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Section on Prevention in the Chemical Industry
Section on Machine and System Safety

VISION ZERO
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Factsheet on Explosion Protection

Tightness of system components and connections

003

A. Introduction

The leakage of gases, liquids, vapours, mists, aerosols and dust has to be prevented so that no hazardous explosive atmosphere caused by these substances can form outside of the plant equipment.

This results in requirements for the tightness of such plants. Whether the principles by which tightness is achieved described here can be applied to preventing an air ingress (i. e. a leakage into the system) has to be assessed for each case individually.

Regarding explosion protection the following classification has been long established and proven over time:

1. "permanently technically tight"
2. "technically tight"
3. "operational escapes of flammable substances possible"

The new terms "normal tightness" and "enhanced tightness" used in EN 1127-1:2019 are based on a different approach as the norm addresses manufacturers and not operators. The terms used in that norm are therefore not identical with the commonly implemented terms used in this fact sheet.

B. Strain on system components and connections

The materials used for the system components and connections must be sufficiently resistant against stresses that are applied during the operation of the plant.

Amongst others the following stresses – especially including repeating stresses – need to be considered:

1. Mechanical stress, e. g. changes of pressure or temperature, conveying of abrasive substances
2. Thermal stress, e. g. conveying at high or low temperatures
3. Chemical stress, e. g.
   - Use of unsuitable materials (conveying of acetylene or hydrogen in copper pipes)
   - Corrosion, as observed e. g. when conveying acids or bases or in form of anodic attack caused by electrical balancing currents

Only personnel who are qualified to professionally fulfill the assigned task due to their functional training, knowledge, skills, and their experience may be appointed to produce or establish connections (planning, design, and assembly).

C. Permanently technically tight system components and connections

With these no leakages are to be expected during normal operations. There are no hazardous areas (no Ex-zones) outside of permanently technically tight and appropriately serviced system components and connections.[1]

The system components and connections have to be made in such a manner, that

1. they remain technically tight due to their construction parameters,
2. alternatively their technical tightness is maintained by ongoing maintenance (inspection, monitoring, maintenance and repair).

[1] This implies that no leaks are to be expected even under rare malfunctions.

C1. Permanently technically tight system components and connections due to their construction features

Construction characteristics of permanently technically tight system components and connections are:

1. Welded system components with detachable components and/or connections which are operationally only seldom detached and have the same characteristics as detachable pipe connections (see the following number 3).

2. System components that can contain sealing elements

2.1 for gases, vapours, liquids:
   a. Shaft bushings with a double-acting mechanical seal, taking into account the service life, e. g. on pumps, agitators,
   b. canned motor pumps,
   c. magnetically coupled pumps (sealless),
   d. diaphragm pumps with double diaphragm and gap monitoring,
   e. fittings with hermetic sealing of the spindle passage by means of bellows and safety stuffing box,
   f. gas-lubricated seals with monitoring of gas flow or pressure,
   g. glandless fittings with permanent magnet drive.

2.2 for dust:
   a. shaft bushings with monitored sealing air, e. g. with labyrinth or stuffing box seals,
   b. fittings with standard sealing systems, e. g. butterfly valves, gate valves of closed construction, ball valves,
   c. magnetically coupled, sealless drive systems

3. Connections for fittings or pipe connections, e. g.

3.1 for gases, vapours, liquids:
   a. inseparable connections, e. g. welded, soldered,
   b. detachable connections that are rarely released during operation, e. g.
      b1. flanges with weld lip seals,
      b2. tongue and groove flanges,
      b3. flanges with projection and recess,
      b4. flanges with V-grooves and V-groove seals,
      b5. flanges with a smooth raised face and special seals, e. g. soft material seals up to and including PN 25 bar, seals with a metal inner edge or metal-coated seals if a mathematical verification shows sufficient safety against the yield point when using standard flanges,
      b6. metallic sealing connections,
      b7. cutting and clamping connections in pipes up to and including DN 32
      b8. NPT thread (National Pipe Taper Thread, conical pipe thread) or other conical pipe threads with a seal in the thread up to and including DN 50, provided they are not exposed to changing thermal loads ($\Delta T > 100$ K).

   Additional requirements for combinations of flange connections with soft material seals, which are considered permanently technically tight, are:
   - Flange and seal were selected and installed according to the manufacturer's specifications,
   - the combination is suitable for the application,
   - the soft material of the seal does not become brittle, nor does it flow impermissibly,
   - the seal is blow-out safe and
   - the surface pressure of the seal is sufficiently above the required minimum pressure.

3.2 for dust, permanent technical tightness can be achieved by flange connections with seals or by clamp closures if the system is only exposed to
   a. low mechanical or thermal stress and
   b. low vibration loads.

C2. Permanently technically tight system components and connections achieved by a combination of technical and organisational measures

Alternatively, the combination of technical and organisational measures can lead to a system component or a connection being permanently technically tight.

1. With proper maintenance, this applies, for example, to the following system components/ connections:

1.1 for gases, vapours, liquids:
   a. dynamically stressed seals, e. g. for shaft bushings in pumps,
   b. thermally stressed seals in system components,
   c. mechanically stressed system components, e. g. when conveying substances with abrasive properties.

1.2 for dust:
   a. self-adjusting stuffing box packings when checking the correct fit and checking the wear limit,
   b. simple sealing systems only for system components/connections
      b1. without internal overpressure,
      b2. under low mechanical and thermal stress and
      b3. with low vibration loads, e. g. on screw conveyors, trough chain conveyors.

The scope and frequency of maintenance depends on the type of connection, construction, mode of operation, stress and condition and properties of the materials. They must be selected and designed in such a way that they guarantee technical tightness permanently.

The scope and frequency of maintenance to maintain permanent technical tightness must be documented in the explosion protection document and in the documents listed there, e. g. in an associated operating manual and/or in the maintenance plan.

Suitable measures for regularly checking the tightness can be:

1. for gases, vapours, liquids:
   a. Inspection of the plant and checking e. g. for streaks, ice formation, odors, and noises due to leaks,
   b. inspection of the system with mobile leak detectors/gas detectors or portable gas warning devices,
   c. continuous or periodic monitoring of the atmosphere by automatically working, permanently installed measuring and warning devices.

2. for dust:
   Inspection of the system and checking for dust emissions, dust deposits and material changes.
   Note: The scope and frequency of checking for leaks can only be reduced with adequate preventive maintenance.

D. Technically tight system components and connections

With these, releases are expected to be rare in normal operation. These system components and connections are to be designed in such a way that during a leak test or leak monitoring or check, e. g.

1. for gases and vapours with foaming agents or with leak detectors/gas detectors,
2. for dust by regularly checking for dust leaks and deposits, as well as visible defects or damage,

no leaks are evident.

Examples of technically tight system components are:

1. for gases and vapours
   a. flanges with a smooth face and no special design requirements for the seal,
   b. cutting and clamping ring connections in lines from DN 32,
   c. shaft seals that are based on simple operating principles, such as e. g. single-acting mechanical seals or stuffing boxes,
   d. detachable connections corresponding to the realization of connections that are permanently technically tight and that are not only rarely removed.

2. for dust:
   a. compensators,
   b. flexible connections,
   c. stuffing box seal,
   d. detachable connections that are not only rarely detached,
   e. access and inspection openings that are not only rarely opened.

E. Checking the system components and connections for leaks

In order to ensure tightness, system components/ connections must be checked as a whole or in sections as follows:

1. Before using for the first time,
2. after lengthy operational interruptions,
3. after changes,
4. after repair or modification,
5. even after an infrequent opening and re-sealing.

Practice has shown that a test plan makes sense.

The proof of tightness takes place in the form of a tightness test under operating pressure with suitable test equipment, such as e. g. described under „Technically tight system components and connections“ or in the form of a pressure test using a test pressure.

In addition, checks are required after maintenance and connection work and as part of periodic site inspections to identify obvious defects, such as

1. checking the torque of flange screw connections after the new assembly of seals,
2. detection of leakiness/leaks such as streaks, drops or formation of ice, formation of mist, noises or odours typical of leaks (as described in section „Permanently technically sealed system components and connections“ Part C2 Paragraph 5 Number 1 Letter a),
3. determination of external changes due to corrosion, discoloration due to excessive temperatures, mechanical damage,
4. detection of undesired oscillations/vibrations.

These checks do not supersede mandatory tests.

F. System components and connections that are not designed to be tight – Reduction of operational escapes of combustible substances

Outside of system components that are neither permanently technically tight nor technically tight, the formation of a dangerous explosive atmosphere is to be expected due to the operational escape of flammable liquids, gases, vapours or dust. Thus, these cannot be described as tight.

Operational exit points are e. g. openings of ventilation and relief lines, transfer connection points, gauge valves, sampling points, drainage facilities and in the case of dust, e. g. transfer points, as well as uncontrolled flange or housing connections (e. g. pump housing).

Technical measures can be taken to reduce the amount of leakage and thus the extent of areas at risk of explosion and/or the probability of the occurrence of an explosive atmosphere (zones) if e. g.

1. a full hose system (hose remains full at all times) is used when transferring liquids,
2. liquid is transferred in closed systems under gas displacement,
3. venting and relief lines are routed into gas collection systems,
4. it is ensured by special equipment at sampling points and dip valves that only small quantities can escape,
5. drainage is carried out via sluices with a small volume with interlocking shut-off valves,
6. object extraction systems are used,
7. the transfer points of products in the form of dust or products containing dust are provided with a casing made of largely dust-impermeable materials – possibly also flexible –,
8. the escape of combustible substances is avoided or reduced by using reduced pressure at operation-related exit points,
9. when using the reduced pressure mode (e. g. 900 mbar absolute), the probability of the occurrence of a dangerous explosive atmosphere in the vicinity of system components (e. g. openings, shaft bushings) is very low.

In the case of dust, organisational measures (e. g. regular cleaning) can reduce dust deposits and thus the extent of areas at risk of hazardous areas and/or the probability of an explosive atmosphere (zones) occurring.

Reference:
The contents of this information are partly taken from German technical rule for hazardous substances 722 (TRGS 722, February 2021).

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