Permit Variation Application Report EPR/KP3235SS

IQE (Europe) Ltd Environmental Permit Variation Application

IQE (Europe) Ltd

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'Experience and expertise working in union'

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Permit Variation Application Report
EPR/KP3235SS

Project:	Environmental Permit Variation Application
For:	IQE (Europe) Ltd
Status:	FINAL Version 2
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Reviewer:	Peter Cumberlidge, Director

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Tables and Figures

1.0 Introduction

1.1 Background

1.1.1 This document is IQE (Europe) Limited's ('the Operator') technical submission to support the application for a Permit Variation to Environmental Permit EPR/KP3235SS. The proposed changes are to the St Mellons Semiconductor Plant ('the Installation)' which is an Installation as described in Schedule 1 of the Environmental Permitting (England and Wales) Regulations 2016 (EPR16) under Chapter 4 of Schedule 1 of EPR16:

Section 4.2 Inorganic Chemicals

Part A (1) (c) Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements—

(i) antimony;
(ii) arsenic;
(iii) beryllium;
(iv) gallium;
(v) indium;
(vi) lead;
(vii) palladium;
(viii) platinum;
(ix) selenium;
(x) tellurium;
(xi) thallium,

where the activity may result in the release into the air of any of those elements or compounds or the release into water of any substance listed in paragraph 7 (1) of Part 1 of this Schedule.

And

(b) Unless falling within any other section, any manufacturing activity which is likely to result in the release into air of any hydrogen halide (other than the manufacture of glass or the coating, plating or surface treatment of metal) or which is likely to result in the release into the air or water of any halogen or any of the compounds mentioned in paragraph (a) (vi) (other than the treatment of water).

1.1.2 The regulated activity comprises the manufacture of advanced electronic and opto-electronic Group III – Group V semiconductor structures using a process known as Metal Organic Vapour Phase Epitaxy (MOVPE).

1.1.3 The installation consists of two production areas, known as 'FAB1' and 'FAB2'. The main manufacturing area is FAB2, FAB1 contains four tools with the remaining space used for associated work.

1.2 Application Information

Type of Application	Installation Permit Variation Application
Permit Variation Application Reference Number	EPR/KP3235SS/V005
Installation Name	St Mellons Semiconductor Facility
Installation Address	IQE (Europe) Limited St Mellons Semiconductor Plant

	Cypress Drive St Mellons Cardiff South Glamorgan CF3 0LW
Registered Office Address	Pascal Close St Mellons Cardiff South Glamorgan CF3 0LW
Company Registration Number	02107558
Installation Grid Reference	ST 24779 81882
Pre-Application Discussion	NA, however, verbal discussions have taken place with the local NRW officer to agree the scope of the application document and applicable guidance.
Legal Status of Operator	There is no change to the legal status of the Operator. The operator is a limited company, trading as IQE (Europe) Limited. The Companies House certificate have been provided in this application in Appendix A.
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1.3 Proposed Changes

1.3.1 This variation is required to consolidate a series of minor operational changes which allow use of new raw materials, some of which are currently allowed under a temporary 'research and development' (R&D) exclusion. The proposed changes comprise:

- The use of propane as a dopant gas in FAB1 (currently authorised under R&D exclusion);
- The use of tertiary butyl hydrazine (TBH) in FAB1 or FAB2 (currently authorised under R&D exclusion);
- The use of germane (1% in hydrogen) in FAB 1 or FAB2;
- The use of tertiary butyl arsine (TBA) in FAB1 or FAB2; and
- The use of tertiary butyl phosphine (TBP) in FAB1 or FAB2; and
- The use of ethylene in FAB1.

1.4 Phased Development

1.4.1 Initially, trials will be carried out to develop new products and in doing so, determine the effectiveness of the new raw materials. Following this initial development phase, all substances except for germane will continue be used for research and development purposes. However, in the future, should an opportunity arise and subject to the outcome of the R&D activities, the Operator employ all substances listed above on a commercial basis. This is the main commercial driver for the variation application.

1.5 Changes to Schedule 1 Permitted Activities

1.5.1 The full profile of Schedule 1 listed Activities and Directly Associated Activities (DAAs) included in this application, including current and proposed activities, is provided in Table 1 below. New activities are highlighted.

Table 1 Listed and Directly Associated Activities

Environmental Permitting (England and Wales) Regulations 2016 Schedule 1 Activity References	Description of specified activity	Limits of specified activity	Change
Chapter 4 Section 4.2 Inorganic Chemicals Part A (1) (c) Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements— (i) antimony; (ii) arsenic; (iii) beryllium; (iv) gallium; (v) indium; (vi) lead; (vii) palladium; (viii) platinum; (ix) selenium; (x) tellurium; (xi) thallium, where the activity may result in the release into the air of any of those elements or compounds or the release into water of any substance listed in paragraph 7 (1) of Part 1 of this Schedule.	Manufacturing via Metal Organic Vapour Phase Epitaxy (MOVPE) of semiconductor crystal wafer substrates	Manufacturing and associated activities undertaken within FAB1 and FAB2 buildings.	No change to regulatory description, new raw materials added, see below. Minor administrative change to 'limits of specified activity'.
Chapter 4 Section 4.2 Inorganic Chemicals Part A (1) (b) Unless falling within any other section, any manufacturing activity which is likely to result in the release into air of any hydrogen halide (other than the manufacture of glass or the coating, plating or surface treatment of metal) or which is likely to result in the release into the air or water of any halogen or any of the compounds mentioned in paragraph (a) (vi) (other than the treatment of water).	Semiconductor manufacture that is likely to result in the release into air of chlorine	Manufacturing and associated activities undertaken within FAB1 and FAB2 buildings.	No change to regulatory description, new raw materials added, see below. Minor administrative change to 'limits of specified activity'.

Environmental Permitting (England and Wales) Regulations 2016 Schedule 1 Activity References	Description of specified activity	Limits of specified activity	Change
Directly Associated Activities			
Directly Associated Activities	Effluent treatment plant and associated infrastructure.	Effluent neutralisation plant serving scrubber units for A3 releases to air. Discharge from scrubbing units only.	There will be new raw materials used which will be treated by existing plant. Minor administrative change to 'limits of specified activity'
	Receipt of raw materials.	Receipt of gases, substrates and other raw materials used in the process.	New raw materials will be used and stored on-site.
	Waste handling and storage.	Storage of liquid and solid wastes arising from the process.	No change.
	Thermal oxidiser.	Abatement of ammonia emissions from machine G5a. Abatement of emissions to air prior to release point A1.	Process emissions will change due to a change in the raw materials used, however, technologies employed will remain the same.
	Wet scrubber	Wet scrubber serving release point A3.	Minor administrative change to 'limits of specified activity' Existing plant, omitted from Table S1.1 in current permit. No change to the process, however the activity needs to be added to the Permit.

1.5.2 The changes comprise a 'normal variation' as there are no changes to production volumes or regulatory descriptions.

2.0 Non-Technical Summary

2.1 About the Operator

2.1.1 IQE (Europe) Limited ("the Operator") is a leading global manufacturer of advanced wafer products and wafer services to the semiconductor industry. IQE manufactures advanced electronic and opto-electronic group III-V semiconductor material structures using a process known as Metal Organic Vapour Phase Epitaxy (MOVPE). This process involves the growth of semiconductors using such substrates as gallium arsenide and indium phosphide in wafer form, and the epitaxial deposition of material onto these substrates using a variety of carrier gases such as arsine and phosphine. The process also utilises gaseous dopants in small quantities to produce epi-layers of a known consistency.

2.2 Proposed Changes to Operations

2.2.1 This variation is required to consolidate a series of minor operational changes which allow use of new raw materials, some of which are currently allowed under a temporary 'R&D' exclusion.

2.3 Description of the Site and its Surroundings

2.3.1 The location and site boundary remains unchanged, therefore there are no changes which impact any of the receptors described in the original application and subsequent variations referenced EPR/KP3235SS. A review of the area surrounding the installation was carried out and there are no new sensitive receptors.

2.4 Point Source Emissions to Air

2.4.1 Emissions to air will change as a result of the proposed changes to raw materials. Abatement plant is employed to minimise emissions and can treat exhaust emissions where required, following proposed changes.

2.5 Point Source Emissions to Water

2.5.1 The proposed changes do not result in any material changes to emissions to sewer. There are no discharges directly into watercourses other than uncontaminated surface water only via the site's segregated surface water drainage system.

2.6 Fugitive Emissions

2.6.1 The proposed changes are unlikely to result in any material increase in fugitive releases to air, land or water due to the proposed controls. As per the current arrangements, fugitive releases from gases stored on-site are prevented by robust storage systems and the installation of gas detection equipment.

2.6.2 It is unlikely that offsite nuisance due to odour will occur as a result of the operation of the installation, currently or as a result of the proposed changes. Releases of potentially odorous gases are well below the odour thresholds.

2.6.3 There is no bulk storage of liquids on-site. Release of fugitive emissions to land and water from stored materials is prevented through appropriate infrastructure and management controls.

2.6.4 A qualitative assessment has been carried out on foreseeable releases of fugitive emissions as a result of the proposed changes, which concludes that the risk to the environment is low in all scenarios considered.

2.7 Management and Control

2.7.1 There are no proposed changes to the management and control of the facility. The Operator has implemented an Environmental Management System (EMS) certified to the standard of ISO14001:2015. The EMS includes all activities connected to the installation and will incorporate the proposed changes. Handling and distribution of the new reactor units, raw materials and other plant and equipment will be managed with the same high levels of control.

2.8 Raw Materials

2.8.1 There will be additional new raw materials which have been quantified and assessed in the permit variation application. Such additional raw materials comprise:

- Propane
- Ethylene
- Germane (1% in hydrogen)
- TBH
- TBA
- TBP

2.8.2 All potentially polluting materials will either be stored in secure locations within buildings or are provided with appropriate primary and secondary containment.

2.9 Waste Generation

2.9.1 There are no additional wastes generated as a result of the proposed changes.

2.10 Energy Use

2.10.1 There will be no changes to energy use.

2.11 Accidents and their Consequences

2.11.1 There are no proposed changes to the management and control of the facility.

2.11.2 The Installation is operated by a dedicated on-site team which has the required skills and experience to operate the Installation safely. The Operator employs an Accident Management Plan (AMP) which meets the relevant NRW guidance. Potential accidents which may arise during the operation of the proposed Installation will be considered and assessed using three elements:

- identification of hazards;
- assessment of the risks (and possible consequences); and
- identification and implementation of techniques to reduce the risks of accidents (and contingency plans for any accidents that may occur).

2.11.3 Where new accident scenarios may occur as a result of the proposed new raw materials stored and used on-site, preventative measures have been included in line with the measures currently in place, which are described in the accident scenarios in the Environmental Risk Assessment (ERA) in Appendix B of this report.

2.12 Noise and Vibration

2.12.1 There will be no changes to noise generated by the Installation.

2.13 Overall Environmental Impact

2.13.1 The potential for impact on the environment as a consequence of the proposed changes to the operation of the Installation has been assessed, taking into account the proposed activities and the presence of identified sensitive receptors.

2.13.2 The main emissions to air are releases of process gases from the reactors and their impact on both human and ecological receptors has been assessed in Section 5.3 of this application and Appendix C. The assessment concludes that the use of the new materials will have an insignificant impact on the environment.

2.13.3 There are no material changes to emissions to sewer or to surface water. Emissions to water from W1 comprise of uncontaminated surface water only.

2.14 Emissions and Monitoring

2.14.1 Emissions from the installation have been quantified. Process monitoring controls including gas detection will be in place to prevent accidental releases from the new release points using the same robust methods as the existing release points. Monitoring is described in Section 6 with no changes proposed to the current regime.

2.15 Installation Issues

2.15.1 The Installation will continue to be operated by a single operator. There are no changes to the installation boundary.

2.16 Planning Permission

2.16.1 The changes to operation will not require changes relating to the installation's planning consent.

3.0 Description of Proposed Changes to the Installation

3.1 Introduction

3.1.1 This section provides a description of the proposed changes to the IQE Europe Semiconductor Facility, as a result of the proposed changes.

3.2 General Description of the Current Facility

3.2.1 The Installation manufactures advanced electronic and opto-electronic Group III - Group V semiconductor structures using a process known as Metal Organic Vapour Phase Epitaxy (MOVPE).

3.2.2 The installation consists of two production areas, known as 'FAB1' and 'FAB2'. The main manufacturing area is FAB2 which houses 10 tools and FAB1 contains four tools.

3.2.3 The installation currently comprises:

- 14 MOVPE wafer growth reactors:
  - 4 production tools within FAB 1 comprising 3 tools.
  - 10 production tools within FAB 2
- gas storage bunker;
- wet scrubber for release point A3;
- effluent treatment plant and associated infrastructure comprising a neutralisation plant serving scrubber units for release point A3;
- thermal oxidiser for the abatement of ammonia emissions from one tool (via A1);
- local exhaust ventilation (LEV) fume extraction;
- boiler plant;
- cooling circuits and other ancillary plant and equipment;
- storage and distribution of raw materials including pressurised and liquefied gases; and
- foul and surface water drainage.

3.3 Overview of the Proposed Changes to Activities

3.3.1 The proposed changes comprise changes to raw materials as described in Section 1.3. These changes are described in the sections below which also describe potential changes to emissions and how they will be minimised.

3.4 Storage of Gases and Other Raw Materials

3.4.1 Gases required in the current manufacturing process will continue to be stored in the external yard in dedicated gas storage bays, within the existing gas bunker and within gas cabinets in a dedicated store within the main building. During the trial phase of introducing the new substances, materials will only be stored at point of use, without any storage in the bunker.

3.4.2 Table 3 provides details of storage arrangements for all new materials stored on-site, including gases.

Propane

3.4.3 Propane is not currently used on site; however, it is proposed to be used as a new dopant gas. A maximum of one 47kg gas cylinder will be stored in a gas cabinet in a dedicated room in the main building. In the event of an accidental release, the propane gas would be diluted with air to reduce flammability.

3.4.4 Alarms are in place to detect release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

Ethylene

3.4.5 Ethylene is not currently used on-site; however, it is proposed to be used as a new dopant gas. A maximum of 15kg of ethylene would be stored within the gas cabinet. A further 15kg of ethylene will be stored within its shipping container within the existing bunker.

3.4.6 Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

Germane

3.4.7 Germane is not currently used on-site; however, it is proposed to be used as a new dopant gas. It will be stored in the extracted quarantine bunker as well as at the point of use within the bubbler location in the tool as per the metal-organic substances currently used on-site. A maximum of 250g of germane within a 50L cylinder (containing hydrogen) would be stored within the gas cabinet.

3.4.8 Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

TBH

3.4.9 TBH is not currently used on site; however, it is proposed to be used as a new metalorganic. It will be stored in the extracted quarantine bunker as well as at the point of use within the bubbler location in the tool as per the metal-organic substances currently used on-site.

3.4.10 A maximum of 300g of TBH would be stored within the gas cabinet. A further 300g of TBH will be stored within its shipping container within the existing bunker.

3.4.11 Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

TBA

3.4.12 TBA is not currently used on site; however, it is proposed to be used as a new metalorganic. It will be stored in the extracted quarantine bunker as well as at the point of use within the bubbler location in the tool as per the metal-organic substances currently used on-site. A maximum of 325g of TBA would be stored within the gas cabinet.

3.4.13 Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

TBP

3.4.14 TBP is not currently used on site; however, it is proposed to be used as a new metalorganic. It will be stored in the extracted quarantine bunker as well as at the point of use within the bubbler location in the tool as per the metal-organic substances currently used on-site. A maximum of 2000g of TBA would be stored within the gas cabinet.

3.4.15 Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. There are no changes to the methods applied to prevent fugitive emissions to air.

Other Raw Materials

3.4.16 There are no changes to the storage of the existing raw materials. There are no changes to water use compared with previous permit variation applications.

Compliance with COMAH Regulations

3.4.17 The proposed additional gases do not change compliance with current COMAH thresholds as the gases are stored and used in very small quantities.

Management of Raw Materials

3.4.18 There are no changes to the techniques employed to minimise raw material use. However, new raw materials are proposed to be used on-site. Quantities of all raw materials proposed are very low, as quantified in Table 3, and are unlikely to present a significant risk to the environment.

3.5 Point Source Emissions to Air

3.5.1 Currently, the following release points are included in the Permit:

- A1 serving FAB1 process gases;
- A2 serving FAB 1 boiler;
- A3 serving FAB 1 and FAB2 process gases;
- A4 serving FAB 2 boiler; and
- A5 serving FAB 2 chemistry station stack.

3.5.2 No changes are proposed to these release points or their locations. However, the two new substances would change the characteristics of the process gases emitted via A1 and A3.

Abatement of Emissions to Air

3.5.3 Existing abatement plant is in place which will treat existing and proposed new substances:

- Residual propane will be treated by the existing thermal oxidiser and then released via emission point A1.
- Residual (trace) levels of TBH will be treated by the existing wet scrubber and then released via emission point A3.
- Residual (trace) levels of germane may be emitted via A3 where it would be released potentially without abatement.
- Residual (trace) levels of TBA will be treated by the existing wet scrubber and then released via emission point A3.
- Residual (trace) levels of TBP will be treated by the existing wet scrubber and then released via emission point A3.
- Ethylene will be treated by the existing thermal oxidiser and then released via emission point A1, which serves FAB1 tools.

3.5.4 There will not be any physical changes to the exhausts, abatement plants or emissions points.

3.5.5 The fate and potential impacts of the new proposed substances on the environment are described in Section 5.3 with mitigation measures. The existing abatement can treat emissions from the facility, following the introduction of these new substances. It is proposed that emissions containing germane do not require abatement as it is used in very small quantities, it is diluted to 1% in hydrogen and decomposes during the reaction. See H1 in Appendix C which demonstrates that even using a very conservative approach, emissions of germane are insignificant.

3.5.6 The abatement technologies are designed to reduce emissions of pollutants to the following performance guarantees, as described in Table 2 below:

Table 2 Abatement Plant Performance

Parameter	Abatement Technology	Performance
Propane	Thermal oxidiser released via A1 which serves FAB1	>99%

Parameter	Abatement Technology	Performance
TBH	Wet scrubber, released via A3 which serves FAB1 and FAB2.	>99%
Germane	None required, highly dilute within hydrogen and decomposes during the reaction (see H1 Assessment in Appendix C). Released via A3 which serves FAB1 and FAB2.	NA
TBA	Wet scrubber, released via A3 which serves FAB1 and FAB2.	>99%
TBP	Wet scrubber, released via A3 which serves FAB1 and FAB2.	>99%
Ethylene	Thermal oxidiser released via A1 which serves FAB1.	>99%

3.5.7 For all substances, the annual throughputs are very low, as described in Table 3.

3.6 Control of Fugitive Emissions to Air

3.6.1 Gas detection and alarms are in place to detect leaks with auto-shut-off valves installed to stop the tools from operating in the event of a release. Process alarms will be reported to the control system for the attention of the operations team.

3.6.2 There is little likelihood that dust or odour will arise from the current activities or proposed changes as there are no sources of dust or odour from the operation of the existing installation or the proposed new Activities.

3.7 Point Source Emissions to Water and to Sewer

3.7.1 There will be no proposed changes to emissions directly to surface water or to the sewer other than minor changes to the effluent arising from the wet scrubber. There may be a slight change to the profile of aqueous emissions due to the treatment of trace levels of the new materials captured from the exhaust gases. This would not result in a material difference to the effluent as residual levels of the new materials are very low based on the following rationale:

- Propane will be combusted in the thermal oxidiser and would not be transferred into the wet scrubber stage of the abatement plant.
- TBH is primarily deposited onto wafers with only trace levels entering the gaseous phase, and subsequently the wet scrubber.
- Germane is used in very dilute quantities (1% in hydrogen), it decomposes during the reaction and is therefore not required to be treated by the wet scrubber (see Appendix C for H1 assessment which demonstrates that emissions are insignificant without abatement).
- TBA is primarily deposited onto wafers with only trace levels entering the gaseous phase, and subsequently the wet scrubber.
- TBP is primarily deposited onto wafers with only trace levels entering the gaseous phase, and subsequently the wet scrubber.
- Ethylene will be combusted in the thermal oxidiser and would not be transferred into the wet scrubber stage of the abatement plant.

3.8 Point Source Emissions to Groundwater and Land

3.8.1 There remains to be no point source emissions to groundwater or land.

3.9 Control of Fugitive Emissions to Sewer, Surface Water and Groundwater

3.9.1 There is minimal potential for the release of fugitive emissions to sewer, surface water and groundwater due to the relatively low inventory of potentially polluting substances stored on-site. Table 3 describes storage arrangements and control measures proposed for all potentially polluting materials stored on-site and has been updated to include changes to the new materials stored.

Table 3 Storage Arrangements and Throughput of Potentially Polluting Materials

Material	Use	Form	Proposed Inventory and Primary Containment	Annual Throughput	Pollution prevention Methods	Surfacing	Fate	Environmental Impact
Propane	New Will be used on one reactor as a dopant gas	Gas	1x 21kg gas cylinder in gas cabinet in building plus 1x21kg cylinder in bunker.	47kg cylinder	Stored in gas cabinet in main building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations. PRV on cylinder (only activated in emergency).	Concrete hard standing with sealed construction joints	Treated by existing thermal oxidiser then released via emission point A1.	H220 Flammable gas Pressurised gas
Ethylene	New Will be used in one existing MOCVD reactor	Gas	15kg cylinder within cabinet plus 15kg cylinder in bunker	90kg	Stored in the extracted quarantine bunker and at point of use bubbler in reactors within building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations	Concrete hard standing with sealed construction joints	Treated by existing thermal oxidiser then released via emission point A1.	H220 Flammable gas H336 STOT SE 3 Pressurised gas

Material	Use	Form	Proposed Inventory and Primary Containment	Annual Throughput	Pollution prevention Methods	Surfacing	Fate	Environmental Impact
Germane (1% in hydrogen)	**New** Will be used in one existing reactor to provide nitrogen atoms	Gas	250g of germane in cylinder which contains hydrogen plus additional 250g cylinder in bunker.	750g germane (1% in hydrogen)	Stored in the extracted quarantine bunker and at point of use bubbler in reactors within building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations	Concrete hard standing with sealed construction joints	Deposited onto wafer. Trace levels are released via emission point A3.	Undiluted properties: H220 - Extremely flammable gas. H280 - Contains gas under pressure; may explode if heated. H330 - Fatal if inhaled.
TBH	**New** Will be used in one existing reactor to provide nitrogen atoms	Liquid/Gas	300g cylinder within cabinet plus 300g cylinder in bunker	600g	Stored in the extracted quarantine bunker and at point of use bubbler in reactors within building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations	Concrete hard standing with sealed construction joints	Deposited onto wafer. Trace levels are treated by existing wet scrubber then released via emission point A3.	H225 (100%): Highly Flammable liquid and vapor H301 (100%): Toxic if swallowed H311 (100%): Toxic in contact with skin H314 (100%): Causes severe skin burns and eye damage H331 (100%): Toxic if inhaled H351 (100%): Suspected of causing cancer

Material	Use	Form	Proposed Inventory and Primary Containment	Annual Throughput	Pollution prevention Methods	Surfacing	Fate	Environmental Impact
TBA	**New** Will be used in one existing reactor	Gas	325g cylinder within cabinet plus 325g cylinder in bunker	6kg	Stored in the extracted quarantine bunker and at point of use bubbler in reactors within building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations	Concrete hard standing with sealed construction joints	Deposited onto wafer. Trace levels are treated by existing wet scrubber then released via emission point A3.	H250 (100%): Catches fire spontaneously if exposed to air H261 (100%): In contact with water releases flammable gas H330 (100%): Fatal if inhaled
TBP	**New** Will be used in one existing reactor	Gas	2kg cylinder within cabinet plus 2kg cylinder in bunker	12kg	Stored in the extracted quarantine bunker and at point of use bubbler in reactors within building, supplied via double contained pipework. Gas detection installed with auto-shut-off. Alarms are in place to detect the release of substances, which if raised, are interlocked with the tools to stop operations	Concrete hard standing with sealed construction joints	Deposited onto wafer. Trace levels are treated by existing wet scrubber then released via emission point A3.	H250: Catches fire spontaneously if exposed to air. H314: Causes severe skin burns and eye damage.

Subsurface Structures

3.9.2 There are no subsurface structures aside from existing surface water drainage and sealed foul/process water drainage. No new subsurface structures are proposed.

Surfacing

3.9.3 There will be no changes to surfacing. The main process areas are surfaced with high quality reinforced concrete hardstanding with sealed construction joints and separate, sealed drainage systems. There will be no external areas where contaminated process water may enter surface water drainage systems, which are segregated from process water systems.

3.10 Management Techniques

3.10.1 The operator has implemented an EMS for the installation. There will be no changes to the management of the facility as a result of the proposed change, and processes will be carried out to the same high standard of environmental performance as the current manufacturing activities. Procedures for the management of raw materials will be updated to describe how they will be stored, used and managed on-site to prevent accidental release.

3.11 Site Condition and Closure

3.11.1 There are no proposed changes to the installation boundary. Additional raw materials, their fate, storage arrangements and potential environmental risks, are described in Table 3.

4.0 Techniques for Process and Emissions Control and BAT Assessment

4.1 Introduction

4.1.1 It was demonstrated in the original application for permit referenced EPR/KP3235SS, that the proposed techniques represented application of the Best Available Techniques (BAT). In the absence of specific BAT guidance for the semi-conductor sector, reference was made to:

- Commission Implementing Decision (EU) 2022/2427 of 6 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for common waste gas management and treatment systems in the chemical sector (notified under document C(2022) 8788) 'WGC BATc'; and

NRW guidance documents have also been considered where there are additional techniques not covered by the above BATcs:

- How to comply with your Environmental Permit, Additional Guidance for the Inorganic Chemicals Sector (EPR 4.03), NRW, September 2014 'EPR 4.03'
- How to comply with your Environmental Permit, National Resources Wales, Version 8, October 2014;

4.1.2 Commission Implementing Decision (EU) 2016/902 of 30 May 2016 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for common waste water and waste gas treatment/management systems in the chemical sector 'CWWWG BATc' was reviewed. However, it was determined that as there are no material changes to emissions to water, which are discharged via sewer and are of very low volume, there were no additional BATcs relevant to the proposed changes to those identified by the WCG BATc.

4.1.3 Based on the conclusion in the original application for permit referenced EPR/AB3893FZ, that the controls in place represent BAT, this section:

- describes the main techniques that will be used to prevent, or where not practicable, minimise emissions as a consequence of the operation of the changes to the Installation; and
- demonstrates how the proposed manufacturing unit continues to apply BAT by prevention of emissions as a priority, or where emissions are minimised by treatment prior to release.

4.1.4 The BAT Assessment is therefore focussed on the changes to the proposed additional raw materials.

4.2 Applicable BAT Requirements

4.2.1 A review of the documents listed has been carried out and the applicability of the BATc requirements are summarised in Table 4 below. Applicable BATcs are highlighted.

Table 4 BATcs

Subject Title	BAT Reference	Applicability	Comment
WGC BATc			
Environmental Management Systems	BAT 1	Yes	Generally applicable.
Inventory of waste gas and waste water streams	BAT 2	Yes	Generally applicable.
OTNOC [1]	BAT 3	Yes	Generally applicable.
Use of abatement	BAT 4	Yes	Generally applicable.

Subject Title	BAT Reference	Applicability	Comment
Combine emission points	BAT 5	No	Not applicable. No changes to emission points.
Design of abatement	BAT 6	Yes	Generally applicable.
Process monitoring (air)	BAT 7	Yes	Generally applicable.
Emissions Monitoring (air)	BAT 8	Yes	Generally applicable.
Use of combustion unit for organic compounds	BAT 9, 10, 11	No	Not applicable, no sources of organic compounds.
PCDD/F emissions to air from thermal treatment of waste gases containing chlorine	BAT 12	No	Not applicable, no thermal treatment of chlorine-containing gases.
Dust and particulate metal emissions and BAT-AELs	BAT 13, 14	No	Not applicable, no dust-generating processes.
Recovery of inorganic compounds	BAT 15	No	Not applicable. Releases are negligible and chemically bonded to other elements, and as such, it is not possible to capture and re-use pollutants.
Thermal abatement	BAT 16	No	Not applicable. No changes to abatement plant infrastructure, which has been accepted as representing BAT in previous application.
NOx abatement	BAT 17	No	Not applicable, NOx emissions are minimal due to abatement technology selection and do not require abatement to meet BAT-AELs (where applicable). No changes to abatement plant infrastructure, which has been accepted as representing BAT in previous application.
Abatement	BAT 18	Yes	Generally applicable.
VOC emissions	BAT 19, 20, 23	Yes	Generally applicable associated with the storage and use of propane and ethylene, however the potential for VOC releases is negligible.
VOC emissions	BAT 21	No	Solvent use is not within the scope of Part 7 of Annex VII to Directive 2010/75/EU.
VOC emissions	BAT 22	No	NA Annual use of propane and ethylene is well below thresholds therefore release above threshold is not possible. See Table 3 for annual throughput of these substances. BAT 22 only applies when the annual quantity of diffuse VOC emissions from the plant estimated according to BAT 20 is greater than the following: For fugitive emissions: — 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B; or — 5 tonnes of VOCs per year in the case of other VOCs. For non-fugitive emissions: — 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B; or — 5 tonnes of VOCs per year in the case of other VOCs.
Sector-specific techniques	BAT 24 to BAT 33.	No	Not applicable to Installation processes.
Process furnaces/heaters	BAT 36	Yes	Generally applicable. Abatement comprises thermal oxidiser.
EPR 4.03 (additional requirements only)			
Energy Efficiency	NA	No	No changes to energy efficiency
Raw Material Use	NA	Yes	Generally applicable

Subject Title	BAT Reference	Applicability	Comment
Storage and Handling of Raw Materials	NA	Yes	Generally applicable
Notes: 1 – OTNOC – Other than normal operating conditions.			

4.3 Management Techniques

4.3.1 The operator has implemented an EMS for the installation. There will be no structural changes to the management of the facility as a result of this Permit Variation Application. The same high standard of management will be applied to the expanded facility that is applied to the current facility.

4.3.2 The AMP has been updated to incorporate controls applicable to the proposed changes, additional scenarios are in Appendix B.

4.3.3 Table 5 below compares the operator's EMS with the standards stipulated in the WCG BATc.

Table 5 BAT 1: BATs for Environmental Management Systems

Technique	Details	Meets BAT?
BAT 1. In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:		
i. commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS.	IQE Management are responsible for the overall effectiveness of the EMS and through clear leadership and commitment will promote continual improvement in all aspects of the EMS. Top Management will define the environmental policy and strategy and ensure that it is appropriate to the nature and scale of the organisations activities, products and services.	Yes
ii. an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment (or human health) as well as of the applicable legal requirements relating to the environment.	Risks and opportunities register and legal register are incorporated into the EMS as core components of the ISO14001:2015 standard.	Yes
iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation.	The Environmental Policy outlines management commitments. The Policy is reviewed at least annually to maintain its relevance and it provides a strategy for environmental objectives.	Yes
iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements.	Setting objectives and performance indicators are incorporated into the EMS as core components of the ISO14001:2015 standard.	Yes
v. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks.	These elements are incorporated into the EMS as core components of the ISO14001:2015 standard. The Operator has in place environmental operating controls at its facility; they are	Yes

Technique	Details	Meets BAT?
	suitable and sufficient to minimise the environmental impact from plant activities. The Operator has established and implemented the processes required to prepare for and respond to, potential emergencies. The Operator will respond in such a way as to prevent or mitigate the environmental impact of any such event should it occur.	
vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed.	These elements are incorporated into the EMS as core components of the ISO14001:2015 standard.	Yes
vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training).	The Operator will ensure that all persons performing tasks for it, or on its behalf, are deemed competent based on having appropriate education, training, skills and experience. The Operator has appropriate systems and procedures in place to identify key skills and competency requirements and for ensuring that plans are in place to provide, assess and record the provision of such training.	Yes
viii. internal and external communication.	The EMS is reviewed at least annually to maintain its relevance and it provides a strategy for environmental objectives.	Yes
ix. fostering employee involvement in good environmental management practices.	This requirement is delivered through training, regular communications and toolbox talks to deliver good environmental practices.	Yes
xi. effective operational planning and process control.	This element is incorporated into the EMS as a core component of the ISO14001:2015 standard.	Yes
xii. implementation of appropriate maintenance programmes;	PPM system in place.	Yes
xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;	AMP in place with emergency protocols for identified accident scenarios,	Yes
xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;	These elements are incorporated into the EMS as core components of the ISO14001:2015 standard. Closure plan in place, which will be updated to include new raw materials.	Yes
xv. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations.	Monitoring is described in Section 6; no changes are proposed. The Operator has in place suitable arrangements for the monitoring and measurement of its activities that could have a significant environmental impact were such monitoring arrangements not in place. To ensure accuracy, reliability and consistency of measurements performed, all measurement equipment is calibrated.	Yes

Technique	Details	Meets BAT?
xvi. application of sectoral benchmarking on a regular basis;	The EMS includes an obligation to strive for continual improvement, which includes reviewing new technologies.	Yes
xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;	The Operator carried out annual audits to monitor and evaluate all key activities undertaken that fall within the scope of the EMS. Records of such audits will be maintained within the EMS system as controlled documents.	Yes
xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;	Nonconformities, implementation of corrective actions are incorporated into the EMS as core components of the ISO14001:2015 standard.	Yes
xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;	The Operator reviews the EMS at planned intervals to ensure its continuing suitability and effectiveness (at least annually or in the event of an incident). The results of the management review are documented and communicated within the organisation.	Yes
xx. following and taking into account the development of cleaner techniques	The EMS includes an obligation to strive for continual improvement, which includes sectoral benchmarking.	Yes
xxi. an inventory of channelled and diffuse emissions to air.	See BAT 2.	Yes
xxiii. an integrated waste gas management and treatment strategy for channelled emissions to air	See BAT 4.	Yes
xxiv. a management system for diffuse VOC emissions to air.	A management system is in place, proportionate to low volumes of VOCs stored on-site.	NA
xxv. a chemicals management system that includes an inventory of the hazardous substances and substances of very high concern used in the process(es); the potential for substitution of the substances that are listed in this inventory, focusing on those substances other than raw materials, is analysed periodically (e. g. annually) in order to identify possible new available and safer alternatives, with no or lower environmental impacts.	Inventory maintained as part of COSHH register. The EMS includes an obligation to strive for continual improvement, which includes sectoral benchmarking which includes the use of materials with a lower environmental impact.	Yes

4.3.4 It is concluded that the proposed techniques meet BAT 1 requirements.

4.4 Inventory of Emissions to Air and Water

4.4.1 Table 6 below describes WCG BAT 2 requirements and the Operator's proposed measures.

Table 6: WCG BAT 2 Inventory of Water Emissions

Technique	Details	Meets BATc?
BAT 2. In order to facilitate the reduction of emissions to air, BAT is to establish, maintain and regularly review (including when a substantial change occurs) an inventory of channelled and diffuse emissions to air, as part of the environmental management system (see BAT 1), that incorporates all of the following features:		

Technique	Details	Meets BATc?
i. information, as comprehensive as is reasonably possible, about the chemical production process(es), including: a. chemical reaction equations, also showing side products; b. simplified process flow sheets that show the origin of the emissions;	Minimal changes to emissions to water (via sewer). Product formulations are highly commercially sensitive and do not form part of this application. Processes are carefully controlled under Site Operating Procedures. Gas properties are well understood by the operator. Emissions to water are discharged via sewer and are minimal. No wastewater treatment proposed on-site due to scale of releases; emissions are released into sewer. Process flow sheets are available and show aqueous releases.	Yes
ii. information, as comprehensive as is reasonably possible, about channelled emissions to air, such as: a. emission point(s); b. average values and variability of flow and temperature; c. average concentration and mass flow values of relevant substances/parameters and their variability (e.g. TVOC, CO, NOX, SOX, Cl2, HCl); d. presence of other substances that may affect the waste gas treatment system(s) or plant safety (e.g. oxygen, nitrogen, water vapour, dust); x e. techniques used to prevent and/or reduce channelled emissions to air; f. flammability, lower and higher explosive limits, reactivity; g. monitoring methods (see BAT 8); h. presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP).	Emissions are described in Section 3.5. There are no proposed changes to monitoring. Current techniques are appropriate following changes to raw material use. Abatement is installed, see Section 3.5. Hazardous properties are well understood and mitigation is in place to prevent incidents. See Section 3.4 and 3.6. COSHH register of materials stored and used on-site is maintained as part of safety and environmental management systems. CLP information is included within this register.	Yes
iii. information, as comprehensive as is reasonably possible, about diffuse emissions to air, such as: a. identification of the emission source(s); b. characteristics of each emission source (e.g. fugitive or non-fugitive; static or moving; accessibility of the emission source; included in an LDAR programme or not); c. the characteristics of the gas or liquid in contact with the emission source(s), including: 1. physical state; 2. vapour pressure of the substance(s) in the liquid, pressure of the gas; 3. temperature; 4. composition (by weight for liquids or by volume for gases); 5. hazardous properties of the substance(s) or mixtures, including substances or mixtures classified as CMR 1A, CMR 1B or CMR 2; d. techniques used to prevent and/or reduce diffuse emissions to air; e. monitoring (see BAT 20, BAT 21 and BAT 22).	Only small volumes stored and used on-site limited potential for fugitive emissions. Hazardous properties are well understood and mitigation is in place to prevent incidents. See Section 3.4 and 3.6. COSHH register of materials stored and used on-site is maintained as part of safety and environmental management systems. CLP information is included within this register.	Yes

4.4.2 It is concluded that the proposed techniques meet WCG BAT 2 requirements, where applicable.

4.5 Accident Management and OTNOC

4.5.1 The AMP has been updated to incorporate controls applicable to the proposed changes, additional scenarios are in Appendix B. The AMP scenarios include abnormal operating scenarios, including those defined as OTNOC in WCG BAT 3. The

4.5.2 Table 7 below describes BAT 3 requirements and the Operator's proposed measures.

Table 7 BAT 3 OTNOC

Technique	Details	Meets BATc?
BAT 3. In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the environmental management system (see BAT 1) that includes all of the following features.		
i. identification of potential OTNOC (e.g. failure of equipment critical to the control of channelled emissions to air, or equipment critical to the prevention of accidents or incidents that could lead to emissions to air ('critical equipment')), of their root causes and of their potential consequences.	See AMP scenarios in Appendix B.	Yes
ii. appropriate design of critical equipment (e.g. equipment modularity and compartmentalisation, backup systems, techniques to obviate the need to bypass waste gas treatment during start-up and shutdown, high integrity equipment, etc.).	Robust, high integrity equipment is procured given the highly technical nature of the processes.	Yes
iii. set-up and implementation of a preventive maintenance plan for critical equipment (	PPM system in place. Maintenance is carried out on critical plant and equipment	Yes
iv. monitoring (i.e. estimating or, where this is possible, measuring) and recording of emissions and associated circumstances during OTNOC.	The Operator has suitable arrangements in place to identify and address deviations from the expected norm which may compromise the overall effectiveness of the EMS or which may lead to an impact upon the environment. All incidents will be recorded.	Yes
v. periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted as recorded in point iv.) and implementation of corrective actions if necessary.	Alarms are in place to detect leaks with auto-shut-off valves to stop flow of pollutant gases. Where possible, OTNOC events will be monitored.	Yes
vi. regular review and update of the list of identified OTNOC under point i. following the periodic assessment of point v	See AMP scenarios in Appendix B. AMP is reviewed every four years or following an incident.	Yes
vii. regular testing of backup systems.	Emergency drills undertaken as part of Accident and Emergency procedures.	Yes

4.5.3 It is concluded that the proposed techniques meet BAT 3 requirements.

4.6 Process Releases to Air

4.6.1 Emissions to air will change as a result of the proposed changes to raw materials. However, potential pollutants are removed from the gas stream by existing abatement plant where required, as described in Section 3.5.

4.6.2 Table 8 below compares the BAT requirements in WCG BATc with technologies and measures proposed for the new emissions profile following implementation of the proposed changes.

Table 8: WCG BAT 4, 6, 18, 36 Emissions Management

Technique	Details	Meets BATc?
BAT 4. In order to reduce channelled emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes, in order of priority, process-integrated recovery and abatement techniques.	The existing wet scrubber (A3) and thermal oxidiser (A1) will abate emissions. Pollutants in gas streams are in very low level residual quantities and therefore recovery is not possible. Germane emissions are insignificant and do not require abatement (see Appendix C).	Yes
BAT 6. In order to reduce channelled emissions to air, BAT is to ensure that the waste gas treatment systems are appropriately designed (e.g. considering the maximum flow rate and pollutant concentrations), operated within their design ranges, and maintained (through preventive, corrective, regular and unplanned maintenance) so as to ensure optimal availability, effectiveness and efficiency of the equipment.	No changes to abatement plant, see Section 3.5. PPM programme is currently in place, which will include new plant and equipment. Maintenance of abatement plant and associated equipment will be carried out in accordance with manufacturer's instructions. Germane emissions are insignificant and do not require abatement (see Appendix C).	Yes
BAT 18. In order to reduce channelled emissions to air of inorganic compounds other than channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NOX emissions), channelled emissions to air of CO, NOX and SOX from the use of thermal treatment, and channelled emissions to air of NOX from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.		
a. Absorption	As above, wet scrubbing (absorption) is employed to remove pollutant gases and is applicable to the changes in emissions. See section 3.5.	NA
b. Adsorption	Not employed. Wet scrubbing and thermal oxidation was determined to meet BAT in previous applications and remains appropriate following proposed changes. See section 3.5.	Yes
c. Selective catalytic reduction (SCR)	Not applicable, no changes to abatement plant infrastructure. No additional NOx sources.	NA
d. Selective noncatalytic reduction (SNCR)	Not applicable, no changes to abatement plant infrastructure. No additional NOx sources.	NA
e. Catalytic oxidation	Not employed. Wet scrubbing and thermal oxidation were determined to meet BAT in previous applications and remains appropriate following proposed changes. Section 3.5.	NA
f. Thermal oxidation	As above, a thermal oxidiser is employed to remove pollutant gases and is applicable to the changes in emissions. See section 3.5.	Yes
BAT 36 [additional requirements to BAT 16]. In order to prevent or, where that is not practicable, to reduce channelled emissions to air of CO, dust, NOX and SOX, BAT is to use technique c. and one or a combination of the other techniques given below.		
c. Optimised combustion	No changes to abatement plant infrastructure.	Yes
d. Absorption	No changes to abatement plant infrastructure.	Yes
BAT-AELs associated with use of thermal oxidation	Not applicable. Thermal oxidiser abatement is individually below 1MWth.	NA
BAT 19 In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to elaborate and implement a management system for diffuse VOC emissions, as part of the environmental management system (see BAT 1), that includes all of the following features: [See note 1]		

Technique	Details	Meets BATc?
i. Estimating the annual quantity of diffuse VOC emissions.	See BAT 20.	NA
ii. Monitoring diffuse VOC emissions from the use of solvents by compiling a solvent mass balance, if applicable.	Not applicable, no in-scope solvents.	NA
v. Establishing and maintaining a database, for diffuse VOC emissions sources that are identified in the inventory mentioned in BAT 2, for keeping record of: a. equipment design specifications (including the date and description of any design changes); b. the equipment maintenance, repair, upgrade, or replacement actions, performed or planned, and their date of implementation; c. the equipment that could not be maintained, repaired, upgraded or replaced due to operational constraints; d. the results of the measurements or monitoring, including the concentration(s) of the emitted substance(s), the calculated leak rate (as kg/year), the recording from OGI cameras (e.g. from the last LDAR programme) and the date of the measurements or monitoring; e. the annual quantity of diffuse VOC emissions (as fugitive and non-fugitive emissions), including information on non-accessible sources and accessible sources not monitored during the year	a. Equipment design specifications for critical plant and equipment are maintained within site management and documentation systems. b. Robust programme of PPM in place with records maintained. c. Records of redundant equipment will be maintained. d & e. Monitoring / estimating of VOC releases will be carried out by mass balance, proportionate to the risk, considering the low inventory of materials stored and used on-site. See Table 3 for storage and throughput quantities of propane and ethylene. Leak detection is carried out on reactors following maintenance prior to start-up. See Note 2.	Yes
BAT 20. BAT is to estimate fugitive and non-fugitive VOC emissions to air separately at least once every year by using one or a combination of the techniques given below, as well as to determine the uncertainty of this estimation. The estimation distinguishes between VOCs classified as CMR 1A or 1B and VOCs that are not classified as CMR 1A or 1B.	Monitoring /estimating of VOC releases will be carried out by mass balance, proportionate to the risk, considering the low inventory of materials stored and used on-site. See Table 3 for storage and throughput quantities of propane and ethylene. See Note 2. Any incidents will be reported to NRW as required by permit conditions with potential releases estimated.	Yes
Note 1: The features points iii., iv., vi., and vii. are only applicable to sources of diffuse VOC emissions for which monitoring according to BAT 22 is applicable. Note 2: BAT 19 states *'The level of detail of the management system for diffuse VOC emissions will be proportionate to the nature, scale and complexity of the plant, and the range of environmental impacts it may have.'*		

4.6.3 It is concluded that the proposed techniques meet BAT requirements, where applicable.

4.7 Efficient Use of Raw Materials and Water

4.7.1 The proposed changes involve changes to raw materials. Table 9 compares the indicative BAT requirements for the Installation provided in NRW's guidance note S4.03 with techniques to be employed at the Installation. Storage and use of raw materials is provided in Table 9.

Table 9 Minimisation of Raw Materials and Water Use

Element	Justification
Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system.	No changes to processes or equipment.
Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances.	No changes to processes or equipment.
Use cleaning techniques that reduce the quantity of water needed.	No changes to processes or equipment.
Establish opportunities for reuse using pinch analysis.	Water use at the Installation is low. No changes to processes or equipment.
Reduce your use of all raw materials and intermediates.	Raw materials will be consumed in the process according to tightly controlled formulae to minimise resources and prevent emissions. Addition is automated by the run program. Application of materials is strictly controlled as the epilayers are deposited onto the surface of the substrate using software to in pre-determined quantities. Additional raw materials will be subject to the same stringent operational controls.
Substitute less harmful materials, or those which can be more readily abated and when abated lead to substances that are more readily dealt with.	Raw material selection is specific to the processes undertaken and alternatives are not currently available.
Understand the fate of by-products and contaminants and their environmental impact.	Emissions from the Installation are minimal due to the application of abatement technology. There is minimal generation of by-products due to the nature of the technology employed.

4.7.2 In line with current NRW requirements and guidance, the operator will carry out the following tasks:

- take appropriate measures to ensure that raw materials and water are used efficiently in the activities by carrying out routine resource efficiency audits;
- maintain records of raw materials and water used in the activities;
- review and record at least every 4 years whether there are suitable alternative materials that could reduce environmental impact or opportunities to improve the efficiency of raw material and water use; and
- take any further appropriate measures identified by a review.

4.7.3 There are no changes to the way that raw material use is minimised and controlled in line with Permit requirements. It can be concluded that following the expansion of operations, the Installation, as varied by this application, continues to meet indicative BAT requirements for raw material use laid out in NRW guidance 'EPR S4.03'.

4.8 Monitoring of Waste Gas Stream Process Parameters

4.8.1 Table 10 below describes BAT 7 requirements and the Operator's proposed measures.

Table 10 BAT 7 Monitoring of Process Parameters

Technique	Details	Meets BATc?
BAT 7. BAT is to continuously monitor key process parameters (e.g. waste gas flow and temperature) of waste gas streams being sent to pretreatment and/or final treatment.	Waste gas flow and temperature will be monitored continuously.	Yes

4.8.2 It is concluded that the proposed monitoring arrangements meet WCG BAT 7 requirements.

4.8.3 BAT8 was reviewed, which lists monitoring requirements for a range of parameters. None of the additional substances proposed in this permit variation application feature in WCG BAT 8. However, a review monitoring of emissions to air was carried out and is presented in Section 6.0.

4.9 Process Releases to Water (via Sewer)

4.9.1 Aqueous process emissions arise from the scrubbers and there are no changes to this plant as a result of the additional raw materials (see Section 3.7). All aqueous emissions are discharged into the foul sewer system in accordance with the Installation's consent issued by the sewerage undertaker, Welsh Water. There are no process emissions released directly into surface water drains.

4.10 Diffuse Emissions from Storage and Handling of Materials

4.10.1 Diffuse (fugitive) emissions may arise from the storage and handling raw materials and wastes as described in Section 3.4. Table 11 below describes the measures specified in S4.03 relating to the storage and handling of materials and the Operator's proposed measures.

Table 11 Storage and Handling of Materials

Indicative BAT	Justification
Measures specified in S4.03	
Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions.	Inventory of liquids is limited to small volumes of maintenance fluids which are stored in drums. Gases are stored in secure containers. Containment arrangements are described in Section 3.4.
Vent storage tanks to a safe location.	There are no bulk liquid containing tanks on-site aside from liquid nitrogen and fire suppressant water, inventory of liquids is limited to small volumes of maintenance fluids. Gases are stored in small volumes in secure containers at point of use or within dedicated gas bunker. Containment arrangements are described in Section 3.4.
Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels.	There are no bulk liquid containing tanks on-site aside from ammonia, liquid nitrogen and fire suppressant water, inventory of liquids is limited to small volumes of maintenance fluids. Containment arrangements are described in Section 3.4.
Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place	A HAZOP study, or equivalent on a risk-basis, will be carried out and included identification and management of risks to the environment relating to the storage and use of the new raw materials.

4.10.2 It is concluded that the proposed techniques meet NRW's S4.03 requirements, where applicable.

4.11 Odour

4.11.1 The new raw materials are not inherently odorous, and they are stored in used in highly controlled conditions. It is considered highly unlikely that odour releases will cause an offsite nuisance arising from the proposed changes.

4.12 Noise and Vibration

4.12.1 There is no new plant or equipment proposed to be installed therefore there will be no changes to the noise profile or application of BAT in relation to noise.

5.0 Impact on the Environment

5.1 Scope of Assessment

5.1.1 An Environmental Risk Assessment has been compiled to determine the environmental risks posed by the storage and use of the new raw materials, and to ensure that there remain no significant impacts on the environment and human health following the proposed changes.

5.1.2 In accordance with EA Guidance, now presented on the .gov website '*Guidance on additional risk assessments you will need to do for an environmental permit and information about the H1 software tool*' (as adopted by NRW) the following assessments have been carried out:

- Air Quality;
- Global Warming Potential;
- Fugitive releases; and
- Accidents.

5.1.3 Emissions to surface water (via sewer) and waste generated will not change materially as a result of the proposed changes, therefore no such assessments have been carried out. However, accidental releases to water have been considered.

5.1.4 Activities are not currently inherently noisy, dusty or odorous and the proposed changes will not affect this, therefore these emissions do not require assessment.

5.2 Important and Sensitive Receptors

5.2.1 The location and site boundary remains unchanged, therefore there are no changes which impact any of the receptors described in the original application and subsequent variations referenced EPR/KP3235SS. A review of the area surrounding the installation was carried out and there are no new sensitive receptors.

5.3 Assessment of Process Emissions to Air

5.3.1 Currently, the following releases are included in the Permit during normal operation:

- A1 serving FAB1 process gases;
- A2 serving FAB 1 boiler;
- A3 serving FAB2 process gases;
- A4 serving FAB 2 boiler; and
- A5 serving FAB 2 chemistry station stack.

5.3.2 No changes are proposed to these release points, abatement techniques or their locations.

5.3.3 The current emissions in the exhaust gases, released via emission points A1 and A3, currently comprise:

- ammonia;
- hydrogen chloride;
- arsenic;
- phosphorus compounds;
- trace levels of metal organics and other raw materials;
- carbon monoxide;
- carbon dioxide; and
- oxides of nitrogen; and
- nitrogen and hydrogen.

5.3.4 Emissions to air will change as a result of the proposed change arising from the use of propane, TBH, germane, TBA, TBP and ethylene. However, these substances are either consumed within the reaction

processes and/or are removed from the gas stream, as described in Section 3.5, to achieve very high levels of removal efficiency.

5.3.5 Residual trace levels of pollutants will be minimised through the high performance of the abatement technologies and the continued use of rigorous Operator controls to ensure that the abatement equipment is operated in line with the manufacturer's recommendations.

5.3.6 The impact of potential pollutants for each new raw material is described in Table 12 and the sections below.

Propane (proposed new dopant gas)

5.3.7 The existing thermal oxidiser will treat the propane released from the process in the exhaust gas prior to release via emission point A1, as described in Section 3.5, with removal rates of over 99%. As propane is combustible, it will be destroyed by the thermal oxidiser and residual levels following abatement are expected to be below detectable levels. The equation below demonstrates how propane (C_3H_8) is thermally reacted to produce carbon dioxide and water.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

5.3.8 On this basis, no further assessment has been carried out.

Ethylene

5.3.9 Ethylene will be treated by the existing thermal oxidiser and then released via emission point A1, which serves FAB1 tools. As ethylene is combustible, it will be destroyed by the thermal oxidiser and residual levels following abatement are expected to be below detectable levels. The equation below demonstrates how ethylene (C_2H_4) is thermally reacted to produce carbon dioxide and water.

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

5.3.10 On this basis, no further assessment has been carried out.

Germane

5.3.11 Germane breaks down releasing hydrogen and allowing the germane to bond to the surface therefore it is predominantly consumed within the reaction. Germane does not require abatement as it is used in very small quantities, diluted to 1% in hydrogen. An H1 Assessment was completed to calculate the ground level concentrations of germane and compare these levels with environmental assessment levels. The results, which are presented in Appendix C, demonstrate that impact is insignificant when applying the conservative screening criteria of the EA's H1 methodology.

TBH

5.3.12 This substance will be consumed during reactions with trimethylgallium and trimethyl indium to release nitrogen atoms, with only very small trace-level quantities potentially released via emission point A3.

5.3.13 The existing wet scrubber will treat the trace levels released from the process in the exhaust gas prior to release via emission point A3, as described in Section 3.5, with removal rates of over 99%. Monitoring is installed in the emissions stack alarm, which would alert operatives to any potential releases. In the event of a release, the process would be stopped as per existing arrangements. As the resultant concentrations in the atmosphere will be at trace levels, environmental impact will be insignificant. On this basis, no further assessment has been carried out.

TBA

5.3.14 This substance will be consumed within the tool during reactions and deposited onto wafers, with only very small trace-level quantities potentially released via emission point A3.

5.3.15 The existing wet scrubber will treat the residual trace levels released from the process in the exhaust gas prior to release via emission point A3, as described in Section 3.5, with removal rates of over 99%. Monitoring is installed in the emissions stack alarm, which would alert operatives to any potential releases. In the event of a release, the process would be stopped as per existing arrangements. As the resultant concentrations in the atmosphere will be at trace levels, environmental impact will be insignificant. On this basis, no further assessment has been carried out.

TBP

5.3.16 This substance will be consumed within the tool during reactions and deposited onto wafers with only very small trace-level quantities potentially released via emission point A3.

5.3.17 The existing wet scrubber will treat the residual trace levels released from the process in the exhaust gas prior to release via emission point A3, as described in Section 3.5, with removal rates of over 99%. Monitoring is installed in the emissions stack alarm, which would alert operatives to any potential releases. In the event of a release, the process would be stopped as per existing arrangements. As the resultant concentrations in the atmosphere will be at trace levels, environmental impact will be insignificant. On this basis, no further assessment has been carried out.

Table 12: Calculated Emissions for New Substances

Parameter	Emissions Concentration in Stack	Abatement	Annual Emissions	Basis for Assessment
Propane	Non detectable	Thermal oxidiser	Negligible	No further assessment, thermal oxidiser will combust substance.
Ethylene	Non detectable	Thermal oxidiser	Negligible	No further assessment, thermal oxidiser will combust substance.
Germane	0.9 ug/m^3	None	19.7 g/year	Germane breaks down releasing hydrogen and allowing the germane to bond to the surface therefore there will be just negligible concentrations of germane in the resultant flue gases. These emissions have been assessed in the H1 in Appendix C.
TBH	Non detectable	Wet scrubber	Negligible	No further assessment, metalorganic is applied to wafer. Abatement in place to remove any trace concentrations in flue.
TBA	Non detectable	Wet scrubber	Negligible	No further assessment, metalorganic is applied to wafer. Abatement in place to remove any trace concentrations in flue. Permit includes arsenic compounds limit. The change in raw materials will not compromise this.
TBP	Non detectable	Wet scrubber	Negligible	No further assessment, metalorganic is applied to wafer. Abatement in place to remove any trace concentrations in flue. Permit includes phosphine compounds limit. The change in raw materials will not compromise this.

Existing Gases

5.3.18 As per current operations, inert gases and hydrogen will continue to be used intermittently. They are not pollutants of concern and no further controls to abate emissions or assessment are proposed.

5.3.19 There are no changes to the use of metalorganics used on-site and chlorine and ammonia will continue to be used, which are controlled by the existing abatement plant.

5.4 Global Warming Potential

5.4.1 As there are no changes to energy use, there will be no change to the global warming potential, other than the negligible amount of combustion gases released into the atmosphere arising from the treatment of propane by the thermal oxidiser.

5.5 Fugitive Emissions, Accidents and Amenity Impact

5.5.1 Activities will be managed and operated in accordance with the Operator's EMS, which will incorporate the Operator's AMP. The AMP will be revised to include the new raw materials. Additional accident scenarios and corresponding management measures are described in the sections below and in Appendix B.

Fugitive Releases to Land and Water

5.5.2 The potential for accidental release of the new raw materials has been considered in this ERA. Metalorganics are highly flammable and whilst they are stored as liquids, they would vaporise upon release, causing release to ground, water and into the air (see below).

5.5.3 The control measures are described in Section 3.4, which are in place to prevent release of the raw materials. Measures include containment of metalorganics within a secure bubbler unit and dedicated extracted quarantine bunker with alarms to alert operatives in the event of a release.

5.5.4 Hazards and management measures concerning raw material storage and use have been identified and assessed in Appendix B, considering the measures in place, the impact is likely to remain low.

Fugitive Emissions to Air

5.5.5 As described above, metalorganics are highly flammable and whilst they are stored as liquids, they would vaporise upon release causing release to ground, water and into the air. Escape of propane, germane (1% in hydrogen) and ethylene gas would result in emissions released into the air.

5.5.6 The control measures are described in Section 3.4, which are in place to prevent a release of raw materials. Measures include containment of gases in robust gas storage cylinders within gas cabinets in the building with alarms to alert operatives in the event of a release.

5.5.7 Hazards and management measures concerning raw material storage and use have been identified and assessed in Appendix B, considering the measures in place, the impact is likely to remain low.

Accidents

5.5.8 The AMP will be updated to include the new raw materials. Additional scenarios from the proposed changes have been identified and assessed in Appendix B which concludes that the risk to the environment remains low.

5.6 Risk Assessments Summary

5.6.1 The tables in Appendix B describe hazards and management measures and assess the main risks to the environment.

6.0 Monitoring and Reporting

6.1 Monitoring of Emissions to Air and BAT-AELs

6.1.1 BAT-AELs and associated monitoring are presented in Section 5, however the basis for the BAT-AELs is presented below in Table 13.

Table 13 Proposed Air Emission Limits and Monitoring Methods

Emission point ref. & location	Source	Current limits	Proposed changes	Basis for Proposed Limit
A1	FAB 1 LEV Stack	Current limits are set at the BAT-AEL limits stipulated in WCG BATc Table 1.6. Ammonia – 10mg/m^3 Hydrogen chloride – 10mg/m^3	Propane used as new dopant gas.	No changes to current limits. Propane levels will be negligible as they will be treated prior to release by thermal oxidiser. Monitoring is installed in the emissions stack alarm, which would alert operatives to any potential releases. In the event of a release, the process would be stopped as per existing arrangements.
A2	FAB 1 Boiler Stack	No changes.		
A3	FAB 2 Process Stack	Arsine and phosphorus compounds (expressed as arsenic) – 0.42mg/m^3 Ammonia – 9mg/m^3	Addition of TBA, TBH and TBP as new metalorganics.	No changes to current limits. Only trace levels of new metalorganics in flue. Addition of TBA will not compromise current arsine limit. Addition of TBP will not compromise current Phosphine limit. Monitoring is installed in the emissions stack alarm, which would alert operatives to any potential releases. In the event of a release, the process would be stopped as per existing arrangements.
A4	FAB 2 Boiler Stack	No changes.		
A5	FAB 2 Chem. Station Stack	No changes.		

Appendices

Appendix A: Company Certificate

FILE COPY

CERTIFICATE OF INCORPORATION

ON CHANGE OF NAME

Company No. 2107558

The Registrar of Companies for England and Wales hereby certifies that

EPITAXIAL PRODUCTS INTERNATIONAL LIMITED

having by special resolution changed its name, is now incorporated under the name of

IQE (EUROPE) LIMITED

Given at Companies House, Cardiff, the 30th June 2000

C02107558T

For The Registrar Of Companies

COMPANIES HOUSE

Appendix B: Environmental Risk Assessment

Table B1: Fugitive Emissions to Water, Ground and Groundwater from New Raw Materials

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
Loss of containment of metalorganics or associated pipework	Leaks from vessels or pipework	Initially transport via the ground and drainage systems, then air transport	Local residents, workforce at local businesses, users of amenity sites, site drainage and onward receiving waters	Low	Medium	Medium	Physical prevention measures include containment and double-contained pipelines where required. An interlock is in place to shut down the process if the substance is detected. Operating procedures and staff training. Maintenance and inspection routines: Leaks are prevented through inspection and maintenance. PPM will be in place to ensure plant and equipment are maintained in accordance with the manufacturer's instructions. Procedures and staff training.	Low

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Procedural control of plant modification (MOC) Design and construction carried out by competent person and inspected by competent person prior to start up. Preventative maintenance, inspection and test regimes Compliance measures in place which comply with requirements of DSEAR. Appropriate labelling of pipework Vessels will be situated well away from roadways and provisioned with barriers to prevent accidental damage. Emergency shutdown system Emergency plan Site security system (entry or sabotage)	

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Design of appropriate access for emergency vehicles Training and simulation/ testing of emergency systems Isolation of pipework and equipment.	

Table B2 Emissions to Air from New Raw Materials

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
Loss of containment of gas causing release	Leaks of process gas from pipework, reactors, gas bunker and from a mechanical failure or cylinder failure	Air transport	Local residents, workforce at local businesses, users of amenity sites	Low	Medium	Medium	Physical prevention measures include double contained pipelines where required. Gas detection and alarms are in place to detect leaks with auto-shut-off valves to stop flow of pollutant gases. Process alarms sound locally and will be reported	Low

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							to the control system for the attention of the operations team. The abatement is specially engineered to handle the gas flows and related operating conditions of the activities. Operating procedures and staff training. Maintenance and inspection routines: Leaks of process gas are prevented through inspection and maintenance, leak detection and repair and avoidance of over-pressurisation. PPM will be in place to ensure plant and equipment is maintained in accordance with the manufacturer's instructions. Procedures and staff training. Procedural control of plant modification (MOC). Design and construction carried out by competent person and inspected by competent person prior to start up.	

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Preventative maintenance, inspection and test regimes. Compliance measures in place which comply with requirements of DSEAR. Appropriate labelling of pipework. Appropriate crash barrier protection for process gas pipework. Bollards and curbing are in place to protect gas bunkers. Emergency shutdown system. Emergency plan. Site security system (entry or sabotage). Design of appropriate access for emergency vehicles. Training and simulation/ testing of emergency systems. Isolation of pipework and equipment	
Release of pollutants	Release points to air (A1 & A3)	Air transport	Local residents, workforce at	Low	Medium	Medium	Thermal oxidiser and scrubbers in place to destroy emissions of ethylene and propane.	Low

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
within exhaust gas			local businesses, users of amenity sites				Germane stored only in dilute quantities (1% in hydrogen) in controlled conditions. Double contained pipework. Small-scale process, limited releases. Auto-shut-down linked to operation of abatement plant. Operator controlled exhaust flow rates. Gas detection and alarms are in place to detect leaks with auto-shut-off valves to stop flow of pollutant gases. Process alarms sound locally and will be reported to the control system for the attention of the operations team. Leaks of process gas are prevented through inspection and maintenance, leak detection and repair and avoidance of over-pressurisation. PPM will be in place to ensure plant and equipment is maintained in accordance with the manufacturer's instructions.	

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Procedures and staff training. Procedural control of plant modification (MOC). Design and construction carried out by competent person and inspected by competent person prior to start up. Preventative maintenance, inspection and test regimes. Emergency shutdown system. Emergency plan. Site security system (entry or sabotage). Design of appropriate access for emergency vehicles. Training and simulation/ testing of emergency systems. Isolation of pipework and / or equipment. Gas alarms and low-pressure switch.	

Table B3 Accident Risks from New Raw Materials

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
Vandalism impacting new plant and equipment	New process gases and associated pipework	Local residents, workforce at local businesses, users of amenity sites, site drainage and onward receiving waters	Low	Medium	Medium	Medium	Security systems in place including alarms, manned security gate and fencing (no change from current measures). Physical prevention measures include double contained pipelines where required. Auto-shut-down linked to operation of abatement plant. Operating procedures and staff training. New substances will be situated well away from roadways and provisioned with barriers to prevent accidental damage. Emergency shutdown system. Emergency plan. Design of appropriate access for emergency vehicles.	Low

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Training and simulation/ testing of emergency systems. Isolation of pipework and equipment.	
Failure of plant	Reactors (existing plant)	Local residents, workforce at local businesses, users of amenity sites, site drainage and onward receiving waters	Low	Medium	Medium	Medium	No new plant or equipment installed. Small-scale process, limited releases. Auto-shut-down linked to operation of abatement plant. Gas detection and alarms are in place to detect leaks with auto-shut-off valves to stop the flow of pollutant gases. Process alarms sound locally and will be reported to the control system for the attention of the operations team. Leaks of process gas are prevented through inspection and maintenance, leak detection and repair and avoidance of over-pressurisation. PPM will be in place to ensure plant and equipment is maintained in	Low

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							accordance with the manufacturer's instructions. Procedures and staff training. Procedural control of plant modification (MOC). Design and construction are carried out by a competent person and inspected by a competent person prior to start-up. Preventative maintenance, inspection and test regimes. Emergency shutdown system. Emergency plan. Site security system (entry or sabotage). Design of appropriate access for emergency vehicles. Training and simulation/ testing of emergency systems.	

Hazard	Source	Pathway	Receptor	Probability of Exposure	Consequence	Magnitude of risk	Risk Management	Residual risk
							Isolation of pipework and/or equipment. Gas alarms and low-pressure switches.	

Appendix C: H1 Assessment

An H1 Assessment was completed to determine the requirement for abatement of germane, which is added as a dopant gas in a dilution of 1% in hydrogen. The germane and hydrogen mixture is discharged into the reactor where a significant fraction (near 100%) is decomposed and the Ge atoms are incorporated into the semiconductor material being grown.

On an extremely conservative basis, this assessment has been completed on the assumption that there is zero decomposition, and all the germane is released to atmosphere via emission point A3. This is not a practical scenario as germane breaks down releasing hydrogen allowing the germane to bond to the wafer surface.

The following steps have been carried out to complete the H1 risk assessment:

Step 1: Calculate the environmental concentration of germane which is the process contribution (PC).

The EA Guidance provides the screening criteria, which states that:

"To screen out a PC for any substance so that you do not need to do any further assessment of it, the PC must meet both of the following criteria:

- *the short-term PC is less than 10% of the short-term environmental standard; and*
- *the long-term PC is less than 1% of the long-term environmental standard.*

If you meet both of these criteria you do not need to do any further assessment of the substance."

Step 2: Identify PCs with insignificant environmental impact to determine if they can be 'screened out' for requiring further assessment.

This is completed by comparing the PC and PEC with the relevant environmental standard.

Step 3: For substances not screened out in step 2, calculate the predicted environmental concentration (PEC) for each substance. The PEC is the PC plus the background concentration of the substance. Again, this is completed by comparing the PC and PEC with the relevant environmental standard.

Step 4: Identify emissions that have insignificant environmental impact to determine if they can be 'screened out' for requiring detailed air emissions modelling. The EA Guidance provides the screening criteria, which states that:

"You'll need to do detailed modelling of emissions that do not meet both of the following requirements:

- *the short-term PC is less than 20% of the short-term environmental standards minus twice the long-term background concentration; and*
- *the long-term PEC is less than 70% of the long-term environmental standards."*

The following input information was used in this assessment, as presented in Table C1 below. There are two potential modes of operation as two different reactors with different characteristics may be employed. The stack conditions are the same for each reactor, as both reactors would use the same stack (A3). Therefore, the assessment has been carried out on the reactor which produces the highest

emissions of germane, measured in grams per second (g/s). Both options are presented below, however the assessment has been carried out using emissions from EU41 as a 'worst case' scenario.

Table C1: Calculated Emissions

Parameter	Value	Comments
EU20 - Germane – Concentration in stack	0.90ug/m^3	Calculated using mass balance. Emissions from EU20 are projected to be lower than those from EU41, therefore EU41 values below have been used in the assessment.
EU20 - Germane – Concentration in stack	0.00001140g/s	Calculated using mass balance. Emissions from EU20 are projected to be lower than those from EU41, therefore EU41 values below have been used in the assessment.
EU41 - Germane – Concentration in stack	6.04 ug/m^3	Calculated using mass balance.
EU41 - Germane – Concentration in stack	0.00007697g/s	Calculated using mass balance.
Air flow rate (A3)	45842 m^3/hr	Measured.
Environmental Assessment Level	6.4ug/m^3 – Long term (LT) 190ug/m^3 – Short term (ST)	Derived from 1% (LT) and 10%(ST) of the Workplace Exposure Limit ref: *'EH40/2005 Workplace exposure limits, HSE, V4, 2020'.*
Background concentration	0ug/m^3	No local sources of germane.
Operational basis	5%	Applied to LT emissions only based on operating based on 4x2hr runs per day for 60 days per year.
Stack height	0m	Assumed zero based on H1 guidance and taking a conservative assessment approach.
Dispersion Factor	148ug/m^3/g/s LT 3900ug/m^3/g/s ST 529ug/m^3/g/s Monthly	Based on zero stack height

The data above was input into the EA's H1 Software tool to produce the following results:

Table C2: H1 Screening Calculations for Germane (EU41 reactor)

Parameter	LT PC ug/m^3	LT EAL ug/ m^3	% PC/EAL	>1% EAL?	ST PC ug/ m^3	ST EAL ug/ m^3	% PC/EALs	>10% EAL?
Germane – Concentration in stack	0.00062	6.4	0.01%	No	0.30019	190	0.16%	No

There are no current operations which require both units to operate simultaneously, however, should this scenario arise in the future, projected impacts of operating both units together have also been calculated in Table C3 below.

Table C3: H1 Screening Calculations for Germane (EU20 and EU41 reactors operating simultaneously)

Parameter	LT PC ug/m^3	LT EAL ug/ m^3	% PC/EAL	>1% EAL?	ST PC ug/ m^3	ST EAL ug/ m^3	% PC/EALs	>10% EAL?
Germane – Concentration in stack	0.00072	6.4	0.01%	No	0.34466	190	0.18%	No

In conclusion, the LT PC is below 1% of the LT EAL and the ST PC is below 10% of the ST EAL and even when considering the conservative basis for the assessment, impacts on the environment are insignificant when applying the EA's H1 screening methodology. The assessment does not take into account the decomposition of Germane during the process and assumes that 100% of germane is released to atmosphere. However, during the reaction process 100% of the germane is decomposed resulting in 0% germane released via the stack. Therefore, no further screening stages or detailed modelling is required to demonstrate that emissions are likely to be insignificant.

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