

Review

Overview of filtered containment venting system in Nuclear Power Plants in Asia



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ABSTRACT

In this paper, we extensively review the status and projection of the Filtered Containment Venting Systems (FCVSs) in the Nuclear Power Plants (NPPs) in Asia. As an important strategy to mitigate the Severe Accidents (SAs) in NPPs, FCVS is designed to prevent the containment overpressure failure by providing containment venting through a filtration system. The 2011 Fukushima Daiichi nuclear accident brought a negative impact to the public faith on the nuclear safety, the accident has led regulatory authorities and policy makers to re-evaluate safety criteria and reinforce safety supervision. As a result, the mitigation of SAs regains attention of nuclear community. Many investigation and research works were initialized or resumed, particularly about the enhancement of FCVS on robustness and filtration efficiency.

Presently, Asia is a region where nuclear energy grow fast. To ensure nuclear safety, the FCVS is being taken into account in the SA mitigation strategy by regulatory authorities. Chinese nuclear safety administration requires NPPs to have adequate and reliable containment venting system. Thus FCVS is either equipped or about to be equipped on most reactors operating or under construction in China. Nuclear companies and research institutions are conducting research and engineering works about FCVS design and function. In South Korea, a government funded project was carried out during 2013–2017, aimed to design a domestic FCVS technology. Confirmatory tests have been performed to evaluate the function of designed FCVS. In Japan, Tokyo Electric Power Company started installing FCVS on the NPPs since 2013. Related research work is performing in Japanese universities and institutions. Taiwan's Atomic Energy Council also requests utility companies to reexamine the present emergency operation procedures and study the strategies such as the addition of required facilities for SA prevention and mitigation in each NPP. It is noticed that India is also investigating the options to mitigate the SAs, including FCVS.

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Abbreviations: AEC, Atomic Energy Council; AOV, Air Operated Valve; ARIEL, Aerosol Removal & Iodine Elimination; BWR, Boiling Water Reactor; CGN, China General Nuclear Power Corporation; CNNC, China National Nuclear Corporation; CNPE, China Nuclear Power Engineering Co., Ltd; CNPEC, China Nuclear Power Engineering Company; CSIC, China Shipbuilding Industry Corporation; CV, Containment Vessel; DF, Decontamination Factor; ECSBS, Emergency Containment Spray Backup System; EDG, Emergency Diesel Generator; EOP, Emergency Operation Procedures; FCVS, Filtered Containment Venting System; HCVS, Hardened Containment Vent System; HPR, Hua-long Pressurized Reactor; INET, Institute of Nuclear and New Energy Technology; JAEA, Japanese Atomic Energy Agency; KAERI, Korea Atomic Energy Research Institute; KHNP, Korea Hydro and Nuclear Power; MOTIE, Ministry of Trade, Industry and Energy (Korea); NDRC, National Development and Reform Commission; NNSA, National Nuclear Safety Administration; NPP, Nuclear Power Plant; NRA, Nuclear Regulation Authority; OPR, Optimized Power Reactor; PHWR, Pressurized Heavy Water Reactor; PCV, Pressurized Containment Vessel; PSI, Paul Scherrer Institut; PWR, Pressurized Water Reactor; SA, Severe Accident; SBO, Station Black Out; SPIC, State Power Investment Corporation; TEPCO, Tokyo Electric Power Company; TPC, Taiwan Power Company; URG, Ultimate Response Guideline; USNRC, United States Nuclear Regulatory Commission; VVER, Vodo-Vodyanoi Energetichesky Reactor (Water-Water Energetic Reactor).

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1. Introduction

In this paper, we review the status of the Filtered Containment Venting Systems (FCVSs) in Nuclear Power Plants (NPPs) in Asia. Acknowledged as a safety measure to mitigate the Severe Accidents (SAs), FCVSs have been installed on some NPPs worldwide since 1980s, and now they become increasingly essential due to the lessons learned from Fukushima Daiichi accident. This accident has a significant influence on the development of nuclear energy projects worldwide. China, being the country constructing the largest number of commercial reactors for the last decade, suspended inland NPP projects and postponed coastal NPP projects after the accident. However, the government did not reverse the policy and determination towards the nuclear energy. After a few years' technical evaluation and review, the development of nuclear energy started to get back on track in China (NDRC, 2007; Zeng et al., 2016).

In 2014, OECD/NEA/CSNI released a status report to summarize the national policy and status of FCVS in OECD countries (OECD/NEA/CSNI, 2014). For example, this report shows that all operating reactors in France are equipped with a sand-bed type FCVS (Fig. 1). An operation procedure has been set up including the containment decompression associated with a filtration system, in which a dry metallic pre-filter is placed upstream of the sand-bed filter inside the containment to retain most radioactive particles. In the appendix of the report, technical descriptions of a few FCVS designs are listed, as summarized in Table 1. NPPs in some other countries,

such as Germany, Switzerland and Sweden, are also equipped with FCVS, as summarized in Table 2. However, the information in some other countries such as the United Kingdom, China and India has not been provided when the report was established. To fill up some missed information, this review paper is prepared by native researchers with the intention to release the detail information about the deployment and related research of FCVS in Asia.

2. FCVS in China (Mainland)

2.1. FCVS in China NPPs

Enhancing the ability to handle SAs and improving nuclear safety and are vital parts of China's nuclear safety strategy. The Chinese National Nuclear Safety Administration (NNSA) requires NPP owners to take extensive measures to improve the plant

Table 1
Major FCVS Designs.

FCVS Type	Company
Sand-bed filter	EDF
Dry filter system, DFM	Westinghouse
FILTRA-MVSS	Westinghouse
SVEN (Safety Venting)	Westinghouse
Wet scrubber and metal fiber	CCI
Combined Venturi scrubber	Orano (AREVA)

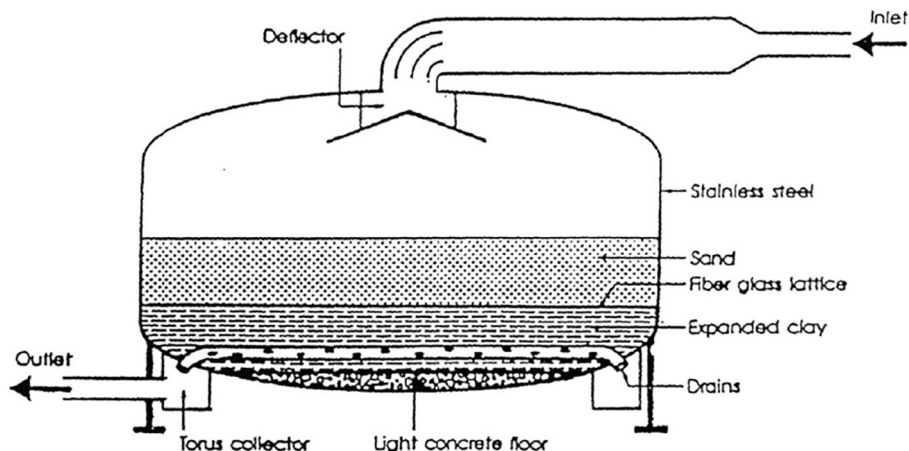


Fig. 1. Sand-bed type filter system (OECD/NEA/CSNI, 2014).

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