Process Engineering

- **Inertisation**
- **Ventilation**

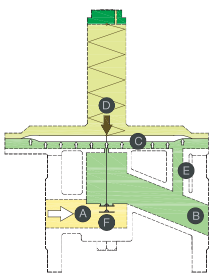
The triumph of low-pressure regulators has its roots in the beginning of the eighties of last century through introduction of the “LRV (Luft Reinhalte Verordnung = Legislation on Prevention of Air Pollution)” in Switzerland and the "TA-Luft (Technical Regulations on Air Pollution Control)” in Germany.

Inertisation through low-pressure inline and low-pressure angle valves

Inertisation and ventilation are required in many applications where products or liquids are processed or stored discontinuously, i.e. on the batch principle.
Chemical and pharmaceutical industry realised rather quickly that “blowing through” of process spaces with nitrogen used before is not very effective. However, the controlled ventilation with pressure reducing and relief valves helps to save costs and to considerably reduce the risk of environmental pollution.

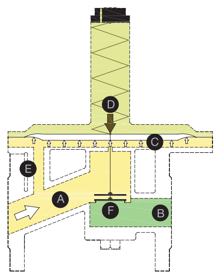
Function
Low-pressure reducing valve

Spring-loaded pressure reducing valves are "relative pressure regulators” designed to keep constant the outlet pressure "B”. The set-point is preselected by means of the setting screw at the spring housing. When in rest position, the regulator is open. As soon as the regulator inlet is exposed to the inlet pressure "A”, the pressure flows through the open valve seat "F” to the outlet and through the drain line "E” into the space below the diaphragm "C”. With the outlet pressure "B” rising, this process continues until the diaphragm force "C” exceeds the spring force "D”. The diaphragm moves up and causes closure of valve seat "F”. If the outlet pressure "B” falls again below the preselected set-point value, the spring force "D” presses the diaphragm down so that the valve seat "F” opens and permits the flow of gas until the equilibrium is established between spring force "D” and diaphragm force "C” so that the valve seat closes again.



Function
Low-pressure relief valve

Spring-loaded relief valves are "relative pressure regulators” for limitation of inlet pressure "A”. The set-point value is preset by means of the setting spring at the spring housing. The regulator is closed when no pressure is applied. In case the inlet pressure "A” builds up on the inlet, this pressure flows through the drain line "E” into the space below the diaphragm. The resultant diaphragm force "C” is compared with the spring force "D”. If the diaphragm force exceeds the spring force, the valve seat "F” opens and the overpressure is discharged to the output side. In case the inlet pressure "A” falls, the diaphragm force "C” gets smaller than the preset spring force "D” (set-point value), the valve seat "F” closes the relief valve so that the fluid flow is stopped. The outlet pressure "B” may be atmospheric or vacuum pressure. In case of slight vacuum pressure the regulator’s performance increases.



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Inertisation

Why inertisation / ventilation?

1. Protection against explosion

Extract from ATEX 137:
The measures taken to prevent the formation of explosive atmosphere are to be superior to all other explosion protection measures.
By replacing the air mixture by an inert gas (inert substances are non-reactive substances that do not react in the particular reaction system), formation of an explosive atmosphere is prevented.

2. ATEX zone reduction

Zone definition to ATEX 137

ZONE 0

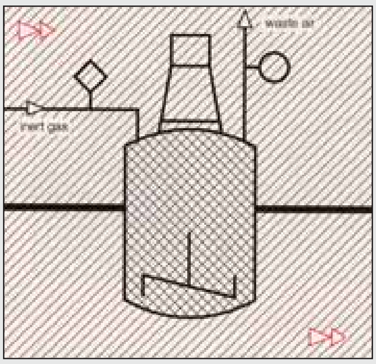
Zone in which the explosive atmosphere as a mixture of air and inflammable gases, vapours or mists is permanently present, present over longer periods or frequently present.

ZONE 1

Zone in which an explosive atmosphere as a mixture of air and inflammable gases, vapours or mists may develop occasionally under normal operation conditions.

ZONE 2

Zone in which an explosive atmosphere as a mixture of air and inflammable gases, vapours or mists cannot develop at all under normal operation conditions or only a short time.



According to SUVA, change between ZONE 0 and ZONE 1 is possible in apparatus construction under conditions of controlled inertisation.

(Literature: Explosion protection: Principles and Minimum Requirements – Zones, Order No. 2153d, suvaPRO, CH-6002 Luzern)

zone 1

zone 2

3. Protection against oxidation

Oxygen contained in the air may react and/or oxidise with other substances. When replacing the air mixture inside a vessel by inert gas, formation of an atmosphere is excluded where oxidation may take. Constant and repetitive conditions are required as the basic prerequisite for validation.

4. Protection against contamination

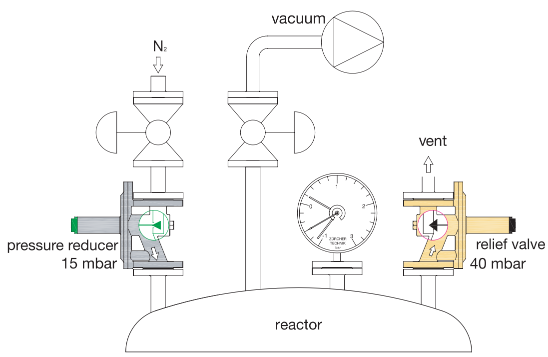
Ventilation in the overpressure procedure is an effective tool for protection of product from external contamination. Ventilation in the vacuum pressure procedure protects the environment against contamination by process fluids.

Inertisation

Reactors work discontinuously in the "batch" operation. When batch processing is completed, reactors are shut down and may be cleaned through the opened manhole. However, this requires previous gas exchange *(inertisation)* before the next process may be started.

Vacuum-pressure inertisation:

The vacuum pump serves to suck off 80% of reactor atmosphere (residual pressure: 200 mbar abs.). Consequently, only 20% of the original oxygen molecules are still present inside the reactor. The missing volume is subsequently replaced by filling with nitrogen. This "thinning" of oxygen content of about 1 : 5 per inertisation cycle will be continued until the residual oxygen content inside the reactor falls below the specified value.
Instead of the described operation with vacuum, inertisation can be made even under overpressure in pressure-resistant reactors.



vacuum-pressure inertisation

Overpressure inertisation:

The pressure inside the reactor is increased to 1 bar by blowing in inert gas and subsequently relieved to atmospheric pressure. In this process, the thinning of oxygen content amounts to some 1 : 2 per inertisation cycle. If the pressure inside the reactor is increased to 2 bar, the thinning rate is about 1 : 3, and so on.
Once the reactor is inertised and ready for process start, the low-pressure differential pressure regulators change over from the inertisation mode to the ventilation mode.

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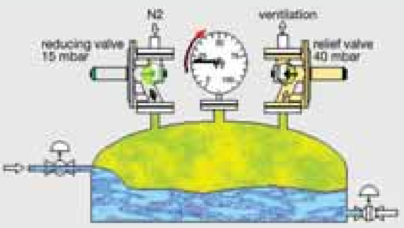
Why ventilation?

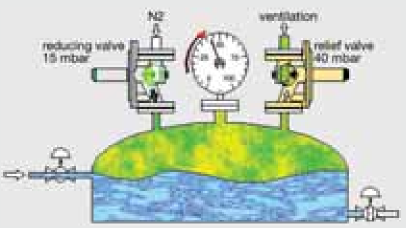
Two pressure regulators are required for optimum ventilation. One pressure reducing valve is needed for the nitrogen flow-in ("breathing-in"), and one relief valve is required for gas flow-out ("breathing-out"). The ventilation process takes place in a pressure range of 10 – 50 mbar in order to minimize the inert gas consumption.

The aim of each ventilation process is to maintain the inert status inside the reactor throughout the fabrication process. The term "ventilation" may be replaced by such terms like "pressure superimposition", "tank blanketing", "padding" or others.

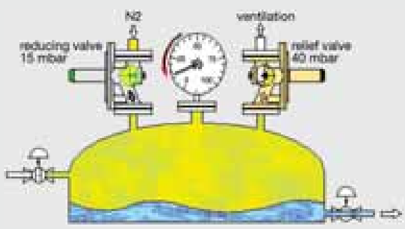
Overpressure ventilation:



The inertised reactor is filled with the product. The internal pressure rises as a function of the filling level.



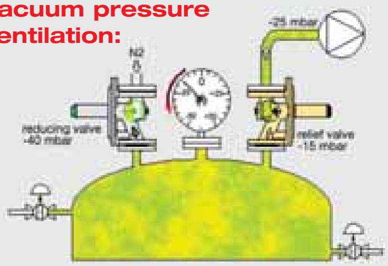
If filling level or temperature level rises so that the reactor pressure exceeds 40 mbar, the relief valve responds and discharges gas into the waste air system.



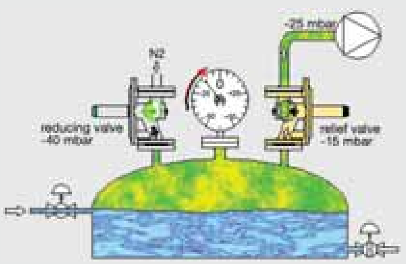
If the reactor cools down or gets emptied, the pressure drops. In case the process pressure falls below the 15 mbar preset on the reducing valve, the reducing valve blows in nitrogen until the pressure reaches 15 mbar again.

If the reactor is reheated or refilled, the low-pressure regulators will automatically feed or relieve in the ventilation mode

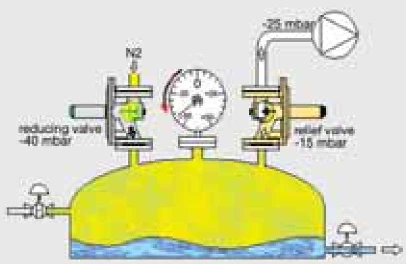
Vacuum pressure ventilation:



The ventilator evacuates the reactor space through the opened vacuum-pressure relief valve. Once the preset value of -15 mbar is reached, the vacuum-pressure relief valve closes again.



If filling level or temperature level falls below – 15 mbar so that the vacuum pressure inside the reactor falls (e.g. to - 12 mbar), the vacuum-pressure relief valve evacuates the gas again into the waste air system so that –15 mbar are reached again.



If the reactor cools down or gets emptied, the vacuum pressure rises. If the value of –40 mbar preset on the vacuum-pressure reducing valve is exceeded (e.g. to –43 mbar), the vacuum-pressure reducing valve blows in nitrogen until the process pressure reaches –40 mbar again.

If the reactor is reheated or refilled, the low-pressure regulators will automatically feed or evacuate in the ventilation mode

Storage tanks, intermediate tanks

Storage tanks, intermediate tanks or simple vessels are normally operated continuously so that only ventilation is required. Inertisation takes place automatically after expiration of a certain period of time.

Centrifuges

Due to their design, centrifuges are frequently neither pressure-resistant nor vacuum-resistant. Should inertisation or ventilation be unavoidable, the pressure flushing principle shall be used. To get an optimum inertisation effect, flushing should not take place continuously but in pulses.

Ventilation under vacuum-pressure or overpressure conditions

If ingress of oxygen into the process is to be avoided (e.g. in the presence of solvents), ventilation shall take place under overpressure conditions. If the escape of process gas is to be avoided, (e.g. in case of toxic fluids), ventilation should take place under vacuum pressure conditions.

Optimisation of inertisation costs

The working points preset on the regulators should be placed as far from each other as possible so that a wide pressure range without gas consumption can be obtained. Costs may be drastically reduced by minimum nitrogen consumption.

- Minimisation of nitrogen - procurement costs
- Minimisation of product loss through discharge into the waste air system
- Minimisation of waste air preparation

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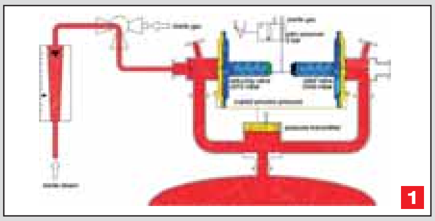
Ventilation in sterilisation engineering

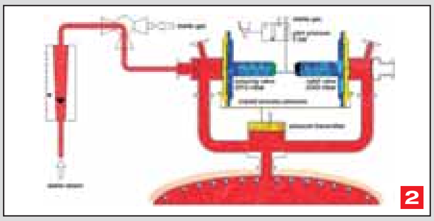
If sterilisation of process space is required, two low-pressure differential pressure regulators (reducing and relief valve) and one pressure transmitter are required.

Sterilisation by ventilation:



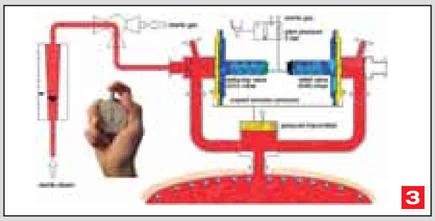
1

The sterile space is flooded with sterile steam through the opened differential-pressure reducing valve. Both regulators are activated with a pilot pressure of 2 bar. The reducing valve is set to 15 mbar and the relief valve is set to 40 mbar.



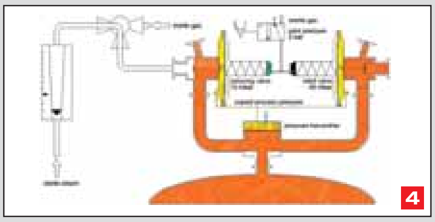
2

Pressure and temperature are reached in all places of the sterile space (saturated-steam curve 133°C at 2 bar). The steam throughput rate falls to the needed amount in order to maintain the pressure and to compensate the temperature loss by radiation. ***Process pressure: 2015 mbar.***



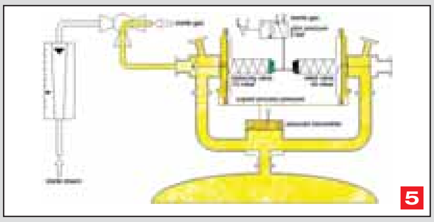
3

The flow meter transmits to process control the message that the sterilisation time has commenced. ***Process pressure: 2015 mbar.***



4

After expiration of holding time, pilot pressure (2 bar) and sterile steam are switched off. The steam pressure is relieved through the relief valve and the production process may start now.
Process pressure: 40 mbar.



5

The control system changes over from sterile steam to sterile gas, and the regulators change over to the ventilation mode and maintain sterility of sterile space during the process.
Process pressure: 15 – 40 mbar.

Benefits of sterilisation with low-pressure sterile regulators

- Sterilisation without cold niches
- Minimum time of sterilisation
- Minimum consumption of sterile steam
- No extra equipment required

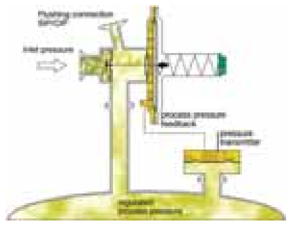
Sterile regulator

Design features of sterile regulator:

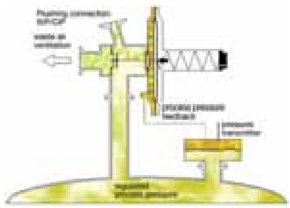
- 100% emptying rate
- No zones of germ formation
- Electro-polished surfaces
- Materials in conformity with FDA codes
- Flushing connection for SIP/CIP
- Overload safe up to 4 bar
- Vacuum resistant

Function of low-pressure sterile regulator

In contrast to conventional pressure regulators, the low-pressure sterile regulators require a clear isolation between process space and control space. To this end, the regulators have an extra isolation diaphragm between the plug/seat assembly and the lower diaphragm housing. Moreover, the 1 : 1 pressure converter is required to lead the process pressure into the space below the diaphragm. In conventional pressure regulators, the pressure feedback takes place through a drain line provided under the diaphragm. Moisture of fluid may settle there on the diaphragm plate. To safely exclude this kind of contamination, the sterile regulators have the process space (plug/seat assembly) isolated from the control space (diaphragm housing). This decoupling of process space from the diaphragm housing allows the interior design of regulator to be made in conformity with sterility requirements thus ensuring emptying, cleaning and sterilisation of regulator to 100%.



sterile reducing valve



sterile relief valve

Last but not least, the low-pressure regulators are designed and manufactured by ZÜRCHER-TECHNIK in Switzerland. We rely on Switzerland as our production site, its competitiveness and its advance in know-how.

Daniel Jäggi / Walter Schawalder

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