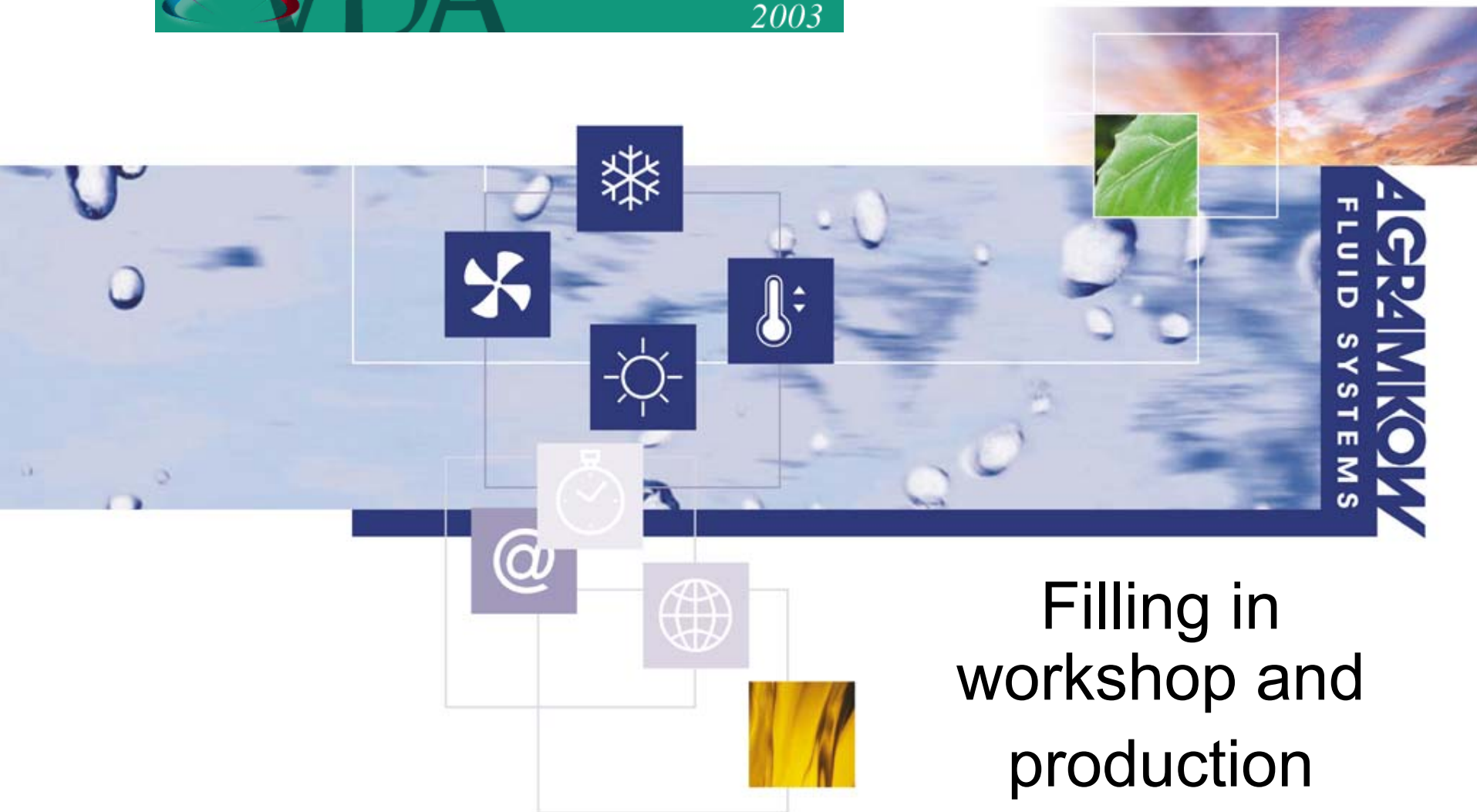
Alternate Refrigerant Wintermeeting
Automotive Air Conditioning and Heat Pump Systems
2003



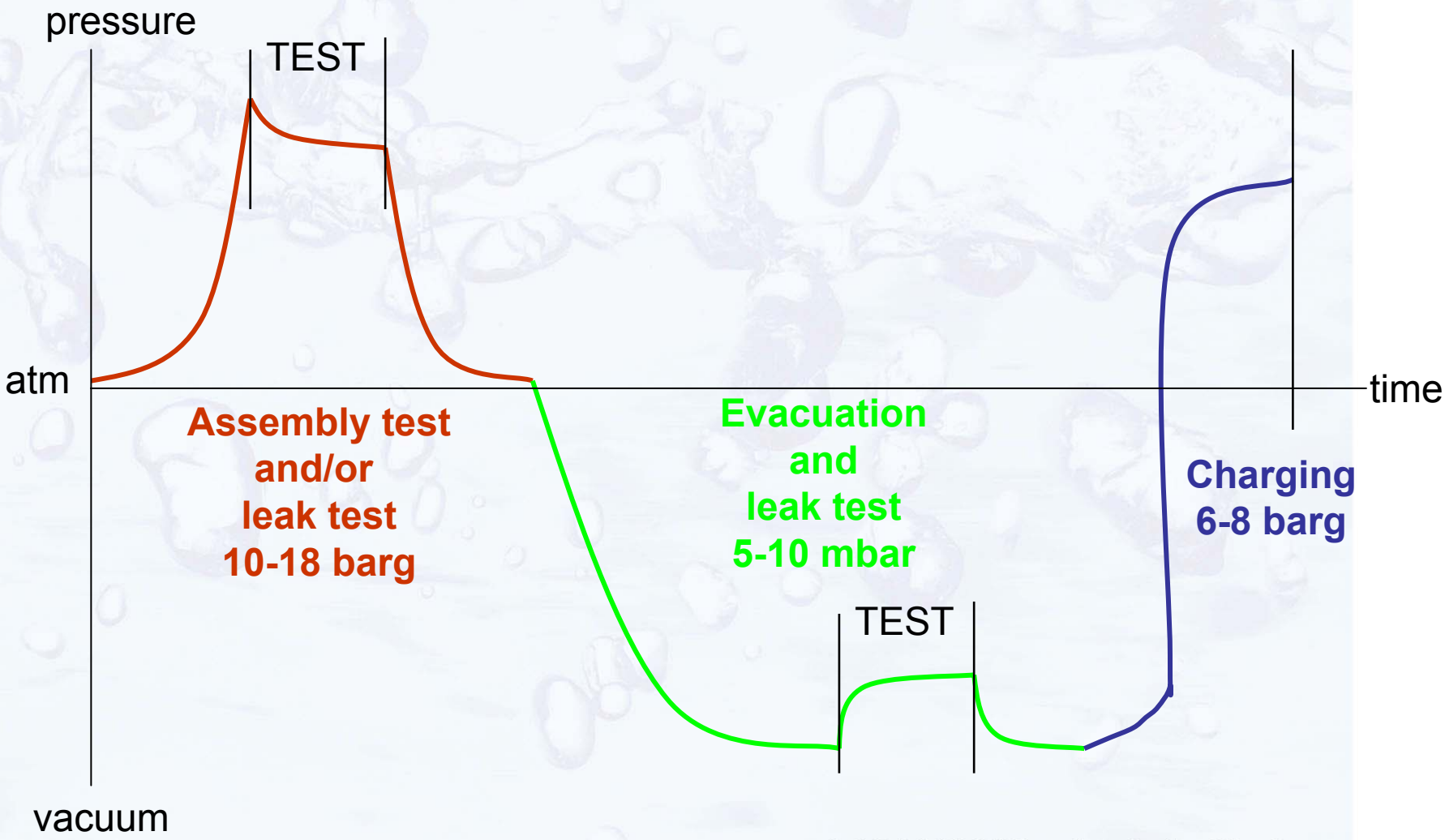
Filling in workshop and production

AGRAMKOW - the Safe Choice...

agenda

- 134a process versus CO2
- CO2 charging
- Leak testing
- CO2 adapters

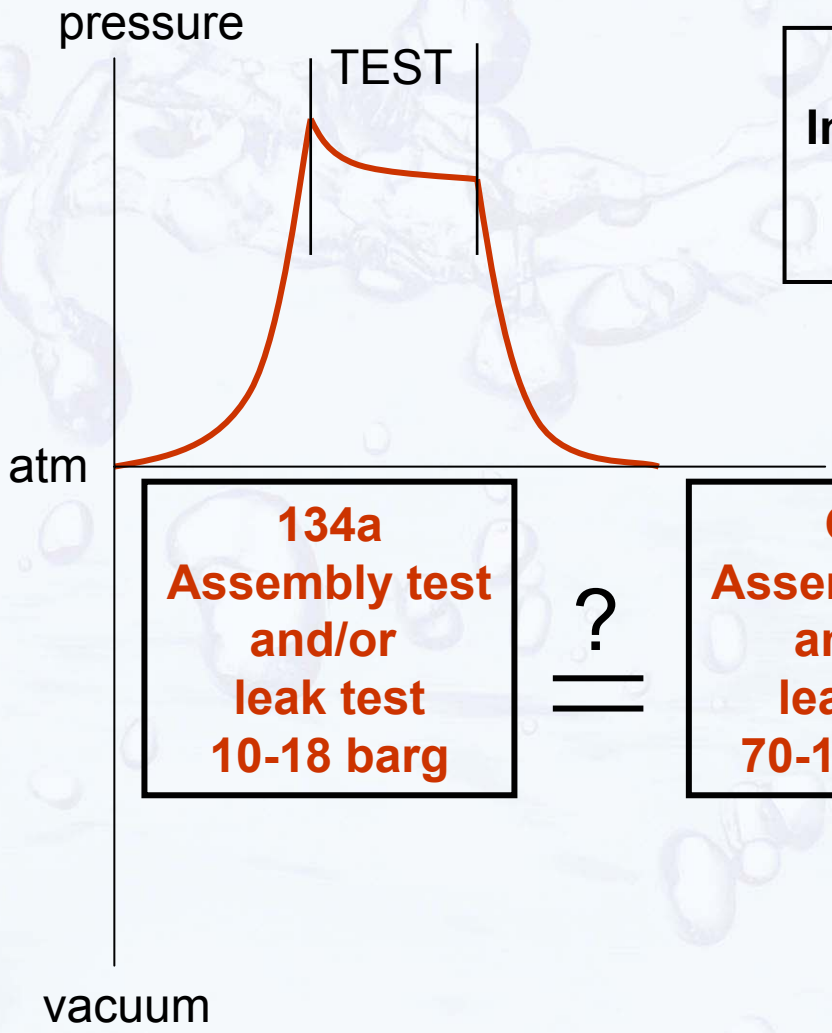
Typical 134a process



AGRAMKOW - the Safe Choice...

Assembly or leak test ?

Typical 134a process versus CO2



Pressure drop method:
In principle only a quick assembly test, checking all circuit components are connected

134a
Assembly test and/or leak test
10-18 barg

?

CO2
Assembly test and/or leak test
70-120 barg

Sniffing:
Assembly test and leak Detection before charging

Assembly or leak test ?

Typical 134a process versus CO2

Calculation figures:
P1=test pressure
P2=pressure drop rate 100Pa/sec = 1mbar/sec
Air-con volume = 1,5 litre
Test medium = Nitrogen
Gas constant = 296,6 J/kg.K

Formula: PxV=mxRxT

Leakage CO2/sec by 15 barg test pressure = approx. 2 mg/sec
(means by a 400gram charge the air-con will be empty in approx 55 hour
Increasing the sensitiveness to 10Pa/sec is equal to approx 23 days)

Leakage CO2/a by 100Pa/sec pressure drop rate test = approx 65 kg/a

Assembly or leak test ?

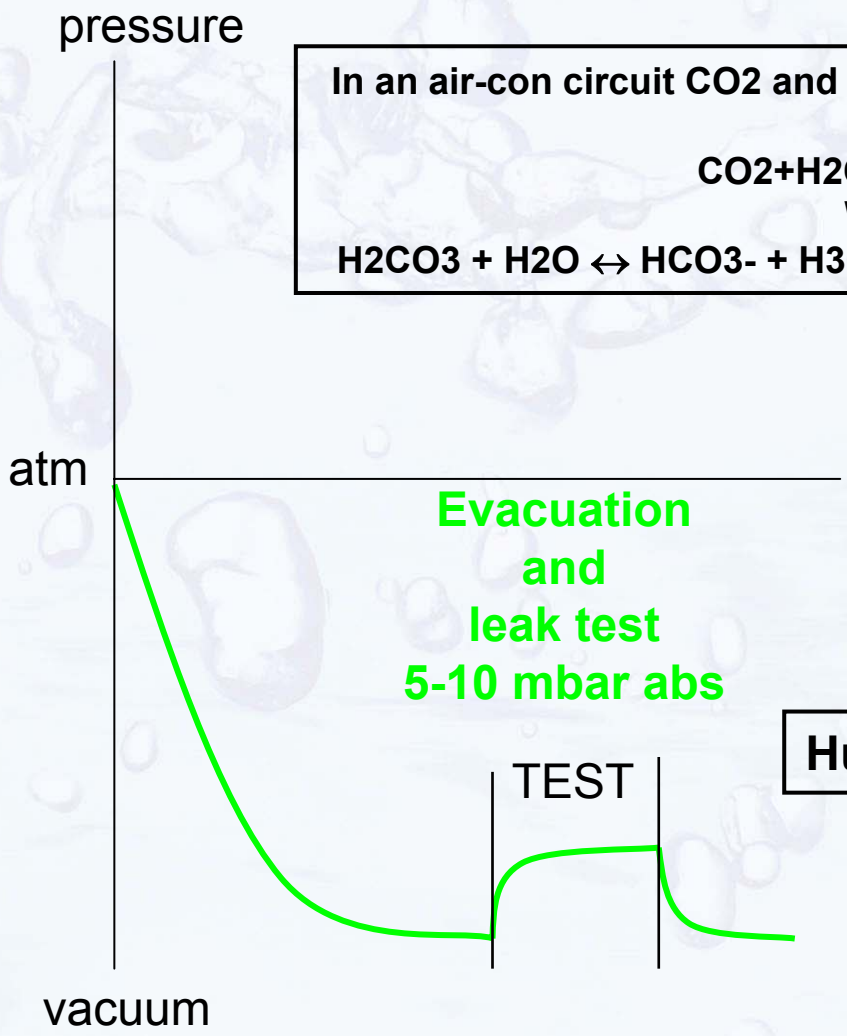
Typical 134a process versus CO2

Tracer gas
Typical
Helium or hydrogen

Leak rate: 1 g/a

Evacuation and leak test ?

Typical 134a process versus CO2



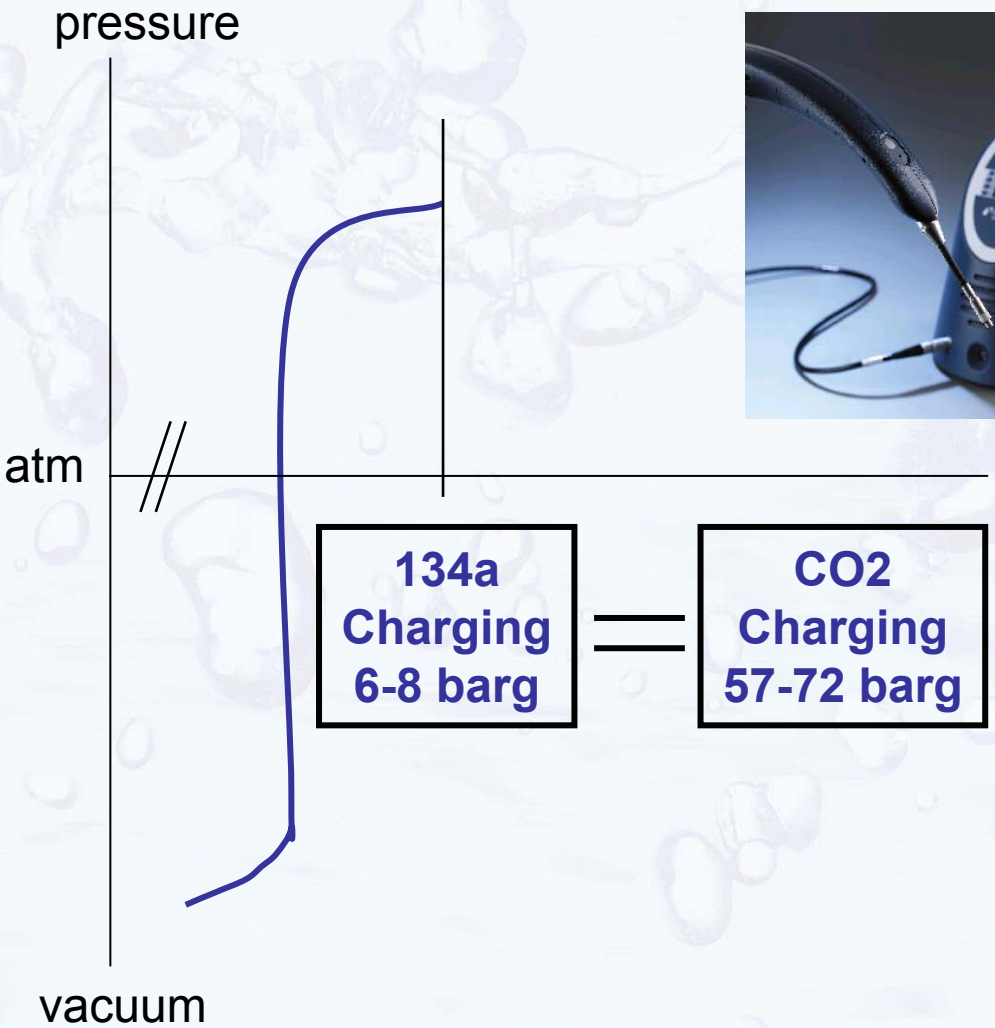
In an air-con circuit CO2 and H2O mainly react with oil and the wear reducing additives in the oil.
$CO_2 + H_2O \leftrightarrow H_2CO_3$ (carbonic acid)
Which might cause
$H_2CO_3 + H_2O \leftrightarrow HCO_3^- + H_3O^+$ (bicarbonat + hydronium ion (activated acid)

Oxygen and mineral oil reacts by:
$2\ CH_3 + 3O_2 \rightarrow 2C_2OH$ (organic acid) + $2\ H_2O$

Humidity evaporate at approx 20mbar abs

Charging (volume production)

Typical 134a process versus CO2



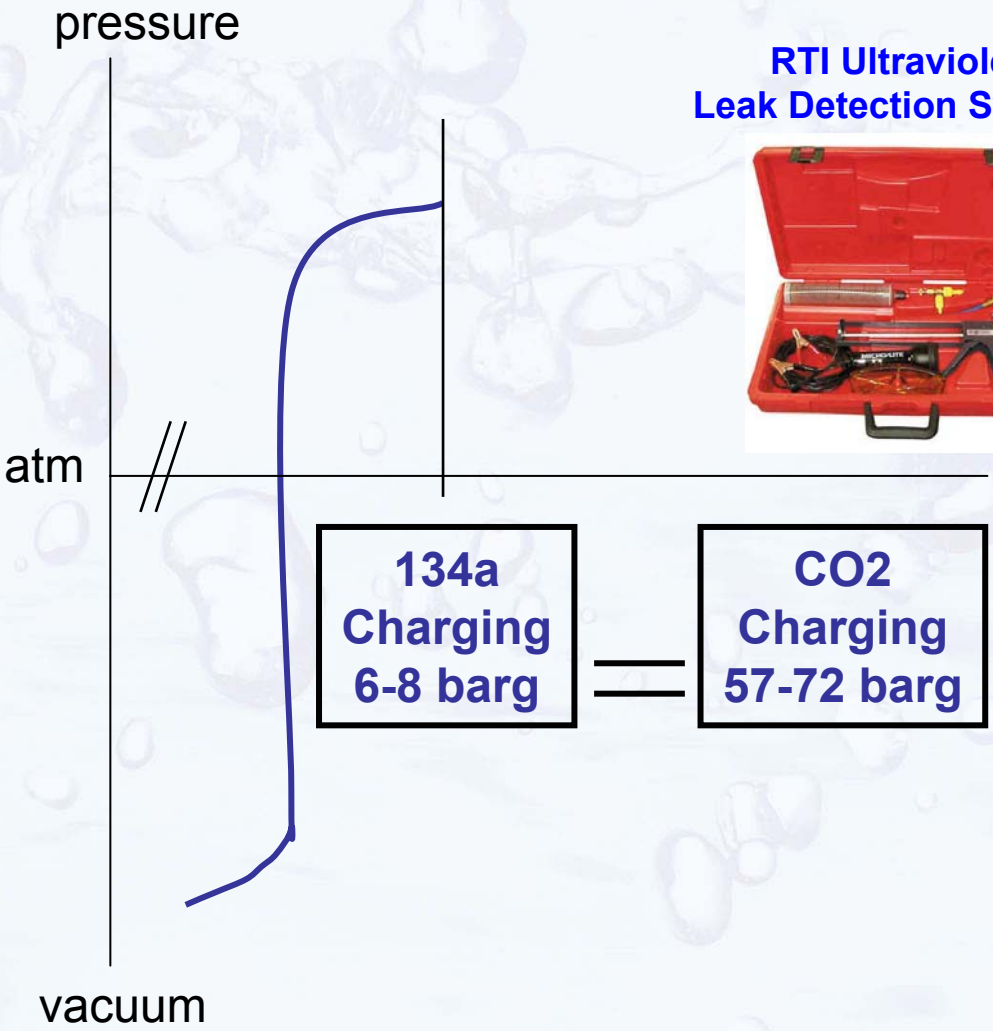
Media sniffing
134a refrigerant

134a Charging 6-8 barg = **CO2 Charging 57-72 barg**

Currently in praxis not possible with CO2
(source inficon)

Charging (workshops)

Typical 134a process versus CO2



RTI Ultraviolet Leak Detection System

134a Charging 6-8 barg = **CO2 Charging 57-72 barg**

Media sniffing
134a refrigerant

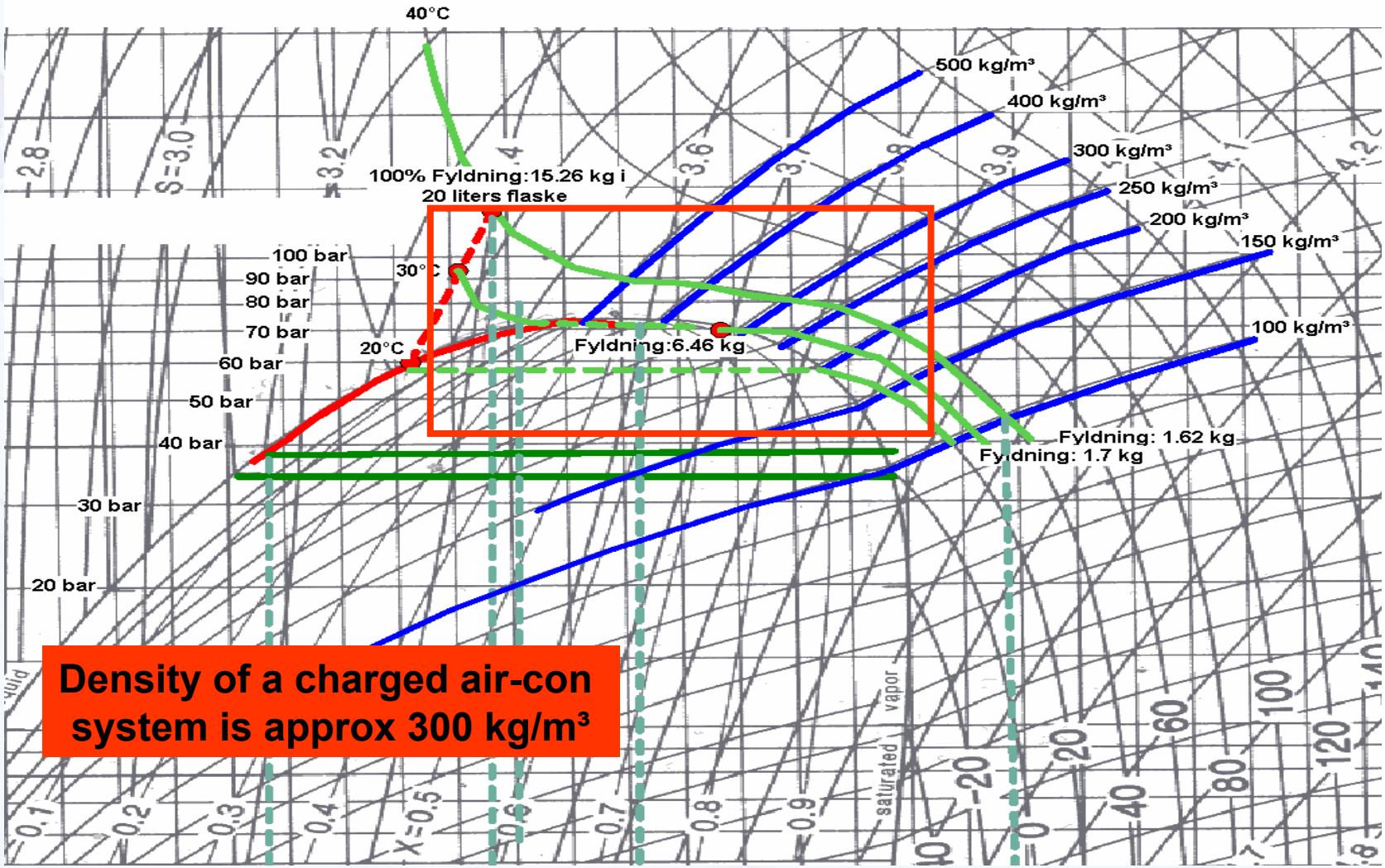
Currently in praxis not possible with CO2
(source inficon)

Charging equipment performance demands

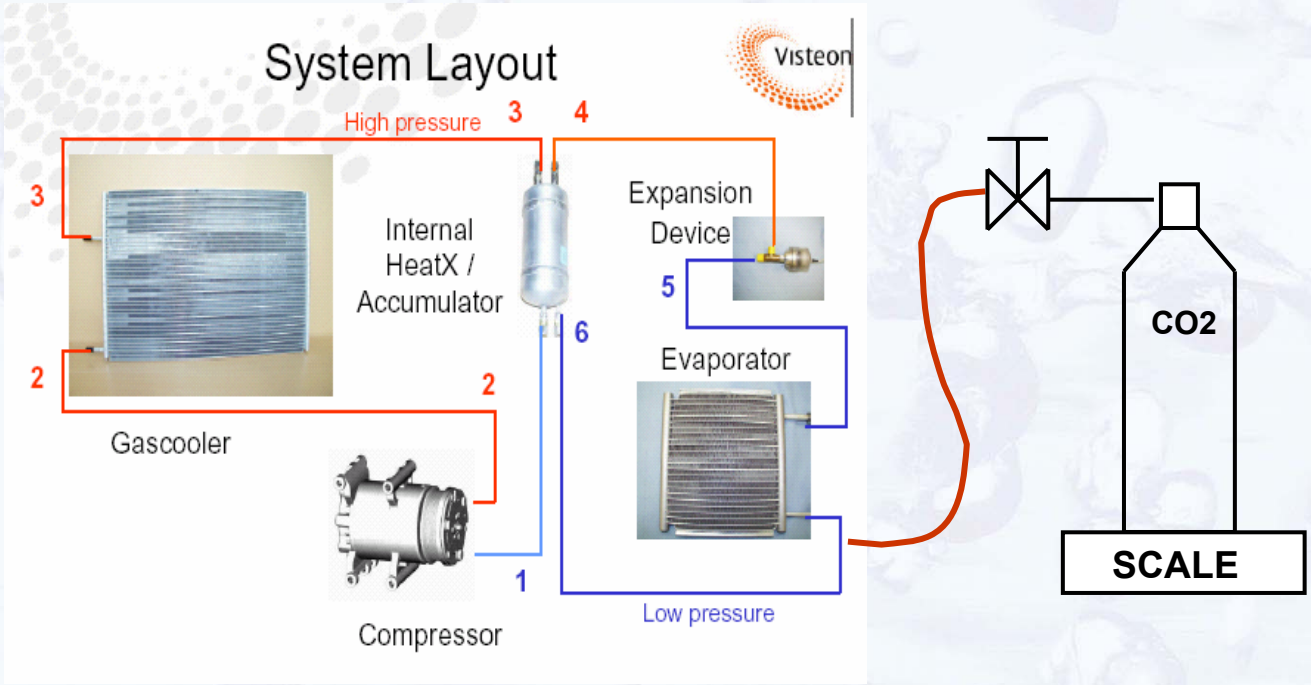
134a process versus CO2

- High charging accuracy
  - (typical ±1% or -0/+25 gram)
- Process capability Cpk > 1,67
- Operating ambient temperature range 5-40º Cel
- Be able to empty media cylinder > 90%
- Deterministic cycle time (approx)

CO2's Thermodynamic properties influence of the charging performance



Laboratory or compressor (in operation) CO2 ”charging”

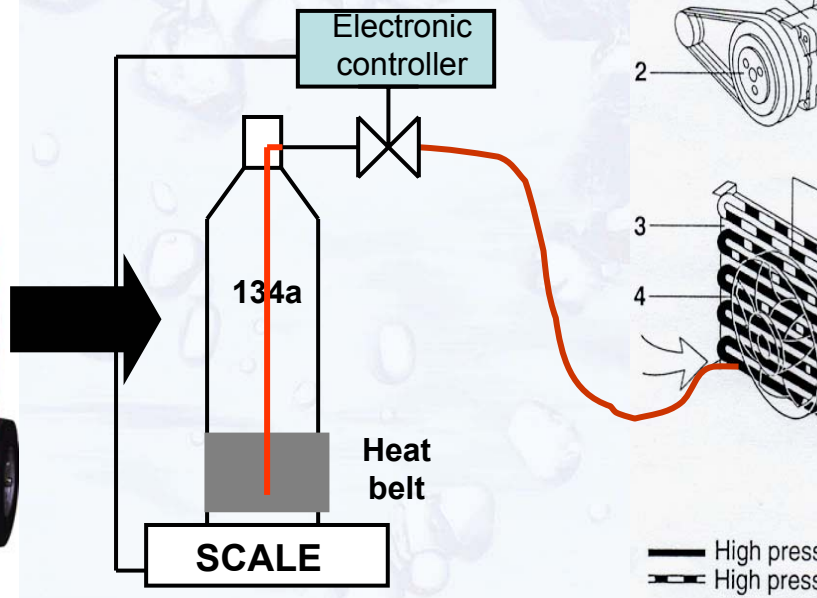


Charging by running compressor in workshops and volume production is not possible

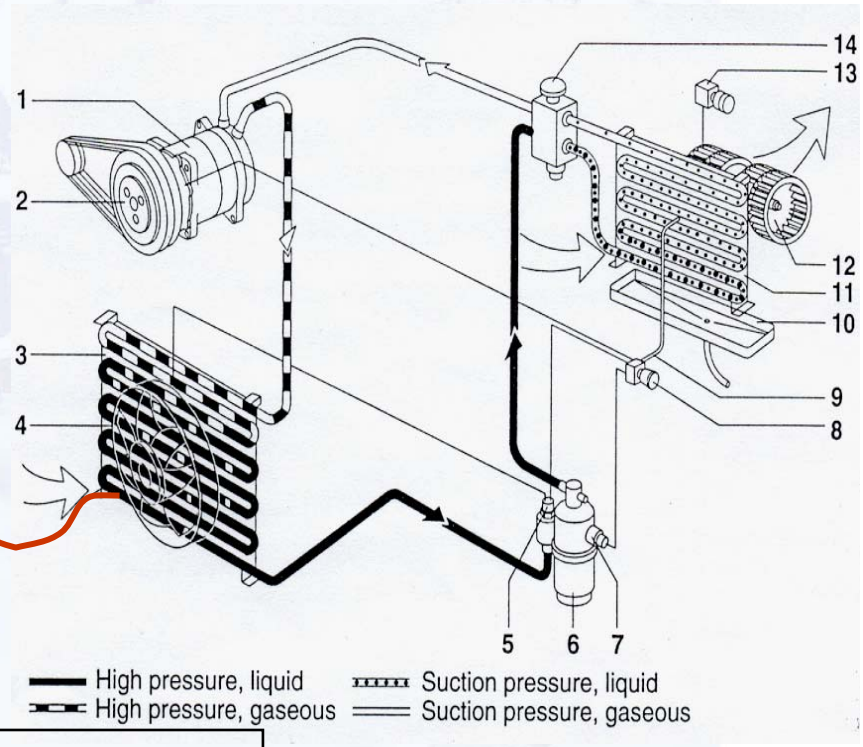
Current 134a charging principle in workshops

Advantage:
-No running compressor
-"High charging accuracy"
-operator safe
-Print-out of process performance

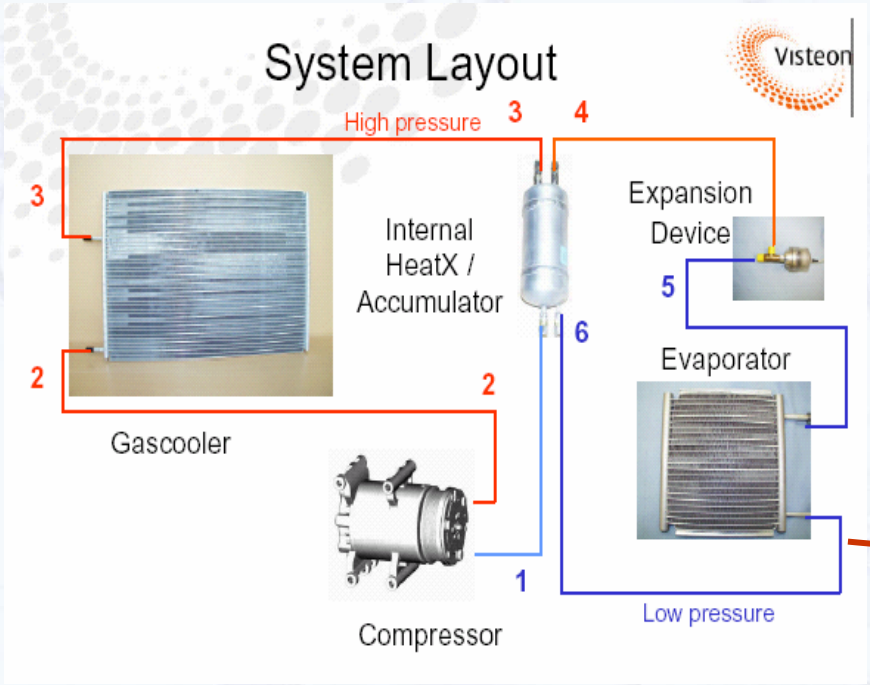
RTI automatic Evac & charge unit

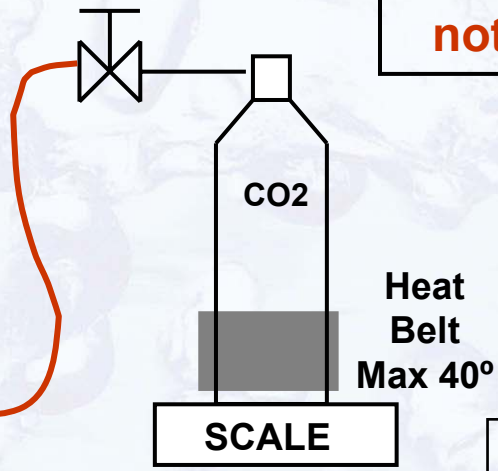


Charging principle "saturated vapor"



Future CO2 charging principle in workshops ?

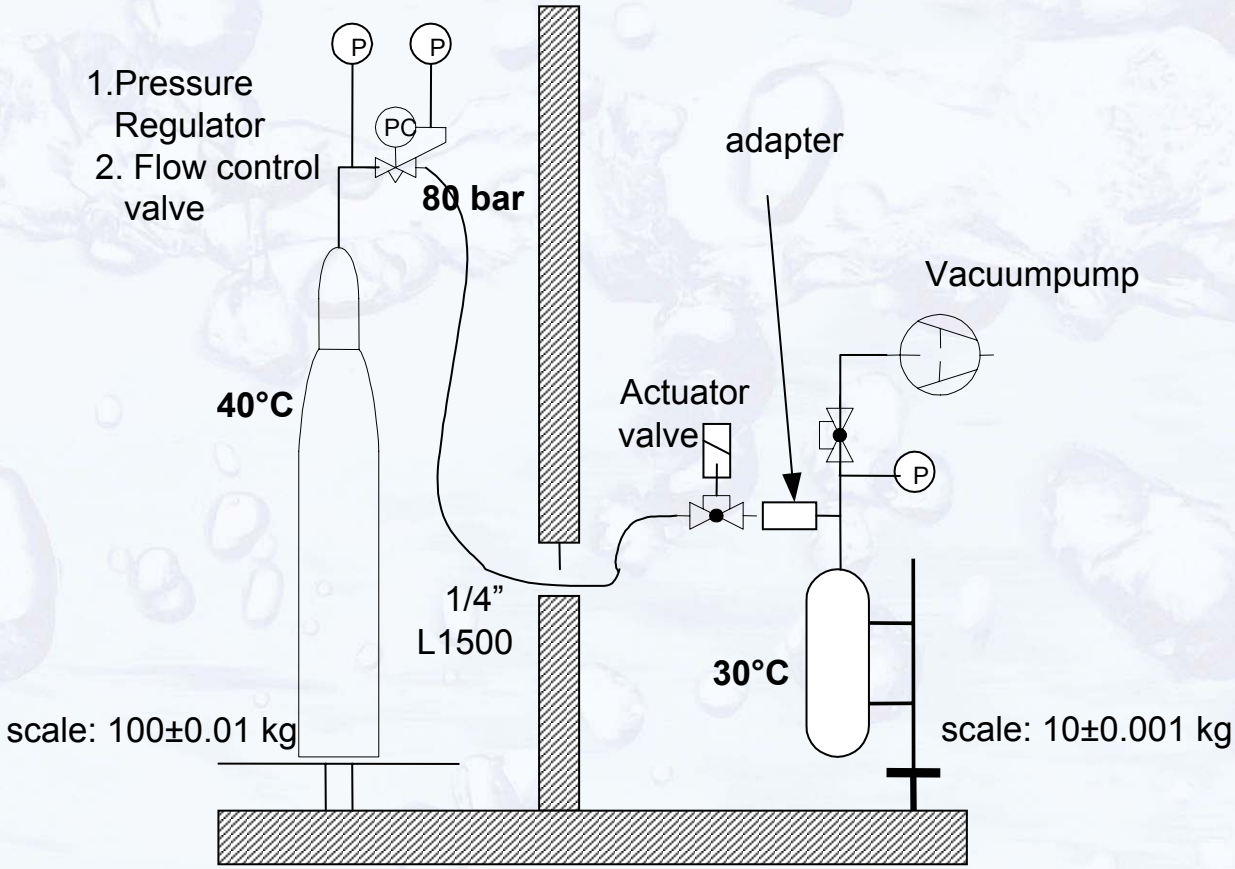




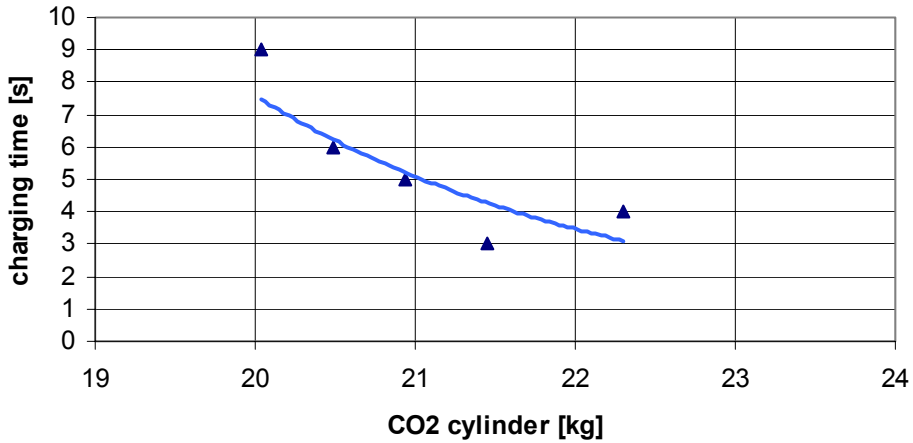
Note: compressor not in operation

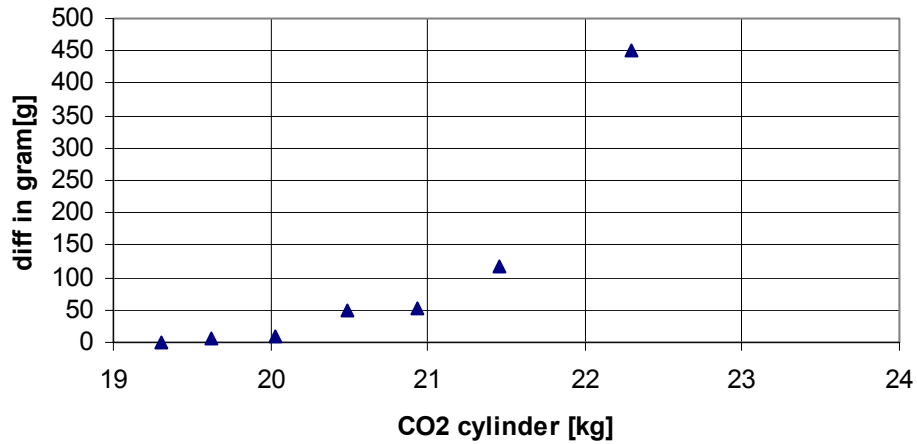
Charging principle "trans critical"

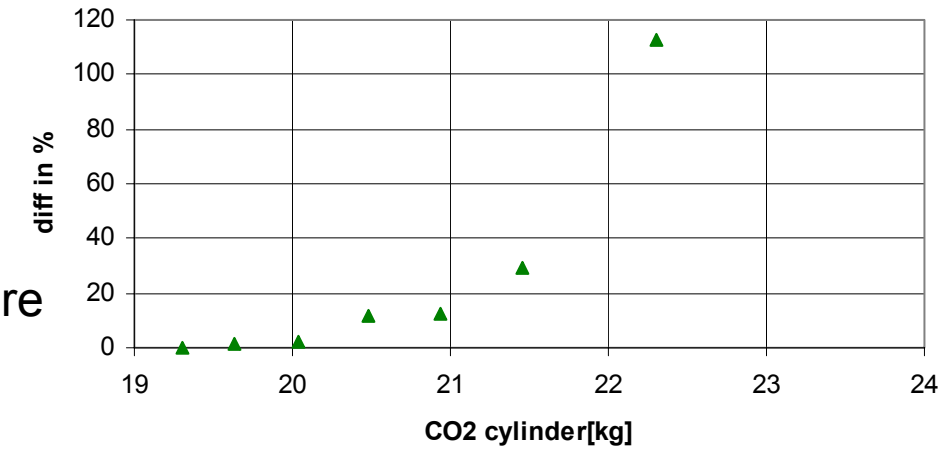
Climate chamber test



Test results (pressure regulator)

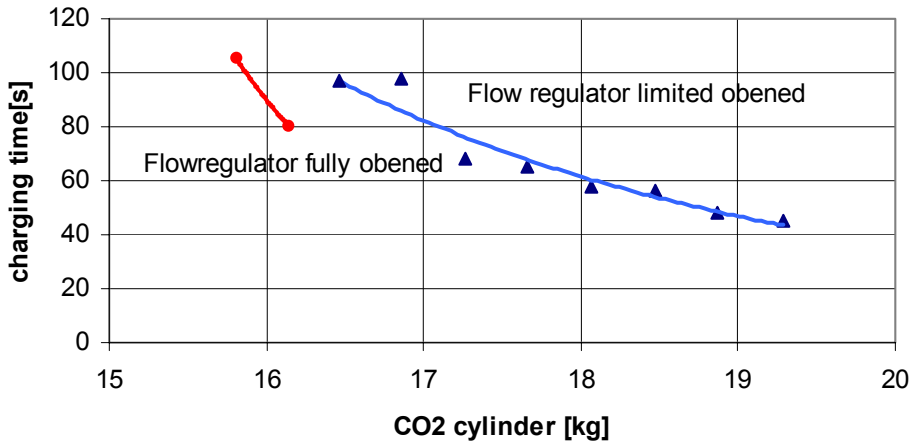


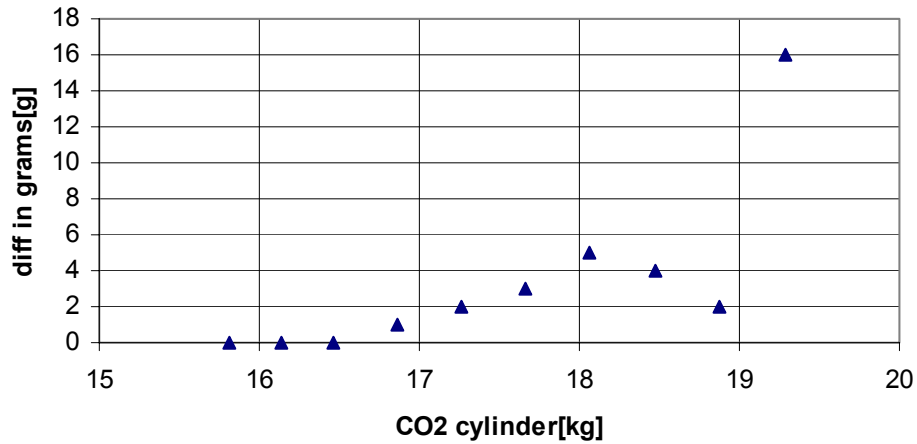




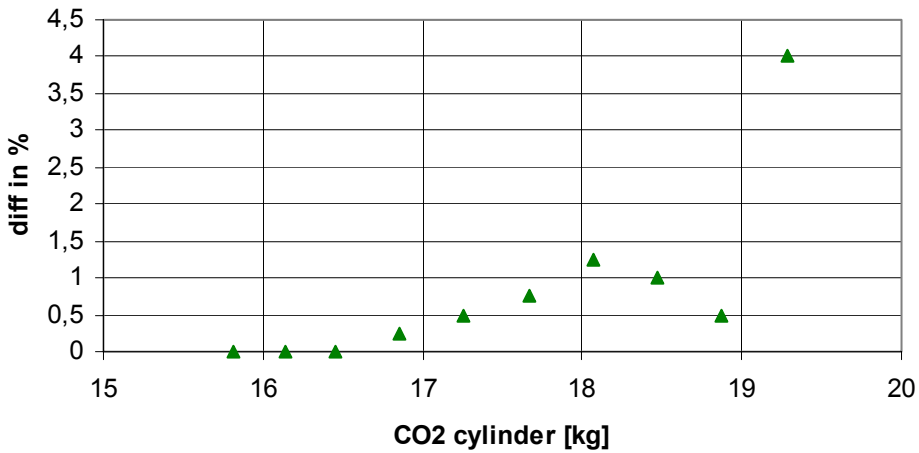
Summary:
-cylinder start density various
-limited charging numbers
-sensitive control loop due to start pressure
-risk of overcharging

Test results (flow regulator)

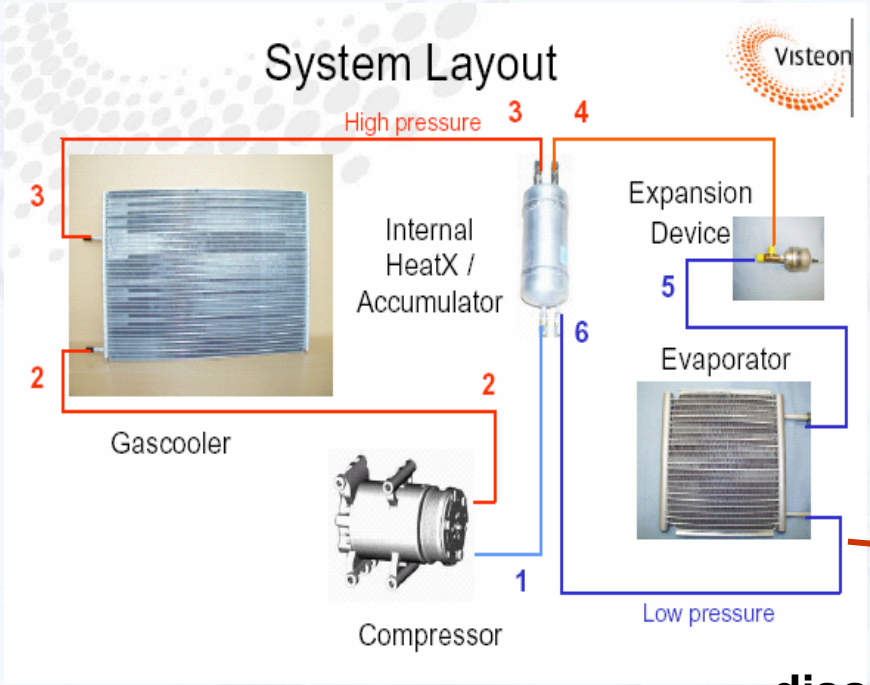


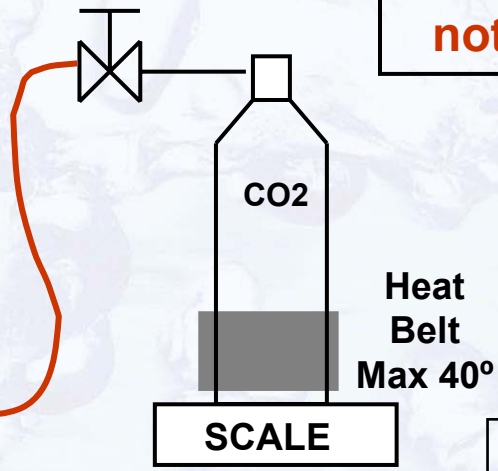


Summary:
-stabile control loop
-improved charging numbers
-improved charging accuracy



Future CO2 charging principle in workshops ?





Note: compressor not in operation

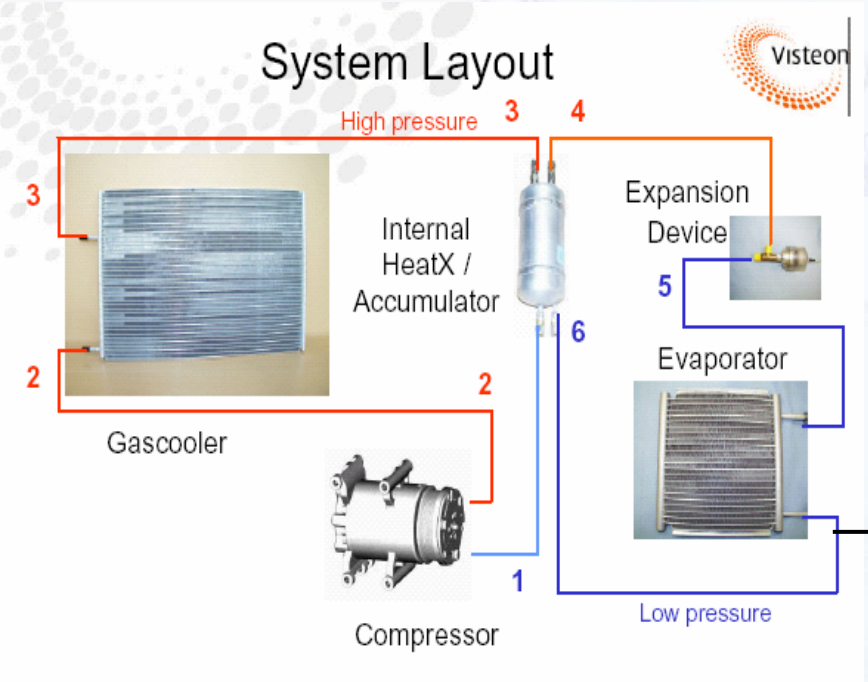
Charging principle "trans critical"

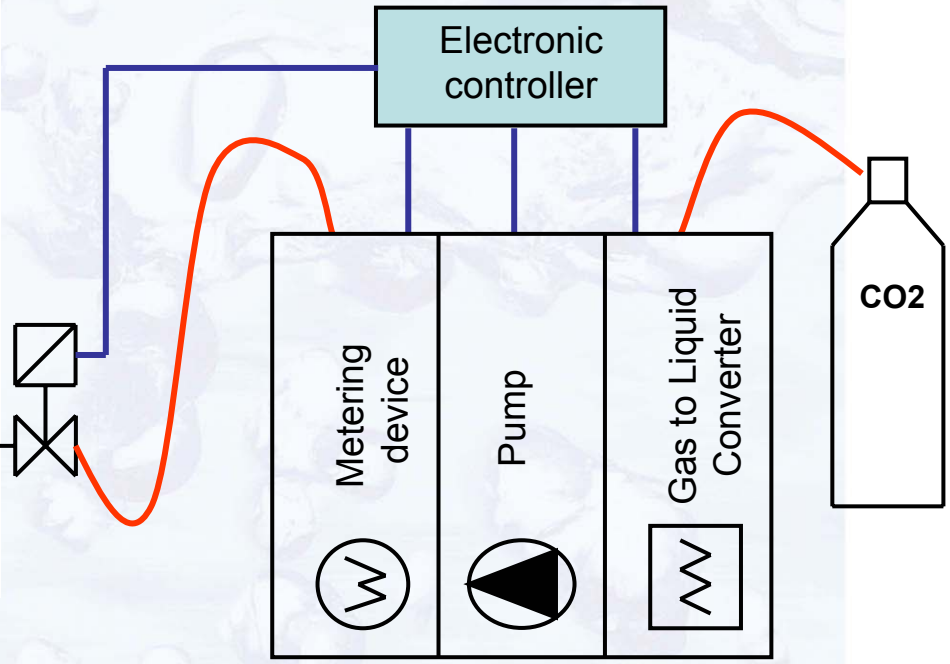
Advantage:
-simple (low cost) equipment
-"sufficient charging accuracy"
-"operator safe"

disadvantage:
-charging performance depend on ambient temperature (and operator)
-emptiness of media cylinder depends on ambient temperature
-do not present "current state of art"

CO2 charging principle

(volume production)





Charging unit

Advantage:

-no influence of charging performance by amb. Temp

-emptying CO2 cylinder

-high charging accuracy

-automatic process (no operator influence)

-operator safe

Line side CO2 charging equip.

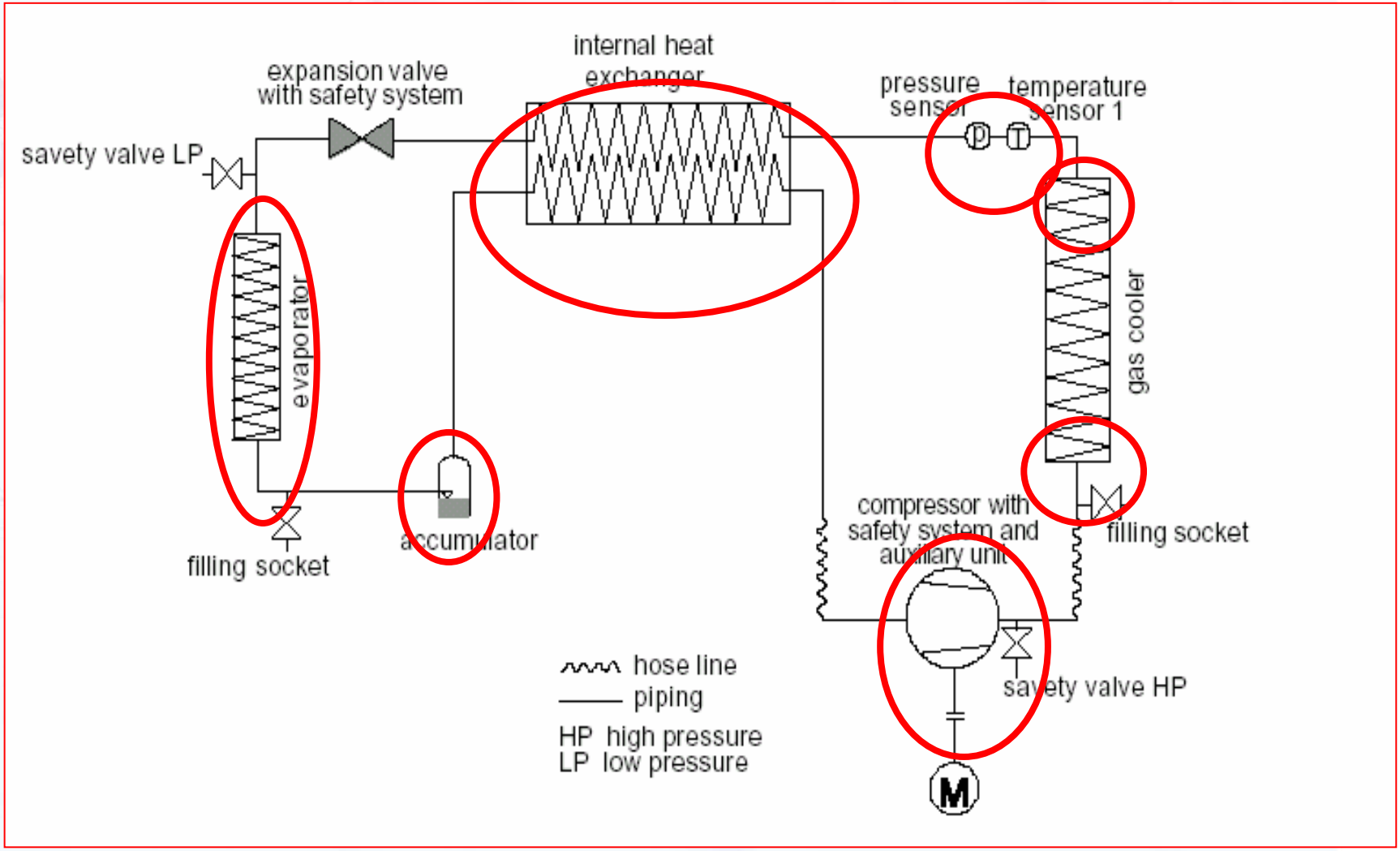
Fully automatic
Process performance

Assembly test

evacuation

charging

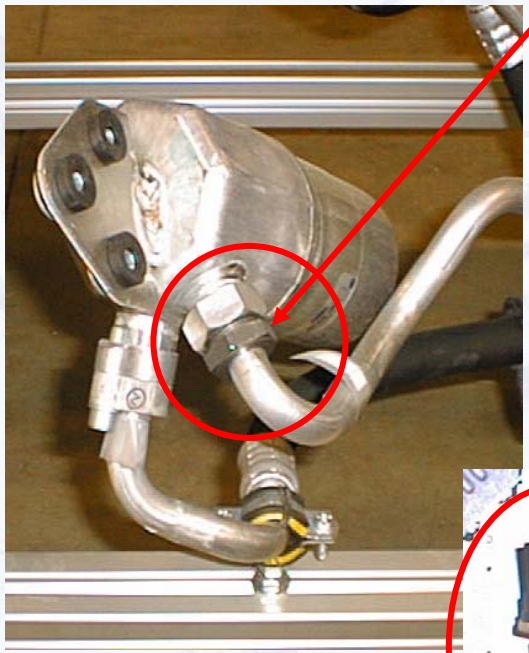
PI diagram (leak spots)



Air-con circuit leak spots

Accumulator/filter

Tube insert/nuts

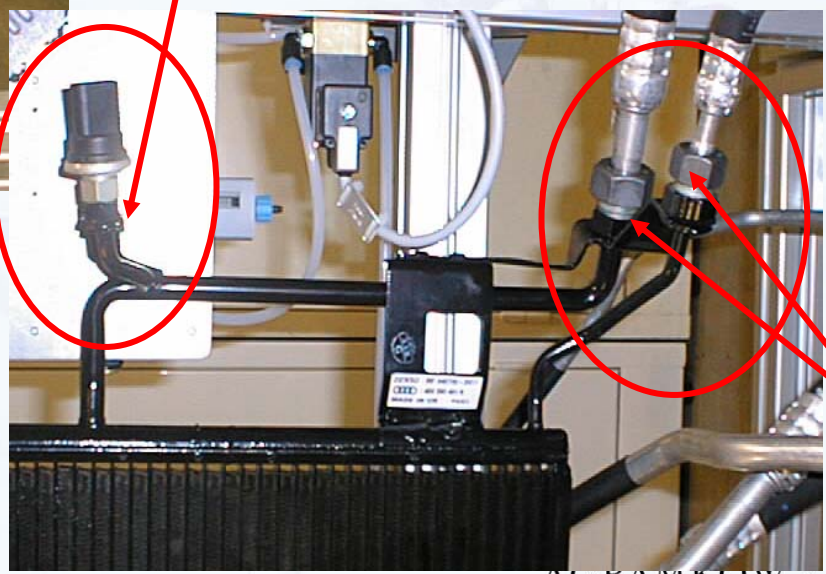


Evaporator connection

Flange/lost O-rings

Pressure switch

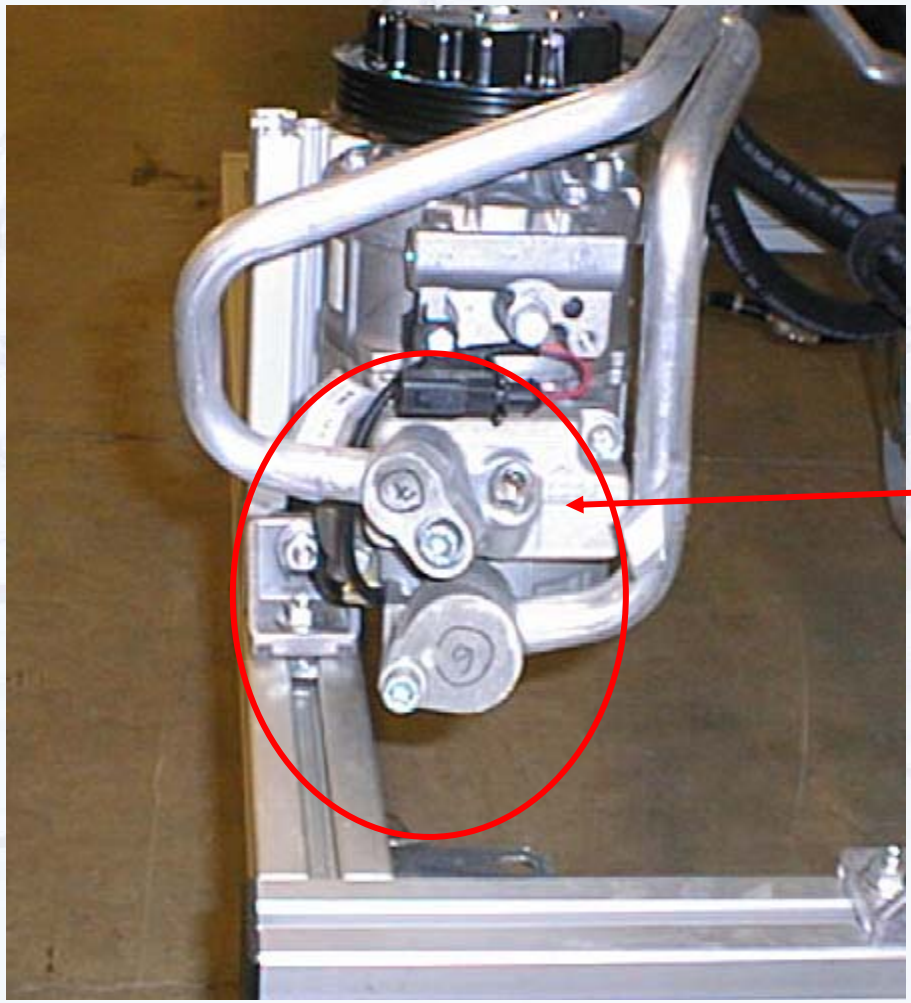
Not solid



Condenser connection

Tube insert/nuts

Air-con circuit leak spots



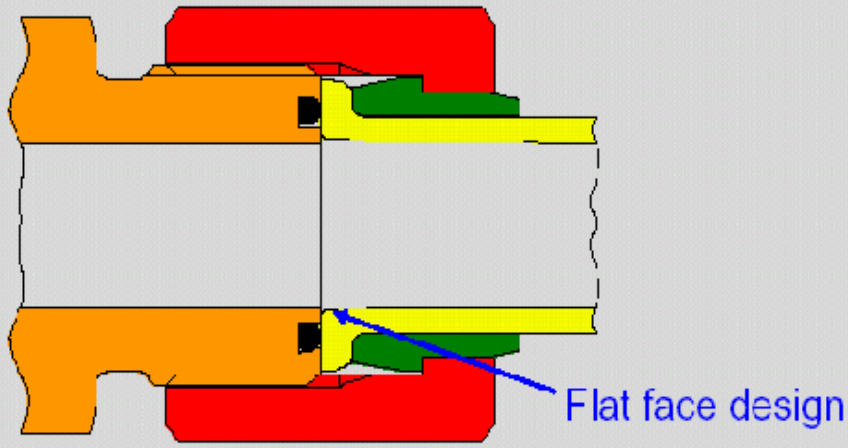
Compressor

Flange/lost O-rings

CO2 assembly

Seal-Lok Design Feature

Resistance to Over-Torque



- Sudden, sharp rise in torque gives a "hit home" assembly feel
- Can withstand 200% of assembly torque without damage
- No component damage as associated with metal-to-metal sealing methods

Parker

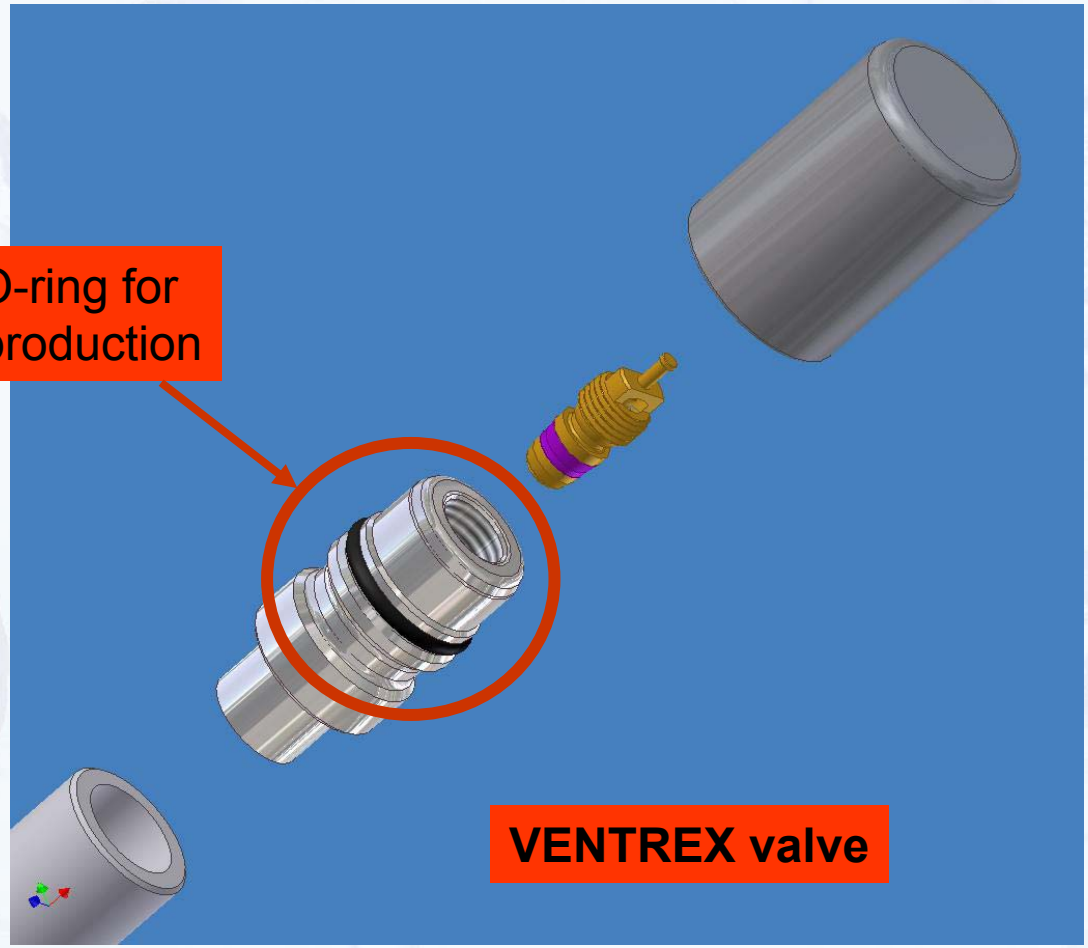
CO2 assembly

Assembly Considerations

Seal-Lok	Compression
• Thread nut fingertight, then slight nut rotation to achieve assembly	• Thread nut fingertight, then multiple nut rotations to achieve assembly
• Assemble to Torque	• Assemble by measuring nut turns
• No Tube Entry, face-to-face contact	• Tube entry into fitting
• Unlimited Remakeability, elastomer seal	• Limited Remakeability due to metal-to-metal seal, surface deformation
• One Sealing Point	• Multiple Sealing Points
• Simple to verify proper assembly by checking torque	• Difficult to verify proper assembly

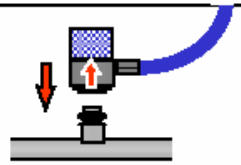
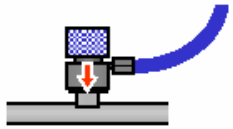
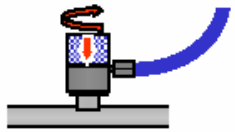
Preferred from An operator view

CO2 assembly

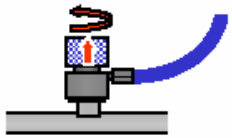
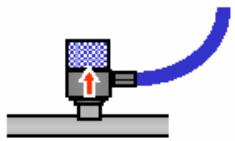
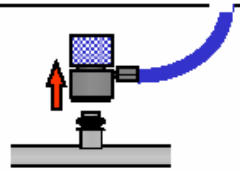


Serviceports & adapters in workshops

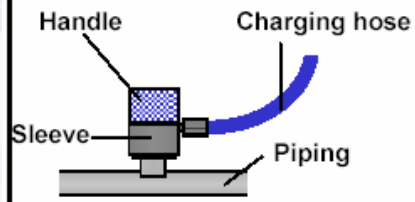
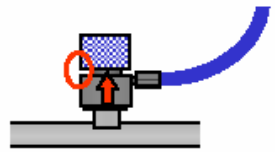
adapting

STEP1	STEP2	STEP3
		
Slide the sleeve upwards	Connect to service valve fitting	Rotate the handle to open the valve

disconnection

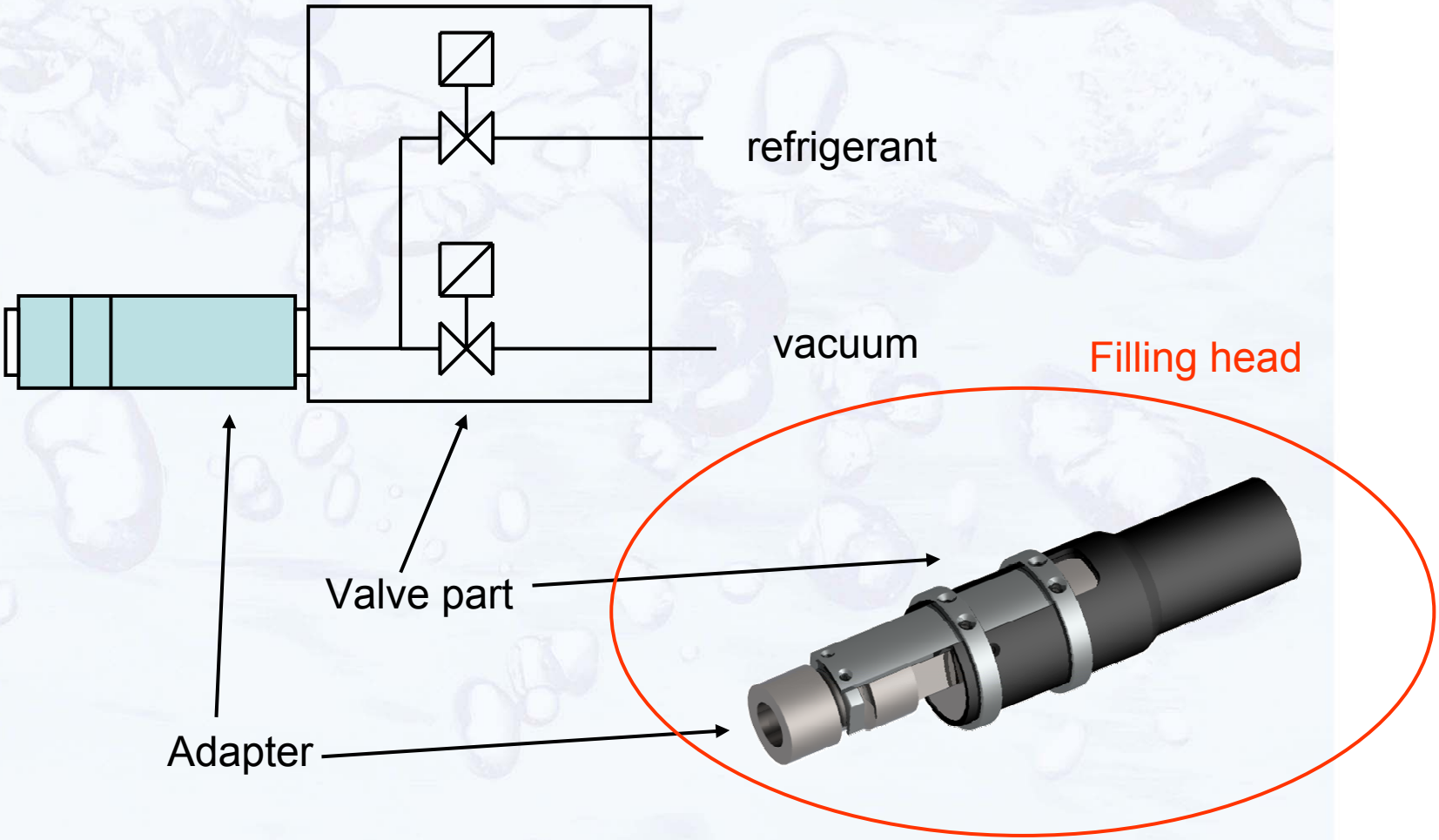
STEP1	STEP2	STEP3
		
Rotate the handle to close the valve	Slide the sleeve upwards	Detach from service valve fitting

processing

When the valve core is opened	When the valve core is closed
	
Handle is in contact to the sleeve. The sleeve can neither be moved, nor detached.	Gap between sleeve and handle. The sleeve can be lifted in order to detach connector.

Source Denso

Service ports & adapters in volume production



Service ports & adapters in volume production

Scenarios that might influence the safety of the operator:

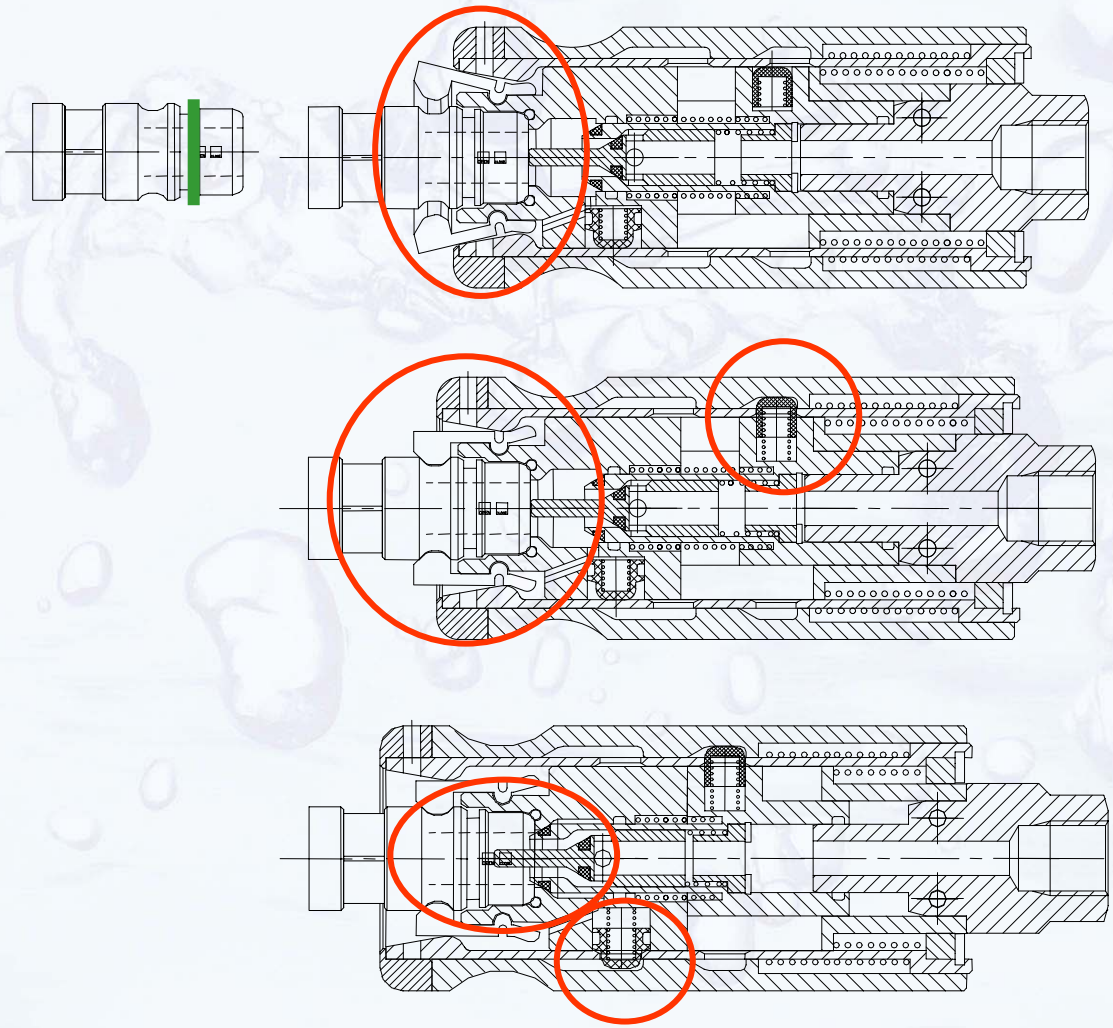
-The check valve in the nipple don't close (mal function) by disconnecting >
    -The filling head turns into a flying hammer
-The charging valve of the filling head do not close after filling (mal function) >
    -the filling head turns into a flying hammer by disconnecting
-The operator disconnects the filling head during charging >
    -the filling head turns into a flying hammer

Production related requirements:

-Safe
-Easy to use
-Reliability

Service ports & adapters in volume production

Adapting (2 step adapter)



Attaching the nipple

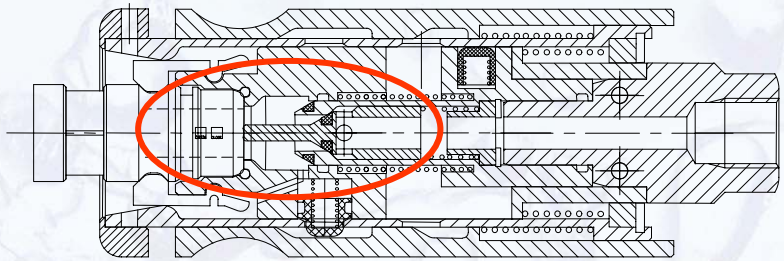
Step1
Claws closed
and locked

Step 2
Check valve opened
and locked

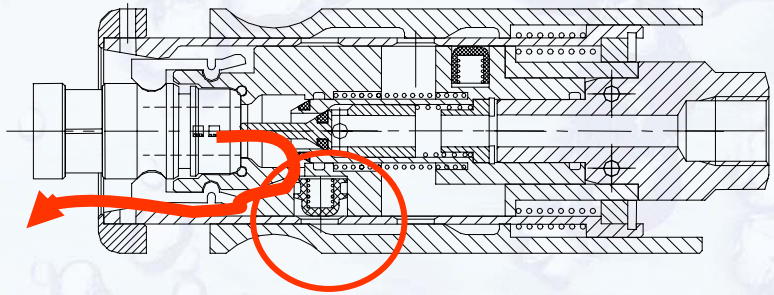
Patent pending

Service ports & adapters in volume production

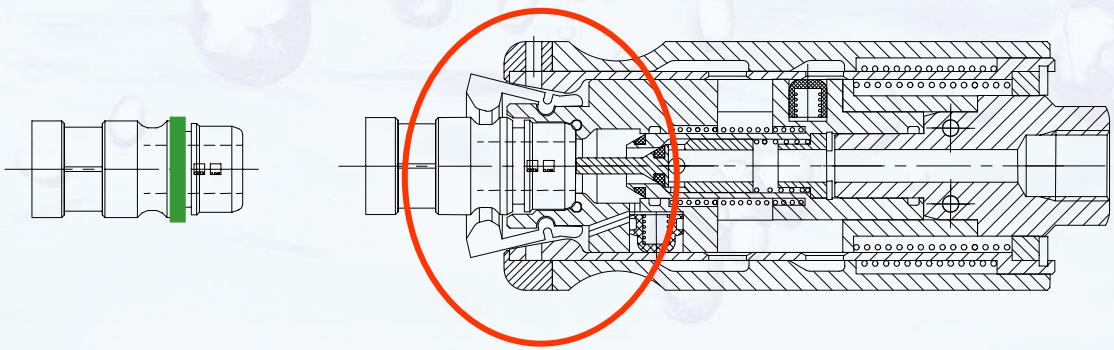
Disconnecting (2 step adapter)



Step 1
Close the check valve



Step 1
Venting remaining gas and unlock



Step 2
Open the claws

Patent pending

conclusion

- Leak detection before charging needs additional attention at volume production
- Leak detection after charging by use of “sniffing” is currently not possible
- CO2 charging includes new and more complex processes both in workshops and volume production. Current 134a equipment can’t be upgraded for CO2. Workshop service units needs additional developments.
- Up-grading the assembly performance (and indirect improve the leakage rate) is in the hand of the designers
- Service adapters for service shops and volume production are in progress

Final

- To support the development of CO2 as an alternative refrigerant AGRAMKOW and Hydro-gas offers charging process tests and technical CO2 know-how to Car manufactures and OEM's.

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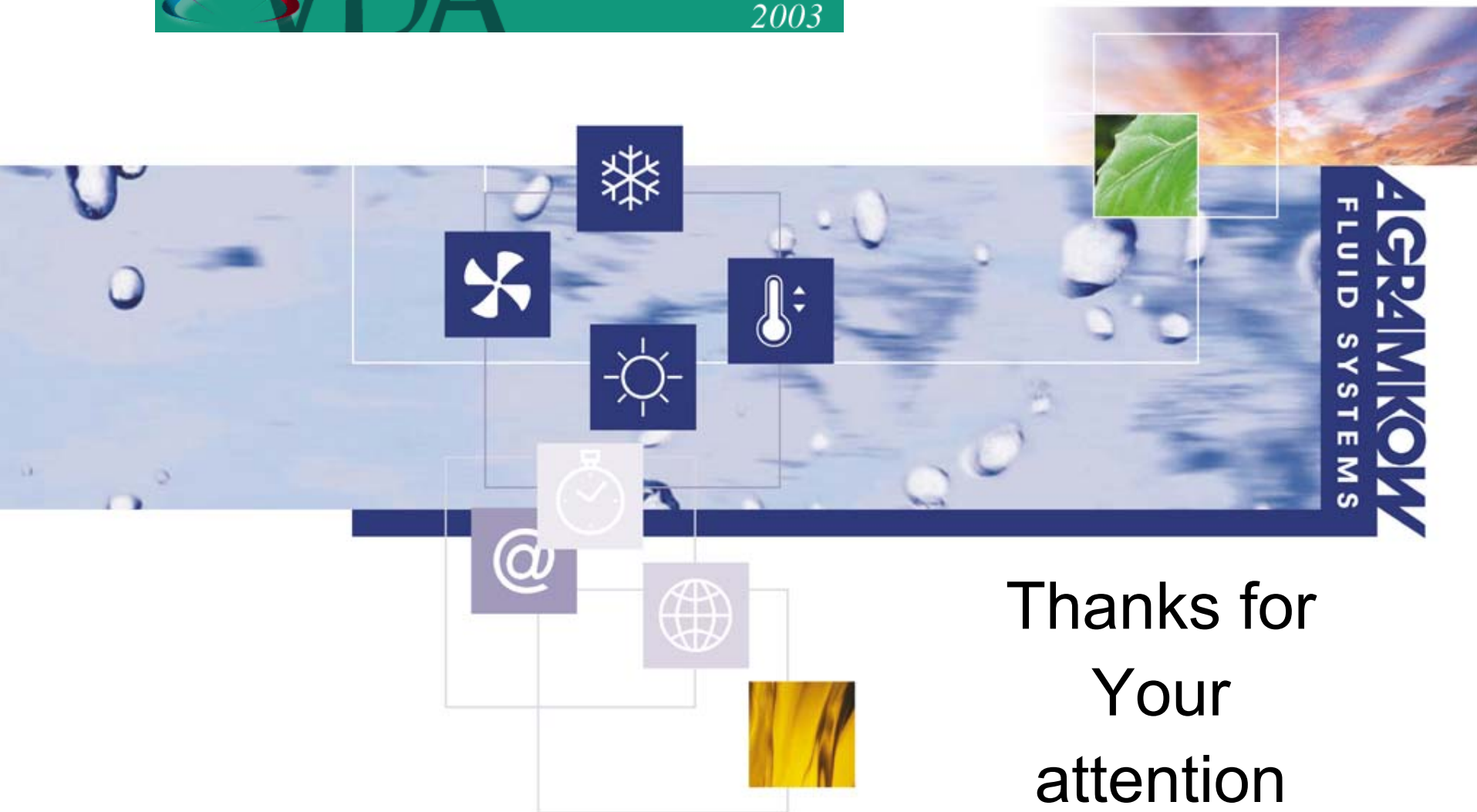
2003



Thanks for Your attention

AGRAMKOW - the Safe Choice...