TEKO
Made in Germany.

TEKOINFO

Cleaner system technology by preventing contamination in CO_2 units.

Dear reader,

This brochure is dedicated to the topic of "contamination in CO_2 refrigeration units" and how we can prevent it. The idea behind it came about following a regular exchange of ideas with many of our refrigeration specialist colleagues, who were increasingly seeing abnormalities in CO_2 units on site.

To a great extent, contamination on and in refrigeration units leads to the function, service life and efficiency being restricted. It is initially irrelevant which refrigerant is being used. However, CO_2 units have special technical and design features. Pipes and components are much smaller, for example. Furthermore, there are more control valves due to the process.

These are only examples that show new solutions needed to be developed for CO_2 units. TEKO therefore relies on a well-balanced number of components in the unit to filter contamination out of the refrigeration circuit. Filters protect the entire unit and foster a longer service life for the refrigeration system.

Both working "cleanly" within the CO_2 refrigeration circuit and regularly changing the filter are therefore absolutely essential. Many refrigeration specialists have confirmed this to me in person.

Simon Ahlers
(CO_2 Unit Product Management)

What contamination can always be found in refrigeration units and where does it come from?

"It's never clean on site. This is why it is particularly important to protect open components – such as pipes – from dust and sand. This granular contamination can penetrate into the refrigeration circuit when components are stored in the open, thus causing further damage. We therefore seal all open components with end caps and clean them again with nitrogen before installation.

Air-side contamination, such as deposits of dust, pollen, foliage, ice, etc., on the heat-transferring surfaces of gas coolers and evaporators results in poorer heat transfer from the refrigerant into the air or vice versa. The poorer heat transfer must then be counteracted through higher temperature differences. As a result, the capacity and efficiency of the refrigeration unit can be on its knees – until the entire system fails completely, through a high-pressure failure or insufficient cold generation, for example. This is why we clean the heat exchanger every time it is maintained and serviced.

Christian Kraus
(K.E.D. Kälte- und Klimatechnik GmbH)

Contaminated machine room

TEKO filter
to protect the unit

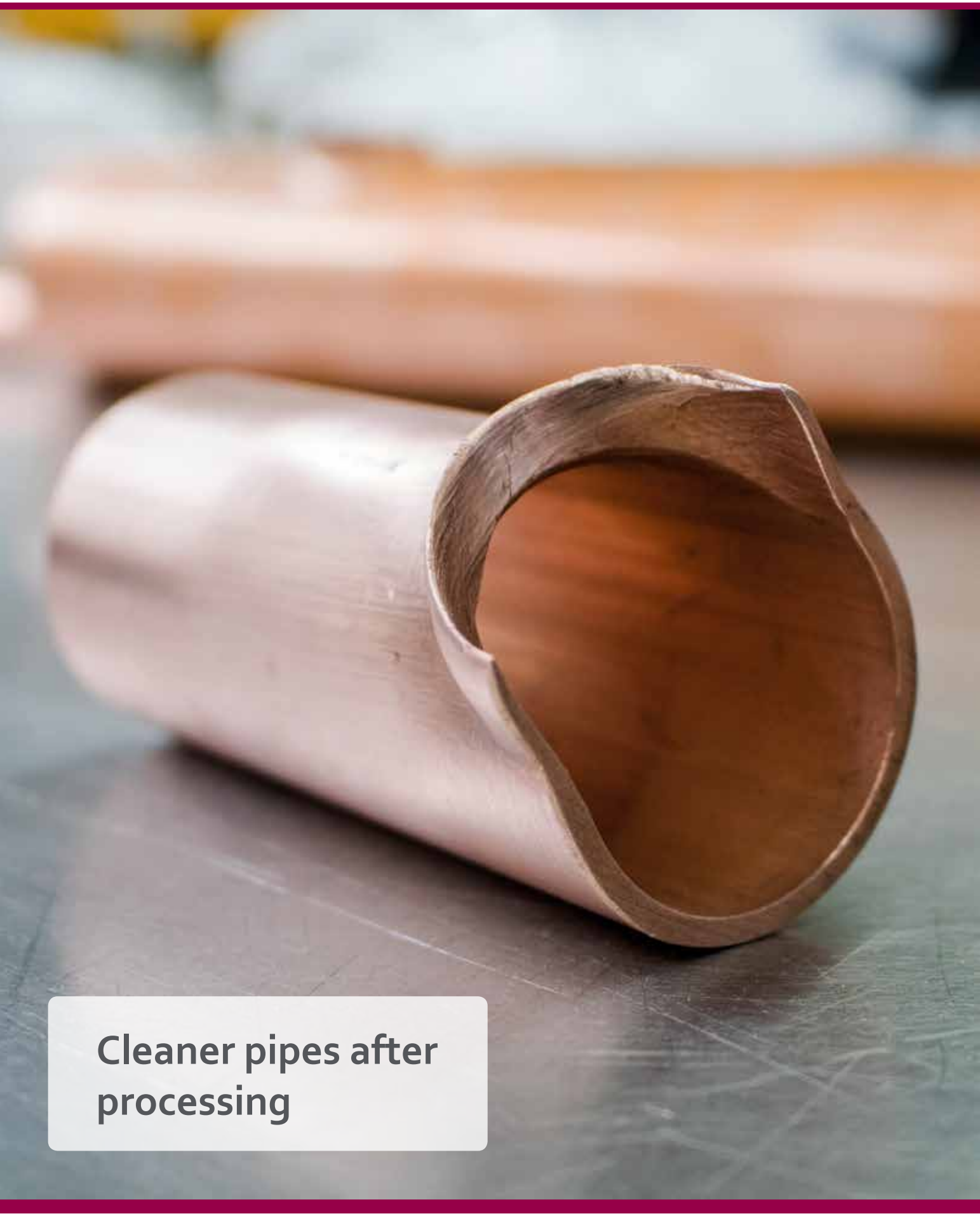
HD valve filter sieve

Suction filter

Oil filter

Coalescing cartridge

Filter-dryer



Cleaner pipes after processing

What contamination can always be found in refrigeration units and where does it come from?

Water

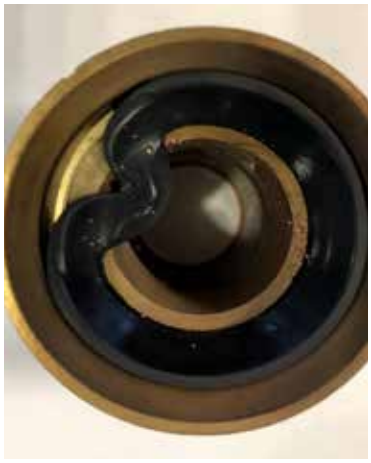
Water is produced by air humidity, unsealed components exposed to rain, when cooling solder joints for example, when manufacturing components from cooling lubricants or from frost damage to heat exchangers

Scale (metal oxide)

Scale (metal oxide) is formed through the oxidation of metal surfaces (e.g. copper pipes) with any oxygen present at very high temperatures (e.g. soldering and welding).

Shavings

Metal shavings may remain in the pipes when machining components (e.g. drilling or milling, filing or grinding). This is why all pipes must be thoroughly cleaned before installation. Shavings may also arise within the on-going system process.



Material wear

When the unit is running, there may be material wear on all moving parts. This is perpetuated by insufficient lubrication (e.g. pistons or valve seats). Material wear causes shavings, dust or splinters in the refrigeration circuit and may cause other components to wear or to become damaged.

"Oil carbon"

If the operating temperature is too high, e.g. triggered by high compressor discharge temperatures, there is a chemical decomposition process in the refrigerating oil. This results in blockages on filters and valves.

Sealing plugs

We are always coming across examples where storage and transport seals have been forgotten. They are there to prevent the inside of components from becoming contaminated. If they are not removed when the component is installed, this may result in contamination and damage within the unit.

Soldering must be carried out using forming gas

What effect does this contamination have on the refrigeration circuit of a CO_2 unit?

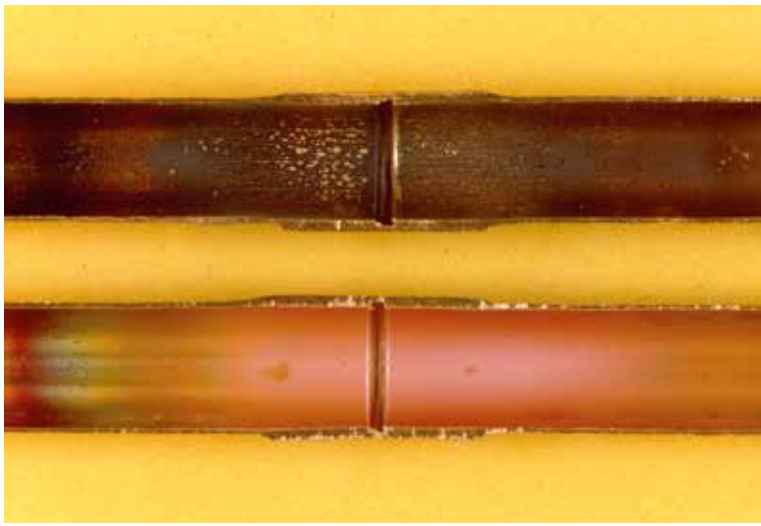
Compared with chemical refrigerants, CO_2 (R 744) has a significantly higher volumetric cooling capacity. Particularly as a gas, the volume of refrigerant transported to dissipate the same amount of heat is considerably smaller. This means that pipes that carry refrigerant are smaller. The same applies to all fitted components, such as valves, which can be – or need to be – made even smaller due to available pressure differences.

In transcritical CO_2 refrigeration units, more control valves are used than in classic F-gas refrigeration units due to the process, and also offer smaller cross-sections. Existing contamination therefore results in more interference, among other things, because valve seats are blocked by dirt or upstream filters become clogged.

Furthermore, CO_2 units nowadays are used with an oil separator that works according to the coalescence principle. A very fine filter is placed in the oil separator, which catches and collects the smallest of oil drops before dropping them into the bottom of the settling tank. This filter is three to four times smaller than common suction filters, for example, which are placed upstream of the compressor inlet. As a consequence, even the smallest of contamination gathers in the oil separator cartridge.

Different contamination also reacts together chemically in the refrigeration circuit. This means the combination of water (residual humidity) and polyolester (lubricant in the compressor) results in alcohol and acid if there is sufficient reaction heat (high compressor end temperature). The acid then in turn attacks the pipe or compressor coils without requiring much reaction heat.

Inductive solder is the solder that oxidises the least. To do so, an electromagnetic induction effect is used to generate heat. While this procedure is available to TEKO at our manufacturing facilities, it cannot be implemented on site, unfortunately.



Difference between two solder samples: with and without forming gas.

(Image: DKI)

How long does contamination stay in the refrigeration circuit?

How long the contamination stays in the refrigeration circuit depends on many circumstances and is hard to predict. It can take a relatively long time – even years – for contamination to be cleaned again.

Regular maintenance, starting shortly after starting up the unit, checking the degree of contamination on the filter and cleaning or replacing the filter inserts as appropriate **will...**

- **result in lower interference frequency;**
- **increase the efficiency of the refrigeration unit;**
- **improve the durability of all components.;**
- **result in a longer system service life.;**

Heavily contaminated, damaged sieve

New sieve

Reinforced sieve

What effects does contamination have on the refrigeration unit?

Generally speaking, there is significantly higher wear on all moving parts as a result of contamination in the refrigeration unit. The clogging of diffusers and sieves increases the pressure drops and results in a higher energy requirement.

Filters and sieves

Filters and sieves catch a great deal of dirt particles from the refrigeration circuit. However, depending on the filter width and size of the dirt particles, not all contamination can be caught from the refrigeration circuit.

When catching dirt, filters and sieves may degrade over time. This may result in higher pressure drops until the unit fails altogether in the worst case scenario.

What does this mean for running a unit? **An increased pressure drop may cause the unit's cooling capacity to fail**. By implication, this results in the unit consuming more power and therefore **more electricity is required**. These losses of efficiency represent **an economic disadvantage for operators.**

If, for example, a filter in the liquid line degrades, it may result in the refrigerant expanding too soon. The evaporator is no longer sufficiently charged with liquid and cooling is insufficient.

Another possible scenario is for the entire unit to fail as a result of blocked filters and sieves. This usually results in costly service interventions and, in the worst case scenario, to damaged goods and significant financial losses.

In our example image – "heavily contaminated, damaged sieve" – the pressure drop was so high that the sieve was compressed. The valve function is no longer assured. So that sieves can withstand higher pressure differences in future, we have developed a reinforced model with our suppliers (see "reinforced sieve" image).

Oil regulating system

The **finest filter** in modern CO_2 cooling systems is usually the **coalescing cartridge in the oil separator. This is where most contamination is found.** Pressure drops caused by the contamination can easily result in the **filter in the cartridge rupturing**. This results in the **separator in the coalescing cartridge no longer working and the oil** in the entire refrigeration circuit **becomes contaminated**.

The effect of the oil at lubrication points (pistons, bearings, valve seats) is dramatically affected by dirt particles. This increases wear significantly, which in turn creates further contamination. The **compressor is exposed to significantly higher wear. Damaged valve seats result in valves no longer closing or working correctly.**

It is extremely important to fill the refrigeration circuit with the **correct volume of oil**. **Overfilling or underfilling can cause further contamination** and damage **within the unit**.

The oil needs a certain period of time, depending on the unit run time and the range of the pipe network, before it flows back through the circuit to the compressor. **If the compressor requires lubricating at any moment when insufficient oil has been transported back again, this results in material wear** within the compressor pistons and valve reeds.

If the refrigeration circuit has been overfilled, the oil may surge back into the compressor through the suction line. The **compressor cannot process too much oil**. Compressor failures caused by oil saturation are often the result. A high volume of oil on heat exchangers also minimises the unit's capacity.

Plate heat exchangers

Plate heat exchangers have **very small channels** that can **easily become clogged by dirt**. This can lead to a **drop in the system performance** or, if completely blocked, in a unit failure.

Valves

If valves become clogged with dirt particles, over time, less refrigerant can pass through the valves and their **control accuracy decreases**. When the valve is completely closed, **the valve drive no longer has sufficient force to operate the valve**. This may result in the **unit failing partially or completely**.

Using an injection valve as an example, the affected evaporator would fail while the rest of the unit would continue to operate.

But the opposite can also happen. Valves can be so affected by dirt particles that they no longer close properly. A f**ixed expansion valve carries the risk of unwanted internal leaks** or even liquid surges in the compressor. A non-closing solenoid valve on the oil level regulator may result in overfilled oil and thus result in oil surges in the compressor.

Have you seen our YouTube channel yet?

In our video podcasts, we use examples to share helpful content and tips and tricks that may make one or two of your work processes easier.

Subscribe to our "TEKO Kältetechnik" channel and always stay up-to-date!

As an example, you'll find our video on replacing a coalescing cartridge here:
https://youtu.be/HIyRTmxUzWc

How can I detect contamination?

A good indicator for determining the degree of contamination in a unit is to look at and **analyse the filter cartridges**.

New coalescing cartridge

When changing the filter cartridge, cut it open and look at the sieve. We recommend photographing the sieve and therefore documenting the degree of contamination. Has the degree of contamination improved following the last change? This is an indication that contamination is reducing in the unit.

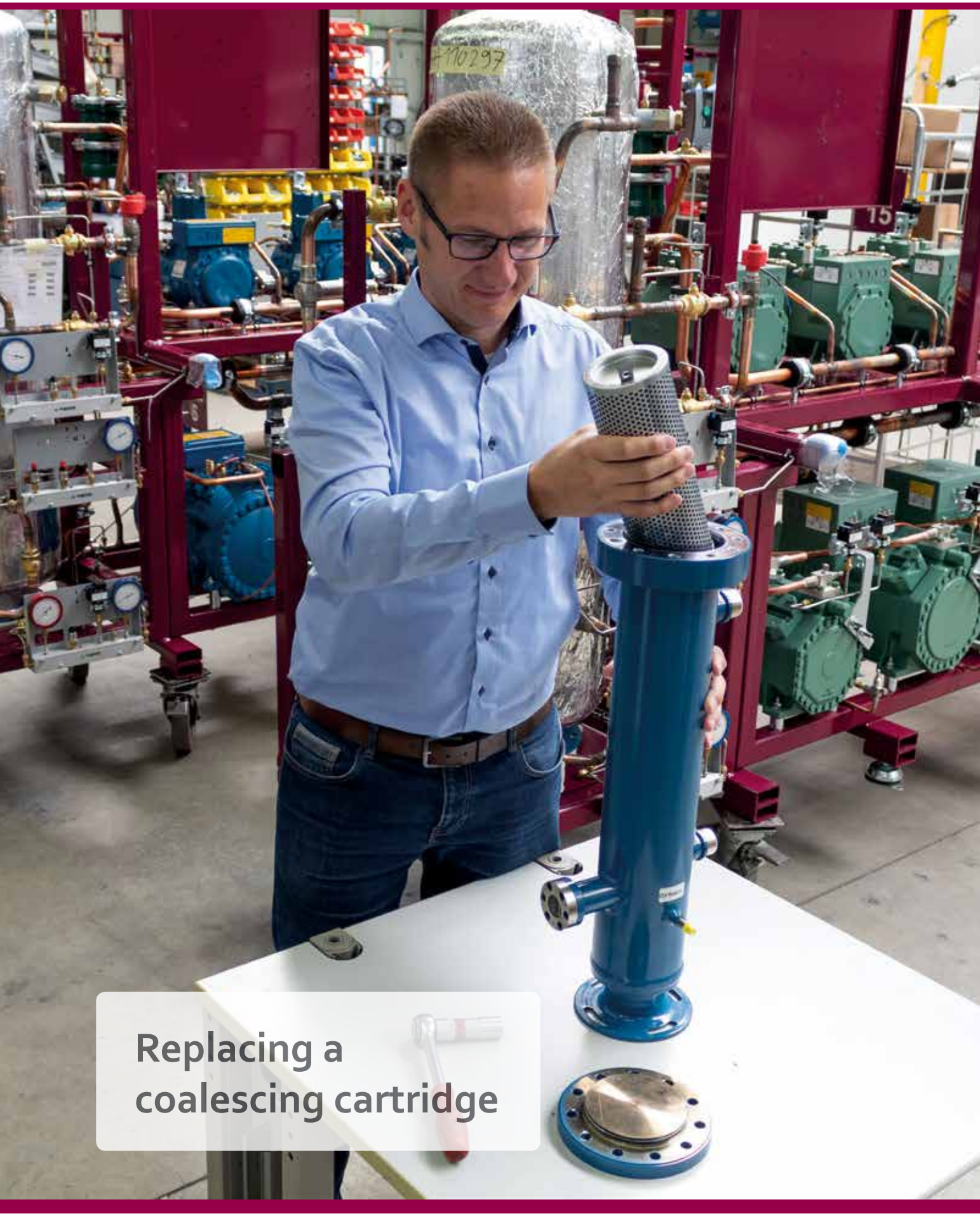
Slightly contaminated coalescing cartridge

Contaminated & ripped coalescing cartridge

Whenever cleaning the unit, also check the prism sight glasses on oil level regulators and oil separators.

Do you often receive <u>error messages</u> that relate to <u>oil management</u>? If this is the case, the condition of the oil in the unit must be checked immediately (volume/contamination).

If the oil is coloured, this is a definite sign that the unit is contaminated. This can usually be seen via the oil sight glasses. In some cases, dirt particles sink in oil so a visual inspection via the sight glasses alone is insufficient. During maintenance, we therefore recommend taking an oil sample from the compressor and running a comparison with fresh oil.



Replacing a coalescing cartridge

What's the best way to minimise contamination in a refrigeration unit?

Soldering with forming gas

We recommend using forming gas when soldering on site to prevent unwanted scale from forming.

Regularly changing the filters in the unit.

Change the filters after start-up and every time the unit is maintained or serviced. These are the specific filters to change:

- **Coalescing cartridge**
- **Filter-dryer**
- **Suction filter**
- **Oil filter**
- **Filter sieves, e.g. upstream of the high-pressure valves**

Check the filter for the degree of contamination, as described under "Analysing the filter cartridges". Even when operating the refrigerating unit normally, dirt is created through wear. Therefore, even after changing filter cartridges that were clean, there may still be dirt.

Handling components before installation

Carefully seal all components during storage and transportation. Humidity and water are also considered unit contamination.

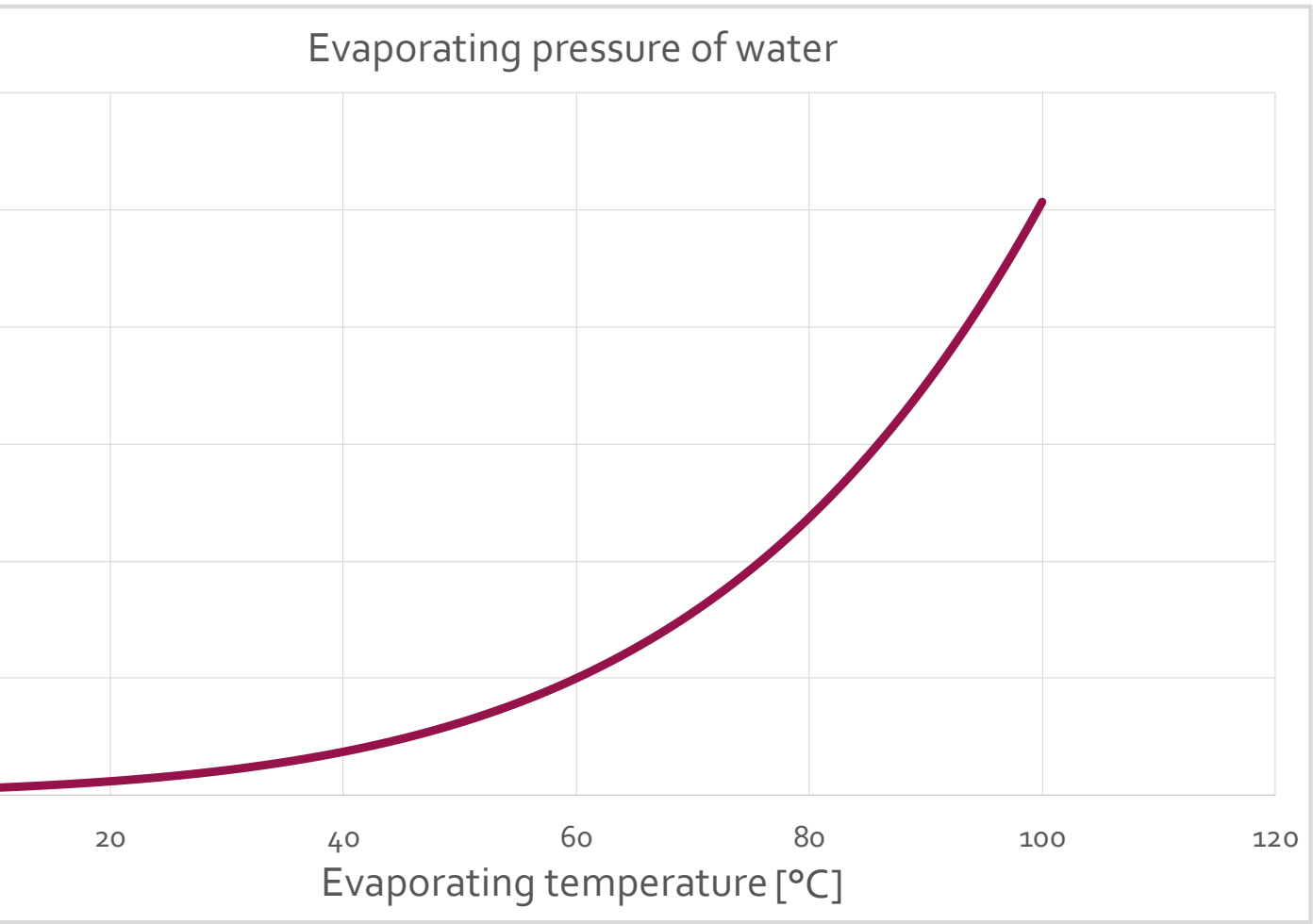
We therefore recommend that the unit is fully evacuated prior to start-up. Always take note of the vacuum pressure. It must be significantly below the ambient temperature (see the vapour pressure curve).

All components must be cleaned prior to installation. Cut or stored pipes must be thoroughly dusted and heat-exchanger surfaces must be cleaned.

Last but not least

Contamination may result in considerable malfunctions, and even damage and system failures. We therefore recommend working as cleanly as possible and when operating the unit, always monitor the degree of contamination and take action if necessary.

This will allow you to continue to enjoy your refrigeration unit for a long time to come.



TEKO Gesellschaft für Kältetechnik mbH
Carl-Benz-Straße 1
63674 Altenstadt
Germany

Tel.: +49 (0) 60 47 / 96 30-100
Fax: +49 (0) 60 47 / 96 30-100
info@teko-gmbh.com
www.teko-gmbh.com

E: Version 1 – August 2019