# Conceptual Design of the In-Vessel CEDM Installation Structure

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## 1. Introduction

Control Element Drive Mechanisms (CEDMs) withdraw, insert or hold the Control Element Assemblies (CEAs) to control the reactor power. Conventional CEDMs are installed outside the reactor vessel (RV) with nozzles penetrating the RV head. However, it has been demanded to develop the In-Vessel CEDM (IV-CEDM) which fundamentally prevents severe events such as rod-ejection and LOCA through the nozzles [1]. It is noted that nuclear energy industry worldwide has shown a special interest in the Small Modular Reactor (SMR) and the IV-CEDM provides many advantages for SMR design. In order to implement the IV-CEDM technologies, it is essential to develop supporting mechanism for the CEDM inside of the Vessel.

This paper describes design requirements of the IV-CEDM installation structure. An embodiment as an applicable example to meet the requirements is also introduced.

## 2. Requirements for Preliminary Design

Although various requirements should be taken into account in designing the IV-CEDM installation structure, only some essential requirements are considered in concept design phase as follows.

The IV-CEDM installation structure shall be designed to support the CEDMs inside the RV. Reasonable supporting mechanism, which enables the structure to be located inside the RV and the CEDMs to be installed on the structure, shall be determined. The supporting mechanism shall resist dead weight of the IV-CEDM and impulse road due to its operation.

The IV-CEDMs are to be energized by the power source from outside the RV [1]. And rod position signal is transferred from the IV-CEDM position indicator to outside the RV [2]. Thus the structure shall be designed to provide penetrations for cables which transfer power and rod position signal. The penetrations shall be designed to have spaces for installation of sealing units. The sealing units will prevent the escape of the reactor coolant from the RV.

On the bottom of the structure, there shall be holes through which the drive shafts are attached to control elements pass.

The structure and the IV-CEDMs will be highly irradiated due to neutrons because they are installed near the nuclear fuels. The structure shall be designed to be installed, dismantled and repaired easily in accordance with As Low As Reasonably Achievable (ALARA) concept. For easy treatment of the structure, integrated design should be applied so that all the CEDMs can be installed and removed all together with the structure.

The reactor coolant circulates inside the RV to transfer heat from the fuel. The structure shall be designed to minimize the resistance of flow. So flow paths for reactor coolant shall be taken into account in the structure design.

## 3. Design Concept

### *3.1 General arrangement*

General arrangement of the IV-CEDM installation structure is shown in Fig. 1. It has a flange to be supported and fixed between the RV upper and lower flanges. To apply this design concept, the RV has a mid-flange which supports the flange of the IV-CEDM installation structure and maintains reactor coolant pressure boundary as well.

Reactor coolant flow is shown as colored arrows in Fig. 1. Low temperature coolant flows down between the IV-CEDM installation structure and the RV shell. The coolant is heated by the fuel and flows up through the hole of the bottom plate of the structure, and then it passes though the spaces between the IV-CEDMs.

The cable sealing units are installed in the side holes of the structure and the cables for the IV-CEDM power and CEA position sensors are routed from inside the RV to outside.

### *3.2 IV-CEDM Installation Structure*

The IV-CEDM installation structure supports the IV-CEDMs as shown in Fig. 2. All the IV-CEDMs should be able to be re-installed and removed at once with the structure. This integrated type design allows easy maintenance and installation. It also enables better access to the IV-CEDMs and guarantees shorter working which in turn leads to less radiation exposure of workers.

Detailed configuration of the IV-CEDM installation structure is shown in Fig. 3. There are radial penetration

holes for the cable sealing units and vertical penetration holes for reactor coolant flow.

Mineral Insulated (MI) cables can be routed from the IV-CEDMs to outside the RV through cable sealing units installed in the holes. The MI cables can be sealed by the sealing units with verified commercial products such as Swagelok.

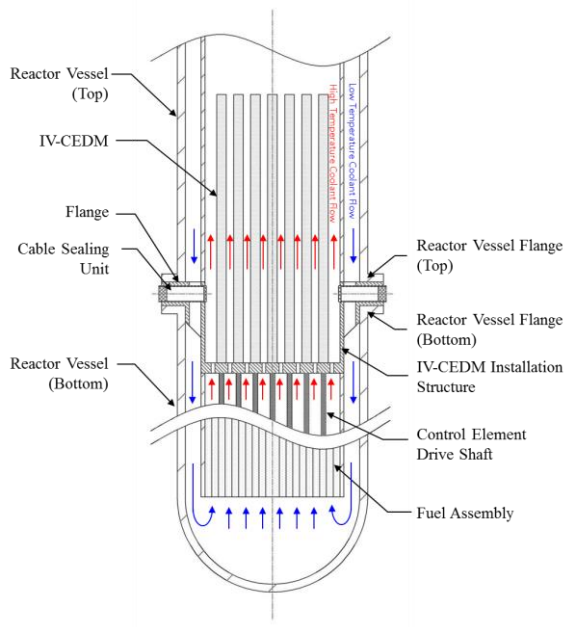


Fig. 1. General Arrangement of the IV-CEDM and RV

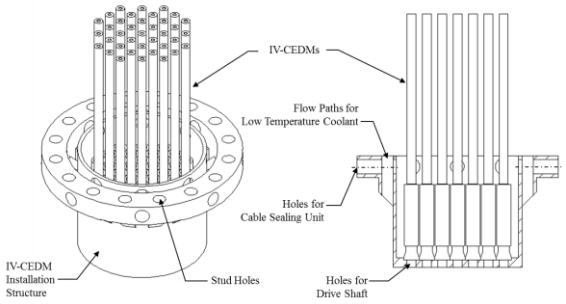


Fig. 2. IV-CEDMs on the Installation Structure

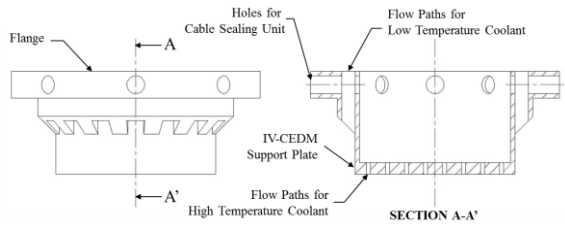


Fig. 3. IV-CEDM Installation Structure

## 4. Conclusions

Essential design requirements for the IV-CEDM installation structure were considered and a conceptual design to meet the requirements was suggested. The main functions of the IV-CEDM installation structure are to support the IV-CEDMs in reactor vessel, and provide not only penetration holes for cable routing and sealing unit but also easy installation, repair and maintenance.

## REFERENCES

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