>Low estimate</b>	<b>2.3</b>	<b>10</b>	<b>0.5</b>	<b>12.8</b>

# **Emissions during the lifetime A European Survey**

- **Method of measurement**
- **3 fleets in Sweden, Germany, Portugal**
- **The main results : average emissions (g/year), trends for annual leak rates depending on countries.**

# The EC/Novem440 study

Empirical basis for regular emissions from EU car fleet



Carried out by Öko-Recherche and ECOFYS

440 measurements at 10 used car dealerships

S - Helsingborg 100

D - Osnabrück 240

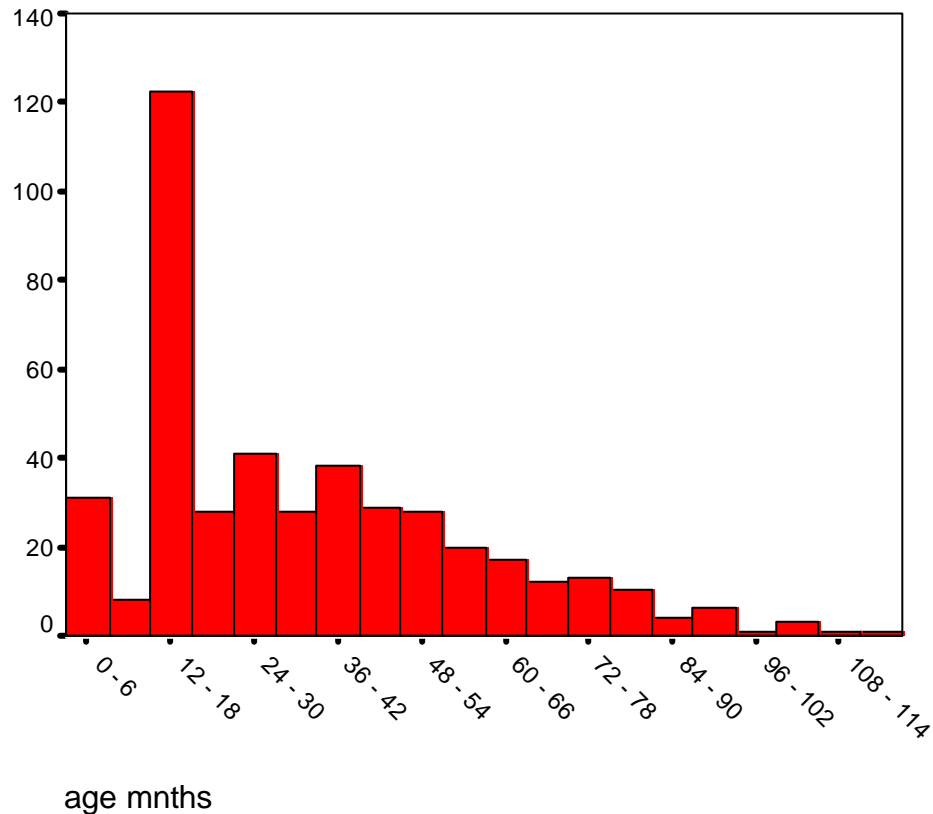
P - Rio Maior 100

Time of tests:

Oct 2002 – Jan 2003

Dedicated protocol and equipment applied by one technician

# Selection of EC/Novem440\* data



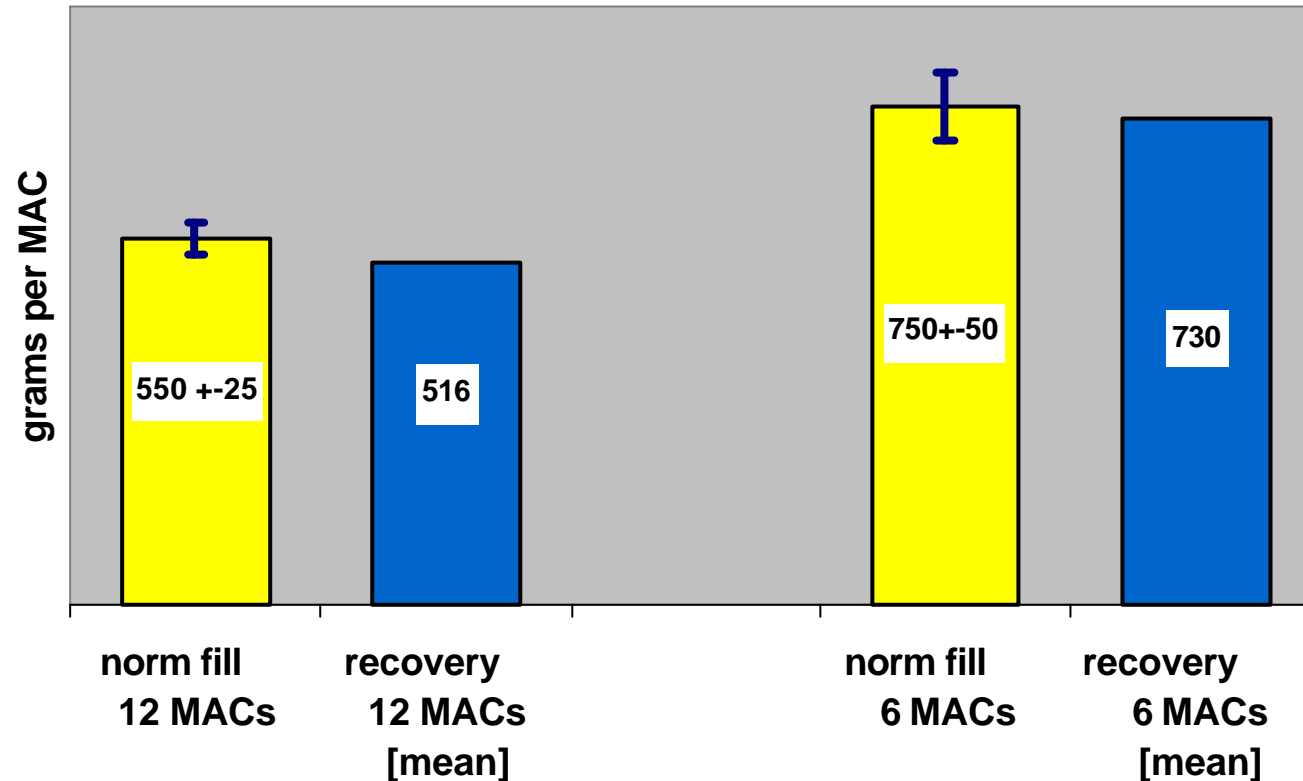
Age distribution of original  
data set EC/Novem440

- refrigerant loss more than 0% and less than 70%
- age greater equal 12 months and less than 72 months
- of 442 vehicles 354 vehicles remain
- under-weighting of young vehicles



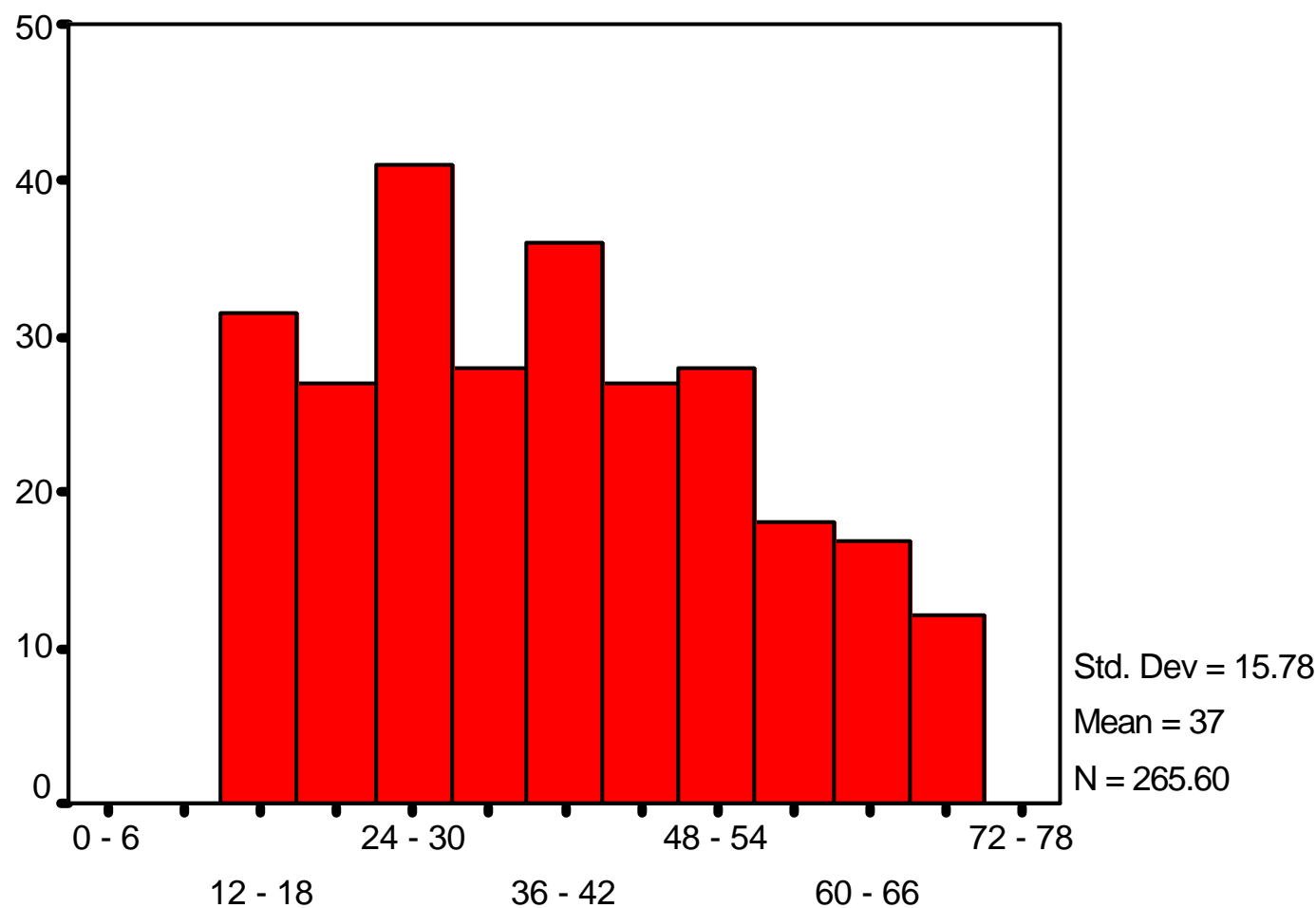
# Does method achieve full recovery?

Nameplate Fill and Recovery from 18 New Cars  
[two different models, mileage 0 km, each]



**Question: First fill inaccurate or the recovery?**

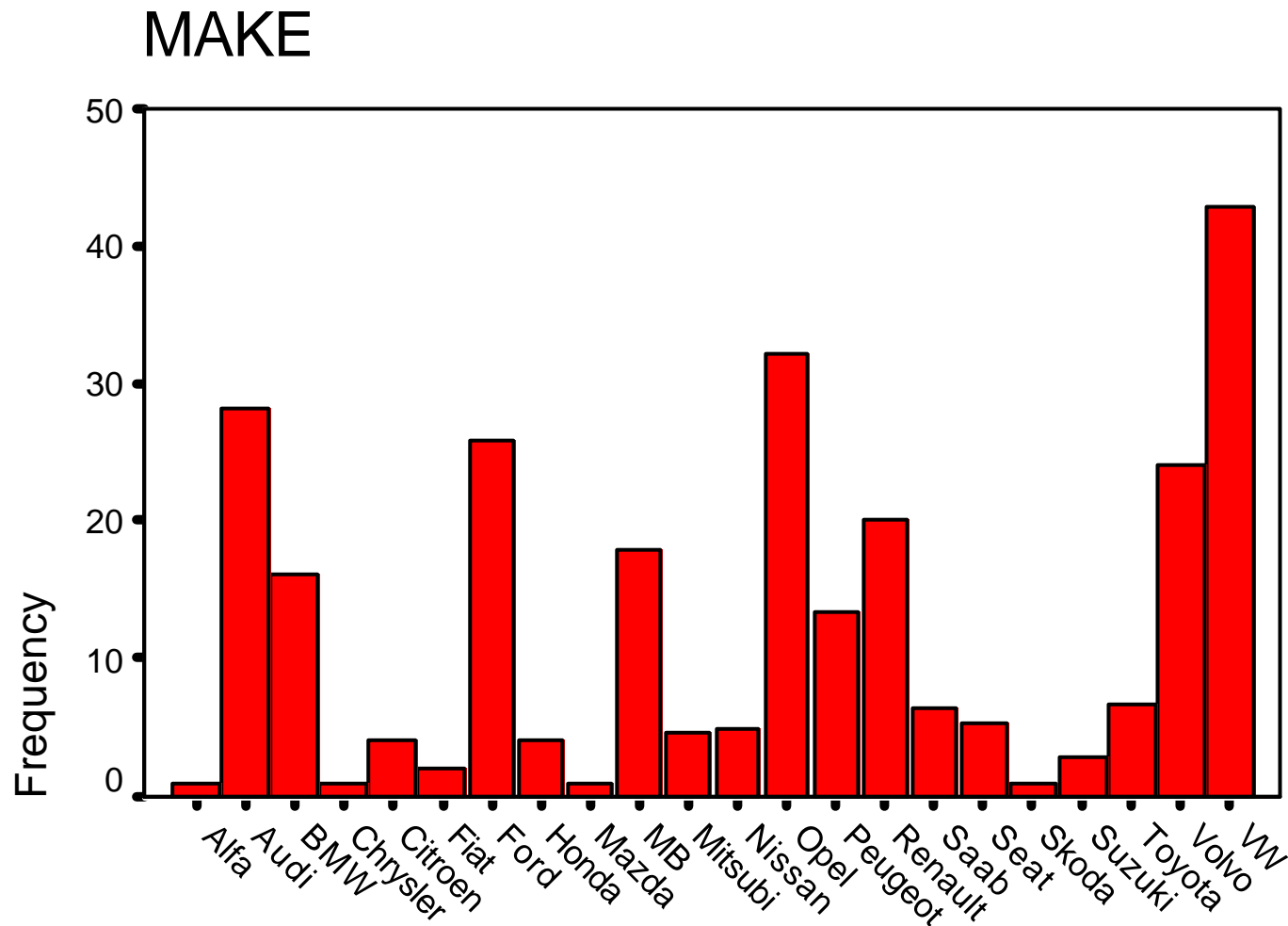
# EC/Novem440\*: age distribution



age mnths

Cases weighted by AGEWEIG2

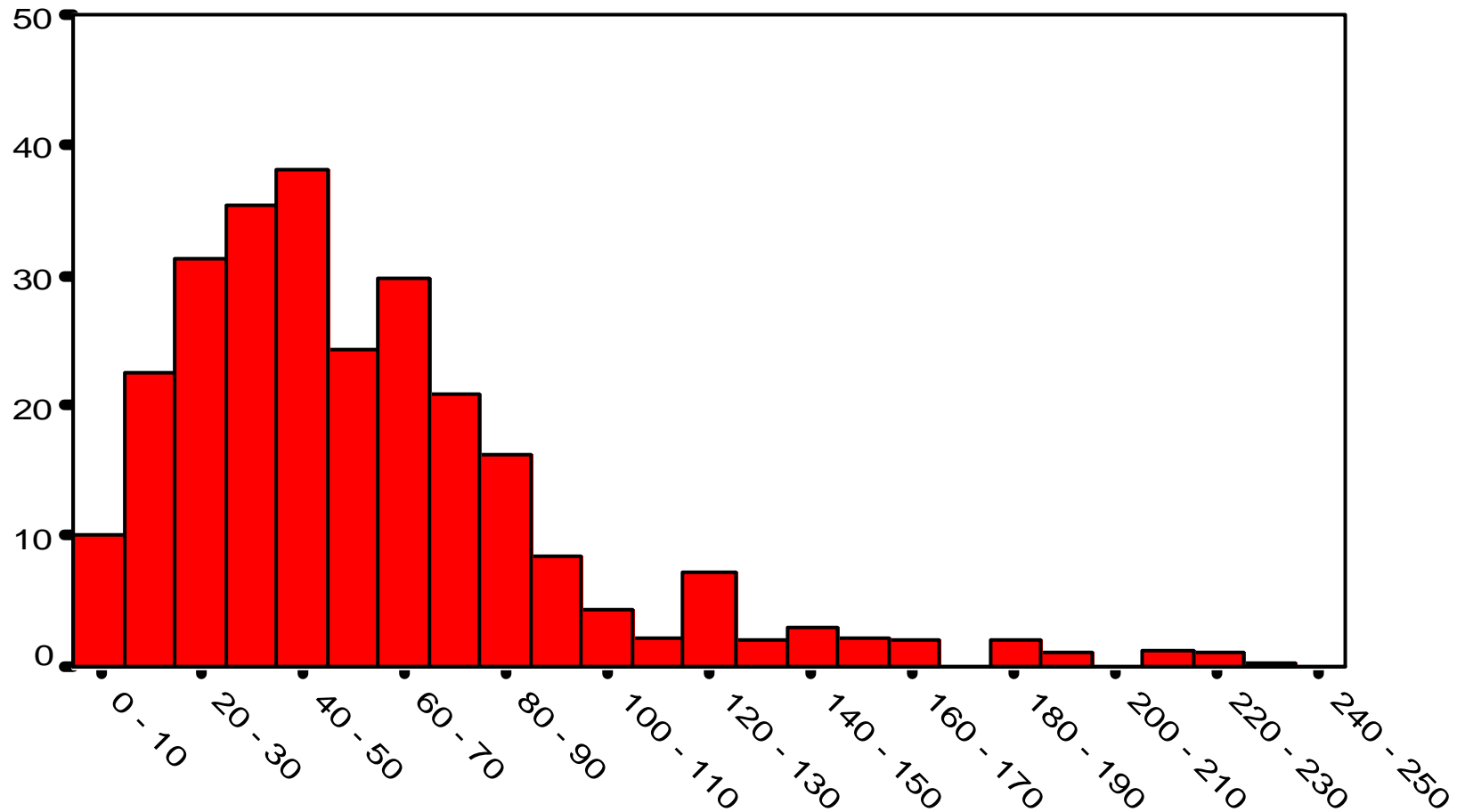
# EC/Novem440\*: manufactures



MAKE

Cases w eighted by AGEWEIG2

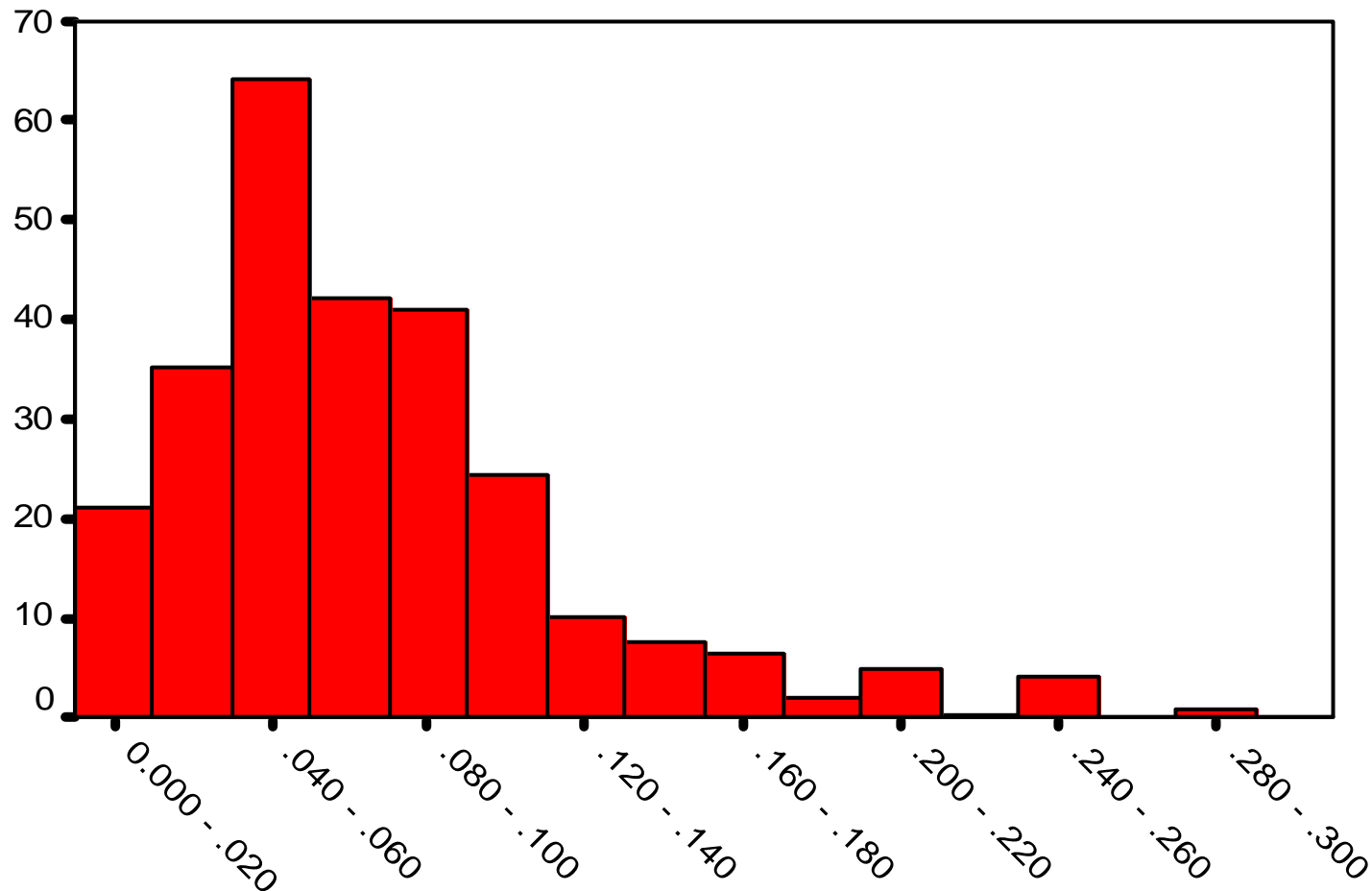
# EU regular leakage rate: 57 g/yr



lss gpyr

Cases w eigh ted by AGEWEIG2

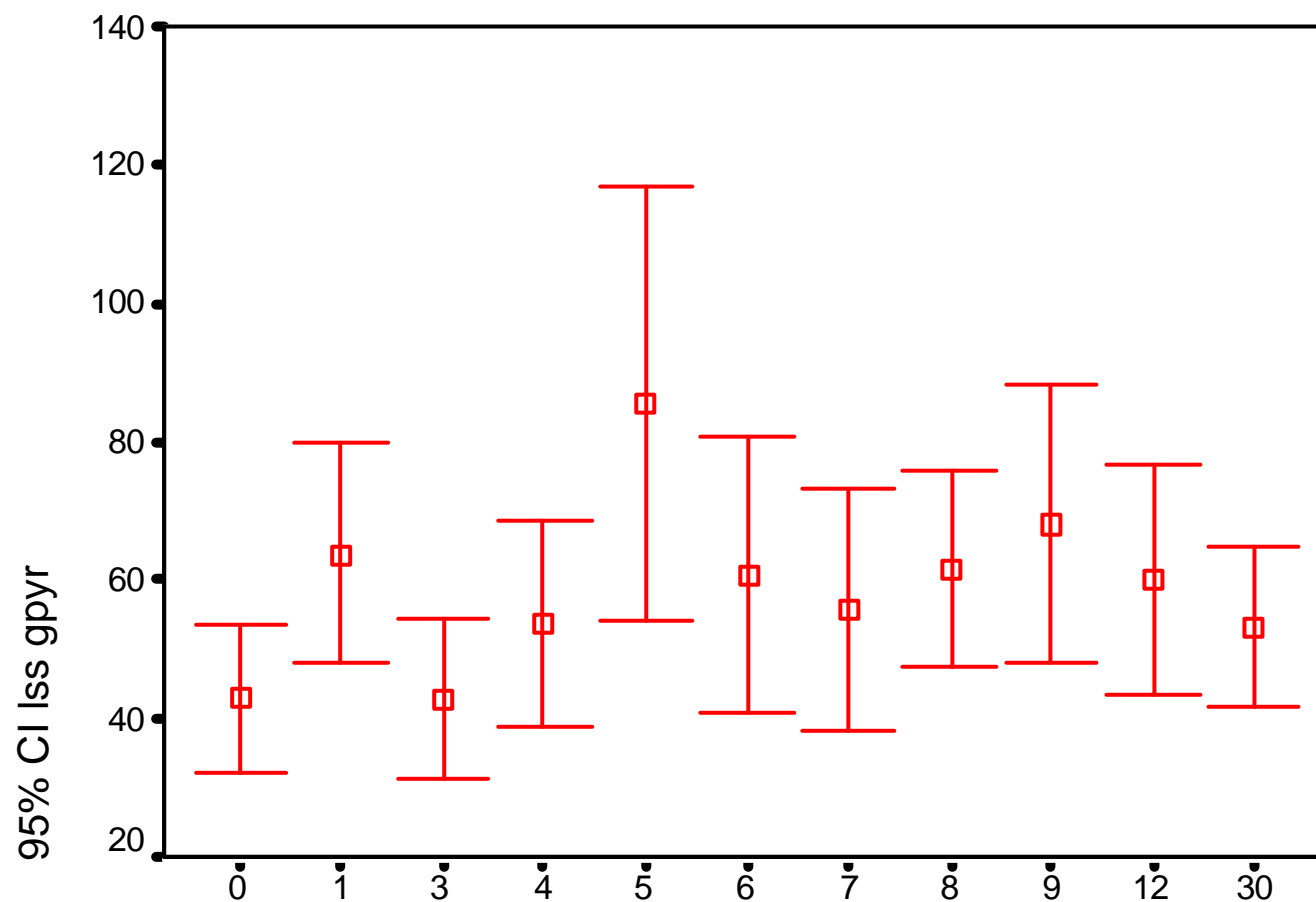
# EU regular leakage rate: 7.7 %/yr



lss pcpyr

Cases w eighed by AGEWEIG2

# Mean regular loss rate per make



CODE

Cases weighted by AGEWEIG2

grams per  
year and  
95%  
confidence  
intervals

# Results of EC/Novem Study

- Reliable method established to determine "regular" losses from MACs
- Broad distribution of leakage rates within EU car population
- Vehicles measured exhibit a mean "regular" loss for vehicles of 57 grams (7.7%) per year for vehicles between 1 and 6 years old
- Impact from climate not found to be significant
- Pronounced differences between makes exist



## Summary of the Ecofys/Öko Recherche survey

<b>Average original refrigerant charge</b>	<b>Average regular losses (7.7%)</b>	<b>Average irregular losses (1.9%)</b>	<b>Total average losses (9.6%)</b>
<b>750g</b>	<b>57,75g/yr</b>	<b>14,25g/yr</b>	<b>72g/yr</b>

# Emissions during the lifetime

## Servicing and repair

- Why servicing ? Insufficient refrigerating capacity
- Method of diagnosis
- The “Gas and Go method”
- Leak control, leak fixing
- Recovery and recharge (recovery efficiency, connections, refrigerant trapping)

# Emissions during servicing

The 2 connecting valves for R-134a



# Emissions during servicing

Connections installed on the 2 service valves



# Emissions during servicing

## Recovery machine





# Emissions during servicing

## Service hoses with and without valves



## Emission estimates during servicing and repair

- The lower the number of servicing the better
- Average emission rate (ER) **for each servicing** in good servicing garage  
 $20 < ER < 50\text{g}$  per serviced car
- Average emission rate (ER) **for each servicing** in not so good servicing garage  
 $100 < ER < 200\text{g}$  per serviced car

Note: higher thresholds correspond to repair.



## Emission estimates at End Of Life

- The EOLV directive: refrigerant recovery is mandatory.
- Minimum efficiency recovery rate (ERR)  
 $80 < ERR < 95\%$
- Bet estimate from NOVEM at scrap:
  - 46% AC systems are empty, and
  - 63% average charge in the still charged AC systems.

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## EU MAC R-134a emission prevision

### Optimistic and realistic global scenarios

	<b>Optimistic scenario (g of R-134a)</b>	<b>Realistic scenario (g of R-134a)</b>
<b>Capacity heels</b>	<b>8</b>	<b>15</b>
<b>Filling of the system</b>	<b>2</b>	<b>2</b>
<b>Regular emissions</b>	<b>690 (7.7%)</b>	<b>690 (7.7%)</b>
<b>Accidents, rupture, corrosion,...</b>	<b>170 (1.9%)</b>	<b>340 (3.8%)</b>
<b>Emissions during servicing</b>	<b>198</b>	<b>409</b>
<b>Emissions at End Of Life</b>	<b>68</b>	<b>41</b>
<b>TOTAL (g of R-134a)</b>	<b>1 136</b>	<b>1 497</b>
<b>TOTAL (kg eq. CO2)</b>	<b>1 477</b>	<b>1 946</b>