

PASSIVE AUTOCATALYTIC RECOMBINER (PAR)

Combustible Gas Control System

Framatome's PAR improve the plant safety by limiting the concentration of combustible gases in the containment atmosphere during design basis and severe accidents without the need for external power supply.

Challenge

During design basis and severe accidents large quantities of combustible gases like hydrogen and carbon monoxide, e.g., from metal-water reactions, and concrete-corium interaction are released to the containment atmosphere. The resulting loads from uncontrolled combustion of these combustible gases can endanger the containment integrity. The containment integrity as last physical barrier for enclosed radioactivity must remain intact, to prevent significant long-term off-site land contamination.

Solution

Framatome's Passive Autocatalytic Recombiner (PAR) offers gas treatment capacities of up to 1500 m³/h per PAR, ensuring the combustible gas concentrations below the safety limits.

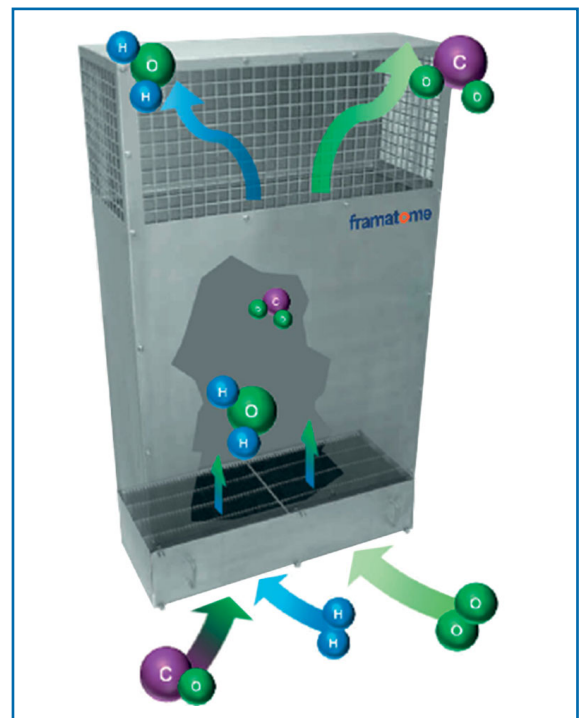
The catalyst is the essential part for the reaction in the recombiner. Framatome's catalyst design is based on thin stainless-steel plates that are coated with multiple noble metals. This design allows the catalytic reaction to start quickly and at low temperatures. The catalyst is at the same time highly 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 to reduce the pressure drop and promote the chimney effect ensuring:

- High flow rates through the recombiner unit during operation
- Formation of local convection loops in the containment
- Mixing of the containment atmosphere to prevent local accumulation of combustible gases

In addition, the housing provides protection of the catalytic plates from water spray and aerosol deposition.

The combustible gas in the atmosphere is recombined when it comes in contact with the catalyst in the lower part of the PAR housing. This exothermal reaction produces heat, which creates buoyancy forces inducing a convective flow. The catalyst is supplied with a large amount of hydrogen, ensuring highly efficient recombination.



Example of a Passive Autocatalytic Recombiner

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.

Technical information

Framatome's PAR has undergone extensive and long-term testing over a wide range of parameters, including successful testing under real core melt accident conditions to evaluate its performance in various accident scenarios in both PWR and BWR plants. Thanks to the thin-plate technology for fast and reliable start-up of the catalytic reaction, Framatome's PARs convinced in international tests with:

- Very fast start-up
- High efficiency
- Consistently high hydrogen depletion rates

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

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

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

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

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

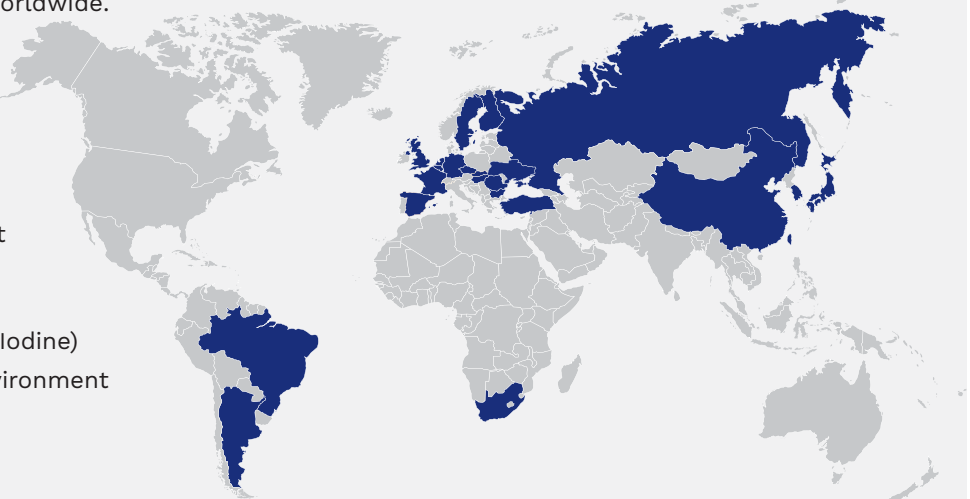
	FR1-150	FR1-320	FR1-960	FR1-380T	FR1-750T	FR1-1500T
Length (mm)	200	370	1010	430	800	1550
Depth (mm)	166	166	166	326	326	326
Height (mm)	1000	1000	1000	1400	1400	1400
Approx. weight (kg)	18	26	60	50	80	130
No. Of catalytic plates	15	32	96	38	75	150
Inlet flow rate (m ³ /h) at 0.1 MPa (a) and 60 °C up to	50	110	330	330	660	1500
Depletion rate (kg/h) at 0.15 MPa (a) and 4 vol- %	0.18	0.40	1.20	1.20	2.40	5.36

References

Passive Autocatalytic Recombiner applications are installed in more than **150** nuclear power reactors worldwide.

Extensive qualification and performance verification testing

- Third party and international testing
- Tests performed with representative severe accident conditions
- Deflagration and Ignition tests
- Poisoning tests (Aerosols and Iodine)
- Tests performed in low O₂ environment



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