# Side Access Procedure for Debris Retrieval of the Fukushima Damaged Reactors - 17127

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## ABSTRACT

IHI has developed a procedure of making an access opening on Biological Shield Wall (hereinafter called BSW) of the first floor in the reactor building. Some organizations have also developed the retrieval methods for top and side access. Top access is to set up the retrieval equipment on the refueling floor where is top of the reactor building. Another method, side access is to deploy those on the first floor. Top access would spend a long time due to long approach between the refueling floor and RPV. Side access is expected to make a shorter way than that of top access, if debris is on the pedestal bottom. Each method will require making a large opening on the building in order to approach fuel debris.

In this report, IHI introduces a plan of making an access opening on the BSW in side access.

## INTRODUCTION

The Fukushima Daiichi Nuclear Power Station Unit 1, 2 and 3 have serious damage on reactor core. All or a part of debris might fall down on the bottom of the Pedestal (See Fig.1). The debris or solid waste will be retrieved under flooding (in water) or air condition. The approaches are also top and side access. The path for carrying debris will be either existing openings or a new opening depending on the approach. However, the existing openings have many limitations. New opening is one of the solutions. This paper explains a secure plan of making a new opening on the BSW of the first floor. The operation will be done in the isolated enclosure to avoid spreading dust and to shield from high radiation which comes through the new opening.

## THE NECESSITY OF A NEW OPENING ON THE BSW

The necessity of a new opening comes from two reasons. One is to make a shorter approach between inside pedestal and outside Primary Containment Vessel (hereinafter called PCV) for easy access. The other is efficient deployment. The equipment and its enclosure will be deployed on straight line for easy rescue and maintenance. When trouble occurs, the equipment can be pulled out from the inside of PCV to enclosure for rescue.

Existing openings of the Pedestal are located reactor building azimuth 45° and 225°. The opening of azimuth 45° can be easily accessed from the first floor. The PCV has one personnel airlock (azimuth 0°) and two equipment hatches (azimuth 135° and 315°) at the first floor for carrying in and out large equipment. These are, however, away from the pedestal opening (azimuth 45°) and there are many interferences near the hatch. (See Fig.2)

Additionally, in case that the hatch is used as the path, the equipment cannot be deployed on straight line. As a result, IHI finally decided to make a new opening near azimuth 45° on the BSW. The opening size will be approximately 1.5m in width x 2m in height as rectangular shape.

As regards the BSW, it surrounds the PCV with 50mm gap and is made of reinforce concrete. The wall thickness is 1.7-2.0m at the first floor. The rebar diameter is 38mm and allocated 2 layers for both inside and outside. The rebar distance is 150mm-200mm for hoop and longitudinal direction. The design concrete strength is 24MPa.

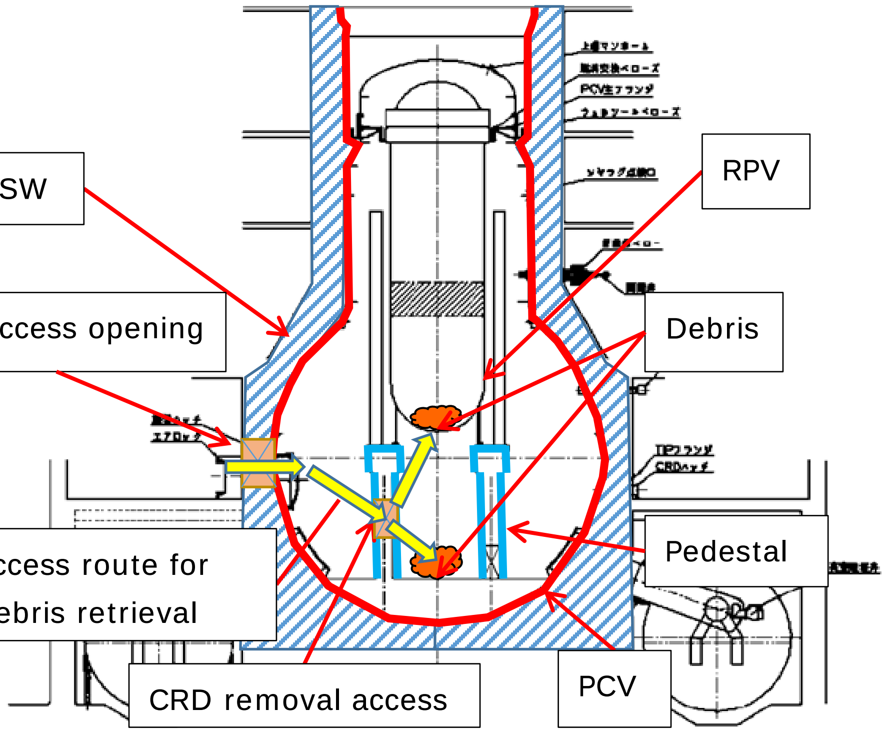



Fig.1. Making a new access opening to BSW

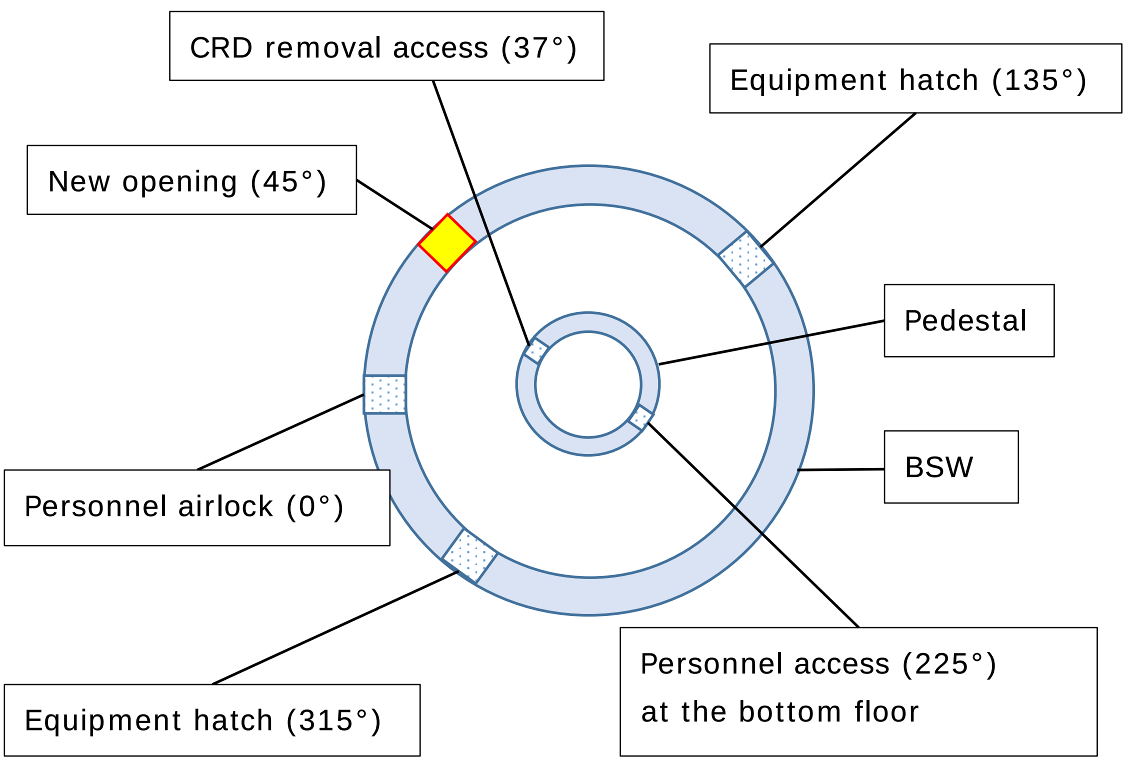



Fig.2. Existing opening on BSW and Pedestal

## THE REQUIREMENTS AND LIMITATIONS FOR THE OPERATION

The requirements for the operation are (1) safety operation, (2) remote control, (3) short schedule, (4) minimizing secondary waste.

As regards the safety, the operation will be done in the isolated enclosure (cell) because of avoiding to spread out dust and to leak radiation. That is, all equipment including utilities is set up in the enclosure.

The operation area at the first floor is still contaminated even though repeated decontaminations were done. Most of operation will be done with remote control utilizing manipulation system without man power.

As a result, it is more preferable that performance of the equipment is to be proven and verified in similar situation. Rescue or maintenance for itself also will be remote control. IHI's remote control system has already been used in reprocessing facilities in Japan.

In order to shorten schedule, the equipment can be applied without large scale modification or development. Additionally, it is to be easy procurement, but not with special specification.

Secondary waste is to be minimized as much as possible. Much secondary waste has possible to confuse and contaminate the system arranged in narrow enclosure.

All equipment and enclosure will be moved by horizontal pulling with air cushion carrier from the main entrance to installation point. The overall size as width, height, length and its weight will be limited within the allowance.

## CANDIDATES OF MAKING AN OPENING METHOD AND EVALUATION

IHI studied the 3 candidates as follows. The candidates were Concrete boring, Water jet, and Tunnel boring machine. These were evaluated in accordance with the requirements and limitation.

(1) Concrete boring has been widely applied in civil construction works. It is one of the most conventional and proven techniques. It will be easy to operate it by remote control. Continuous holes for making a large opening are required because the applied core size will be approximately 150 - 200mm in diameter. A core sleeve occasionally gets sticking because of catching rebar fragment. It will be easily removed by hand working under clean circumstance, but not for the BSW. This is main concern for the concrete boring.

(2) Water jet has been also widely applied in civil construction works. By using ultra high pressure water, a target material is cut and removed. When cutting a steel product, abrasive is needed to be mixed in water. This will produce a large amount of secondary waste (used abrasive) as well as water. It will need not only main water jet system, but also collecting system for water and used abrasive.

(3) Tunnel boring machine
A tunnel boring machine has been applied to excavate tunnels with a circular cross section. This does not need continuous holes to make a large opening. Short schedule is expected. Size and weight limitations have to be considered because the installation area is narrow and concrete slab has not enough strength supporting heavy equipment.

The table I shows the result of evaluation of above candidates in accordance with the requirements. According to the result, IHI chose concrete boring as the best technique at this moment among the candidates.

Table I Evaluation of method to make an access opening to BSW

| No. | Item to be evaluated | Concrete boring | Water jet | Tunnel boring machine |
|---|---|---|---|---|
| 1 | Safety and secure operation | Accept, but hold for stuck sleeve | Accept | Accept |
| 2 | Enabling Remote operation | Accept | Not | Accept |
| 3 | Short schedule (To be able to deploy quickly) | Accept | Accept | Accept, but hold for its weight and size |
| 4 | Minimizing secondary waste. | Accept | Not | Accept |

Even though concrete boring and tunnel boring machine is same score, the size and weight of the tunnel boring machine will be heavier than that of concrete boring. Arrangement in the enclosure has not been decided yet at this moment. Consequently, the current plan is prepared by concrete boring.

## CONFIGURATION OF EQUIPMENT FOR MAKING AN ACCESS OPENING

The following are main equipment of making an access opening on the BSW. (See Fig.3)

(1)Shielding door

Shielding door protects radiation from inside PCV. When an operator comes into the enclosure, the shielding door shall be closed. The shielding door is normally opened during operation.

(2)Enclosure

Enclosure is a box that is made of thick steel plate and isolates the installation area from radiation and contaminated dust. It provides the concrete boring tool, crane, and positioning frame.

(3)Enclosure access door

Enclosure has an access door for entering the inside enclosure.

(4) Concrete boring tool (Core sleeve)

Concrete boring tool is used for making a hole to BSW.

(5) X-Y positioning frame

X-Y positioning frame makes specific position against the BSW

(6) Crane

Crane is used for carrying in or out the core sleeve.

(7)Wire saw

This is a main rescue and critical system. The wire saw cuts a stuck core sleeve over the opening at outside the shielding door, when a core sleeve was stuck due to catching fragment. After that, the shielding door will be closed and rescue the trouble sleeve.

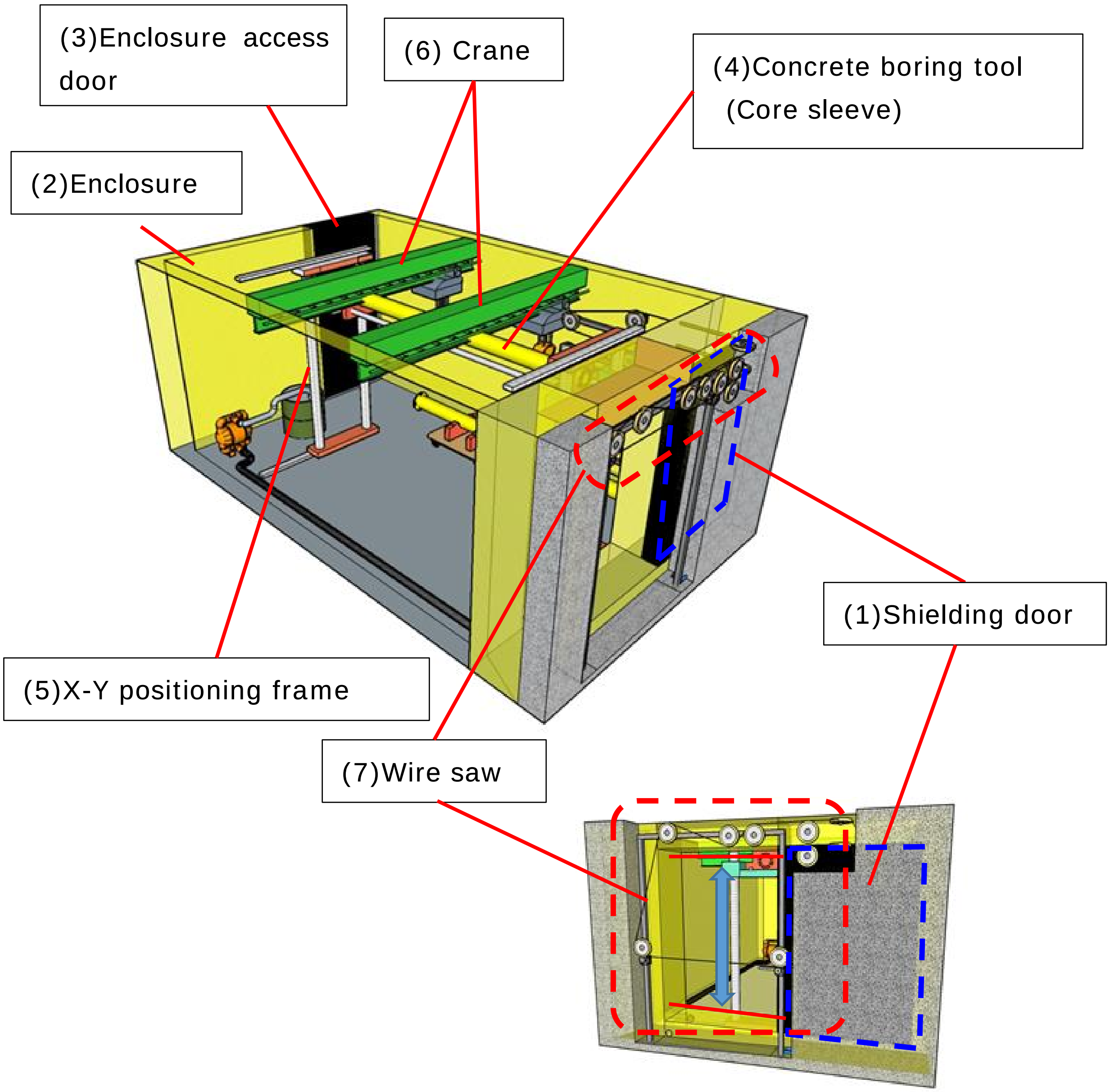



Fig.3. Configuration of equipment for making an access opening

## PROCEDURE OF MAKING AN ACCESS OPENING

The shielding door and enclosure are carried at the installation point. The concrete boring tool and its utilities system are installed in the enclosure in advance. The enclosure will be installed following the installation of the shielding door.
Concrete boring, exchange core sleeve, collection of water and concrete fragment will be done in the enclosure with a ventilator.

The following are main operation steps (See Fig.4).

(1) Excavation
Most of excavation works are done in the enclosure. The shielding door is opened and X-Y positioning frame positions a core sleeve on a specific position against the BSW. Diameter of Core sleeve will be 150-200mm. Core boring is started with supplying cooling water. Feed speed will be 5-10mm /min. Core sleeve is stopped and pulled out by automatic, when the sleeve reaches at the opposite side. Pulled out sleeve will be handled and moved down on the designated area on the floor. Drain water will be gathered with a pan on the floor and periodically carried it out to the outside enclosure.

(2) Exchange the core sleeve
As large opening will be made by continuous small holes, a core sleeve is repeatedly exchanged. This operation will be manual operation under closing shielding door. This is because of more simple mechanical system in the narrow space. Used core sleeve will be approximately 200kg and cannot be handled by manual operation. The crane supports these handling or exchanging work.

(3) Repeat excavation and exchange core sleeve
The above works stipulated in (1) and (2) are repeated until completion of the work. Used core sleeve will be treated as a solid waste and carried out to the outside reactor building.

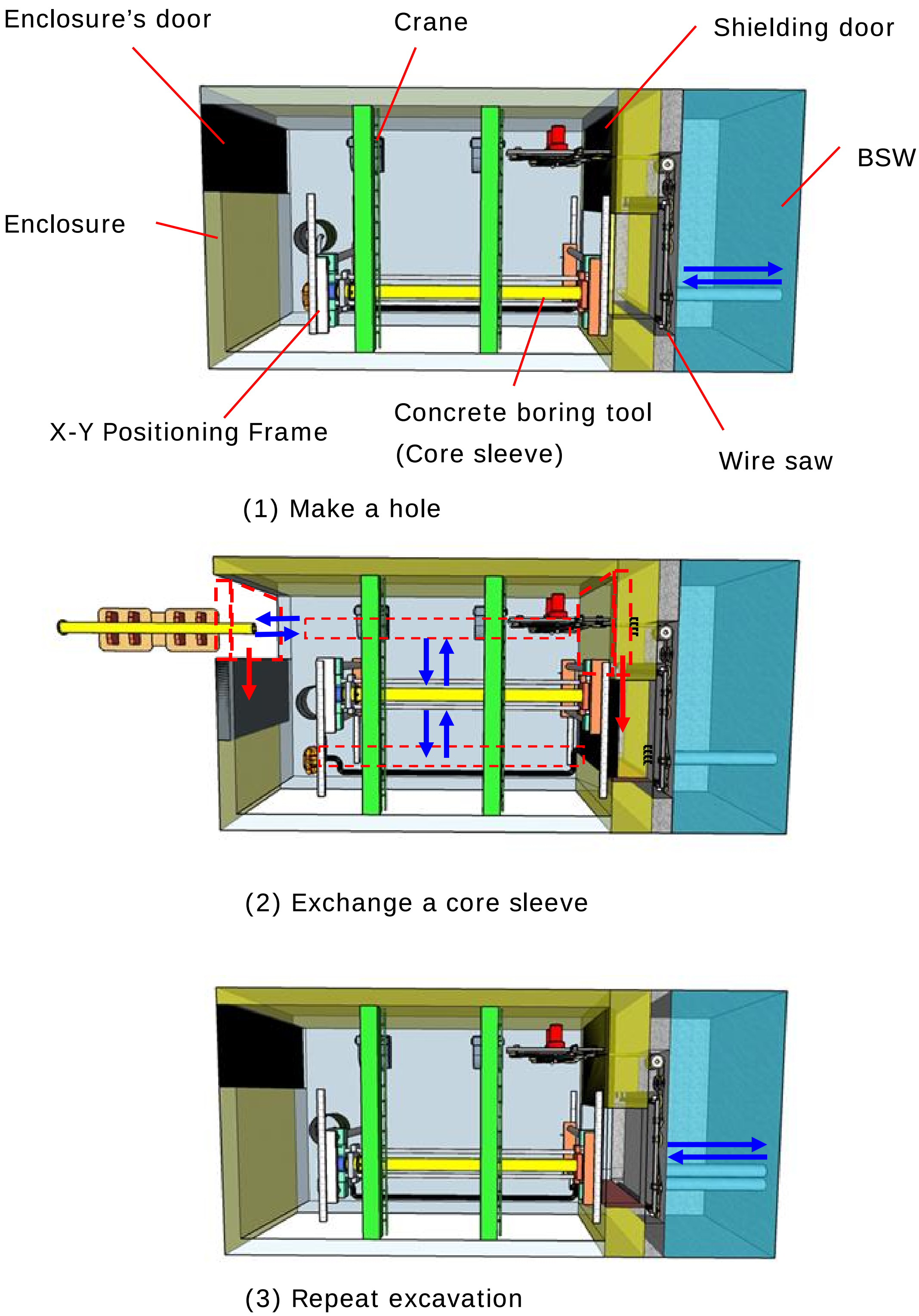



Fig.4. Procedure for making an access opening

## PROCEDURE TO RESCUE CORE SLEEVE

If a core sleeve catches fragments due to rebar cutting, the sleeve has a possibility to be stuck. The stuck sleeve will be cut at outside the shielding door. After that, the shielding door is closed to protect from radiation. The following are procedures for rescue of the stuck sleeve. (See fig.5)

(1)Cut the stuck sleeve by wire saw

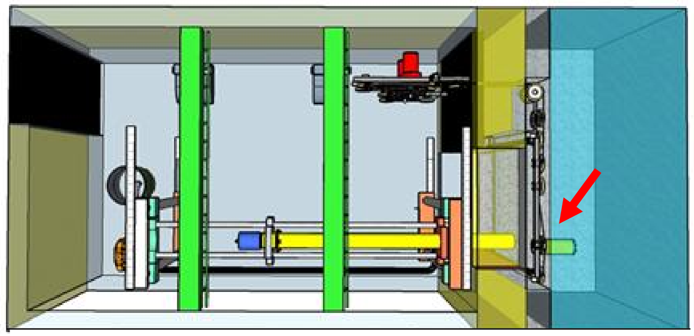
In order to cut the stuck sleeve, wire saw system is to place at just outside the shield door. (See fig. 5) Cutting area of the wire saw covers whole opening surface. Cutting wire supported by several pulleys comes down and cut the stuck sleeve. This operation will be remote control. Wire saw is simple system and there is no rescue system for itself.

(2) Exchange the core sleeve

The end of cut sleeve is dismounted and carried out to outside the enclosure. Then, larger diameter core sleeve is set.

(3) Rescue the stuck sleeve

Rescue will be done with larger diameter core sleeve. The diameter will be 10-30mm greater than that of the stuck sleeve. Outside the stuck sleeve will be cored with larger diameter sleeve until the stuck sleeve can be removed. After removing it, the operation will be continued with the sleeve to the opposite side without exchanging normal diameter sleeve.



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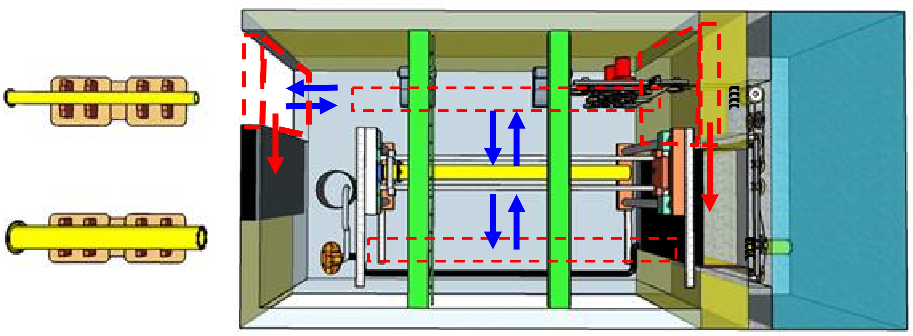
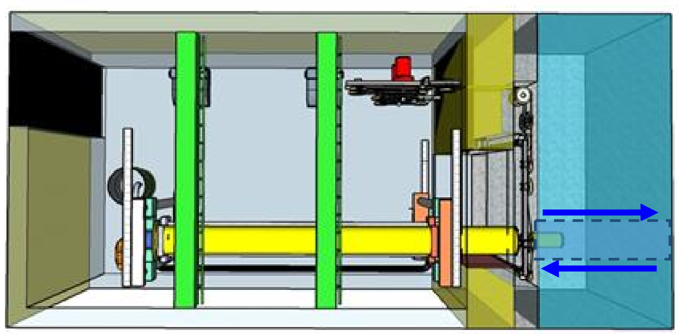


(2) Exchange the core sleeve



(3) Make a hole by using larger size core boring tool than former one.

Fig.5. Procedure to rescue the core sleeve

## THECHNICAL ISSUES

Technical issues to be resolve of making an access opening to BSW are following.
(1) Against radiation performances of the equipment to be used.
(2) Exchange equipment by remote operation with manipulation system.
(3) Large opening excavation for massive concrete with large diameter rebar.

## CONCLUSION

IHI and DAIICHI-CUTTER KOGYO CORPORATION (hereinafter called DIC) introduced an excavation technique and equipment against the BSW. Most of them will be needed to verify the actual performance under full scale test. IHI and DIC believe that the technique and equipment are to be secure and practical in accordance with our experiences.

## ACKNOWLEDGMENTS

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