TUNNELWORKS BTEC LEVEL 3 PROJECT IDEAS

Engineering Unit 3: Engineering project ideas

Tutor guide

About these project ideas

These project ideas support Unit 3: Engineering project (T/600/0252) used within QCF level 3 BTEC National qualifications in Engineering. This unit aims to enable learners to specify, plan and implement an engineering project and present its outcome. Different options support students on Mechanical, Manufacturing, Maintenance and Electrical/Electronics pathways.

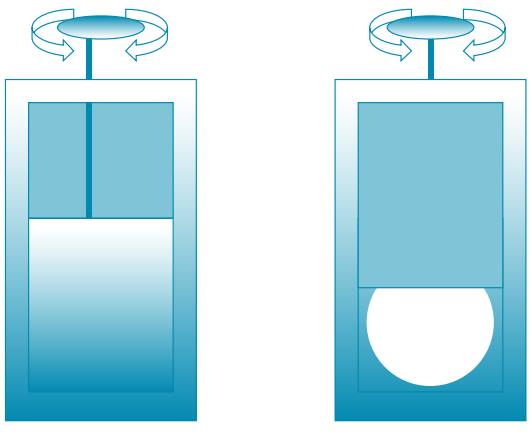
You can also use these ideas to support Unit 16: Engineering Drawing for Technicians and Unit 17: Computer Aided Drafting in Engineering or extend them to provide assessment opportunities for elements of Unit 1: Health and Safety in the Engineering Workplace and Unit 8: Engineering Design.

These ideas are a starting point. Adapt each one to suit your students and the time and facilities you have available. Allow students to develop the ideas into their own projects.

Project focus - penstocks

The project idea for each course strand is focused around penstocks, a type of flow control equipment used to control or isolate flows of water, wastewater, sewage and other fluids.

A penstock is a form of sluice or gate that can be raised or lowered to allow or prevent the flow of water through a pipe, tunnel or channel. The penstock consists of the door, a frame in which it fits and can move up and down, and a spindle, a long threaded bar that is turned to raise or lower the door. The spindle is commonly turned by a handle, wheel or electric motor/actuator. Push buttons or an electronic control circuit linked to water level sensors may control the actuator/motor.



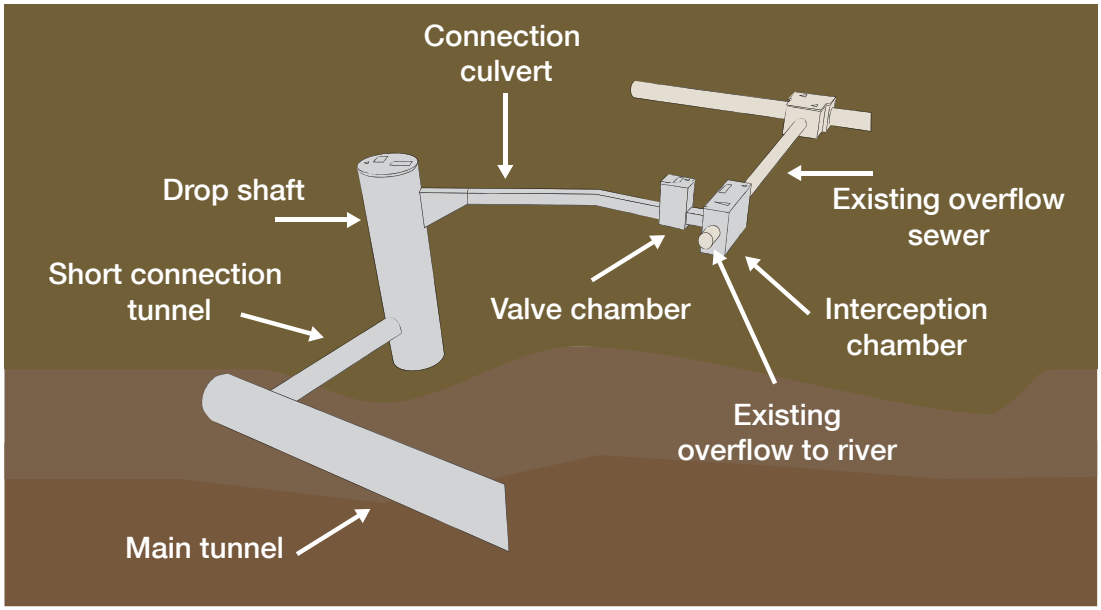
Background - the Thames Tideway Tunnel

The Thames Tideway Tunnel is a major new sewer that will help tackle the problem of sewage overflows from London's sewers and will protect the River Thames from increasing pollution for at least the next 100 years, enabling the UK to meet European Union environmental standards. The Tunnel will control the 34 most polluting combined sewer overflows (CSOs), as identified by the Environment Agency, which currently discharge untreated sewage directly into the River Thames after it rains.

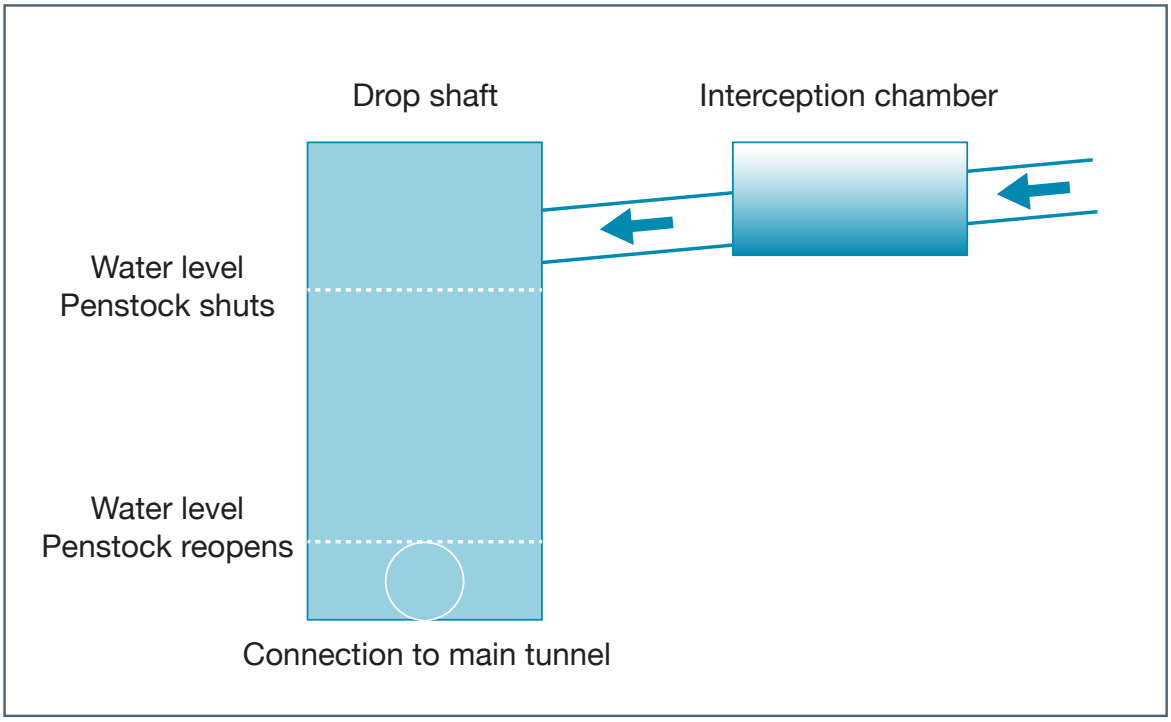
The majority of London's sewers collect both sewage and rainwater and after heavy rainfall the volume flowing through the sewers is a lot higher than the system can take. The original Victorian system is designed to discharge this excess sewage directly into the River Thames through a series of combined sewer overflows (CSOs). The new Thames Tideway Tunnel will control the most polluting CSOs by capturing combined rainwater and sewage and allowing it to flow down a new tunnel before being pumped out for treatment at Beckton Sewage Treatment Works.

Combined Sewer Overflows - the Thames Tideway Tunnel design context

The combined sewer overflows (CSOs) that will connect to the main Tunnel will do so via an interception chamber and a valve chamber, which will be built onto the existing pipework from the sewer into the River Thames. From there the diverted flow will travel down a connecting culvert to a drop shaft, where it will fall down to join the main Tunnel, deep underground.



Penstocks in each interception chamber will be used to control whether or not combined rainwater and sewage flow down into the main Tunnel, or, only in the most extreme weather events, spill into the river when the main Tunnel is already full (the Tunnel is designed to store the water and sewage that enters it from the CSOs until this can be pumped to the surface for treatment at Beckton Sewage Treatment Works. The Tunnel will have a gentle 'fall' of 1 in 790 and so will fill progressively, from East to West). This means knowing whether the main Tunnel is full at each CSO location in order to prevent further flows flowing into the tunnel when full at a particular location. Water level sensors, which will use ultrasound or lasers, will provide this information to a control system for the penstock in each CSOs' valve chamber. The water level in the drop shaft will be used:



Key documents for more information

For more information about The Thames Tideway Tunnel and CSOs visit:

Thames Tideway Tunnel
http://www.thamestunnelconsultation.co.uk/

Tunnel construction and CSOs
http://www.thamestunnelconsultation.co.uk/what-we-are-doing/tunnel-route/

Document Library
http://www.thamestunnelconsultation.co.uk/document-library/

Students will find lots more information about penstocks on the internet.

HamBaker Ltd Penstocks catalogue (PDF)
http://www.hambaker.co.uk/docs/FC_Penstocks.pdf

HamBaker Ltd Penstock installation manual (PDF)
http://www.hambaker.co.uk/docs/Installation%20and%20Maintenance%20Manual.pdf

Ideas to help students

Start by using the web and PDF links above to familiarise yourself with the Thames Tideway Tunnel, CSOs and penstock design, operation and maintenance. This may help you identify ways to personalise projects to suit students, or other project opportunities based on this scenario.

1. Mechanical

- Students should use the information to create a specification for their system and then produce designs.
- Consider the use of a gearbox to reduce the rotation speed and change the direction of motion from a horizontal axle to a vertical spindle.
- Students will need to think about the operating environment and the forces acting on the system due to the mass of the door and the pressure acting on its surface. They should consider materials for bearings and other moving parts.
- Students could produce a scale model of their design to demonstrate and test it. To do this they may need to make reasonable assumptions about how the penstock will be located, and the motor to raise and lower the door. Internet research and images, and the PDFs on the previous page, can all help.
- Students could modify, develop and add detail to outline designs such as those in the PDFs above.

2. Manufacturing

- Students should focus on the door and frame.
- They will need to pay careful attention to design, thinking about the design or moulding for the initial casting of each main component, and the machining required to obtain flat 'working' surfaces such as each face on the frame, and the edge of the door.
- Students will need to think about the forces acting on the system due to the mass of the door and the pressure acting on its surface, and include suitable strengthening features in their designs for both the door and frame.
- Students could mould and machine a scale model of their design to demonstrate and test it.
- Students could modify, develop and add detail to outline designs such as those in the PDFs above.

3. Maintenance

- Students need to understand the location and operating environment and research into underground access and sewer inspection will help here.
- Within the limits of what is required for the Unit assessment, help students develop a specification or scope for their procedure that is suitably broad or focused. As a minimum, the project should cover the basic operation, condition and safety of the penstock door and frame, but students can also include the raising and lowering system and even an electronic control system that is based on a laser or ultrasound water level detector (the student briefing for the Electrical/Electronic engineering strand provides more detail).
- Students should include tests to ensure the penstock operates to specification.

4. Electrical/electronic

- Students need to think of how to sense the water level in the main Tunnel and compare this to the reference values at which the penstock door must close or open again.
- Students may want to think of ways to avoid rapid closing or opening when the level fluctuates close to either value.
- The system needs to include manual controls.
- Students can optionally think of a way to test that the sensor is functional.
- The system will need to include suitable equipment for controlling a three-phase, high-current motor.
- Students could build a test version of their circuit, using scaled real-world values to test its operation instead of the values given in the specification. However, they must show that their final design will work to specification.

1. Mechanical engineering student brief

Background

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The majority of London's sewers collect both sewage and rainwater and after heavy rainfall the volume flowing through the sewers is a lot higher than the system can take. The original Victorian system is designed to discharge this excess sewage directly into the River Thames through a series of combined sewer overflows (CSOs). The new Thames Tideway Tunnel will control the most polluting CSOs by capturing combined rainwater and sewage and allowing it to flow down a new tunnel before being pumped out for treatment at Beckton Sewage Treatment Works.

The combined sewer overflows (CSOs) that will connect to the main Tunnel will do so via an interception chamber and a valve chamber, which will be built onto the existing pipework from the sewer into the River Thames. From there the diverted flow will travel down a connecting culvert to a drop shaft, where it will fall down to join the main Tunnel, deep underground.

Penstocks in each interception chamber will be used to control whether or not combined rainwater and sewage flow down into the main Tunnel, or, only in the most extreme weather events, spill into the river when the main Tunnel is already full. (The Tunnel will have a gentle 'fall' of 1 in 790 and so will fill progressively, from East to West).

A penstock is a form of sluice or gate that can be raised or lowered to allow or prevent the flow of water through a pipe, tunnel or channel. The penstock consists of the door, a frame in which it fits and can move up and down, and a spindle, a long threaded bar that is turned to raise or lower the door. The spindle will be turned by an electric motor/actuator. An electronic control circuit linked to water level sensors will control the actuator/motor.

Your task

Design the mechanical elements of the system for raising and lowering the penstock door.

Key information

- Your design must use a rotating threaded metal spindle to raise the door.
- Your design must include how your system will connect to the motor axle and the penstock door.
- The door will have a mass of approximately 900kg.
- The door needs to rise 1.5m in 300 seconds.
- The motor's axle speed will be 1500 rpm.
- You can include a gearbox in your design.

2. Manufacturing engineering student brief

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Your task

Design the penstock door and frame.

Key information

- The door and frame must be made from BS EN 1561 min 250 cast iron.
- The door should be 50mm thick.
- Key faces should be machined to designed dimensions and tolerances.
- The door should have a nominal opening of 1.5m x 1.5m and should be able to rise at least 1.5m within the frame.
- The penstock should operate with an on-seating head. That is, when closed, the pressure should force the door onto the frame.
- The frame should be designed to fix to a flat concrete surface using bolts.
- There should be a seal between the frame and door.

3. Maintenance engineering student brief

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Your task

Design an inspection and maintenance procedure for a penstock in a valve chamber.

Key information

- Your inspection and maintenance schedule must take into account the location and nature of the valve chamber. This will be underground, accessible via an inspection hatch and ladder leading to a walkway to the penstock. The ladder and walkway both have safety rails. Beyond the safety rails will be a sewage water channel, which may be deep and fast flowing.
- The door needs to rise 1.5m in 300 seconds when operated by a control system that includes a water level sensor in the main Tunnel.

Your procedure must consider or include:

- When to access the penstock to carry out this procedure
- Risk assessment and control measures
- PPE specifications
- Attention to the:
  - Frame and door
  - Leakage
  - Fixing
  - Operation through a full raising/lowering cycle
  - Lubrication
  - Safety

4. Electrical/electronic engineering student brief

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Your task

Design the electrical/electronic control system for raising and lowering the penstock door.

Key information

- The penstock door needs to close when the water level in the main Tunnel below the CSO is 'full'.
- The drop shaft takes water from the interception chamber to the main Tunnel
- The main Tunnel will be considered 'full' under the CSO when the water level in the drop shaft reaches 10m below ground level.
- The penstock door should open again when the water level in the drop shaft reduces to 30m below ground level.
- Water level sensors must cope with full submersion for extended periods.
- The system needs to include manual controls and a test facility.
- The control system must operate a three phase electrical actuator/motor with an operating voltage of 415V and operating power of 5kW.