Management Summary- Venting & Flaring of hydrogen

The Dutch distribution network operators are currently conducting various pilots regarding distribution of hydrogen. For carrying out these pilots safely, clarity in advance is needed about the safety of crucial gas operations such as purging during venting (*commissioning*) and degassing (*(temporary) decommissioning*) of hydrogen pipes.

The aim of this study and the study of purging of hydrogen pipes[1] is to come to a safe and efficient way of venting (*commissioning*) hydrogen distribution pipes, making them pressure less and degassing them (*(temporary) decommissioning*).

The result of this study is a set of standard operating procedures and – if necessary – suggestions for modifications to the Esders[2] equipment, such that hydrogen can be vented or flared safely and efficiently.

The substantiation of these standard operating procedures is laid down in this report and in Kiwa report Purging of hydrogen pipes. This concerns a number of theoretical considerations and the results of practical tests.

Conclusions

Venting versus flaring

Consideration of all the advantages and disadvantages of both techniques leads to the conclusion that both techniques are considered to be of equal standing and suitable for hydrogen.

Remarks:

- When **venting**, the hydrogen plume can be ignited unintentionally, but the liability for this to occur is considered to be very low.
- When **flaring**, one must be aware of trees and shrubs in the area.

Venting

From a safety point of view and with due observance of the usual safety measures, venting is a suitable and simple method for purging hydrogen pipes. From a safety point of view, it is comparable with natural gas. Venting hydrogen is 40 times less harmful to the environment.

For shots of the performed practical tests, see:

- Venting of hydrogen is being made visible by adding smoke
- Venting of hydrogen and air is being made visible by adding smoke

Venting installation

It is not necessary to modify the Esders venting installation; the standard venting installation – as being used for venting natural gas – is also suited for venting hydrogen.

The following remarks are relevant:

- When purging[3] hydrogen pipes with an inert gas, the use of a hydrogen flame arrestor is not necessary.
  Reasoning: in this case flame flashback is impossible.
- The following applies when purging hydrogen pipes with air:
  - It is not necessary to use a hydrogen flame arrestor.
    Reasoning: the liability the hydrogen plume will be ignited – and that flame flashback will occur in the pipeline – is considered very low. It is noted here that dust – if present in the pipe and carried along with the gas flow – could possibly lead to ignition of the vented hydrogen*.
  - The use of a hydrogen flame arrestor can be used as an extra safety measure. The liability of (too much) obstruction of het gas flow to be vented is a disadvantage*.

*) See recommendations.

Flaring

From a safety point of view and with due observance of the usual safety measures, flaring is a suitable and quite simple method for purging hydrogen pipes. From a safety point of view, it is of equal standard to flaring of natural gas.

For shots of the performed practical tests, see:

- Flaring of hydrogen with a standard flaring-installation, with a diffusor and arrestor
- Flaring of hydrogen with a standard flaring-installation, without a diffusor but with an arrestor
- Flaring of hydrogen. The hydrogen flaring-installation has a different setup

[1] See Kiwa report Spoelen van waterstofleidingen, benodigde spoelsnelheid bij het ontluchten en ontgassen, GT-200289. "(Purging of hydrogen pipes, required purging speed for commissioning and decommissioning)"
[2] Esders provided the equipment for the study and contributed to the costs of the study
[3] When purging is mentioned, this refers to both venting (*commissioning*) and degassing (*decommissioning*).

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Flaring installation

It is not necessary to modify the Esders flaring installation; the standard flaring installation – as being used for natural gas flaring – can also be used for flaring hydrogen.

The following remarks are relevant:

- When purging hydrogen pipes with inert gas, the use of a hydrogen flame arrestor is not necessary.
  Reasoning: in this case flame flashback is impossible.
  Remark: however, if nitrogen purging has been incomplete, causing air to remain in a pipe section, the following applies:
  - If it concerns a 'dead' branch that has not been purged with nitrogen, then the liability of flame flashback is negligible. After all, more than 20% of air must then be included in the hydrogen-nitrogen mixture to be flared in order to cause flame flashback, and this is considered very unlikely. In this case, the air is absorbed by diffusion and this process runs sufficiently slow.
  - If it concerns a mesh pipe that is included in the purging with hydrogen, but has not been purged with nitrogen, then flame flashback cannot be excluded. In this case it is recommended to use a hydrogen flame arrestor (pay attention to the limitation of the flow rate) or to switch over to venting.
- When *commissioning* hydrogen pipes, where the air is expelled directly by hydrogen, a hydrogen flame arrestor must be used. The disadvantage of this is that the flow of gas to be flared is (possibly too much) obstructed*.
  Reasoning: when flaring without a hydrogen flame arrestor, there is a considerable risk of flame flashback.

*) See recommendations.

Standard operating procedures

The draft standard operating procedures such as these have been drawn up, for example for The Green Village, with regard to venting and flaring, can be used safely.

The following remarks are relevant:

- When purging hydrogen pipes with inert gas, the use of a hydrogen flame arrestor is not necessary.
- The following applies for purging hydrogen pipes with air:
  - The use of a hydrogen flame arrestor is not necessary for **venting** (see above for venting).
  - For **flaring**, a hydrogen flame arrestor must be used (see above for flaring).
- With regard to the distances that must be observed, the following applies:
  - When **venting**, a minimum distance from ignition sources must be maintained that is ≈ 1.3 times longer than for natural gas (based on 10% LEL).
  - When **flaring** hydrogen, the same minimum distance can be maintained for the area to be cordoned off as when flaring natural gas.

Table 1 summarizes the results.

Recommendations

It is recommended to:

- investigate whether dust particles (rust particles), which may be present in the hydrogen network (the former natural gas network), can lead to unintentional ignition of the hydrogen and to a flame flashback.
- investigate the flow resistance of the required hydrogen flame arrestor(s) at various flow rates.
- investigate whether air-moving of hydrogen pipelines can be used safely or even add to safety.
  Remark: if the hydrogen flow is diluted by air-moving or can be diluted to such an extent that the gas-air mixture to be vented is below LEL, this method can be used for both *decommissioning* and *commissioning*.

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Table 1: Overview venting and flaring

Action	Method	Perge medium	Flame arrestor	Reasoning/remark
Commissioning	Venting	Inert gas (nitrogen)	No	• Flame flashback impossible • Igniting hydrogen plume very unlikely
	Flaring	Inert gas	No	• Flame flashback impossible
	Venting	Air	No	• Igniting hydrogen plume very unlikely, so igniting hydrogen plume very unlike • If it is liable that substance (rust) from the pipe is swirled away with the flow, this may possibly lead to ignition of the vented hydrogen (and to flame flashback) • *Further research recommended*
	Venting	Air	If applied	• Possible obstruction of the hydrogen flow to be vented • *Further research recommended*
	Flaring	Air	Yes	• Significant risk of flame flashback
Decommissioning	Venting	Inert gas	No	• Flame flashback impossible • Igniting hydrogen plume very unlikely
	Flaring	Inert gas	No	• Flame flashback impossible
	Venting	Air	No	• Igniting hydrogen plume very unlikely, so flame flashback very unlikely • If it is liable that substance (rust) from the pipe is swirled away with the flow, this may possibly lead to ignition of the vented hydrogen (and to flame flashback) • *Further research recommended*
	Venting	Air	If applied	• Possible obstruction of the hydrogen flow to be vented • *Further research recommended*
	Flaring	Air	Yes	• Significant risk of flame flashback
Conversion natural gas to hydrogen	Flaring	Hydrogen (expels natural gas)	No	• Flaring due to the environmental impact of natural gas

Commissioning and decommissioning is visualized in Figure 1.

Management Summary- Venting & Flaring of hydrogen

Table 1: Overview venting and flaring

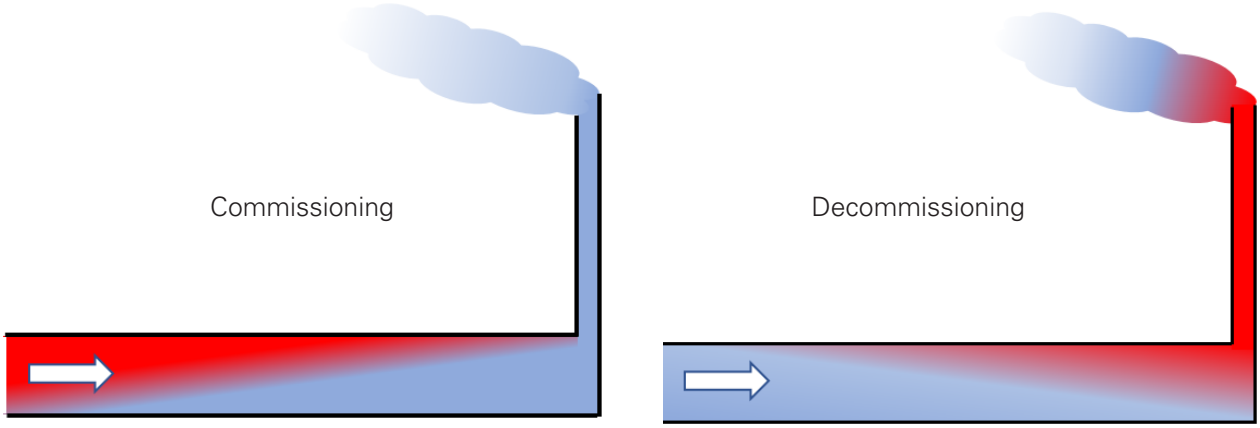

Figure 1 *Left: this depicts venting (commissioning): nitrogen is expelled by hydrogen*
Right: this depicts degassing (decommissioning): hydrogen is expelled by nitrogen
The practice of purging involves the creation of a certain degree of layering and mixing, which is shown in the figure