Development of ISA Method Applied to Uranium Fuel Fabrication and Enrichment Facilities

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Abstract

Integrated safety analysis (ISA) procedures have been developed for uranium fuel fabrication and enrichment facilities aimed at the establishment a risk-informed inspection system by Japan Nuclear Energy Safety Organization (JNES). The main purpose is to develop a grading evaluation method of Items-Relied-On-For-Safety (IROFS) taking into account the original ISA method by NRC.

The major efforts include the preparation of the risk level matrix and the reliability data. For the risk level matrix, that is an important criterion, the consequence and likelihood categories were defined based on the Japanese regulation laws, rules and safety examination guides. For reliability data, the component failure rates were prepared from generic component failure database considering the operating and environmental conditions of the major components in the facilities. The grading evaluation method of IROFS was newly developed because it is necessary to utilize the results of ISA for the inspections and maintenances in a practical manner. How to utilize the results of grading evaluation method of IROFS was also studied. The trial analyses using the developing ISA procedure were performed, and the results and insights from them were reflected to improve the procedure. The all efforts were summarized as a “ISA procedure Manual (first edition).”

These efforts clarified key issues to be addressed in implementing ISA and provide an outlook that the “developed ISA Procedure” can be used for identification of IROFS, grading evaluation of IROFS and utilization of the obtained risk information for inspections and maintenances.

1. Introduction

One of the major goals for the Nuclear and Industrial Safety Agency (NISA) is to further enhance scientific justification in the safety regulations as well as to realize more effective and efficient safety regulations. To achieve the goal the utilization of risk information has been discussed as one of effective means [1-1] .

JNES, an organization providing technical supports to the NISA, has been developing an ISA procedure for domestic use since 2004 according to the policy of the NISA in order to establish more reasonable and effective risk-informed inspections and maintenances at uranium fabrication and enrichment facilities.

A preliminary version of procedure manual for uranium fabrication and enrichment facilities in Japan was prepared based on the related documents in USA (1-2, 1-3, 1-4, 1-5, 1-6, 1-7,1-8). Using this preliminary procedure manual, trial analyses were conducted for typical processes in the uranium fabrication and enrichment facilities, namely the sintering and UF_6 evaporation processes respectively. Through these trial analyses, modifications of the procedure were identified. At the same time a grading evaluation method of IROFS was developed. The procedure to utilize the results of the grading evaluation for inspections and maintenances was also studied.

In addition, the component failure rates were prepared from generic component failure databases in the literatures (1-9, 1-10) by considering the operating and environmental conditions of the major components in the uranium fabrication and enrichment facilities. The way to define the failure duration was also established.

For the risk level matrix, which is an important index in ISA, the consequence and likelihood categories were defined based on the regulation laws, rules and safety standards in Japan.

Taking all results above into account, the preliminary procedure manual was revised, and a "ISA Procedure Manual (first edition)" (1-11) was prepared.

2. ISA Procedure manual

2.1. Steps of the ISA

The steps of the ISA for uranium fabrication and enrichment facilities are as follows;

(1) to comprehensively review all relevant hazards, including radiological and chemical consequence due to nuclear criticality, fire, explosion, etc,

(2) to make sure that IROFS can make the risk level criteria of a accident sequence acceptable, and

(3) to perform the grading evaluation of each IROFS

2.2 Outline of the procedure

Outline of the developed ISA procedure are as follows(see Figure 2.1);

I. Collect and summarize process information, e.g. material and hazard source lists,

II. Implement process hazard analysis, and list up all potential hazards that lead to exposure,

III. Evaluate consequence of the all hazards ignoring all safety measures, and identify hazards requiring IROFS,

IV. For the hazards determine accident sequences and identify IROFS, and evaluate consequence and likelihood to assign risk level (the product of the value of consequence category and that of the likelihood category) of the accident sequence,

V. When the risk level of an accident sequence meets the criteria (risk level < 8, see Figure 2.2), perform grading evaluation of relevant IROFS. When the risk level of an accident sequence does not meet the criteria, measures including additional IROFS should be considered to meet the criteria. Identify how to utilize the results for inspections and maintenances of IROFS.

2.3 Scope of analysis

(1) Events to be assessed

Internal events are to be assessed. External events (disasters caused by natural phenomena or manmade events) are out of the scope of the assessment.

(2) Status of facilities subject to assessment

Operational mode, start-up mode, and mode for shutting down operations are to be assessed. The shut-down state is to be assessed when a hazard that leads to exposure, and when inadequate of inspections and maintenances during shut-down period to cause a hazard in a subsequent status (an operational mode, a start-up mode, etc.)

(3) Objects of the analysis of exposure

An analysis of radiation and chemical exposure is conducted for facility workers and offsite public in the vicinity of the site.

(4) Items exempt from process hazard analysis

In the process hazard analysis, static components such as containers, valve body, and piping that are unlikely to be broken by internal events such as wear, corrosion and erosion, as well as buildings and structures, are assumed to keep their original safety functions. However, connecting parts in the piping such as flanges, welding and seals, etc. are assumed to have possibility leading troubles.

2.4. Identification of hazards and strategy for their evaluation

The point in the process hazard analysis ignoring all safety measures is to identify all potential hazards exhaustively. For that purpose, HAZOP analysis [1-5] and the FMEA [1-5], which are suitable for detailed analysis of events sequences, are applied to be conducted using the process information such as material and hazard source lists.

When the HAZOP analysis is used, the analysis is divided into two steps. The first step is a review of a combination of guide words and parameters to list up initiating events exhaustively. The second step is the HAZOP analysis using the results of the first step.

At first the selection of hazards requiring IROFS from those in the list is conducted using only the result of consequence analysis. At this stage, and the likelihood category of any hazard is regarded conservatively as the category 4 (not unlikely) (see Figure 2.2) , therefore evaluation to categorize likelihood is not conducted. Since the frequencies of initiating events are mostly in the range from 10^{-1} to 10^{-2}/year based on the trial analysis, the likelihood category of the hazards goes into the category 4 in most cases when safety measures are ignored.

When the risk level of each hazard is greater than 8 (i.e. consequence category is greater than 2), each hazard is evaluated by taking IROFS into account.

Since any criticality events in uranium fabrication and enrichment facilities have a possibility to cause significant radiological exposure of facility workers, the consequence categories of the criticality events are assigned to the highest consequence level, i.e. category 4, without any exposure analysis.

2.5. Risk level matrix development

2.5.1. Consequence category

Consequence categories are defined both for radiological and chemical exposures respectively, as shown in Table 2.1.

Consequences of radiological exposure are categorized into 4 consequence categories, because low-level radiological exposures need to be closely evaluated in order to utilize the ISA results for the improvement of the inspection and maintenance methods. A number 1, 2, 3 or 4 is assigned to each category. The relationship between the exposure levels used in the consequence category and these in regulations and standards is shown in Table 2.2. When the exposure levels are found in regulations and standards to uranium fabrication and enrichment facilities, their levels are applied. And when they are not found, those for reactor facilities are applied.

Consequences of chemical exposures are categorized into 3 consequence categories depending on the level of exposure by referring to the categorization of the USNRC[1-3]. A number 1, 3 or 4 is assigned to each category according to the consistency with the radiological exposure in each category. The Acute Exposure Guideline Level (AEGL) (2-1) of the USEPA is applied for the chemical consequence category.

2.5.2 Likelihood category

Likelihood of accident sequences are categorized into 4 likelihood categories: “Extremely unlikely,” “Highly unlikely,” “Unlikely,” and “Not unlikely.” A number 1, 2, 3 or 4 is assigned to each likelihood category as shown in Table 2.3. The rule of defining likelihood categories is described below.

(1) Lower occurrence limit of “Extremely unlikely” accident sequences
The criteria of the likelihood is defined as “equal to or less than 10^{-6}/year (likelihood index of -6.0 or less) based on the following reason.

(a) For hypothetical accidents with highest consequences assumed based on an engineering analysis, the exposure at the boundary of the peripheral monitoring area is estimated to be 1 Sv at maximum.
(b) Since the evaluation of the relative concentration (χ/Q) in the ISA is conducted under conservative conditions (such as constant wind direction, etc.), the level of risk is evaluated conservatively by a factor of 10 compared with that calculated as the “average risk of cancer fatality for individuals in the public in a certain range of distance from a facility” (2-2) as defined in the safety goal in Japan (2-3) .
Therefore, 1Sv at the boundary of the peripheral monitoring area corresponds to 0.1 Sv or less based on the calculation method of the safety goal in Japan.
(c) The fatality rate of the exposure of 0.1 Sv in the offsite is 0.05/Sv.(2-4)
(d) Assuming that the number of accident sequences that cause 0.1 Sv or less at the boundary of the peripheral monitoring area is 200, and that the boundary value in the likelihood category 1 is 10^{-6}/year, the risk meets the Japanese safety goal (10^{-6}/year = 0.1Sv×0.05/Sv×200 cases×10^{-6}/year). If the boundary value of the likelihood category 1 is 10^{-5}/year, the allowable number of accident sequence to achieve the safety goal is 20.
(e) The number of accident sequence that results in the exposure of 0.1 Sv is expected to be 20 or more based on the experiences including trial analyses for typical processes of uranium fabrication and enrichment facilities.
(f) From the above considerations, the lower occurrence limit of the “Extremely unlikely” accident sequences is defined as 10^{-6}/year.

This limit is lower than the criteria in NUREG-1520[(1-3)]. The logic to set it is planed to be further improved.

(2) Lower occurrence limit of “Highly unlikely” accident sequences
In order to satisfy the criteria, the accident sequences in the consequence category 4 need to be the likelihood category 1, and those in the consequence category 3 need to be the likelihood category 2 or 1. For facility workers and offsite public, the lower occurrence limit for the radiological exposure in the consequence category 3 is defined as one order magnitude lower than that of the consequence category 4. Therefore, the likelihood in the likelihood category 2 is defined as equal to or less than 10^{-5}/year (likelihood index of -5.0 or less), which is higher than that in the likelihood category 1 (equal to or less than 10^{-6}/year) by a factor of 10.

(3) Lower occurrence limit of “Unlikely” accident sequences
The boundary value between “unlikely” and “not unlikely” is set based on occurrence or non-occurrence of accident during the life of facilities. The likelihood of accident to occur once during the lifetime (approx. 30 to 50 years) is equal to or less than approx. 2×10^{-2} to 3.3×10^{-2}/year, thus these values are considered “not unlikely.” The lower occurrence limit of “unlikely” is defined lower than those by a factor of 10, i.e. equal to or less than 10^{-3}/year (likelihood index of -3.0 or less).

2.5.3 Risk level matrix

The risk level matrix is shown in Figure 2.2. It is based on the above-mentioned consequence categories and likelihood categories. The values in the matrix indicate risk levels which are the products of the number assigned to each consequence and the likelihood category. An accident sequence with a value of 8 or higher in the risk level matrix does not to satisfy the criteria. Measures should be taken including providing additional IROFS need to be considered because the IROFS is insufficient in this case.

2.6 Improvement of the accuracy of evaluation for accident sequence frequency

2.6.1 Calculation procedure for components failure rates index

An index method, which is recommended in NUREG-1520, is the evaluation method of components failure rates based on operation and failure experiences. The accuracy of the

evaluation would be enhanced by using existing generic component failure databases in addition to this method for evaluating likelihood of accident sequences.
In order to improve the accuracy of the evaluation of the frequency of initiating events and failure rates of IROFS, the generic databases [1-9,1-10] of nuclear reactor, marine oilfields and chemical plants were surveyed to collect failure rate data of the major systems and components used in uranium fabrication and enrichment facilities, such as exhauster and hydrogen detector. Then IROFS failure rate can be evaluated for the case with or without component failure data according to the procedure in Figure 2.3. The procedure to convert the component failure data to numerical index is also shown in Figure 2.3.

2.6.2 How to set the duration

There are two types in initiating events and failures of IROFS, “f-type” and “p-type.”
(a) A “f-type” event is characterized by a frequency of occurrence in a certain operation period[2-5].
(b) A “p-type” event is characterized by a probability of failure on demand[2-5].

An accident sequence is represented by a combination of “f-type” events with a dimension of “per year” and “p-type” events with no dimension.
The “f-type” events are divided into “fr-type” and “fi type” depending on the unavailability. The “fr-type” events are for component failure need to repair, and the “fi type” for inspection outage.
They are defined as follows.

(a) The “fr-type” events are defined as “Failure of components, which can be immediately detected as anomaly of process operation caused by the failure,” e.g. failure of an exhaust fan and failure of a spare exhaust fan after startup.
(b) The “fi-type” events are defined as “Failure of components, which cannot be detected before inspections, because it would be difficult to distinguish whether a failure of component is due to the anomaly of the process or failure of a component constantly monitoring process operation conditions,” e.g. failure of a hydrogen detector and failure of a pressure level detector.

The components that cause “fr-type” events are those that require keeping operation until the repair of the failed component in the upper stream of the accident sequence is completed, or the process is being shut down safely. Therefore, the required duration for the components

involved in this type of event to fulfill its function is the repair time (duration) of the failed component or the time required to stop the process. However it is preferable to choose the longer one, from a conservative viewpoint. For uranium fabrication and enrichment facilities, it is considered that the former will be longer than the latter.
The components involved in the “fi-type” events are left un-repaired until they are inspected, since the failure is not detected before being inspected. It is not possible to know when the component stopped its proper operation during the inspection interval. Therefore, the developed procedure employed the inspection or check interval of the component conservatively as the duration of the failure.

2.7 Grading evaluation of IROFS

2.7.1 Relationship between operation limits and conditions and IROFS

In the ISA procedure, the relationship between IROFS and the operational limits and conditions (OLC) is analyzed for accident sequences. Figure 2.4 illustrates the process of events progress and how to analyze the relationship above. The result is utilized in the step 3 of the grading evaluation of IROFS as described later.
OLC are specified by the boundaries that an operational process can be kept within normal operation and does not cause any significant damage to items important to safety nor lead to accident conditions[2-6,2-7].

2.7.2 Grading evaluation method of IROFS

Grading of identified IROFS in terms of their safety significance can achieve more effective and efficient inspection commensurate to the significance of IROFS. Therefore a method to conduct the grading evaluation was suggested not only from the viewpoint of risk level lowering but also from different view points.
The procedures of the grading evaluation of IROFS are as follows.

(1) Step 1
Significant IROFS are selected in the step 1 based on the following rules.

I. Priority in the selection of significant IROFS
   (a) IROFS involved with more accident sequences
   (b) IROFS related to engineered control
   (c) IROFS related to other significant IROFS in safety aspect

II. Among the IROFS lowering likelihood category or frequency

(a) For hazards in the consequence category 1 to 3, select one IROFS.

(b) For hazards in the consequence category 4, select two or more IROFS.

The basic procedure of the step 1 is as follows:

(a) Set accident sequence groups for facility workers and offsite public independently focusing on status of the facilities, hazard, and quality of risk level,

(b) Classify the IROFS in the group into those that lowering likelihood category or prevent events sequences and those that lower consequence category. The degree that each IROFS involves in the total accident sequence is also identified.

(c) Select significant IROFS which is necessary for the all accident sequences of the group to meet the criteria. The selection is based on the basic rule I described above.

(d) Additional significant IROFS will be selected according to the basic rule II described above.

(2) Step 2

Each significant IROFS is graded according to the following three substeps, i.e. Step 2-1, 2-2 and 2-3. The larger the total number of the mark "○" is, the more significant the IROFS is.

(a) In the Step 2-1, IROFS are graded based on the level of involvement in accident sequences (whether they are commonly used or not). For the accident consequence groups formed in the step 1, when a significant IROFS is involved all accident sequences in two or more groups, then the IROFS is rated "⊙," when involved in all accident in one group, then rated "○"and when involved in some of accident sequences in one group, then rated "-."

(b) In the Step 2-2, IROFS are graded based on the redundancy. When a significant IROFS has redundancy, it is rated"○," and when it does not, it is rated "-."

(c) In the Step 2-3, IROFS are graded based on their management type. In case that the management type is engineered control, they are rated"⊙," in case of an enhanced administrative control, they are rated"○," and in case of a simple administrative control, they are rated "-."

(3) Step 3

A significant IROFS is classified into the following 4 grades from a viewpoint of accident progress, e.g. with or without relevance to the OLC.

G (Green): Not lead to the deviation from OLC, and possible to return to normal operation,

Y (Yellow): Related to the deviation from OLC,
O (Orange): Prevention of accident progress,
R (Red): Most important in accident progress

An example of the grading evaluation results of IROFS for facility workers is shown in Table 2.4. The result of the table indicates that standby exhaust fan, operating exhaust fan and operator response to a signal of gas detectors are more important than other significant IROFS. When the grading evaluation is not for workers but for public, more important IROFS change from exhaust fans to HEPA filters.

2.8 Utilization of risk information for inspections and maintenances

2.8.1 Risk information obtained from ISA and how to use them

Risk information obtained at each step in the developed ISA is shown in Figure 2.5. Risk information for inspections and maintenances of facilities especially in the operation stage are expressed in italics in the figure. Table 2.5 shows the risk information, how to utilize risk information and potential utilization.

2.8.2 Scheme of utilizing risk information for the inspections and maintenances of IROFS

How to utilize the grading results of significant IROFS for inspections and maintenances, which based on Table 2.5, is shown in Figure 2.6. For significant IROFS, the risk information obtained through ISA can be compared with the current inspections and maintenances to identify measures including additional inspections.
When comparing the "frequency of initiating events" and the "current frequency of inspections," the statement in the reference 1-7, "It is preferable that the frequency of inspection of the relevant IROFS is equivalent to or one order of magnitude higher than the frequency of initiating events" can be referred to.
For non-significant IROFS, which are inspected by regulatory agencies or by licensees, it should be considered what kind of inspections or maintenances are required for them.

3. Conclusion

As discussed above, key issues to be addressed in implementing ISA were clarified. Thus an outlook was obtained that the "developed ISA Procedure" can be used for identification of

IROFS, grading evaluation of IROFS and utilization of the obtained risk information for inspections and maintenances. The “ISA Procedure Manual (first edition)” was also established.

Following issues are future activities.
(a) Improvement of method to identify IROFS in a more appropriate manner
(b) Validation of the logic to set boundary values of likelihood categories
(c) Study how to reflect risk information in safety regulations in a concrete manner

Acknowledgment

The authors are grateful to experts in domestic uranium fabrication and enrichment facilities and JAEA staff who participated in discussions and provided valuable comments on the ISA procedure.

Table 2.1 Consequence categories on radiological and chemical exposure

Category	Facility workers	Offsite public
4	*RD > 1 Sv **CD > AEGL-3 (Danger for life)	RD > 250 mSv, or 30 mg sol U intake CD > AEGL-2 (Long-lasting or serious health effects)
3	100 mSv < RD ≤ 1 Sv (Health effects with change in blood) AEGL-2 < CD ≤ AEGL-3 (Long-lasting or serious health effects)	5 mSv < RD ≤ 250 mSv (Health effects with change in blood or its possibility) AEGL-1 < CD ≤ AEGL-2 (Effects such as extreme discomfort, or strong irritation)
2	50 mSv < RD ≤ 100 mSv	1 mSv < RD ≤ 5 mSv
1	Accidents of lower radiological or chemical exposures than those above in this column	Accidents of lower radiological or chemical exposures than those above in this column

*RD = Radiological dose (Effective dose) ,**CD = chemical dose

Table 2.2 Exposure level and regulations / standards

	Exposure level	Regulations and standards	Remarks
Facility workers	1 Sv	Not stipulated in Japan; criterion for the ISA in the USA	Based on 64 FR 41338 in the USA
	100 mSv	Article 6, "Notification No.13 specifying radiation dose limit in accordance with the provision in the rules regulating nuclear fuel fabrication businesses" (December 26, 2000)	Dose limit for radiation workers engaged in emergency tasks.
	50 mSv	Article 8, "Notification No. 13"	Dose limit for radiation workers (per year) in ICRP Pub.60（1990）
Offsite public	250 mSv	"Guideline for siting nuclear reactors" (May 27, 1964)	For whole body
	Intake 30 mg of soluble uranium	Not stipulated in Japan, criterion for the ISA in the US	Based on "UF_6 Public Risk", PNL-10065, in the USA
	5 mSv	"Examination guide for safety design of light water nuclear power reactor facilities" (March 2001), "Examination guide for the safety of reprocessing facilities" (March 2001)	Risk may be considered "low" if the estimated effective dose for the public is below 5 mSv per accident.
	1 mSv	Article 3 ,"Notification No. 13"	Concentration limit in the area other than supervised area (for one year), ICRP Pub.60（1990）

Table 2.3 Likelihood category of accident sequences

Likelihood category		Frequency of accident sequence
1	Extremely unlikely	$\leq 10^{-6}$/y/event （Frequency index≤-6.0）
2	Highly unlikely	$>10^{-6}$/y/event, $\leq 10^{-5}$y/event （Frequency index≤ -5.0）
3	Unlikely	$>10^{-5}$/y/event, $\leq 10^{-3}$/y/event （Frequency index≤-3.0）
4	Not unlikely	$>10^{-3}$/y/event

		（Frequency index>-3.0）

Table 2.4 Grading evaluation results of IROFS (Example)

Process: Object: Workers[Note1)]

IROFS	Step 1[Note 2)]	Step 2[Note 3)]				Step 3[Note 4)]	Summary of importance
		Step 2-1	Step 2-2	Step 2-3	Integration		
	Grading results	Commonalty ⦿ : 2 groups or more ○ : 1 group - : Part of 1 group	Redundancy ○ : Yes - : No	Control type ⦿ : Eng. control ○ : Enhanced admin. control - : Admin. control	Importance from grading evaluation A : high B : medium C : low	Accident progress	
Operating exhaust fan	P-1	⦿	○	⦿	A	O	P-1AO
Standby exhaust fan	P-1	⦿	○	⦿	A	R	P-1AR
Operator response by to a signal of gas detectors	P-1	⦿	○	○	A	O	P-1AO
Feed water pump – Control mechanism	P-2	○	○	⦿	A	G	P-2AG
Feed water tank vent	P-2	○	○	⦿	A	Y	P-2BY
Emergency evacuation	M-1	⦿	—	-	B	O	M-1BO
Alarm and operator response	P-2	—	—	○	C	Y	P-2CY
Leak check of piping	P-1	⦿	○	○	A	G	P-1AG
Actuation of shut-down valve at the temperature high signal	P-1	○	○	⦿	A	Y	P-1AY

Note: 1) Evaluation shall be performed for facility workers and offsite public independently.
2) P-1: Significant IROFS in view of lowering likelihood category, P-2: IROFS other than those selected in P-1, that would be effective in lowering frequency or preventing occurrences. M-1: significant IROFS in view of mitigating consequences.
3) Evaluation based on the number of ○ in the Step 2-1, 2-2 and 2-3 (⦿ is counted two ○.) A: four or more, B: two or three and C: less than one.

4) G (Green): Not lead to the deviation from OLC, and possible to return to normal operation, Y (Yellow): Related to the deviation from OLC, O (Orange): Prevention of accident progress, R (Red): Most important in accident progress

Table 2.5 How to use Risk information

Risk information	Items to be improved	Potential utilization
Hazards with high consequence	Consequence level (Public 1mSv, Workers 50mSv)	How to perform inspections and maintenances* Content of Operational Safety Program
Level of IROFS failure rate and initiating events failure frequency	Component failure rate data, Index table (NUREG-1520)	Validation of interval of inspections and maintenances*
Significant IROFS	Risk level matrix, Step 1 Grading evaluation	Validation of objects and method of inspections and maintenances*
Role of significant IROFS	Step 3 Grading evaluation (OLC, Safety margin)	Validation of method of inspections and maintenances*
Grade of significant IROFS	Step 2&3Grading evaluation	Validation and determination of interval and method of inspections and maintenances*

* Including management measures such as education, training and procedure manual

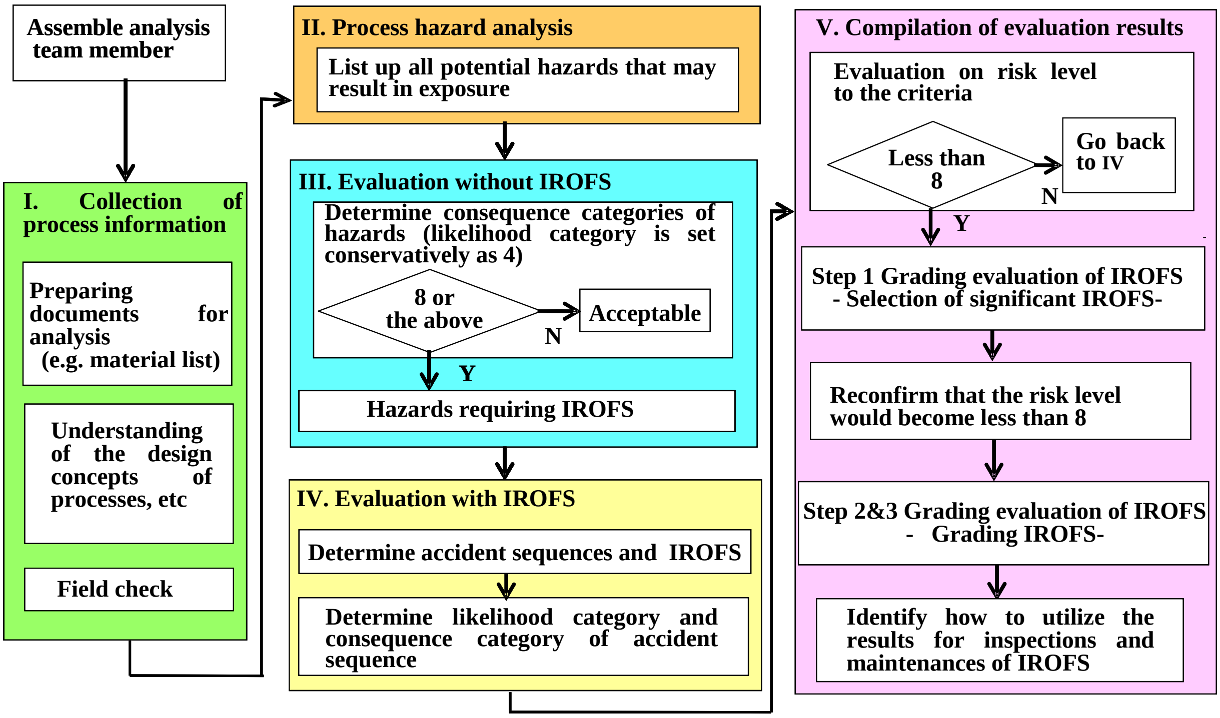

Figure 2.1　Procedure for ISA in Japan

		Likelihood Category			
		Extremely unlikely 1	Highly unlikely 2	Unlikely 3	Not unlikely 4
Consequence Category	4	**4**	**8**	**12**	**16**
	3	**3**	**6**	**9**	**12**
	2	**2**	**4**	**6**	**8**
	1	**1**	**2**	**3**	**4**

Figure2.2 Risk Level Matrix

The values in the matrix indicate risk levels, which are the products of the number assigned to each consequence category and likelihood category.

Check if risk level of individual accident sequence is less than 8 (in white areas). If it is in yellow zone, measures should be taken including providing additional IROFS.

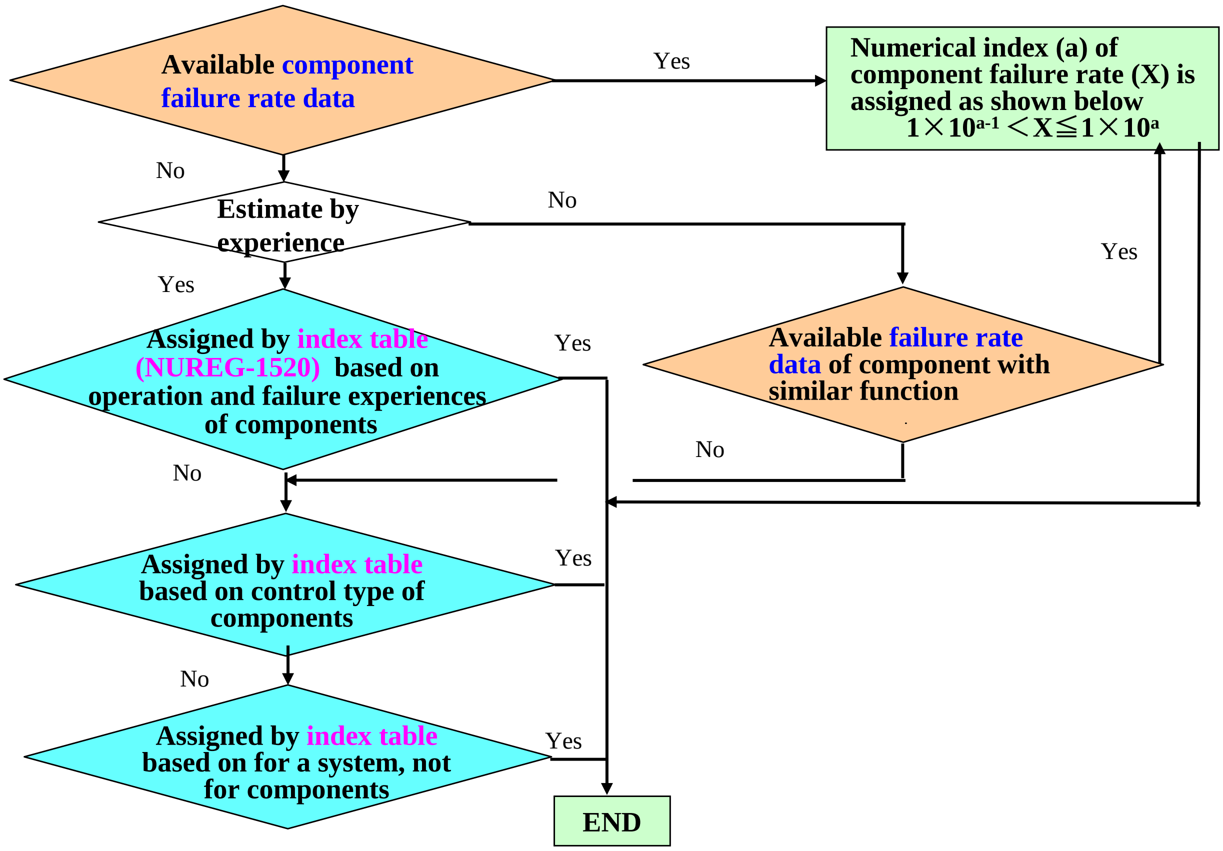

Figure 2.3 Assignment procedure of failure rate index numbers

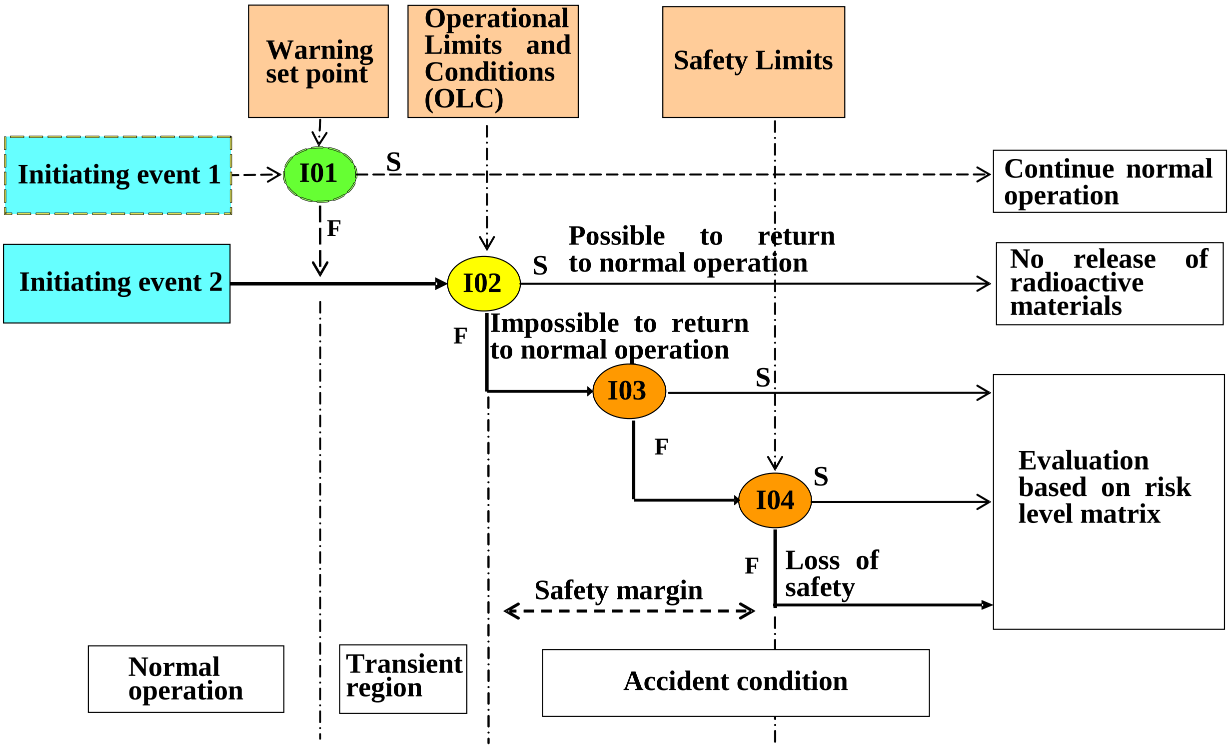

Figure 2.4 Flow diagram of accident sequence analysis

I01 to I04 indicate IROFS.

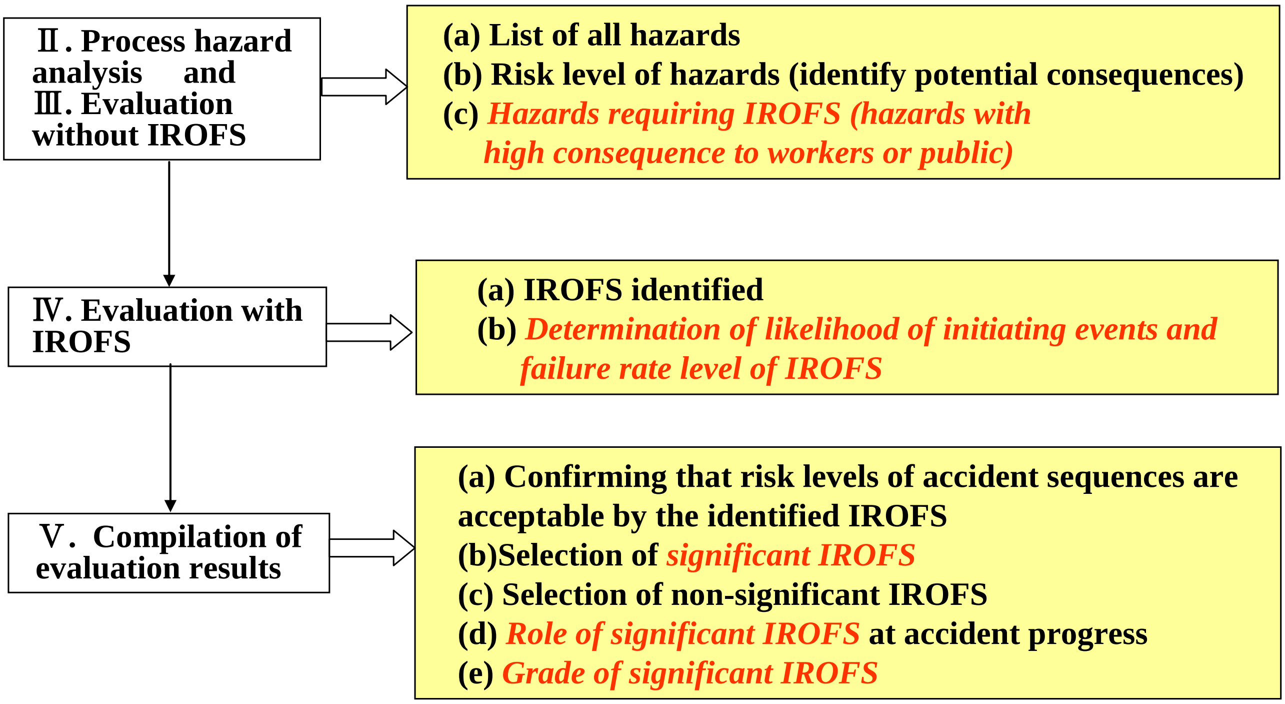

Figure 2.5 Risk information obtained through ISA

Information indicated in italics is that related to inspection and maintenance of facilities during the operation stage.

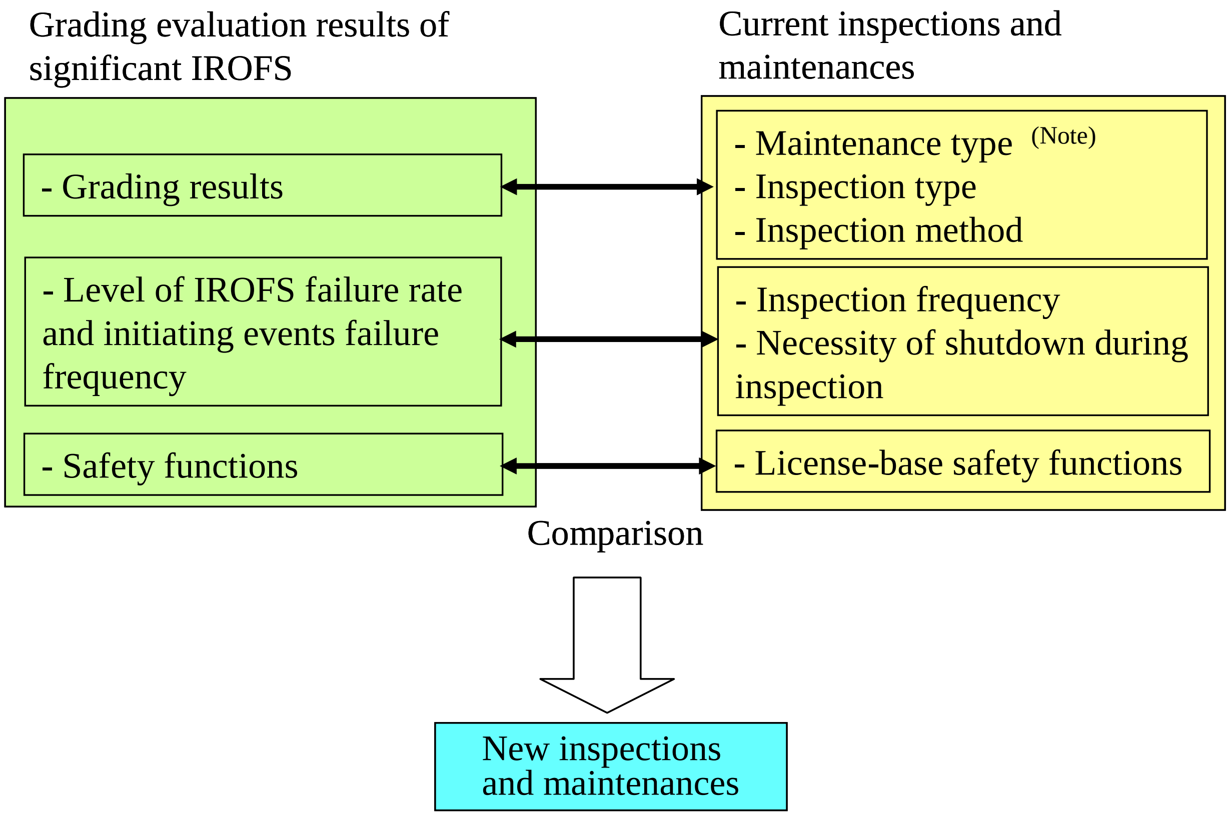

Figure 2.6 How to utilize the grading results of significant IROFS for inspections and maintenances

Note : Preventive maintenance (time based maintenance, condition based maintenance), corrective maintenance, etc.

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