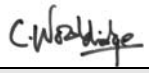
UK EPR	UK EPR GDA PROJECT			
	Title: Resolution Plan for GI-UKEPR-RC01			
	RP unique number:	Revision No.:	Effective Date:	Page No.:
	GI-UKEPR-RC01-RP	Rev 0	05.07.2011	1 of 11

Approved for EDF by: A. PETIT *Name/Initials*  *Date* *04/07/2011*	Approved for AREVA by: C. WOOLDRIDGE *Name/Initials*  *Date* *04/07/2011*

Resolution Plan Revision History

Rev.	Description of update	Date issued
Rev 0	First revision	05/07/2011

1.0 GDA ISSUE

GDA Issue Title	Main Assessment Area	Related Assessment Area
Combustible Gas Control Systems	Reactor Chemistry	Severe Accidents

GDA Issue	Impact of Passive Autocatalytic Recombiners during accidents

2.0 OVERVIEW OF SCOPE OF WORK

As part of the GDA Step 4 assessment of Reactor Chemistry of the UK EPR, the ONR inspectors have assessed the Combustible Gas Control System (CGCS) of the UK EPR, used to control and mitigate the release of combustible gases into the containment during accident sequences.

EDF and AREVA have provided a large amount of details on the design, functionality and corresponding analysis to provide evidence that the required safety goals are met with sufficient margins.

The principle chemistry related components of the CGCS are the Passive Auto-catalytic Recombiners (PARs) that remove hydrogen and carbon monoxide via an entirely passive process given that sufficient oxygen is present in the containment atmosphere.

The regulators have requested further information and supporting evidence to demonstrate that specific adverse effects and uncertainties possibly resulting from the modelling of chemical or physical aspects do not significantly influence the analysis and justification of the CGCS in a way that the requested safety goals cannot be met. To this end the ONR has requested additional sensitivity studies to investigate these specific aspects.

3.0 GDA ISSUE ACTIONS AND RESOLUTION PLAN DELIVERABLES

3.1 Action GI-UKEPR-RC01.A1

Action I/D	Action Description
GI-UKEPR-RC01.A1	EDF and AREVA to provide a sensitivity analysis, or alternative means agreed by the regulator, to demonstrate the operation of the UK EPR Combustible Gas Control System (CGCS) with reduced performance of the Passive Autocatalytic Recombiners (PARs). In the current UK EPR safety case the PARs are assumed to work at 100% “efficiency” throughout an accident (i.e. the flow is adjusted so that 100% of the inlet hydrogen is removed). Information has been provided on the derivation of the performance characteristics of individual PAR units. EDF and AREVA claim that their effectiveness is bounded by the current analyses including one analysis with removal of selective complete PARs (6 equipment room PARs and 1 dome recombiner) as a surrogate for reduced PAR efficiency. While this provides a degree of comfort in the CGCS, it does not demonstrate how the system would behave following an overall “efficiency” reduction in all recombiners, as opposed to selective removal of a few entire units. In addition, it has not been demonstrated that adequate consideration has been given to local flows when modelling the UK EPR (i.e. convective flows in the containment acting in the opposite direction to the flow through the PAR). As above, this effect too could result in reduced PAR performance and should be analysed given that this cannot be ruled out. With agreement from the Regulator this action may be completed by alternative means.

3.1.1 Planned submissions in response to GI-UKEPR-RC01.A1

3.1.1.1 Description of Scope of Work

The modelling of PARs in the current UK EPR safety case makes use of the assumption that 100% of the hydrogen that is simulated to enter the PAR will be removed while the overall flow through the PAR, and therefore the amount of hydrogen to be removed, is controlled by the governing equations to remove the required amount of combustible gas from the containment atmosphere.

EDF and AREVA have provided detailed discussion on modelling and realization of the different relevant aspects in containment simulations and provided claims and arguments for the adequacy and applicability of these models (Several TQ responses and Response to RO-UKEPR-78 Action 1). Furthermore, EDF and AREVA have provided arguments that the methodology of performing analyses of representative and bounding scenarios is a measured approach to account for potential uncertainties in the analyses and to exclude the existence of any cliff-edge effects. Additionally, information on dedicated analyses of postulated partially reduced performance of CGCS components have been performed to demonstrate that the system is sufficiently dimensioned to fulfil its design

intention even with the assumption of additional aggravation of the accident as compared to the standard best-estimate severe accident approach.

The ONR requests EDF and AREVA to also demonstrate the CGCS system performance would still be sufficient under the postulated assumption that the entire PARs system operates with reduced performance as compared to the empirically determined governing equations to account for any hypothetical effect that is not adequately represented in the chemical/physical realisation or the flow characteristics of the CGCS computational model.

3.1.1.2 Description of Methodology to be employed

It is proposed to perform a sensitivity study in order to provide sufficient evidence that the CGCS is able to fulfil its design requirements under the postulated hypothetical assumption that all PARs operate with reduced performance.

Based upon the Flamanville 3 studies presented in the response to RO-UKEPR-78 - Action 2, one scenario will be selected for re-simulation of the in-vessel phase with COCOSYS with reduced global PAR performance.

Task 1:

The selected scenario will be chosen such that high hydrogen release rates are present and a large overall hydrogen mass is released during the simulation.

A letter describing the chosen bounding scenario and appropriate justification (including justification of deactivated PARs) will be sent to the ONR for agreement

Task 2:

The corresponding sensitivity analysis simulation will be analyzed with respect to the safety goals of the CGCS.

The following safety goals will be revisited explicitly:

(1) Limitation of the global average hydrogen concentration below the limit of 10vol.-% to exclude fast global hydrogen combustion that might challenge the containment integrity.

(2) Limitation of the integral global hydrogen concentration below the flammability limit (4vol.-%) during the first 12 hours of the severe accident.

Furthermore, the analysis of the selected scenario with reduced global PAR performance will be compared to the corresponding simulation with PAR performance as simulated by the unaltered empirically determined PAR correlations to show the effect of a postulated reduced efficiency. A comparison will be made also on the compartment level, i.e. the local time history of recombiner performance and hydrogen concentration will be compared in various relevant containment compartments like dome, equipment rooms and accessible rooms.

Additionally, a second case with complete deactivation of selected PARs but unaltered PAR performance will also be presented for comparison.

Task 3:

These studies will provide additional information on the CGCS system performance for a range of sensitivities additional to the original system design. If the study reveals an adverse effect, it will be detailed in the corresponding PCSR sub-chapters. If shown to have no adverse effects, a reference to this additional study will be included for completeness.

Schedule:

Task 1: Description of bounding scenario and appropriate justification by 15/07/11

Task 2: Sensitivity analysis - Submission of the supporting document to the ONR by 30/09/2011.

Task 3: PCSR Update - Submission of draft PCSR chapter by 16/12/2011.

3.1.1.3 Deliverable description	**Submission date to HSE/EA**
Letter EPR00XXXN Letter presenting the bounding scenario considered for high hydrogen release rates and large overall hydrogen mass released during the simulation.	15/07/2011
Document PEPA-G/2011/en/XXXX Document presenting the combustible gas control system sensitivity analysis for reduced PAR performance	30/09/2011
PCSR CHAPTER 16 - SUB-SECTION 2.2.3 Assessment of Hydrogen Control Addition of reference to additional study on reduced PAR performance.	Draft 16/12/2011 Final 27/01/2012

3.2 Action GI-UKEPR-RC01.A2

Action I/D	Action Description
GI-UKEPR-RC01.A2	EDF and AREVA to provide a sensitivity analysis, or alternative means agreed by the regulator, to demonstrate the performance of the UK EPR Combustible Gas Control System (CGCS) in case of a bounding accident scenario. An important input to the assessment of any accident mitigation system is the source term in terms of the rate and mass of combustible gases released into containment. The CGCS in UK EPR will have a limited overall depletion rate based upon the installed equipment (i.e. number and size of PAR units). EDF and AREVA have described the analysis using "representative" and "bounding" scenarios with the latter oxidising around 75% of the available fuel cladding and the former predicting lower levels. While this provides a degree of comfort that the analysis uses best estimate source terms, a detailed analysis including bounding conditions has to be supplied to demonstrate the adequacy of the system design. With agreement from the Regulator this action may be completed by alternative means.

3.2.1 Deliverables already submitted to HSE/EA in response to GI-UKEPR-RC01.A2

The following deliverables have already been submitted but have not yet been assessed by ONR.

	Date of submission
Full response to RO-UKEPR-78 – Action 2 – Modelling of combustible gases in containment (sent through Letter EPR00848R). These documents provide an analysis of the combustible gas control system performances, based on the FA3 design and provide assurance that the design proposed for UK EPR is acceptable with regards to the behaviour of the containment during accident conditions which involve combustible gas releases. These analyses include assessment of two representative and one bounding case (and justification of the selection of the scenarios). - PEPA-G/2011/en/1009 Rev A – Gas distribution in the containment during a severe accident and assessment of the potential hydrogen combustion risk - PEPA-G/2011/en/1010 Rev A – Temperature loads from gas release, recombiner operation and slow hydrogen combustion in the dome during a severe accident - PEPA-G/2011/en/1011 Rev A –	08/04/2011

Pressure loads from fast hydrogen combustion during a severe accident and assessment of the risk of a deflagration-to-detonation transition - PEPA-G/2011/en/1012 Rev A – Hydrogen combustion after reactor vessel failure during a severe accident	

3.2.2 Planned submissions in response to GI-UKEPR-RC01.A2

None

3.3 Action GI-UKEPR-RC01.A3

Action I/D	Action Description
GI-UKEPR-RC01.A3	EDF and AREVA to provide a sensitivity analysis, or alternative means agreed by the regulator, to demonstrate the potential impact of operation of the UK EPR CGCS on iodine volatility in containment. With agreement from the Regulator this action may be completed by alternative means.

3.3.1 Planned submissions in response to GI-UKEPR-RC01.A3

3.3.1.1 Description of Scope of Work

During a severe accident iodine is a main concern and much effort is put into its management, including containment sprays and buffered sumps. A large portion of fission products released from fuel during an accident are in the form of metal iodides, which are relatively involatile and are efficiently captured. Metal iodides (importantly CsI) are not stable when heated and can yield gaseous iodine, in a humid atmosphere, at temperatures representative of recombiner operation.

In response to TQ-UKEPR-1428 EDF/AREVA stated that this potential effect is not included in the current UK EPR analysis, as it can be considered negligible due to the bounding source term used for UK EPR studies. An R&D dedicated study of this effect is scheduled for 2011.

In order to provide further reassurance that this is not a significant concern, EDF and AREVA will provide a sensitivity analysis to demonstrate the potential impact of operation of the UK EPR CGCS on iodine volatility in containment. Conditions and scope of work for this study have been discussed during a dedicated meeting held on 20th May 2011.

3.3.1.2 Description of Methodology to be employed

RECI analytical experiments have shown a conversion of iodine aerosols into gaseous iodine with a rate of 60%. The experimental conditions of RECI experiments being rather far from reactor conditions, new experiments were conducted in THAI facility and have shown conversion rates between 1 and 3%. There are currently no conclusive results on the investigation of the production of gaseous iodine from CsI by operation of PARs. To cope with the different uncertainties related to iodine chemistry, EDF/AREVA uses a reference source term based on experimental results. It is representative of the equilibrium between iodine deposition, organic iodide production on painted surfaces and gaseous iodine removal by oxidation products of air under radiation. The desorption phenomenon is taken into account in this long term equilibrium.

A research program provided by the IRSN (Institut de Radioprotection et de sûreté Nucléaire) and EDF is planned in 2011 to analyse the impact of CGCS (PARs) on iodine volatility in containment. The two objectives of this program are:

- to analyse two THAI experiments regarding the potential production of gaseous iodine from CsI through operation of PARs.
- to determine the consequences of the previous results on Source Term, by using the latest developments of iodine chemistry models.

Depending on the date of availability of the results from the R&D program EDF and AREVA propose that:

- if the results of the R&D program are available on time, the output of this study will be sent to the Regulators. .
- If the results of the R&D program are not available on time, a sensitivity analysis using MAAP codes with a new iodine chemistry model developed by EDF R&D on the basis of EPICUR experiments will be used.

Update of the PCSR will be performed according to the results of the studies.

Schedule:

Sensitivity study: submission of the sensitivity study to the ONR by mid-December.

PCSR update by the end of January 2012 (draft)

3.3.1.3 Deliverable description	**Submission date to HSE/EA**
Document XXX – Impact of PARs operation on iodine volatility Analysis to demonstrate the potential impact of operation of the UK EPR CGCS on iodine volatility in containment	16/12/2011
PCSR CHAPTER 16 - SUB-SECTION 2.3 – Radiological Consequences of core melt sequences Update of PCSR to include results of additional study on Impact of PARs operation on iodine volatility in containment	Draft 17/02/2012 Final 30/03/2012

4.0 SUMMARY OF IMPACT ON GDA SUBMISSION DOCUMENTATION

4.1 GDA submission documents impacted by GDA Issue and scheduled to be created (C) or updated (U) within GDA

GDA Submission Documents	C/U	Related GDA Issue Action(s)	Submission Date to HSE/EA
SSER sub-chapters			
PCSR CHAPTER 16 - SUB-SECTION 2.2.3 Assessment of Hydrogen Control	**U**	GI-UKEPR-RC01.A1	Draft 16/12/2011 Final 27/01/2012
PCSR CHAPTER 16 – SUB- SECTION 2.3 – Radiological Consequences of core melt sequences	**U**	GI-UKEPR-RC01.A3	Draft 17/02/2012 Final 30/03/2012
GDA reference design documents (SDM in UKEPR-I-002)			
None			
Other GDA submission supporting documents			
Document PEPA-G/2011/en/XXXX - Combustible gas control system sensitivity analysis for reduced PAR performance	**C**	GI-UKEPR-RC01.A1	30/09/2011
Document XXX – Sensitivity study - Impact of operation of PARs on iodine volatility	**C**	GI-UKEPR-RC01.A3	16/12/2011

5.0 JUSTIFICATION OF ADEQUACY

GI-UKEPR-RC1.A1:

Sensitivity analyses are normally employed to demonstrate the extent to which possible uncertainties influence the results and conclusions of a computer simulation. The range of any uncertainty is used to support the adequacy of these simulations for application of the code to a selected scenario.

To rule out that any effect, possibly not considered adequately in the CGCS PAR model, influences the overall conclusions of the safety analysis in a significant way, such a sensitivity study is proposed.

This study is intended to show that CGCS PAR system is still able to fulfil its design requirements even under the assumption of a postulated hypothetical reduced system performance. Furthermore, the analysis will show the sensitivity of the results to any effect that could potentially result in a reduced PAR system performance. Therefore such a sensitivity study is well suited to dispel any concerns about potential modelling issues that can not be completely ruled out based on reasonable arguments.

GI-UKEPR-RC1.A2:

Several different criteria, among them the overall released hydrogen mass and the corresponding release rates, have been investigated during the selection process of scenarios for the analysis of the CGCS to further investigate scenarios that include bounding accident conditions with respect to the CGCS. The complete analysis is presented in answer to RO-UKEPR-78 – Action 2. It is shown that the CGCS is able to fulfil it design intention even in case of the analysed bounding severe accident scenario.

GI-UKEPR-RC1.A3:

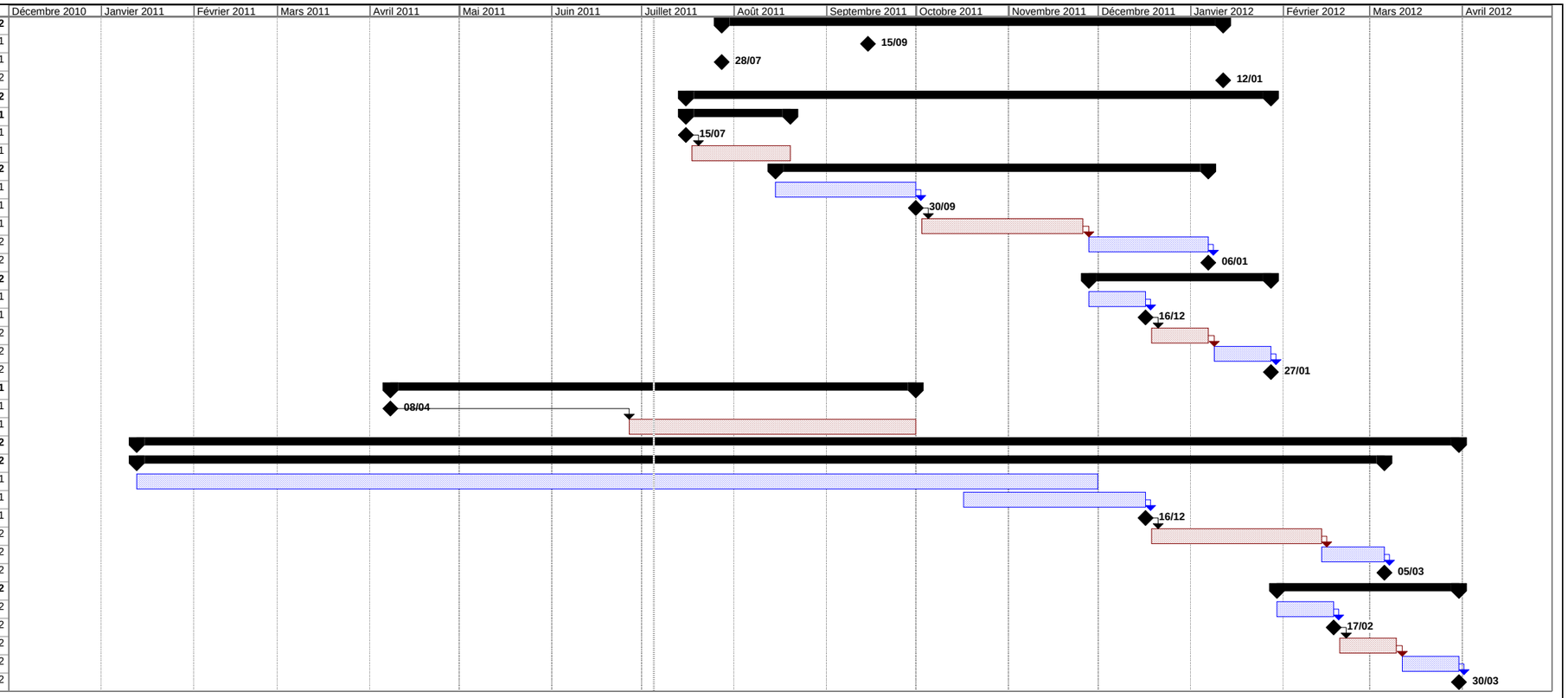
The research program provided by IRSN and EDF will analyse two THAI experiments that concern the production of gaseous iodine from CsI by operation of PARs and will determine the consequences of the previous analytical and experimental results on Source Term, by using the latest developments of iodine chemistry models.

The results of research program proposed by AREVA and EDF will provide a demonstration of the potential impact of operation of the UK EPR CGCS on iodine volatility in containment environment. This analysis will show that the reference source term used by EDF/AREVA is bounding.

6.0 TIMETABLE AND MILESTONE PROGRAMME LEADING TO THE DELIVERABLES

Consult the following page for the associated timetable and milestone programme.

N°		Nom de la tâche	Durée	Début	Fin
1		**Meetings**	**120 jours**	**Jeu 28/07/11**	**Jeu 12/01/12**
2		Meeting 1 - If necessary - Feedback on Ac	0 jour	Jeu 15/09/11	Jeu 15/09/11
3		Meeting 2 - if necessary - Feedback on Ac	0 jour	Jeu 28/07/11	Jeu 28/07/11
4		Meeting 3 - if necessary - Feedback on Ac	0 jour	Jeu 12/01/12	Jeu 12/01/12
5		**Action 1 - Reduced PAR performance**	**140 jours**	**Ven 15/07/11**	**Ven 27/01/12**
6		**Action 1.1 - Selection of bounding scen**	**25 jours**	**Ven 15/07/11**	**Ven 19/08/11**
7		Letter with proposed bounding scenar	0 jour	Ven 15/07/11	Ven 15/07/11
8		ONR review and approval of boundin	25 jours	Lun 18/07/11	Ven 19/08/11
9		**Action 1.1 - Sensitivity Calculation**	**105 jours**	**Lun 15/08/11**	**Ven 06/01/12**
10		COCOSYS calculation and draft repo	35 jours	Lun 15/08/11	Ven 30/09/11
11		Transmission to ONR	0 jour	Ven 30/09/11	Ven 30/09/11
12		ONR Review	40 jours	Lun 03/10/11	Ven 25/11/11
13		Update following ONR comments if n	30 jours	Lun 28/11/11	Ven 06/01/12
14		Submission of revised report	0 jour	Ven 06/01/12	Ven 06/01/12
15		**Action 1.2 - PCSR Update**	**45 jours**	**Lun 28/11/11**	**Ven 27/01/12**
16		Draft PCSR update and review	15 jours	Lun 28/11/11	Ven 16/12/11
17		Submission of updated PCSR to ONI	0 jour	Ven 16/12/11	Ven 16/12/11
18		ONR review	15 jours	Lun 19/12/11	Ven 06/01/12
19		Update following ONR comments	15 jours	Lun 09/01/12	Ven 27/01/12
20		Submission of revised report	0 jour	Ven 27/01/12	Ven 27/01/12
21		**Action 2 - Detailed CGCS analysis**	**126 jours**	**Ven 08/04/11**	**Ven 30/09/11**
22		Transmission of RO78 -Action 2 Response	0 jour	Ven 08/04/11	Ven 08/04/11
23		NII Review (date to be confirmed)	70 jours	Lun 27/06/11	Ven 30/09/11
24		**Action 3 - Sensitivity study for iodine**	**317 jours?**	**Jeu 13/01/11**	**Ven 30/03/12**
25		**Action 3.1 - Sensitivity dtudy**	**298 jours?**	**Jeu 13/01/11**	**Lun 05/03/12**
26		R&D Research Program	230 jours	Jeu 13/01/11	Mer 30/11/11
27		Sensitivity analysis and report drafting	45 jours?	Lun 17/10/11	Ven 16/12/11
28		Submission to ONR	0 jour	Ven 16/12/11	Ven 16/12/11
29		ONR review	41 jours	Lun 19/12/11	Lun 13/02/12
30		Update following ONR comments	15 jours	Mar 14/02/12	Lun 05/03/12
31		Submission of revised report	0 jour	Lun 05/03/12	Lun 05/03/12
32		**Action 3.2 - PCSR Update**	**45 jours**	**Lun 30/01/12**	**Ven 30/03/12**
33		Draft PCSR update	15 jours	Lun 30/01/12	Ven 17/02/12
34		Submission of updated PCSR to ONI	0 jour	Ven 17/02/12	Ven 17/02/12
35		ONR Review	15 jours	Lun 20/02/12	Ven 09/03/12
36		Update following ONR comments	15 jours	Lun 12/03/12	Ven 30/03/12
37		Submission of revised report	0 jour	Ven 30/03/12	Ven 30/03/12



Projet : GI-FS03_V1
Date : Mar 05/07/11

Tâche | Avancement | Récapitulative | Tâches externes | Échéance
Fractionnement | Jalon | Récapitulatif du projet | Jalons externes