WE SAY: THE INNER VALUES COUNT!

TECHNICAL MANUAL
DIAPHRAGM EXPANSION VESSELS

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### Information to standards

Mentioned and quoted standards refer to the following versions:

- EN 12828:2013-01-01 Heating systems in buildings - Design for water-based heating systems
- ÖNORM H 5151-1:2010-12-15 Planung von zentralen Warmwasser-Heizungsanlagen mit oder ohne Warmwasserbereitung - Teil 1
- ÖNORM H 5155:2013-09-01 Wärmedämmung von Rohrleitungen und Komponenten in haustechnischen Anlagen
- ÖNORM M 7777-2:2013-09-01 Solarthermische Anlagen - Teil 2

### Disclaimer

We improve our products permanently and so we reserve the right to make modifications anytime and without previous announcements. We assume no warranty for correctness or completeness of the present document. Any claims, particularly claims for damages and loss of profit or financial losses must be excluded!
1. General

1.1 Operating principle and construction

Sealed diaphragm expansion vessels are safety devices for systems which use a liquid heat transfer medium - primarily water - to transport heat resp. cold to the particular loads.

A diaphragm expansion vessel consists of 2 chambers, which are divided by a high-quality membrane. In EDER expansion vessels this membrane is designed as a bag and encloses the medium completely. There is no contact between the medium and the metal wall of the vessel, thus corrosion is avoided.

The water chamber stores the change in water volume due to heating up. In case of cooling down the pressure inside the gas chamber presses the medium back to the system.

figure: expansion vessel in operation

Minimum system temperature

The expansion vessel contains a water reserve.

The system temperature rises

The expansion vessel accommodates the incurring expansion volume inside the membrane.

Maximum system temperature

The expansion vessel stores the expansion volume completely

1.2 The meaning of the gas pressure

A missing resp. incorrect set gas pressure affects the complete operation of the entire system.

Therefore a individual inspection and adjustment of the gas pressure must be done prior to commissioning resp. once a year.

As mentioned above, the gas pressure shall ensure that the expansion volume is pressed back to the system in case of cooling down. Also it protects the vessel from overfilling.

If the gas pressure is missing or too small, the expansion vessel accommodates too much water at low system temperatures. In case of heating up, there is no room left for the physical expansion. Furthermore the durability of the expansion vessel is affected due to over-use of the membrane.

If the gas pressure is too high, the capacity of the vessel is reduced and the function of the system is disturbed too.

Due to the fact that the pressure in both chambers is equal, the expansion vessel must be pressure relieved when checking the gas pressure.

To check the gas pressure without draining the system, special armatures, so-called maintenance units, are available.

The gas pressure can be checked with a conventional tire-pressure gauge.

The necessary pressure within the gas chamber depends on the static height above the connection point of the expansion vessel.

If the temperature is above 100°C, the gas pressure must be increased by the value of the vapour pressure.
In this case the membrane must be protected from excessive temperature too.

After adjusting the gas pressure to the plant, the system can be filled to the adequate system pressure.

The detailed sizing procedure is described in Section 3.

1.3 Application

The main applications of diaphragm expansion vessels are
- central heating systems
- climatic and cold water systems
- solar systems
- drinking and service water systems
- water hammer arrestors
- etc.

2. Product overview

- Heating, climatic and cold water systems
- Heating, solar, cold water
- Sanitary systems
- Refrigeration systems
- Solar systems
3. Sizing

The Sizing of expansion vessels is made according to relevant standards, for example EN 12828. A too small resp. incorrect sized expansion vessel affects the function of the system just as a incorrect set gas pressure.

If the expansion vessel is too small, it is unable to store the entire expansion volume. In case of heating up, a part of the expansion volume gets lost via the system safety valve. When cooling down, this volume is missing and the pressure falls below its minimum value. Negative pressure arises and the system sucks air via various components (stuffing boxes, air vents etc.). Corrosion and circulation problems are the consequences. To ensure a proper function, special attention must be paid to the correct sizing of the expansion vessel.

3.1 Safety expansion vessels for heating, climatic and cold water systems

3.1.1 hydraulic connection

example: elko-flex eder safety expansion vessel in hanging position

![Diagram of the hydraulic connection](image)

elko-flex eder safety expansion vessels for sealed systems are sized according to the standard EN 12828 „Heating systems in buildings“.

A correct and sufficient sizing ensures a trouble-free operation of the system.

elko-flex eder safety expansion vessels store the temperature-dependent changes in water volume in sealed heating, climate and cold water systems with a maximum operating pressure of 3, 5, 6 resp. 10 bar and a maximum operating temperature of 90 °C (max. long-term temperature of the vessel is 70 °C). If the max. operating temperature is higher (max. 110 °C), an EV cooling vessel (compare „accessory“) must be installed. This cooling vessel ensures an adequate cooling of the expansion volume before it gets into the expansion vessel.

According to ÖNORM H 5151-1 the use of more than one diaphragm expansion vessels must be avoided.
The recommended connection point of the safety expansion vessel is the (pressure-)neutral point in the pipe system. At this point the static resp. the final pressure is constant, independent from the operation of the circulation pumps. The position of the integration point should be chosen in such a way that the pressure on the suction side of the circulation pump is sufficient for operation, e.g. avoiding cavitation, and high temperatures affecting the diaphragm of the expansion vessel.

### 3.1.2 Sizing of diaphragm expansion vessels according to EN 12828*:

* In Austria the standard ÖNORM H 5151-1 may also be applied as a supplement to EN 12828.

The size of the diaphragm expansion vessel depends on:

- the total content of the system \( V_{\text{System}} \)
- the static height \( h_{\text{st}} \)
- the final pressure \( p_{\text{fin}} \)
- the density \( \rho \) of the used medium, depending on the lowest and the maximum set operation temperature

Calculation of the **gas pressure (minimum operating pressure)** \( p_0 \) in the System:

\[
p_0 = p_{\text{fin}} + 0,2 + p_V
\]

\( p_{\text{fin}} \): final pressure

\( p_V \): vapour pressure at temperature \( \vartheta_{\text{max}} \)

Generally, specific values for the vapour pressure are values for pure water without any antifreeze additives (see table 3)

\( V_{\text{ex}} \): expansion volume

\( V_{\text{WR}} \): real water reserve volume in the pressure vessel used.

Additional requirements of other system components need to be taken into consideration. An addition of at least 0,2 bar to the static height is recommended.

\( p_{\text{st}} \): static height pressure - pressure only resulting from the difference in height \( h_{\text{st}} \) between the position of the pressurization system and the highest point of the heating system.

\( p_{\text{ini}} \): initial pressure

\( p_{\text{ini}} \): initial pressure

10 meter water column (mWs) ~ 1 bar

Operating band of the pressurization system

### Illustration of the different pressure levels:

- \( p_{\text{ini}} \)
- \( p_{\text{fin}} \)
- \( p_{\text{FAZ}} \)
- \( p_0 \)
- \( p_V \)
- \( p_{\text{st}} \)

\( \vartheta_{\text{max}} \): maximum set system temperature

\( \vartheta_{\text{min}} \): lowest system temperature

\( p_{\text{FAZ}} \): pressure at which the pressure limiter operates.

\( p_{\text{ini}} \): filling pressure - required pressure in the system if the lowest possible temperature is not given. (for filling of make-up)
calculation example:
(sealed heating system with $\theta_{\text{max}} = 95 ^\circ \text{C}$)

The water column above the expansion vessel is 7 m. How large does the gas pressure $p_0$ have to be?

solution:
given: $h = 7 \text{ mWS} \rightarrow p_a = 0,7 \text{ bar}$
$v = 0 \text{ bar}$

asked for: $p_0$

$p_0 = p_a + 0,2 + p_v = 0,7 + 0,2 + 0 = 0,9 \text{ bar}$

The gas pressure $p_0$ within the vessel must be 0,9 bar.

Later the total content of the system $V_{\text{System}}$ must be determined. It is the total content of the pipework, heat emitters, heat generators and connected auxiliary circuits. Where it is not feasible to make an accurate calculation, extra care should be taken in estimating the volume.

If the volumes of the individual components are unknown, the volume of the system can be determined approximately by using the nominal power of the heat generator and the plant-specific water content $f_w$ (table 1).

$$V_{\text{System}} = f_w \times \Phi_{\text{NL}}$$

$\Phi_{\text{NL}}$ max. power of the heat generator [kW]

$f_w$ plant-specific water content [l/kW]

(table 1)

The expansion volume $V_{\text{ex}}$ is the increase in volume caused by temperature increase between the lowest possible temperature of the heating system and the maximum set operating temperature of the heat generator.

$V_{\text{ex}}$ is determined by using the expansion coefficient $e$:

$$V_{\text{ex}} = V_{\text{System}} \times e$$

$$e = 1 - \frac{\rho_{\text{max}}}{\rho_{\text{min}}}$$

$\rho_{\text{max}}$ density of the medium at the maximum set operating temperature of the heat generator [kg/m$^3$] (table 5)

$\rho_{\text{min}}$ density of the medium at the lowest system temperature [kg/m$^3$] (table 5)

Note: The density of water (table 5) will be affected by the density of additive substances (e.g. antifreeze additives).

Usually the lowest system temperature is equal to the filling temperature of 10 °C.

Used additive substances can affect the material of the diaphragm!

calculation example:

How large is the expansion volume of a sealed heating system with convectors and a nominal power of $\Phi_{\text{NL}} = 30 \text{ kW}$?

solution:
given: $\Phi_{\text{NL}} = 30 \text{ kW}$
$f_w = 9 l/kW$ (acc. to table 1)
$\theta_{\text{max}} = 95 ^\circ \text{C}$

asked for: $V_{\text{ex}}$

$$V_{\text{System}} = f_w \times \Phi_{\text{NL}} = 9 \times 30 = 270 l$$

$$e = 1 - \frac{\rho_{\text{max}}}{\rho_{\text{min}}} = 1 - \frac{950,7}{999,7} = 4,9 \%$$

$$V_{\text{ex}} = V_{\text{System}} \times e = 270 \times 4,9 \% = 13,23 l$$

The expansion volume is 13,23 l.
In addition to the expansion volume, the expansion vessel should have a minimal water reserve.

The water reserve $V_{WR}$ compensates possible water losses in the system. Expansion vessels with a nominal volume up to 15 l should accommodate at least 20% of this volume as a water reserve. Expansion vessels with a nominal volume greater than 15 l should accommodate a water reserve of at least 0.5% of the total content of the system, however, at least 3 l.

\[
V_{WR} = \frac{V_N \times 20}{100} \quad \text{if } V_N \leq 15 \text{ l}
\]

\[
V_{WR} = \frac{V_{\text{System}} \times 0.5}{100} \geq 3 \quad \text{if } V_N > 15 \text{ l}
\]

$V_{WR}$ water reserve [l]
$V_N$ nominal volume of the expansion vessel [l]
$V_{\text{System}}$ total content of the system [l]

**calculation example:**

How large does the water reserve $V_{WR}$ have to be, if the total content of the heating system is 1.050 litres?

**solution:**

given: $V_{\text{System}} = 1.050$ litres

asked for: $V_{WR}$

Note: Due to the total content of the system it can be assumed that the nominal volume of the expansion vessel is greater than 15 litres!

\[
V_{WR} = \frac{V_{\text{System}} \times 0.5}{100} = \frac{1.050 \times 0.5}{100} = 5.25 \text{ l}
\]

The water reserve $V_{WR}$ is 5.25 litres.

The final pressure $p_{fin}$ indicates the highest pressure in the operating range of the heating system. It should not be higher than the set pressure of the safety valve minus a difference in shut-off overpressure, the so-called closing pressure difference $p_{SD}$.

According to EN ISO 4216-1 a closing pressure difference of 20%, at least 0.6 bar is admissible.

\[
p_{SD} = p_{SV} \times 20\% \geq 0.6 \text{ bar}
\]

\[
p_{fin} = p_{SV} - p_{SD}
\]

$p_{SD}$ closing pressure difference [bar]
$p_{SV}$ set pressure of the safety valve [bar]
$p_{fin}$ final pressure [bar]

Note: The standard ÖNORM H 5151-1 specifies the closing pressure difference $p_{SD}$ with 10% of the set pressure (blow-off pressure) $p_{SV}$ of the safety valve, at least 0.5 bar.

Usually in Austria the **minimum set pressure of the safety valve $p_{SV}$** is defined with 2 bar above the static pressure $p_{stat}$, at least 3 bar!

\[
p_{SV} = p_{stat} + 2 \geq 3 \text{ bar}
\]

**calculation example:**

How large is the final pressure $p_{fin}$ in a sealed heating system with a static height of 7 m?

**solution:**

given: $h_{stat} = 7$ mWs $\rightarrow$ $p_{stat} = 0.7$ bar

asked for: $p_{fin}$

\[
p_{SV} = p_{stat} + 2 = 0.7 + 2 = 2.7 \text{ bar}
\]

The minimum value is 3 bar $\rightarrow$ $p_{SV} = 3$ bar

\[
p_{fin} = p_{SV} - p_{SD} = 3 - 0.6 = 2.4 \text{ bar}
\]

The final pressure $p_{fin}$ is 2.4 bar.
Calculation of the minimum nominal volume $V_{N,min}$ of diaphragm expansion vessels:

$$V_{N,min} = (V_{ex} + V_{WR}) \times \frac{p_{fin} + 1}{p_{fin} - p_0}$$

- $V_{N,min}$: minimum nominal volume [l]
- $V_{ex}$: expansion volume [l]
- $V_{WR}$: water reserve [l]
- $p_{fin}$: final pressure [bar]
- $p_0$: gas pressure [bar]

**Calculation example:**

Calculate the necessary nominal volume $V_{N,min}$ and the gas pressure $p_0$ for a diaphragm expansion vessel in a system with a total content of $V_{System} = 320$ l and a static height of $h_s = 8$ mWs. The maximum operating temperature is $\theta_{max} = 95 \, ^\circ C$.

**Solution:**

- Given: $V_{System} = 320$ litres, $h_s = 8$ mWs $\Rightarrow p_s = 0,8$ bar, $\theta_{max} = 95 \, ^\circ C$
- Asked for: $V_{N,min}$, $p_0$

**Determination of the gas pressure $p_0$:**

$$p_0 = p_s + 0,2 + p_v = 0,8 + 0,2 + 0 = 1 \, \text{bar}$$

**Determination of the set pressure $p_{SV}$:**

$$p_{SV} = p_s + 2 = 0,8 + 2 = 2,8 \, \text{bar}$$

The minimum value is $3 \, \text{bar} \Rightarrow p_{SV} = 3 \, \text{bar}$

**Determination of the final pressure $p_{fin}$:**

$$p_{fin} = p_{SV} - p_{SD} = 3 - 0,6 = 2,4 \, \text{bar}$$

**Determination of the expansion volume $V_{ex}$:**

$$V_{ex} = V_{System} \times e = 320 \times 3,8 \% = 12,2 \, \text{l}$$

**Determination of the water reserve $V_{WR}$:**

Due to the total content of the system it can be assumed that the nominal content of the expansion vessel is greater than 15 litres.

$$V_{WR} = \frac{V_{System} \times 0,5}{100} = \frac{320 \times 0,5}{100} = 1,6 \, \text{l}$$

The minimum value is $3 \, \Rightarrow V_{WR} = 3 \, \text{l}$

**Determination of $V_{N,min}$:**

$$V_{N,min} = (V_{ex} + V_{WR}) \times \frac{p_{fin} + 1}{p_{fin} - p_0}$$

$$V_{N,min} = (12,2 + 3) \times \frac{2,4 + 1}{2,4 - 1} = 36,8 \, \text{l}$$

The required expansion vessel has to have a minimum nominal volume of 36,8 litres.

During commissioning the gas pressure must be set to 1,0 bar.

**Selection and correct sizing of the diaphragm expansion vessel:**

$$V_N \geq V_{N,min}$$

For diaphragm expansion vessels the initial pressure $p_s$ shall be confirmed for the selected vessel as follows:

$$p_{ri} = \frac{p_{fin} + 1}{1 + \frac{V_{ex}}{V_n} \times \frac{p_{fin} + 1}{p_0 + 1}} - 1$$

The correct sizing of the expansion vessel is ensured as long as:

$$p_{ri} \geq p_0 + 0,3 \, \text{bar}$$

Otherwise the nominal volume $V_n$ should be increased until the condition above is met.
calculation example:

Using the determined nominal volume, the expansion vessel can be selected from the tables in section “technical data”. It should be noted that the next larger expansion vessel must be selected!

solution:
given: \( V_{N,\text{min}} = 36.8 \text{ l} \)
asked for: appropriate expansion vessel

→ selected vessel: elko-flex eder N 50
nominal volume \( V_{N} \): 50 litres
max. operating pressure: 3 bar
max. long-term temperature: 70°C

\[
p_{\text{el}} = \frac{\frac{V_{\text{ex}}}{V_{N}} + 1}{1 + \frac{\frac{V_{\text{ex}}}{V_{N}} + 1}{\frac{V_{\text{el}}}{p_{0}} + 1}} - 1 = 1.41 \text{ bar}
\]

\[
p_{\text{el}} \geq p_{0} + 0.3 \text{ bar}
\]

\[
p_{\text{el}} \geq 1 + 0.3 \text{ bar} = 1.3 \text{ bar}
\]

The required term is fulfilled, the selected elko-flex eder N50 can be used.

Note: According to ÖNORM H 5151-1 a pump-controlled pressurization device is state of the art in larger systems (nominal power 100 kW and higher, total content 5000 litres and higher or 100 m² solar collector area).

The nominal volume \( V_{N,\text{min}} \) of these expansion vessels is determined as follows (acc. to EN 12828):

\[
V_{N,\text{min}} = (V_{\text{ex}} + V_{\text{WR}}) \times \frac{1}{\eta}
\]

\( \eta \) utilization efficiency of the expansion vessel (at pressureless elko-mat eder expansion vessels → \( \eta = 100 \% \))

The filling pressure \( p_{\text{fil}} \) is the required pressure in the system if the lowest possible temperature \( \theta_{\text{min}} \) is not given (for filling of water make-up).

\[
p_{\text{fil}} = \frac{V_{N} \times \frac{p_{0} + 1}{V_{N} - V_{\text{System}} \times \left(1 - \frac{p_{\text{fil}}}{p_{\text{min}}}\right) - V_{\text{WR}}}}{V_{N} \times \frac{p_{0} + 1}{V_{N} - V_{\text{System}} \times \left(1 - \frac{p_{\text{fil}}}{p_{\text{min}}}\right) - V_{\text{WR}}} - 1}
\]

\( p_{\text{fil}} \) filling pressure [bar]
\( p_{0} \) gas pressure [bar]
\( V_{N} \) nominal volume of the expansion vessel [l]
\( V_{\text{System}} \) total content of the system [l]
\( V_{\text{WR}} \) water reserve [m³]
\( p_{\text{fil}} \) density of the medium at the current system temperature during fill or make-up process [kg/m³] (table 5)
\( p_{\text{min}} \) density of the medium at the lowest system temperature [kg/m³] (table 5)

calculation example:

Determine the filling pressure \( p_{\text{fil}} \) for the above mentioned system.

solution:
given: \( p_{0} = 1 \text{ bar} \)
\( V_{N} = 50 \text{ litres} \)
\( V_{\text{System}} = 320 \text{ litres} \)
\( V_{\text{WR}} = 3 \text{ litres} \)
\( \theta_{\text{fil}} = 60^\circ \text{C} \)

asked for: filling pressure \( p_{\text{fil}} \) of the system

\( \theta_{\text{fil}} = 60^\circ \text{C} \)

→ \( p_{\text{fil}} = 983.1 \text{ kg/m³} \)

\[
p_{\text{fil}} = \frac{V_{N} \times \frac{p_{0} + 1}{V_{N} - V_{\text{System}} \times \left(1 - \frac{p_{\text{fil}}}{983.1}\right) - V_{\text{WR}}}}{V_{N} \times \frac{p_{0} + 1}{V_{N} - V_{\text{System}} \times \left(1 - \frac{p_{\text{fil}}}{999.7}\right) - V_{\text{WR}}} - 1}
\]

\[
p_{\text{fil}} = 50 \times \frac{1 + 1}{50 - 320 \times \left(\frac{983.1}{999.7}\right)} - 3
\]

\( p_{\text{fil}} = 1.24 \text{ bar} \)

The filling pressure \( p_{\text{fil}} \) is 1.24 bar.
In ÖNORM H 5151-1 the filling pressure $p_a$ is determined as follows:

To ensure that the diaphragm expansion vessel can accommodate the water reserve in the cold state of the system, the filling pressure must be at least equal to the value $p_{a,\text{min}}$:

$$p_{a,\text{min}} = \frac{V_N x (p_s + 1)}{V_N - V_V} - 1$$

$p_s$ relative gas pressure ($p_s + 0.3 \geq 1.0$ bar)

$V_V$ water reserve $\triangleq V_{\text{WR}}$ in EN 12828

The filling pressure must not exceed the value $p_{a,\text{max}}$:

$$p_{a,\text{max}} = \frac{p_s + 1}{1 + \frac{V_N x (p_s + 1)}{V_N x (p_s + 1)}} - 1$$

$p_s$ final pressure $\triangleq p_s$ in EN 12828

$V_s$ expansion volume $\triangleq V_{\text{ex}}$ in EN 12828

$p_V$ relative gas pressure ($p_V + 0.3 \geq 1.0$ bar)

The filling pressure must be confirmed with the following term:

$$p_{a,\text{max}} \geq p_{a,\text{min}} + 0.2$$

$p_{a,\text{max}}$ max. filling pressure of the cold system

$p_{a,\text{min}}$ min. filling pressure of the cold system

If this term is not fulfilled, the next larger expansion vessel must be selected and confirmed.

Note: The real filling pressure of the system should be between the minimum filling pressure $p_{a,\text{min}}$ and the maximum filling pressure $p_{a,\text{max}}$.

The correct and adequate sizing is essential for a problem-free function of the system.

3.1.3 Sizing of the expansion pipe acc. to ÖNORM H 5151-1:

The following point must be considered:

- To determine the dimension of the expansion pipe the nominal power of the heat generator must be known.
- For systems with a nominal power lower than 500 kW the minimum dimensions can be taken from table 2.
- The maximum flow rate within the expansion pipe must not exceed 0.15 m/s.

Note for the insulation of the expansion pipe:
According to ÖNORM H 5155 expansion pipes must only be insulated up to 10 cm from the connection to the system return.
3.2 Expansion vessels for warm water sanitary systems

elko-san eder San D series expansion vessels are mainly used in sealed warm water sanitary systems.

They prevent opening and thus the crusting of the safety valves during preparation of warm water, precious water can’t get lost during heating-up. Due to the special construction the water can flow through the vessel. Therefore the increasing hygienic requirements get fulfilled. The diaphragm is made of food-safe and tasteless material, connection and flange are made of stainless steel.

An adequate sizing ensures the compliance of the points mentioned above and guarantees a problem-free operation.

To calculate an elko-san eder San D series expansion vessel the following technical specifications of the systems are necessary:

- volume of the water boiler
- max. warm water temperature
- inlet pressure (set pressure of the pressure reducing valve)
- set pressure of the safety valve

The adjoining diagrams can be used to simplify the sizing of elko-san eder San D expansion vessels.

The diagrams are based on a gas pressure of 0,2 bar lower than the idle pressure of the water supply. The reduced volume of the vessel, caused by the water reserve resp. expansion factors acc. to standard is already considered.

After sizing and selection of the expansion vessel the relevant accessory can be selected.

Caution: elko-san eder San D expansion vessels are installed to the system via 2 pcs. elko-flex eder maintenance units.

The gas pressure (acc. to the calculation) must be set during commissioning.

selection diagram 1

set pressure of the safety valve: 6 bar
inlet pressure (press. reducing valve): 3,7 bar
gas pressure within the expansion vessel: 3,5 bar

selection diagram 2

set pressure of the safety valve: 6 bar
inlet pressure (press. reducing valve): 2,7 bar
gas pressure within the expansion vessel: 2,5 bar
3.3 Safety expansion vessels for refrigeration systems

elko-flex eder Cool series safety expansion vessels are designed to use in refrigeration systems (cold water systems, chillers)

The diaphragms are resistant to common antifreeze fluids based on glycol. The connection flange is made of stainless steel.

3.3.1 hydraulic connection

elko-flex eder Cool series safety expansion vessels are designed for wall mounting. Generally the vessel is installed with the connection on the bottom and a pipe loop to the system return. Thus the diaphragm is protected against too cold temperatures in refrigeration systems.

The operating temperature of elko-flex eder Cool safety expansion vessels is between -10 °C und +70 °C. Outside of this range the vessel must be protected with an EV cooling vessel.

The expansion pipe must be installed in a way that no cushion air can be enclosed. Otherwise a proper venting device must be installed.

3.3.2 Sizing of safety expansion vessels for refrigeration systems*

* sizing follows EN 12828.

To ensure maintenance without emptying the system, the vessel must be installed with a maintenance unit.

example: elko-flex eder Cool

To calculate an elko-flex eder Cool series safety expansion vessel the following technical specifications of the system are necessary:

- total content of the refrigeration system $V_{System}$ [l]
- max. ambient temperature $T_{max}$ which can occur at standstill of the cold generator [°C]
- min. temperature $T_{min}$ in the refrigeration system, corresponds to the lowest flow temperature of the cold generator [°C]
- static height pressure $p_{st}$ [mWs]
- max. operating pressure $p_{sv}$ of the system [bar]
The correct gas pressure $p_0$ (minimum operating pressure) avoids low pressure (with the result of diffusion etc.) in low temperature situations of normal operating systems. Therefore an addition to the static height pressure $p_s$ should be considered preventively, whereby the minimum operating pressure is higher than necessary.

$$p_0 = p_s + 0.2$$

- $p_0$: min. operating pressure [bar]
- $p_s$: static height pressure - pressure only resulting from the difference in height $h_s$ between the position of the pressurization system and the highest point of the refrigeration system
- 10 meter water column (mWs) $≈$ 1 bar

Calculation of the expansion volume $V_{ex}$:

$$V_{ex} = V_{system} \times e$$

$$e = 1 - \frac{\rho_{\text{max}}}{\rho_{\text{min}}}$$

- $e$: expansion coefficient
- $\rho_{\text{max}}$: density of the medium (e.g. water/antifreeze mix) at ambient temperature [kg/m³] (table 5)
- $\rho_{\text{min}}$: density of the medium at the lowest flow temperature [kg/m³] (table 5)

Used additive substances can affect the material of the diaphragm!

Calculation of the water reserve $V_{WR}$:

$$V_{WR} = \frac{V_N \times 20}{100} \quad \text{if } V_N \leq 15 \text{ l}$$

$$V_{WR} = \frac{V_{system} \times 0.5}{100} \geq 3 \quad \text{if } V_N > 15 \text{ l}$$

- $V_{WR}$: water reserve [l]
- $V_N$: nominal volume of the expansion vessel [l]
- $V_{system}$: total content of the system [l]

Usually in Austria the minimum set pressure of the safety valve $p_{sv}$ is defined with 2 bar above the static pressure $p_s$, at least 3 bar!

$$p_{sv} = p_s + 2 \geq 3 \text{ bar}$$

The final pressure $p_{fin}$ indicates the highest pressure in the operating range of the refrigeration system. It should not be higher than the set pressure of the safety valve minus a difference in shut-off overpressure, the so-called closing pressure difference $p_{SD}$.

According to EN ISO 4216-1 a closing pressure difference of 20%, at least 0.6 bar is admissible.

$$p_{SD} = p_{sv} \times 20 \% \geq 0.6 \text{ bar}$$

$$p_{fin} = p_{sv} - p_{SD}$$

- $p_{SD}$: closing pressure difference [bar]
- $p_{sv}$: set pressure of the safety valve [bar]
- $p_{fin}$: final pressure [bar]

Note: The standard ÖNORM H 5151-1 specifies the closing pressure difference $p_{SD}$ with 10% of the set pressure (blow-off pressure) of the safety valve, at least 0.5 bar.

Calculation of the minimum nominal volume $V_{N_{min}}$ of diaphragm expansion vessels:

$$V_{N_{min}} = \frac{(V_{ex} + V_{WR}) \times (p_{fin} + 1)}{p_{fin} - p_0}$$

- $V_{N_{min}}$: minimum nominal volume [l]
- $V_{ex}$: expansion volume [l]
- $V_{WR}$: water reserve [l]
- $p_{fin}$: final pressure [bar]
- $p_0$: gas pressure [bar]

Selection and correct sizing of the diaphragm expansion vessel:

$$V_N \geq V_{N_{min}}$$
For diaphragm expansion vessels the initial pressure \( p_{ini} \) shall be confirmed for the selected vessel as follows:

\[
p_{ini} = \left( \frac{p_0 + \frac{1}{V_{N}} + \frac{1}{V_N \times p_{ini} + 1}}{\frac{p_0 + 1}{p_0 + 1}} - 1 \right)
\]

The correct sizing of the expansion vessel is ensured as long as:

\[
p_{ini} \geq p_0 + 0.3 \text{ bar}
\]

Otherwise the nominal volume \( V_N \) should be increased until the condition above is met.

During \textit{filling of cold water systems} special attention must be paid to the current operating mode of the system. It must be differentiated whether the system gets filled for the first time or a make-up process takes place (e.g. during maintenance).

Calculation of the \textbf{filling pressure} \( p_{fil} \) for the first fill of a cold water system:

\[
p_{fil} = V_N \times \left( \frac{p_0 + 1}{V_N - V_{System} \times \left( 1 - \frac{\rho_{def}}{\rho_{min}} \right) - V_{WR}} \right)
\]

\( p_{fil} \) filling pressure \([ \text{ bar }]\)

\( p_0 \) gas pressure \([ \text{ bar }]\)

\( V_N \) nominal volume of the expansion vessel \([ \text{ l}]\)

\( V_{System} \) total content of the system \([ \text{ l}]\)

\( V_{WR} \) water reserve \([ \text{ m}^3]\)

\( \rho_{def} \) density of the medium at filling temperature \([ \text{ kg/m}^3]\) (table 5) *

\( \rho_{min} \) density of the medium at the lowest flow temperature \([ \text{ kg/m}^3]\) (table 5)

* If the system gets filled with water, the filling temperature is 10 °C (in general). Depending on the storage temperature of the added antifreeze fluid the temperature of the medium could be higher.

Calculation of the \textbf{filling pressure} \( p_{erg} \) for make-up (=supplement pressure):

\[
p_{erg} = V_N \times \left( \frac{p_0 + 1}{V_N - V_{System} \times \left( 1 - \frac{\rho_{erg}}{\rho_{min}} \right) - V_{WR}} \right)
\]

\( p_{erg} \) filling pressure (=supplement pressure) \([ \text{ bar }]\)

\( p_0 \) gas pressure \([ \text{ bar }]\)

\( V_N \) nominal volume of the expansion vessel \([ \text{ l}]\)

\( V_{System} \) total content of the system \([ \text{ l}]\)

\( V_{WR} \) water reserve \([ \text{ m}^3]\)

\( \rho_{erg} \) density of the medium at the current system temperature during make-up process \([ \text{ kg/m}^3]\) (Table 5)

\( \rho_{min} \) density of the medium at the lowest flow temperature \([ \text{ kg/m}^3]\) (Tabelle 5)

\textbf{calculation example}:

Calculate the appropriate diaphragm expansion vessel for a refrigeration system:

\textbf{solution}:

given: \( h_s = 2 \text{ mWs} \rightarrow p_{st} = 0.2 \text{ bar} \)

\( V_{System} = 280 \text{ litres} \)

ethylene glycol 34 % (up to -20 °C)

\( g_{max} = 30 \text{ °C} \)

\( g_{min} = -10 \text{ °C} \)

\( p_s = 3 \text{ bar} \)

asked for: appropriate expansion vessel

filling pressure for first fill

filling pressure for make-up

\( p_0 = p_{st} + 0.2 = 0.2 + 0.2 = 0.4 \rightarrow \text{ set 1 bar} \)

\( e = 1 - \frac{\rho_{max}}{\rho_{min}} = 1 - \frac{1045}{1064} = 1.8 \% \)

\( V_{ex} = V_{System} \times e = 280 \times 0.018 = 5.04 \text{ l} \)

\( V_{WR} = \frac{V_{System} \times 0.5}{100} \geq 3 \)

\( V_{WR} = \frac{280 \times 0.5}{100} = 1.4 \text{ l} \rightarrow V_{WR} = 3 \text{ l} \)
Better heating.

Technical manual
diaphragm expansion vessels

SIZING

\[ p_{SV} = p_{a} + 2 \]
\[ = 0,2 + 2 = 2,2 \rightarrow \text{set: } p_{SV} = 3 \text{ bar} \]

\[ p_{ID} = p_{SV} \times 20 \% \geq 0,6 \text{ bar} \]
\[ = 3 \times 0,2 = 0,6 \rightarrow p_{ID} = 0,6 \text{ bar} \]

\[ p_{tn} = p_{SV} - p_{ID} = 3 - 0,6 = 2,4 \text{ bar} \]

\[ V_{N_{min}} = (V_{ex} + V_{WR}) \times \frac{p_{tn} + 1}{p_{tn} \cdot p_{0}} \]
\[ = (5,04 + 3) \times \frac{2,4 + 1}{2,4 - 1} = 19,5 \text{ l} \]

→ selected vessel: elko-flex eder Cool 25
nominal volume \( V_{n} \): 25 litres
max. operating pressure: 6 bar
max. long-term temperature: 70 °C

\[ p_{ex} = \frac{p_{tn} + 1}{1 + \frac{V_{ex}}{V_{N}} \times \frac{p_{tn} + 1}{p_{0} + 1}} - 1 \]
\[ = \frac{2,4 + 1}{1 + \frac{5,04}{25} \times \frac{2,4 + 1}{2,4 - 1}} - 1 = 4,15 \text{ bar} \]

\[ p_{ex} \geq p_{h} + 0,3 \text{ bar} \]
\[ p_{ex} \geq 1 + 0,3 \text{ bar} = 1,3 \text{ bar} \]

The required term is fulfilled, the selected elko-flex eder Cool 25 can be used.

matching maintenance unit:
elko-flex eder maintenance unit 3/4" a/i

For the first fill of the cold water system, the used medium is a water/antifreeze mix with 34 % ethylene glycol, the storage temperature is \( s_{hi} = 20 \text{ °C} \) \( \rightarrow p_{adi} = 1050 \text{ kg/m}^3 \)

\[ p_{hi} = V_{hi} \times \frac{p_{0} + 1}{V_{hi} - V_{System} \times (1 - \frac{p_{adi}}{p_{3mn}}) - V_{WR}} - 1 \]
\[ = 25 \times \frac{1 + 1}{25 - 280 \times (1 - \frac{1050}{1050})} - 3 \]

\[ p_{hi} = 1,73 \text{ bar} \]

The necessary filling pressure for first fill is 1,73 bar.

asked for: Filling pressure for make-up during annual maintenance.

During maintenance the average temperature of the cold water system is \( s_{erg} = -5 \text{ °C} \) \( \rightarrow p_{berg} = 1062 \text{ kg/m}^3 \)

\[ p_{erg} = V_{hi} \times \frac{p_{0} + 1}{V_{hi} - V_{System} \times (1 - \frac{p_{berg}}{p_{3mn}}) - V_{WR}} - 1 \]
\[ = 25 \times \frac{1 + 1}{25 - 280 \times (1 - \frac{1062}{1050})} - 3 \]

\[ p_{erg} = 1,33 \text{ bar} \]

The necessary filling pressure for make-up \( p_{erg} (= \text{supplement pressure}) \) is 1,33 bar

Note: According to ÖNORM H 5151-1 a pump-controlled pressurization device is state of the art in larger systems (nominal power 100 kW and higher, total content 5000 litres and higher or 100 m² solar collector area)

The nominal volume \( V_{N_{min}} \) of these expansion vessels is determined as follows (acc. to EN 12828):

\[ V_{N_{min}} = (V_{ex} + V_{WR}) \times \frac{1}{\eta} \]

\( \eta \) utilisation efficiency of the expansion vessel (at pressureless elko-mat eder expansion vessels \( \rightarrow \eta = 100 \% \)
calculation example:

Calculate the correct expansion vessel for a cold water system. The static height of the system is 12 mWs, the system is filled with 450 litres of water.

The flow temperature of the system is 5 °C, the ambient temperature is 30 °C.

solution:
given: \( h_s = 12 \text{ mWs} \rightarrow p_a = 1,2 \text{ bar} \)
\( V_{\text{System}} = 450 \text{ litres} \)
\( \vartheta_{\text{max}} = 30 \degree \text{C} \)
\( \vartheta_{\text{min}} = 5 \degree \text{C} \)

asked for: appropriate expansion vessel filling pressure for first fill filling pressure für make-up

\[
p_0 = p_a + 0,2 = 1,2 + 0,2 = 1,4 \rightarrow \text{set 2 bar}
\]
\[
e = 1 - \frac{p_{\text{max}}}{p_{\text{min}}} = 1 - \frac{995,7}{999,9} = 0,4 \%
\]
\[
V_{\text{ex}} = V_{\text{System}} \times e = 230 \times 0,004 = 1,8 \text{ l}
\]
\[
V_{\text{WR}} = \frac{V_{\text{System}} \times 0,5}{100} \geq 3
\]
\[
V_{\text{WR}} = \frac{450 \times 0,5}{100} = 2,25 \text{ l} \rightarrow V_{\text{WR}} = 3 \text{ l}
\]
\[
p_{\text{SV}} = p_a + 2
= 1,2 + 2 = 3,2 \rightarrow \text{set: } p_{\text{SV}} = 6 \text{ bar}
\]
\[
p_{\text{SD}} = p_{\text{SV}} \times 20 \% \geq 0,6 \text{ bar}
= 6 \times 0,2 = 1,2 \rightarrow p_{\text{SD}} = 1,2 \text{ bar}
\]
\[
p_{\text{IN}} = p_{\text{SV}} - p_{\text{SD}} = 6 - 1,2 = 4,8 \text{ bar}
\]
\[
V_{N,\text{min}} = (V_{\text{ex}} + V_{\text{WR}}) \times \frac{p_{\text{IN}} + 1}{p_{\text{IN}} - p_0}
\]
\[
V_{N,\text{min}} = (1,8 + 3) \times \frac{4,8 + 1}{4,8 - 1} = 7,33 \text{ l}
\]

→ selected vessel: elko-flex eder Cool 18
nominal volume \( V_N \):
18 litres

\[
p_{\text{IN}} = \frac{p_{\text{IN}} + 1}{1 + \frac{V_{\text{WR}}}{V_{\text{IN}}} \times \frac{p_{\text{IN}} + 1}{p_0 + 1}} - 1
\]
\[
p_{\text{IN}} = \frac{4,8 + 1}{1 + \frac{7,33}{18} \times \frac{4,8 + 1}{1 + 1}} - 1 = 1,66 \text{ bar}
\]
\[
p_{\text{IN}} \geq p_0 + 0,3 \text{ bar} = 1 + 0,3 = 1,3 \text{ bar}
\]

The required term is fulfilled, the selected elko-flex eder Cool 18 can be used.

The cold water system is filled with water with a filling temperature of \( \vartheta_{\text{fil}} = 10 \degree \text{C} \)
\( \rightarrow p_{\text{fil}} = 999,8 \text{ kg/m}^3 \)
\[
p_{\text{fil}} = V_N \times \frac{p_{\text{fil}} + 1}{V_N - V_{\text{System}} \times (1 - \frac{p_{\text{fil}}}{p_{\text{min}}}) - V_{\text{WR}}} - 1
= 18 \times \frac{2 + 1}{18 - 450 \times (1 - \frac{999,8}{999,9}) - 3}
\]
\[
p_{\text{fil}} = 2,61 \text{ bar}
\]

The necessary filling pressure for first fill is 2,61 bar.

The make-up happens in deactivated status of the cold water system. At that time the average system temperature is \( \vartheta_{\text{erg}} = 15 \degree \text{C} \)
\( \rightarrow p_{\text{erg}} = 999,2 \text{ kg/m}^3 \)
\[
p_{\text{erg}} = V_N \times \frac{p_0 + 1}{V_N - V_{\text{System}} \times (1 - \frac{p_{\text{erg}}}{p_{\text{min}}}) - V_{\text{WR}}} - 1
= 18 \times \frac{2 + 1}{18 - 450 \times (1 - \frac{999,2}{999,9}) - 3}
\]
\[
p_{\text{erg}} = 2,68 \text{ bar}
\]

The necessary filling pressure for make-up \( p_{\text{erg}} (= \text{supplement pressure}) \) is 2,68 bar
3.4 Safety expansion vessels for solar systems

elko-flex eder Solar series safety expansion vessels are designed to use in solar systems.

The diaphragms are resistant to common antifreeze fluids based on glycol. The connection flange is made of stainless steel.

3.4.1 Hydraulic connection

Depending on type and construction of the elko-flex eder Solar safety expansion vessel, it must be mounted to the wall (up to Solar 60) or to the ground (Solar 90 and higher).

Generally the vessel is installed with the connection on the bottom and a pipe loop to the system return. Thus the vessel is protected against too high temperatures which affect the lifetime of the diaphragm.

The maximum long-term temperature of the diaphragm is 70 °C. If the temperature can exceed, the vessel must be protected with an EV cooling vessel.

The expansion pipe must be installed in a way that no cushion air can be enclosed. Otherwise a proper venting device must be installed.

To ensure maintenance without emptying the system, the vessel must be installed with a maintenance unit.

Example: elko-flex eder Solar safety expansion vessel in hanging position

![Diagram](image)

1 ... cut-off device
2 ... circulation pump
3 ... check valve
4 ... safety valve
5 ... safety drain
6 ... collector
7 ... elko-flex eder Solar safety expansion vessel
8 ... elko-flex eder maintenance unit
9 ... warm water boiler

3.4.2 Sizing of diaphragm expansion vessels for solar systems*:

* sizing follows EN 12828.

An adequate sizing of the expansion vessel ensures the compliance with the pressure limits over the entire temperature range and guarantees a problem-free operation.

Depending on the situation and type of the elko-flex eder Solar expansion vessel the volume must be calculated in a way that the maximum operating pressure does not exceed at the maximum operating temperature. Also unwanted low pressure must be avoided in case of too low temperatures (e.g. negative temperatures).

To calculate an elko-flex eder Solar series safety expansion vessel the following technical specifications of the system are necessary:

- total content of the solar system $V_{\text{System}}$ [l]
- total content of the collector $V_{c}$ [l]
- max. standstill temperature [$^\circ$C]
- max. temperature $T_{\text{max}}$, to prevent the content of the collector from evaporating [$^\circ$C]
- static height pressure $p_{\text{st}}$ [mWs]
- max. operating pressure $p_{\text{op}}$ of the system [bar]
The correct gas pressure $p_0$ (minimum operating pressure) avoids evaporating of the medium in normal operating mode of the solar system. Also it avoids low pressure (with the result of diffusion etc.) during cooling down and at standstill of the system in winter.

$$p_0 = p_n + 0.2 + p_v$$

$p_0$ min. operating pressure = gas pressure (effectively avoiding evaporation, cavitation, vacuum) = nominal inlet pressure of the pressurization system [bar]

$p_n$ static height pressure - pressure only resulting from the difference in height $h_n$ between the position of the pressurization system and the highest point of the solar system

10 meter water column (mWs) ~ 1 bar

$p_v$ vapour pressure [bar] at temperature $\theta_{max}$ Specific values for common antifreeze fluids are specified in table 3

Calculation of the expansion volume $V_{ex}$:

$$V_{ex} = V_{system} \times e$$

$$e = 1 - \frac{\rho_{\theta_{max}}}{\rho_{\theta_{min}}}$$

$e$ expansion coefficient

$\rho_{\theta_{max}}$ density of the medium (e.g. water/antifreeze mix) at the maximum temperature before evaporation [kg/m³] (table 5)

$\rho_{\theta_{min}}$ density of the medium at filling temperature [kg/m³] (table 5)

Usually the filling temperature is specified with 10 °C.

Used additive substances can affect the material of the diaphragm!

Calculation of the water reserve $V_{wr}$:

If $V_n \leq 15 l$

$$V_{wr} = \frac{V_n \times 20}{100}$$

If $V_n > 15 l$

$$V_{wr} = \frac{V_{system} \times 0.5}{100} \geq 3$$

$V_{wr}$ water reserve [l]

$V_n$ nominal volume of the expansion vessel [l]

$V_{system}$ total content of the system [l]

Usually the minimum set pressure of the safety valve $p_{sv}$ is defined with 2 bar above the static pressure $p_n$, at least 3 bar!

$$p_{sv} = p_0 + 2 \leq 3 \text{ bar}$$

The final pressure $p_{fin}$ indicates the highest pressure in the operating range of the solar system. It should not be higher than the set pressure of the safety valve minus a difference in shut-off overpressure, the so-called closing pressure difference $p_{SD}$.

According to EN ISO 4216-1 a closing pressure difference of 20 %, at least 0,6 bar is admissible.

$$p_{SD} = p_{sv} \times 20 \% \geq 0,6 \text{ bar}$$

$$p_{fin} = p_{sv} - p_{SD}$$

$p_{SD}$ closing pressure difference [bar]

$p_{sv}$ set pressure of the safety valve [bar]

$p_{fin}$ final pressure [bar]

Note: The standard ÖNORM H 5151-1 specifies the closing pressure difference with 10 % of the set pressure (blow-off pressure) $P_{sv}$ of the safety valve, at least 0,5 bar.

Calculation of the minimum nominal volume $V_{n,min}$ of diaphragm expansion vessels:

It must be considered, that the content of the collector (or at least a part of it) can be heated to
the standstill temperature of the collector. The standstill temperature depends on the collector and can exceed 160 °C, it must be requested from the manufacturer.

Due to this high temperatures, the content of the collector can evaporate, thus the medium is protected against further rising temperatures.

Note: Most antifreeze fluids based on propylene glykol are suitable for long-term temperatures of max. 170 °C. Higher temperatures result in faster aging and thermal decomposition of the antifreeze fluid.

Therefore expansion vessels must be sized big enough to accommodate the content of the collector $V_k$:

$$V_{n,\text{min}} = (V_{ex} + V_k + V_{WR}) \times \frac{p_{ini} + 1}{p_{ini} - p_0}$$

$V_{ex}$ expansion volume [l]
$V_k$ total content of the collector (as declared by the manufacturer of the collector) [l]
$V_{WR}$ water reserve [l]
$p_{ini}$ final pressure [bar]
$p_0$ gas pressure [bar]

If the expansion vessel is sized too small, the system pressure exceeds the set pressure of the safety valve. The safety valve opens and medium gets lost. During cooling down this medium is missing, diffusion would be the consequence.

**Selection and correct sizing of the diaphragm expansion vessel:**

$$V_N \geq V_{n,\text{min}}$$

For diaphragm expansion vessels the initial pressure $p_{ini}$ shall be confirmed for the selected vessel as follows:

$$p_{ex} = \frac{p_{ini} + 1}{\frac{1}{V_{ex} + V_k + V_{WR}} \times \frac{p_{ini} + 1}{p_0 + 1} - 1}$$

The correct sizing of the expansion vessel is ensured as long as:

$$p_{ini} \geq p_0 + 0.3 \text{ bar}$$

Otherwise the nominal volume $V_n$ should be increased until the condition above is met.

Calculation of the *filling pressure* $p_{fil}$ of the solar system in cold state:

$$p_{fil} = V_N \times \frac{p_0 + 1}{V_N - V_{\text{System}} \times (1 - \frac{p_{fil}}{p_{ini}}) - V_{WR}}$$

$p_{fil}$ filling pressure [bar]
$p_0$ gas pressure [bar]
$V_N$ nominal volume of the expansion vessel [l]
$V_{\text{System}}$ total content of the system [l]
$V_{WR}$ water reserve [m³]
$p_{ini}$ density of the medium at the current system temperature during fill or make-up process [kg/m³] (table 5)
$p_{am,\text{min}}$ density of the medium at the lowest system temperature [kg/m³] (table 5)

**calculation example:**

Calculate the appropriate diaphragm expansion vessel for a solar system:

**solution:**

given: $h_{st} = 12 \text{ mWs} \rightarrow p_{st} = 1.2 \text{ bar}$
$V_{\text{System}} = 37 \text{ litres}$
$V_e = 18 \text{ litres}$
propylene glycol 39% (-20 °C) evaporation at 120 °C
asked for: appropriate expansion vessel
Technical manual

diaphragm expansion vessels

**Technical Manual**

**Diaphragm Expansion Vessels**

- **Note:** According to ÖNORM H 5151-1 a pump-controlled pressurization device is state of the art in larger systems (nominal power 100 kW and higher, total content 5000 litres and higher or 100 m² solar collector area).

The nominal volume $V_{N,\text{min}}$ of these expansion vessels is determined as follows (acc. to EN 12828):

$$V_{N,\text{min}} = (V_a + V_{\text{ev}}) \times \frac{1}{\eta}$$

$\eta$ utilisation efficiency of the expansion vessel (at pressureless elko-mat eder expansion vessels $\rightarrow \eta = 100\%$)

**Note:** In solar systems with a set pressure of 10 bar of the safety valve elko-flex eder U-10 series expansion vessels can be installed.

### Notes

<table>
<thead>
<tr>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

- **Safe bet.**
3.5 Sizing with online design programme elko-online

Explanation of the procedure using the following example:

Determine the appropriate diaphragm expansion vessel for a heating system, which consists of a Biovent C15 and an akku ESP 1000 buffer tank using the online design programme elko-online.

given: \( \Phi_{he} \) of the heat generator = 15 kW
\( T_{flow} = 85^\circ C \) \( V_{System} = 1300 \text{ l} \)
\( T_{return} = 65^\circ C \) \( h_{st} = 5 \text{ mWs} \)
\( T_{max} = 90^\circ C \) \( p_{SV} = 3 \text{ bar} \)

asked for: appropriate expansion vessel
necessary gas pressure \( p_0 \) within the vessel

1. Start the design programme online at: http://elko-online.eder-expansion.at and enter the data of your system (figure 1).

2. By clicking the “calculate” button, you are taken to the interim result page. This page shows the results of the calculation and the appropriate products resp. expansion vessels (figure 2).

3. After selecting the required variant and the suitable accessory, click the “finish” button. This opens the result page, where your selected products are summarized. Furthermore, it shows the necessary gas pressure for the current system and the appropriate filling pressure of the cold system (figure 3).

Result:

- appropriate expansion vessel: elko-flex eder N 100
- necessary gas pressure \( p_0 \):
  \( p_0 = 0.8 \text{ bar} \)

If you want to save your calculation or get a corresponding offer, you need to register at elko-online. As an unregistered user, you can’t use these additional functions.

In both cases, you can print the result for your further use.

http://elko-online.eder-expansion.at
3.6 Formulary

**gas pressure** \( p_0 \)

\[
p_0 = p_{st} + 0.2 + p_v
\]

**total content of the system** \( V_{\text{System}} \)

\[
V_{\text{System}} = f_v \times \Phi_{NL}
\]

**expansion volume** \( V_{\text{ex}} \)

\[
e = 1 - \frac{\rho_{\text{max}}}{\rho_{\text{min}}}
\]

\[
V_{\text{ex}} = V_{\text{System}} \times e
\]

**water reserve** \( V_{WR} \)

\[
V_{WR} = \frac{V_s \times 20}{100}
\]

if \( V_s \leq 15 \) l

\[
V_{WR} = \frac{V_{\text{System}} \times 0.5}{100} \geq 3
\]

if \( V_s > 15 \) l

**minimum set pressure of the safety valve** \( p_{SV} \)

\[
p_{SV} = p_{st} + 2 \geq 3 \text{ bar}
\]

**closing pressure difference** \( p_{SD} \) (acc. to EN ISO 4126-1)

\[
p_{SD} = p_{SV} \times 20\% \geq 0.6 \text{ bar}
\]

**final pressure** \( p_{fin} \)

\[
p_{fin} = p_{SV} - p_{SD}
\]

**min. nominal volume of the expansion vessel** \( V_{N,\text{min}} \)

\[
V_{N,\text{min}} = (V_{\text{ex}} + V_{WR}) \times \frac{p_{fin} + 1}{p_{fin} - p_0}
\]

**initial pressure** \( p_{ini} \)

\[
p_{ini} = \frac{p_{fin} + 1}{1 + \frac{V_{\text{ex}}}{V_N} \times \frac{p_{fin} + 1}{p_0 + 1}} - 1
\]

**filling pressure** \( p_{fil} \)

\[
p_{fil} = V_N \times \frac{p_0 + 1}{V_N - V_{\text{System}} \times (1 + \frac{p_{\text{fin}}}{p_{\text{fin} - p_0}}) - V_{WR}} - 1
\]

**minimum set pressure of the safety valve** \( p_{SV} \) in solar systems

\[
p_{SV} = p_0 + 2 \geq 3 \text{ bar}
\]

**min. nominal volume of the expansion vessel** \( V_{N,\text{min}} \) in solar systems

\[
V_{N,\text{min}} = (V_{\text{ex}} + V_k + V_{WR}) \times \frac{p_{fin} + 1}{p_{fin} - p_0}
\]

**initial pressure** \( p_{ini} \) in solar systems

\[
p_{ini} = \frac{p_{fin} + 1}{1 + \frac{V_{\text{ex}} + V_k}{V_N} \times \frac{p_{fin} + 1}{p_0 + 1}} - 1
\]
3.7 Tables

**table 1:**

<table>
<thead>
<tr>
<th>system type resp. type of heat emitters</th>
<th>plant-specific water content ( f_{sn} ) [l / kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>boiler, radiators, UFH</td>
<td>ca. 17</td>
</tr>
<tr>
<td>gravitational heating</td>
<td>ca. 17</td>
</tr>
<tr>
<td>under floor heating</td>
<td>ca. 17</td>
</tr>
<tr>
<td>boiler, sectional radiators</td>
<td>ca. 15</td>
</tr>
<tr>
<td>boiler, flat radiators</td>
<td>ca. 13</td>
</tr>
<tr>
<td>flow heaters, air heaters</td>
<td>ca. 9</td>
</tr>
<tr>
<td>convectors</td>
<td>ca. 9</td>
</tr>
</tbody>
</table>

**table 2:**

minimum nominal size of the expansion pipe in systems with a nominal power lower than 500 kW acc. to ÖNORM H 5151-1

<table>
<thead>
<tr>
<th>DN</th>
<th>nom. power of the heat generator [kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>up to 120</td>
</tr>
<tr>
<td>25</td>
<td>from 120 to 500</td>
</tr>
</tbody>
</table>

The max. flow rate within the expansion pipe must not exceed 0,15 m/s.

**table 3:**

relative vapour pressure \( p_V \) of water and common antifreeze fluids

<table>
<thead>
<tr>
<th>temperature ([\degree C])</th>
<th>water</th>
<th>relative vapour pressure ( p_V ) ([\text{bar}])</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23 % vol. (to -10 °C)</td>
<td>34 % vol. (to -20 °C)</td>
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**table 4:**

water content of various pipes

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<th>pipe content ([\text{l/m}])</th>
<th>dimension ([\text{mm}])</th>
<th>pipe content ([\text{l/m}])</th>
<th>dimension ([\text{mm}])</th>
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<tr>
<td>15 ((1/2&quot;))</td>
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<td>0,20</td>
<td>60,3 x 2,3</td>
<td>2,44</td>
<td>15 x 1</td>
<td>0,13</td>
</tr>
<tr>
<td>20 ((3/4&quot;))</td>
<td>26,9</td>
<td>0,37</td>
<td>76,1 x 2,6</td>
<td>3,95</td>
<td>18 x 1</td>
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</tr>
<tr>
<td>25 ((1&quot;))</td>
<td>33,7</td>
<td>0,58</td>
<td>88,9 x 2,9</td>
<td>5,42</td>
<td>22 x 1</td>
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</tr>
<tr>
<td>32 ((5/4&quot;))</td>
<td>42,4</td>
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<tr>
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table 5: density $\rho$ of water and common antifreeze fluids

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<th>propylene glycol</th>
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<td>34 % vol. (to -20 °C)</td>
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### Quick Selection Table for Diaphragm Expansion Vessels

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### Technical Manual

**Diaphragm Expansion Vessels**

Better heating.
4. Technical data

4.1 Safety expansion vessels for heating, climatic and cold water systems

elko-flex eder N series

Safety expansion vessels for sealed heating, climatic and cold water systems acc. to EN 12828. Constructed with a non-exchangeable diaphragm to accommodate the expansion volume, gas filling with gas pressure valve, connection for a maintenance unit and single-point mount.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. safety temperature of the system without/with cooling vessel: 90/110 °C
max. temperature at the connection point: 70 °C
max. operating pressure: 3 bar

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1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
3... single-point mount
elko-flex eder NP series

Safety expansion vessel, specifically designed for sealed heating systems with buffer tanks, acc. to EN 12828. Constructed with a flanged exchangeable diaphragm to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed as standing vessel with well-designed and functional stand feet.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. safety temperature of the system without/with cooling vessel: 90/110 °C
max. temperature at the connection point: 70 °C
max. operating pressure: 3 bar

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1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
elko-flex eder SG series

Safety expansion vessel for sealed heating, climatic and cold water systems acc. to EN 12828. Constructed with a flanged exchangeable diaphragm to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed as standing vessel with well-designed and functional stand feet.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.  
max. safety temperature of the system without/with cooling vessel: 90/110 °C  
max. temperature at the connection point: 70 °C  
max. operating pressure: 3 bar

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<td>RAL 3001</td>
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1 ... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)  
2 ... gas pressure valve with sealing cap and valve protection cap
elko-flex eder C series

Safety expansion vessel for sealed heating, climatic and cold water systems acc. to EN 12828. Constructed with a flanged exchangeable diaphragm to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit (in scope of delivery). Compact design as standing vessel with well-designed and functional stand feet.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. safety temperature of the system without/with cooling vessel: 90/110 °C
max. temperature at the connection point: 70 °C
max. operating pressure: 3 bar

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1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
**elko-flex eder CV series**

Safety expansion vessel for sealed heating, climatic and cold water systems acc. to EN 12828. Constructed with a flanged exchangeable diaphragm to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit (in scope of delivery). Compact and reinforced design as standing vessel with well-designed and functional stand feet.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.

- max. safety temperature of the system without/with cooling vessel: 90/110 °C
- max. temperature at the connection point: 70 °C
- max. operating pressure: 5 bar

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1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
4.2 Universal vessels for heating, climatic and cold water systems

elko-flex eder U_-6 series

Universal safety expansion vessel for sealed heating, climatic and cold water systems acc. to EN 12828, refrigeration systems, solar systems and cold water sanitary systems. Non-flow-through construction with a flanged exchangeable diaphragm (resistant to common antifreeze fluids, the flange is made of stainless steel) to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed for wall mount installation incl. functional mounting bracket (18 - 50 l) resp. as standing vessel with well-designed and functional stand feet (90 - 300 l).

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. temperature at the connection point: 70 °C
max. operating pressure: 6 bar

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<td>85</td>
<td>R1</td>
<td>81,4</td>
<td>RAL 3001</td>
</tr>
</tbody>
</table>

1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
elko-flex eder U_-10 series

Universal safety expansion vessel for sealed heating, climatic and cold water systems acc. to EN 12828, refrigeration systems, solar systems and cold water sanitary systems. Non-flow-through construction with a flanged exchangeable diaphragm (resistant to common antifreeze fluids, the flange is made of stainless steel) to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed for wall mount installation incl. functional mounting bracket (15 - 60 l) resp. as standing vessel with well-designed and functional stand feet (120 - 300 l).

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. temperature at the connection point: 70 °C
max. operating pressure: 10 bar

<table>
<thead>
<tr>
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<td>R1</td>
<td>84,0</td>
<td>RAL 3001</td>
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</tbody>
</table>

1... connection for expansion pipe (installation in system return, max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
4.3 Expansion vessels for warm water sanitary systems

elko-san eder San D series

Safety expansion vessel for warm water sanitary systems. Constructed with a flanged exchangeable diaphragm (made of food-safe and tasteless material, the flange is made of stainless steel) to accommodate the expansion volume (caused by heating-up of the water boiler), gas filling with gas pressure valve and - for flow-through - connections for two maintenance units. Designed for wall mount installation incl. functional mounting bracket (20 - 60 l) resp. as standing vessel with well-designed and functional stand feet (90 - 300 l).

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. temperature at the connection point: 70 °C
max. operating pressure: 10 bar

<table>
<thead>
<tr>
<th></th>
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<td>230</td>
<td>R3/4</td>
<td>6,9</td>
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<td>230</td>
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<td>R1</td>
<td>35,0</td>
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<td>R1</td>
<td>89,0</td>
<td>RAL 5015</td>
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</table>

1... connection FROM the system
2... connection TO the system
2... gas pressure valve with sealing cap and valve protection cap
4.4 Expansion vessels for cold water sanitary systems

elko-san eder San series

Safety expansion vessel for cold water sanitary systems to absorb pressure surges or as water pressure tanks. Constructed with a flanged exchangeable diaphragm (made of food-safe and tasteless material, the flange is made of stainless steel), gas filling with gas pressure valve and connection for a maintenance unit. Designed for wall mount installation incl. functional mounting bracket (15 - 60 l) resp. as standing vessel with well-designed and functional stand feet (120 - 300 l).

Tested in accordance with directive 97/23/EC (PED). max. temperature at the connection point: 70 °C max. operating pressure: 10 bar

Caution: elko-san eder San series expansion vessels are not intended as shock absorbers in their proper sense!

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<td>R3/4</td>
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<td>RAL 5015</td>
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<td>San 60</td>
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<td>230</td>
<td>R3/4</td>
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<td>80</td>
<td>R1</td>
<td>84,0</td>
<td>RAL 5015</td>
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</table>

1... connection for expansion pipe (max. long-term temperature at the connection point 70 °C)
2... gas pressure valve with sealing cap and valve protection cap
4.5  Safety expansion vessel for refrigeration systems (cold water systems, chillers)

elko-flex eder Cool series

Safety expansion vessel for refrigeration systems. Constructed with a flanged exchangeable diaphragm (resistant to common antifreeze fluids, the flange is made of stainless steel) to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed for wall mount installation incl. functional mounting bracket.

Tested in accordance with Pressure equipment directive (PED) 97/23/EC.
max. temperature at the connection point: 70 °C
min. temperature at the connection point: -10 °C
max. operating pressure: 6 bar

![Diagram of Cool 18 - Cool 50]

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<td>230</td>
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<td>230</td>
<td>R3/4</td>
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<td>R3/4</td>
<td>14,8</td>
<td>RAL 7035</td>
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</table>

1... connection for expansion pipe to the cold water system
2... gas pressure valve with sealing cap and valve protection cap
4.6 Safety expansion vessel for solar system

elko-flex eder Solar series

Safety expansion vessel for solar systems. Constructed with a flanged exchangeable diaphragm (resistant to common antifreeze fluids, the flange is made of stainless steel) to accommodate the expansion volume, gas filling with gas pressure valve and connection for a maintenance unit. Designed for wall mount installation incl. functional mounting bracket (18 - 50 l) resp. as standing vessel with well-designed and functional stand feet (90 - 300 l).

Tested in accordance with directive 97/23/EC (PED).
max. temperature at the connection point: 70 °C
max. operating pressure: 6 bar

Note: The U_-6 series can be used as an alternative to the Solar series. For solar systems up to max. 10 bar the U_-10 series can be installed.

<table>
<thead>
<tr>
<th>type</th>
<th>nom. content</th>
<th>standard gas pressure</th>
<th>D [mm]</th>
<th>H [mm]</th>
<th>t / h [mm]</th>
<th>connection</th>
<th>weight [kg]</th>
<th>colour</th>
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</thead>
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<td>365</td>
<td>230</td>
<td>R3/4</td>
<td>7,9</td>
<td>RAL 6010</td>
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<td>Solar 25</td>
<td>25</td>
<td>3,5</td>
<td>360</td>
<td>400</td>
<td>230</td>
<td>R3/4</td>
<td>9,8</td>
<td>RAL 6010</td>
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<td>500</td>
<td>230</td>
<td>R3/4</td>
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<td>RAL 6010</td>
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<tr>
<td>Solar 50</td>
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<td>3,5</td>
<td>360</td>
<td>580</td>
<td>230</td>
<td>R3/4</td>
<td>14,8</td>
<td>RAL 6010</td>
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<td>RAL 6010</td>
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</table>

1 ... connection for expansion pipe to the solar system
2 ... gas pressure valve with sealing cap and valve protection cap
5. Accessory

5.1 elko-flex eder maintenance unit

An elko-flex eder maintenance unit is a connection accessory for diaphragm expansion vessels for approved integration into a system with all necessary maintenance functions.

To ensure a proper function of the vessel and the whole system for a long term expansion vessels with a constant primary pressure have to be checked regularly (recommended every year, but at least every 2 years). Though the gas pressure in the vessel in the water-sided, pressureless condition is proved and corrected if necessary.

The vessel has to be separated from the system by an armature and to be emptied.

Excerpt of standard EN 12828: During operation the connection between the pressurization system and the heat generator has to be permanently open. For maintenance it is recommended to build in a valve between the pressurization system and the heat generator. The valve has to be secured against unintended closing, equipped with a drainage valve and used as a shut-off device.

Excerpt of standard ÖNORM H 5151-1: Between expansion- or pressurization system and heat generator maintenance and exchange of expansion- or pressurization devices has to be enabled by suitable equipment.

Technical data:
max. operating pressure: 10 bar
max. operating temperature: 95 °C

<table>
<thead>
<tr>
<th>type</th>
<th>connection to system [&quot;]</th>
<th>connection to vessel [&quot;]</th>
<th>length [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; a/a</td>
<td>R3/4</td>
<td>R3/4</td>
<td>104</td>
</tr>
<tr>
<td>3/4&quot; a/i</td>
<td>R3/4</td>
<td>Rp3/4</td>
<td>87</td>
</tr>
<tr>
<td>1&quot; a/i</td>
<td>R1</td>
<td>Rp1</td>
<td>101</td>
</tr>
</tbody>
</table>

5.2 elko-mat eder EV cooling vessel

EV cooling vessels are intended for cooling the expansion volume before it enters the safety expansion vessel. Therefore the safety expansion vessel is protected against too high temperatures.

EV cooling vessels must be provided if the temperature at the connection point exceeds the max. allowed temperature of 70 °C

max. operating temperature (=safety temperature) of the system: 110 °C

Special versions of EV cooling vessels for operating temperatures higher than 110 °C can be delivered on request.

example: elko-flex eder safety expansion vessel with EV cooling vessel:
5.3 elko-flex eder SV safety valve
elko-mat eder SV safety valve

To ensure that the maximum operating pressure is not exceeded, each heat generator of a heating system has to be assured by a safety valve. The safety valve must be installed as close as possible to the heat generator - as long as the heat generator is not equipped with a safety valve ex works.

Safety valves shall:

- have a minimum dimension of DN15
- open at a pressure which does not exceed the maximum operating pressure of the system. Further it must avoid an exceeding of more than 10 % of the max. operating pressure. In case of a max. operating pressure of not more than 3 bar an exceeding of 0,5 bar is admissible.
- be designed in a way that the pressure loss does not exceed 3 % in the inlet pipe and 10 % in the outlet, compared to the set pressure of the safety valve.
- be installed at an easy accessible position and as close as possible to the flow pipe of the heat generator. Between the heat generator and the safety valve no shut-off device must be installed!

4.3.1 Selection of the safety valve:

To select a suitable safety valve the following technical specifications are necessary:
- nominal power of the heat generator
- set pressure of the safety valve $p_{SV}$

Safety valves should be dimensioned and set so that the operating overpressure in normal heating operation resp. in case of failure cannot be exceeded by more than 10 %. When the operating overpressure is below 3 bar, a pressure in excess of maximal 0,3 bar is admissible. The safety valves should close when the pressure drops within a range of 10 % of the response overpressure. A pressure reduction of 0,3 bar is admissible with response overpressures below 3 bar.

<table>
<thead>
<tr>
<th>static height $h_{st}$ of the heating system [ mWs ]</th>
<th>min. set pressure $p_{SV}$ [ bar ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h_{st} \leq 10$</td>
<td>3,0</td>
</tr>
<tr>
<td>$h_{st} &gt; 10$</td>
<td>$p_{st} + 2,0$</td>
</tr>
</tbody>
</table>

The selection of the safety valves based on their relief capacity depends on their type-examination.

The relief capacities of elko-flex eder SV resp. elko-mat eder SV safety valves are summarized in table 7.

### table 7:
Relief capacities of elko-flex eder SV / elko-mat eder SV safety valves

<table>
<thead>
<tr>
<th>set pressure $p_{SV}$ [ bar ]</th>
<th>relief capacity of the safety valve [ kW ] in reference to the inlet dimension and the set pressure $p_{SV}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN15 (1/2&quot;)</td>
<td>50</td>
</tr>
<tr>
<td>DN20 (3/4&quot;)</td>
<td>100</td>
</tr>
<tr>
<td>DN25 (1&quot;)</td>
<td>200</td>
</tr>
<tr>
<td>DN32 (5/4&quot;)</td>
<td>350</td>
</tr>
<tr>
<td>DN40 (6/4&quot;)</td>
<td>600</td>
</tr>
<tr>
<td>DN50 (2&quot;)</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>undeliverable</td>
</tr>
<tr>
<td>5</td>
<td>undeliverable</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>undeliverable</td>
</tr>
<tr>
<td>10</td>
<td>undeliverable</td>
</tr>
</tbody>
</table>
BETTER HEATING. SAFE BET.

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