Filtered Containment Venting System

Proven Technology — Passive Operation
In the event of a core melt accident, the reactor containment might suffer damage resulting from overpressure caused by the decay heat generated inside the containment over a long period. The challenge is maintaining containment integrity and preventing significant off-site long-term dose issues.

Main Requirements:
- **Limit** the excessive pressure build-up inside the containment
- **Protect** the structural integrity of the ultimate fission product barrier
- **Retain** the airborne activity of the vented gas
dependent on its characteristics.
- **Return** the accumulated activity to the containment

To meet this challenge, AREVA offers the Filtered Containment Venting System (FCVS). Its process is double-staged and uses the advantages of a high speed venturi scrubber technology combined with highly-efficient filter features. All components are installed in the pressure vessel and operate under sliding pressure conditions.

### Design of the High Speed Sliding Pressure Retention Process

**Stage 1: High Speed Venturi Section**

The venturi scrubber unit is operated at pressures close to the prevailing confinement pressure.

**Stage 2: Metal Fiber Filter Section**

In the second cleaning stage, the micro-aerosol filter combination additionally equipped with metal fibers down to 2 μm helps avoiding significant long-term re-entrainment. The gas exiting from the pool venturi section contains small amounts of penetrating aerosols as well as small scrubbing water droplets. Both are removed from the gas by means of a high-efficiency droplet separation unit and a micro-aerosol filter stage downstream. In the first part of the filter unit, the water droplets are agglomerated and removed. The second part of the filter unit retains the aerosol particles that are usually too small for retention by any scrubber and droplet separator devices.

**Cost-effective filtered venting system with excellent aerosol and iodine removal efficiency**
Further System Features
Activity Recirculation
During the venting process, iodine and aerosol are quantitatively separated inside the nozzle throats and stored in the venturi pool. The purpose of this recirculation of pool liquid is to store the activity inside the containment instead of keeping it outside the containment, e.g. in the venting system. The expected range of activity recirculation to the containment is 95 - 99%.

Integrated Auxiliary System Function
In addition, the system includes provisions for inertization with nitrogen or steam filling, conditioning, draining, and in-situ measuring of thermohydraulic properties. When not in operation, the system is kept inerted.

Modular and Compact
Based upon its modular, compact design, the AREVA FCVS is easy to backfit into existing buildings at low cost. The scrubber and filter easily adapt to any reactor type, unit size, type of containment, or other design parameters without loss of efficiency or the need for requalification.

Operation of the System
The combined scrubber-filter system is connected to the containment either by two isolation valves or an isolation valve with a rupture disc and a venting line. The filtered vent gas is routed to a stack via a discharge line that is normally closed by a rupture disc but opens at a small overpressure of approx. 7.25 psi. Containment venting is initiated manually in accordance with the written emergency procedures by opening the containment isolation valves. Those may be operated either by independent batteries or manual remote. After this initiating action, the system works in an entirely passive mode.

The venting pressure of the system can range from approx. 2.9 - 145 psi gauge and may drop during venting without any loss of removal efficiency. To terminate venting when desired pressure is reached, one or both isolation valves are closed.

The sliding pressure operation could provide important system-inherent additional venting mass flow capacities, e.g. in case of delayed venting more than 50% of design venting mass flow rate is possible. Passive Venting & Forced Flow Filtered Leakage Control
For long-term containment leakage control, e.g. of single shell containments, etc., the system can be equipped with a forced flow leakage control module. This module is again operated under high speed venturi conditions and equipped with additional filter stages, e.g. like metal fiber filters and molecular sieves.

This technology enables efficient long-term containment leakage control for post severe accident situations of e.g. > weeks or - months and very high aerosol and iodine retention (elemental & organic) of up to 99.99%.

Extensive Process Qualification
Full-scale efficiencies test under a wide range of pressure conditions up to 145 psi demonstrates very high efficiencies of retention rates of aerosols, elemental iodine and organic iodide.

The two stage retention technology is tested in accordance with the international Advanced Containment Experiments (ACE) filter test program.

Typical System Data
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Pressure</td>
<td>29/145 psi</td>
</tr>
<tr>
<td>Design Temperature</td>
<td>39/392 °F</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>2.9 - 145 psi</td>
</tr>
<tr>
<td>Mass Flow Rate</td>
<td>e.g. 1.6 - 27 lbs/s</td>
</tr>
<tr>
<td>Decay Heat</td>
<td>&lt; 200 kW</td>
</tr>
</tbody>
</table>

“Protect the public, protect the asset, protect the company.”
Reliable Operation
• With the containment isolation valves open, the system operates passively without any power and can be isolated at any time.
• Due to the critical expansion at the orifice on the discharge side, the system operates within a narrow, almost constant velocity range with optimum filter efficiency.
• The high speed venturi nozzle section, operated at even >500 ft/s, enables quantitative retaining of the activity in the pool.
• The decay heat from the aerosols is removed passively by evaporation without any overheating of components.
• Process does not need make-up water for up to one week, depending on the specific design.

Optimum Efficiency
• The two-stage retention process enables gas velocities which result in relatively small process dimensions and high retention.
• Large overload capacity for throughput, aerosol decay heat and aerosol mass quantities are a special design feature.
• Large throat diameters prevent aerosol clogging in the nozzles.
• Low activity content at the scrubber unit due to recirculation of the water to the containment.

Quick Delivery and Integration
AREVA prefabricates the filter vessel and performs preliminary erection work while the plant is still online and completes installation during a normal outage. Our extensive full system installation experience allows us to complete commissioning one and a half years from date of order.

To accelerate backfitting into power plants already in operation, or if transportation of the complete system is not feasible, the filtering system can be assembled on-site. AREVA has both the know-how and the experience to deliver and combine the complete venting system to the plants in operation including civil works if required.

Benefits at a Glance
• Proven technology
• No power supply required for operation
• Prevention: Serves as an alternative heat sink to reduce core damage frequency
• Mitigation: Removes up to 99.99% of aerosols and 99.5% iodines during venting
• Seismically-qualified
• Easy to backfit in part due to compact design
• Simple maintenance

Installed in over 50 plants worldwide starting in 1987 to the present.
AREVA provides its customers with solutions for low-carbon power generation in North America and all over the world.

As the leader in nuclear energy and a significant, growing player in the renewable energies sector, AREVA combines U.S. and Canadian leadership, access to worldwide expertise and a proven track record of performance. Sustainable development is a core component of AREVA’s strategy.

More than 4,000 U.S. and Canadian employees work every day to make AREVA a responsible industrial player helping to supply ever cleaner, safer and more economical energy to the greatest number of people.

www.us.areva.com