Directive 98/8/EC concerning the placing of biocidal products on the market

Inclusion of active substances in Annex I to Directive 98/8/EC

Assessment Report

ACROLEIN

Product-type 12 (SLIMICIDE)

Annex I

ACROLEIN (PT12)

Assessment Report

Finalised in the Standing Committee on Biocidal Products at its meeting in September 2009 in view of its inclusion in Annex I to Directive 98/8/EC

CONTENTS

1. STATEMENT OF SUBJECT MATTER AND PURPOSE 4
1.1. Procedure followed 4
1.2. Purpose of the assessment report 4
1.3. Overall conclusion in the context of Directive 98/8/EC 5
2. OVERALL SUMMARY AND CONCLUSIONS 6
2.1. Presentation of the Active Substance 6
2.1.1. Identity, Physico-Chemical Properties and Methods of Analysis 6
2.1.2. Intended Uses and Efficacy 6
2.1.3. Classification and Labelling 6
2.2. Summary of the Risk Assessment 7
2.2.1. Human Health Risk Assessment 7
2.2.2. Environmental Risk Assessment 18
2.2.3. List of Endpoints 27
3. DECISION 28
3.1. Background to the Decision 28
3.2. Decision regarding Inclusion in Annex I 28
3.3. Elements to be taken into account by Member States when authorising products 28
3.4. Requirement for further information 30
3.5. Updating this Assessment Report 30
APPENDIX I: LIST OF ENDPOINTS 31
Chapter 1: Identity, Physical and Chemical Properties, Classification and Labelling 31
Chapter 2: Methods of Analysis 34
Chapter 3: Impact on Human Health 36
Chapter 4: Fate and Behaviour in the Environment 41
Chapter 5: Effects on Non-target Species 45

Chapter 6: Other End Points 47

APPENDIX II: LIST OF INTENDED USES.....48

1. STATEMENT OF SUBJECT MATTER AND PURPOSE

1.1. Procedure followed

This assessment report has been established as a result of the evaluation of Acrolein as product-type 12 (Slimicide), carried out in the context of the evaluation of new active substances provided for in Article 8(2) of Directive 98/8/EC concerning the placing of biocidal products on the market[1], with a view to the possible inclusion of this substance into Annex I to the Directive.

Acrolein (CAS no. 107-02-8) was notified as a new active substance, by Baker Petrolite Ltd, hereafter referred to as the applicant, in product-type 12. The United Kingdom was chosen as Rapporteur Member State to carry out the assessment on the basis of the dossier submitted by the applicant.

On 20 December 2005 the UK competent authorities received a dossier from the applicant. The Rapporteur Member State accepted the dossier as complete for the purpose of the evaluation on 18 July 2006.

On 11 June 2008 the Rapporteur Member State submitted to the Commission and the applicant a copy of the evaluation report, hereafter referred to as the competent authority report. The Commission made the report available to all Member States by electronic means on 17 June 2008. The competent authority report included a recommendation for the inclusion of Acrolein in Annex I to the Directive for PT 12.

In order to review the competent authority report and the comments received on it, consultations of technical experts from all Member States (peer review) were organised by the Commission. Revisions agreed upon were presented at the TMIV08 Technical Meeting held in December 2008 and the competent authority report was amended accordingly.

The present assessment report contains the conclusions of the Standing Committee on Biocidal Products, as discussed during its meeting held on May 2009.

1.2. Purpose of the assessment report

This assessment report has been developed in support of the decision to include Acrolein in Annex I to Directive 98/8/EC for product-type 12. The aim of the assessment report is to facilitate the authorisation in Member States of individual biocidal products in product-type 12 that contain Acrolein. In their evaluation, Member States shall apply the provisions of Directive 98/8/EC, in particular the provisions of Article 5 as well as the common principles laid down in Annex VI.

For the implementation of the common principles of Annex VI, the content and conclusions of this assessment report shall be taken into account.

1 Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing biocidal products on the market. OJ L 123, 24.4.98, p.1

However, where conclusions of this assessment report are based on data protected under the provisions of Directive 98/8/EC, such conclusions may not be used to the benefit of another applicant, unless access to these data has been granted.

1.3. Overall conclusion in the context of Directive 98/8/EC

The overall conclusion from the evaluation is that it may be expected that there are products containing Acrolein for the product-type 12 which will fulfil the requirements laid down in Article 10(1) and (2) of Directive 98/8/EC. This conclusion is however subject to:

i. compliance with the particular requirements set out in this assessment report,

ii. the implementation of the provisions of Article 5(1) of Directive 98/8/EC, and

iii. the common principles laid down in Annex VI to Directive 98/8/EC.

Furthermore, these conclusions were reached within the framework of the uses that were proposed and supported by the applicant (see Appendix II). Extension of the use pattern beyond those described will require an evaluation at product authorisation level in order to establish whether the proposed extensions of use will satisfy the requirements of Article 5(1) and of the common principles laid down in Annex VI to Directive 98/8/EC.

2. OVERALL SUMMARY AND CONCLUSIONS

2.1. Presentation of the Active Substance

2.1.1. Identity, Physico-Chemical Properties and Methods of Analysis

The evaluation has established that for the active substance notified by Baker Petrolite none of the manufacturing impurities and additives are considered to be of potential concern.

The methods of analysis for the active substance as manufactured, and for the determination of impurities and additives, have been validated.

2.1.2. Intended Uses and Efficacy

The assessment of the biocidal activity of the active substance demonstrates that it has a sufficient level of efficacy against the target organism(s) and the evaluation of the summary data provided in support of the efficacy of the accompanying product, establishes that the product may be expected to be efficacious.

In addition, in order to facilitate the work of Member States in granting or reviewing authorisations, and to apply adequately the provisions of Article 5(1) of Directive 98/8/EC and the common principles laid down in Annex VI of that Directive, the intended uses of the substance, as identified during the evaluation process, are listed in Appendix II.

2.1.3. Classification and Labelling

On the basis of this review, the UK CA proposes the following classification for acrolein, given in Table 2.1. As the representative product is almost identical, the classification and labelling is the same.

Table 2.1 UK CAs proposed classification for Acrolein and the representative product (Magnacide B® Microbiocide) following evaluation

Classification	**UK CAs proposed classification for acrolein and the representative product (Magnacide B® Microbiocide) following evaluation**
Class of danger	T+: Very toxic T: Toxic, F: Highly flammable C: Corrosive, N: Dangerous to the environment
R-phrases	R11: Highly flammable R24: Toxic in contact with skin. R26/28: Very toxic by inhalation and if swallowed. R34: Causes burns R50: Very toxic to aquatic organisms

2.2. Summary of the Risk Assessment

2.2.1. Human Health Risk Assessment

2.2.1.1. Hazard identification

2.2.1.1.1. Toxicology Hazard Summary

The toxicity of acrolein has not been investigated in humans, although this is not considered to be a data gap. Many of the animal studies were completed before the introduction of specific guidelines or GLP practices, and so the quality of some of these studies is lower than would be expected of studies completed recently. However, the data obtained from these studies is of a standard acceptable for the purpose of this review. Studies to assess the toxicological hazards of acute toxicity, irritation, sensitisation, repeat dose toxicity, mutagenicity, carcinogenicity, developmental toxicity and fertility have been performed. Toxicity caused by acrolein is predominantly due to its highly reactive nature; consequently effects consistent with this (i.e. local irritation) are found in all species via all exposure routes.

Acrolein is very toxic via the oral and inhalation routes and toxic following dermal application. There were no differences in sensitivity between sexes or the 3 rodent species tested. Following all routes of exposure, signs of local toxicity consistent with the corrosive potential of acrolein were observed. The oral LD_{50} values reported for acrolein (10.3 mg/kg and 11.8 mg/kg for male and female rats, respectively and 13.9 mg/kg and 17.7 mg/kg for male and female mice, respectively) indicate classification with T+; R28 is appropriate; the dermal LD_{50} value (LD_{50} 231 mg/kg) indicates classification with T; R24 is appropriate; and the inhalation LC_{50} values (LC_{50} 57.9 mg m^{-3} and 18.5 mg m^{-3} for one and four hour exposures, respectively) that classification with T+; R26 is appropriate.

Skin lesions of varying severity (including necrosis) were observed in an acute dermal study at dose levels of 200 mg/kg bw and above, and skin necrosis at dose levels of 7 mg/kg bw/d and upwards was observed in a 21 day dermal repeated dose study. These data have been considered by the EU Classification and Labelling Working Group and acrolein is accordingly classified with Corrosive, R34. Evidence of acrolein's potential to act directly at the respiratory tract and cause effects consistent with local irritation (i.e. epithelial necrosis) has been observed in acute inhalation studies. It can be concluded that acrolein meets the EU criteria for classification as a respiratory tract irritant (Xi; R37); however, this is not necessary as acrolein is classified with C; R34.

An adequate animal study for sensitisation is not available. Further animal sensitisation studies have not been performed due to animal welfare concerns, based upon acrolein's corrosive nature. Given that acrolein is classified as C; R34, appropriate risk mitigation measures should be in place to prevent any exposures that could result in skin sensitisation. Classification for skin sensitisation is not proposed.

The effect of repeated exposure to acrolein has been investigated by the oral, dermal and inhalation routes across a number of species. The toxic effects associated with acrolein exposure by all routes are consistent with reactivity at the site of contact. Consequently, the NOAELs derived from these studies relate to local rather than systemic toxicity.

The effect of acrolein following repeated oral exposure has been investigated in rats, mice and dogs. In a rat 90 day study, no significant, treatment-related toxicity was observed at 5 mg/kg bw/d (the highest dose tested); while in a 2 year study a NOAEL of 0.05 mg/kg bw/d was identified (based on increased mortality at higher dose levels). In a mouse 14 day study, a NOAEL of 4.6 mg/kg bw/d was identified (based on local irritation and mortality at higher dose levels); while in an 18 month study, a NOAEL of 2 mg/kg bw/d was identified (based on increased mortality at higher dose levels). In a 1 year dog study, a NOAEL of 0.1 mg/kg bw/d was identified (based on an increased frequency of vomiting as a consequence of local irritation).

The effect of acrolein following repeated dermal exposure has been investigated in a 3 week study in rabbits. A NOAEL could not be identified, given that a significant reduction in bodyweight gain and local irritation (including dermal necrosis) were reported in increasing severity from 7 mg/kg bw/d, the lowest dose tested.

The effect of acrolein following repeated inhalation exposure has been investigated in rats, mice, dogs, rabbits, hamsters, guinea pigs and monkeys in studies of limited quality. Following exposure of rats, guinea pigs, dogs and monkeys 8 h/d, 5 d/wk for 6 weeks, effects consistent with local toxicity were observed across all species at a dose level of 0.7 ppm (1.6 mg m^{-3}), the lowest dose tested. Following intermittent exposure of rats, rabbits and hamsters, 6 h/d, 5 d/wk for 90 d, the rat proved the most sensitive species with signs of respiratory tract irritation reported at a dose level of 0.4 ppm (0.9 mg m^{-3}), the lowest dose tested. Following 90 day continuous exposure of rats, guinea pigs, dogs and monkeys, signs of toxicity were reported in all species apart from rats, at 0.22 ppm (0.5 mg m^{-3}), the lowest dose tested. Overall, an inhalation NOAEC could not be identified from any of these studies.

In the oral studies, deaths were observed at dose levels of less than 5 mg/kg bw/d, which is the cut off dose level for classification for this endpoint. Although this cut-off relates to a 90 day study, the deaths occurred early in the lifetime studies. The dose levels at which the deaths were observed are low enough to indicate that classification with R48/25 may be appropriate. However, the cause of the deaths cannot be definitely attributed to the toxic effects of acrolein. The European Commission Working Group on the Classification and Labelling of Dangerous Substances considered these data in 1999 and concluded that it was not appropriate to classify acrolein for repeated dose toxicity as the deaths could be attributed to local corrosion. Therefore, the UK CA does not propose classification for this endpoint.

Deaths occurred in a 21 day dermal study at doses of 21 mg/kg bw/d. The cut off dose for classifying with R48/24 is 10 mg/kg bw/d for a 90 day study. Assuming a linear multiplication, a cut-off of 30 mg/kg bw/d would be appropriate for a 21 day study. Thus, classification with R48/24 should be considered. However, the effects observed are likely to be a result of local corrosion, therefore, the UK CA does not support classification for repeated dose effects.

Toxicity manifested as death or lung emphysema was found at doses of 3.7 ppm to 4.9 ppm (equivalent to 8.5 – 11.3 mg m^{-3}) in inhalation studies in rodents, monkeys and dogs with exposure duration ranging from 42 to 90 days. The cut off for classification with R48/23 is 25 mg m^{-3} for a 90 day study. Thus, classification may be considered appropriate. However, the European Commission Working Group on the Classification and Labelling of Dangerous Substances considered the inhalation data in 1999 and concluded that it was not appropriate to

classify acrolein for repeated dose toxicity as the deaths could be attributed to local corrosion. Therefore, the UK CA does not propose classification for this endpoint.

In vitro, acrolein produced positive results in bacteria cell gene mutation assays, while in mammalian cells negative results were reported in standard gene mutation and chromosome aberration assays performed across a number of different cell lines. *In vivo*, acrolein produced negative results in a rat bone marrow micronucleus test and in mouse dominant lethal assays.

The positive results observed *in vitro* in bacteria indicate that a second *in vivo* assay should be conducted. However, given the corrosive nature of acrolein, the UK CA does not consider that additional *in vivo* testing is appropriate based on animal welfare considerations. In addition, the use of biocidal products containing acrolein in this dossier is restricted to the occupational environment where exposure is expected to be minimal.

Overall, based on the available genotoxicity data and the fact that no treatment-related tumours were reported in rat and mouse carcinogenicity assays, the UK CA does not consider classification for genotoxicity to be appropriate.

Acrolein has been tested for carcinogenicity in a 2-year gavage study in Sprague- Dawley rats and an 18-month gavage study in CD-1 mice. No significant increases in tumours or neoplastic changes were observed. However, the validity of the results of these studies may be diminished by the survival rates reported at all dose levels. Given the absence of an increase above controls of tumours or neoplastic effects, coupled with the lack of genotoxic activity in *in vivo* tests, it is considered to be sufficient evidence to conclude that acrolein does not show carcinogenic potential. Based on these data, the UK CA does not consider classification for carcinogenicity to be appropriate.

The potential of acrolein to induce developmental toxicity has been investigated in rats, mice and rabbits. In rabbits, no toxicologically significant, treatment-related toxicity was reported. In rats and mice, evidence of developmental toxicity was observed but in most cases this was observed at doses causing marked maternal toxicity in the dams and was considered to be a secondary, non-specific consequence to maternal toxicity. However, the only evidence of possible specific developmental toxicity was observed in mice at a dose level of 6.3 mg/kg/day and above, reported as the presence of subcutaneous oedema. Unfortunately the test report is poorly written and provides no information on the severity of the subcutaneous oedema. As a consequence, it is not known whether this recorded change is a slight localised oedema, which is considered to be a very minor change and unlikely to have adverse health consequences; or anasarca (a generalised accumulation of fluid in the subcutaneous tissues and body cavities), which is considered to be a severe change. To try to gain a better understanding of the toxicological significance of the actual change that occurred in the mouse study, the Applicant has provided additional background information on the condition of anasarca, which is considered below.

The Applicant identified two possible aetiologies for anasarca (also described as hydrops fetalis), one immune-related and the other non-immune-related. In the immune-related condition, anasarca is associated with alloimmune general foetal haemolysis (as a result of maternal antibodies passing through the placenta into the foetus). However, no evidence of haemolysis in the foetuses was reported in the mouse study, indicating that it is unlikely the change recorded as subcutaneous oedema was an immune-related anasarca. It should be noted

that although an increased incidence of haemorrhage was present in the acrolein treated groups, this is likely to be the result of extravasation of whole blood rather than lysis of erythrocytes, possibly as a result of the procedures used to handle the foetuses. Supporting evidence for the absence of haematotoxicity following exposure to acrolein comes from the repeated doses studies, in which no evidence for haematotoxicity was observed.

Non-immune anasarca can have a more diverse aetiology, but tends to be associated with cardiovascular disease, including arrhythmias, myocardial infarction, angiomas, premature closure of the foramen ovale, right or left heart hypoplasia and single ventricle. The cardiovascular disease is thought to lead to fluid balance problems which manifest as widespread and marked oedema. Major morphological changes in the cardiovascular system would probably be detectable in the mouse developmental toxicity study, but effects such as arrhythmias and myocardial infarction would not. In the mouse study, the increased incidence of subcutaneous oedema was not associated with any cardiac malformations. This suggests that the change recorded as subcutaneous oedema was less likely to be non-immune anasarca.

Additional evidence that the reported subcutaneous oedema was unlikely to be anasarca is provided by an analysis of the foetal bodyweight data. If anasarca was present it would be expected that foetal bodyweight would be increased. However, in the mouse study, group mean foetal bodyweight in the highest dose group, in which over 30 % of the foetuses examined were reported to show subcutaneous oedema, is slightly lower than controls. Unfortunately, individual foetal data is not available to conduct a more detailed analysis of the relationship between foetal bodyweight and the presence of subcutaneous oedema.

Overall, the weight of evidence suggested that the change in mice recorded as subcutaneous oedema is a minor variation. As a result of this, classification for developmental toxicity is not considered to be appropriate. Additional support for this position is provided by the developmental toxicity studies in rats and rabbits in which no evidence of developmental toxicity was observed.

Effects on fertility parameters due to acrolein were not observed in two 2-generation studies in different strains of rat when administered at doses of up to 7.2 mg/kg bw/d. The only effect seen in pups was a reduction in body weight in one of the studies at a dose where severe parental toxicity was observed. NOAELs for parental toxicity of 1 mg/kg bw/d and for foetotoxicity of 3 mg/kg bw/d were identified. The available information indicates that classification for fertility effects is not appropriate.

2.2.1.1.2. Critical Endpoints

The lead health effect following exposure to acrolein is corrosivity with toxicity manifested at the site of contact. Acrolein is classified as Very Toxic following acute inhalation exposure.

Following repeat inhalation exposure, a LOAEC of 0.4 ppm (0.9 mg m^{-3}) is identified in rats (the most sensitive species) following intermittent exposure 6 h/d, 5 d/wk for 90 d. This value will be used in the risk characterisation. At this concentration, slight squamous metaplasia was observed in the nasal cavity of one rat.

2.2.1.1.3. Uncertainties

Dermal Absorption Values Used in the Risk Assessment

A dermal absorption study has not been conducted using acrolein. A QSAR dermal penetration assessment indicates that 2 % acrolein is absorbed over the first hour following a single dermal application. However, this study is based upon a 1 % solution of acrolein, whereas its concentration in the technical grade substance is 92 to 97 %. Due to the discrepancy in the concentration of acrolein used, this assessment is not considered useful. Consequently, the default value, as prescribed by the Technical Guidance Document on Risk Assessment, is applicable. Acrolein has a molecular weight of 56.06 and a log Pow of 0.04. Thus, the UK proposes to use a worst-case dermal absorption value of 100 % acrolein for the risk characterisation of acrolein.

Inter- and Intra-species Variability

The toxicity caused by acrolein via oral, dermal or inhalation exposure results from local irritation/corrosivity as a result of its chemical reactivity. There is no definitive information available to identify the relative sensitivities of humans compared with experimental animals in relation to the ability of acrolein to cause these effects. The assessment factors for both intraspecies and interspecies variability are derived based on the methodology described in the Guidance Document "Risk Characterisation of Local Effects" agreed at Biocides Technical Meeting I 2009. With regard to interspecies variability, no assessment factor is necessary for oral and dermal exposure scenarios, while for inhalation exposure scenarios a factor of 2.5 will be used (to account for the assumption that humans will be more sensitive than animals to effects on the respiratory tract). With regard to intraspecies variability, acrolein produces local irritation on contact by virtue of its highly reactive nature. This will occur in the absence of metabolic transformation of the acrolein molecule. Consequently, toxicokinetic variability in the human population will not influence the potential of acrolein to induce local irritation. Therefore, it is not considered necessary to include the toxicokinetic element of the intraspecies factor and only the toxicodynamic factor of 3.2 will be used for oral, dermal and inhalation exposure scenarios.

Route to Route Extrapolation

Due to the corrosive nature of acrolein, toxicity associated with exposure is manifested locally, therefore only local effects caused by local concentrations of acrolein are considered relevant to the risk characterisation. Based on the use patterns identified within this dossier for this product, no exposure via the oral route is anticipated. In addition, it is predicted that dermal exposure will be very low, so dermal exposure scenarios are not considered further. Relevant inhalation studies are available, therefore, comparison of exposure routes for the purposes of route-to-route extrapolation is not necessary for this risk characterisation. A direct comparison will be made with the predicted air concentrations (in mg m^{-3}) to establish a MOE and this will also be compared with the calculated Acceptable Exposure Concentration (AEC).

Dose-response/severity of key health effect

Following single exposure to acrolein, classification with Very Toxic following inhalation and oral exposure (T+; R26/28) and Toxic following dermal exposure (T; R24) is considered

appropriate. However, the lead health effect for acrolein is corrosivity (classification with C; R34 is appropriate) manifested as toxicity at the site of contact following both single and repeated exposures. Of the inhalation studies available, the most comparable to OECD guidelines involved intermittent exposure 6 h/d, 5 d/wk for 90 d, and this will be used as the basis of the risk characterisation for acute, medium term and chronic inhalation exposure scenarios. In this study, a LOAEC of 0.4 ppm (0.9 mg m^{-3}) was identified in rats following intermittent inhalation exposure (whole body) 6 h/d, 5 d/wk for 90 d, based on metaplastic and inflammatory changes in the nasal cavity of a single male. At 1.4 and 4.9 ppm (3.2 and 11.3 mg m^{-3}), changes in the respiratory tract (destruction and hyper- and metaplasia of the epithelial lining and inflammatory alterations) were observed with increasing severity, number of sites and numbers of animals affected, all animals of the high dose group having changes in the epithelial lining of the nasal cavity, occasional necrotising rhinitis and tracheal effects. Effects on the bronchi were also observed in the top dose group (focal bronchopneumonia and bronchitis, bronchiolitis, increased numbers of mucus producing cells and accumulation of alveolar macrophages). Three rats of each sex died in the high dose group; oedema, collapsed areas of lung and haemorrhage were observed. Significant decreases in bodyweight were observed at 1.4 and 4.9 ppm (2/8 %, 15/13 % and 38/25 % for males/females in 0.4, 1.4 and 4.9 ppm (0.9, 3.2 and 11.3 mg m^{-3}) dose groups, respectively). An increase in relative organ weights (lung, heart, kidneys and adrenals) was observed in the top dose group.

As this study yields a LOAEC (at which only slight effects were seen) but not a NOAEC, an additional assessment factor of 3 will be applied to the rat LOAEC to estimate the highest no-effect concentration in the rat. For chronic inhalation exposure scenarios an additional assessment factor of 2 will be applied as the LOAEC is extrapolated from a subchronic to a chronic study.

Thus, for acute and medium term exposure scenarios an overall assessment factor of 24 (interspecies: 2.5 **x** intraspecies: 3.2 **x** LOAEC to NOAEC: 3) will be used; this is equivalent to an AEC value of 0.0375 mg m^{-3}. For chronic inhalation exposure scenarios an overall assessment factor of 48 (interspecies: 2.5 **x** intraspecies: 3.2 **x** LOAEC to NOAEC: 3 **x** subchronic to chronic study: 2) will be used; this is equivalent to an AEC value of 0.019 mg m^{-3}.

2.2.1.2. Exposure assessment

2.2.1.2.1. Industrial/professional users

Production / formulation of active substance and formulated products

Magnacide B® Microbiocide is technical grade acrolein. It is manufactured and packaged in the United States of America (USA) and shipped into the EU ready for use, hence there are no production/formulation exposure scenarios to consider for this product.

Application of product

Magnacide B® Microbiocide is to be used as a slimicide to control bacteria in produced water and water injection systems on offshore oil rigs. It is stored in cylinders or tanks and will be injected into the water system using enclosed pressurised transfer lines (typically pressurised to

around 270 – 340 kPa and never above 550 kPa). This product is always used in an enclosed system, therefore under normal conditions of use there should be negligible exposure.

Relevant exposure paths

A potential for primary exposure to operators occurs as a result of handling the acrolein injection lines during the setting up, monitoring and dismantling of the equipment and in the event of an unexpected small scale release during the application process. The procedure for setting up equipment prior to an acrolein treatment includes checks for leaks. In addition, there is a requirement to purge lines with nitrogen and flush with methanol at the end of treatment and in the rare event that there is a need to change tanks/cylinders during treatment. This is intended to prevent polymerisation of residual acrolein in the treatment lines and will also minimise the potential for exposure during coupling and uncoupling tasks. It is considered that exposure as a result of unexpected small scale releases could theoretically occur by the dermal and inhalation routes. The main routes of exposure are summarised in Table 2.2.

Table 2.2 Summary of human exposure paths to acrolein

Exposure path	Industrial use	Professional use*	General public	Via the environment
Inhalation	Not applicable	Yes**	Not applicable	No
Dermal	Not applicable	Yes**	Not applicable	No
Oral	Not applicable	No	Not applicable	No
* Includes professional operators and secondary exposures to other oil rig workers. ** Unexpected small scale releases only.				

There are no measured exposure data for this product that are relevant for treatments carried out in the conditions likely to be experienced in the North Sea. No indicative exposure values are available in the TNsG for the use scenarios described above. The UK CA has therefore compared the control approaches recommended by the applicant with the approaches that comply with the requirements of the Framework Directive (89/391/EEC) and the Chemical Agents Directive (98/24/EC). The UK CA has also used the Estimation and Assessment of Substance Exposure (EASE) model described in the TNsG (Part 2, page 219) to estimate typical exposures.

Acrolein is classified as very toxic by inhalation (R26). For medium scale use i.e. kilogramme quantities of a highly volatile liquid with this hazard the UK CA considers that full enclosure is the most appropriate control strategy. This is the approach that is proposed by the applicant with the requirement for suitable PPE for tasks where there is the greatest potential for unintended small scale releases. To protect operators and others, alarms will be used in Magnacide B Microbiocide storage areas and on the operators' facilities at the injection pump skids to act as a warning against gross leaks that could lead to the formation of explosive atmospheres. Alarms will also indicate potentially toxic levels of acrolein. The UK CA considers that the measures set out by the applicant are appropriate.

The UK CA has used the EASE model to predict potential exposure during normal operation. For a highly volatile substance that is used in a fully contained closed process, EASE predicts that dermal exposure will be very low and therefore this is not considered further in the risk assessment. EASE predicts airborne concentrations of 0 – 0.1 ppm (0 – 0.23 mg m^{-3}; 6-hour TWA). On this basis it will be assumed that the maximum potential short-term or long-term exposure is 0.1 ppm (0.23 mg m^{-3}; 6-hour TWA). Since acrolein treatments are carried out using enclosed treatment lines and the operator is required to wear suitable coveralls, suitable gloves (e.g. butyl) and, where treatment lines are handled directly, suitable RPE (the Applicant specifies a full face air purifying respirator fitted with an organic vapour cartridge), in reality the potential for exposure is considered by the UK CA to be minimal.

2.2.1.3. Risk Characterisation

Primary exposure

Risk characterisation for the product

As previously stated, given that local toxicity is the key health concern following inhalation exposure to acrolein, the risk characterisation will be conducted by comparing external concentrations using the margin of exposure (MOE) and the AEC approaches. It is not appropriate to calculate systemic doses and so the Acceptable Exposure Level (AEL) approach is not included in the risk characterisation. The maximum estimated exposure to Magnacide B Microbiocide obtained from the EASE model has been compared to the LOAEC of 0.4 ppm (0.9 mg m^{-3}) obtained in rats, considered appropriate for the risk characterisation of acute and medium term exposure scenarios. From these external values, an MOE is calculated. This will be compared with the overall Assessment Factor of 24 (2.5 for interspecies variation, 3.2 for intraspecies variation and 3 for using a LOAEL as the starting point). It is assumed that if the MOE is ≥ 24, then the risks to the professional user under the conditions specified are acceptable. In addition, the calculated exposure value is compared to the AEC for acute/medium term of 0.0375 mg m^{-3} for inhalation exposure scenarios. If the calculated exposure value is below the AEC then the risks to the professional user under the conditions specified are acceptable. As the EASE model does not take account of the use of PPE, the calculation of the MOE presented below in Table 2.3 is made assuming no PPE is worn.

Table 2.3 Summary of predicted primary inhalation exposure during a 6 hour application based on EASE estimates

Exposure scenario	Recommended PPE	Uptake by inhalation (worst case)	LOAEL	MoE
Weekly application of product at a treatment rate of 250 mg/l	Full face air purifying respirator fitted with organic vapour cartridge, suitable gloves, suitable overall	EASE predicts a maximum exposure of 0.1 ppm (0.23 mg m^{-3}); 6-hour TWA)	0.4 ppm (0.9 mg m^{-3})	4
Daily application of product at a treatment rate of 50 mg/l	Full face air purifying respirator fitted with organic vapour cartridge, suitable gloves, suitable overall	EASE predicts a maximum exposure of 0.1 ppm (0.23 mg m^{-3}); 6-hour TWA)	0.4 ppm (0.9 mg m^{-3})	4

EASE predicts an exposure of 0.23 mg m^{-3}, in the absence of protective equipment, which is clearly above the AEC value of 0.0375 mg $m^{-3}$and leads to an MOE of 4 (ie < 24). Therefore, in the absence of protective equipment this would not be considered to represent a level of acceptable risk. However, this MOE of 4 does not take account of the requirement for Magnacide B Microbiocide operators to wear RPE when handling the treatment lines. Hence in reality, exposure will be much lower than the worst case prediction used here and there will be a much greater margin of exposure. In addition, as acrolein is corrosive, any toxicity resulting from exposure to acrolein will be expressed as an immediate contact event and so, it is highly unlikely that exposure will be prolonged, as exposed personnel will remove themselves from the vicinity of the exposure. As a consequence of this, comparison of the LOAEL of 0.4 ppm (0.9 mg m^{-3}) following exposure for 6 h/d, 5 d/wk for 90 d represents a conservative approach. On this basis, the UK CA considers that the risks to operators from the use of Magnacide B Microbiocide following the procedures specified by the applicant are acceptable.

Assessment of risks from the presence of impurities of concern in the active substance

Magnacide B® Microbiocide is technical grade acrolein with a purity range 92 - 98 %. The EU Preparations Directive (99/45/EC) identifies situations in which components in a preparation must be taken into account when determining the correct hazard classification for a preparation that is supplied into the EU market. Decisions on whether or not to include the hazards of particular components in the overall hazard classification for the preparation rest on the concentration at which each component is present. None of the additives and impurities in Magnacide B® Microbiocide are present at or above a concentration that would require their hazards to be taken into account. On this basis, the UK CA considers that the control measures that are proposed for Magnacide B® Microbiocide will be sufficient to minimise the risks that may arise from the additives and impurities that are present.

Amateur users including the general public

Slimicide products based on Acrolein are used exclusively by professional workers on off-shore oil rigs. There are no amateur uses for this product.

Secondary (indirect) exposure as a result of use

Relevant exposure paths

The only group potentially at risk from secondary exposure to Magnacide B® Microbiocide is oil rig personnel who are not directly involved with the acrolein treatment. Secondary exposure could potentially occur as a result of an unintended small scale release or via the produced water system. Various measures are proposed that will minimise the potential for secondary exposure to occur. To minimise the potential for secondary exposure as a result of an unintended small scale release, an exclusion zone is established around the application equipment during treatment to restrict access. All staff will be informed about the exclusion zone during the briefings that take place at the start of each work shift. The Framework Directive (89/391/EEC) places a duty upon employees to comply with safety instructions given to them by their employers. It is therefore to be expected that workers will comply with the requirement not to cross the barriers marking the perimeter of the exclusion zone.

Safeguards will also be put in place to minimise the chances for accidental exposure during routine water sampling or planned system maintenance immediately after treatment. The acrolein safety management programme will include instructions on the minimum time that must elapse between acrolein treatment and any water sampling or planned maintenance. This will allow time for acrolein that has been introduced into the produced water system to degrade and for dislodged bacteria to be filtered out. The applicant indicates that a 2-day period would be typical. The UK CA notes that the half-life for hydrolysis of acrolein at 25°C and a pH of 9.3 has been determined to be 14 hours (Haag *et al* 1988a). The temperature of the oil/water mixture as it reaches the surface is typically around 50 – 60ºC but may reach temperatures up to 100 ºC in older oilfields. Although the water will cool during its passage through the produced water system, there is scope for degradation of injected acrolein by hydrolysis. Acrolein once injected into the produced water system will also be rapidly diluted by the large volume of water flowing through the produced water system (16966 m^3/day based on information used in the CHARM model). The UK CA therefore considers that a 2-day delay will be sufficient. It is expected that oil rig staff will be informed via the briefings about restrictions on water quality sampling and planned maintenance activities. Baker Petrolite will also place warning tags on access valves/ports that might be accessed. It is also noted that all tasks on offshore oil rigs are governed by a permit to work system and in many cases it is possible for access valves to pipelines to be locked closed from a central control room, preventing inadvertent access. The use of warning tags will reinforce the messages given during pre-shift briefings that the produced water system must not be accessed. Since employees are required under the Framework Directive (89/391/EEC) to comply with safety instructions given to them by their employers it is expected that workers will comply with any restrictions on water quality sampling and planned maintenance.

There is a potential for exposure if urgent maintenance work needs to be carried out during or immediately after treatment. In order for the pre-use risk assessment that is required under the Framework Directive (89/391/EEC) and Chemical Agents Directive (98/24/EC) to be suitable and sufficient it must consider the steps to be taken if such an event occurs.

Overall, the UK CA considers that these measures are sufficient to minimise secondary exposure. Given that secondary exposures are predicted to be minimal the UK CA has not attempted to calculate exposures for these scenarios.

Combined exposure

It is not considered necessary to assess combined exposure in this case since there are no other potential sources of exposure to acrolein.

Overall assessment of the risk for the use of the active substance in biocidal products

Risks from primary exposure

Since acrolein treatments are carried out using enclosed treatment lines and the operator is required to wear coveralls, suitable gloves and, where treatment lines are handled directly, suitable RPE, in reality the potential for exposure is considered by the UK CA to be minimal. An MOE of 4 has been determined in the absence of protective equipment based on the comparison of a worst case exposure value of 0.1 ppm (0.23 mg m^{-3}; 6-hour TWA) predicted from the EASE model with a LOAEC of 0.4 ppm (0.9 mg m^{-3}) from a rat inhalation study.

Although, this MOE is below the MOE value of 24 (and above the AEC of 0.0375 mg m^{-3}) considered to represent a level of acceptable risk, it does not take account of the requirement for Magnacide B Microbiocide operators to wear RPE when handling the treatment lines. Hence in reality, exposure will be much lower than the worst case prediction used here and there will be a much greater margin of exposure. In addition, any toxicity resulting from exposure to acrolein will be expressed as an immediate contact event and so, it is highly unlikely that exposure will be prolonged, as exposed personnel will remove themselves from the vicinity of the exposure. As a consequence of this, comparison of the LOAEL of 0.4 ppm (0.9 mg m^{-3})) following exposure for 6 hours per day, 5 days per week for 90 days represents a conservative approach. On this basis, the UK CA considers that the risks to operators from the use of Magnacide B Microbiocide following the procedures specified by the applicant are acceptable.

Risks from secondary exposure

The UK CA considers the measures described by the Applicant for use of the product are sufficient to minimise secondary exposure. Thus, the risks arising from secondary exposures are considered to be acceptable.

Risks from combined exposure

It is not considered necessary to assess combined exposure in this case since there are no other potential sources of exposure to acrolein.

2.2.2. *Environmental Risk Assessment*

2.2.2.1. Fate and distribution in the environment

Marine aquatic compartment (including sediment)

Predictions of the fate and behaviour of acrolein in the marine environment have by necessity been taken from data carried out under standard test guidelines, which are largely centred on the freshwater environment. Therefore, the applicability of the available data must be considered in terms of predicting the environmental behaviour of this substance in the proposed marine exposure scenario.

Firstly, distribution in the marine environment must be considered and the data most pertinent to this are the partition coefficients (log K_{ow} of 0.04 and K_{oc} of 150.3 l kg^{-1}), which are key parameters in defining the distribution between water and sediment in the marine environment. The 'Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC (new notified substances), Commission Regulation (EC) No 1499/94 (existing substances) and Directive 98/8/EC (biocidal products)' (EC, 2003) explains that the differences are mainly due to water solubility and speciation. In the case of acrolein, a highly soluble and polar compound, the impact of seawater on solubility is unlikely to be sufficiently great as to have a significant effect on the partitioning behaviour compared to freshwater. Therefore, no adjustment has been made for the marine assessment to the data provided. In addition, the TGD quotes a typical reduction factor on solubility conversions from freshwater to seawater of 1.36 (Xie *et al*,. 1997), which would equate to a solubility of 175 g l^{-1} (238/1.36) for acrolein at 25 ºC and is very high (even considering the temperature effects). Supporting data for this endpoint is available from the adsorption/desorption and soil degradation studies, which demonstrated that acrolein would remain largely in the water phase, with between only 20 and 30 % lost to either the sediment, degradation or the atmosphere.

Secondly, degradation in seawater is an important factor for this use pattern, as acrolein will be used to treat water injection and oil production systems (not drilling muds) against bacterial build-up, after which emissions directly to the ocean will occur. The ability of an environment to support the biodegradation of a xenobiotic depends primarily on the;

- presence of competent degraders,
- concentration,
- intrinsic properties of the chemical in question,
- concentration of the nutrients and organic matter along with
- the presence of molecular oxygen.

It is recognised that the degradation capacity of the marine environment varies greatly; with this capacity decreasing the further away from land the emission takes place. This is because open ocean environments tend to be less turbulent and lower in xenobiotics (lower adaptational potential), nutrients and organic matter compared to estuarine environments. Offshore environments are often characterised as oligotrophic. The low concentrations of xenobiotics are hardly degraded as primary substrates and, due to the low microbial biomass activity, the degradation of xenobiotics as secondary substrates is also assumed to be limited. Therefore, it is not surprising that acrolein was not found to be readily biodegradable in natural seawaters but

was in fact toxic or inhibitory to the seawater microorganisms; as can be expected at the concentrations tested (2.0 and 3.5 mg acrolein l^{-1}).

In the sediment environment around offshore oil platforms, whilst it can be expected that the associated microbial biomass may be more adapted to the degradation of xenobiotics, [that are continuously emitted through the various uses in oil production] the actual capacity for degradation will remain low by comparison with that of coastal or estuarine environments closer to land. In addition, the microbial communities in the water column and sediment surfaces will be subject to drift with currents suggesting that the establishment of stable communities of competent degraders will be impeded. Therefore, this issue has to be addressed when converting biodegradation half-life data gathered for freshwater scenarios for the marine environment. According to the TGD after an adjustment for pH and temperature (9 °C and not 12 °C), then an adjustment to take account of the reduced degradation capacity is required:

$$DT_{50}values: DT_{50[Freshwater]} \xrightarrow{\times 4} DT_{50[Estuary]} \xrightarrow{\times 3} DT_{50[Open-sea]}$$

Degradation processes can be expected to begin as soon as the active substance is exposed to seawater with acrolein undergoing two simultaneous degradation processes as observed in both soil and water.

Unlike hydrolysis where bonds are broken irreversibly, the reaction of acrolein with water creates equilibrium to form 3-hydroxypropanal, which in turn is in equilibrium with its hydrated form [3,3-dihydroxy-1-propanol]. Organic and inorganic compounds in the environment catalyse the hydration reaction. Acrolein has been shown to be hydrolysed/hydrated reasonably quickly in water at environmental temperatures and pH with a predicted DT_{50}s in the open sea at 9 °C somewhere between ~5 d (pH 7) and ~2 d (pH 9). Under conditions of bright sunlight, abiotic photodegradation of acrolein was shown to proceed at a rate much slower than hydrolysis and therefore, the aqueous photolysis rate could not be measured. However, this route is not considered to be significant for the degradation of acrolein in water, with a DT_{50} of 70 d predicted from the available data.

Under aerobic water-sediment conditions, hydrolysis/hydration was shown to be one of the main degradation pathways, with no acrolein detectable after 48 h. Acrolein was also shown to undergo rapid self-oxidation and reduction, with no acrolein products detectable after 120 h. Therefore, acrolein was shown to undergo rapid hydrolysis and biodegradation with a DT_{50} of 5.1 d (pH 8, converted to 9 °C) in freshwater, which according to the TGD for open seas would equate to 61.2 d (5.1 x 4 x 3) after adjustment for reduced degradation potential. However, as the degradation is thought to be largely through hydration, it may not be appropriate to adjust the overall DT_{50} using the reduced biodegradation capacity. It was concluded that the most appropriate degradation endpoint would be that taken from the hydrolysis study alone i.e. the DT_{50} of ~5 d (adjusted to 9 °C). However, it has not been necessary to take into account degradation during the risk assessment.

When metabolites were identified within the biodegradation studies and the;

- volatilisation of acrolein,
- reduced environmental temperature (9 °C) and
- lower biodegradation potential

in the open sea environment is taken into account [compared to the laboratory] it may be concluded that the levels of metabolites will be significantly reduced. Therefore, whilst screening data on these substances are available, no further quantitative consideration of acrolein breakdown products has been made within the risk assessment because of their significant lower toxicities (see Section 2.2.2.2, Table 2.4).

Terrestrial compartment

Whilst the use pattern does not require any further consideration of the soil compartment within this exposure assessment, from the data submitted the UK CA has concluded that there are no metabolites of concern in soil and that mineralisation of acrolein in the presence of soil microbes is likely.

Air compartment

Acrolein is a volatile substance but has been shown to break down due to direct photolysis and photo oxidation by ⁻OH radicals and ozone under atmospheric conditions with DT_{50} values reported between 20.3 h [predicted, indirect photolysis] and 10.9 d [study, direct photolysis]. The UK CA notes that of the degradation products formed, carbon dioxide and methane are registered as greenhouse gases and thus the use of acrolein adds to the global environment.

2.2.2.2. Effects assessment

The assessment factors used to define the PNECs for acrolein in the various environmental compartments of concern have been taken from the TGD. No PNEC derivations for the metabolites of acrolein have been produced. This is because the available screening data suggests that the aquatic toxicity of these compounds is significantly lower than the parent compound as shown in Table 2.4 and the initial acrolein marine exposure data (no degradation) used for the risk assessment is considered acceptable.

Table 2.4 Available aquatic toxicity data for the main metabolites of acrolein

Metabolite	Method of testing	Endpoint
3-hydroxypropanol	QSAR estimations of ecotoxicity (EPIWIN v 3.11)	LC_{50} Fish (96 h) = 60 mg l^{-1} EC_{50} *Daphnia* (48 h) = 318 mg l^{-1} EC_{50} Algae (96 h) = 22 110 mg l^{-1}
3-hydroxypropionic acid	QSAR estimations of ecotoxicity (EPIWIN v 3.11)	Predictions indicate that the substance will not be toxic to aquatic organisms.
Allyl alcohol	Acute ecotoxicology tests:	Ecotoxicity to goldfish: LC_{50} (24 hr) = 1 mg l^{-1} Phytobacterium *phosphoreum*: EC_{50}= 216-608 mg l^{-1}
Acrylic acid	Acute ecotoxicology tests:	LC_{50} Fish (96 h) = 27 mg l^{-1} EC_{50} *Daphnia* (48 h) = 95 mg l^{-1} EC_{50} Algae (96 h) = 0.04 mg l^{-1} Carp - 100ppm, 100 % mortality within 24hrs.

There are no PNEC derivations for acrolein in the sewage treatment plant (STP) or soil compartments as these are not required for the risk assessment of acrolein based on the intended use pattern.

Predicted No Effects Concentration in marine waters

The toxicity of acrolein to aquatic organisms is documented for acute endpoints in 3 trophic levels, which includes 2 taxonomic marine invertebrate groups. In addition there are chronic endpoints available for all 3 trophic levels.

Acute

Bluegill Sunfish (*L. macrochirus*): LC_{50} (96 h) = 22.4 µg a.s. l^{-1} [Freshwater *sp*.]
Sheepshead minnow (C. *variegatus*): LC_{50} (96 h) = 570 µg a.s. l^{-1} [Euryhaline *sp*.]
Water Flea (*D. magna*): EC_{50} (48 h) = 23 µg a.s. l^{-1} [Freshwater *sp*.]
Mysid shrimp (*M. bahia*): EC_{50} (96 h) = 500 µg a.s. l^{-1} [Marine *sp*.]
Eastern oyster (C. *virginica*): EC_{50} (96 h) = 180 µg a.s. l^{-1} [Marine *sp*.]
Algae (*S. costatum*): E_rC_{50} (72 h) = 11 µg a.s. l^{-1} [Marine *sp*.]

Chronic

Fathead minnow (*P. promelas*): NOEC = 11.4 µg a.s. l^{-1} [Freshwater *sp*.]
Water Flea (*D. magna*): NOEC = 16.9 µg a.s. l^{-1} [Freshwater *sp*.]
Algae (*S. costatum*): NOE_rC (72 h) = 5.1 µg a.s. l^{-1} [Marine *sp*.]

The acrolein risk assessment has been based on the marine risk assessment guidance within the TGD. Therefore, in order to calculate the PNEC an assessment factor (AF) has to be derived for the marine environment based on all available aquatic tests.

The resulting chronic endpoint demonstrated that algae (*S. costatum*) represent the most sensitive trophic level tested against acrolein with a NOE_rC (72 h) of 5.1 µg a.s. l^{-1}, which is consistent with acrolein's algicidal activity. [Acrolein is registered for direct application to water as an algicide in the US.]

Following discussions with all other Member States it was agreed at the technical meeting (TMIV08) that the PNEC should be derived from the NOE_rC for algae with an assessment factor of 50 applied = 5.1/50 = 0.102 µg a.s. l^{-1}.

(i) Predicted No Effects Concentration in marine sediments

There are no relevant sediment toxicity endpoints available for acrolein. This is considered acceptable to the UK CA as the use pattern should not result in significant exposure of this environment. In addition, according to the TGD, no sediment assessment is triggered because of the log K_{ow} is < 3 (0.04 At 25 ^{O}C) and the K_{oc} < 500 (arithmetic mean, K_{oc} of 150.3 l kg^{-1}). Therefore, data on the toxicity of acrolein to sediment-dwelling organisms is not considered necessary.

2.2.2.3. PBT assessment

According to the TGD, 'The Persistent, Bioaccumulative and Toxic (PBT) assessment is considered to be different from the local and regional assessments approaches, as it seeks to protect ecosystems where risks are more difficult to estimate'. Under the Biocidal Products Directive (BPD), a PBT assessment is needed to demonstrate that a substance does not fulfil

selection under the United Nations Environment Programme – Persistent Organic Pollutants convention (UNEP-POPs) to limit emissions to the environment of those chemicals with high potential for persistence, bioaccumulation, long-range transport and adverse effects on human health and the environment. Any substance which is found to be either a PBT or very Persistent very Bioaccumulative (vPvB) substance shall not be allowed on Annex I unless releases to the environment can be effectively prevented.

According to the TGD, the PBT assessment is particularly relevant when considering an 'open sea' scenario for the marine risk assessment. This is therefore particularly critical for the assessment of acrolein, which will routinely (weekly) be released at sea as part of the waste produced waters.

Persistence

Data have been presented, which shows that acrolein degrades rapidly in the aquatic environment (at 9 ºC) with predicted hydrolysis DT_{50} values of 5.4 d (pH 7.2) and 2.2 d (at pH 9.3) and biodegradation DT_{50}s in sediment-water of ~ 5 d. Therefore, the a.s. does not fulfil the criteria for a persistent compound according to the TGD (> 40 d in freshwater and/or > 120 d in freshwater sediment).

Bioaccumulation

A substance is considered to have the potential to fulfil the criterion of bioaccumulation when the log K_{ow} exceeds 4.5 and for acrolein, a log K_{ow} of 0.04 has been shown from available data. In addition, as the BCF is < 2000 (trigger according to TGD) there is no concern of bioaccumulation and biomagnification of acrolein in the environment and the bioaccumulation criterion is not fulfilled.

Toxic

According to the most sensitive endpoints available for acrolein (72 h E_rC_{50} of 0. 011 mg l^{-1}, and NOE_rC of 0.0051 mg l^{-1} against *Skeletonema costatum*) the chronic endpoint is below the trigger of < 0.01 mg l^{-1}. Therefore, the toxic criterion is fulfilled according to the TGD.

As acrolein has fulfilled only one of the above 3 criteria, it is not a PBT substance and should not result in long-term adverse effects when released in the open sea as a result of biocidal use.

2.2.2.4. Exposure assessment

The available environmental exposure scenario document (ESD) on slimicides (EC, 2003b) considers use in offshore drilling muds only, which is different from the intended use of acrolein in oil production and/or water injection systems. However, the ESD does support the use of the Chemical and Risk Management model (CHARM), of which v2.3 has been used by the Applicant for their assessment of acrolein. CHARM is a harmonised model agreed and adopted by the Oslo and Paris Commissions (OSPAR) for ranking chemicals on the basis of the calculated hazard quotients (HQ). In addition, the UK CA has also carried out a separate risk assessment using a simplistic worst-case approach based on the proposed use pattern for the product.

The exposure scenario produced by the Applicant, in the absence of agreed EU exposure guidance for slimicide products used in oil production and water injection systems on oil

platforms, was considered acceptable by the UK CA. However, within this document the UK CA has presented 2 approaches for the exposure assessment of acrolein:

1. CHARM model approach presented by the Applicant.

2. UK CA simplistic calculation assuming a worst-case application.

1) CHARM model approach presented by the Applicant

Aquatic phase: Emissions to the marine environment from use and discharge of chemicals offshore have been evaluated using the CHARM model. The assessment was carried out by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the Applicant.

There are several model approaches offered by CHARM because the calculation rules for estimating a predicted environmental concentration (PEC) depend on the types of application, since they might be introduced into the environment in a different way. Application groups considered in the CHARM model are:

- production chemicals (with injection chemicals and surfactants as special cases)
- drilling chemicals (water based muds only)
- cementing chemicals (i.e. spacer and mixwater)
- completion and workover chemicals

For chemical applications to the water injection or oil production system, these would fall under the CHARM 'production chemicals' model for assessment. However, this model currently only allows continuous injection dosages to be assessed, and makes no provision for batch treatment regimes. The only model within CHARM that is currently capable of estimating release from a batch treatment is the 'completion/workover chemicals' model. Use of this model to assess the environmental impact of offshore chemicals that are applied in a batch treatment has been ratified by CEFAS for use under the UK Offshore Chemical Regulations 2002 and their approach is fully accepted by the UK CA for biocides. Therefore, the Applicant's exposure scenarios have used both of the above mentioned model approaches along with realistic worst-case assumptions based on the proposed product and its intended use patterns.

The product is used weekly at the minimum efficacious level (50 mg l^{-1} for 4 – 6 h) and the oil/water released will be monitored using differential pulse polarimetry to ensure no excess is released to the environment. Monitoring in the field using this method has been performed for similar uses and has shown that the level of active substance released is < 20 µg l^{-1}. However, as this is a new use there is no available monitoring data for use on Northern Hemisphere offshore oil production platforms. The limit of detection (20 µg l^{-1}) is higher than the lowest NOEC value used to determine the marine predicted no effect concentration or PNEC (algae 6.7 µg l^{-1}), therefore risk characterisation [PEC:PNEC] for the environment will be performed.

The Applicant considers that acrolein will adsorb to organic matter (despite a K_{oc} of 121.42) in the oil/water flows and pipe surfaces when 'in-use' where it will undergo mineralisation to CO_2 through biocidal action and degradation. In the waste waters the remaining active substance

will then be removed through volatilisation (31920 Pa at 25 °C) and photodegradation in air (DT_{50} = 10.9 d).

If negligible amounts of the active substance were released, evidence from anaerobic and aerobic freshwater-sediment radio-labelled studies, and the soil transformation study indicates that microbes can adapt to acrolein. From these studies, the Applicant has concluded that seawater micro-organisms, in particular those found in sediments would also adapt to the active substance. The same studies showed that acrolein may bind irreversibly with organic and inorganic particles, where bound microbes in the particles transform the active substance and CO_2 is released. The Applicant states that microbial population within sediments is larger and more variable than that found primarily in the aqueous compartment; hence microbial transformation of the absorbed active substance can be predicted. However, due to the limitations outlined in Section 3.3.1.1 the rate of degradation of the active substance/product in the aquatic (marine) compartment is significantly reduced when compared to the original laboratory studies.

The outputs from the CHARM models are;

- Production chemicals injection model = 0.001 mg l^{-1}
- Completion/workover chemicals model = 0.002 mg l^{-1}

Sediment phase: The Applicant considered that there is evidence from anaerobic and aerobic freshwater-sediment radio-labelled studies that acrolein may bind irreversibly with organic and inorganic particles. The UK CA is not convinced of this as losses through volatilisation may have also explained the low recoveries experienced. Therefore no sediment assessment has been considered.

2) UK CA approach – simplistic PECsaltwater calculation

Aquatic phase: Whilst it can be accepted that the above calculation approach as appropriate for this product (based on the advice given by experts within CEFAS responsible for the OCNS), the following scenario has been formulated to refine the risks and address some of the concerns raised by the assumptions made by both the Applicant and the CHARM approach.

The TGD firstly considers the incidence of direct discharge into the marine environment as a result of industrial activity on the coastline. As for inland assessments the PEC will be dependant on 2 factors; dilution and the presence/absence of an STP.

In the case of acrolein, the issue differs because we are discussing releases out in the open sea and not coastal releases, hence no STP can be assumed. With regards to dilution, the TGD considers that discharge to the coastal zone will result in a greater local dilution than for the freshwater environment. The TGD considers that the initial dilution will be 10 (as for freshwater) but that further dilution due to currents should be assumed particularly if the point of release is subject to tidal influence. In the TGD, a dilution factor of 100 is assumed to represent a worst-case level for the coastal zone, which for some oils rigs located in the North Sea may be considered appropriate. The suggestion is then to use the equation 45 - 49 in the TGD to obtain $Clocal_{seawater}$.

$$Clocal_{saewater} = \frac{Clocal_{eff}}{(1 + Kp_{susp} \times SUSP_{water} \times 10^{-6}) \times DILUTION}$$

$Clocal_{eff}$ = concentration of substance in emission
Kp_{susp} = solids-water partitioning coefficient of suspended matter
$SUSP_{water}$ = concentration of suspended matter in the river
DILUTION = dilution factor
$Clocal_{seawater}$ = local concentration in surface water during weekly 6 hour emission episode

The scenario being investigated for acrolein is an open sea assessment not coastal, therefore the a dilution as small as 100 is not appropriate as this is based on a discharge of 2000 m^3 per day to the marine environment – which is very low when we compare this to the daily volume discharged for produced water from an offshore platform (according to CHARM defaults) is ~17000 m^3 per day.

The TGD does recognise that the dilution can reach 1000 (see explanation of symbols under equation 46). However, using the above calculation with 1000 dilution is significantly > PEC than can be expected according to the CHARM model as presented by the Applicant for acrolein, which assumes that;

a) the local aquatic environment below the rig is within a 500 m radius with a 150 m depth [1.18 x 10^8 m^3] and
b) the regional aquatic environment is 3200 m width x 3200 m length x 150 m depth [1.54 x 10^9 m^3].

Therefore, the UK CA has defined a local exposure scenario by focusing on the intended use pattern of weekly batchwise additions of acrolein to the oil production/water injection processes for up to 6 h a day (default used in CHARM/24 x 6) and calculated the PEC based on a default CHARM volumes (local volume 1.18 x 10^8 m^3; regional volume 1.54 x 10^9 m^3) of receiving waters beneath and beyond the oil platform using the following equation;

$$PEC_{saltwater} = \frac{[LOD(F_{6h} \times 1000)]}{[(F_l + Vp) \times 1000]}$$

$PEC_{saltwater}$ = predicted environmental concentration in marine water [µg l^{-1}]
LOD = limit of detection [Acrolein 20 µg l^{-1}]
F_1 = Total fluid production [16966 m^3 d^{-1} CHARM default suitable for North Sea platforms]
F_{6h} = Fluid production in 6 hours [16966 m3 d^{-1}/24 h x 6 h = 4241.5 m^3]
Vp = volume of ambient water per platform [local volume 1.18 x 10^8 m^3; regional volume 1.54 x 10^9 m^3 CHARM default suitable for North Sea platforms]

The resulting $PEC_{saltwater}$ from the above approach is 7.19 x 10^{-4} µg l^{-1} for the local scale and 5.51 x 10^{-5} µg l^{-1} for the regional scale, which are clearly lower than that predicted data by the CHARM approach. However, it is the UK CA opinion that these PEC data reflects realistic refined values as the approach takes into account the risk mitigation of on-site monitoring and pre-discharge steps for neutralisation and depletion of acrolein in produced waters. No degradation has been taken into account in marine waters.

Sediment phase: The data presented give no cause for concern for the sediment compartment based on the adsorption/desorption data. The UK CA also considers that the use pattern further removes the concern because the discharge will be to an open ocean, where sedimentation (deposition) of any suspended sediment will be slow and hence any residues are likely to have dispersed and degraded in the interim.

2.2.2.5. Risk characterisation

Through the proposed usage pattern of the product, the UK CA consider that there will be no direct release to surface water from use of the product on off-shore oil rigs. Therefore, the risk characterisation focuses on the exposure of marine waters. No long term effects will be seen in the open sea according to the PBT assessment presented above in Section 2.2.2.3.

1) CHARM model approach presented by the Applicant

Aquatic phase: Monitoring of the waste waters on the rig will be used to ensure that there is no excess of the active substance used in the system and hence no release to the marine environment. However, as this is a new biocidal use, local marine monitoring data is not available to prove that release will not occur. Therefore, risk characterisation for the marine environment using the CHARM model has been performed.

In reality, this active substance will undergo degradation directly upon application. There will be approximately equal partitioning of degradants to the aqueous and sediment phases. There would be no release to the marine environment as the biological load would remove all active substance from the oil/water flow. In the case of minimal accidental release under aerobic conditions, oxalic acid and carbon dioxide will be the primary degradants found 5 days after the emission episode. Under anaerobic conditions, degradants will have peaked by day 8 after emission, with carbon dioxide and oxalic acid as the primary degradants 30 days after the emission episode.

In conclusion, the calculated PEC values may only be considered to be applicable for up to 24 h after application. Therefore the PEC:PNEC ratios calculated by the CHARM model are inappropriate. Based on the known degradation characteristics of the active substance and the realistic use pattern (batch application), the active substance will not be present in the aquatic compartment within 5 days of application, with carbon dioxide the only degradant being present 30 days after application. The values obtained for the risk characterisation (PEC:PNEC) are:

- Production chemicals injection model = 9.80
- Completion/workover chemicals model = 19.61

These data suggest that the use of acrolein in the proposed product presents an unacceptable risk to marine waters.

2) UK CA approach – simplistic PECsaltwater calculation

Aquatic phase only: The UK CA approach is simplistic, but can be considered as a refinement approach to that presented by the Applicant above. This is because the UK CA scenario addresses some of the concerns raised by the Applicants approach and the CHARM model (see Section 2.2.2.4). The UK CA scenario allows for the;

- product to be used i.e. acrolein has reacted before discharge,
- risk mitigation measures to be tested i.e. on-site monitoring to ensure a maximum level of 20 μg l^{-1} is released,
- discharge occurs for the 6 hours of treatment only,
- use of default CHARM data gathered from existing off shore sites in the EU [and so is directly applicable].
- prediction of risks in local and regional areas.

The values obtained for the risk characterisation of marine waters using this approach are 0.007 (local) and 0.0005 (regional), which suggests that the use of acrolein in the proposed product does not pose an unacceptable risk to marine waters.

Conclusion

Acrolein, when used as a weekly slimicide treatment in oil production and water processing pipelines on offshore oil rigs is unlikely to pose any long-term risks to the environment. The controlled use and on-site monitoring systems can be considered to provide adequate mitigation such that direct exposure of the environment to acrolein is expected to be minimal.

2.2.3. List of Endpoints

In order to facilitate the work of Member States in granting or reviewing authorisations, and to apply adequately the provisions of Article 5(1) of Directive 98/8/EC and the common principles laid down in Annex VI of that Directive, the most important endpoints, as identified during the evaluation process, are listed in Appendix I.

3. DECISION

3.1. Background to the Decision

Acrolein has been assessed for use as a biocide in offshore oil recovery. Other potential uses have not been evaluated. However the single scenario that has been risk assessed for human health and environment indicates that:

- the risks for the users of the biocidal product for this exposure scenario are acceptable as long as products are used with appropriate PPE and that safe operational procedures are established such as air monitoring with appropriate alarm systems and the demarcation of exclusion zones at the site of biocide application.

- the risks to the marine environment are acceptable as long as certain conditions of use are imposed such as monitoring of waste water and treatment of waste water, if necessary, prior to discharge.

Principles of good working practice should be applied and label instructions and recommendations on the products respected.

3.2. Decision regarding Inclusion in Annex I

Acrolein shall be included in Annex I to Directive 98/8/EC as an active substance for use in product-type **12** (Slimicide), subject to the recommended provisions of the risk assessment associated with the use area of the product.

Identity

Chemical name (IUPAC)	: Acrylaldehyde
Chemical name (CA)	: 2-propenal
CAS No	: 107-02-8
EINECS No	: 203-453-4

Purity & Proposed Product Type

Purity	: Typically 96.3 % w/w
Proposed Product Type	: 12 (Slimicide)

3.3. Elements to be taken into account by Member States when authorising products

When assessing the application for authorisation of a product in accordance with Article 5 and Annex VI, Member States shall assess, where relevant for the particular product, those exposure scenarios and those risks to compartments and populations that have not been representatively addressed in the Community Level risk assessment.

Member States shall consider the following recommendations when assessing product authorisation for products to be used in offshore oil recovery:

(1) Products should only be sold to and used by specifically trained professionals and must be labelled appropriately to ensure safe storage, handling, use and disposal in accordance with national arrangements.

(2) The end user should carry out a Risk Assessment that addresses both primary and secondary exposure of personnel to acrolein prior to implementing a treatment programme, specifically the use of appropriate personal and respiratory protective equipment and the demarcation of an exclusion zone around the application site. More specifically:

- The Applicant has recommended that standard personal protective equipment for all operators conducting biocide treatments with acrolein on offshore oil recovery installations should be a full-face air purifying respirator with organic vapour cartridges, suitable gloves (e.g. butyl) and suitable overalls.

- To comply with the requirements for operators working outdoors on offshore oil recovery installations, the overalls must be fire retardant and safety boots must be worn. Ear protection is also often required.

- In addition to PPE, the company requires that a portable eye wash or fresh water supply and neutralizing solution (aqueous sodium carbonate) is available to operators during acrolein treatments and a drench shower should be situated close to sites where acrolein treatments take place.

(3) Although efficacy was proven, none of the tests were done according to the recommended treatment (50 – 250 ppm applied for 4 – 6 hours on a weekly basis). This should be taken into account at the product authorisation stage.

(4) The risk assessment should establish operational procedures setting out a safe system of work for both operators applying the biocide and other personnel who maybe exposed to the biocide during application and other operations.

(5) The safe system of work should include instructions for personnel carrying out work tasks that include storage, application, sampling and maintenance of equipment and for personnel carrying out tasks in other areas where exposure to acrolein may occur. Air - monitoring with audible and visible alarms (via in-situ photo ionisation detectors) should be considered in areas where the biocide is applied to the water systems and in enclosed areas where acrolein biocides are stored or used.

(6) The safe system of work should also describe arrangements for controlling exposure in the event of unplanned releases (leaks, spillages) including the requirements for exclusion zones, air monitoring, alarm systems and medical treatment.

The environmental risk assessment indicates that for the scenario investigated, Acrolein 99.7 - 99.8 % w/w (plus hydroquinone as a stabiliser at 0.2 – 0.3 %) would not result in unacceptable risk to the marine environment. However, this assessment is based on the assumptions that the following recommended risk mitigation measures are in place at the site-

of-use and are implemented as part of the standard operating practice at the product authorisation assessment. More specific recommendations at this stage include:

(1) The product should be used for a maximum of 6 h during any week.

(2) The waste waters containing acrolein are monitored prior to discharge.

(3) Waste waters are only allowed to be discharged if the levels of acrolein are at or below the LOD of 20 µg l-1.

(4) If waste waters are found to exceed the discharge limit of 20 µg acrolein l-1, appropriate action (i.e. neutralisation or placed in reservoir/holding tanks) must be undertaken prior to discharge.

(5) The need to address any specific national conditions and/or undertake regional assessments should be considered, as only local environmental risk assessments have been carried out in this evaluation.

Emergency Responders

The PPE specified for emergency responders is chemically resistant overalls, suitable gloves, boots and an air supplied respirator.

All necessary measures must be taken to reduce the risk of fire and explosion when handling the product.

3.4. Requirement for further information

The UK CA considers that the evaluation has shown that sufficient data have been provided to verify the outcome and conclusions, and permit the proposal for the inclusion of acrolein on to Annex I of Directive 98/8/EC.

3.5. Updating this Assessment Report

This assessment report may need to be updated periodically in order to take account of scientific developments and results from the examination of any of the information referred to in Articles 7, 10.4 and 14 of Directive 98/8/EC. Such adaptations will be examined and finalised in connection with any amendment of the conditions for the inclusion of acrolein in Annex I to the Directive.

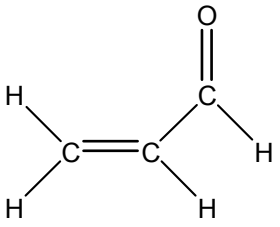
Appendix I: List of endpoints

Chapter 1: Identity, Physical and Chemical Properties, Classification and Labelling

Active substance (ISO Common Name)	Acrolein
Function (*e.g.* fungicide)	Slimicide

Rapporteur Member State	United Kingdom

Identity

Chemical name (IUPAC)	Acrylaldehyde
Chemical name (CA)	2-propenal
CAS No	107-02-8
EC No	203-453-4
Other substance No.	Not applicable
Minimum purity of the active substance as manufactured	91.3 % w/w
Identity of relevant impurities and additives (substances of concern) in the active substance as manufactured (g/kg)	Confidential
Molecular formula	C_3H_4O
Molecular mass	56.06
Structural formula	

Physical and chemical properties

Melting point	- 87 °C
Boiling point	52.8 °C
Temperature of decomposition	The active substance is unstable at room temperature. It is stabilised by the addition of a 'radical annihilator'
Appearance	At 20 °C and 101.3 kPa: Physical state: Liquid Colour: Clear Odour: Extreme sharp, piercing odour
Relative density	0.8875 at 20 °C
Surface tension	73.2 nN/m; not surface active
Vapour pressure	31920 Pa at 25 °C
Henry's law constant	7.46 $Pa.m^3/mol$ at 25 ºC
Solubility in water	237628 mg/l at 25 °C
Solubility in organic solvents	Results at 24 °C Acetone: > 214 g/l Dichloromethane: > 214 g/l Ethyl acetate: > 214 g/l Methanol: > 214 g/l n-Heptane: > 214 g/l Toluene: > 214 g/l
Stability in organic solvents used in biocidal products including relevant breakdown products	The active substance will not be used in biocidal products containing organic solvents.
Partition coefficient (log P_{ow})	Log P_{ow} = 0.04
Dissociation constant	The active substance does not contain any functional groups that would undergo dissociation
UV/VIS absorption (max.) (if absorption > 290 nm state ε at wavelength)	Spectra confirms the chemical structure
Flammability	Acrolein has a spontaneous ignition temperature of 234 °C.
Flash point	Acrolein is highly flammable and has a flash point of – 25 °C. It does not warrant a classification of extremely flammable because its boiling point is greater than 35 °C.
Explosive properties	From the chemical structure of acrolein, screening calculations and experience in use it can be

	concluded that acrolein is not explosive.
Oxidizing Properties	From the chemical formula it can be concluded that it is not an oxidizer.
Reactivity towards container material	Based on information from experience of use packaging acrolein the recommended container material for direct contact with acrolein is 370 lb steel containers.

Classification and proposed labelling

with regard to physical/chemical data	F:R11: Highly flammable
with regard to toxicological data	T+;T: R24: Toxic in contact with skin. R26/28: Very toxic by inhalation and if swallowed. R34: Causes burns
with regard to fate and behaviour data	none
with regard to ecotoxicological data	N: R50: Very toxic to aquatic organisms

Chapter 2: Methods of Analysis

Analytical methods for the active substance

Technical active substance (principle of method)	Gas Chromatography, using Flame Ionization Detection, for the analysis of acrolein, its dimer and the impurities benzene and acetone in the active substance. The method was suitably validated.
Impurities in technical active substance (principle of method)	Karl Fischer for the analysis of water in the active substance.
Stabilisers in the technical active substance (principle of method)	High Performance Liquid Chromatography, for the analysis of the stabiliser hydroquinone. The method was suitably validated.

Analytical methods for residues

Soil (principle of method and LOQ)	The use pattern of acrolein (off-shore oil-rigs) would lead to negligible exposure to soil, therefore it is considered that studies into analytical methods in soil are not necessary.
Air (principle of method and LOQ)	n.a.
Water (principle of method and LOQ)	Gas Chromatography with Electron Capture Detection. The method was suitably validated.
	Differential Pulse Polarography. The method was suitably validated.
Body fluids and tissues (principle of method and LOQ)	As there will be no exposure to humans, this study is not necessary. A review into the disposition and metabolism of acrolein, hydroquinone and 3-hydroxypropanal has been performed (Section A6.2, Annex Point IIA, VI. 6.2.). The data suggests rapid excretion of acrolein when administered orally to rats, mainly in the urine but with a significant amount being exhaled. Only very limited amounts of radioactivity were found in tissues at 7 days post dose. There is very limited information on human metabolism; it is likely that acrolein metabolism is similar in rats and humans. It is therefore considered that studies into analytical methods in animal and human body fluids and tissues are not necessary. The review into the disposition and metabolism of hydroquinone showed that significant amounts of radioactivity were still present in the carcass 7 days after the dermal dose was administered. However

	as this level is below the no adverse effect level, it is considered that studies into analytical methods in animal and human body fluids and tissues are not necessary.
Food/feed of plant origin (principle of method and LOQ for methods for monitoring purposes)	The use pattern of Acrolein (off-shore oil rig) would lead to negligible contamination of food or feeding stuffs. In accordance with the TNsG on Data Requirements for the Biocidal Products Directive, it is therefore considered that these studies are not necessary.
Food/feed of animal origin (principle of method and LOQ for methods for monitoring purposes)	The use pattern of Acrolein (off-shore oil rig) would lead to negligible contamination of food or feeding stuffs. In accordance with the TNsG on Data Requirements for the Biocidal Products Directive, it is therefore considered that these studies are not necessary.

Absorption, distribution, metabolism and excretion in mammals

Rate and extent of oral absorption:	In the rat, at low dose levels (of the order of 2.5 mg/kg) acrolein is well absorbed (100 %), however, at higher dose levels (15 mg/kg), polymerisation of the substance occurs and absorption is reduced (60 – 70 %) of administered dose.
Rate and extent of dermal absorption:	No suitable studies are available to assess the dermal absorption of acrolein. Consequently, the default value, as prescribed by the Technical Guidance Document on Risk Assessment, is applicable. Acrolein has a molecular weight of 56.06 and a log Pow of 0.04. Thus, a dermal absorption value of 100 % is derived for aqueous acrolein.
Rate and extent of inhalation absorption:	Although no studies via this route of exposure have been submitted, the EU ESR review on acrolein reports that 74 – 82 % of inhaled acrolein vapour in dogs is 'retained' by the upper respiratory tract and 66 – 70 % by the lower respiratory tract. This retention may represent either bound or absorbed acrolein, but there are no data to quantify the proportion of each. Overall, a precautionary inhalation absorption value of 100 % is considered appropriate.
Distribution:	Following absorption acrolein and/or its metabolites are widely distributed around the body.
Potential for accumulation:	Bioaccumulation is not anticipated.
Rate and extent of excretion:	The majority of acrolein and/or its metabolites was rapidly eliminated within 48 hours of dosing, with the urine and exhaled CO_2 being the major routes of excretion.
Toxicologically significant metabolite(s)	None.

Acute toxicity

LD_{50} oral	Rat: 10.3 mg/kg male, 11.8 mg/kg female Mouse: 13.9 mg/kg male, 17.7 mg/kg female
Rat LD_{50} dermal	Rabbit: 231.4 mg/kg
Rat LC_{50} inhalation	Rat: 1 hr: 57.9 mg m^{-3} Rat: 4 hr: 18.5 mg m^{-3}
Skin irritation	Classified as Corrosive; R34
Eye irritation	Classified as Corrosive; R34
Skin sensitization (test method used and result)	A suitable skin sensitisation study is not available. A further sensitisation study has not been conducted due to animal welfare concerns because of acrolein's corrosive nature

Repeated dose toxicity

Species/ target / critical effect	Toxicity following acrolein exposure is a result of its corrosive nature producing initially local effects at the site of contact.
Lowest relevant oral NOAEL / LOAEL	**$NOAEL_{short\text{-}term}$:** 4.6 mg/kg/d, 14 day mouse study (local irritation and mortality at higher dose levels). **$NOAEL_{medium\text{-}term}$:** 0.1 mg/kg/d, 1 year dog study (local irritation at higher dose levels) **$NOAEL_{long\text{-}term}$:** 0.05 mg/kg bw/d, 2 year rat study (mortality at higher dose levels)
Lowest relevant dermal NOAEL / LOAEL	**LOAEL:** 7 mg/kg/d, 3 week rabbit study (based on local irritation and decreased bodyweight gain).
Lowest relevant inhalation NOAEL / LOAEL	**$LOAEL_{short/medium\text{-}term/long\ term}$:** 0.4 ppm, (0.9 mg m^{-3}) rat, 6 h/d, 5 d/wk, 90 days (local irritation).

Genotoxicity	*In vitro*, acrolein produced positive results in bacteria cell gene mutation assays, while in mammalian cells negative results were reported in standard gene mutation and chromosome aberration assays performed across a number of different cell lines. *In vivo*, acrolein produced negative results in a rat bone marrow micronucleus test and in mouse dominant lethal assays.

Carcinogenicity

Species/type of tumour	No treatment-related tumours identified in rats or

	mice.
Lowest dose with tumours	Not applicable.

Reproductive toxicity

Species/ Reproduction target / critical effect	No treatment-related effects on fertility were observed in rats at dose levels up to 7.2 mg/kg/d.
Lowest relevant reproductive NOAEL / LOAEL	**$NOAEL_{parental\ toxicity}$:** 1 mg/kg bw/d **$NOAEL_{foetototoxicity}$:** 3 mg/kg bw/d
Species/Developmental target / critical effect	No treatment-related effects on development in the absence of maternal toxicity observed in rabbits or rats. Subcutaneous oedema was observed in mice pups in a dose-related manner and although the greatest frequency occurred at a maternally toxic dose, it cannot be conclusively considered to be a secondary effect to such toxicity.
Lowest relevant developmental NOAEL / LOAEL	Rabbit **$NOAEL_{Maternal}$**: > 2 mg/kg/d **$NOAEL_{foetototoxicity}$:** > 2 mg/kg/d Rat **$NOAEL_{Maternal}$**: 3.6 mg/kg/d **$NOAEL_{foetototoxicity}$:** 6 mg/kg/d Mouse **$NOAEL_{Maternal}$**: 6.3 mg/kg/d **$NOAEL_{foetototoxicity}$:** 4 mg/kg bw/d

Neurotoxicity / Delayed neurotoxicity

Species/ target/critical effect	Not applicable
Lowest relevant developmental NOAEL / LOAEL.	Not applicable

Other toxicological studies

....	None submitted

Medical data

....	None submitted

Summary	Value	Study	Safety factor
ADI (if residues in food or feed)	Not Required		
AEL (acute)	Not applicable		
AEL (medium-term)	Not applicable		
AEL (long-term)	Not applicable		
$AEC_{inhalation}$ (acute/medium term)	0.0375 mg m^{-3}	Rat, 62 d, intermittent exposure	24 (2.5 x 3.3 x 3)
$AEC_{inhalation}$ (long term)	0.019 mg m^{-3}		48 (2.5 x 3.2 x 2)
Drinking water limit	Not Required	N/A	N/A
ARfD (acute reference dose)	Not Required	N/A	N/A

Acceptable exposure scenarios (including method of calculation)	
Professional users	An MoE of 4 has been determined. It should be noted that the EASE prediction from which this MOE is determined does not take account of the requirement for operators to wear RPE when handling the treatment lines. Hence in reality, exposure will be much lower than the worst case prediction used here and there will be a much greater margin of exposure.
Production of active substance:	The active substance (acrolein) and product (Magnacide B® Microbiocide) are manufactured and packaged in the USA. Magnacide B® Microbiocide is shipped into the EU ready for use, hence there are no production/formulation exposure scenarios to consider for this product.
Formulation of biocidal product	See "Production of active substance"
Intended uses	Magnacide B® Microbiocide is to be used as a slimicide to control bacteria in produced water and water injection systems on offshore oil rigs.

Secondary exposure	The only group potentially at risk from secondary exposure to Magnacide B® Microbiocide is oil rig personnel who are not directly involved with the acrolein treatment. The company has proposed various safeguards to minimise the chances for secondary exposure to occur during normal use including the use of exclusion zones around the treatment lines and restricting access to the produced water system for 2-days after treatment. The UK CA considers that these measures are sufficient and has therefore not attempted to quantify secondary exposure.
Non-professional users	This product is not intended for amateur use.
Indirect exposure as a result of use	This product is only intended for use on offshore oil rigs. Under normal conditions of use there should be no indirect exposure to the general public.

Chapter 4: Fate and Behaviour in the Environment

Route and rate of degradation in water

Hydrolysis of active substance and relevant metabolites (DT50) (state pH and temperature)	pH 9.3 (25 ºC): 0.6 d (9 ºC): 2.2 d
	pH 7.2 (25 ºC): 1.5 d (9 ºC): 5.4 d
	pH 5.3 (25 ºC): 3.8 d (9 ºC): 13.7 d
Photolytic / photo-oxidative degradation of active substance and resulting relevant metabolites	40 ºN: DT_{50} 70 d 3-hydroxypropanal (possibly formed by hydration and not photolysis)
Readily biodegradable (yes/no)	No
Biodegradation in seawater	The study available showed that there was limited potential for biodegradation in the marine environment at 2.0 and 3.5 mg l-1 due to the toxicity of acrolein.
Distribution in water / sediment systems (active substance)	Aquatic: pH 6.1, 25 ºC No acrolein detected in the system at 48 h **Half-Life (h)** **Original (25 ºC)** 33.7 **Converted (9 ºC)** 121.2
Distribution in water / sediment systems (metabolites)	**Aerobic:** All metabolites of acrolein are polar and highly water soluble and are less volatile than acrolein. Due to the rapid degradation of acrolein through these pathways, the loss of radioactivity through volatility of acrolein was further inhibited. After 32 d, most of the remaining radioactivity was detected in the aqueous phase of the test system at approximately 25 % of the initial dose, while the radioactivity in the sediment phase amounted to approximately 20 % of the initial dose. The decrease in radioactivity in the aqueous phase was not a result of sorption to solids but rather due to the rapid mineralization of acrolein metabolites to carbon dioxide Consequently, the carbon dioxide formed was found to be the major product in volatile traps. The mineralization of acrolein also took place in the sediment phase. Inorganic

	bicarbonate and carbonate anions absorbed strongly to the sediment which explains why the more non-polar solvents (e.g., acetonitrile, methanol) were not suitable for extracting sediment samples. **Anaerobic:** All metabolites of acrolein are polar and highly water soluble and are less volatile than acrolein. After 30 days, most of the remaining radioactivity was detected in the aqueous phase of the test system at approximately 29 % of the initial dose, while the radioactivity in the sediment phase amounted to approximately 22 % of the initial dose. By Day 93, most of the remaining radioactivity was detected in the sediment phases of the test system at 20 % of initial dose, while the radioactivity in the aqueous phase amounted to approximately 7.0 % of the initial dose. On Day 178, the radioactivity remaining in the aqueous phase was 5 % of the initial dose and in the sediment was 11 % of the initial dose. The observed decrease in radioactivity in the aqueous phase was a result of sorption to solids and also due to the rapid mineralization of acrolein metabolites to carbon dioxide. Consequently, the carbon dioxide formed was found to be the major product in volatile traps. The mineralization of acrolein also took place in the sediment phase. Inorganic bicarbonate and carbonate anions absorbed strongly to the sediment which explains why the more non-polar solvents (e.g., acetonitrile, methanol) were not suitable for extracting sediment samples.
Non-extractable residues	N/A

Route and rate of degradation in soil

Mineralization (aerobic)	Carbon dioxide: – formed rapidly within the seven days and shows a more gradual release up till the termination of the study. The majority of the activity was released within several days and approximately 50 % of the released activity was carbon dioxide. After six days, the released activity was entirely carbon dioxide and appeared to follow a zero-order release rate up to the end of the study.

Laboratory studies (range or median, with number of measurements, with regression coefficient)	<table><tr><th rowspan="2">Substance</th><th colspan="2">DT_{50} (d)</th></tr><tr><th>Original (22 ± 1 °C)</th><th>Converted (12 °C)</th></tr><tr><td>**Acrolein**</td><td>0.175</td><td>0.39</td></tr><tr><td>**Acrylic acid and 3-hydroxypropionic acid mineralised to CO_2**</td><td>29</td><td>65</td></tr><tr><td>**Bound acrolein mineralised to CO_2**</td><td>410</td><td>912</td></tr></table>
	DT_{90lab} (20°C, aerobic): -
	DT_{50lab} (10°C, aerobic): -
	DT_{50lab} (20°C, anaerobic): 11 days DT_{50lab} (12°C, anaerobic): 21 days
	degradation in the saturated zone: -
Field studies (state location, range or median with number of measurements)	DT_{50f}: Not available
	DT_{90f}: Not available
Anaerobic degradation	Not available
Soil photolysis	Not available
Non-extractable residues	Not available
Relevant metabolites - name and/or code, % of applied a.i. (range and maximum)	Not available
Soil accumulation and plateau concentration	Not available

Adsorption/desorption

Ka , Kd	Kp = 0.97 (mean)
Ka_{oc} , Kd_{oc}	K_{oc} = 150.3 l kg^{-1} (mean)
pH dependence (yes / no) (if yes type of dependence)	Not pH dependent

Fate and behaviour in air

Direct photolysis in air	Observed DT_{50} – 10.9 d Calculated DT_{50} – 7.7 d
Quantum yield of direct photolysis	0.0786
Photo-oxidative degradation in air	Latitude: 37:27:15N 122:10:43W Season: Summer (July) DT_{50} 10.9 d
Volatilization	Not available

Monitoring data, if available

Soil (indicate location and type of study)	Not available
Surface water (indicate location and type of study)	Not available
Ground water (indicate location and type of study)	Not available
Air (indicate location and type of study)	Not available

Toxicity data for aquatic species (most sensitive species of each group)

Species	Time-scale	Endpoint	Toxicity
Fish			
Lepomis macrochirus	96 h FT	LC_{50}	22.4 µg l^{-1}
Cyprinodon variegatus	96 h FT	LC_{50}	570 µg l^{-1}
Pimephales promelas	35 wk FT	NOEC	11.4 µg l^{-1}
Invertebrates			
Daphnia magna	48 h FT	EC_{50}	23 µg l^{-1}
Mysidopsis bahia	96 h FT	EC_{50}	500 µg l^{-1}
Crassostrea virginica	96 h FT	EC_{50}	180 µg l^{-1}
Daphnia magna	21 d FT	NOEC	16.9 µg l^{-1}
Algae			
Skeletonema costatum	72 h ST	E_rC_{50}	11 µg l^{-1}
Skeletonema costatum	72 h ST	NOE_rC	5.1 µg l^{-1}
Microorganisms			
Not available	-	-	-

Effects on earthworms or other soil non-target organisms

Acute toxicity to …….	Not available
Reproductive toxicity to……..	Not available

Effects on soil micro-organisms

Nitrogen mineralization	Not available
Carbon mineralization	Not available

Effects on terrestrial vertebrates

Acute toxicity to mammals	Not available
Acute toxicity to birds	*Anas platyrhynchos* (mallard duck) 21 d LD_{50} > 30.2 mg a.s. kg^{-1} bw
Dietary toxicity to birds	Not available
Reproductive toxicity to birds	Not available

Effects on honeybees

Acute oral toxicity	Not available
Acute contact toxicity	Not available

Effects on other beneficial arthropods

Acute oral toxicity	Not available
Acute contact toxicity	Not available
Acute toxicity to ……..	Not available

Bioconcentration

Bioconcentration factor (BCF)	0 [no active substance could be detected in tissues] Tested in fish and shellfish
Depuration time (DT_{50}) (DT_{90})	Not applicable
Level of metabolites (%) in organisms accounting for > 10 % of residues	Metabolites > 10 % total ^{14}C-residues in edible fish tissues: Malonic acid - ~ 10 % Glycidol - ~55 % (Channel catfish only) 1,3-propanediol – 34 % (Bluegill sunfish only) Propiolic acid – 10.5 % (Bluegill sunfish only) Glyceric acid – 19 % (Bluegill sunfish only) Metabolites > 10 % total ^{14}C-residues in edible shellfish tissues: Glycidol – 17 % (Crayfish only) Lactic acid – 15 % (Crayfish only) Glycerol – max 65.5 % (Crayfish only) Propiolic acid – 16 % (Clam only) Glyceric acid – 21 % (Clam only) Carbohydrate – 30.5 % (Clam only)

Chapter 6: Other End Points

Not applicable.

Appendix II: List of Intended Uses

Acrolein has been evaluated for its intended use as a slimicide in water systems supporting offshore fossil fuel recovery.

The product is only intended for use by professional operators.

Product Type	Slimicide Product Type 12
Concentration used	Initial Treatment typically: 50 to 250 ppm for 4 to 6 hours on a weekly basis Maintenance: adjusted to maintain optimized reduction in bacteria levels.
Target Organism	Broad range of heterotrophic bacteria, including hydrogen sulphide generating sulphate-reducing bacteria.
Categories of User	Professional only
Packaging	Magnacide B® Microbiocide is packaged as a ready-for-use formulation in pressurised cylinders (containing 168 kg acrolein) or 'skid tanks' (containing 1113.6 kg acrolein) specifically built for use with this product.
Type of Application	To be applied as a batch treatment at a storage tank, at the heater/treater, in the separator tank, in the precipitator, at the producing or injecting head or at any other easily accessible location.
Storage	Flammable Liquid Storage, Toxic Storage, Environmentally Hazardous Storage. Store in a secured and well ventilated area. Keep away from heat, sparks and flame. Keep away from incompatibles. Keep container tightly closed and dry. To avoid fire or explosion, ground container equipment and personnel before handling product.

Data supporting the active substance for its use against the intended target organisms have demonstrated sufficient efficacy for inclusion onto Annex I to be recommended.

To date, there are no known resistance issues when using acrolein against the target organisms.