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Off-Gas Treatment

Recombination Unit: Hydrogen Risk Mitigation during Power Operation

The recombination unit reduces the hydrogen and oxygen concentration by catalytically recombining hydrogen and oxygen to water. Gaseous tritium is transferred to the liquid phase for further treatment

Challenge

Hydrogen and oxygen are generated in the reactor during power operation by radiolysis. By the primary coolant transfer to the auxiliary systems degassing of hydrogen and oxygen can result in an unintended accumulation of hydrogen. Operational experiences globally highlights several incidents that have occurred during the operation of light water reactor gas treatment systems.

Solution

The recombination unit in the off-gas purging flow continuously converts hydrogen with oxygen to water by a catalytically enhanced chemical reaction.

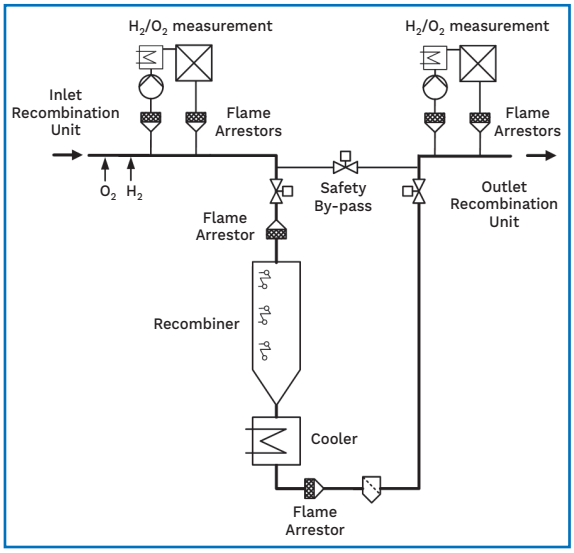
Hydrogen and oxygen sensors installed upstream of the recombiner continuously monitor the hydrogen and oxygen concentration at the inlet of the recombination unit.

Based on these measurements the concentration ratio of hydrogen to oxygen is automatically adjusted to achieve complete conversion of the gases within the recombiner.

In the recombiner hydrogen reacts with oxygen to water at a Palladium based catalyst. The released heat of reaction is evacuated from the gas. The hydrogen and the oxygen concentration downstream of the recombiner is continuously measured to immediately identify any potential process anomalies.

All potential ignition sources are encapsulated by passively working flame arrestors which serve as additional safety back-up for the implemented active safety features.

If required, the recombination unit can be delivered skid-mounted. The system can be installed in all types of power reactors.



Recombination Unit: Typical System Design

Customer benefits

- Mitigation of hydrogen risk during power operation
- Reduction of gaseous radioactive waste by recycling option for the carrier gas
- Sizing optimized on customer needs
- Fault-tolerant design
- Robust, fully automated design requiring less operator actions
- Well-proven modular design

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Technical information

Recombiner

• Design Temperature:	400°C
• Design Pressure:	20 bar_g
• Operating Temperature:	up to 360°C
• Material:	Stainless Steel
• Catalyst:	Pd / inorganic carrier
• Size (typical PWR):	
- Diameter:	550 mm
- Height:	1800 mm
• Power consumption:	approx. 3 kW

H_2 / O_2 Monitoring Devices[1)]

• Hydrogen Measurement:	Thermal conductivity
• Hydrogen Measurement:	0-4 / 0-0.5 vol.-%
• Oxygen Measurement:	Paramagnetic
• Oxygen Measurement:	0-2 / 0-1 vol.-%

Performance

• Outlet concentration H_2	≤ 0.3 vol.-%
• Outlet concentration O_2	≤ 0.1 vol.-%
• Accumulated operating hours:	> 900 accumulated reactor years

[1)] Ranges can be adjusted based on specific needs

Recombiner

Catalyst

H_2 / O_2 measurement

References

• Western Europe:	18 PWR / 8 BWR
• America:	2 BWR / 2 PHWR / 2PWR
• Asia:	4 PWR / 4 BWR

BWR: boiling water reactor
PWR: pressurized water reactor
PHWR: pressurized heavy water reactor

Key figures

Installed and operated in more than **30** nuclear power plants (BWR and PWR) worldwide.

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