

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	JAMES GAMBS	Student ID number:	146380
Programme:	HNC Process Operations Engineering		
Module:	Environmental Protection and Sustainable Manufacturing Systems		
Module code:	PCPO4003	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Richard Wray	Internal Verifier:	Lance Rutherford
Assignment Title:	Research Report	Word count (or equivalent):	2000
Submission deadline:	15/05/19	Return date of provisional marks & written feedback:	29/05/19
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

LO1, LO2.

TASK DESCRIPTION

Investigative report

There are many examples of industrial manufacturing plant, equipment and process that pose a potential risk to the environment and/or where operations may meet or fall short of the requirements for sustainable manufacturing.

For this assignment you are required to analyse a chosen industrial process at your place of work with respect to environmental protection and sustainable manufacturing systems.

Research Guidance

- Fully research the industrial plant, equipment and manufacturing process design and operation
- Evaluate specific aspects associated with meeting environmental protection, legal requirements and best practice
- Evaluate specific aspects associated with ensuring sustainable manufacture can be achieved through efficient equipment, plant and process operation
- Develop conclusions and recommendations on how the process could be improved with respect to environmental protection and manufacturing sustainability

Note: When choosing a work based plant, equipment or process please ensure you have your employers permission to use relevant information in your assignment. Do not include names of personnel or commercially sensitive information.

Research evaluation

You will produce the written report in a clearly structured and professional manner. The report should evaluate the findings of your research and present logical arguments and conclusions. It is expected that you will organize your report following a pattern to that suggested below:

- A brief abstract
- An introductory section outlining the background, the scope and intended readership
- A clear statement of the aim and objectives of the report
- Central sections, explaining any findings, arguments and outcomes
- A suitably structured conclusion that draws together the findings of your research and any recommendations you are making

When writing your report make sure that you:

- Use acceptable academic language and tone
- Check spelling and grammar
- Show that you can evaluate evidence from reference sources and use this material to make a logical and consistent argument
- Make sure that you analyse and evaluate arguments and evidence in a way that meets your stated outcomes and objectives

Report structure

The report document must be constructed in a formal and professional manner using an appropriate word-processed program. The completed report should contain the following sections:

- A cover page or document title page
- A table of contents page
- Sections or paragraph headings related to each aspect of the report
- Headers on each page with the title of your report
- Paragraphs should be spaced using '1.5 line spacing'
- Footers on each page with the author's name on the right hand side and 'Page ... of ...' on the left
- A references page and bibliography as appropriate
- Appendices where appropriate for larger quantities of data
- Diagrams, charts or tables, suitably incorporated and labelled
- The text format should be Times New Roman or Ariel with a font size of 12
- A word count of 2000 words ($\pm 10\%$)

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS

NOTE: The guidance offered below is linked to the five generic assessment criteria overleaf.

1. Engagement with Literature Skills

Your work must be informed and supported by scholarly material that is *relevant* to and *focused* on the task(s) set. You should provide evidence that you have accessed an appropriate *range* of sources, which may be academic, governmental and industrial; these sources may include academic journal articles, textbooks, current news articles, organisational documents, and websites. You should consider the *credibility* of your sources; academic journals are normally highly credible sources while websites require careful consideration/selection and should be used sparingly. Any sources you use should be current and up-to-date, mostly published within the last five years or so, though seminal/important works in the field may be older. You must provide *evidence* of your research/own reading throughout your work, using a suitable referencing system, including in-text citations in the main body of your work and a reference list at the end of your work.

Guidance specific to this assessment: You must provide evidence of individual research with respect to the area of study and provide relevant referencing.

2. Knowledge and Understanding Skills

At level 4, you should be able to demonstrate knowledge of the underlying concepts and principles associated with your area(s) of study. *Knowledge* relates to the facts, information and skills you have acquired through your learning. You demonstrate your *understanding* by interpreting the meaning of the facts and information (knowledge). This means that you need to select and include in your work the concepts, techniques, models, theories, etc. appropriate to the task(s) set. You should be able to explain the theories, concepts, etc. to show your understanding. Your mark/grade will also depend upon the *extent* to which you demonstrate your knowledge and understanding.

Guidance specific to this assessment: Your report should show you gained knowledge of the subject area.

3. Cognitive and Intellectual Skills

You should be able to present, evaluate and interpret qualitative and quantitative data, in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of your subject(s) of study. You should be able to evaluate the appropriateness of different approaches to solving problems related to your area(s) of study and/or work. Your work must contain evidence of logical, analytical thinking. For example, to examine and break information down into parts, make inferences, compile, compare and contrast information. This means not just describing what! But also justifying: Why? How? When? Who? Where? At what cost? You should provide justification for your arguments and judgements using evidence that you have reflected upon the ideas of others within the subject area and that you are able to make sound judgements and arguments using data and concepts. Where relevant, alternative solutions and recommendations may be proposed.

Guidance specific to this assessment: The report should show analysis of the research.

4. Practical Skills

At level 4, you should be able to apply the basic underlying concepts and principles to evaluate and interpret these within the context of your area of study. You should be able to demonstrate how the subject-related concepts and ideas relate to real world situations and/or a particular context. How do they work in practice? You will deploy models, methods, techniques, and/or theories, in that context, to assess current situations, perhaps to formulate plans or solutions to solve problems, or to create artefacts. This is likely to

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Name: James Gambs

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Excellent: Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	25	18
2. Knowledge and Understanding Skills		
Very good: Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding.	25	15
3. Cognitive and Intellectual Skills		
Good: Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid arguments and logical judgements.	30	16
4. Practical Application Skills		
Very good: A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	10	6
5. Transferable Skills for Life and Professional Practice		
Very good: Work is accurate, coherent, fluent, well-structured and organised. Can work effectively independently and/or as part of a team, with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness. Please see additional comments in assignment text.	10	6

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		61%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

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Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

61 %

involve, for instance, the use of real world artefacts, examples and cases, the application of a model within an organisation and/or benchmarking one theory or organisation against others based on stated criteria.

Guidance specific to this assessment: The report indicates a level of research with respect to the application and deployment of the equipment, materials or processes that form the basis of the area of study.

5. Transferable Skills for Life and Professional Practice

Your work must provide evidence of the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility. This includes demonstrating: that you can communicate the results of your study/work accurately and reliably, and with structured and coherent arguments; that you can initiate and complete tasks and procedures, whether individually and/or collaboratively; fluency of expression; clarity and effectiveness in presentation and organisation. Work should be coherent and well-structured in presentation and organisation.

Guidance specific to this assessment: Your work should be well organised and presented in a professional manner.

GENERIC ASSESSMENT CRITERIA

Level 4

In accordance with the Framework for Higher Education Qualifications, at the end of Level 4 students will be expected to have demonstrated knowledge of the basic underlying concepts and principles of a subject, and an ability to evaluate and interpret these within the context of that area of study. They should be able to present, evaluate and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of their subject(s) of study. They will have learned how to evaluate different approaches to solving problems, and will be able to communicate the results of their study/work accurately and reliably, and with structured and coherent arguments. They will be able to undertake further training and develop new skills within a structured and managed environment and will have the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility.

Level 4	Category	FAIL 0-29%	MARGINAL FAIL 30-39%	SATISFACTORY (3 rd / Pass) 40-49%	GOOD (2.2 / Pass) 50-59%	VERY GOOD (2.1 / Merit) 60-69%	EXCELLENT (1 st / Distinction) 70-84%	EXCEPTIONAL (1 st / Distinction) 85-100%
	Engagement with literature (including reading, referencing, academic conventions and academic honesty)	Little or no evidence of reading and/or reliance on inappropriate sources. Views and findings mostly unsupported and non-authoritative. Referencing conventions used incoherently or largely absent.	Poor engagement with essential reading. No evidence of wider reading. Reliance on inappropriate sources, and/or indiscriminate use of sources. Heavily reliant on information gained through class contact. Inconsistent and weak use of referencing.	Engagement with a limited range of mostly relevant and credible sources but with some reliance on information gained through class contact. Some omissions and minor errors. Referencing conventions evident though not always applied accurately or consistently.	Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing may show minor inaccuracies or inconsistencies.	Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. Generally sound referencing, with no/very few inaccuracies or inconsistencies.	Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	Exceptional engagement with an extensive range of relevant and credible literature. High-level referencing skills consistently applied.

Level 4	FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category	0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
Knowledge and understanding (Knowledge of the basic underlying concepts and principles of a subject.)	Major gaps in knowledge and understanding of the basic underlying concepts and principles of the subject matter. Inclusion of irrelevant material. Substantial inaccuracies.	Gaps in knowledge of the basic underlying concepts and principles, with flawed or superficial understanding. Some significant inaccuracies and/or irrelevant material.	Limited knowledge and understanding of the basic underlying concepts and principles within the subject area. Some elements may be missing.	Knowledge of the basic underlying concepts and principles is accurate with a good understanding of the field of study but lacks depth and/or breadth.	Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding.	Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.	Exceptional, detailed knowledge and understanding of the basic underlying concepts and principles
Cognitive and Intellectual skills (Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.)	Wholly or almost wholly descriptive work. Little or no evaluation of the underlying concepts and principles. Failure to develop arguments, leading to illogical or invalid judgements. Minimal or no use of evidence to back up views.	Largely descriptive work, with superficial evaluation of the underlying concepts and principles. Weak interpretation of data, flawed development of arguments and judgements. Information accepted uncritically, uses generalised statements made with scant evidence and unsubstantiated opinions. Ideas sometimes illogical and contradictory.	Limited attempt at evaluation of the underlying concepts and principles, tending towards description. Can interpret qualitative and quantitative data but with some errors. Some evidence to support emerging arguments and judgements but these may be underdeveloped or with a little inconsistency / mis-interpretation.	Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid arguments and logical judgements.	Sound evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements.	Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.	Exceptional evaluation of the underlying concepts and principles based on evidence. Outstanding interpretation of qualitative and quantitative data. Exceptional ability to devise arguments using evidence and make wholly appropriate and valid judgements.

Level 4	Category	FAIL 0-29%	MARGINAL FAIL 30-39%	SATISFACTORY (3 rd / Pass) 40-49%	GOOD (2.2 / Pass) 50-59%	VERY GOOD (2.1 / Merit) 60-69%	EXCELLENT (1 st / Distinction) 70-84%	EXCEPTIONAL (1 st / Distinction) 85-100%
	Practical skills (Different approaches to solving problems in particular contexts.)	Limited or no use of taught, basic methods, materials, tools and/or techniques. Little or no appreciation of the context of the application. Very weak evidence of different approaches to problem-solving in particular contexts.	Rudimentary application of taught, basic methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application. Weak evidence of different approaches to problem-solving in particular contexts.	An adequate awareness and mostly appropriate application of basic methods, materials, tools and/or techniques. Basic appreciation of the context of the application. Can identify problems in particular contexts and propose basic alternative approaches or solutions though there may be errors.	A good and appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions.	A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	An advanced application of a range of taught, basic methods, materials, tools and/or techniques. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	Exceptional levels of application and deployment skills in particular practical contexts. Outstanding identification of problems in particular contexts and formulation of wholly appropriate, thoughtful solutions / different approaches.

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	Transferable skills for life and professional practice (Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.)	Work is poorly structured, disorganised, inaccurate and/or confusingly expressed. Very weak use of language and/or very inappropriate style. Failure to work effectively individual or as part of a group. Little or no evidence of the skills for employment requiring the exercise of some personal responsibility.	Work is poorly presented in a disjointed manner. It is loosely, and at times incoherently, structured, with information and ideas often poorly expressed. Weak use of language and/or inappropriate style. Flawed approach to individual or group work, meeting only partial obligations to others. Limited evidence of the skills for employment requiring the exercise of some personal responsibility.	Mostly ordered presentation and structure in which relevant ideas / concepts are reasonably expressed. Work may lack coherence and/or accuracy in places. Can work as part of a group, meeting most obligations to others but perhaps with limited involvement in group activities. Demonstrates the basic skills for employment requiring the exercise of some personal responsibility, with some areas of minor weakness.	Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed. Can work effectively independently and/or as part of a team, with clear contribution to group activities. Demonstrates the skills for employment requiring the exercise of some personal responsibility, with some areas of strength and some of minor weakness.	Work is accurate, coherent, fluent, well-structured and organised. Can work effectively independently and/or as part of a team, with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness.	Work is coherent, very fluent and is presented professionally. Can work effectively independently and/or as part of a team, with an excellent contribution to group activities. Demonstrates excellent skills for employment requiring the exercise of some personal responsibility with an appetite for further development.	Work is accurate, exceptionally coherent, very fluent and presented well. Can work effectively independently and/or as part of a team, with an exceptional contribution to group activities. Demonstrates exceptional skills for employment requiring the exercise of some personal responsibility with an appetite for further development.

THIS DOCUMENT IS ALSO AVAILABLE IN WELSH

HNC Process Operations Engineering

Environmental Protection and Sustainable Manufacturing Systems: PCPO4003

Research Report



James Gambs – 146380

Research Report

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Abstract

The Waste Water Treatment Plant (WWTP) at Pembroke Refinery has been analysed with respect to environmental protection and sustainable manufacturing systems. The WWTP on a refinery is a challenging section of the process plant. The majority of processes on the refinery produce wastewater that cannot be discharged until treated by the WWTP. Therefore the WWTP is required to run with no unplanned downtime, one of the two identical halves of the WWTP must be in operation at all times otherwise production at the refinery will likely be halted. The treatments being utilised at Pembroke Refinery were found to be fit for purpose. The equipment and process design delivering the treatments were also found to be fit for purpose. During the report there were some observations and potential improvements that have been covered which may allow for improvement in order to increase reliability. Many of these observations are already being undertaken at Pembroke Refinery in ongoing projects, this was discovered during the research of the report.



Introduction

The WWTP at Pembroke Refinery was researched whilst working on the plant itself in an operations role, as well as observations made whilst working with the instruments department as well as an electrical contractor.

The scope of this document is to highlight areas of potential improvement in meeting environmental protection and ensuring sustainable manufacture as well as highlighting any shortfalls.

The readership is intended to be solely the lecturer marking and evaluating the work for Pembrokeshire College and University of Wales Trinity Saint David.



Research Report

Aims and objectives

The aim of this work is to develop the researchers knowledge of what is, and is not environmentally acceptable during the process of industrial manufacturing.

The objectives are;

- To objectively evaluate the aspects of the WWTP associated with meeting environmental protection, legal requirements and best practice.
- To objectively evaluate the aspects of the WWTP associated with ensuring sustainable manufacture, with regards to equipment, plant and process.

Findings, arguments and outcomes

In order to provide a comprehensive report on the WWTP it is necessary to briefly explain typical influent water composition, the methods used for treating the influent water and the required water composition of the effluent water with regards to the Integrated Pollution Prevention and Control permit.

Influent Water

An oil refinery typically produces wastewater as part of the refining process, which refines crude oil into products such as petrol or diesel. The typical composition for influent water to a refinery WWTP has been recorded by Ishak, S., & Malakahmad, A., (2013) and can be seen below in Figure 1.

Parameters	Range	Average
COD	744-1673	1209
BOD ₅	205-448	327
pH	7.50-9.41	8.46
Turbidity	402-419	411
Color	3400-3650	3525
Nitrate	3.30-4.90	4.10
TSS	280-340	310
Alkalinity	133-138	136
Ammonia nitrogen	40-45	43
Oil and grease	48-97	73
Phosphorus	1.67-1.73	1.70
TOC	184-217	201
Phenol	1.16-1.44	1.30
Sulphide	14-17	16
Sulphate	40-50	45
TKN	82-95	89
Benzene	33.31-34.36	33.85
Toluene	38.58-41.08	39.83
Ethylbenzene	1.80-1.90	1.85
Xylene	30.03-33.04	31.54

All the units are in mg/L, except turbidity (NTU), color (Pt Co) and pH

Figure 1: Typical refinery WWTP influent water

Processing the Influent Water

The influent water first enters an American Petroleum Institute (API) separator, which essentially draws a length of wood across the top of the influent wastewater in order to separate the solid oil particles from the water. This process is based upon the difference in specific gravity between water and oil.

The influent water then enters the dissolved air flotation (DAF) in order to remove suspended solids from the water. Water cycles from an aerator and the DAF so that the suspended solids adhere to air bubbles, are drawn up and to a level where a skimmer is able to remove them from the water.

The water then enters into a neutralisation sump via a partial flume, in the sump dosing of acid or alkaline occurs in order to neutralise the wastewater.

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The water then enters into two equalisation basins, which allow the water of different levels of contamination as well as different types of contamination to equalise and provide the downstream stages with a flow of consistent strength and contamination, avoiding shocks to the carefully balanced system.

Water flows from the equalisation basins via a weir and into a heating sump which has steam piped into it in order to heat the water, this heating supports the bacteria used in the downstream stages.

Water flows from the heating sump and into the dosing sump where bacteria is dosed into the water whilst it flows into the aeration basins.

The aeration basins retain the wastewater in large basins, which have heat from the heating sump, bacteria from the dosing sump and air which comes from compressors which compress air and distribute it across the incoming flows of waste water via submerged distributors.

Following 18-hour residency time in the basins, the water then flows via gravity to a clarifier. There is one clarifier for each train of processing A and B. The dead bacteria is scraped off the top of the clarifier and disposed of. The live bacteria sits at the bottom of the clarifier and is channelled by scrapers at the bottom into the bacteria sump where it can be recycled back to the dosing sump.

The clarifiers then drain via gravity to the clarified water sump which then flows by gravity to the off test recycle sump, which allows the water to be pumped immediately to The Haven, recirculated back to the beginning of the process or flow to the off test pond for pumping to the Haven later on.

Evaluate specific aspects associated with meeting environmental protection, legal requirements and best practice.

In order to understand how Pembroke Refinery approaches meeting environmental protection, legal requirements and best practice, it is important to understand who defines the standards to meet.

Pembroke Refinery as well as all other industrial sources of emissions to the environment in the UK, must be registered and comply to the IPPC permit system so that all emissions created by any industrial site are recorded, reported, approved and monitored. If they are breached then suspension of operations, fines and prosecutions can all be used against an organisation (Department for Environment, Food and Rural Affairs (DEFRA), 2013).

As part of the IPPC permit, there are requirements that the site operator must adhere to and these are based on best available techniques (BATs). Some of the aspects Associated with Pembroke Refineries compliance will be briefly evaluated for this report.

In order to meet environmental protection requirements, one of the steps that BATs recommends for environmental protection as well as legal requirements is to profile and record the wastewater prior to it arriving at the treatment plant. The site operator does this very well, each unit that discharges to the WWTP must fill in a permit to discharge so that the WWTP knows what waste is being sent to it and when.

The influent is tested three times a day to ensure that the characteristics match the maximum quantities that the WWTP is capable of treating. If these are found to exceed limits then the system can be put on circulation, which allows the influent to be diluted in the surge pond and avoids the WWTP being shocked by particularly strong influent, which may damage the biological section of the plant.

This example illustrates how Pembroke Refineries WWTP meets environmental protection and legal requirements using best practice defined by the European Parliament.

An aspect of environmental protection is the location of the WWTP and its storage ponds, BATs require an 'Optimised storage location' which requires the facility to be as far away as technically and economically possible from sensitive receptors. In this example this would be Milford Haven and its tributaries, which are numerous streams around the refinery. This is an occasion where the site operator does not fully comply with the BAT but the European Parliamentary BATs acknowledge that this would not be economically possible for a plant established in 1964. It also states where economically possible and in this example it would not be, to move the WWTP away from its current location. ✓

Another aspect of environmental protection is that different areas of the plant at Pembroke Refinery have different run-off areas. So cleaner run off from the West section of the plant is channelled towards the West reservoir. This can then be used to dilute the WWTP as and when required. The BAT document states that segregated water streams is something generally required of new plants so it is a very good thing that Pembroke Refinery possess this functionality given it has been operating since 1964. This form of influent regulation is also recommended by Wang, L., et al (2004). ✓

Evaluate specific aspects associated with ensuring sustainable manufacture through efficient equipment, plant and process operation.

Whilst the IPPC permit does cover a lot of what Pembroke Refinery must do with regards to the management of emissions, it is left open to guided interpretation as to how the operator achieves this with equipment management and plant design. The IPPC permit and European Parliament provides information as already discussed on BATs but the equipment management used to achieve this is left open to the permit holder, in this case Pembroke Refinery. ✓

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One aspect mentioned in BATs is that pipework should be, wherever possible, above ground in order to facilitate the finding of leaks (The European Commission, 2018). This enables the plant to continue functioning to its environmental compliant aims by ensuring efficient equipment. This is especially true of the main discharge pipeline, where if any leaks occurred it could be considered uncontrolled discharge and a breach of the IPPC permit. Pembroke Refinery mitigates this occurring by regularly inspecting the pipeline to ensure that no leaks are occurring.

The flow of the WWTP at Pembroke Refinery is completely duplicated so that two separate systems, which are mirror images of each other exist. This enables appropriate maintenance to be carried out as well as redundancy, should there be a failure of the process. If one stream should fail then all influent water can be directed to the other stream. This may require some re-circulation to occur in order for the increased volume to be treated to the required standard but it does enable the WWTP to continue to function. This is a very positive action taken by Pembroke Refinery in order to ensure continuous operating of the plant.

Do they compare the performance of the two systems?

An area of potential improvement is the PH monitoring and adjustment system on the WWTP system. Currently the addition of alkaline treatment to bring the PH of the plant to a neutral range of between 6-9 is done manually at the Parshall flume. Measurements are taken manually using test kits and then the operator analyses the test results in order to determine what amount of PH treatment is required in order to maintain the process within the required parameters.

An important aspect of the WWTP is the biological treatment of the wastewater, this is important for compliance with the IPPC permit. This is achieved in the aeration basins with microbes, which reduce the chemical oxygen demand (COD) of the water to be discharged by the WWTP. If this was not done then a high COD in the water being discharged could be harmful to aquatic life in the Haven. This section is protected by numerous equipment, plant and process operations. The compressors used to aerate

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the basins are triplicated so that redundancy is provided, an example of efficient equipment management.

There are controls in place so that should certain sections of the refinery feeding into the WWTP start to produce high amounts of ammonia for example, the WWTP is notified so that they can prevent high amounts of ammonia reaching the aeration basin and killing the microbes. Once the microbes have exited the aeration basin and been collected in the clarifiers, they are then channelled to one 'bug-sump' where they are stored until being pumped back into the aeration basin to treat more water. This is a weak point of the process where if the pump failed or the sump itself failed, the system would have to stop functioning, as it would no longer be biologically treating the wastewater until a replacement pump was installed or the broken pump fixed.

An example of efficient plant operation which Pembroke refinery carries out extremely well is good housekeeping on the units which therefore ensures that the amount of solid waste reaching the WWTP is minimised and therefore the reliable and efficient running of equipment which might otherwise be clogged and made inoperable.



Conclusion

The WWTP at Pembroke Refinery complies on all requirements placed upon it by the IPPC permit, which allows the effluent water to be discharged to Milford Haven. In some instances such as the automatic PH dosing, Pembroke Refinery is going above and beyond what is required of it under the IPPC permit.

A recommendation from this assignment is that the PH dosing which is currently manual be updated for an automated system. A PH measuring probe is recommended to continually and automatically monitor the PH levels in the water passing through the plant. An automatic dosing system would then administer the PH treatments be that acid or alkaline into a specific part of the flow into the equalisation basins which would then allow the treatments to settle out and not shock the downstream sections of plant. This recommendation is currently under consideration and will hopefully be utilised to improve the plants efficiency and reliability.

Any non-compliance of Pembroke Refinery to BAT is exempt with the IPPC permit due to the age and design of the plant.

The overall aims and objectives have been successfully met as evaluation of the required aspects of the WWTP have been carried out. The researcher has also learnt valuable information on these aspects of the WWTP which may help during the researcher's career at Pembroke Refinery. ✓

You could have included more analysis of the retained improvements for the system.

References

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