

ADDENDUM

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Pressure-relieving and Depressuring Systems

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**ISO 23251 (Identical), Petroleum and natural gas
industries—Pressure-relieving and depressuring
systems**



Addendum 1 to Pressure-relieving and Depressuring Systems

Section 5.15.7.4 Liquid cooling service

Insert the following at the end of the paragraph:

... along with the following values of C1 and C2:

In SI units:

$$C_1 = 66\,300$$

$$C_2 = 108\,900$$

In USC units:

$$C_1 = 21\,000$$

$$C_2 = 34\,500$$

Insert the following at the end of Section 5:

5.23 Overfilling process or surge vessel

5.23.1 General

Many process or surge vessels, including columns and towers, have a liquid level present during normal, start-up, or shutdown conditions. Experience has shown that this equipment can be overfilled under certain conditions. If the source pressure of a liquid feed or supply line can exceed the relief device set pressure and/or the design pressure of the equipment, then overfilling shall be included in the system design. System design options to deal with liquid overfill include but are not limited to,

- a) increasing the system design pressure and/or pressure relief device set pressure within pressure design code allowances; and/or
- b) designing a pressure relief system that can safely accommodate the overfill (including the effects of operator intervention response as discussed in 5.4); and/or
- c) installing a safety instrumented system (SIS) to prevent the liquid overfill.

For all three options, all phases of operation shall be evaluated. Particular attention shall be given to start-up and other non-routine operations where process conditions (e.g., flow rates, temperature and density) can be different from normal and where conditions that lead to overfilling can be more likely to occur when compared with normal operations.

If option a) is chosen, the user shall validate the design (foundation, piping, etc.) consistent with the liquid overfill scenario.

If option b) is chosen, the user shall select the pressure relief devices, design their inlet and outlet piping, validate the foundation design, etc. consistent with the liquid overfill scenario. If operator intervention is used as part of the system design, then the risk of failure of the operator to properly intervene shall be addressed. The pressure relief device may discharge back into a disposal system such as a lower pressure section of the process, or to flare or to other disposal systems. If it is a basis for the disposal system design, then the user shall consider liquid overfill when designing the knockout drum, collection headers, etc. The design of the disposal system shall prevent the discharge of liquids above their flash point directly to atmosphere (into the air or on the ground) if there is an unacceptable risk as a result of a vapour cloud explosion or other

hazardous condition. See 6.3.2.4 for cautions regarding the atmospheric discharge of liquids. See 6.6 regarding options for the disposal of liquids.

5.23.2 Mitigation measures

When designing the system to mitigate liquid overflow, the following can affect the design and shall be evaluated.

- a) the risk of failure of the operator to respond properly;
- b) operator training and operating procedures that include instrumentation behaviour;

EXAMPLE If a differential-pressure or displacer-level measurement reads low compared to actual level when the fluid specific gravity is less than the design gravity. This can mean that the indicated level cannot reach 100 % even if the actual level is well above the measured range.

- c) availability of instrumentation that is required for adequate operator intervention;
- d) availability of instrumentation that is required for safety instrumented system (SIS) response;
- e) the potential consequence associated with relief stream disposition (e.g., discharge back into the process, discharge to atmosphere, discharge to a treatment system such as flare, etc.);
- f) the pressure design code requirements.

If operator intervention and/or SIS options are selected, then a risk analysis method shall determine the adequacy of the protection.

5.23.3 Level instruments

Some criteria to consider when evaluating level instrumentation and alarms to demonstrate availability and independence from the basic process control system include the following.

- a) whether the level instruments used for safeguards against overfilling are on separate process taps from the process control system;
- b) whether level instruments used for safeguards against overfilling are susceptible to the same common mode device failures as those used for the basic process control system. Diverse instrumentation can minimize the potential for common-mode device failures (e.g., differential pressure and radar, displacer and float, etc.);
- c) whether the instruments are proven in use for the specific process applications;
- d) whether the range of at least one of the level measurement(s) would indicate a valid level reading over the full range between the high critical alarm point and any shutdown or interlock point;
- e) whether operating characteristics of the level measurement during off-design, start-up, and shutdown operations are considered in display of level, setting alarms, trip points, operator training, and operating procedures.

6.6.23 a)

Insert the following after the second paragraph:

Sizing of the quench drum is discussed in 7.3.2.3.2. In addition to the quenching of vapours, the drum is typically required to provide vapour-liquid separation, liquid retention and disposal. If the quench drum is part of a header network consisting of multiple relief devices or tie-ins, then see 6.7 and 7.3.4 for additional design guidance.

Insert the following at the end of Section 6:

6.7 Disposal through common vent stack

The general principles in 6.3 also apply to designs involving multiple relief devices discharging into a common header manifold that is either vented directly to atmosphere through a common vent stack or through a separator, quench, blowdown, scrubber or other drum where liquid is collected and the vapour is discharged through a common vent stack. In particular, the considerations that need to be evaluated for these systems shall include the following.

- a) Guidance on determining design loads is given in 7.1.
- b) Relief manifold system design is discussed in 7.2.3 and 7.3.1.3.
- c) Guidance on liquid disposal options is given in 5.23 and 6.6.
- d) Because these systems can encounter a wide range of relief loads, consequence assessment shall evaluate both the scenarios representing the design loads but also smaller releases which result in lower discharge velocity and consequent greater tendency for the plume to drop to grade level in a hazardous concentration. Guidance on the specification and location of the vent stack is given in 7.3.4. Note that the guidance in 6.3.2 applies only to individual relief device tail pipes that discharge to atmosphere.

CAUTION — If there is a vapour cloud explosion hazard associated with one or more relief cases or discharges, then one of the following shall be used:

- disposal by a flare (see 6.4); or
- discharging into a lower pressure system (see 6.5); or
- application of HIPS (see Annex E); or
- eliminating the relevant relief cases (redesign of equipment, etc.).

The user shall assess hazards other than a vapour cloud explosion associated with the release and determine appropriate mitigation measures.

Change the title of Section 7.3.2.1 to read:

7.3.2.1 Flare knockout drums

Section 7.3.2.1.2, change the paragraph after item b) to read:

The volume occupied by the liquid should be based on a release that lasts 20 min to 30 min. Larger hold-up volume may be required if it takes longer to stop the flow. Any accumulation of liquid retained from a prior release (from pressure-relief devices or other sources) should be added to the liquid indicated in items a) and b) above to determine the available vapour-disengaging space.

The risk of overfilling the flare knockout drum shall be assessed. Most flares are not designed to effectively combust liquid. These evaluations should consider the effect of

- the amount of liquid in the knockout drum prior to the release including the removal time,
- liquid weight on flare header and flare stack mechanical integrity,
- discharging liquid from the flare (i.e., potential for flame-out, excessive smoke and unburned hydrocarbon emissions, discharge of “burning rain”, pool fires around the flare stack, etc.), and
- flare siting/location in proximity to areas where people can be exposed, property fence-line, unit, etc.

Replace 7.3.2.3 to read:**7.3.2.3 Knockout drums venting to atmosphere****7.3.2.3.1 General**

Atmospheric blowdown systems are knockout drums with stacks open to atmosphere.

CAUTION — If there is a vapour cloud explosion hazard associated with one or more relief cases or discharges, then one of the following shall be used:

- disposal by a flare (see 6.4); or
- discharging into a lower pressure system (see 6.5); or
- application of HIPS (see Annex E); or
- eliminating the relevant relief cases (redesign of equipment, etc.).

The user shall assess hazards other than a vapour cloud explosion associated with the release and determine appropriate mitigation measures.

The criteria in 7.3.2.3.2 and 7.3.2.3.3 can be used to design atmospheric knockout drums for releases which have no vapour cloud explosion hazard.

7.3.2.3.2 Atmospheric knockout drums (without quench provisions)

All of the following criteria shall be met.

- a) The design of the atmospheric knockout drum shall meet the design criteria for flare knockout drums in 7.3.2.1.
- b) The atmospheric knockout drum shall be designed to knock out liquid droplets such that any remaining droplets or the plume cannot reach working areas, property line or other critical areas at a hazardous

concentration. The droplet size criteria for atmospheric knockout drums should be more stringent than for flare knockout drums (See 7.3.2.1) because most flares are capable of burning small droplets [151].

- c) See 7.3.4 for design guidance on the vent stack.

7.3.2.3.3 Atmospheric knockout drums (with quench provisions)

This subclause addresses the design of the atmospheric knockout drums with quench provision (e.g., quench drum) where the quench liquid is water that cools and/or condenses the released material. The design of drums where the quench liquid is not water or where quenching non-petrochemical releases can use the principles given below but may require additional or different considerations.

All of the following criteria shall be met:

- a) The design of the quench drum shall meet the design criteria for flare knockout drums in 7.3.2.1. In general, a vertical cylindrical vessel is preferred.
- b) The quench drum shall have a liquid removal system capacity equal to the maximum quench water supply plus condensed and/or liquid hydrocarbons. If backup quench is required, as per item h) below, then the liquid removal system shall be sized to handle the maximum flow from both sources of quench along with the maximum condensed release flow. No valves shall be provided in the gravity drain line.
- c) If a gravity drain is used, then the quench drum should have a liquid holdup that is sufficient to create the static head necessary to push the liquid out of the gravity drain at the rate required by b) but not reach the bottom of the contactors as shown in Figure D.2.
- d) Water requirements are normally based on reducing gas and liquid outlet temperatures. Selection of optimum temperature is based on considerations of temperature and composition of entering streams, the extent to which subsequent condensation of effluent vapours downstream of the drum can be tolerated, and the maximum temperature limitations of the disposal system (e.g., sewer).
- e) The maximum temperature in the quench drum reservoir shall be selected to avoid drying out the drum and losing the liquid seal. Some margin shall be provided to stay below the local atmospheric boiling temperature.
- f) The water holdup in the base of the drum shall be sized to absorb the maximum heat of the release for enough time for the quench to be fully established.
- g) The water supply shall be reliable. If a fixed basin of water is used, then the basin shall have adequate capacity to supply the maximum condensable quench requirement for 30 minutes.
- h) The quench water shall be automatically actuated by high temperature or flow in the inlet line. The availability (SIL level) of the quench water system shall be determined (see E.4.2). An emergency backup water connection may be required to achieve the necessary SIL level. Possible consequences from failure of the quench water, resulting in release of excessive vapours to atmosphere and/or hot liquids to the sewer, shall be considered.
- i) A continuous make-up water supply shall be provided to maintain the outlet seal.
- j) The atmospheric knockout drum shall be designed to knock out liquid droplets such that any remaining droplets or the plume cannot reach working areas, property line or other critical areas at a hazardous concentration [151].
- k) Drum internals to improve vapour-liquid contact should be provided. Scheiman's articles [116], [117] cover design criteria for one type of internals frequently used in this service.

- l) The seal height in the liquid effluent line (assuming 100 % water at the maximum drum liquid temperature) normally is sized for 175 % of the maximum drum operating pressure, or 3 m (10 ft), whichever is greater (see Figure D.2).
- m) Maximum drum operating pressures are typically in the range of 7 kPa to 14 kPa (1 psig to 2 psig). Higher pressures are acceptable providing that maximum allowable pressure relief device back pressures are not exceeded. A higher pressure will reduce the size of the off gas piping but will require a deeper seal leg and can lead to excessive sewer gassing. Steam generated in the condensable blowdown drum due to evaporation of cooling water shall be included in the drum effluent gas stream composition when calculating back pressures.
- n) The quench water system shall be equipped with suitable winterization and freeze protection.
- o) Alarms may be provided to alert operators in the event that design liquid levels are exceeded.

Delete the last paragraph of Section 7.3.2.4.

**Section 7.3.4.1 Sizing,
Insert the following at the end of the second paragraph:**

The pressure drop across the vent stack shall be included in the calculation of the total back pressure on relief devices flowing into the header network. See 7.3.1.3 for more details.

**Section 7.3.4.2 Design Details
Replace the first two paragraphs with the following:**

The principles in 6.3 and 6.7 shall be used when selecting the vent stack height and location. The siting of vent stacks discharging to atmosphere should consider personnel health and safety, noise, potential odour, potential ground level concentrations, potential liquid carryover, ignition sources, and thermal radiation. Dispersion modelling, consequence analysis, and/or risk analysis are valuable tools for evaluating whether vapours discharged from the vent stack pose flammable, toxic, or other hazards to personnel. These systems often handle a wide range of relief loads. The dispersion analyses and consequence assessments shall evaluate the range of conditions (flow rate, composition, temperature, etc.) the stack is expected to handle.

NOTE Smaller releases result in a lower discharge velocity, which can have a tendency for the plume to drop to grade level in a hazardous concentration.

The height and location of the vent stack shall be selected so that the concentration of vapour at a point of interest is below the lower flammable limit of the vapour. The lower threshold for flammability concerns can be satisfied by ensuring the concentration at potential sources of ignition, personnel location or other vulnerable areas does not exceed 0,1 times to 0,5 times the lower flammable limit. Electrostatic ignition of atmospheric releases is discussed in 6.3.4.1.4. In any case, the radiant heat intensity for vent stacks shall be evaluated for an ignitable vapour. This shall be done by the same means as used for flare stacks, and the same limits of radiant heat intensity shall apply. Radiant heat levels rather than dispersion can sometimes govern the vent stack design in determining stack height.

Toxic thresholds are generally much lower than the flammability thresholds in certain applications and can become the governing factor.

If dispersion and consequence analyses indicate that flammable or toxic or radiant heat levels might be exceeded, the design needs to be improved. Design options include but are not limited to elimination of

relevant relief cases (via HIPS, redesign of equipment, etc.), removal of relevant relief devices from the vent system, or elimination of the vent system (e.g., connection to a flare).

The potential for flashback shall be considered. An example of a method to mitigate flashback is to install an appropriate and reliable continuous purge gas at a rate determined by the Husa correlation to prevent air intrusion (see 7.3.3.3.3). Steam is not an effective purge fluid for preventing air infiltration because it can condense.

Insert the following reference in the Bibliography, and re-number the remaining references:

[151] D.W. JOHNSON and J.L. WOODWARD, *Release, a Model with Data to Predict Aerosol Rainout in Accidental Releases*, Published by Center for Chemical Process Safety, ISBN 0-8169-0745-5



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