

A risk monitor tool for transferring plant logs

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Abstract: Implementing the use of risk monitors at nuclear stations has traditionally required manual input of information regarding plant configuration. This paper outlines the findings of a project for developing and implementing a tool for mapping and transferring information from plant logs and planning tools automatically into a risk monitor. It reads event log data from a desired data source, converts and merges it with event logs in the risk monitor database, the merged log is then validated for inconsistencies and can be either saved to an XML file or imported directly into the risk monitor. The tool has been proven by client to be very efficient reducing manual efforts as much as possible when importing logs from existing systems and databases to the risk monitor.

1. INTRODUCTION

RiskSpectrum RiskWatcher^[1] is a risk and trip monitor for assessing risks both quantitatively and qualitatively at nuclear power plants, offshore drilling rigs, but also has the potential for monitoring risks at other types of facilities. It assesses risks based on a Probabilistic Safety Analysis (PSA) model (fault tree and event tree model), and is able to take into account plant operating modes, equipment outages, system configurations, periodic tests, environmental factors, etc.

The needs to use risk monitor to monitor online risk, simulate possible scenarios and plan outages have increased in recent years, especially in China when the authority published the technical policy for configuration risk management in the end of 2019^[2]. Meanwhile, it has always been a headache for the user to input plant configurations (e.g., the component take out events) to risk monitor, especially when a plant has been running for many years with its own logs and the user wants to migrate those logs to risk monitor. As an example, the work order system for Sanmen Nuclear Power Plant (in China) contains the information that can be used in a risk monitor, but there is so much data that it is nearly impossible to manually copy that information to the risk monitor, and the data increases with time, making it is difficult to keep the risk monitor synchronized with the work order system.

Figure 1: Work Order Information

Considering that modern plants usually have electrical log system, it becomes a big challenge to import those logs to risk monitor, which can potentially be an obstacle to extend risk monitor application.

2. REQUIREMENTS

Requirements on the import tool from Sanmen Nuclear Power Station, are to import logs from the plant's work order system to risk monitor.

The tool should eliminate manual efforts as much as possible when importing logs from existing systems and databases to the risk monitor. It should read event log data from the desired data source, convert and merge it with the event logs in the risk monitor database. The merged logs should then be validated for inconsistencies and be either saved to an XML file or imported directly into the risk monitor. The key features include:

- Support multiple data source types: It should support to read logs from general data sources, e.g., Excel, SQL Server, Oracle, and customized data sources (e.g., online logs from other systems).
- Automatically detect conflicts: It should automatically detect conflicts, between data source logs and existing risk monitor logs.
- Automatically resolve conflicts: It should have a function that can automatically resolve all conflicts based on user-defined rules.
- Automatic importing: It should be possible to read logs from a data source, resolve conflicts and import them to the "Online" event history of the risk monitor event log automatically every hour, for example. The time interval can be customized.

3. DESIGN & IMPLEMENTATIONS

3.1. Architecture

Below is the software architecture of the tool.

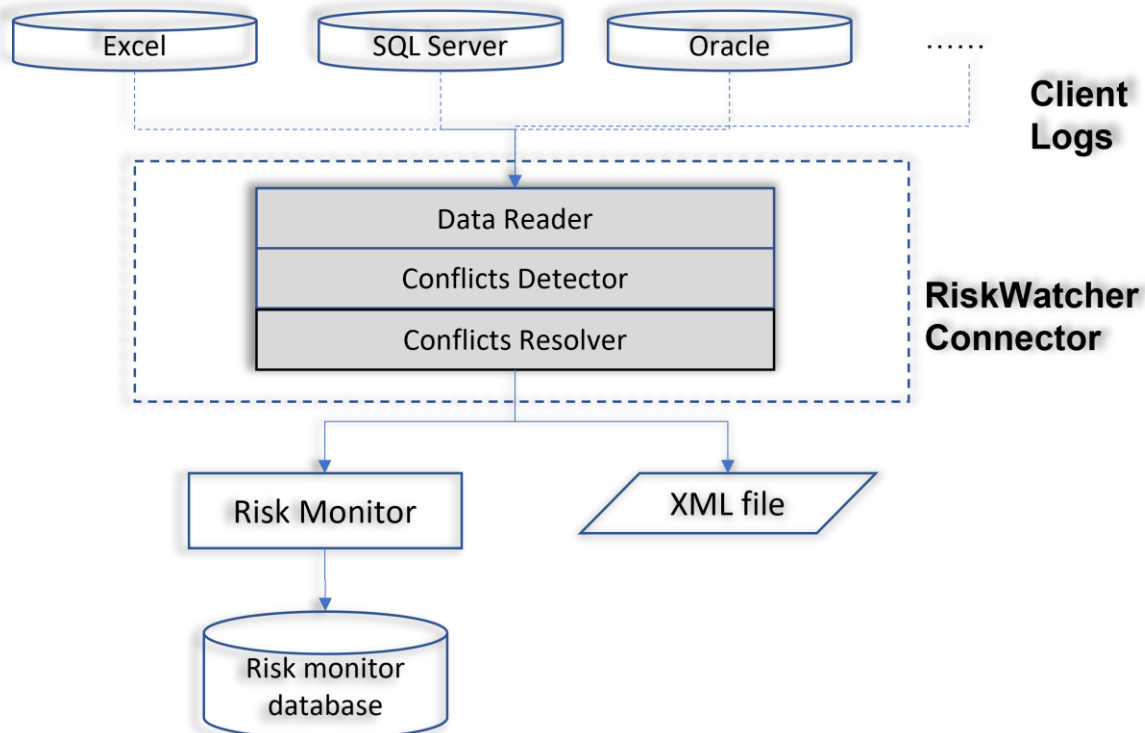


Figure 2: Architecture

The tool (*RisSpectrum RiskWatcher Connector*) generally contains 3 key modules:

- **Data Reader:** be responsible to read logs from different data sources.
- **Conflicts Detector:** to handle conflicts/overlapping when a configuration is defined in different time scope, e.g., a component is taken out by multiple work orders, those work orders happen in different time range, which is overlapping.
- **Conflicts Resolver:** the logs read from the data source can be in conflict with existing risk monitor logs or with other logs from the data source, e.g., a component is taken out consecutively on different time.

3.2. Data Reader

The data reader module is designed, so that it can support almost all types of data sources, some clients may not allow external tool to connect their database directly (e.g., due to IT infrastructure restriction). In this case, they are allowed to develop their own module that can be used by the data reader.

3.3. Conflicts Detector

An element is contradictory if:

- Plant operating mode (POM): If the same POM is defined at a date where its application would be before or after the same POM in the event history, without another POM in-between.
- Environmental factor (EF): If the same EF is defined at a date where its application would be before or after the same EF in the event history, without either an EF off (when it is not mutual-exclusive with others) or selection of another EF alternative (when it is mutual-exclusive with others) in-between. The EF must consider the grouping of EFs.

- System configuration (SC): If the same SC is defined at a date where its application would be before or after the same SC in the event history, without either a system configuration off (when it is not mutual-exclusive with others) or selection of another system configuration alternative (when it is mutual-exclusive with others) in-between. The SC must consider the grouping of SCs.
- Component: If the component event (take out or restore) is overlapping with the existing events.

There are currently two algorithms for handling the conflicts based on the type of the data source:

- Real-time source (logs include only start date) – uses the original algorithm.
- Planning source (logs include both start and end date) – uses the time period algorithm.

3.3.1 Original Algorithm

The conflicts are handled as below:

- Duplicated records are removed silently.
- Handle take out/restore overlapping with specified rule. Assume “Earliest” is selected for component take out, and “Latest” is selected for component restore. First, it scans through event log for all take out and restore events. Then:
 - if it detects more than one consecutive take out event of a certain component, keep the first one.
 - if it detects more than one restore event of a certain component, keep the last one.
- The algorithm applies also to system configuration, environmental factor event in a similar way, but the default option is always “Earliest”, the reason is that for take out and restore events, it is easy to estimate the conservative selection, but it is not for system configuration, environmental factor, and plant operating mode events.

The user can make their own choices based on the situation. The rules can be configured via Data Source Configuration Wizard inside the tool, for all possible log types:

The screenshot shows a configuration window titled "Specify which datetime should be used when resolving conflicts in converted logs". On the left is a sidebar with navigation options: "Choose Data Source", "Config Data Driver", "Column Mappings", "Destination Server", "Authentication", "ID Mappings", and "Conflict Rules" (which is selected). The main area contains a list of event types with corresponding dropdown menus for selecting a resolution rule:

Event Type	Selected Rule
Component Take Out	Earliest
Component Restore	Latest
Component Group Take Out	Earliest
Component Group Restore	Latest
System Configure On	Earliest
System Configure Off	Earliest
Mutual-exclusive System Configure On	Earliest
Environmental Factor On	Earliest
Environmental Factor Off	Earliest
Mutual-exclusive Environmental Factor On	Earliest
Operating Mode On	Earliest

At the bottom right of the main area, there is a link: [Reset All to Defaults...](#)

Figure 3: Rules for Original Algorithm

An example is presented below to illustrate the process. In the image below, each line segment represents an outage period (for mapping types of component take out or component group take out). So, T1 is TakeOut1, R1 is Restore1 and so on.

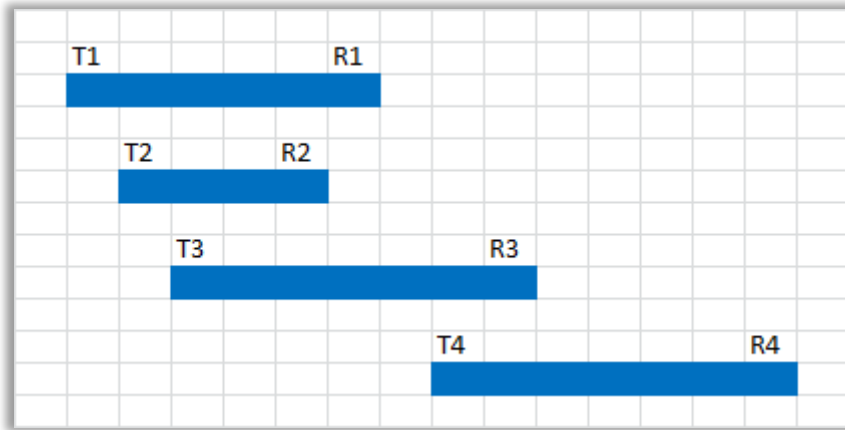


Figure 4: Example for Original Algorithm

When the data is read, it will be interpreted as this sequence:

T1, T2, T3, R2, R1, T4, R3, R4

The consecutive events are identified:

{T1, T2, T3}, {R2, R1}, T4, {R3, R4}

When the rules are applied, T1 gets selected from the first set, because it is the first take out event in that set. R1 gets selected from the second set because it is the last restore event in that set. Similarly, R4 gets selected from the third set.

After applying the rules, the sequence becomes:

T1, R1, T4, R4

So, the final outage periods will be [T1, R1] and [T4, R4].

3.3.2 Time Period Algorithm

The difference between time period algorithm and the original algorithm is how the overlapping events are handled. It includes a different way of defining conflict rules:

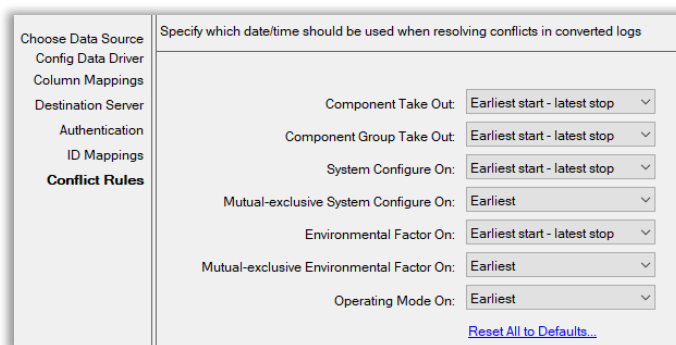


Figure 5: Rules for Time Period Algorithm

The time period algorithm is used only for planning source (logs include both start and end date), component (group) restore, system configuration off, and environmental factor off events are not considered here. If the converted logs contain restore or off logs (when user specifies mappings for them), overlapping will always be handled by the original algorithm with “Latest” rule for them.

Below is an example for the process. Assume that a component is taken out and restored on different days of the month.

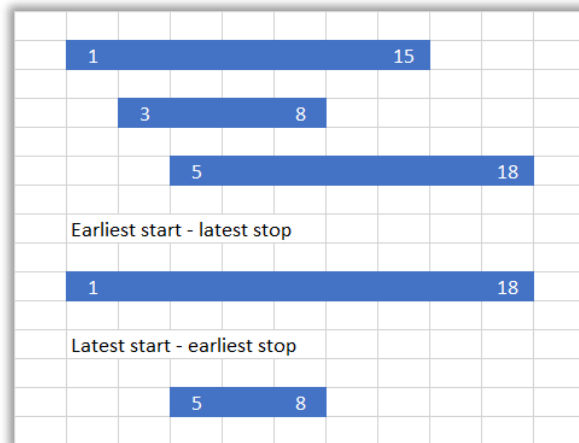


Figure 6: Example for Time Period Algorithm

The component is taken out on the 1st and restored on the 15th, then taken out on 3rd and etc. When the algorithm is applied, it sorts the intervals and then starts applying the chosen option for the rule.

“Earliest start – latest stop”:

1. It takes [1, 15] and [3, 8] and merges them into [1, 15].
2. It takes [1, 15] and [5, 18] and merges them into [1, 18].

The final result is [1, 18].

“Latest start – earliest stop”:

1. It takes [1, 15] and [3, 8] and merges them into [3, 8].
2. It takes [3, 8] and [5, 18] and merges them into [5, 8].

The final result is [5, 8].

3.4. Conflicts Resolver

When import logs to risk monitor, the conflicts resolver module can resolve all conflicts with pre-defined rules, as below.

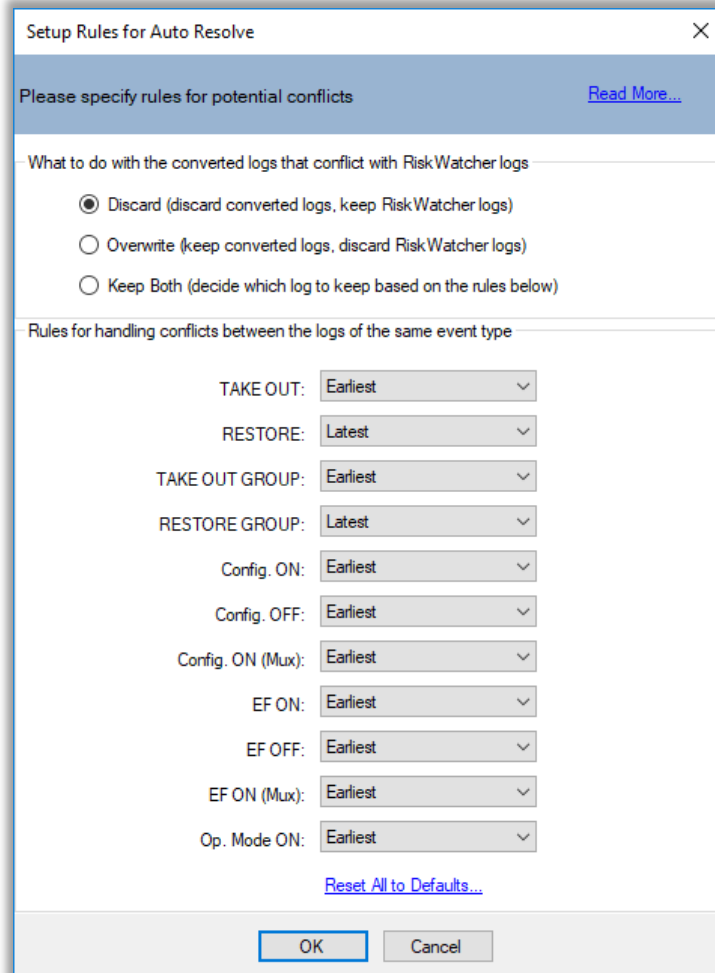


Figure 7: Auto Resolve Rules

User firstly has 3 options:

- **Discard:** discard data source logs, existing logs in risk monitor are not affected.
- **Overwrite:** overwrite logs in risk monitor, so that they are replaced by data source logs.
- **Keep Both:** keep both and resolve conflicts by event type.

Selecting the 3rd option, the user can select the rule for each event type, e.g., by default, for take out event, the Earliest one is used, while for restore event, the Latest one is used, then we will get conservative results in risk monitor.

4. Results

The tool was run in Sanmen Nuclear Power Plant for some time, and it turns out to be very useful on helping to do risk evaluation and import logs into risk monitor, below are some screenshots from the client for their overhaul planning. In **Figure 8**, 40 conflicts are detected, each conflicting log is marked with exclamation icon. In **Figure 9**, those conflicting logs are removed by auto resolve process.

风险监测器日志 X

目标计划: 102大修20210603

ID	事件	操作时间
RTS1	Config. ON	2021/6/27 4:30:00
PA1	Config. ON	2021/6/26 21:30:00
POSJ	Op. Mode ON	2021/6/26 19:30:00
POSI	Op. Mode ON	2021/6/26 12:30:00
EGC	Config. ON	2021/6/23 7:30:00
POSH	Op. Mode ON	2021/6/22 4:30:00
RCSC	Config. ON	2021/6/22 4:30:00
POSQ	Op. Mode ON	2021/6/21 9:30:00
POSG	Op. Mode ON	2021/6/20 14:30:00
POSL	Op. Mode ON	2021/6/17 11:30:00
POSN	Op. Mode ON	2021/6/11 16:30:00
POSL	Op. Mode ON	2021/6/8 23:30:00
POSM	Op. Mode ON	2021/6/7 12:30:00
POSF	Op. Mode ON	2021/6/7 6:30:00
RCSO	Config. ON	2021/6/6 12:30:00
EGO	Config. ON	2021/6/4 19:00:00
POSE	Op. Mode ON	2021/6/4 14:00:00
POSD	Op. Mode ON	2021/6/4 12:00:00
1RNSMP01A	Config. ON	2021/6/4 12:00:00
PA2	Config. ON	2021/6/4 5:06:00
POSC	Op. Mode ON	2021/6/3 21:30:00
RTS2	Config. ON	2021/6/3 21:30:00
POSA	Op. Mode ON	2021/6/3 0:00:01
1DWSP01A	Config. ON	2021/6/3 0:00:01
1FSMP01B	Config. ON	2021/6/3 0:00:01
RCSC	Config. ON	2021/6/3 0:00:01
TTB1	Config. ON	2021/6/3 0:00:01
EGC	Config. ON	2021/6/3 0:00:01
PA1	Config. ON	2021/6/3 0:00:01
SFPDH1	Config. ON	2021/6/3 0:00:01
RTS1	Config. ON	2021/6/3 0:00:01
CP	Config. ON	2021/6/3 0:00:01
1CASMS01A	Config. ON	2021/6/3 0:00:01
1CASMS01B	Config. ON	2021/6/3 0:00:01
1CCSMEE01A	Config. ON	2021/6/3 0:00:01

转换的日志

过滤视图: All items

序号	选中	ID	事件	操作时间	工单
1	<input checked="" type="checkbox"/>	1-CAS-PL-V014	TAKE OUT	2021/6/10 15:19:28	<21012477>
2	<input checked="" type="checkbox"/>	! 1-CDS-MP-01A	TAKE OUT	2021/6/10 15:19:28	合并工单
3	<input checked="" type="checkbox"/>	! 1-CDS-MP-01B	TAKE OUT	2021/6/10 15:19:28	合并工单
4	<input checked="" type="checkbox"/>	! 1-CDS-MP-01C	TAKE OUT	2021/6/10 15:19:28	合并工单
5	<input checked="" type="checkbox"/>	! 1-CDS-PL-V005B	TAKE OUT	2021/6/10 15:19:28	<20024279>
6	<input checked="" type="checkbox"/>	1-CVS-MP-01A	TAKE OUT	2021/6/10 15:19:28	合并工单
7	<input checked="" type="checkbox"/>	1-CVS-MP-01B	TAKE OUT	2021/6/10 15:19:28	合并工单
8	<input checked="" type="checkbox"/>	1-CVS-PL-V045	TAKE OUT	2021/6/10 15:19:28	<20008039>
9	<input checked="" type="checkbox"/>	1-CVS-PL-V084	TAKE OUT	2021/6/10 15:19:28	合并工单
10	<input checked="" type="checkbox"/>	1-CVS-VT-IST004	TAKE OUT	2021/6/10 15:19:28	<20022061>
11	<input checked="" type="checkbox"/>	! 1-CWS-MP-01A	TAKE OUT	2021/6/10 15:19:28	合并工单
12	<input checked="" type="checkbox"/>	! 1-CWS-MP-01B	TAKE OUT	2021/6/10 15:19:28	合并工单
13	<input checked="" type="checkbox"/>	! 1-CWS-PV-103	TAKE OUT	2021/6/10 15:19:28	合并工单
14	<input checked="" type="checkbox"/>	! 1-CWS-PV-104	TAKE OUT	2021/6/10 15:19:28	合并工单
15	<input checked="" type="checkbox"/>	! 1-CWS-EC-142(52)	TAKE OUT	2021/6/10 15:19:28	<20025978>
16	<input checked="" type="checkbox"/>	1-ECS-EK-14T(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
17	<input checked="" type="checkbox"/>	1-ECS-EK-24(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
18	<input checked="" type="checkbox"/>	1-ECS-EK-31(DC1)(89)	TAKE OUT	2021/6/10 15:19:28	<21007683>
19	<input checked="" type="checkbox"/>	! 1-ECS-ES-1M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
20	<input checked="" type="checkbox"/>	1-ECS-ES-2(89)	TAKE OUT	2021/6/10 15:19:28	<21005529>
21	<input checked="" type="checkbox"/>	! 1-ECS-ES-2M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
22	<input checked="" type="checkbox"/>	1-ECS-ES-32(52)	TAKE OUT	2021/6/10 15:19:28	<20025243>
23	<input checked="" type="checkbox"/>	! 1-ECS-ES-3M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
24	<input checked="" type="checkbox"/>	1-ECS-ES-41(52)	TAKE OUT	2021/6/10 15:19:28	<21006217>
25	<input checked="" type="checkbox"/>	1-ECS-ES-41(89-DC1)	TAKE OUT	2021/6/10 15:19:28	<21006217>
26	<input checked="" type="checkbox"/>	1-ECS-ES-42(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
27	<input checked="" type="checkbox"/>	1-ECS-ES-42(89-DC1)	TAKE OUT	2021/6/10 15:19:28	<21006217>
28	<input checked="" type="checkbox"/>	! 1-ECS-ES-4M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
29	<input checked="" type="checkbox"/>	1-ECS-ES-52(52)	TAKE OUT	2021/6/10 15:19:28	<20025243>
30	<input checked="" type="checkbox"/>	! 1-ECS-ES-5M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
31	<input checked="" type="checkbox"/>	1-ECS-ES-61(52)	TAKE OUT	2021/6/10 15:19:28	<21006217>
32	<input checked="" type="checkbox"/>	1-ECS-ES-61(89-DC1)	TAKE OUT	2021/6/10 15:19:28	<21006217>
33	<input checked="" type="checkbox"/>	1-ECS-ES-62(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
34	<input checked="" type="checkbox"/>	1-ECS-ES-62(89-DC1)	TAKE OUT	2021/6/10 15:19:28	<21006217>
35	<input checked="" type="checkbox"/>	! 1-ECS-ES-6M1(52)	TAKE OUT	2021/6/10 15:19:28	合并工单
36	<input checked="" type="checkbox"/>	1-ECS-EV-31(52)	TAKE OUT	2021/6/10 15:19:28	合并工单

输出

> Fetching is finished

> Validate converted logs against 102大修20210603, started at 2022/4/13 15:27:56.
 40 conflicts and 0 duplicated records are detected.

> Validation is finished.

Total Converted Logs: 454 | Conflicts: 40 | Deleted: 13.

Figure 8: Detect Conflicts

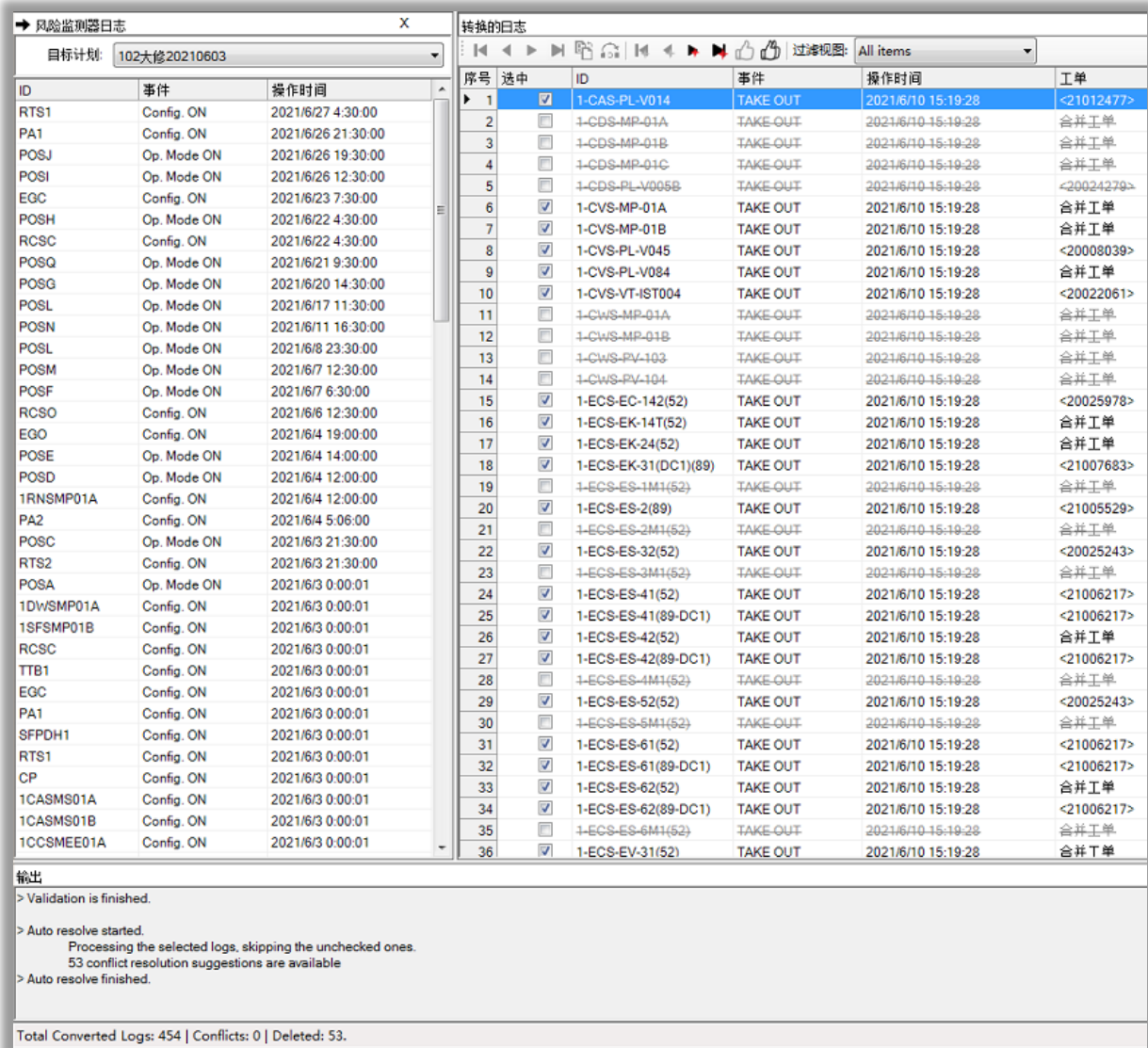


Figure 9: Auto Resolve

5. CONCLUSION

This paper describes the why and how RiskSpectrum RiskWatcher Connector has been developed and used in a nuclear power plant. RiskSpectrum RiskWatcher Connector has proven to be an effective tool helping clients to eliminate manual efforts for migrating plant configurations from information systems to a risk monitor.

A challenge when importing data from different sources is to detect conflicts between data source logs and existing risk monitor logs. Automatic detection and resolution of the conflicts is essential to fulfill the aim of eliminating manual efforts as much as possible.

Following the promotion of plant digitization and comprehensive application of risk management methodology in nuclear industry, it will become an essential tool to facilitate the use of risk monitors.

References

- [1] <https://www.lr.org/en/riskspectrum/technical-information/riskwatcher/>.
- [2] https://www.mee.gov.cn/xxgk2018/xxgk/xxgk09/202001/t20200103_757137.html.