The influence of hydrogen on the soft materials in RNO gas pressure regulation installations

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Gas Pressure Regulation Installations (GPRIs) contain multiple and several types of soft components, with the main purpose to seal and prevent gas leakage. To be able to support the hydrogen transition and to reduce our dependence on fossil fuels, the network operators need to know to what extent their installations are suitable for hydrogen gas. Possible hazards associated with the use of hydrogen, in which soft components can play a role, are difficult to estimate. Firstly, hydrogen gas differs from natural gas in both thermo-physical properties and combustion properties. Secondly, hydrogen gas behaviour differs strongly depending on the service conditions, e.g. temperature and pressure. Hydrogen is often used in extreme temperature and pressure conditions, where completely different effects occur. These effects should not be mixed up with effects in normal temperature ranges and low-pressure conditions.

Therefore, this investigation was started by the branch organisation of regional network operators (RNO) (Netbeheer Nederland) that deals with GPRIs. For this investigation first an identification was done on the multiple soft components used in RNO GPRIs. It includes a wide range of polymers: rubbers and plastics, lubricants (main constituent oil), epoxy resins and adhesives. These materials have been assessed to determine the compatibility with hydrogen gas, including permeability and mechanical testing etc. Also, the effect of THT (sulphur containing odorant) was assessed. The outcome of this literature investigation shows that the soft materials used in the RNO gas pressure control installations and found in this study, are also suitable for the distribution of hydrogen.

Furthermore this research is used to identify possible shortcomings of these materials, which could form an obstacle and ensure that distribution of hydrogen takes place as safely identify the risks of increased permeation compared to the application with natural gas and stimulate the development of a certification scheme for hydrogen, both for new and currently used materials and components.

A gas pressure regulation installation can be distinguished in the following parts:

- valves (inlet, balancing and outlet valve);
- safety valve and safety shut-off valve;
- pressure and flow regulators;

- pipes under pressure and without pressure;
- pressure (manometer), flow or flow measuring points;
- flange connections with gaskets;
- screw and compression connections;
- dust filters;
- supplies to facilitate assembly, such as lubricants.

These parts work under (relatively) low pressure (max. 8 bar) and normal temperatures (-20 till +60^{o}C). Soft materials include the polymers: rubbers and plastics, lubricants (main constituent oil), epoxy resins and adhesives.

When soft materials in a GPRI come into contact with hydrogen, other aspects in terms of risks or the correct functioning of components can occur compared to natural gas. The risk level with regard to natural gas is shown in table 1.

Possible hazards associated with the use of hydrogen in which soft materials can play a role are identified below, see table 1, and compared with natural gas.

Table 1. Summary of possible primary risks and indication of the relative risks of hydrogen on soft materials compared to their application with natural gas. Green is no extra risk, yellow little extra risk and orange: moderate risk

Possible consequences	Primary risks of the influence of hydrogen on soft materials in gas pressure regulation installations		Risk level compared to natural gas
Leakage; **Contamination of the hydrogen**;	Small size of the molecule	Permeation;	
		Vibrations;	
	Interactions with materials;	Physically: Stress relaxation and/or permanent shape change and abrasion and wear;	
		Chemically and ageing.	

*under normal circumstances

This literature study shows that in GPRIs for RNOs there are no material interactions with hydrogen possible because of the absence of high pressures (> 900 bar) and / or extreme temperatures. Only extreme conditions could result in volume change and compression differences in the materials that could lead to degradation. The effects of hydrogen on the degeneration of soft (and also other) materials are negligible at low pressure (≤ 8 bar) and relatively slow pressure variations.

Lubricants, based on silicone, fluoride, etc., do not cause a chemical reaction with hydrogen, regardless of the concentration. Tetrahydrothiophene (THT), the odorant in natural gas used in the Netherlands, is, just like hydrogen, non-corrosive. The combination of durability and hydrogen does not pose an additional risk to the life of the lubricants used compared to natural gas.

It is no problem to continue to use the current soft materials in the GPRIs. However, the possibly higher permeation of hydrogen must be taken into account, possibly by taking additional (ventilation) measures. Specific proof that there are no problems remains difficult, because there is no systematic and complete overview of the materials used, not even from suppliers and manufacturers. A test and certification process specifically for applications with hydrogen can offer more certainty.

The recommendations of this report are:

- Encourage the development of a certification scheme for hydrogen, both for new and for existing / applied materials and components. At new stations with a hydrogen application, use components and materials with this certification. This provides the greatest possible certainty.
- Within this certification scheme, at least include the following material properties for the individual types of soft materials in the assessment:
    - compatibility (swelling and extraction);
    - mechanical properties (especially stress relaxation and/or permanent set change) and;
    - permeation/leakage for use in hydrogen gas pressure regulation installation applications (temperature and pressure range).
- A permeation test is the preferred material property test and the leakage test is preferred as a component test.
    - When switching to hydrogen, the limits of the maximum leakage and minimum ventilation must be redetermined.
- Current (pilot) projects in the field of hydrogen gas stations do not have to be put on hold until this certification scheme is ready. This literature study did not reveal any problems for the combination of soft materials and hydrogen. A condition for this is that all materials used are approved for use with natural gas.
- Make an inventory of the risks of possibly increased hydrogen permeation (compared to natural gas) based on experience with pilot projects and possibly supplemented with laboratory experiments and then consider whether adjustment of product or system standards is necessary.
    - Make an inventory of the risks of possibly increased hydrogen permeation (materials where permeation plays a role) based on experience with pilot projects and possibly supplemented with laboratory experiments and then consider whether adjustment of product or system standards is necessary.

- No indications have been found in the literature that hydrogen deteriorates or improves the function of a lubricant. If there are parts in a gas pressure regulating installation that contain lubricants and come into contact with the gas, it is recommended to also assess the influence of any degradation of the lubricants on their intended function (sealing and reducing wear).