Study on Methodology to Evaluate Risk Importance Based on "Segment"

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Introduction

Background

- ✓ PSA based categorization of SSCs generally has been focused on components.
- ✓ The number of components modeled in PSAs became over 2,000
- ✓ Such large number of components leads to somewhat hard to understand the characteristics of systems.

Objective of this study

- ✓ Development of the risk metrics to understand characteristics of systems usefully

the methodology to evaluate risk importance of SSCs focusing on **“Segment”**

“Segment”: a group of components identified in terms of component roles for system function

Note : Target system in this study is a fluid system only

The roles of components for system function

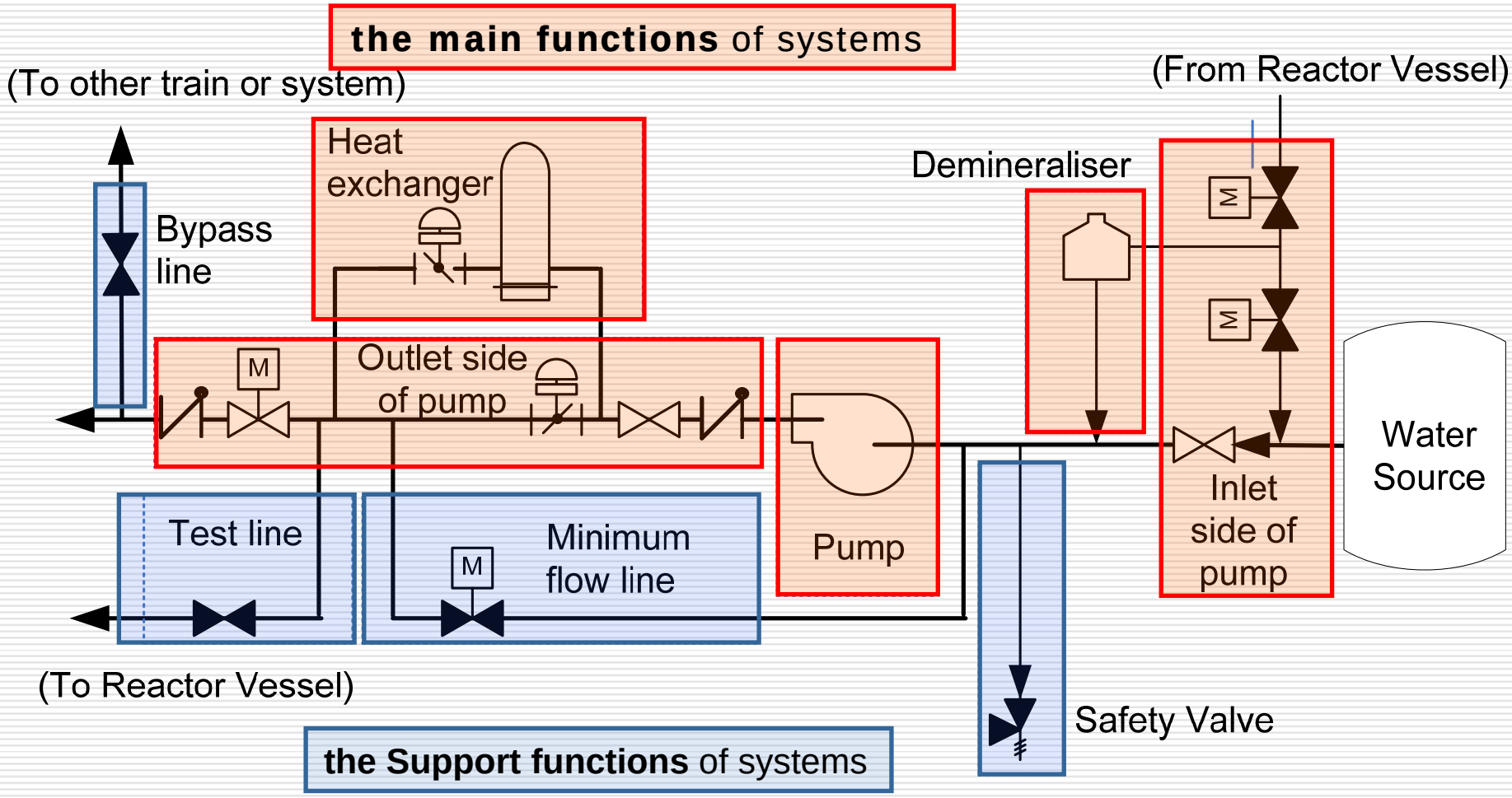


Figure 1: Example of a Fluid System

Types of roles of components relevant to fluid systems

Table1: Types of roles of components

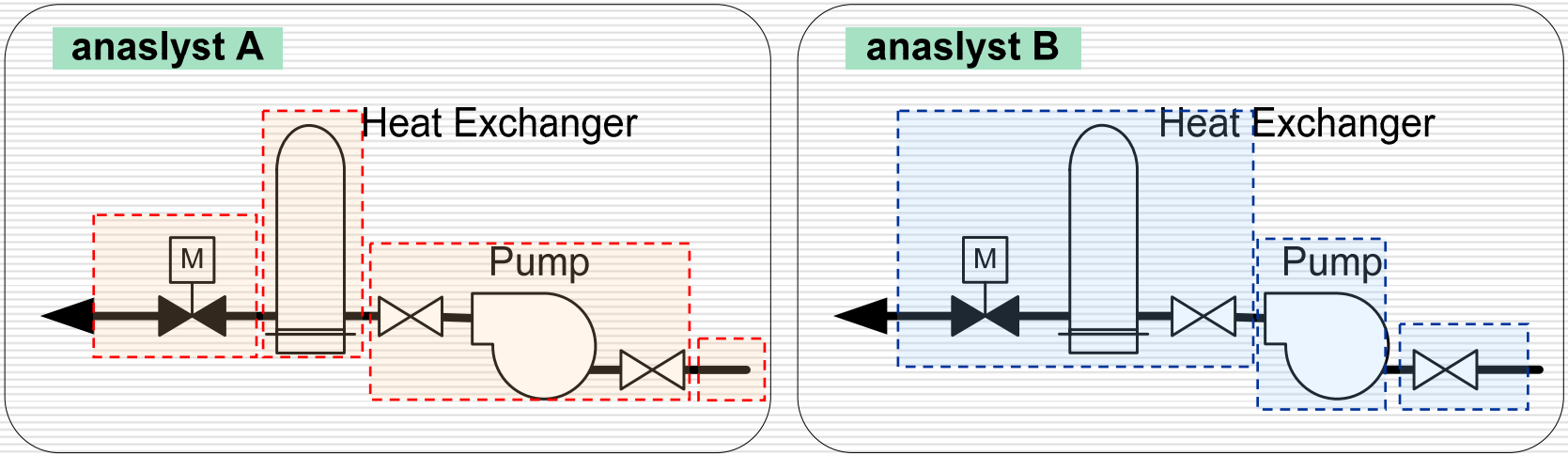
"Segment"	Roles of Components
Inlet flow path	To suct the water from the water source of the system to the pump (e.g. inlet section of the system)
Outlet flow path	To inject the water to reactor vessel (e.g. outlet section of the system)
Pressurizing fluid	To pressurize the water (e.g. pump)
Heat exchanging	To cool the water (e.g. heat exchanger)
Cleanup	To cleanup the water (e.g. demineralizer)
Preservation of the system integrity	To preserve the integrity of system function(s) (e.g. minimum flow line and safety valves)
Testability	To confirm the integrity of system function(s) (e.g. test line),
Diversity	To preserve the diversity of the role of components (e.g. bypass line)

ISSUE to Identification of “Segments”

ISSUE to be addressed in Identification of “Segments”

Improper identification of “Segments”

⇒Variation of analysts’ knowledge and/or experiences



Approach to resolve issue

Establishment of prescriptive rules for identifying the “Segments”

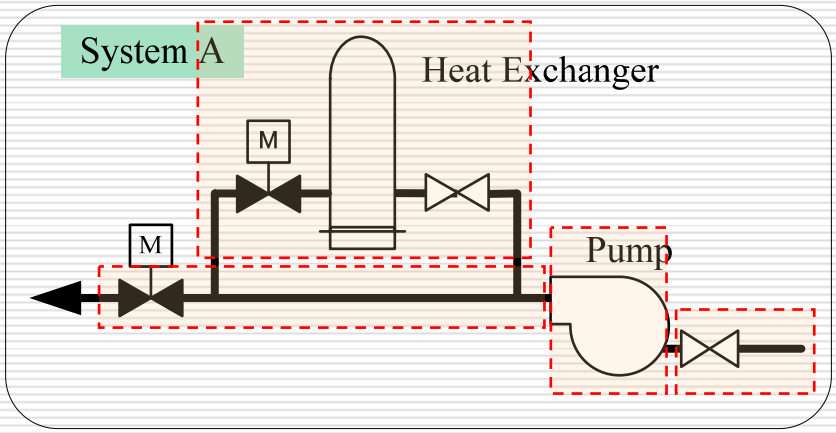
Four Rules for Identification of “Segments”

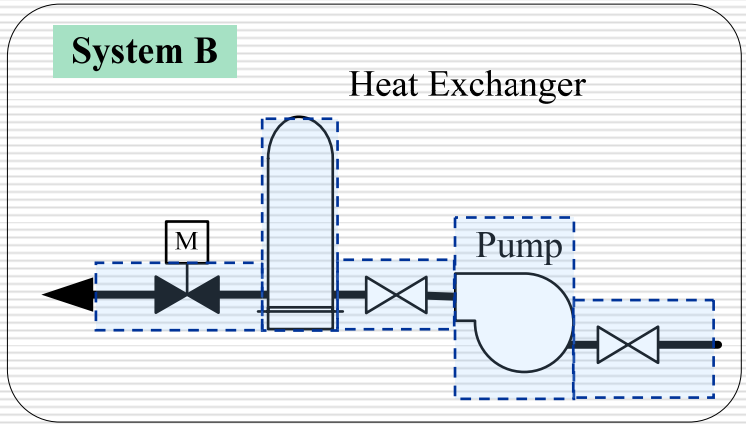
a. All fluid systems modeled in PSA shall include the “Segments” of “Outlet flow path” and “Inlet flow path

b. “Segment” composed of single component maybe allowed.

c. The boundaries between “Segments” in a system shall be defined at the branching points of pipes or the joint points of components and pipes.

d. “Segments” shall not be share components with other “Segments





Trial evaluation of risk importance based on “Segments”

Plant type :a typical **BWR5** of Japan
Fluid systems modeled in PSA :**16 Systems**
Number of total components : **approximately 2,500**
Risk Importance : **FV(Fussell-Vesely) Importance**
RAW(Risk Achievement Worth) Importance

	in series configuration	in parallel configuration
FV Importance	$FV(S)=\sum_i FV(X_i)$	$FV(S)=FV(X_i)$
RAW Importance	$RAW(S)=(\frac{1}{Q}-1)FV(S)+1$	

the result of identification of “Segment”

Number of total “Segment” : Approximately **125 “Segments”**

Identification of "Segment" for a Typical BWR5 of Japan

System \ Role of "Segment"	Inlet flow path	Outlet flow path	Pressurizing flow	Heat exchanging	Cleanup	Preservation of system integrity	Testability	Diversity
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	○	○	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	○	—	—
High Pressure Core Spray System	○	○	○	—	—	—	○	—
Low Pressure Core Spray System	○	○	○	—	—	○	○	—
Residual Heat Removal System	○	○	○	○	—	○	—	○
Reactor Core Isolation Cooling System	○	○	○	○	—	○	○	—
Fuel Pool Water Cooling System	○	○	○	○	○	—	—	○
Reactor Water Clean-up System	○	○	○	○	○	—	—	○
Make Up Water Condensate	○	○	○	○	○	—	—	○
High Pressure Core Spray Service Water System*	○	○	○	○	—	○	—	—
Residual Heat Removal Service Water System*	○	○	○	○	—	○	—	—
Residual Heat Removal Sea Water System*	○	○	○	—	—	—	—	—
Emergency Auxiliary Equipment Cooling Water System*	○	○	○	○	—	○	—	—
Primary Containment Venting System	○	○	○	—	○	—	—	○
Reactor Building Closed Cooling Water System	○	○	○	—	—	○	—	—
Fire Protection System	○	○	○	—	—	—	—	—

Approximately 4/5 of the total "Segments" are **relevant to the main functions of systems**

Approximately 1/5 of the total "Segments" are **relevant to the support functions of systems**

Risk Importance of “Segments” in a Typical BWR5

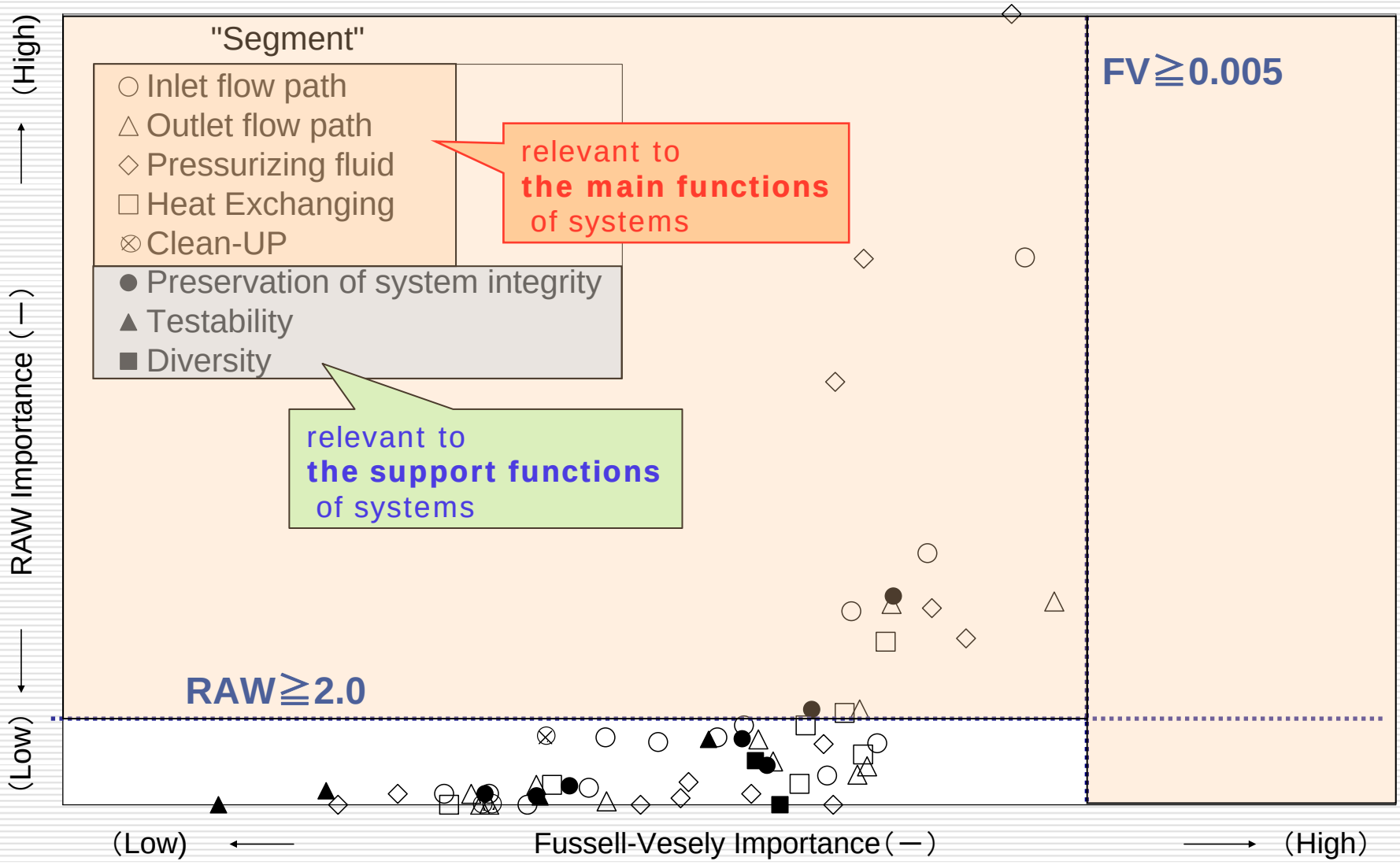


Figure 2: The Evaluation of the Risk Importance of “Segments” in a Typical BWR5

High Risk Importance Segments of a Typical BWR5

Table 3: High Risk Importance Segments of a Typical BWR5

No	System	Role of "Segment"
1	Control Rod Hydraulic System	Pressurizing fluid
2	Containment Venting System	Inlet flow path
3	Residual Heat Removal Sea Water System*	Pressurizing fluid
4	Residual Heat Removal Service Water System*	Pressurizing fluid
5	Residual Heat Removal Sea Water System*	Inlet flow path
6	Residual Heat Removal Sea Water System*	Outlet flow path
7	Emergency Auxiliary Equipment Cooling Water System*	Outlet flow path
8	Emergency Auxiliary Equipment Cooling Water System*	Inlet flow path
9	Emergency Auxiliary Equipment Cooling Water System*	Inlet flow path
10	Residual Heat Removal System	Pressurizing fluid
11	Emergency Auxiliary Equipment Cooling Water System*	Heat exchanging
12	Residual Heat Removal Service Water System*	Outlet flow path
13	Residual Heat Removal System	Heat exchanging
14	Emergency Auxiliary Equipment Cooling Water System*	Preservation of system integrity
15	Residual Heat Removal Service Water System*	Preservation of system integrity

*): Emergency Component Cooling Water Systems (ECCWS)

the characteristics of Risk Importance of “Segments”

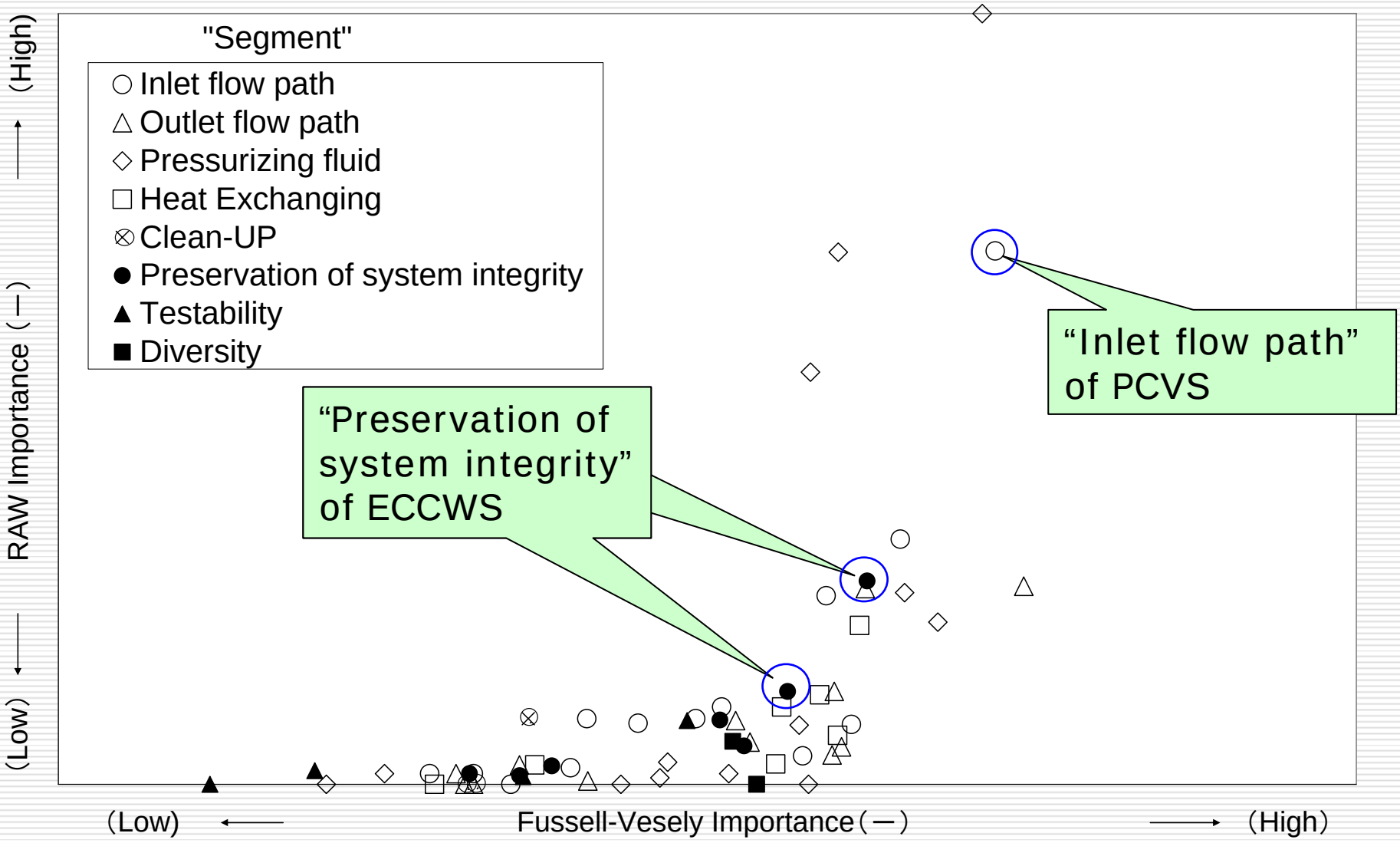


Figure 2: The Evaluation of the Risk Importance of “Segments” in a Typical BWR5

SUMMARIES

(1) We has been developed the methodology to evaluate the risk importance of SSCs focused on "Segment“. The eight types of roles of component are defined for identification of “Segment”. The prescriptive rules for applications of the types of the roles are established.

(2) The trial evaluation results showed approximately 125 “Segments” with 15 “Segments” of high risk importance were identified for a typical BWR5. The results also showed the methodology developed in this study could provide the characteristics of the systems modeled in PSA in terms of the risk importance.

Thank you for Your Attention

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