T-LEVELS | Institute for Apprenticeships & Technical Education

# T Level Technical Qualification in Design and Development for Engineering and Manufacturing (8730-14)

## 8730-035 Employer-Set Project Exemplar – A Grade

## Summer 2023

City & Guilds | eal

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# Introduction

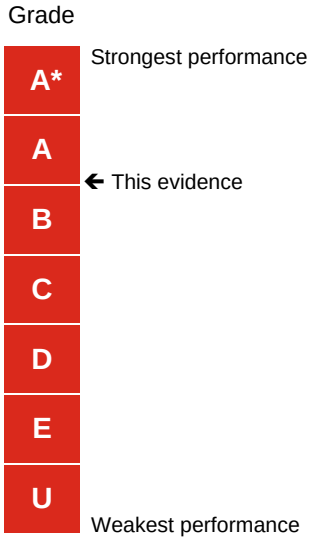
**Summer 2023 Results**

This document is aimed at providers and learners to help understand the standard that was required in the summer 2023 assessment series to achieve an A grade for the 8730-035 Design and Development for Engineering and Manufacturing Employer-Set Project (ESP).

Providers and learners may wish to use it to benchmark the performance in formative assessment against this to help understand a potential grade that may be achieved if a learner was to attempt the next summative assessment series.

The Employer-Set Project is graded A* to E and Unclassified.

The exemplar evidence provided for the A grade displays the holistic standard required across the tasks to achieve the A grade boundary for the summer 2023 series.




The Employer-Set Project brief and tasks can be downloaded from here.

**Important things to note**:

- We discussed the approach to standard setting/maintaining with Ofqual and the other awarding organisations before awarding this year. We have agreed to take account of the newness of qualifications in how we award this year to recognise that students and teachers are less familiar with the assessments (Vocational and technical qualifications grading in 2023 – Ofqual blog), whilst also recognising the standards required for these qualifications.

- The exemplar evidence presented, as a whole, was sufficient to achieve the A grade. However, performance across the tasks may vary (i.e. some tasks completed to a higher/lower standard than an A grade).

Marking of this Employer-Set Project is by task and Assessment Objective, below is a summary of these along with the mark achieved by the evidence presented and the maximum mark available for each aspect.

| Task | Assessment Objectives | Mark achieved | Max mark available |
|---|---|---|---|
| **Task 1 Research** | - AO1 Plan their approach to meeting the project brief<br>- AO2a Apply core knowledge<br>- AO3 Select relevant techniques and resources to meet the brief | 7 | 9 |
| | - AO2b Application of core skills | 4 | 6 |
| **Task 2 Design** | - AO1 Plan their approach to meeting the project brief<br>- AO3 Select relevant techniques and resources to meet the brief | 4 | 6 |
| | - AO2a Apply core knowledge | 3 | 6 |
| | - AO2b Application of core skills | 4 | 6 |
| | - AO5a Realise a project outcome – was the right outcome achieved<br>- AO5b Review how well the outcome meets the brief, how well the brief was met, the quality of the outcome in relation to the brief | 4 | 6 |
| **Task 3 Plan** | - AO1 Plan their approach to meeting the project brief<br>- AO3 Select relevant techniques and resources to meet the brief | 4 | 6 |
| | - AO2a Apply core knowledge | 4 | 6 |
| | - AO2b Application of core skills | 4 | 6 |
| **Task 4 Present** | - AO1 Plan their approach to meeting the project brief<br>- AO3 Select relevant techniques and resources to meet the brief | 5 | 6 |

| | | | |
|---|---|---|---|
| | - AO2a Apply core knowledge | 4 | 6 |
| | - AO2b Application of core skills | 4 | 6 |
| | - AO5a Realise a project outcome – was the right outcome achieved<br>- AO5b Review how well the outcome meets the brief, how well the brief was met, the quality of the outcome in relation to the brief | 5 | 6 |
| **Maths** | - AO4a Use of Maths skills | 2 | 3 |
| **English** | - AO4b Use of English skills | 3 | 3 |
| **Digital skills** | - AO4c Use of digital skills | 2 | 3 |

**What evidence was being assessed for the maths, English and digital skills:**

Maths:

- Annotations on sketches (Task 2)
- Dimensioning and scaling CAD drawing (Task 2)
- Hydrostatic pressure calculations (Task 2)
- Calculation of timescales and critical path within the Programme of work (Task 3)

English:

- Technical brief (Task 1)
- Notes detailing how the designs meet the brief requirement (Task 2)
- Supporting statement for the programme of work (Task 3)
- Presentation delivery (orally) and materials to support presentation (e.g. slides etc) (Task 4)

Digital:

- Types of sources used for Research (Task 1)
- CAD Drawing (Task 2)
- Presentation of the programme of work (Task 3)
- Presentation materials (slides, handouts, notes etc) (Task 4)

# Task 1 Research

| | |
|---|---|
| **Assessment number (eg 1234-033)** | 8730-035 |
| **Assessment title** | Employer-Set Project |

| | |
|---|---|
| **Candidate name** | <first name> <surname> |
| **City & Guilds candidate No.** | ABC1234 |

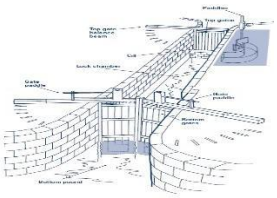
| | |
|---|---|
| **Provider name** | <provider name> |
| **City & Guilds provider No.** | 999999a |

| | |
|---|---|
| **Task(s)** | 1 |
| **Evidence title / description** | **Evidence expected for marking:**<br>Technical brief (typically 1500 words)<br>Research notes<br>List of references/sources<br><br>**Evidence submitted for marking:**<br>Technical brief (typically 1500 words)<br>List of references/sources |
| **Date submitted by candidate** | DD/MM/YY |

# Lock Restoration LTD

# *Mechanical*

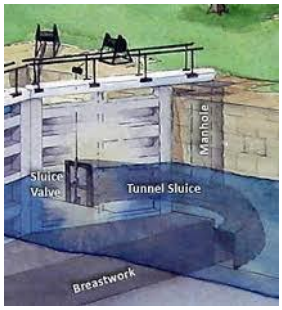
Lock gates are reliant on the hinges they are fitted to in order to keep water inside the main compartment of the lock and to fluently turn when required. The operation of the lock is thus dependant on the hinge and the lack of permeability of the gate. Each lock normally contains 2 gate systems. The upper gate is to allow the filling of the main chamber for access from upstream and the lower gate is to allow access to and from downstream.



(Narrowboat, Canal, 2023)

Furthermore the brief indicates that each of the 2 systems, lower and upper, should be operable separate to each other, so it is reasonable that each set of gates should be independent in power and mechanical systems for redundancy too.

Lock gates themselves are traditionally large paddles that fit together in order to maintain a watertight seal to keep the main chamber of the lock at the designated water level. Both gates should have the same base height. Locks also have small passages for water to flow in and out of the main channel called sluices for filling and draining, in modern day these passages are controlled with valves.




(Ken.W.Watson, 2023)

The design brief specifies the gates to have a height of 6m and to be fit in a 4.2m wide opening, indicating 2.1m of space per single gate on each side. With a maximum water differential of 3.5m, the formula to be used later for hydrostatic pressure is:

Pressure = Fluid Density x Gravity x Depth of Fluid

(Ltd, Martin Childs, 2023)

This is a simplistic view of 1 side of a gate, showing a basic structure of perpendicular beams. This also shows a basic opening and closing mechanism for the gate, applying leverage to make the process easier. Additionally this image shows an approach to comply with health and safety with the path of the beam clearly marked out on the floor and with a railing to prevent being too close to the gate, improving the design as a whole.

Also, this design is fitting to ISO 14001, widely recognised as the 'environmental management system' (BSI, 2023)

Another approach to opening locks is with a windlass. ' This is an L shaped handle which is fitted to the spindle on the paddle.' (Hire, ABC Boat, 2023). This is like a manual winch. The advantages this holds over the elongated beam is that less space is taken up by the mechanism and will thus look neater and more visually appealing too. The disadvantage of this is that the windlass may take longer to open the gate than the beam because the windlass takes advantage of gear ratios for its torque, meaning the general operation is drastically slowed.

Both of these options are manual, however the windlass can be easily converted to be electrically powered to better fit the brief for a more automated system.

**Autonomous Systems:**

As previously mentioned, a revolving system is very easy to operate and takes a smaller space than systems applying large amounts of leverage. This brings the idea of a simple motor powered system involving gears. To fit the brief the motor should be small enough to fit in a small box placed next to each gate to keep the aesthetic design of the gate high and to be easily accessible and serviceable.

A separate method of remote control for the gates is through a motor connected to a rack and pinion gear

(Spec, Global, 2023)

This is a simple diagram of a rack and pinion gear, demonstrating the potential of the system to move an object laterally in  one direction and back. This system could be useful for the lock gate because it is very easy to operate and service, fitting the design brief for easy maintenance.

Using a motor for the remote control of the gate is essential. Motors can be switched on using a variety of long range applications so it makes sense that from the operation centre, the gates can be opened and closed without complexity. However using motors for the gate will obviously require electrical power. Because each pair of gates must be independent, the pairs must use individual mains access to neutralise a simultaneous failure and to increase redundancy.

**Hinges:**

There are many types of hinges, however to comply with the brief, the lock gates require exceptional hinges in order to with stand a maximum 3.5m of water pressure. On the other hand, hydrostatic pressure can work to the advantage of the gates.

(Lock (water navigation), 2023)

It is shown at this lock in Germany that the hydrostatic pressure of the water is helping to keep the gates closed. This is because the angle of the gates is forced by the water in such a way that the water is pushing the gates shut.

The first idea for a hinge is one large hinge ranging all the way down each gate. This is the strongest possible hinge as it has the most action, but would require expensive maintenance due to the size and purpose of each. These can be simplistic, with just a long beam or may involve interconnected points ranging all the way down the 6m of the gate. The interconnected point approach is beneficial because it would mean smoother operation however it would also be more prone to damage.

The additional option is to incorporate a swivel at the top and bottom of the gate, which is very simple and effective, but will bring a lower factor of safety to the gate. ‘Modern steel agates are operated by electricity’

(Consider The Source, 2023), which is beneficial as steel is a reliable material and can provide a long term gate with decent strength.

**Seals:**

The mechanical seals of the lock are to mitigate water loss from the main chamber. The materials of these seals will be discussed later in the research alongside the other materials for everything else. One concept about this though is that the seal must work in conjunction with the environment and the hinges.

**Safety:**

The lock gate mechanisms should all be covered with access provided as a secondary option behind keeping people safe. The brief also specifies the majority of this should be within an observable box. Thus, objects such as fire extinguishers of necessary types should be present near the area. Also, the main gates should be withheld with railings to add another level of safety to the project.

# *Technological*

There is a technological element to this project, in which the suitable technology for the operation must be durable and be able to withstand likely humid conditions and to present a viable and reasonable alternative to manually operating the lock or even locating the operator at the lock itself. In order for this to happen the lock mechanism must be capable of completing very operation possible for manual operation but to also complete it in a more efficient manner, whether that be speed, cost, or general efficiency or health and safety. However because the main site is located away from the lock , the diseconomies of scale come into play and leave the lock subject to more health and safety and liability issues if an accident occurs.

The brief specifies that the gates will be operated off-site, presenting the need for a partially automated system at the lock. The main requirements for remote control are:

1. Sensor, the operator must have an input of the current state of the lock and know what is currently happening.
2. Receiver, the operator must be able to send commands to the gates in order for them to be used.
3. Action, the gates must have a system to operate themselves without nearby human interaction.

1:

The types of sensors needed must be able to show the operator which gates are open, the current water level, and if the lock is in use. The first scenario can be solved with a camera at each pair of gates so the operator  can see a clear image of the state of each gate. The water level can be solved with cameras and markings on the canal wall, or with other types of sensors e.g. pressure sensors. The third scenario can be solved with possible radio contact

from the oncoming vessel to the off-site area, or with a signal or some sort to alert the operator that a vessel is waiting to use the lock.

(Pexels, 2023)

This example of a camera is ideal as they present a clear image and require low maintenance. However they require a connection to the grid. For Pressure sensors, the idea is to record a change in pressure when the sensor is submerged, for example if the sensor is placed 5m up and it is triggered consistently then the water level has reached at least 5m.

**2:**

A possible solution is to place a nearby arial, which can then transfer the commands via underground cable or another HSE compliant and safe option so the gates. This would allow for the long range operation provided the arial is at a high enough quality and reliability. It is not recommended to use systems such as Wi-Fi because of the likely very long range required.

**3:**

The action of the lock gates is covered in the document already however additional systems may be required to ensue they work properly. For example, a safety button must be installed, specified in the design brief, in order to alert the operator to close or open the gates quickly in case of emergency. This could either be controlled by sensors or operated by someone near the lock, someone travelling on a vessel as an example.

In the technological side of the project, it is also important to consider how each system will work in conjunction with one another, otherwise it will be a waste of resources and time. The sensors required to give the operator a virtual idea of the situation must be of very high quality to aid in liability accident avoidance.

The technology chosen as final will be of high quality to ensure the efficiency of the lock is kept stable.

# *Materials*

**Gate:**

The design brief indicates that the lock gates must last a long time, be sustainable, and preferably low density for maintenance and removal if need be. This warrants the use of metals and certain plastics , compliant to BS EN 17472 for the 'Sustainability of Construction Works' (BSI, 2023). Metals should only be used if they do not rust, meaning many ferrous alloys par stainless steel etc are not suitable for the gates.

A material such as stainless steel is also durable and recyclable, fitting to some of the specifications required. However this material is also heavy, and could cause issues with maintenance as the gates will need to be removed periodically for certain aspects of maintenance and this could present an issue if stainless steel is used too much.

Plastics are another option, with the brief's specification leading towards FRP, fibre reinforced polymer, as a viable option. The main benefits are that it is very corrosion resistant, lightweight, and long lasting with low fatigue too. (Fibrwrap, 2023) On the other hand, this material is quite flexible.

This raises the idea that using a combination of both materials would be very beneficial because the benefits of FRP overshadow the disadvantage of Stainless steel, and the strength and low flexibility in comparison means the gate would fit almost all criteria of the brief. With correct proportions and applications of each material the gate would be lightweight, strong, and very durable and long lasting while also being recyclable so this is a very good combination of materials to use. To comply with HSE these materials are also safe to use, and can be maintained and worked on efficiently.

**Mechanism:**

The mechanism itself will be unlikely to be subject to as much erosion as the main gate as it will be covered as much as possible in corrosion resistant material. Furthermore the brief specifies the need for an aesthetically appealing design, warranting the use of a cover of the mechanical elements to both be beneficial physically but also for the eye. The mechanism itself should be made of metals as metals can withstand high strains, which would be required for turning a large lock gate with water resistance. Cast iron is a cheap source of strength for gears and mechanical objects, and other steels would also work too. Steel is a good category of material for this because of the low cost due to the simple materials it is made from. However, the maintenance of this project is likely to include welding so the mechanism must be well ventilated if this is required in order to ensure the safety of everyone involved with the lock.

The motor comes under this topic as there are many different choices of motor. However it is evident that the motor must have a large torque to warrant using electrical power to use the gates anyway.

(DANFOSS, 2023)

This is an example of possible motors that could be used due to their high torque, ideal for moving heavy weight. Motors like this are also mainstream so in the event of a failure in terms of liability, the motor can be easily tracked down to when it was made and also to easily find a replacement motor in case the motor company is not liable for the fault of the motor.

It is plausible that different materials will be chosen depending on the final mechanical design because different systems will be more/less abrasive and will require slightly different properties. For example cast iron could be replaced with high speed steel for faster mechanisms with more action points for less overall wear and maintenance requirements in the future.

**Seal:**

The seal of the lock is essential for minimising leakage. The issue presented for seal materials is that they must be environmentally friendly and not soluble. The other requirements for the seal, supported by the design specification is that they must maintain their properties and usefulness while the lock is in use, meaning when subject to motion the seal must not break too much. A minimal leak is alright for the locks as long as the upstream lock can support the leak of the downstream gate, to maintain the target water level in the main chamber.

The types of sealant that fit the brief the best are thus resins. Resins are liquids that set into a rubbery texture, which makes them very useful for watertight operations. One candidate is UPE, Polyester resin. This is widely used in the ‘marine industry’ (Exel Composites, 2023) which makes it suitable for watertight uses and being used underwater as a whole.

On the other hand, there is the possibility of using more organic materials for the project such as white oak, a wood which can effectively absorb liquid and is soft enough to act as a

sealant if positioned correctly. The main advantage of this is that it works well after being subject to movement unlike chemical seals, however the wood will rot over time and will thus be likely to require more maintenance than the chemical counterparts.

This means that the best option for the specification is organic materials yet they yield higher costs when in use, which will be decided on in the design period of the project where material costing can be fully evaluated to determine the best option here.

# *Summary*

Each component of the project has been evaluated in terms of materials and how each material researched and written on is the ideal candidate for the purpose. The Gates can be operated independently with added redundancy and the project has been researched in a way that the topics cover the design specification fully.

The mechanical systems of this project are believed to fully adhere to the brief in order to meet the demands of Lock Restoration Limited and the electrical components and semi-automation systems are selected to provide a mix of ease of use with cost and efficiency too.

**Health and Safety:**

The lock gate and it's brief have been researched with the idea of complying to the HSE regulations such as COSHH with ventilation of the mechanical systems in case of welding and with railings to physically protect pedestrians and people in general from injuring themselves at the gates. Furthermore, when taking into consideration the seal, the possible materials are environmentally friendly to ensure that the lock is as little environmentally disturbing as possible.

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# Task 2 Design

| | |
|---|---|
| **Assessment number (eg 1234-033)** | 8730-035 |
| **Assessment title** | Employer-Set Project |

| | |
|---|---|
| **Candidate name** | <first name> <surname> |
| **City & Guilds candidate No.** | ABC1234 |

| | |
|---|---|
| **Provider name** | <provider name> |
| **City & Guilds provider No.** | 999999a |

| | |
|---|---|
| **Task(s)** | 2 |
| **Evidence title / description** | **Evidence expected for marking:**<br>Sketches for two designs and a CAD drawing<br>Supporting calculations<br>Notes<br><br>**Evidence submitted for marking:**<br>Sketches for two designs and a CAD drawing for preferred design.<br>Support calculations (on drawing)<br>Notes |
| **Date submitted by candidate** | DD/MM/YY |

Both designs are constructed with the same materials in different layouts, F.R.P and stainless steel. These materials were chosen as when combined they can yield a high strength capable of withstanding enough hydrostatic pressure and are lighter than solid metal gates due to the lower density of F.R.P. Each gate is 6m tall, with the fist gate being 2.1m long, at a flat angle. The second gate is angled 10’ inwards, causing the length of 2.13m. Above each gate there is a rail guarded walkway to aid in maintenance of both sides of the canal. This complies with health and safety due to the mesh that should be applied to each side to prevent falls.

Adjacent to each gate is a receiver that can take the commands from the off-site control facility and move the gate in the required direction. On gate 1, the receiver box is extended to allow for a high torque motor with a large reduction to power the gates. This high torque motor is connected to a set of bevel gears to allow smooth and efficient power transfer from the motor to the gate. Also, the motor is limited in terms of RPM to prevent large waves and potential swells caused by opening the gates too quickly. On gate 2, the receiver box is not extended, but is connected to a set of 2 hydraulic pistons per gate. Each piston islocated evenly on the door, and slowly outputs the force and extension required to open or close each gate.

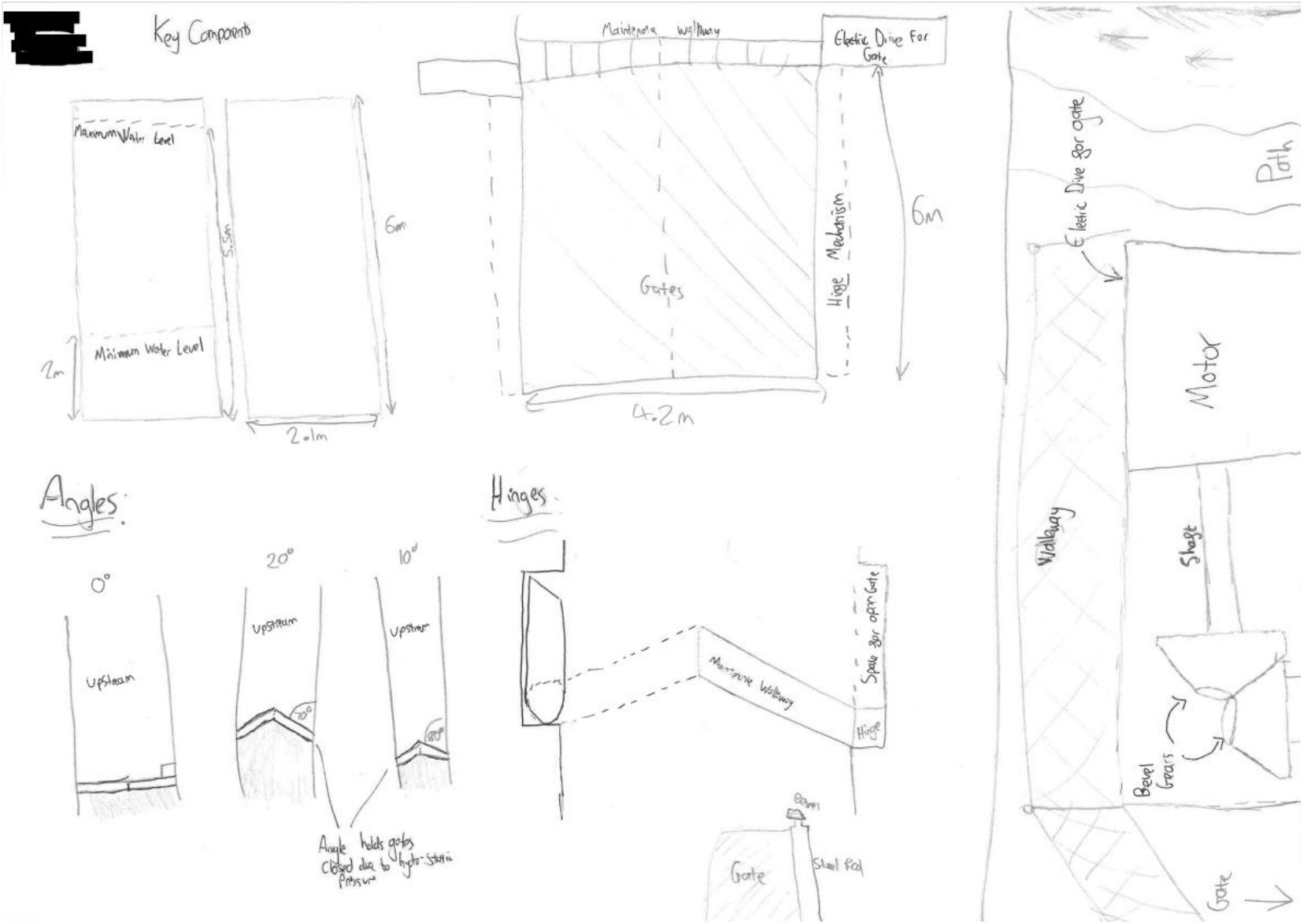
For the remote operation of each gate there is a surveillance camera looking over each pair of gates to give the off-site operator a clear view of what is happening at each gate. A P.I.R sensor is also installed at each gate 1m up and downstream to alert the operator in emergencies and to also cancel any input to the gates in case a vessel is too close. This proximity sensor may need is included as part of the receiver box and is connected to the emergency signal generator too.

All of these components are connected to the mains power source. However, each gate pair will be powered independently so that if one set of gates fails due to an electrical fault then the other gates are redundant. Each design incorporates these features to ensure the brief is met.

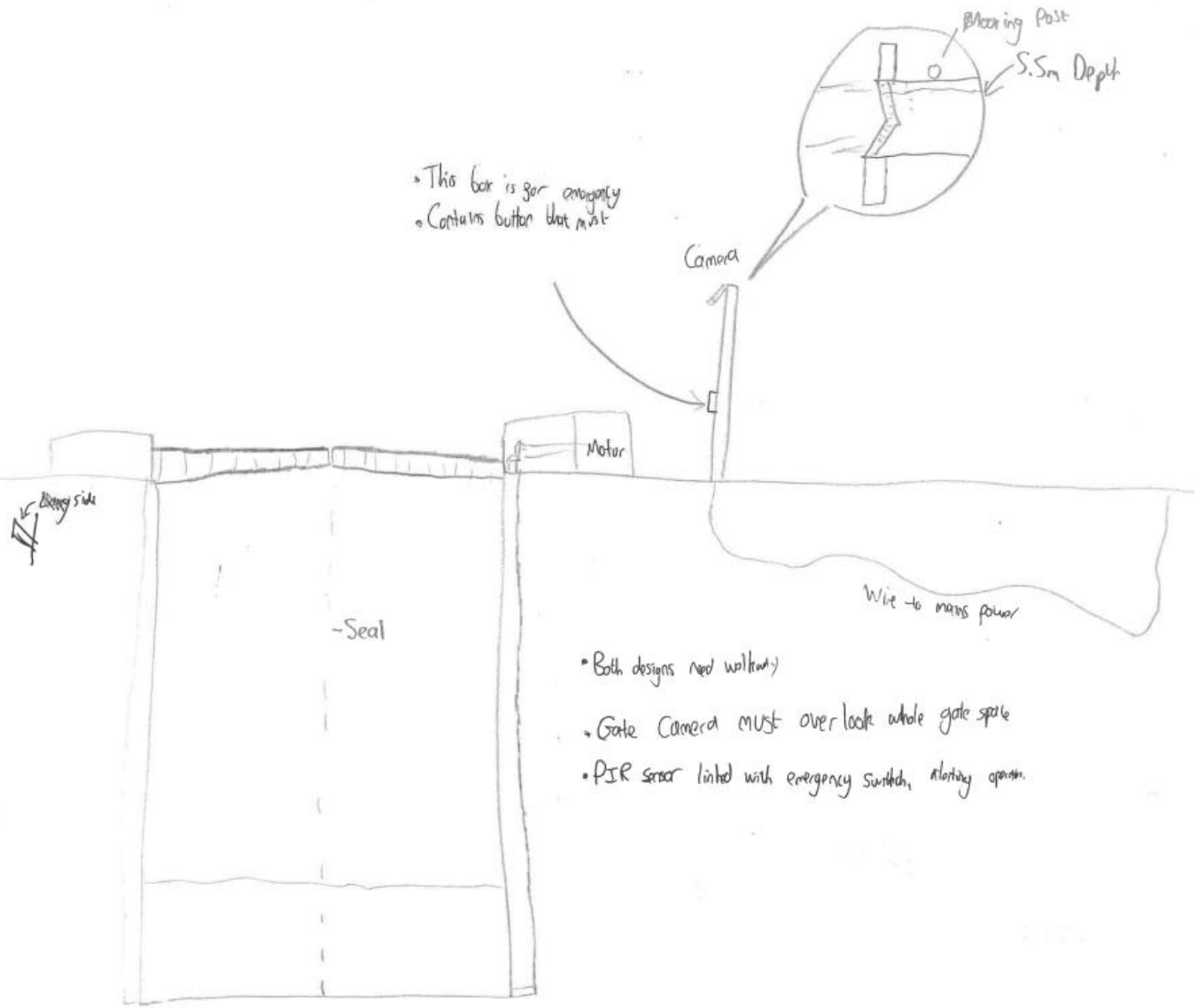
For the aesthetics of each design, the stainless steel will be produced with a smooth finish, especially on gate design 1 as the steel must connect efficiently with the partnered gate to minimise leaks. All F.R.P will be painted black. For safety reasons the walkway is installed, which has a small impact on the aesthetics of the design.

Furthermore the service box containing the receiver , emergency signal and motor* on gate 1 will be produced as small as possible, with room for maintenance and ventilation, meaning the box will not harm the looks of the project too much. On the other hand the box is mandatory to protect this equipment too.

[redacted]


Key Components
Maximum Water Level
Minimum Water Level
5.5m
6m
2m
2.1m
Maintenance walkway
Electric Drive For Gate
Gates
Hinge Mechanism
6m
4.2m
Angles:
0°
20°
10°
Upstream
Upstream
Upstream
Angle holds gates closed due to hydro-static pressure
Hinges
Space for arm Gate
Maintenance Walkway
Hinge
Gate
Steel Rod
Electric Drive for gate
Path
Motor
Walkway
Shaft
Bevel Gears
Gate

General Overview & Calculations




For 10° Gate angle, each side must be

$$\frac{2.1}{\sin(80)} = 2.13\,m$$

Hydrostatic pressure = Density × 9.81 × Depth

Depth difference = 5.5 − 2 = 3.5m

$1000 \times 9.81 \times 3.5 = 34335\ N/m^2$

• This assumes that no other forces act on the gate.

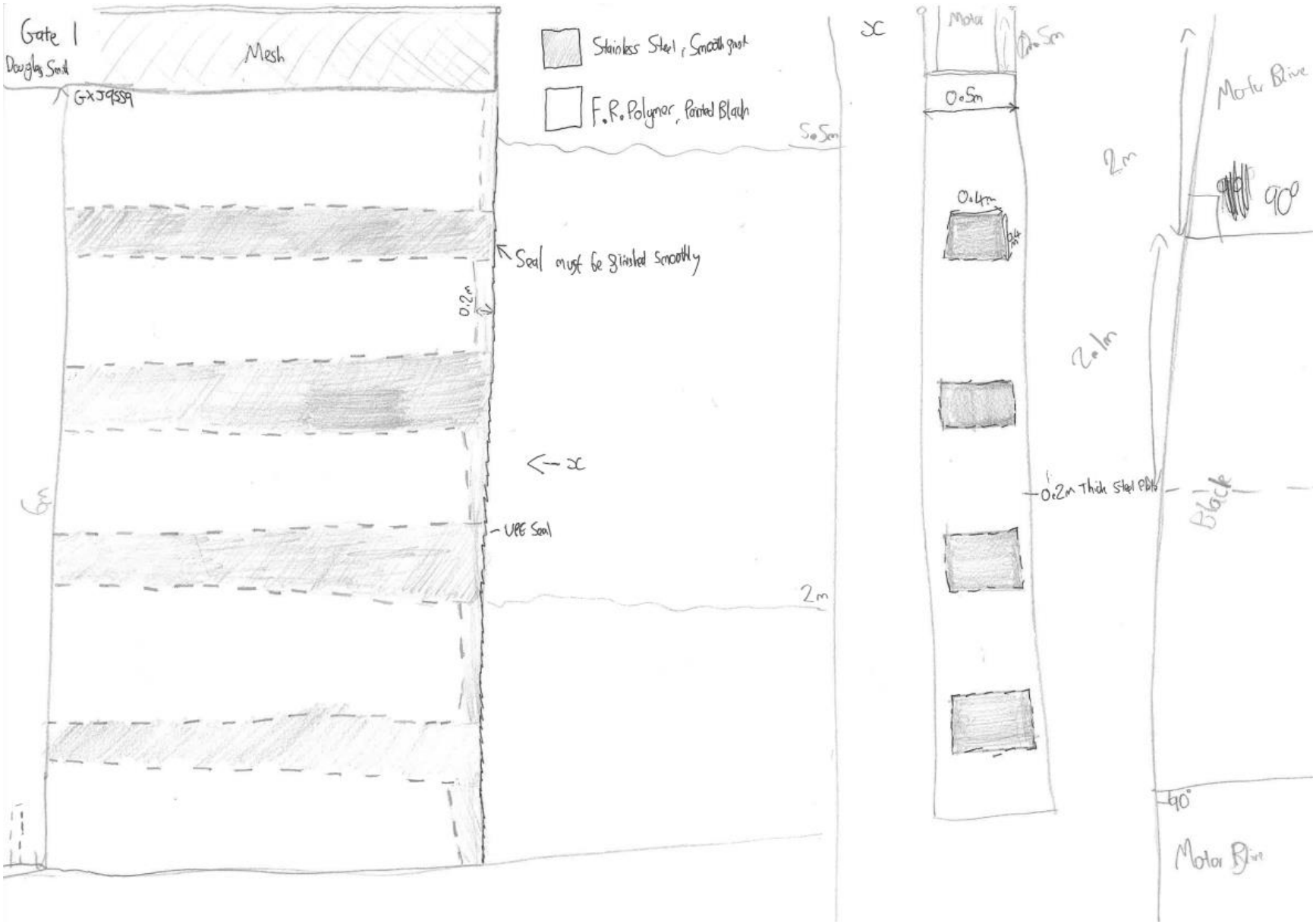
$$\left(\frac{5.5-2}{2}\right) + 2 = 3.75m$$

Force acts 3.75m up gate

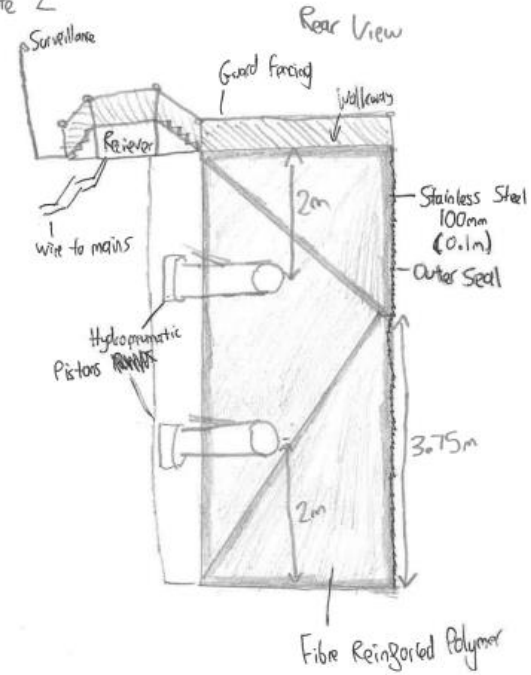
• Both designs need walkway

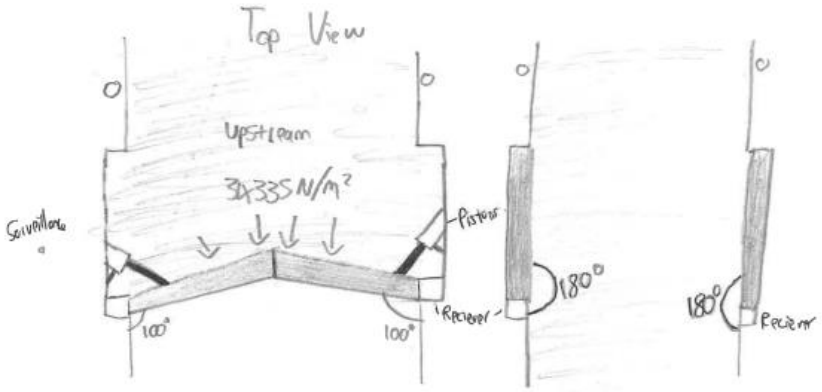
• Gate Camera must overlook whole gate space

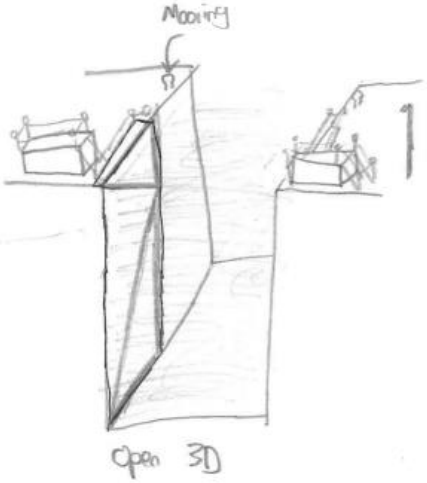
• PIR sensor linked with emergency switch, alerting operator.

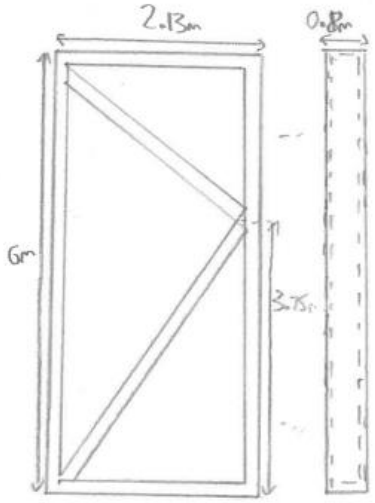

Gate 1
Douglas Seal
Mesh
Stainless Steel, Smooth grout
F.R. Polymer, Painted Black
5.5m
Seal must be finished smoothly
0.2m
x
6m
UPE Seal
2m
x
Motor
0.5m
0.5m
0.4m
0.4m
0.2m Thick Steel Plate
Motor Drive
2m
2.1m
90°
Block
90°
Motor Drive

Gate 2

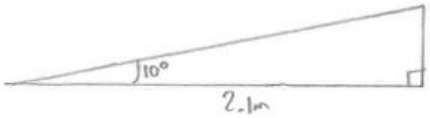


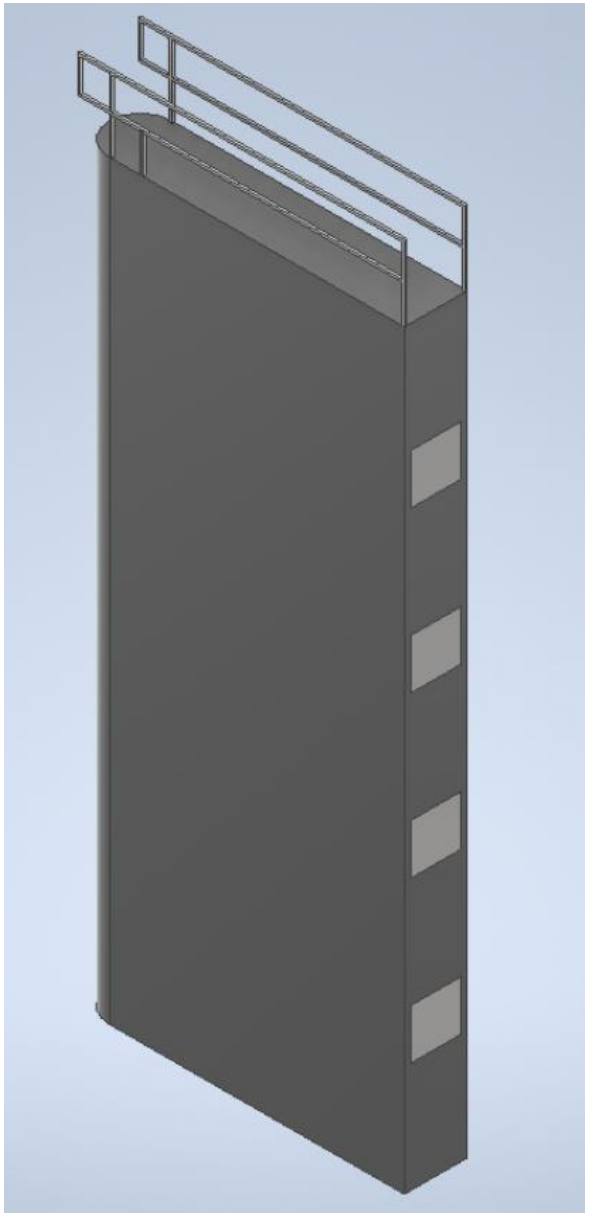



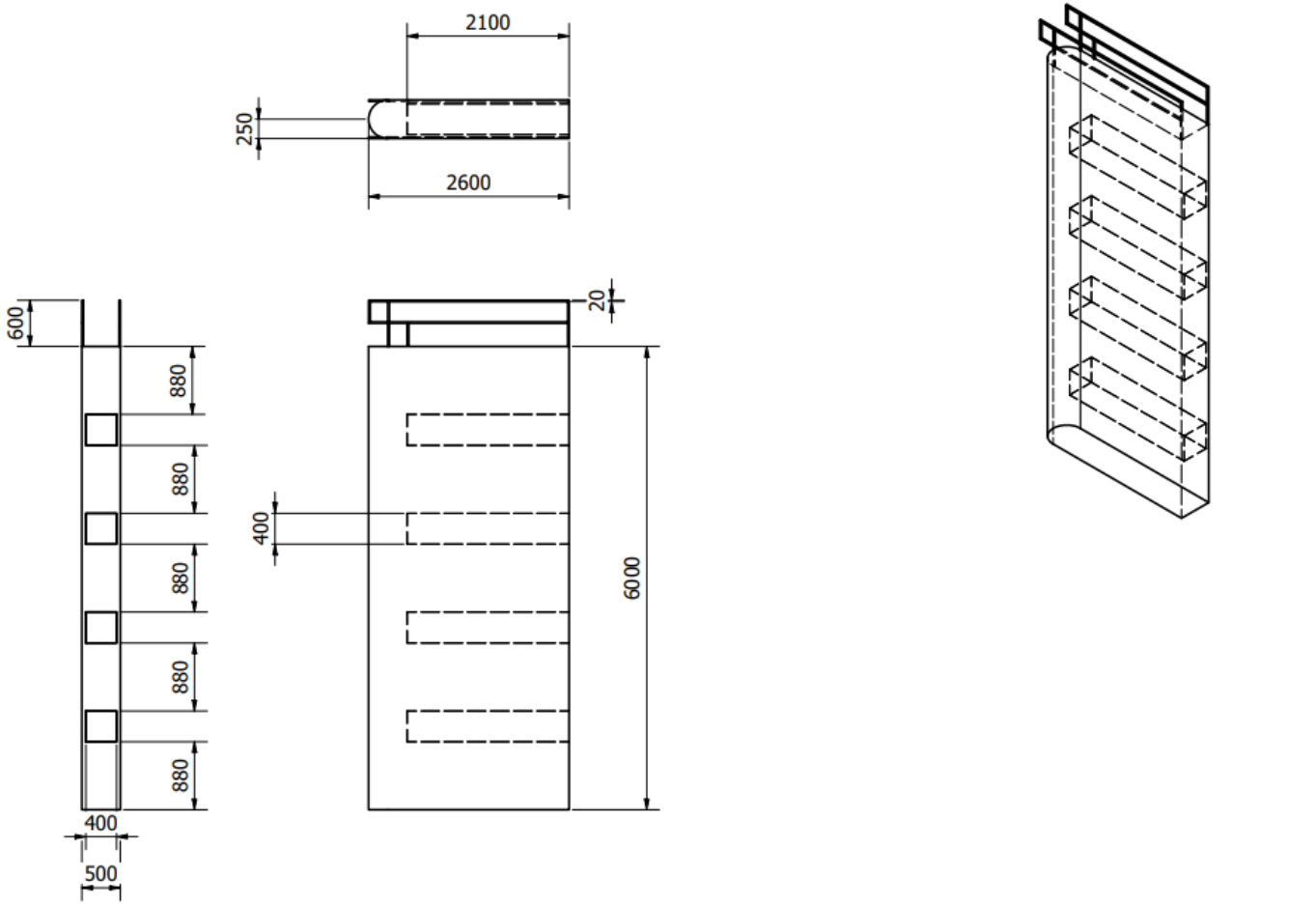

- Pistons have to open door slowly to avoid waves and potential damage to vessel.
- Gate sealed at inner edge with UPE.



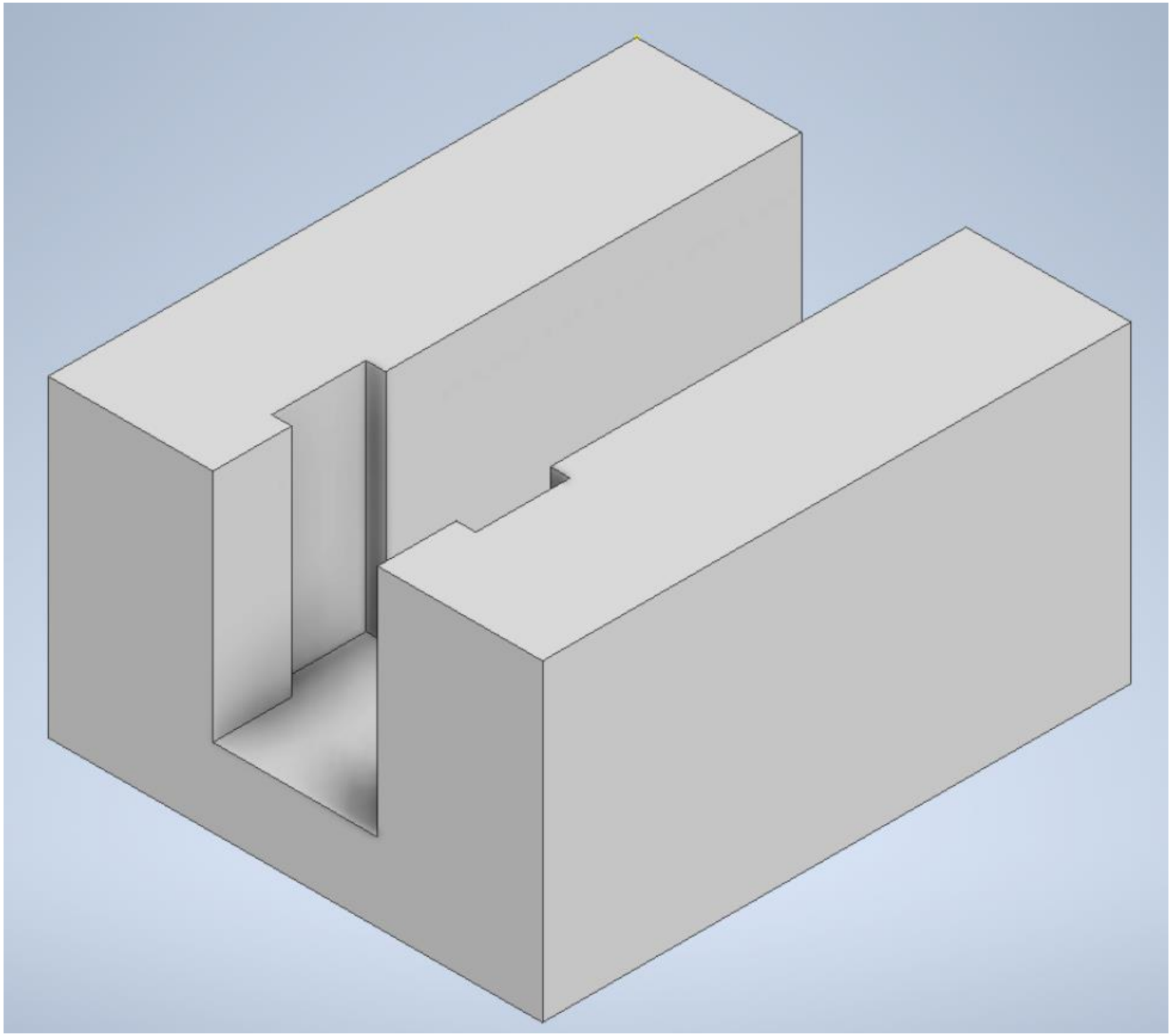

$$\cos(10) = \frac{2.1}{H}$$

$$H = \frac{2.1}{\cos(10)} = 2.13\text{m}$$






| DESIGNED BY | CHECKED BY | APPROVED BY | DATE | | DATE | |
|---|---|---|---|---|---|---|
| ExamVocN012 | | | | | 28/03/2023 | |
| | | | | GATE | ISSUE | SHEET 1 / 1 |



# Task 3 Plan

| | |
|---|---|
| **Assessment number (eg 1234-033)** | 8730-035 |
| **Assessment title** | Employer-Set Project |

| | |
|---|---|
| **Candidate name** | <first name> <surname> |
| **City & Guilds candidate No.** | ABC1234 |

| | |
|---|---|
| **Provider name** | <provider name> |
| **City & Guilds provider No.** | 999999a |

| | |
|---|---|
| **Task(s)** | 3 |
| **Evidence title / description** | **Evidence expected for marking:**<br>Programme of work plan (one side of A4)<br>Supporting statement (typically 1000 words)<br><br>**Evidence submitted for marking:**<br>Programme of work plan (one side of A4)<br>Supporting statement (typically 1000 words) |
| **Date submitted by candidate** | DD/MM/YY |

# Programme of Work

The project can be split into 2 parts, the manufacturing of the product and its installation. The manufacturing side includes all the relevant processes required in order to produce the product out of its environment. The installation side of this task involves placing the product into the correct environment in order for it to do its specific job.

## Manufacturing:

### Key parts

**Stainless steel** is a necessary component of the lock gate and provides critical structural integrity to the gate to allow it to withstand the hydrostatic pressure that the gate is designed for. Stainless steel is an alloy, composing of iron, carbon, nickel, chromium, molybdenum, and other metals. These materials are important to alloy with steel because they provide the properties such as low reactivity and hardness required for the situation. In order to manufacture the stainless steel, each metal must be melted down and mixed. This process can take around 12 hours for melting however this number is a baseline calculation and assumes all the required stainless steel is manufactured simultaneously. Furthermore, hot work will be needed on the steel in order to meet the specification of 400mm x 400mm rods placed evenly up each gate and cold work may be required to make sure the tolerances are met. The tolerances are in place to minimise extra space within the gate that can lead to leakages or faults in the stress and strain capabilities. In addition, each bar should go through heat treatment to further reinforce its structural strength.

The handrails of the gates at the top are also to be manufactured out of stainless steel. This is due to the low corrosion properties of the material. These properties are important for the railings because they are subject to high levels of humidity at all times, and this would reduce the factor of safety of the rails if they were not resistant to corrosion. Because the rails act as a safety feature it is essential that they remain as strong as possible and do not deteriorate over time.

**FRP's** primary use in this project is as the bulk of the gate. The FRP's role in the project is to form the shape of the canal gate and to act as a barrier to the stainless steel beneath. FRP carries properties such as the low reactivity, high corrosive resistance and low density that make it ideal for the situation. The low density of this material makes it 1/3 of the weight of steel and alike resources so making the parts of the gate which do not require reinforcement out of this material is optimal.

For the production of FRP, the fibres are first strung out before being added to a resin impregnator. This forms the basic structure of the fibres. After this, the fibres are woven and this can be in 2 different ways, however the chosen method is 90'. Because the fibres are woven perpendicularly, they gain a decent level of strength at the benefit of low density and thus lightweight. The downside of this is the cost and this process can take up to a week, however like the stainless steel this assumes all required FRP is produced at the same time.

FRP will also be used to make the footing on-top of the gate. This is because certain styles of FRP

make for solid flooring and the large array of shapes available allow for the material to contain grooves to maintain the grip of the worker when in wet conditions.

**The hinge** for each gate is to also be manufactured out of stainless steel. On the other hand, this process is different to the formation of 400mm x 400mm bars as each hinge must rotate freely whilst keeping its strength. Each hinge will require a billet of a 600mm cube; 2 hinges per gate and thus 4 for a gate each side on a canal. 4 x 600mm cubes of stainless steel is very expensive however it is within the budget and stainless steel is still the optimal choice for this task. This also comes with the added complication of requiring large machines to complete the process.

Each product will also require large ball bearings in a 'watertight' space to reduce wear over time. This requires precise machining; in combination with the raw cost of the materials will make the hinges an expensive feature of each gate.

**Electrical** features in the gate will all require access to the mains power. As stated in the technical brief the components from each will be grouped to their respective gate before being connected to the mains power. This is for added redundancy and more efficient maintenance.

Each surveillance camera can be outsourced and bought in as a finished product. For these to work proficiently they are to be mounted in the air at a height of 3m, giving the off-site operator a clear and informative view of the gates and systems.
The PIR sensor located at every set of gates will also be bought as a finished product. This is a critical part of the safety of the lock and should thus be manufactured by experts in that field.

Each receiver for the pistons will be placed next to the gates in a weather proof maintenance box and this ensures their lifetime. Furthermore, an arial is required to aid in wet weather and for the collection of signals from the off-site facility.

**The pistons** on each gate are to be manufactured from Inconel , a process which is very time consuming and expensive due to the hard machining job of the material. It is necessary to use Inconel because each piston must be able to open and close effectively under very high pressure and thus must be made of a strong and durable material. This process could take weeks, depending on the machining time of the Inconel and the precise fitting of the hydropneumatics. This brings the cost of each gate higher, but within the budget nonetheless compared to the cheaper materials such as steel.

### Assembly:

This would require the majority of the FRP and Stainless steel to be fitted together. This is a slow process because the steel is designed to fit tightly into the FRP to increase strength and reduce leaks.

Each canal gate must contain the 4 steel bars and the FRP shell in order to work properly and this should be completed before sending the gate to transport, minus the railings which are a fast installation onsite.

# Installation:

Note all time assumptions are made under the impression that and necessary groundwork on the canal to fit the gate system is already complete.

### Key stages:

**Logistics** play a key part of this project. This is because each component is likely to come from different companies due to the range of materials and technologies required to produce each part. Because of this, each component should be transported and then installed before additional components arrive to minimise the need for storage. E.g., all hinges installed first before the gate is installed. For each component to be transported, HGV's are required, which are expensive to hire and will also take up to a week to deliver all the resources. On-top of this, there will be a large insurance fee to make sure no damage occurs to the gates as this could lead to critical failure or rapid leaks.

**The installation of the gate** would be to first install the hinges. The hinges are essential for the gate and sit deep into the side of the canal, making it logical to install first.

To install the hinges they should be lowered into place via mobile crane as this allows for precise placement as well as a stable vertical insertion of the part. The mobile crane would be able to install one hinge at a time and  this could take up to a day to make sure all 4 hinges are in place before moving on to the next gate set. The next component to install would be the gate itself. As mentioned prior, the gate as a sub-assembly will be almost compete and it should be lowered into place with a mobile crane again because of the movement capability of the crane and strength required to accurately position the gate onto the hinges. This would require up to a day for each set of gates, however it would be logical to install the gates directly after the hinges due to the mobile crane already in presence. As an example it would likely cost the company more money and time to rehire the crane again after a week or so.

**The installation of the mechanical components** is primarily focused on the hydro-pneumatic pistons as they are the key component for opening and closing each gate. With the assumption that all the groundwork is complete, there will be spaces in the side of each cut-out of the canal wall to accommodate the 2 pistons per gate. In conjunction, the pistons should be connected to each other to ensure no unnecessary moments or mechanical stress are applied to the gate. The pistons are heavy due to the material used and must be installed very carefully to reduce the risk of losing the seal which drives the piston.

**The electrical components** must all be connected to mains power as mentioned prior. This includes, 2 cameras, 2 receivers, and a PIR sensor for each set of gates (a gate at each bank of the canal). Requiring some wire to run above the canal on powerlines this is essential to be installed **after** the mechanical components are finished because the mobile crane presents a threat to the power cables and vice-versa. It will be important to add a firewall to the receiver for basic security reasons, and this can be done from off-site.

Many of the components for the canal can technically be produced in a batch, as each is the same.

However, they should be produced separately. As each component plays a critical role in the gates and is quite niche, producing them in a batch means all of the components will have to be withdrawn if a fault is found in just one of them. Thus, a separate manufacturing method should be used.

### Labour:

Each key part of the project requires different ability and thus a variety of labour components. The main materials needed for the project are stainless steel, FRP and Inconel. All 3 of these materials require different timescales and costs to produce the desired components.

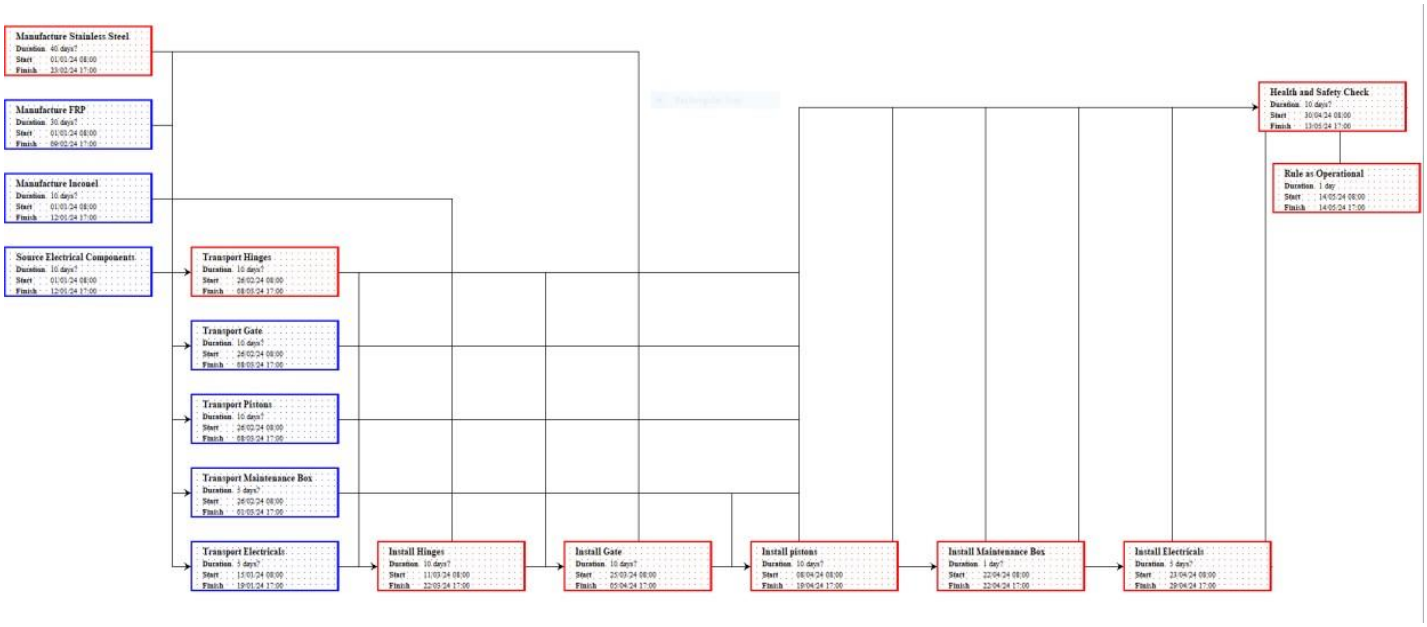
The Stainless steel must be produced first by a steelworks, then shaped correctly by large manufacturing firms. Furthermore, a bar of this material at such a large size could be classed as a custom order which will further increase the manufacturing time and thus cost of the bars. An estimate for the time is 8 weeks, allowing for the importation of the raw materials from overseas if need be. Each hinge will also need outsourcing to a machining company which raises the labour costs even further. However, the safety rails will be relatively cheap as they require a low amount of material compared to the other components.

For the FRP, the process itself can take up to 2 weeks, however each gate requires a very large volume of FRP. Because of this you could expect 4-6 weeks of just FRP production, which can be quite expensive. Estimating an average rate of £10h with 20 employees overseeing the production on 40h work weeks, this brings the possible cost to £48,000 for labour. This charge will not be directly added to the material cost but the company responsible for the FRP must charge additional money in order to support the labour costs to keep the company afloat. This also assumes the production of the thin layer of FRP as footing for health and safety on the gate walkway. Inconel is exceedingly difficult to machine. Consequently, finding companies willing to machine such material will be more expensive than steel, as the material can easily damage tools. Because of this, the pistons will be one of, if not the most expensive component of the gate. This nickel based superalloy could take up to a week of pure machining in order to meet the specification.

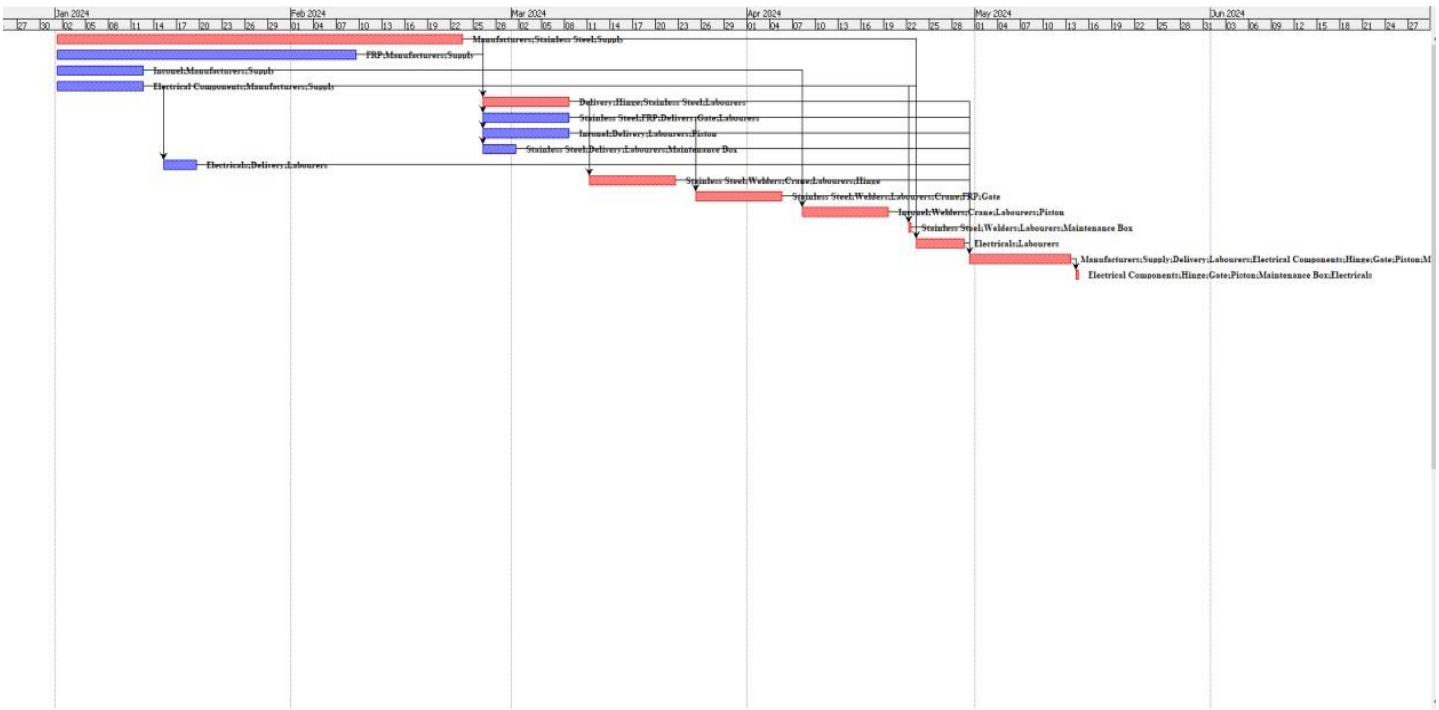
For the assembly of the project, many welds will be required. This means more labour costs still as skilled welding is expensive to fund, and must be TIG welding because the stainless steel can otherwise prove dangerous to work on. This includes the gate hinges, the safety rails, and the gate. A mobile crane is also needed and has the possibility of being on hire for more than 20 weeks due to the delays in use from the hinges being installed and then welded fully before the gate is installed and then the pistons etc.

This choice of labour is necessary to comply with the material choice which is optimal for the project. Total labour costs of the lock gate that are liable to the lock company could range around £30000 depending on the employees used and how long the project draws out for.

Here is a Network Diagram showing an estimated time for 1 set of gates:




This diagram shows us that the product could be fully operational by May. However this accounts for only 1 set of gates, of which there are 5 total. So the installation time can increase and still fit within the 52 week time period. Furthermore the red shows the critical path, with the hinge transport being listed as critical because it begins the sequence of installations after the hinge. However due the assumption that the installation process is 4 weeks per gate system then each of the chain-installation systems may be done simultaneously to meet this deadline. This is a Gannt chart form:



Accompanied by a tabled format:

| | | Name | Duration | Start | Finish | Predecessors | Resource Names |
|---|---|---|---|---|---|---|---|
| 1 | | Manufacture Stainless Steel | 40 days? | 01/01/24 08:00 | 23/02/24 17:00 | | Manufacturers;Stainless Steel;Supply |
| 2 | | Manufacture FRP | 30 days? | 01/01/24 08:00 | 09/02/24 17:00 | | FRP;Manufacturers;Supply |
| 3 | | Manufacture Inconel | 10 days? | 01/01/24 08:00 | 12/01/24 17:00 | | Inconel;Manufacturers;Supply |
| 4 | | Source Electrical Component | 10 days? | 01/01/24 08:00 | 12/01/24 17:00 | | Electrical Components;Manufacturers;Su... |
| 5 | | Transport Hinges | 10 days? | 26/02/24 08:00 | 08/03/24 17:00 | 1 | Delivery;Hinge;Stainless Steel;Labourers |
| 6 | | Transport Gate | 10 days? | 26/02/24 08:00 | 08/03/24 17:00 | 1;2 | Stainless Steel;FRP;Delivery;Gate;Labou... |
| 7 | | Transport Pistons | 10 days? | 26/02/24 08:00 | 08/03/24 17:00 | 1;3 | Inconel;Delivery;Labourers;Piston |
| 8 | | Transport Maintenance Box | 5 days? | 26/02/24 08:00 | 01/03/24 17:00 | 1 | Stainless Steel;Delivery;Labourers;Maint... |
| 9 | | Transport Electricals | 5 days? | 15/01/24 08:00 | 19/01/24 17:00 | 4 | Electricals;Delivery;Labourers |
| 10 | | Install Hinges | 10 days? | 11/03/24 08:00 | 22/03/24 17:00 | 5 | Stainless Steel;Welders;Crane;Labourers... |
| 11 | | Install Gate | 10 days? | 25/03/24 08:00 | 05/04/24 17:00 | 6;10 | Stainless Steel;Welders;Labourers;Crane... |
| 12 | | Install pistons | 10 days? | 08/04/24 08:00 | 19/04/24 17:00 | 3;10;11 | Inconel;Welders;Crane;Labourers;Piston |
| 13 | | Install Maintenance Box | 1 day? | 22/04/24 08:00 | 22/04/24 17:00 | 4;10;11;12 | Stainless Steel;Welders;Labourers;Maint... |
| 14 | | Install Electricals | 5 days? | 23/04/24 08:00 | 29/04/24 17:00 | 1;4;8;13 | Electricals;Labourers |
| 15 | | Health and Safety Check | 10 days? | 30/04/24 08:00 | 13/05/24 17:00 | 5;6;7;8;9;10;11;12;13;14 | Manufacturers;Supply;Delivery;Labourer... |
| 16 | | Rule as Operational | 1 day | 14/05/24 08:00 | 14/05/24 17:00 | 15 | Electrical Components;Hinge;Gate;Piston... |

This table of a Gannt chart shows some estimated times for operations as well as the resources needed for the project. The maximum possible time can be ruled as four and a half months, adequate for 1 set of gates. This is because if the multiplied time for 5 gates is used, the project will take well over the time scale of 1 year, however only the transport and installation of the materials will make a significant difference to the time scale.

However it is to assume that the full installation of a gate system takes only 4 weeks so it is possible that the installation stages are intertwined.

# Supporting Statement:

The basic health and safety factors apply to any project. This includes things such as choosing grippy substances for walkways to minimise the chance of slipping etc.. The gate follows this in numerous ways. The first way is by making the walkways above the gate out of FRP, which can be moulded to be grippy and maintain grip during wet conditions. Another way is the safety railing above the walkway to prevent any falls and to help workers balance if need be. The maintenance box contains a vent that can be opened in order to regulate fumes if any sort of welding must occur in that area. The PIR sensor is in place for if a boat gets too close to the gates, which is for health and safety as the sensor prevents the gates from opening into the boat, possibly causing damage to both parties. Furthermore, the canal wall is railed off too, preventing accidents from falling into the main chamber

or even into the piston area with the accommodating space for the gate. These are examples of the many health and safety features of the project.

The lock gate also works within many regulations that are important for the safety of all stakeholders. Firstly, COSHH applies to any welding done within the manufacturing and assembly of the project. To comply with this regulation, all welders working with stainless steel will be TIG welding, with ventilated helmets to reduce the chance of harm via fumes that may arise if other forms of welding such as arc welding are used. Within the maintenance box there will be a RIDDOR book to make sure each accident is well documented so that improvements can be made to reduce the risk of those accidents happening again. Other regulations such as the working at height regulations are also followed, with the safety railings on the walkway of the gates applying as any falls from that height are very dangerous.

The risks associated with this project are that the large component sizes means they can be dangerous to handle. For example each gate weighs well over 50 tons and if they fell over they could cause major harm. The risk assessment however is to be conducted after the full installation of the gate system to check all aspects are working as they should be. If part of the gate system fails this risk assessment then it will simply be replaced by a fully functioning part as the design full adheres to heal and safety for risk assessments.

The main 2 standards that the project allies with are BS 8000 and ISO 9001. These standards represent the manufacturing and quality standards for the UK and are widely followed. The gate build quality will be overseen and reported fully throughout the process of production, before the health and safety checks and approval apply. This is done to provide a full quality check of the gate before it is put to use. Furthermore, because all the components of the lock will be reported on, liability is easily traced as each and every part will have a listing of where it is from etc, as part of ISO 9001. BS 8000 also applies to make sure the manufacturing of the lock and all components are done properly and the standard also unifies each component's dimensions to make the job of the workers and welders easier. ISO 14001 can also be mentioned as part of the standards as ISO 14001 is the environmental management standard. Because large sections of land must be removed in order to install the lock gate it is necessary to take care of the surrounding environment; the gate should also be constructed of nontoxic materials as marine life could be endangered otherwise.

The equipment required for the construction of the gate is specialist and the project cannot be done without it. The main example for this is that a mobile crane is required to install the hinges, the gate and the pistons. There are other ways of installing these however they are more timely and even more costing than a mobile crane. The other forms of equipment needed is TIG welding gear for the welding specialists, for the hinges, gate and pistons. All of this equipment will be quality checked before use to present maximum health and safety to everyone involved. Another form of specialist equipment needed is tooling capable of forming a mains connection. This will help the electrical engineers involved with their work and will likely lead to a better overall connection with the mains.

The waste created by the project is mostly metal swarf, as components like the hinges and piston shafts have to be cut down to size. These swarf bins can be emptied with the manufacturing companies and sent to recycling centres to help reuse unwanted metal. Other forms of waste

include the dirt from excavating the canal wall to allow for the gates to remain flush with the rest of the wall. This dirt is not contaminated in any way and thus can be used elsewhere without worries of pollution or other wrongdoings. In addition to this, waste produced in the welding operations and fitting operations is likely to be gaseous. However because the canal is outdoors, there should already be enough air flow to reduce harmful fume concentration.

The environmental considerations for this project involve the instalment of the locks and making sure that any damage that can be prevented is prevented. For example, trees next to the gates should be preserved as wildlife such as ducks may dwell there besides the canal. Furthermore, the canal surrounding the designated lock area should be drained carefully in order to allow all the species of marine life to exit the area before it becomes dry. ISO 14001 also plays a part in the environmental condition of the surrounding area as it helps to keep the environment in a sustainable situation and free from harm after projects like the lock gates are installed.

Here is a list of assumptions made for the project and plan of work:

- The gate installation will only take 4 weeks
- That the gates are under consistent hydrostatic pressure and will not be subject to waves etc
- That the water height never breaches 5.5m
- There will be little to no build-up of sediment on the floor of the canal
- All bars of stainless steel are made in the same composition
- All resins used in the FRP are the same and the FRP contains no weaknesses
- Hydrostatic pistons can retain the watertight seal over time
- HGVs can fit next to the canal in order to transport parts
- The gates and all accompanying resources are produced completely on time with no delays
- There are no delays in construction of the gates
- Workers are paid £10/h
- Welders are all fully skilled and will have no fault completing the joining
- All electrical components can rely on mains power and require little maintenance
- All regulations regarding the project stay the same
- There are no changes in legislation during or before the construction of the lock begins
- Every worker has PPE
- The off-site facility will have no problems in communication between it and the receiver.
- There is space for a mobile crane to fit next to the canal without causing environmental harm
- The materials used in the process are perfect with no faults or issues in integrity

# Task 4 Present

| | |
|---|---|
| **Assessment number (eg 1234-033)** | 8730-035 |
| **Assessment title** | Employer-Set Project |

| | |
|---|---|
| **Candidate name** | <first name> <surname> |
| **City & Guilds candidate No.** | ABC1234 |

| | |
|---|---|
| **Provider name** | <provider name> |
| **City & Guilds provider No.** | 999999a |

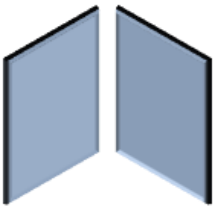
| | |
|---|---|
| **Task(s)** | 4 |
| **Evidence title / description** | **Evidence expected for marking:**<br>Presentation materials<br><br>**Evidence submitted for marking:**<br>Presentation materials |
| **Date submitted by candidate** | DD/MM/YY |

# Lock Restoration LTD

Canal Lock Gate Project

Newer Canal Gates Built to Last

## What is the project?



- Aims to replace the old gates
- Each new set will be durable and sustainable
- The gates can be controlled from offsite
- Each gate will be easy to maintain

## How have we met spec

- Each gate is long lasting and lightweight providing easier maintenance
- The receiver boxes allow full offsite control in partnership with the surveillance
- The gates can meet the required hydrostatic pressure quotient
34335N/M^2
- Full production and installation can be completed within timescale of 52 weeks

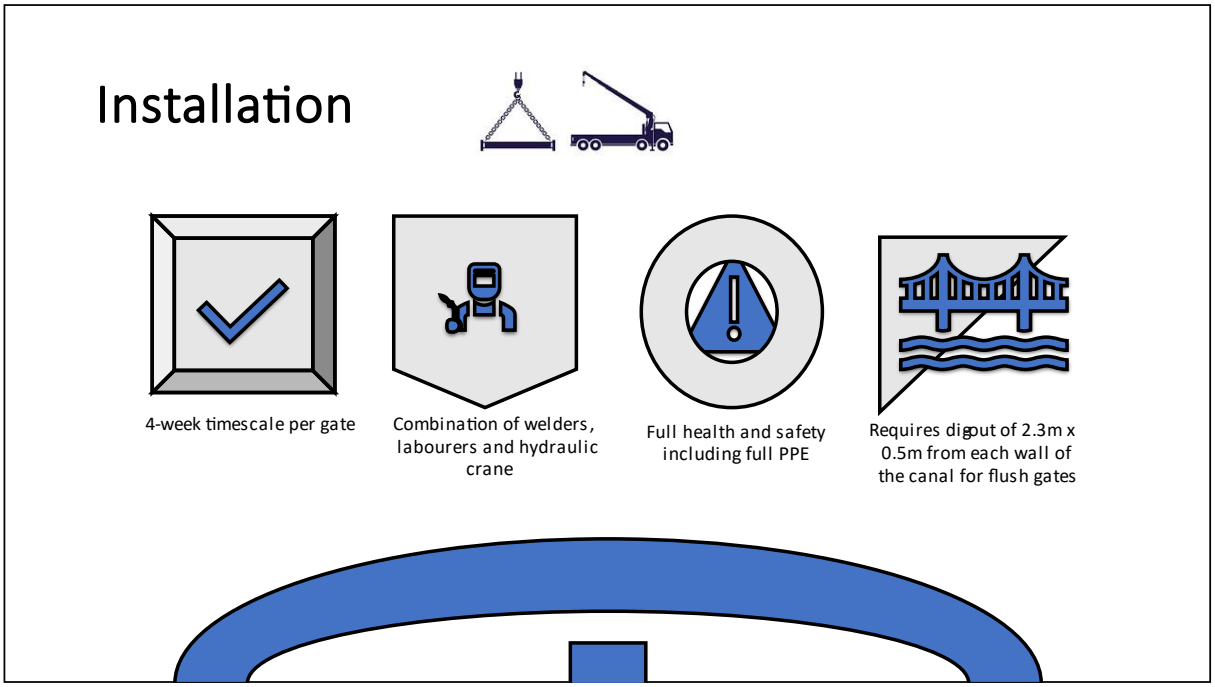
## Why is this the best option?

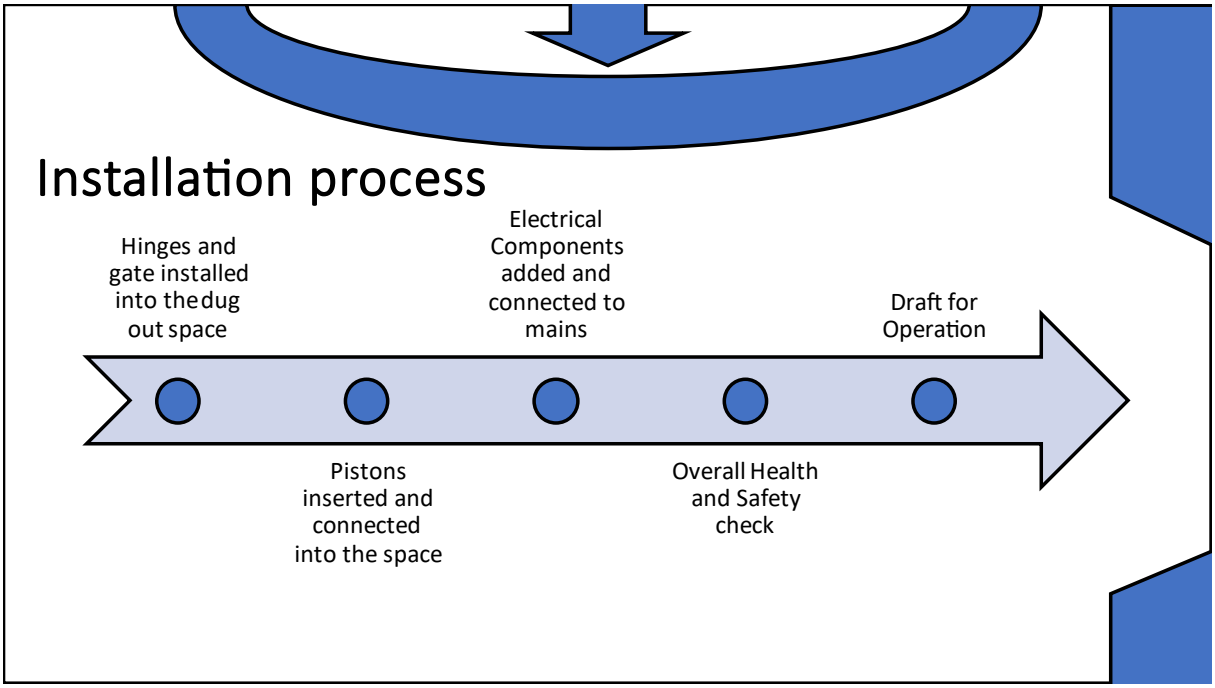
The material choice means each part of the gate functions perfectly

All components of the gate are chosen based on the brief's criteria

The gate is easily removable for maintenance

Perfect balance of budget, time and quality


Installation
4-week timescale per gate
Combination of welders, labourers and hydraulic crane
Full health and safety including full PPE
Requires dig out of 2.3m x 0.5m from each wall of the canal for flush gates


Installation process
Hinges and gate installed into the dug out space
Pistons inserted and connected into the space
Electrical Components added and connected to mains
Overall Health and Safety check
Draft for Operation

# Durability

Inconel Piston parts to maintain strength over time

- Gates made from Fibre Reinforced Polymer and stainless steel
- Complementary material choice

FRP:
+ Lightweight
+ Corrosion Resistant
- Low strength in comparison to metals
- High production cost

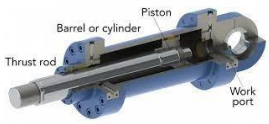
Stainless Steel:
+ Strong with high tensile strength
+ Ideal for reinforcement
- Dense and heavy
- Susceptible to scratches and erosion

Combination of Materials:
+ Lighter than pure metal designs
+ FRP acts as corrosion barrier
+ Strength reinforced by the stainless steel
+ Can last for a long time in bad conditions

# Function

Each gate can be operated independently

Proximity Infra-Red (P.I.R) Sensor to detect vessels too close to the gates




Hydro-pneumatic pistons open and close gates

Full surveillance connected to gates

## Safety

- Walkways above the gates are fenced
- Special FRP mould for walkway
- Wall Excavation fenced
- Fire extinguishers

## Cost

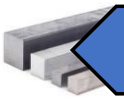
Work done back-to-back

Best quality materials from cheap sources

Recycled resources

Installation carried out subsequently

## Issues with the project



Each gate is expensive to produce

The transportation of materials to on -site

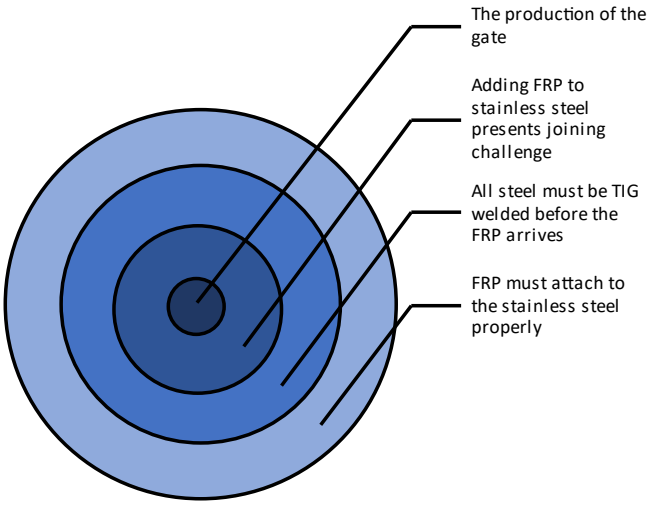
Regulations and legislation

Power Supply

## How were these overcome:

- The installation of the gate in 4 weeks cuts down on labour cost
- Environmental specialists to keep nature in the loop
- Room will be made at the bank of the canal for HGV access
- Small overhead powerline to the other side of the canal

# What was the largest issue?



# Employer-Set Project – Presentation Q & A Record (Task 4)

**8730-12 T Level Technical Qualification in Maintenance, Installation and Repair for Engineering and Manufacturing**

**8730-033 Employer-Set Project (Summer 2023)**

| | |
|---|---|
| **Candidate name** | <first name> <surname> |
| **City & Guilds candidate No.** | ABC1234 |
| **Date** | DD/MM/YY |

| | |
|---|---|
| **Provider name** | <provider name> |
| **City & Guilds Provider No.** | 999999a |

Record observation notes below to inform external marking. **Notes must be detailed, accurate and differentiating.**

| Tutor questions to candidate | Candidate responses |
|---|---|
| What did you find the most challenging aspect of the brief? | The function of the gate to open and close. |
| What I the most problematic part about ongoing maintenance of the design? | Pistons and hinge assembly for maintenance, drain lock. |
| How sustainable is the proposed design? | Materials easily sources. FRP can use natural resins. Stainless steel is recyclable |
| | |

| | |
|---|---|
| | |

| Any other comments |
|---|
| |

| Tutor signature | Date |
|---|---|
| X _____ | DD/MM/YY |

If completing electronically, double click next to the ‘X’ to add an electronic signature once the record is **finalised**.

## Get in touch

The City & Guilds Quality team are here to answer any queries you may have regarding your T Level Technical Qualification delivery.

Should you require assistance, please contact us using the details below:

Monday - Friday | 08:30 - 17:00 GMT

T: 0300 303 53 52

E: **technicals.quality@cityandguilds.com**

W: **http://www.cityandguilds.com/tlevels**

Web chat available **here**.

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