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REGULATORY OBSERVATION Resolution Plan

RO Unique No.:	RO-UKHPR1000-0029
RO Title:	Internal Fire PSA
Technical Area(s)	PSA
Revision:	0
Overall RO Closure Date (Planned):	2021-04-30
Linked RQ(s)	RQ-UKHPR1000-0015/RQ-UKHPR1000-0466/RQ-UKHPR1000-0467
Linked RO(s)	
Related Technical Area(s)	Internal Hazards
Other Related Documentation	


Scope of Work

Background and Regulator's Expectations

The Requesting Party (RP) has submitted the Internal Fire Level 1 Probabilistic Safety Assessment (PSA) model and report (Ref. 1) for UK HPR1000.

The Office for Nuclear Regulation (UK) (ONR) has reviewed the report and has found gaps in the scope of the modelling and the approaches used. While the response to RQ-UKHPR1000-0015, 0466 and 0468 (Ref. 2, 3 and 4) have provided some useful information, there remain areas of Internal Fire PSA modelling that need to be performed during Generic Design Assessment (GDA) in order for the scope of the PSA to be comprehensive enough to understand the level of risk from internal fires. These gaps are:

- 1) Absence of sufficient level of details and scope regarding detailed fire modelling;
- 2) Absence of multi-compartment analysis;
- 3) Absence of consideration of the effect of fires on nearby power and control cables;
- 4) Absence of explicit consideration of multiple spurious operations due to fires at 'pinch-points' in the design;
- 5) Absence of information showing how the ignition frequencies have been evaluated and how ignition source counts and transient influencing factors have been established.

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These gaps need further work to be done by the Requesting Party (RP) to ensure that the Internal Fire PSA meets ONR expectations during GDA phase. These works are described in the present Resolution Plan for RO-UKHPR1000-0029.

Description of the Response and of the Scope of Work

This resolution plan provides a response for the gaps on Internal Fire Level 1 PSA, including:

- 1) A plan to demonstrate that all relevant detailed fire scenarios (including but not limited to the MCR) have been included in the Internal Fire PSA;
- 2) A plan to demonstrate that multi-compartment fires have been considered in the Internal Fire PSA;
- 3) A plan to demonstrate that cable-routing has been considered in the Internal Fire PSA;
- 4) A plan to demonstrate that multiple spurious operations due to fires at 'pinch-points' in the design have been included in the Internal Fire PSA;
- 5) A plan to demonstrate the evaluation of fire compartment ignition frequencies has been performed to an acceptable level, appropriate for the Internal Fire PSA.


Deliverable Description

RO-UKHPR1000-0029.A1 – Demonstrate that detailed fire modeling has been performed to an acceptable level appropriate for the internal fire PSA

The Regulatory Observation Action 1 states that:

General Nuclear System Limited should demonstrate that detailed fire modelling has been performed to an acceptable level in the internal fire PSA. This may be addressed by updating the extant internal fire PSA, or by issuing a new separate report during GDA timescales.

- *It is expected the detailed fire modelling to be performed on all fire compartments quantitatively screened in and to provide evidence the steps provided in NUREG/CR-6850 guidance Section 11 have been evaluated.*
- *For the MCR in addition to the abandonment analysis, the other steps provided in NUREG/CR-6850 guidance Section 11.5.2 need to be performed.*
- *For the MCR need to provided evidence that explicit Main Control Board modelling has been performed using guidance provided in NUREG/CR-6850 guidance Section 11.5.2 and Appendix L.*
- *For the detailed fire modeling (this includes the MCR) need to fully evaluate consequences from suppressed fires.*
- *All assumptions need to be justified, this includes the credited system availability and reliability*

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factors, and automatic / manual detection and suppression times.

For Regulatory Observation Action 1, RP's planned response consists of the following work:

- 1) The detailed fire modelling, for all the fire compartments quantitatively screened in, will be performed to evaluate different fire scenario frequencies in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020. The general procedure of detailed fire modelling is referred to NUREG/CR-6850 (Ref.5). A simplified method (hand calculation) will be adopted for some fire compartments which have less significant fire risk.
- 2) The procedure of detailed fire modelling for the MCR is referred to in NUREG/CR-6850 (Ref. 5). This will be reflected in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020.


Besides the MCR abandonment analysis, the failure of equipment induced by fire (even if the fire is suppressed) will be also evaluated. For example, a fire affecting the Emergency Control Panel (ECP) may cause spurious shutdown.

In UK HPR1000, Plant Computer Information & Control System (KIC [PCICS]) is the main digital means for operators to monitor and control the unit. It is based on computerised technology soft control. The design of Operator Workplaces (OWP) is different from the one defined for the Main Control Board (MCB) which is based on hardwired technology hard control in NUREG/CR-6850 (Ref.5). In UK HPR1000, the OWP is an operation and monitoring terminal (including visual display unit, keyboard and mouse). If the OWP is available, the operators will use the OWP to perform the monitoring and control operation tasks of the plant. However, the control and instrumentation circuits of safety function are not located in MCR, they are located in the I&C cabinet rooms (fire compartment BSA3601SFI, BSB3601SFI, BSC3701SFI and BSC28D1SFS).

The Auxiliary Control Panel (ACP) is used to control a unit in case of the loss of OWPs. When the OWPs are in operation mode, the ACP is only used for monitoring and all controls are blocked. If a fire occurs in ACP, the control function is not lost.

The Main Control Board (MCB) modelling presented in *Appendix L*, NUREG/CR-6850 (Ref.4) is not applicable to UK HPR1000. For a situation where fire affects an OWP, the function of this OWP is considered to be failed, and the control function will be switched to another OWP and the failed OWP will be blocked.

- 3) All the assumptions will be justified in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020.

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RO-UKHPR1000-0029.A2 – Demonstrate that multi-compartment analysis has been considered in the internal fire PSA

The Regulatory Observation Action 2 states that:


General Nuclear System Limited should demonstrate that MCA scenarios have been considered in the internal fire PSA. This may be addressed by updating the extant internal fire PSA, or by issuing a new separate report during GDA timescales.

- *Show evidence that MCA has been performed in accordance with NUREG/CR-6850 guidance Section 11.5.3 and quantitatively evaluate the risk.*
- *The interfacing barriers between fire compartments need to be reviewed and barrier feature need to be counted in order to determine a barrier failure probability, this should include consideration for random barrier failure.*

For Regulatory Observation Action 2, RP's planned response consists of the following work:

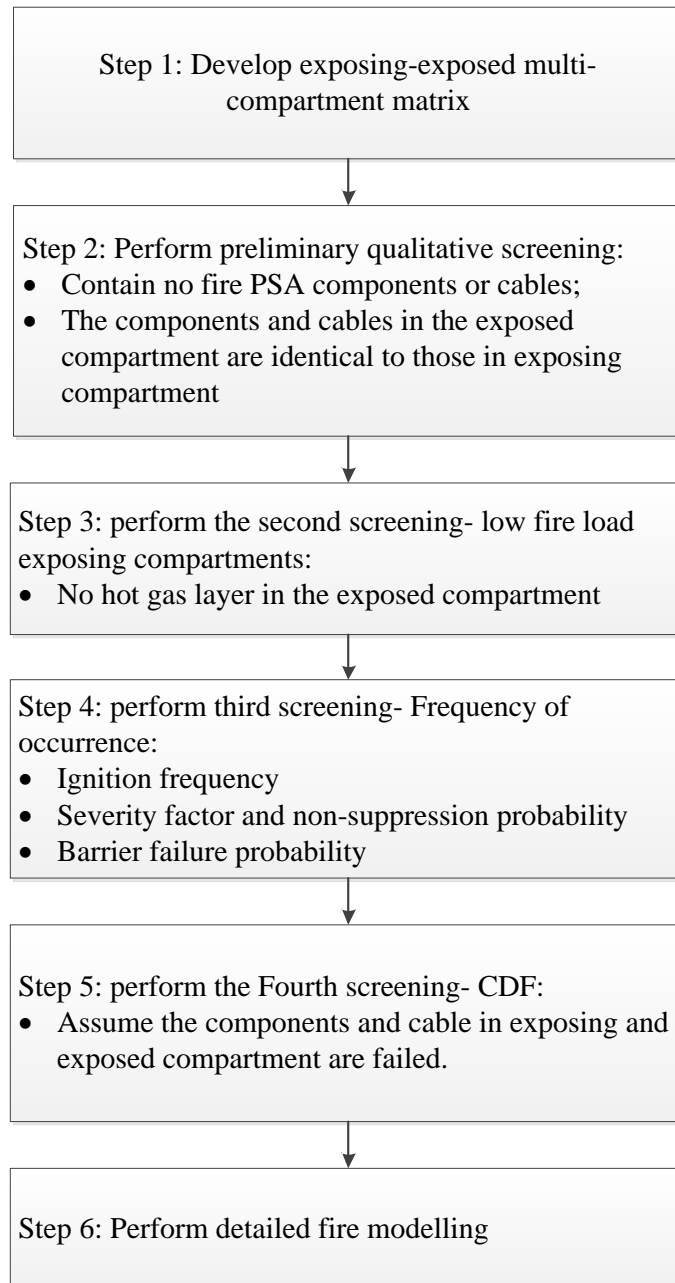
The multi-compartment analysis will be performed in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020. The general procedure of multi-compartment analysis is shown in F-1 according to NUREG/CR-6850 (Ref.5) and is described as follows:

- 1) To develop an exposing-exposed multicompartment matrix.
- 2) To perform preliminary qualitative screening. The corresponding exposing-exposed multicompartment is screened out if:
 - ✓ The exposed compartments contain no fire PSA components or cables, or
 - ✓ The components and cables in the exposed compartment are identical to those in the exposing compartment.
- 3) To perform secondary screening. If the fire load in exposing compartment is so low that no hot gas layer is generated in the exposed compartment, the corresponding exposing-exposed multicompartment can be screened out. In this step, the recommended 98% percentile of the Heat Release Rate (HRR) probability distribution will be used which provides conservative results.
- 4) To perform the third screening. The scenario frequency is calculated by multiplying ignition frequency, combined severity factor and non-suppression probability and barrier failure probability. The barrier failure probabilities are from NUREG/CR-6850 (Ref.5).
- 5) To perform the fourth screening. In this step, it is assumed that all the fire PSA components and

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cables in exposing and exposed compartments are failed, and then a conservative CDF is calculated.

6) To performed detailed fire modelling. The scenarios that are not screened out in the preceding steps are analysed using the same method as single compartment.



F-1 General Procedure of Multi-compartment Analysis

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RO-UKHPR1000-0029.A3 – Demonstrate that cable routing has been considered in the internal fire PSA

The Regulatory Observation Action 3 states that:

General Nuclear System Limited should demonstrate that cable routing has been considered in the internal fire PSA. The extant assumption that there will be no consequences beyond the fire compartment boundary (i.e. cable routing for each fire compartment is self-contained or fire compartments are large enough such that cables crossing from one fire compartment to another fire compartment is unlikely) is considered overly optimistic and does not meet ONR expectations. This action may be addressed by updating the extant internal fire PSA, or by issuing a new separate report during GDA timescales.

- *The cable routing for PSA components must be established based on a credible source, e.g. the design reference plant (FCG3) cable layout or detailed analysis of the electrical design.*

For Regulatory Observation Action 3, RP's planned response consists of the following work:

The cable routing for PSA components will be considered using FCG3 data, and the influence of cables will be evaluated in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020. The influence of cables includes the following aspects:

- 1) The updated partitioning of the fire compartment (divided into smaller fire compartment, etc.);
- 2) The identification of components impacted by fire;
- 3) The identification of targets in fire modelling;
- 4) Consequence analysis;
- 5) The fire induced circuit analysis.

RO-UKHPR1000-0029.A4 – Demonstrate that multiple spurious operations due to fires at 'pinch-points' in the design have been included in the internal fire PSA

The Regulatory Observation Action 4 states that:

General Nuclear System Limited should demonstrate that multiple spurious operations due to fires at 'pinch-points' in the design have been included in the internal fire PSA. This may be addressed by updating the extant internal fire PSA, or by issuing a new separate report during GDA timescales.

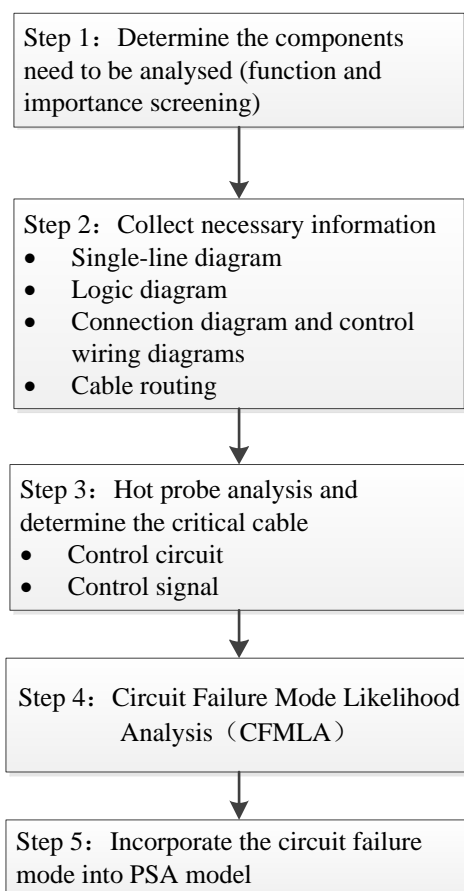
- *Evidence needs to be presented that a systematic process has been exercised to identify fire*

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scenarios which could lead to multiple spurious operations. The resulting consequences need to be incorporated in the PSA model, along with appropriate fire frequency estimation.


For the Regulatory Observation Action 4, RP’s planned response consists of the following work:

The detailed circuit failure analysis will be performed with the the cable routing information based on FCG3 in the updated *Internal Fire Level 1 PSA* report to be submitted in December 2020. The general procedure of detailed circuit failure analysis is shown in F-2.



F-2 General Procedure of Detailed Circuit Failure Analysis

Based on above methodology, for one fire compartment, the scenarios of spurious operations of different components are identified. For Multiple Spurious Operation (MSO), the FAQ 07-0038 (Ref. 6) and the generic MSO list from NEI 00-01(Ref. 7) will be taken as reference. Other scenarios which are not included in the generic MSO list will be determined from P&ID, cutset or sequences.

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RO-UKHPR1000-0029.A5 – Demonstrate the evaluation of fire compartment ignition frequencies has been performed to an acceptable level appropriate for the internal fire PSA

The Regulatory Observation Action 5 states that:


General Nuclear System Limited should demonstrate that ignition frequency evaluation has been performed to an acceptable level in the internal fire PSA. This may be addressed by updating the extant internal fire PSA, or by issuing a new separate report during GDA timescales.


- *Explanation of how the fixed ignition sources have been counted and the reference(s) used to determine the number and type of ignition source found in each room.(e.g. equipment layout drawings, equipment datasheets).*
- *Describe the process and inputs used when assigning transient influencing factors to each fire compartment.*
- *Show the intermediate steps and results of the frequency calculation to allow the frequency calculation to be fully verified and to ensure the generic per plant basis ignition frequencies has been preserved.*

For Regulatory Observation Action 5, RP's planned response consists of the following works:

- 1) To add the description of fixed fire ignition sources and counting method, including the inputs. For example, for the Bin 15 (Electrical cabinets (Non high-energy arcing fault (HEAF))), the counting method is shown as follows:
 - ✓ Electrical cabinets representing such items as switchgears, motor control centers, DC distribution panels, relay cabinets, control and switch panels (excluding panels that are part of machinery), fire protection panels, etc.
 - ✓ Simple wall-mounted panels housing less than four switches are excluded.
 - ✓ Well-sealed electrical cabinets that have robustly secured doors (and/or access panels) and that house only circuits below 380V are excluded
 - ✓ Electrical cabinets are counted by their vertical segments.

The inputs to determine the location of the ignition source are from SDM (Chapter 5) and information from FCG3.
- 2) To add the description of the method to assign transient influencing factors to each fire compartment, including the inputs.
- 3) To add the detailed description of fire ignition frequency calculation, including:
 - ✓ Explanation of the equations to calculate the fire ignition frequencies

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<p>✓ Listing values for all fire ignition sources in each fire compartment. The results of this analysis will be provided in the updated <i>Internal Fire Level 1 PSA</i> report to be submitted in December 2020.</p>			
<p>Impact on the GDA Submissions</p>			
<p>The result of the five Regulatory Observation Actions will be incorporated into the updated <i>Internal Fire Level 1 PSA</i> report (Rev. B) which will be submitted to ONR by 12/18/2020.</p>			
<p>Timetable and Milestone Programme Leading to the Deliverables</p>			
<p>See attached Gantt Chart in APPENDIX A.</p>			
<p>Reference</p>			
<p>[1]. CGN, Internal Fire Level 1 Probabilistic Safety Assessment, GHX00650005DOZJ02GN, Rev. A.</p> <p>[2]. Clarification of PSR Section 14.3.1.2.3 - Fire PSA Cable Modelling, RQ-UKHPR1000-0015.</p> <p>[3]. High Priority Fire PSA Queries, RQ-UKHPR1000-0466.</p> <p>[4]. Other Internal fire PSA Queries, RQ-UKHPR1000-0468.</p> <p>[5]. EPRI/NRC-RES. Fire PRA methodology for nuclear power facilities, Final Report, NUREG/CR-6850, EPRI 1011989, 2005.</p> <p>[6]. FAQ 07-0038, Lessons Learned on Multiple Spurious Operations, Rev. 2.</p> <p>[7]. NEI. Guidance for Post-Fire Safe Shutdown Circuit Analysis, NEI 00-01, Rev. 4, 2019.</p>			

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APPENDIX A RO-UKHPR1000-0029 Gantt Chart

Tasks and Schedule	2020												2021				
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	
RO Action 1, 2, 3, 4 and 5																	
Update and submission of "Internal Fire Level 1 PSA (Rev B)"																	
Assessment																	
Regulators Assessment																	
Target RO Closure Date																	