

**Safety concept proposal
for R744-A/C-systems
in passenger cars
Update 2005**

**Ad hoc working group
of VDA OEMs**

Content

- Purpose
- Risk analysis
- Safety barriers in the refrigerant cycle
- FMEA for the cabin
- Safety requirements
- Status of the “safe evaporator”
 - Corrosion mechanism
 - Life cycle test
 - Quality assurance

Purpose of the safety concept

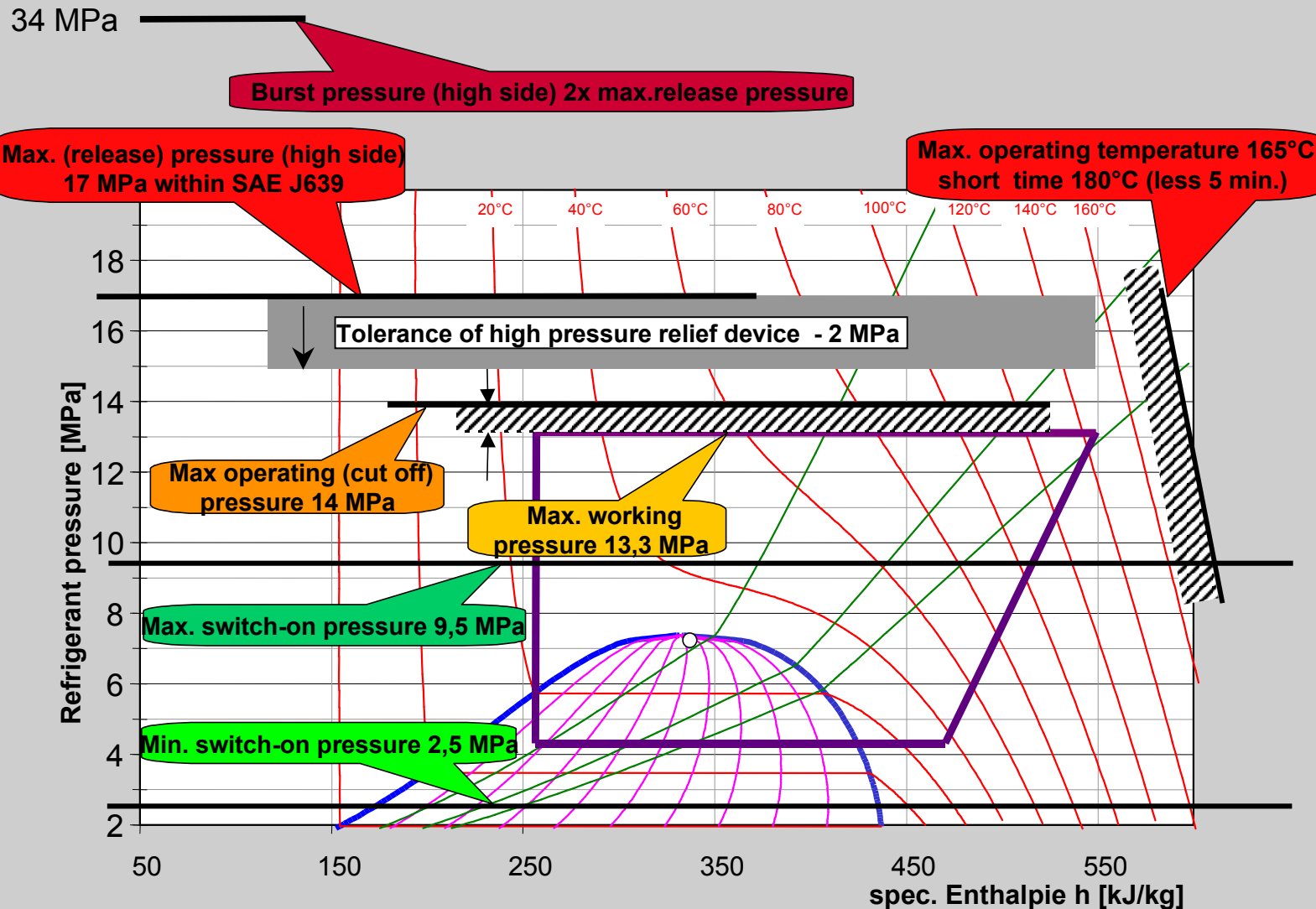
- ⇒ Applicable to all car segments
- ⇒ Applicable from manually to automatically controlled AC-HVAC-systems
- ⇒ Applicable to all CO₂-refrigerating-systems
- ⇒ All (critical) operating conditions covered
 - Ignition off --> parked car --> passengers inside (sleeping)
 - Ignition on
 - > HVAC-blower off
 - > HVAC-blower on --> compressor on
 - > recirculation mode (idle or stop-and-go)

Risk analysis

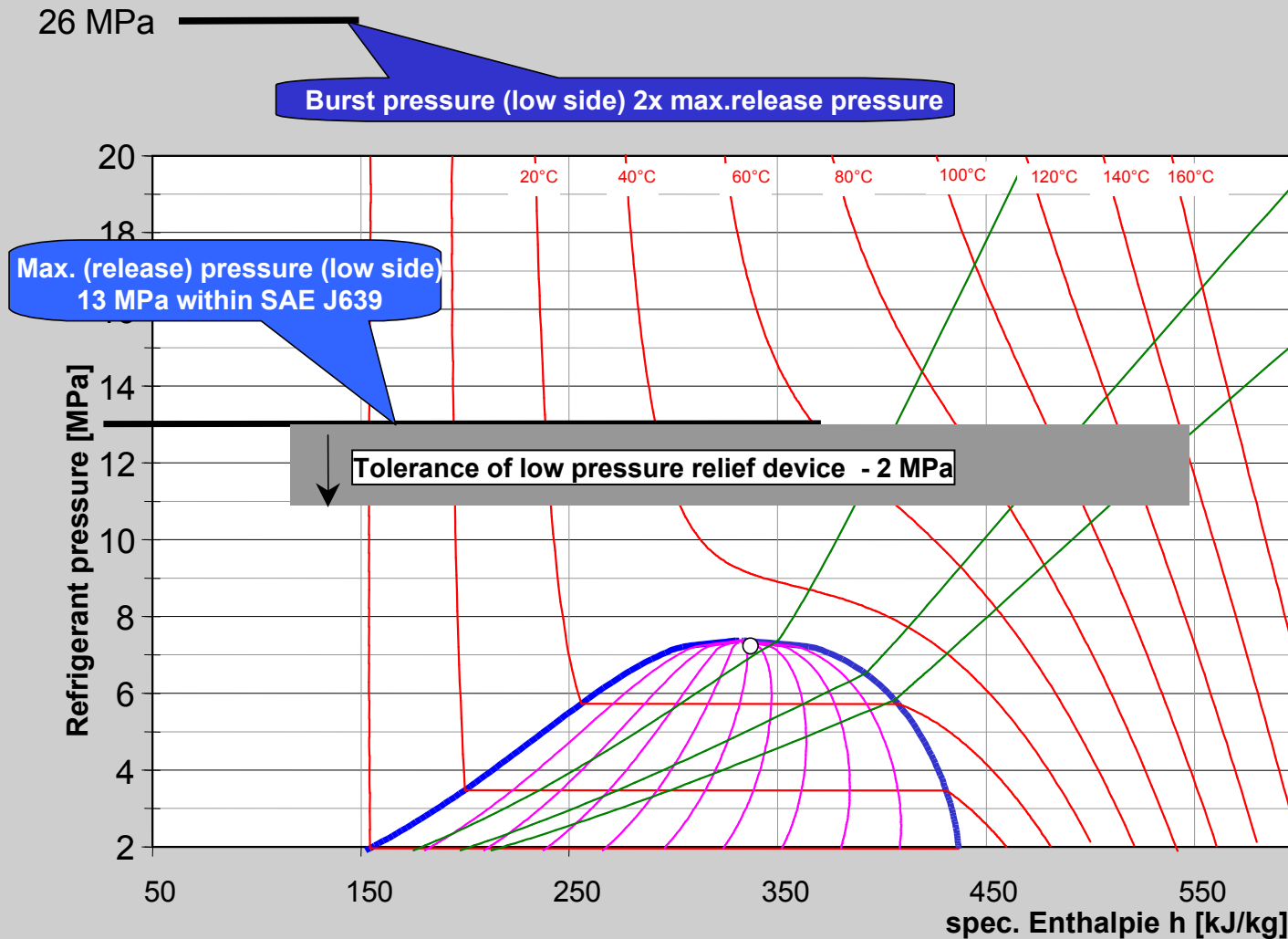
Safety targets

1. To protect driver from loss of concentration and reaction
2. To protect all passengers from health problems
3. To protect persons outside the vehicle from damage
4. To prevent all safety-relevant systems of the vehicle from negative impacts

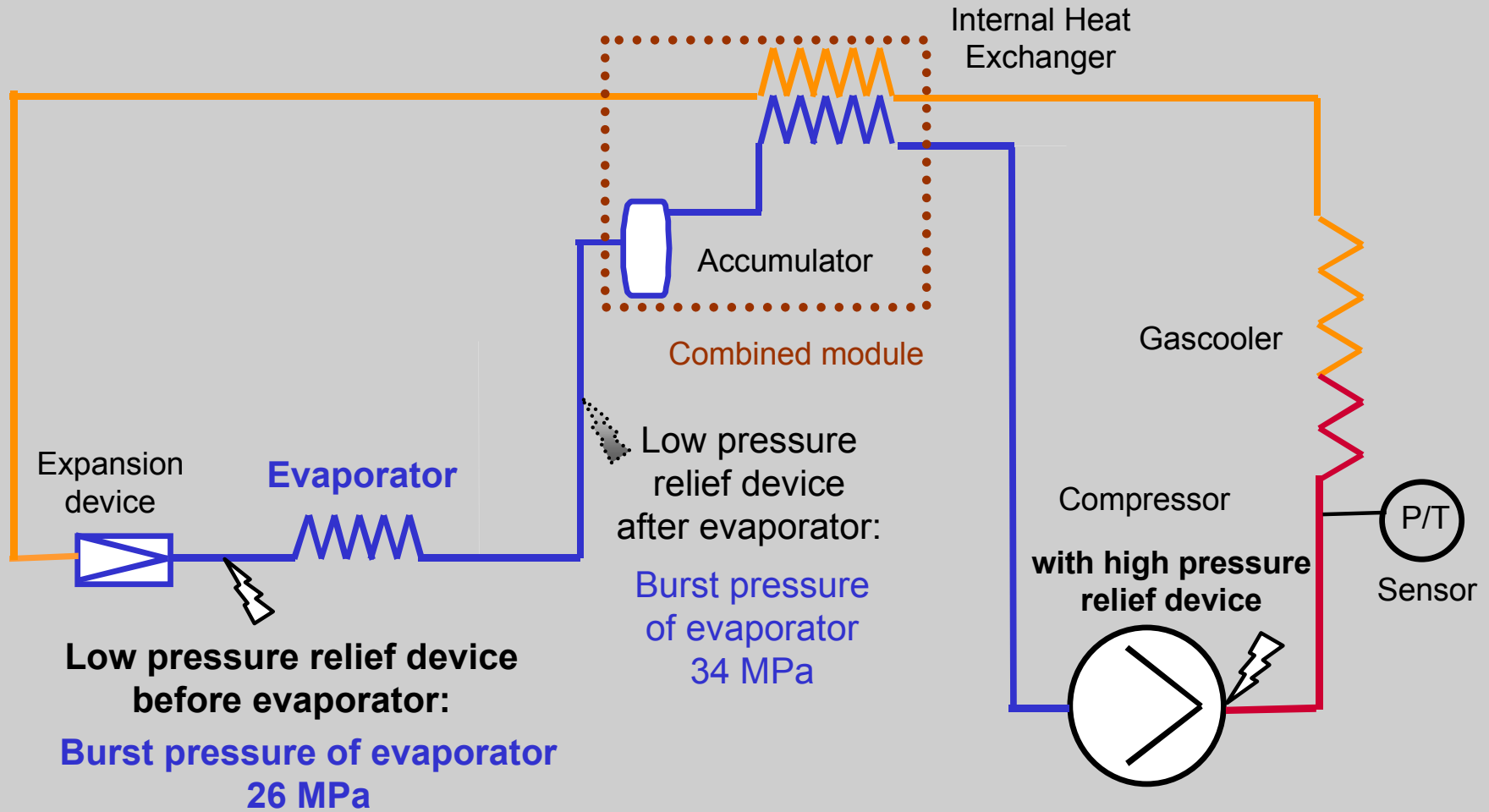
Safety barriers in the refrigerant cycle



Safety barriers in the refrigerant cycle



Safety barriers in the refrigerant cycle



FMEA for the cabin

to protect driver and passengers

Importance analysis

- Relevant situation:
 - Windows closed
 - Recirculation mode
- Relevant events:
 - I. Leak at in- and outlet-pipes of evaporator
 - II. Leak at evaporator core

FMEA for the cabin

to protect driver and passengers

Potential failure modes

- Production process quality
 - Semi-finished parts
 - Brazing
- Material fatigue
 - Pressure cycling
 - Vibration
- Handling
 - Transport
 - Assembly
- Corrosion

Safety requirements

I. Leak at in- and outlet-pipes

For Brazing quality

⇒ Full-automatic brazing of in- and outlet pipes to evaporator core

For Transport

⇒ Mechanical support of the evaporator's in- and outlet pipes inside the HVAC-unit

For Assembly

⇒ Removable refrigerant-side fittings outside the cabin

Safety requirements

II. Leak at evaporator core

For Material fatigue (pressure cycling, vibration)

⇒ Design for burst pressure of 26 MPa at end-of-life

For Corrosion

⇒ Life cycle test including corrosion

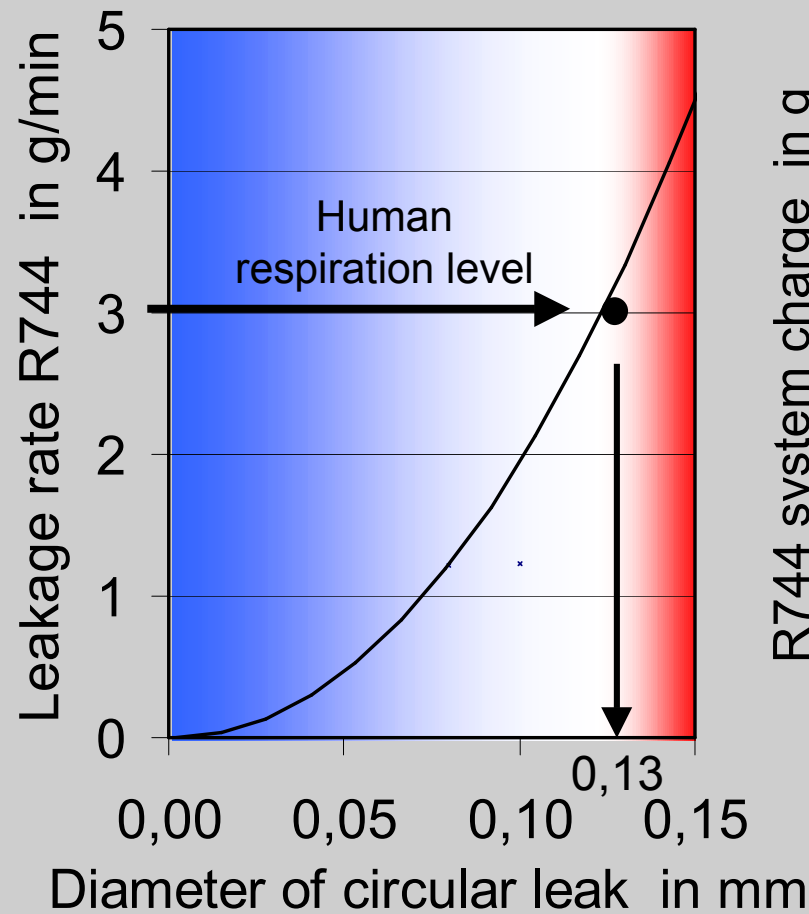
For Production process quality (semi-finished parts, brazing)
and Handling (transport, assembly)

⇒ Quality assurance from production to assembly

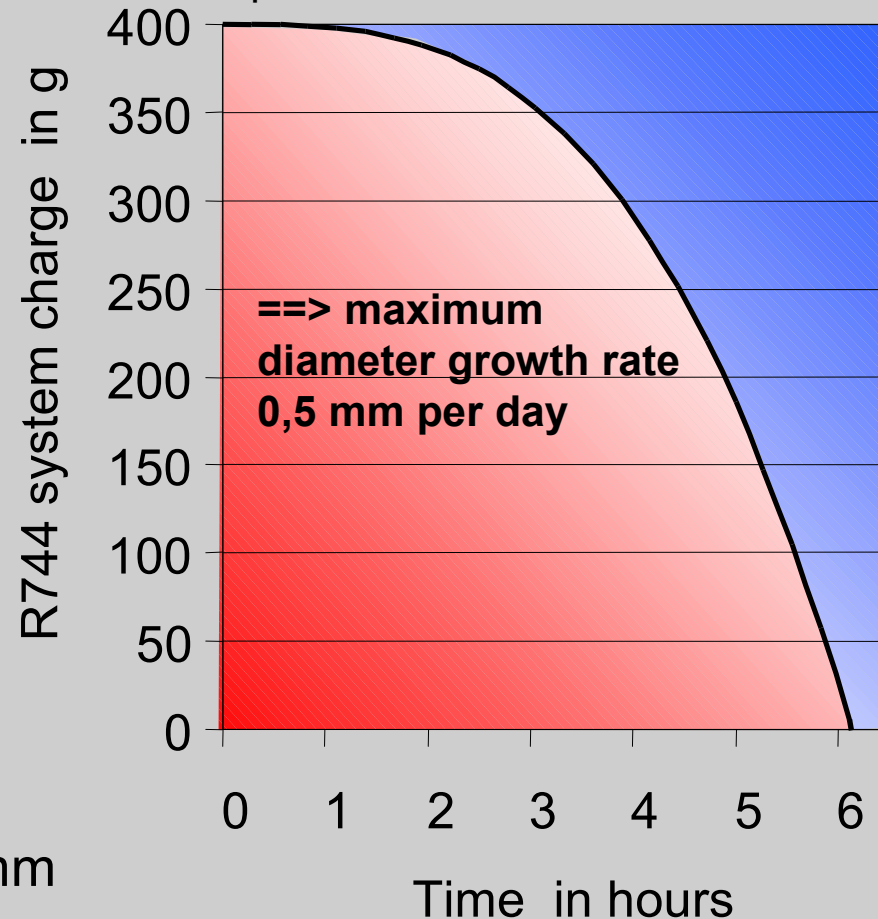
==> Fundamental safe evaporator

Status of the “safe evaporator”

– Corrosion mechanism



Continuously growing circular leak up to 0,13 mm diameter



Status of the “safe evaporator”

- Positive supplier feedback concerning evaporator design
- Proposal for life cycle test during development
 - bending test of in- and outlet pipe
 - pressure cycle test
 - shake test
 - corrosion test (**is being developed**)
 - pressure cycle test
 - > burst test with 26 MPa
- Quality assurance for all (100%) evaporators and HVACs from production to assembly is being developed

Summary

- Safe evaporator applicable to all car segments with all kinds of HVAC- and R744-systems
 - Safe evaporator considers all operating conditions
 - Corrosion mechanism on R744-evaporators has to be evaluated
 - Quality assurance needs to be defined
- ⇒ Higher safety than today