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1 Description of System

1.1 Purpose of Supplementary Loading

The Supplementary loading system includes the following components:
- Control unit
- Safety valve with pneumatic actuator

The existing installation and piping of the components at the plant to be protected is shown in Figure 2, Page 3 (Schematic Diagram Series 700).

The use of supplementary loading valves mainly serves two purposes :

1. Reduction of the difference between the set pressure and the operating pressure:
Due to the physical characteristics, the functionality of directly acting safety valves has certain restrictions as regards the difference between the operating and the set pressure and thus the achievable tightness, i.e. the max. operating pressure is 85% of the set pressure. This value can be increased to 96% if supplementary loading valves are used.

2. Reduction of opening and reseating-pressure:
The opening and reseating pressure differences of uncontrolled full-lift safety valves of +5% (pressure increase) and -10% (pressure drop), referred to the set pressure according to AD-Merkblatt A2, can be reduced to +1% / -3%, respectively, if supplementary loading valves are used.

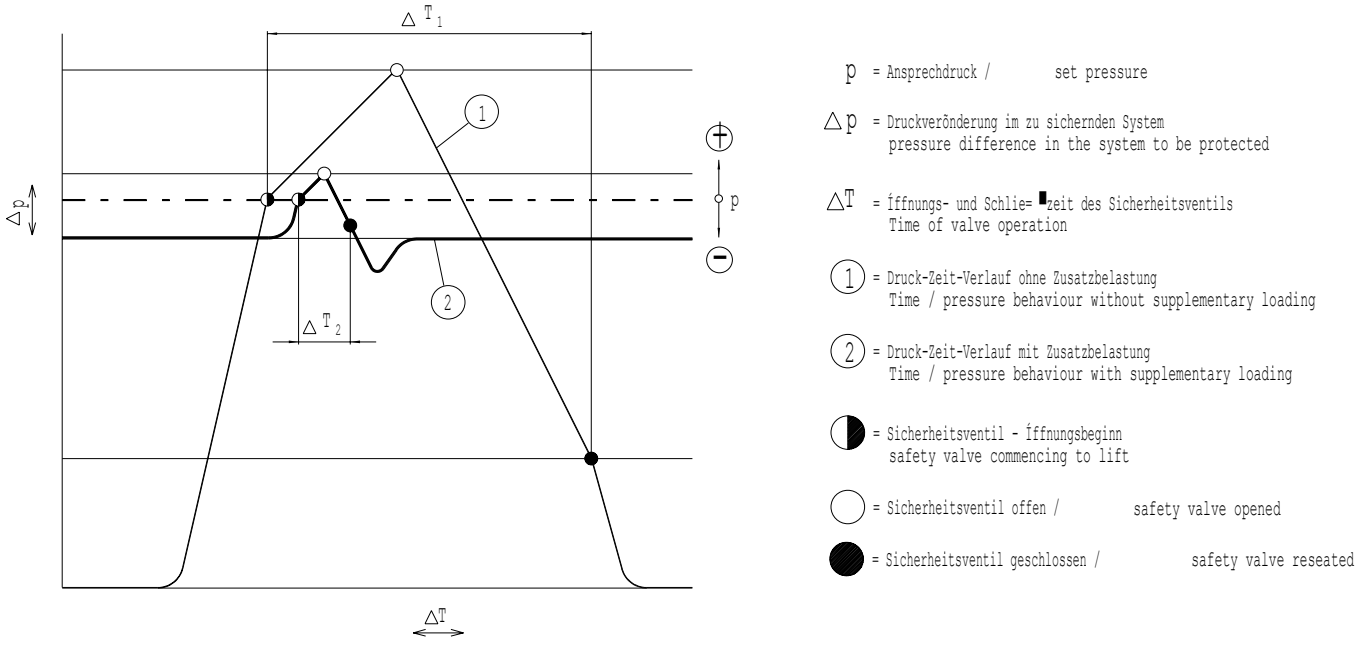

Fig. 1: Time/Pressure characteristic with and without supplementary loading
(The diagram shows the typical pressure/time behaviour of the plant to be protected during opening and closing of safety valves with and without supplementary loading. The specific values depend on the design of the plant and components. They can be determined by LESER Service staff by measurement on site (diagnosis))

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1.2 Description of Function

With the supplementary loaded safety valve, the spring loaded reseating action is subjected to a supplementary force supplied by a pneumatic actuator. To enable a plant-wide control of the system pressure, the control system is provided with the required control pulses via three medium-loaded pressure-tapping lines (see Fig. 2).

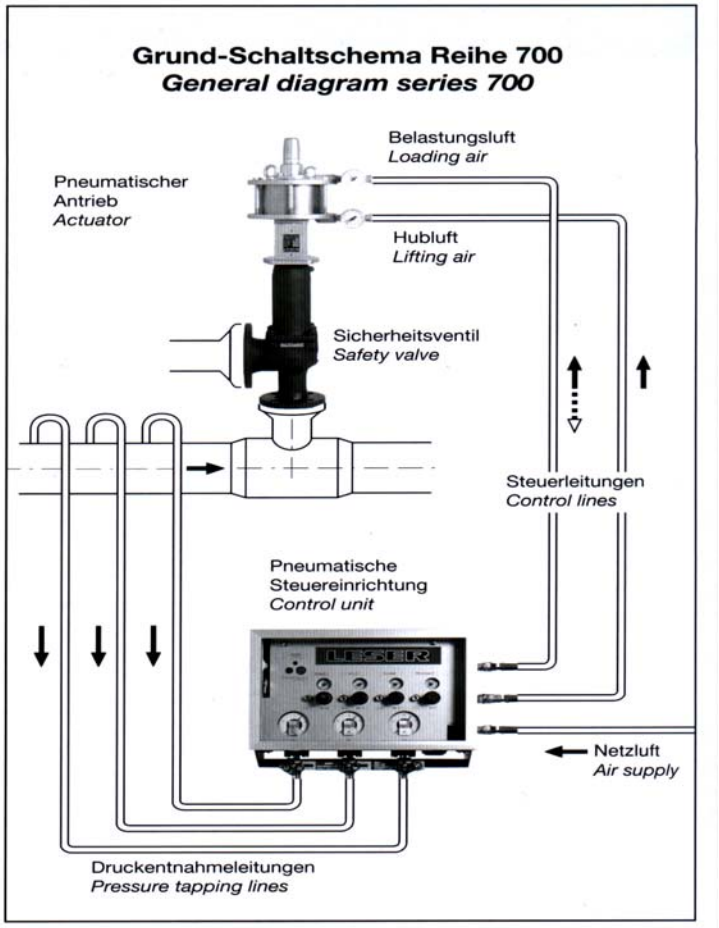

Fig. 2: Schematic Diagram Series 700

When the specified set pressure is reached in the part of the plant to be protected, the control system generates the loading air pressure. Then the safety valve can open as required.
Due to the directly acting lift air support of the pneumatic actuator, the opening pressure difference is reduced to +1%.

If the lifting air pressure is active, the valve opens, fully independent of the back-pressure.

If the pressure is below the set switching pressure (normally 1 % of set pressure) the loading air pressure is generated again. The valve closes faster, i.e. at a lower reseating pressure difference (up to -3%).

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1.3 Advantages

The advantages of the pneumatic supplementary loading include:

- Seat-tightness until opening, because there is sufficient sealing power despite the lower difference between the operating and the set pressure.
  ⇨ This results in a more efficient utilization of the permissible operating pressure of the plant (up to 96% of the set pressure)

- No leakage losses during operation due to pressure variations in the system (in particular with system pressures > 85% (referred to set pressure))
  ⇨ Thus, higher availability and utilization of the plant to be protected and the safety valve as well as less environmental pollution, if applicable.
  In the case of steam applications the thermal efficiency is increased, too, as a result.

- Controlling the valve opening sequence possible if several safety valves are used.
  ⇨ e.g. in the case of steam boiler installations where opening of the superheater valve must have priority over opening of the drum valve.

- Lower medium losses **and** higher cost efficiency **due to**:
  - Shorter opening and reseating cycles
  - Valve opens completely as soon as the set pressure is exceeded by +1%
  - Valve closes as soon as the pressure is 3% below the set pressure

- Opening of safety valve independent of the back-pressure, since the opening of the safety valve is supported by the supplementary lift air, which guarantees full opening of the safety valve in any case.
  ⇨ Thus the existing connections of the safety valve can possibly be used, even if a higher load is to be discharged than before.

- The safety valve settings can be checked at any time during operation and corrected using the set pressure characteristic (LWN 361.03 Fig.6, Page 6).
  ⇨ In this way the operation does not have to be interrupted and unnecessary losses due to shut-down and start-up of the plant are avoided.

- Very stable and accurate working behavior of the safety valve, independent of the load to be secured or possible pressure variations.
  Without supplementary loading, this would only be possible to a limited extent by using a vibration prevention device or a friction absorber.

- Lower thermal load on the safety valve due to shorter relieve times.

- Lower environmental impact (noise development) due to less frequent and shorter relieving

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1.4 Applications

Typical applications for controlled (supplementary loading) safety valves include:

- **Plants requiring monitoring**, where the max. operating pressure is higher than 85% of the maximum allowable working pressure (MAWP) (independent of operating temperature)!

- **Steam generation plants with drum and superheater control systems** by means of safety valves where opening of the superheater valve must have priority over the opening of the drum valve.

- **Old and new plants**, where the max. allowable operating pressure is already reached. Due to the new, higher operating pressure values, the productivity can be increased, e.g. in paper industry, by increasing the speed of the paper drying rollers.

- **Plants with varying operating pressure values** and / or frequent pressure peaks (e.g. waste incinerators / waste power plants).

- Other plants requiring exact and constant pressure values and temperatures**, e.g. in paper industry** (to avoid a web break caused by temperature changes in the paper drying rollers).

- **Plants with non-defined or varying high external back-pressure** on the outlet side of the safety valve.

- **Power plants in residential areas**, to reduce the duration of relieving cycles and thus the noise development when the safety valves are actuated.

- **Chemical plants** to avoid environmental pollution.

- Plants where **costly energy, medium and performance losses** are to be avoided.

- **Plants with low MAWP**, where the reseating pressure difference required for proper closing of the safety valves cannot be reached.

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1.5 Requirements to be met by the plant operator

- Three pressure tapping points must be available at the vessel or system to be protected.

- Installation of the pressure tapping lines between the plant to be protected and the control system, water supply must be provided, if necessary, to protect the control system against medium temperatures above +60°C.
  Additionally, the pressure tapping lines must be protected against freezing, e.g. by means of a trace heating system ($t_{min\ all.}$ = +2°C).

- The control system must be protected against non-permissible temperatures (if temparature is < 2°C, a heating system is required / if temperature is > 60°C a cooling system is required).

- Dried, oil- and dust-free control air supply (instrumentation air, dew point +2°C). The service air must be cleaned, if necessary, by means of a micro filter.

- The control lines leading to the pneumatic actuator must have an inner diameter of 15 mm (see AD-Merkblatt ADA2 Section 5.8.3).

- Required service air pressure min. 4 bar / max. 10 bar (required flow rate, see LWN 361.02, Section 1.7, Page 11).

- Regular, annual functional check of safety valves and associated control systems according to AD-A2 Merkblatt Section 5.9, TRD 421 Section 5.1 and VD-TÜV Merkblatt 768, e.g. by LESER (also refer to LWN 361.04).

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1.6 Approvals

The LESER supplementary loading system is type-tested according to the requirements of the applicable technical regulations (e.g AD-Merkblatt A2 and TRD 421) and permitted in the following countries:

Germany

Denmark

Finland

Austria

Sweden

Belgium

Spain

The Netherlands (Stoomwezen)

Russia (DIN GOST)

Poland (UDT)

Switzerland

CE Label (Marking)

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1.7 Approaches for pay-off calculations

1.7.1 Example: Paper mill

By using supplementary loading valves it was possible to increase the pressure in the paper drying rollers by 10 % from 4 to 4.4 bar gauge, resulting in a temperature increase from 154°C to 158°C.
According to the plant operator, an increase in the operating pressure of 0.1 bar results in a productivity increase of some 0,7 % per paper drying roller (cylinder).
(This means that with a paper machine equipped with 10 paper drying rollers, for example, productivity would be increased by 7%.)

The plant carrier reported that due to the application of a supplementary loading system there was a considerably rarer paper tears in the system and therefore a clearly increased production (t/h) of the final product could be reached.

Approach for payoff calculations:
Increase in productivity as a result of a higher drying rate.

1.7.2 Example: Chemical industry

By using supplementary loading valves it was possible to operate the plant at 16 bar (previously 14.5 bar), without additional plant modifications.
This resulted in a temperature increase of 8°C and thus in significant cost reductions due to reduced steam input.

According to the operator of the plant, the investment paid off after a period of just three months.

Approach for payoff calculations
Lower steam input (Steam costs: approx. 30.- € / t_{steam})

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1.8 Application examples (schematic diagrams) / diagram of control unit

Figures 3 to 6 (Pages 9 to 12) show four schematic diagrams of typical supplementary loading applications. In case you need a schematic diagram for your specific application, simply contact us. (Diagram of control unit, see LWN 361.02, Page 7 / Description of Function)

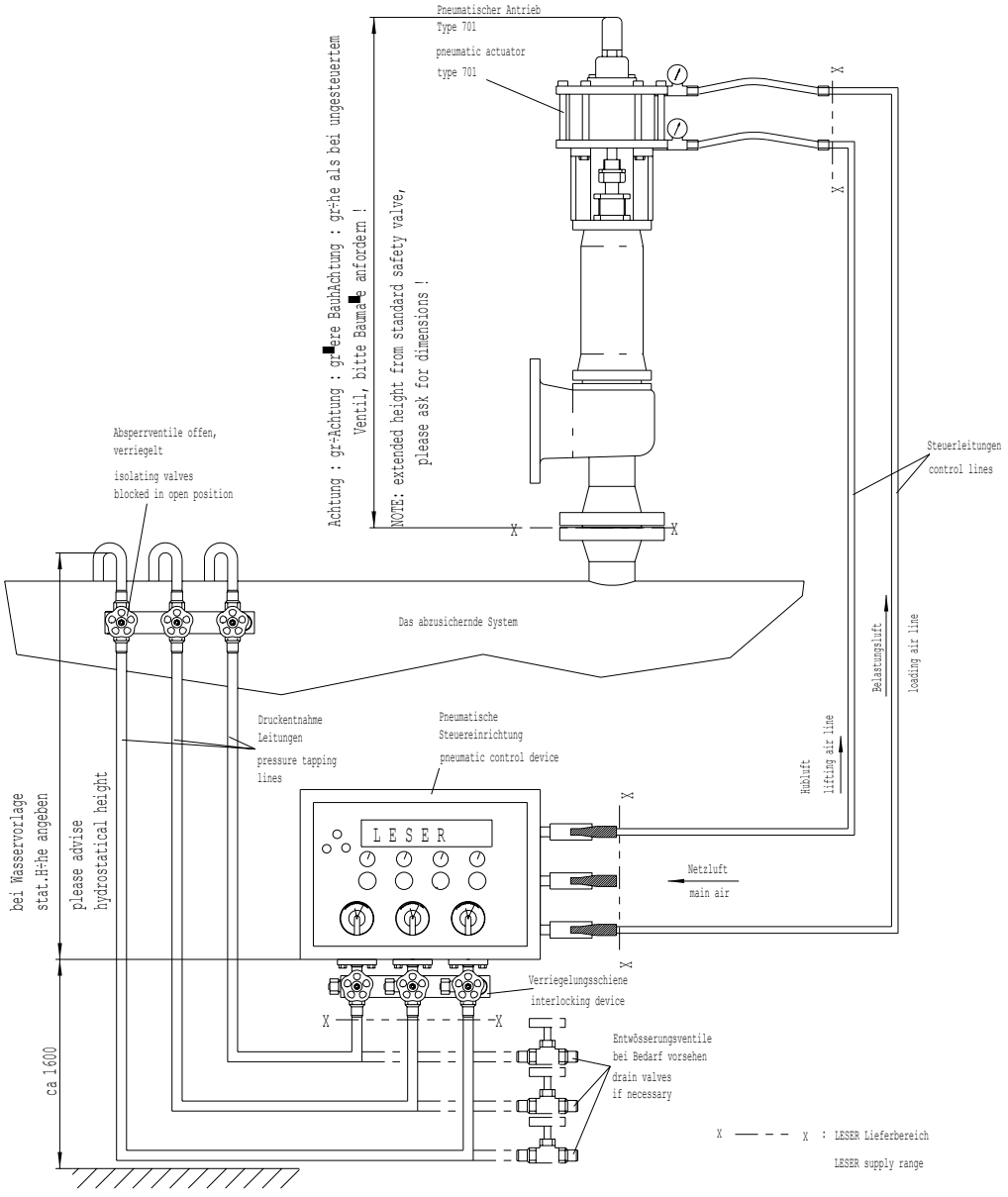

Fig. 3: Schematic diagram - Pneumatic supplementary loading

Description:
The pressurized system is protected by **ONE** supplementary loaded safety valve. The three pressure switches are obtained via the pressure tapping lines from the **SAME** system to be protected.

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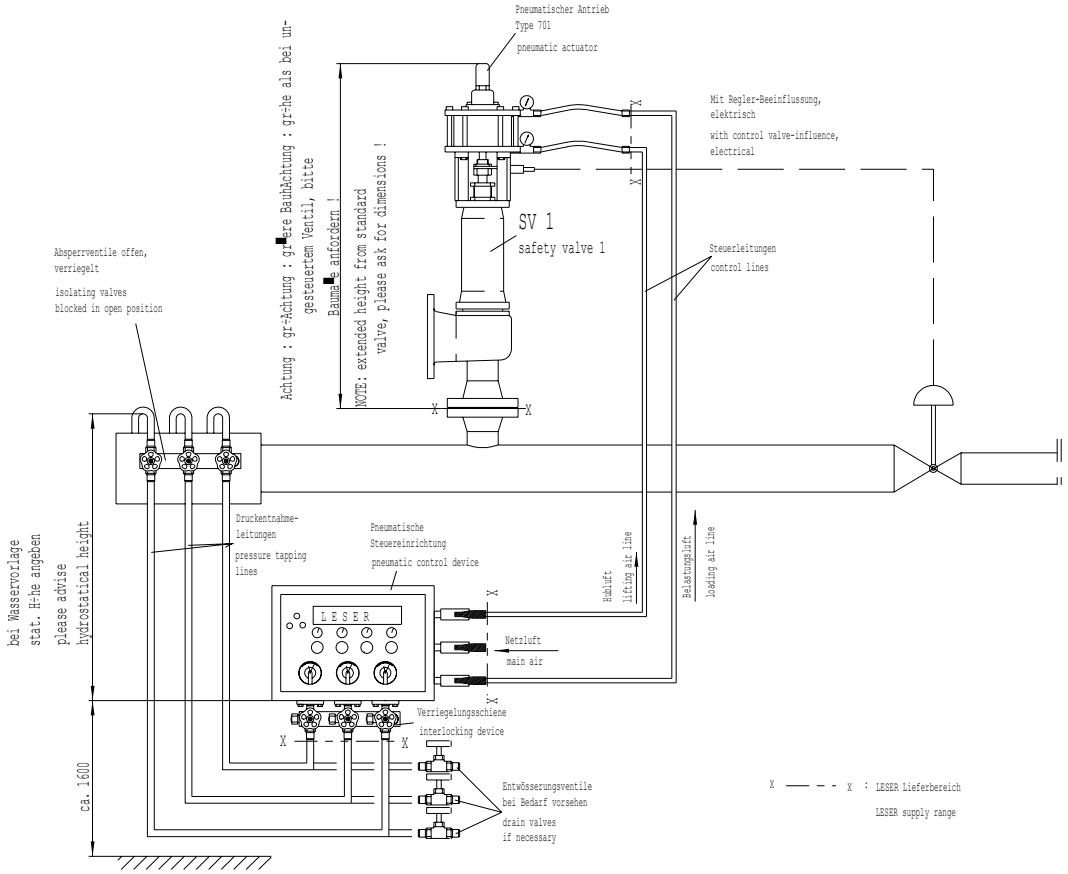

Fig. 4: Schematic diagram for 1 valve and different pressure levels

Description:
The pressurized system is protected by **ONE** supplementary loaded safety valve. The three pressure switches are obtained via the pressure tapping lines from the **SAME** system to be protected.

Additionally, the controlled safety valve is equipped with an electric momentary-contact limit switch. The signal of this limit switch influences a possibly existing pressure control valve to avoid re-controlling (quick opening) when the safety valve is open.
(Function: see LWN 361.03, Section 1.6 / Page 5, Accessories)

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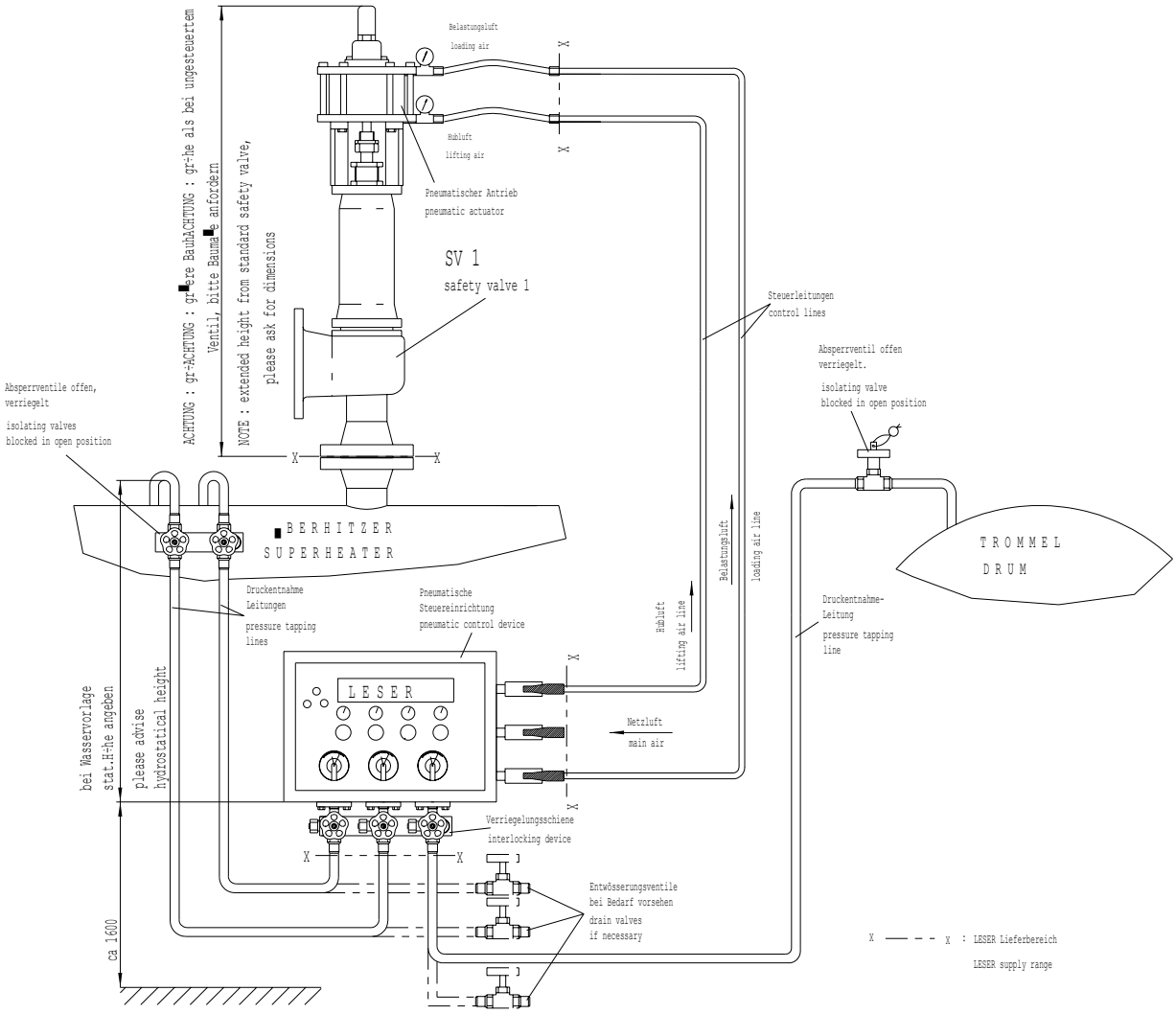

Fig. 5: Schematic diagram - with control valve-influence (electrical)

Description:
Protection of a steam generator with drum and superheater. The system is fully protected by means of one supplementary loading valve on the superheater. The control unit receives the three pressure information / switching pulses required from the superheater (2 pressure tapping lines) and from the drum (1 pressure tapping line). The pressure settings of the pressure switches are different and adjusted to the pressure drop between the drum and the superheater.

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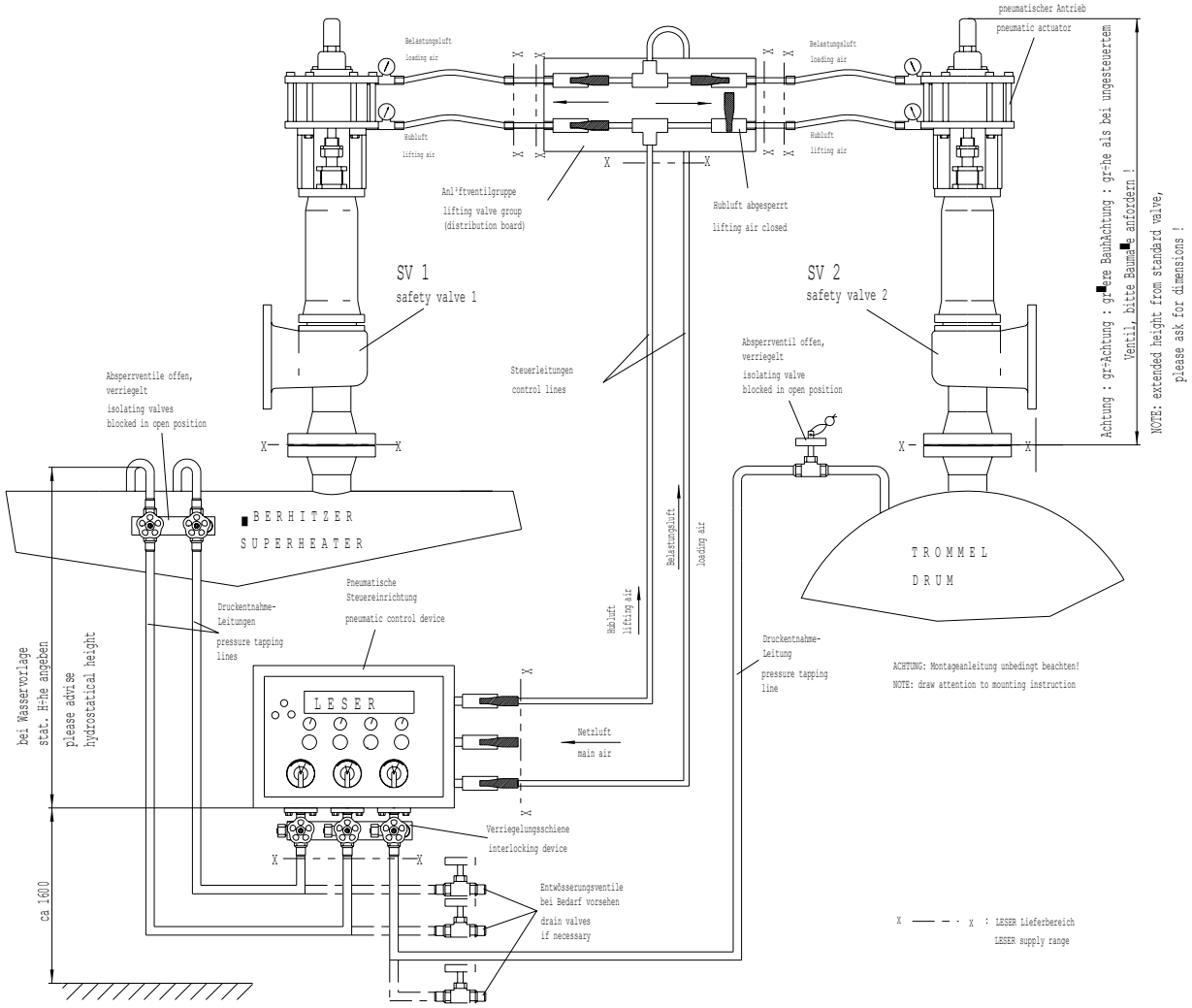

Fig. 4: Schematic diagram for 2 valves with different pressure levels

Description:
Protection of a steam generator with drum and superheater by means of on controlled safety valve on the drum and one on the superheater.
The control unit receives the three pressure information / switching pulses required from the superheater (2 pressure tapping lines) and from the drum (1 pressure tapping line).

To ensure that opening of the superheater safety valve (SV1) has priority over the drum safety valve (SV2), the lifting air supply to SV2 is closed. In this way supplementary loading of SV2 is still maintained, but there is no lifting air support when the set pressure is reached. Thus it is made sure that pressure or performance peaks are mainly relieved by SV1. The pressure settings of the pressure switches are different and adjusted to the pressure drop between the drum and the superheater.