

Technical Note

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1. Introduction

Swansea University in partnership with the regional semiconductor industry is proposing a new Centre for Integrative Semiconductor Materials ('CISM') at the Swansea University Bay Campus. The CISM will provide an integrated facility for semiconductor research and technology development and will provide a number of services including research and development, prototyping, process development, incubation, engagement and training.

This note looks at the environmental permitting implications for Swansea University for the new facility and recommends the next steps in this regard. This note does not include consideration of environmental permitting requirements for any 'customers' who may rent space at the facility and / or operate their own separate manufacturing facilities.

2. Facilities

The facility will consist of:

- New building housing
 - Research laboratories,
 - Clean room for process development
 - II/III-VI metal organic chemical vapor deposition (MOCVD) growth facility
 - Customer bays for SME incubation
 - Offices
- New gas cylinder storage bunker
- Backend materials integration and packaging capability i.e. construction of microchips from the manufactured materials

It has also been assumed there is chemical storage on site.

A number of furnaces / ovens are noted in the equipment list and it is understood that all of these are electric.

2.1. Materials

2.1.1. Gases

A number of gases are used in the equipment. Estimates of gas volumes to be stored on site are shown below:

| Gas Cylinders | Volume stored on site (Sm ³) |
|------------------------------|--|
| Oxygen | 30.11 |
| Oxygen MCP | 156.72 |
| Argon MCP | 156.44 |
| Argon | 30.11 |
| Helium | 30.30 |
| Ammonia | 12.97 |
| Octafluorocyclobutane (C4F8) | 16.02 |
| Sulphur Hexafluoride (SF6) | 15.73 |
| Chlorine (Cl2) | 6.23 |
| Boron Trichloride (BCl3) | 3.67 |
| Tetrafluoromethane (CF4) | 18.25 |
| Methane (CH4) | 23.48 |

| | |
|--------------------------|--------|
| Nitrous Oxide (N2O) | 74.80 |
| Acetylene (C2H2) | 9.75 |
| Silane (SiH4) | 6.93 |
| Trifluoro methane (CHF3) | 9.51 |
| Forming Gas | 8.40 |
| Forming Gas MCP | 125.99 |
| Purge Nitrogen (N2) | 29.40 |
| Hydrogen (H2) | 14.42 |

2.1.2. Hazardous substances

A number of acids and bases are used (phosphoric acid, sulphuric acid, nitric acid, hydrochloric acid, hydrobromic acid, acetic acid, sodium hydroxide, potassium hydroxide, tetramethylammonium hydroxide and some undefined acid/bases) though it is not known in what volumes these are stored on site.

Hydrogen peroxide is also used on site but it is not known in what volumes this is stored.

2.1.3. Solvents

A number of solvents (isopropanol, acetone, ethanol, methanol, heptane, ethyl acetate, xylene, dimethyl sulfoxide, etc.), are noted in the mass balance though it is not known in what volumes these are stored on site.

2.1.4. Semiconductor Materials & Metals

A number of semiconductor materials (gallium nitride, silicon dioxide, silicon nitride, silicon oxynitride, aluminium oxide) are noted in the mass balance though it is not known in what volumes these are stored on site.

A number of metals are used on site (aluminium, titanium, gold and chromium) as noted in the mass balance although it is not known in what volumes these are stored on site.

3. Environmental Permitting Requirements

Under regulation 12 of the Environmental Permitting (England and Wales) Regulations 2016 (as amended) ('EPR 2016 as amended'), a person may not operate a regulated facility or cause or knowingly permit a water discharge activity or groundwater activity, unless they have obtained an environmental permit to do so.

A 'regulated facility' is defined in regulation 8 as any of the following (unless exempt):

- (a) an installation;
- (b) mobile plant;
- (c) a waste operation;
- (d) a mining waste operation;
- (e) a radioactive substances activity;
- (f) a water discharge activity;
- (g) a groundwater activity;
- (h) a small waste incineration plant;
- (i) a solvent emission activity;
- (j) a flood risk activity.

3.1. Exemptions

3.1.1.1. General - Research and Development

Clause 3 of Part 1 of Schedule 1 of the EPR 2016 (as amended) defines the activities that are “*not to be taken to be an activity falling within Part 2 of this Schedule*” i.e. those that are not considered activities that require installation environmental permits.

Clause 3 (c) includes those activities that are “*carried on at an installation, other than a waste incineration plant or a waste co-incineration plant, or by means of Part B mobile plant, where the installation or plant is used solely for research, development or testing of new products or processes*”.

‘Installation’ is defined as “*(a) a stationary technical unit where one or more activities are carried on, and (b) any other location on the same site where any other directly associated activities are carried on.*”

‘Activity’ is defined as “*subject to this Part, an activity listed in Part 2 of this Schedule*”.

It is Atkins understanding that the CISM facility will solely be used for research and development and therefore would meet this description and should not require an environmental permit for an installation activity. Clarification is needed relating to the extent of the activities undertaken on site and in particular, on the ‘backend materials integration and packaging capabilities’ and any integration with ‘customer bays for SME incubation’ which may indicate production for commercial purposes (see ‘Regulatory Guidance Note 2’ section below).

3.1.1.2. Medium Combustion Plant

Clause 2, Part 1, Schedule 25A of the EPR 2016 (as amended) defines ‘medium combustion plant’ and notes some exemptions. Such exclusions include those noted in Article 2(3) or (4) of the Medium Combustion Plant Directive (‘MCPD’) which include ‘reactors used in the chemical industry’ and ‘research, development or testing activities relating to medium combustion plants’.

It should also be noted that the definition of ‘combustion plant’ as set out in the MCPD is. ‘*any technical apparatus in which fuels are oxidised in order to use the heat thus generated*’ so would not include electric powered ovens / furnaces.

It is understood that the furnaces used at the facility are all electric and are therefore not considered ‘combustion plant’.

3.1.1.3. Solvent Emission Activities

Clause 1, Schedule 14 (on Solvent Emissions Activities) of the EPR 2016 (as amended) which brings solvent emission activities in to regulation under the EPR 2016 (as amended), states that Schedule 14 does not apply to installations used solely for research activities, development activities or the testing of new products or processes.

It is Atkins understanding that the CISM facility will solely be used for research and development and therefore would meet this description and should not require an environmental permit for an installation activity for solvent emissions activities. Clarification is needed relating to the nature and extent of any solvent emission activities undertaken on site however, to confirm.

3.2. If not deemed exempt

3.2.1. MOCVD

Schedule 1, Part 2, Chapter 4 of the EPR 2016 (as amended) lists those chemical activities that require an environmental permit. These activities are split into Part A(1) and Part B.

The most relevant section for CISM is likely to be Section 4.2 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.’

As CISM activities include the manufacture of Group II/III – Group V semiconductor structures using a process known as Metal-Organic Chemical Vapour Deposition (‘MOCVD’).

The activities undertaken may also fall under Section 4.2 A(1)(b) ‘Unless falling within any other Section, any manufacturing activity which is likely to result in the release into the 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)’, due to some of the gases used.

3.2.2. Furnaces

It is understood that all furnaces are electric and assumed that there are no combustion plant at the facility (including generators). If this is incorrect, Schedule 25A of the EPR 2016 (as amended) regulates medium combustion plant which is defined as a combustion plant with a rated thermal input equal to or greater than 1 megawatt but less than 50 megawatts, and any combination of combustion plants unless excluded by the Medium Combustion Plant Directive. Schedule 25B of the EPR 2016 (as amended) regulates specified generators which are defined as a generator, other than an excluded generator, with a rated thermal input more than or equal to 1 megawatt and less than 50 megawatts or in the case of a generator used to meet a capacity agreement or an agreement to provide balancing services, than 50 megawatts⁰. Where more than one generator is operated on the same site by the same operator for the same purpose, the rated thermal input of all is considered, even if one or more generators has a thermal input of less than 1 megawatt.

Confirmation is required from CISM that the furnaces are all electric powered, is required to confirm the furnaces can be excluded from the environmental permitting requirements.

If CISM use / will use any combustion plant including generators at the facility, further information on this plant should be provided to ascertain if an environmental permit is required.

3.2.3. Solvents

It is not known what solvents are used for at the facility. As noted in 3.1.1.3, Schedule 14 of the EPR 2016 (as amended) brings solvent emissions activities (and where applicable, exceeding the relevant solvent consumption thresholds) into regulation and refers to activities listed in Annex VII of the Industrial Emissions Directive which include:

- Adhesive coating;
- Coating activity¹;
- Coil coating;
- Dry cleaning;
- Footwear manufacture;
- Manufacturing of coating mixtures, varnishes, inks and adhesives;
- Manufacturing of pharmaceutical products;

¹ Coating activities do not include the coating of substrate with metals by electrophoretic and chemical spraying techniques.

- Printing;
- Rubber conversion;
- Surface cleaning;
- Vegetable oil and animal fat extraction and vegetable oil refining activities;
- Vehicle refinishing;
- Winding wire coating;
- Wood impregnation;
- Wood and plastic lamination;

Further information is required from CISM on what the solvents are used for at the facility, to determine whether or not any solvent emissions activities are undertaken at the facility and if so, whether or not they can be excluded from the environmental permitting requirements on the basis of being used 'solely for research activities, development activities or the testing of new products or processes'.

3.3. Regulatory Guidance Note 2

3.3.1. Chapter 4 - Chemical Industry

Regulatory Guidance Note 2 Appendix 1 provides commentary on the relevant sections of EPR 2016 (as amended) but does not provide anything relevant relating to activities specifically falling under Section 4.2 A(1) (c). It does however have a generic note relating to all section 4 activities, on the definition of 'manufacturing' used in specific activity descriptions (such as in Section 4.2 A(1) (c)) and notes on 'commercial purposes' and 'chemical plant' that may be relevant to CISM.

Note 4.2: Chemical Plant "Chemical Plant" should be taken to mean industrial plant and machinery (i.e. not domestic equipment) which is designed and constructed for the containment and control of the chemical reaction(s) that takes place as part of the chemical process. A reaction vessel would normally constitute "chemical plant" whereas a reaction on an open surface or within a mould designed to produce a final product shape would not normally constitute "producing in chemical plant". "Industrial" plant and machinery is that which is suitable for commercial production – generally but not necessarily in tonnes per annum quantities - of a particular chemical or closely related range of chemicals. Plant for producing tonnage quantities of individual chemicals per year will clearly be industrial but the production of smaller quantities may also be carried out in "chemical plant". For example, for laboratory or research chemicals, "industrial" plant could be arrays of standard reconfigurable laboratory glass equipment - but such plant would normally be regarded as being of industrial scale only if the total annual output of chemical products is likely to exceed 1 tonne or the production of any single product (or group of related products) is likely to exceed 100 kg in any 12 month period. However, in the pharmaceutical and plant health product sectors, where substances with specific physiological activity are the products, the "active ingredient" products are generally of high value and produced in relatively small volumes so "industrial" plant could be much smaller. For "active ingredient" production, of pharmaceuticals "industrial" plant should generally be taken to mean that associated with single product production likely to exceed 20 kg in any 12 month period. For biopharmaceuticals the scale of active ingredient production can be significantly smaller (in the order of 1kg) and still be carried out in "industrial" plant (this could, for example, be due to the very low yield from the production processes, with associated high waste volumes).

Note 4.3: Commercial Purposes "Commercial purposes" means conducting an activity, alone or with another activity, to meet a demand from another organisation or person for the chemical produced and receiving financial payment for it. An exception arises where the demand comes from market testing in which case, even though there may be no direct financial payment for it, the production activity is regarded as constituting "commercial purposes" since there is a clear intention to proceed to commercial sales subject only to the outcome of the test.

"Note 4.4: "Manufacturing" (used in specific activity descriptions, e.g. 4.2 A(1) (h)) includes a wider range of activities than "producing" and is not limited to those involving a chemical reaction in chemical plant, even where the product can be described as being a "chemical". However, its meaning should still be taken to include "for commercial purposes". The most common scenario for the "manufacture of a chemical" is mixing or formulation - but simple dilution of acids, alkalis or salts would not usually be regarded as listed activities."

It is understood that the activities undertaken at CISM are for research and development purposes and the semiconductors are not sold for financial gain, although the definition in note 4.3 encompasses 'market testing' within 'commercial purposes'. Further clarification is needed from CISM as to whether the activities undertaken

are considered 'market testing' (and will proceed to commercial sales in the future). The note 4.3 examples include further commentary, in particular, in:

Example 2 that: *"Producing a pesticide in multi-kilogram quantities for the purpose of field tests by farmers would be an example of production for market testing and therefore production for commercial purposes; producing the same [chemical] in-house in smaller quantities to establish basic efficacy or undesirable effects, would normally be a research activity. In general, when undertaken in-house, only production intended to test or demonstrate the commercial viability of the [chemical] (usually through distribution to third parties) would be likely to meet the test for commercial purposes"*.

Example 4 that: *"Producing a novel substance (or even supplying a known compound) for the R&D programme of a separate pharmaceutical company is considered to be producing for "commercial purposes", whatever the end-use of the substance supplied - but the requirement for a Permit will also depend on whether or not the installation meets the "industrial" and other criteria for "Chemical plant" (Note 4.2)"*

It has been assumed that the production of the semiconductors is purely for research and development purposes to be carried out in-house (and for which CISM has been set up to do) to refine the best processes / materials etc that could be used to produce semiconductors and that information will be passed on to the wider CISM network of partners who will themselves produce the products for sale rather than Swansea University CISM site. It could therefore be argued an environmental permit for a section 4.2 A(1)(c) installation is not required however further information is required to confirm these assumptions including the extent of 'backend materials integration and packaging capabilities' activities and any potential integration with customers renting space at the facility ('customer bays for SME incubation). Once clarified this should be discussed with Natural Resources Wales, particularly with reference to Note 4.3 examples 2 and 4 and how Natural Resources Wales view the CISM research and development programme.

4. COMAH

The COMAH Regulations aim to limit the consequences of a major accident to people, local communities and the environment. COMAH thresholds are set for dangerous substances and where these will be met / exceeded the COMAH Competent Authority must be formally notified.

The Control of Major Accident Hazards Regulations 2015 defines 'dangerous substances' as *"(subject to regulation 3(2)(b) and (c)) a substance or mixture—*

- (a) listed in column 1 of Part 2 of Schedule 1; or*
- (b) in a category listed in column 1 of Part 1 of Schedule 1"*

This includes specific listed substances (a) and those with hazardous properties (b).

As noted in section 1, CISM use a number of hazardous substances in their processes on site and more detail on volumes / masses stored of these substances needs to be provided in order to determine whether COMAH threshold are being / will be met / exceeded, requiring a COMAH notification.

5. Hazardous Substances Consent

Hazardous Substances Consent ('HSC') is needed if specified hazardous substances (see Schedule 1 to the Planning (Hazardous Substances) Regulations 2015) are stored or used at or above specified controlled quantities however a consent may also be required for the presence of hazardous substances below the controlled quantity specified for that substance:

- Where more than one hazardous substance with the same type of hazard is present then all of those substances are added together to determine whether consent is required for them.
- Other substances used in processes where a hazardous substance could be generated as a result of a loss of control of the process. Operators should consider all types of scenarios including during storage that are reasonable to foresee and may lead to hazardous substances being generated. [1].

HSC is required for hazardous substances present at any establishment that falls within the scope of the Seveso III Directive (2012/18/EU), whose aim is the prevention of major accidents involving dangerous substances. 'Establishment' is defined in Article 3 of the directive and means any installation or collection of installations which are within an area of land under the control of the same person or body [1].

HSC is a planning control enabling the hazardous substances authority (normally the same as the local planning authority) to decide on the whether the presence of hazardous substances are appropriate in relation to risk to the community [2].

The [COMAH competent authority](#) (in most cases HSE and Natural Resources Wales acting jointly) advises the hazardous substances authority on the nature and severity of the risk to persons in the vicinity and the local environment arising from the presence of a hazardous substance. The COMAH competent authority is a statutory consultee and must be consulted by the hazardous substances authority before hazardous substances consent can be granted.

When the application for a HSC is made, the COMAH competent authority create a three-zone map (hazardous substances consultation zones) which is issued to the local planning authority (LPA) detailing three levels of risk zones. If any future planning applications are proposed within these zones the LPA is required to consult the COMAH competent authority [3] [2].

HSE guidance [2] recommends applying for HSC in parallel with any COMAH preparatory work.

Once further information on the quantities of dangerous substances stored on site is known, and the requirements of the Planning (Hazardous Substances) Regulations 2015 can be explored in more detail, a decision on whether or not HSC is needed can be made.

6. Discharge of effluents

It is assumed that there are no proposals to make any discharges from CISM to watercourses or waterbodies, ground or groundwater. If any are proposed, they should be reviewed to determine the position with regard to permitting.

Any discharge of effluent from the CISM building to the sewerage system is likely to need a Trade Effluent Consent under the Water Industry Act 1991; this requires an application to Dŵr Cymru Welsh Water, which requires details including, information on the applicant, location and nature, volume and composition of the trade effluent.

7. Further Information Required / Clarifications

1. Are the 'backend materials integration and packaging capability' facilities limited to construction of microchips from the manufactured materials that are retained on site?
2. Confirmation that no part of the process will be integrated with any customer renting space at the facility who may use their own equipment.
3. Please provide quantities of hazardous substances stored on site
4. Confirmation that the Swansea University CISM site will not be manufacturing semiconductors for sale or market testing semiconductors ahead of future sale
5. Confirmation that the activities will be solely research and development relating to processes / materials / technology etc and that no semiconductors or components of semiconductors will be supplied to wider CISM partners / customers / third parties (i.e. only the information / data derived from research and development activities will be supplied).

6. Confirmation of capable annual throughput of 'production' of semiconductors or components at the CISM facility
7. In relation to the furnaces, confirmation that all are electric.
8. If the furnaces are not all electric and / or there are any other combustion plant at the facility, including generators, further information should be provided including rated thermal input, the use of the plant and details of any capacity agreement or agreement to provide balancing services.

8. Recommendations & Conclusions

The facility may be exempt from environmental permitting requirements for EPR 2016 (as amended) Schedule 1, Part 2, Chapter 4 chemical activities and Schedule 14 solvent emissions activities, based on the facilities use as a research and development facility but further information, as noted in section 7, is required in order to confirm this understanding.

The facility is very likely to be exempt from environmental permitting requirements relating to medium combustion plant based on Atkins' understanding that no combustion plant is used at the facility and the furnaces are powered by electric.

The facility uses hazardous substances covered by COMAH and therefore there is a potential that the facility may need to be registered as a COMAH facility. Further information on masses / volumes stored is required to clarify the position.

The facility uses hazardous substances covered by the Planning (Hazardous Substances) Regulations 2015 and therefore there is a potential that the facility may need an HSC. Further information on masses / volumes stored is required to clarify the position.

It is recommended that further information is gathered as noted in section 7 to confirm the environmental permitting and COMAH requirements. Once the requirements have been clarified discussions should be held with Natural Resources Wales (and potentially the Local Authority if any activities fall under Part A(2) or Part B of the EPR 2016 (as amended) Schedule 1, Part 2) to confirm the position with the regulator.

9. References

- [1] Ministry of Housing, Communities and Local Government, “Hazardous Substances,” November 2019. [Online]. Available: <https://www.gov.uk/guidance/hazardous-substances#Deciding-hazardous-substances-consent>. [Accessed November 2019].
- [2] Health & Safety Executive, “HSE’s Understanding COMAH: A Guide to New Entrants,” November 2013. [Online]. Available: <http://www.hse.gov.uk/comah/guidance/understanding-comah-new-entrants.pdf>. [Accessed November 2019].
- [3] Planning Inspectorate, “Other Planning Permissions You May Require: Hazardous Substances Consent ,” [Online]. Available: https://www.planningportal.co.uk/info/200187/your_responsibilities/40/other_permissions_you_may_require/13. [Accessed November 2019].