framatome

Passive Autocatalytic Recombiner

Combustible Gas Control System

The Framatome Passive Autocatalytic Recombiner improves the plant safety by limiting the concentration of combustible gases in design basis and severe accidents without external power supply.

Challenge

During design basis and severe accidents large quantities of combustible gases like hydrogen and carbon monoxide are released to the containment atmosphere. In case of uncontrolled combustion the resulting loads can endanger the containment integrity. The containment integrity as last barrier preventing radioactive releases has to be ensured under all circumstances.

Solution

Framatome developed a combustible gas control system based on the principle of catalytic oxidization, the Passive Autocatalytic Recombiner (PAR). With a gas treatment capacity of up to 1500 m³/h per PAR unit, combustible gases will be safely eliminated and their concentration can be kept below the safety thresholds.

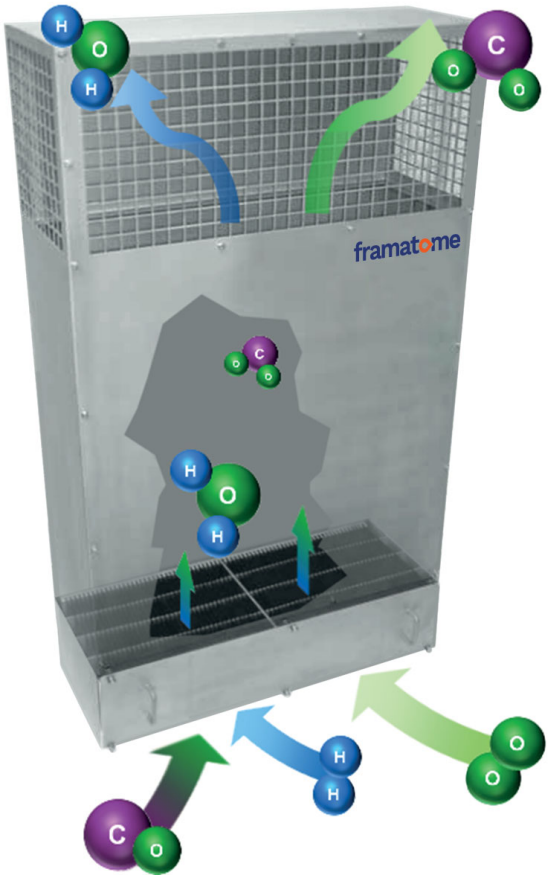
The essential part of the recombiner is the catalyst. The Framatome catalyst design is based on thin stainless steel plates coated with multiple noble metals. It allows the fast start of the catalytic reaction at low temperature and is highly resistant to poisoning in severe accident situations.

The PAR housing is designed with a high inlet cross section at the bottom and a lateral gas outlet at the top. This design reduces the pressure drop and promotes the chimney effect that causes:

- a high flow rate through the recombiner in operation
- The formation of local convection loops in the containment
- The mixing of the containment atmosphere to prevent local accumulation of combustible gas
- Additionally the housing protects the catalyst from spraying of water and aerosol deposition

Upon contact with the catalyst in the lower part of the PAR housing, the combustible gas in the atmosphere is recombined. The heat from this reaction causes buoyancy forces that induce a convective flow, thus supplying the catalyst with a large amount of hydrogen that ensures a highly efficient recombination.

Your performance
is **our** everyday **commitment**



Framatome PAR FR1-750T

Customer benefits

- Low investment and high cost benefit
- Reliable and flexible system
- High hydrogen depletion and flow rate
- High inlet cross section leads to self-acceleration of the recombination
- Easy to implement
- Simple to maintain
- Start of operation without operator action
- Highly efficient recombination rate to space / weight ratio

Differentiators

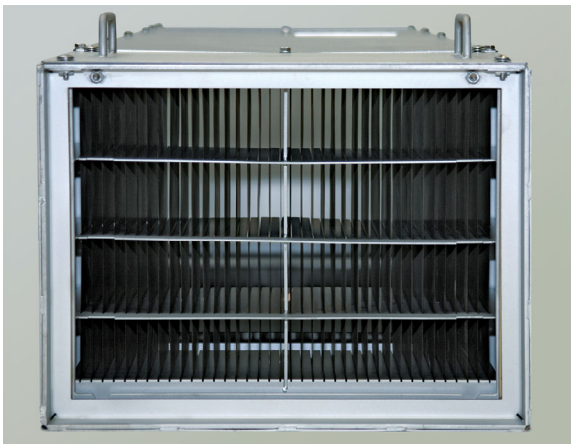
The Framatome PAR has been subject to extensive and long-term testing over wide range of parameters including successful test under real core melt accident conditions in order to evaluate it in various accident scenarios in both PWR and BWR. Thanks to the thin-plate technology for fast and reliable start-up of the catalytic reaction, the Framatome PAR convinced during international tests with:

- its very fast start-up,
- its high efficiency and
- its constantly high hydrogen depletion rates.

As soon as the PAR housings with the catalysts are assembled, the hydrogen reduction system is ready for operation. A functional check of a representative process section of the PAR is confirmed during the site acceptance tests and the in-service inspections.

An inspection drawer ensures quick access to the catalytic plates. The design allows a quick and easy removal of the catalytic plates for inspection and testing. The functionality of a PAR process section is usually tested under representative conditions with test gas containing hydrogen in a dedicated test device developed by Framatome (TIRE – Transportable In-service Inspection and Regeneration Equipment).

The TIRE can also be used for the regeneration of the catalyst in case of pollution. This contributes to the low operational expenditures of the Framatome PAR.



PAR FR1-380T from below with view of the catalytic plates.

Hydrogen mitigation applications with Framatome PARs

- Replacement of existing hydrogen recombiners and combustible gas control systems for design-basis accidents
- Hydrogen mitigation during severe accidents
- General limitation of combustible gas concentration
- Combination with post-accident venting and ignition functions possible

Technical information

The Framatome PAR is available in different sizes, allowing for the best possible arrangement in the various compartment areas.

	FR1-150	FR1-320	FR1-960	FR1-380T	FR1-750T	FR1-1500T
Length (mm)	200	370	1010	430	800	1550
Depth (mm)	166	166	166	326	326	326
Height (mm)	1000	1000	1000	1400	1400	1400
Approx. weight (kg)	18	26	60	50	80	130
No. Of catalytic plates	15	32	96	38	75	150
Inlet flow rate (m^3/h) at 1 bar and 60°C up to	50	110	330	330	660	1500
Depletion rate (kg/h) at 1.5 bar and 4 vol- %	0.18	0.40	1.20	1.20	2.40	5.36

References

To date, Framatome has been contracted, delivered and installed PAR-based H_2 Control systems in more than 150 nuclear power plants in Europe, Asia and Africa, including test equipment and, if required, with regeneration mode.

Excellent operating results were achieved even under adverse conditions such as oil fire or oil aerosols from the main coolant pump, boric acid, or a significant high concentration of organic carbon-hydrogen compounds.

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