

1st YEAR DESIGN CHALLENGE PROJECT SPECIFICATION AND RULES 2023

Institution of
**MECHANICAL
ENGINEERS**

IMechE 1st YEAR DESIGN CHALLENGE

INTERNAL PIPE CLIMBER



Project Specification for the 2023 Internal Pipe Climber 1st Year Undergraduate Design Challenge

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Note: this specification must be read in conjunction with the document "IMechE 1st & 2nd Year Design Challenge - General Specification 2023" available on the [IMechE Design Challenge website](#).

Please check the IMechE Design Challenge website for updates.

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List of Amendments

Version	Page	Details	Date
1.0	-	Full Release	05-10-2022
1.1	5	'Transparent' added to the pipe description for clarity	06-11-2022
	6	3.7 added: 'The chain is not part of the operational envelope'	
	9	5.4 added: 'The Device Controller is allowed to hold their device in position...'	

Please report any errors to Emma.Pateman@imeche.org so that corrections can be made.

List of Major Changes Since 2018

- Motor type specified to prevent very short run times – see regulation 3.2.
- The chain is now 0.106 kg/m – see regulation 3.6.

1. Introduction

The Design Challenge, organised by the Institution of Mechanical Engineers, is an annual competition for students in their first year of study on an undergraduate engineering degree programme. The Challenge comprises five parts, all of which are detailed in the General Specification.



This year the challenge is to design, build and test a device to simulate pipeline pigging. Such a device, known as a 'pig', is used to perform various cleaning, clearing, maintenance, inspection, dimensioning, process and pipeline testing operations on new and existing pipelines.

Figure 1: A Pipeline Pig

The challenge is to design, build and test a device to climb up the inside of a piece of vertical transparent pipe, lifting an increasing load. The 'device' can be of any construction, limited only by cost, and size, within the specification detailed below. However, the device must be totally self-contained, and must have no other means of external control, except for a launch switch. Full details are given later.

The device must only be powered by an electric motor, as specified in these regulations. In previous years, pipe climbers had become too fast, to the point of it making timing difficult for the judges. The reason for having a motor specification is to ensure that devices have a limited speed, and to encourage teams to think about reducing mass and friction within the drive mechanism. Alternative, or auxiliary, forms of motive power are not allowed.

The relative performance will be determined by the quickest times taken for the device to pull an increasing load to the top of their pipe and return to the starting point at the bottom. The increasing load will be in the form of a chain, where the weight of chain to be lifted is specified as 0.106 kg/m.

In the spirit of the competition, it is expected that the device be designed, developed and manufactured by students within the facilities of their university. Any member of the team should have a good understanding of the design principles, theories, manufacturing methods and materials used.

Note: this specification must be read in conjunction with the document "IMechE 1st & 2nd Year Design Challenge – General Specification 2023" available on the [IMechE Design Challenge website](#).

2. Competition Conditions

The test area will consist of up to four identical pipes to allow for parallel runs between teams. Each pipe is made from transparent PVC-U, has an internal diameter of 0.105m and is 2.5m long. The "Device Controller" is allowed to hold their device in position up to or below the datum line (0.3m above bottom of pipe) before starting. The teams competing in a heat will be required to start their devices simultaneously. Once started there can be no outside interference. Having started their device, the Device Controller must then step away from the pipe. The pipes will be vertical, noting that surfaces will be uniform within normal production tolerances.

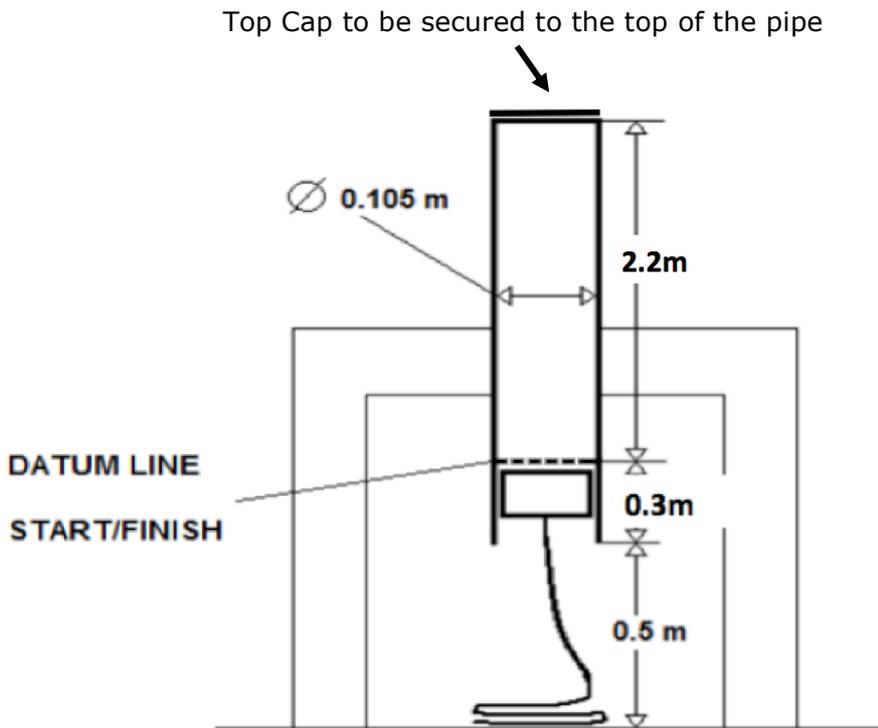
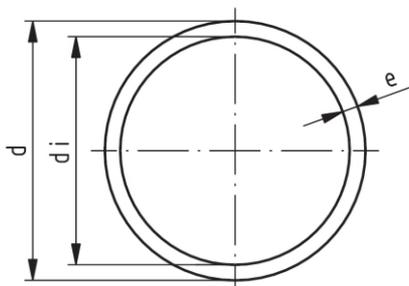


Figure 2: The Internal Pipe Climber and Test Rig



Outside Diameter d	110.0 mm
Wall Thickness e	2.2 mm
Inside Diameter d_i	105.6 mm

Figure 3: Pipe Dimensions

3. Technical Regulations for the Internal Pipe Climber

- 3.1 The device can be of any type, but it must be totally self-contained, and at all times during the competition fit within a pipe internal diameter of 0.105m and length 0.3m. On the day of the competition this will be checked using a gauge.
- 3.2 The pipe will be 2.5m long. According to the manufacturer's specification, the outside diameter is 110.0mm and the wall thickness is 2.2mm, giving an internal diameter of 105.6mm. Further details, including where to download a CAD model of a section of pipe, are included in Appendix 1.
- 3.3 The device must be driven by a motor rated with a maximum supply voltage of 6V and a maximum power of 2W. Teams should purchase their own motor and must provide a specification sheet as proof of the motor rating at the competition.
- 3.4 Other drive-train items – battery box(es), wiring, gears and shafts, for example – must be selected and purchased or designed, made and assembled by the team.
- 3.5 No proprietary, pre-programmed or programmable control units may be used. This means Arduinos, or similar devices, cannot be used, even as simple motor speed controllers.
- 3.6 Parts from existing devices (i.e. entire wheel and motor assemblies) are not permitted.
- 3.7 The chain will be 2.5m long, with a weight of 0.265kg for the 2.5m length (0.106kg/m). The link thickness is 2.5mm. The chain is not part of the operational envelope. Further details are included in Appendix 1.
- 3.8 Each device must have a quick and simple method of attaching and detaching the chain, which should not require the use of tools. It is up to individual teams as to how this is achieved, but any coupling must not cause the device to violate the control volume dimensions.
- 3.9 Failure of the attachment or loss of the chain will result in disqualification from that heat.
- 3.10 Team members must not tamper with the inner surface of the pipe. No substances, such as adhesives or lubricants, can be used between the device and the pipe. Devices must not cause any damage or leave any debris on the internal surfaces of the pipe.
- 3.11 Devices must be started remotely via a low voltage, wired, electrical switch. For convenience, when starting, this can be on a short lead that dangles out of the bottom of the pipe.
- 3.12 The start switch and its wiring is the only component that is excluded from the operational envelope.
- 3.13 Devices must be regarded as safe and reasonable and conform with the General Specification as judged by the member of staff responsible for the

team. Consideration should be given to guarding if there is risk of entanglement or entrapment.

4. Competition Rules for the Internal Pipe Climber

- 4.1 All devices must be available for scrutineering prior to commencement of the competition.
- 4.2 No practice runs in the pipes are permitted, but devices may be tested away from the pipes for all other functionality.
- 4.3 Teams will compete head to head in qualifying for a place in the final. The relative performance will be determined by the time taken to complete a run.
- 4.4 During qualifying every team will attempt three runs, each run being in a different pipe.
- 4.5 Qualifying runs will consist of up to four teams running in parallel.
- 4.6 The time will be recorded for each successful attempt.
- 4.7 The time is measured from the "Starters Order" until the top of the device passes the datum in the downward direction. The device must contact the top cap after the upward travel and before the downward travel.
- 4.8 Each team's fastest time from qualifying will determine the overall leaderboard.
- 4.9 Teams must attempt all three runs in qualifying to have their quickest time to be recorded.
- 4.10 The top four teams in qualifying returning the quickest times will progress to the final.
- 4.11 In the event of a tie at the end of qualifying, or in the final, there will be a re-run of one single attempt. If there is a further tie, the lightest device will be the winner.
- 4.12 In the unlikely event of there being a technical fault with the test apparatus (not devices) deemed to unfairly disadvantage a team, there will be a rerun.
- 4.13 The time limit for a run will be 2 minutes. Time will start from the end of the timekeepers starting countdown.
- 4.14 Participating teams will have a minimum of 1 minute before a run to prepare their device in the pipe.

- 4.15 Teams not ready within the allotted time before a run will forfeit that attempt.
- 4.16 Each team must appoint a 'Device Controller' who will be the only person to attend to the device during a run.
- 4.17 Device Controllers must step back from the pipe, immediately after starting their device, on a count of 3, 2, 1, GO!
- 4.18 Once a run has started the device may not be touched until it is over.
- 4.19 If a device is started before the starters order it will forfeit that attempt.
- 4.20 The device may not be caught; if required impact protection should be designed as part of the device.
- 4.21 During a run, all other team members must be outside the test area.
- 4.22 A judge will be allocated to each test area to ensure the correct procedure is followed.
- 4.23 Repairs and minor alterations are allowed to the device between each attempt within a 1 minute time limit.
- 4.24 It is permissible to replenish the device's energy source between the heat and final but not during individual runs during a heat or the final. This means that the energy source can be replenished once during the competition.
- 4.25 If a device does not meet these requirements, and modification cannot be made within the allocated time period to allow it to comply, then it will be deemed withdrawn from this part of the competition.
- 4.26 A camera (smartphone) will continuously film the activity in the competition so that if there is a dispute it can easily be resolved.
- 4.27 Breach of any rule during competition will forfeit that heat or final.
- 4.28 Continued breaches or behaviour unbecoming of the spirit of the challenge will result in the team being disqualified from the competition.
- 4.29 Any queries about the equipment during the competition must be raised with the head judge. Only the team leader is allowed to approach the official and the team must abide by any decision made.

5. Run Procedure for the Internal Pipe Climber

- 5.1 Clear instruction on the running order for the heats and finals will be given at the event.
- 5.2 All teams must display an A4 sheet detailing the teams name and University when competing. The name sheets will be supplied by the competition host.

- 5.3 The device must be loaded into the pipe during the one minute preparation time. The chain must be attached during this period.
- 5.4 The Device Controller is allowed to hold their device in position up to, or below, the datum or start line before starting.
- 5.5 Device Controllers will raise their hand clearly to show readiness within the one minute period. If all the teams are ready, an attempt can commence.
- 5.6 Once ready, teams will be instructed to "Prepare to Start" and then on a count of 3,2,1, GO! each team will start their device.
- 5.7 The device cannot be touched until the judge signifies that an attempt is complete.
- 5.8 Once all devices have stopped, the judges will record the run times.
- 5.9 The run procedure should be configured by the organisers such that one team does not run in the same pipe twice during a heat or the final.

6. Scoring for the Internal Pipe Climber Competition

Regional Finals

In the Regional Finals, individual awards are made for each section of the competition.

- 6.1 For the Regional Finals, the winner of The Challenge in each region will qualify for the National Finals.

National Final

In the National Final, points are accumulated for each section of the competition.

- 6.2 The maximum score available in the heats or final is 30 points.
- 6.3 The fastest team in the heats or final will be awarded 30 points.
- 6.4 The slowest team in the heats or final will be awarded 10 points.
- 6.5 Other teams will be awarded points on a linear pro rata basis, rounded down. Example scores are shown in Appendix 2.
- 6.6 Teams failing to finish a run will be awarded zero points.
- 6.7 Scores from the heats will be carried forward to the final. 30 points will be available in the final, meaning a total of 60 points is possible for the pipe climber competition.

Appendix 1 – Equipment List and Suppliers

All prices approximate and correct at time of publishing.

Links are provided for ease of reference only, these are not nominated suppliers.

	<p>Pipe: 2.5m long, outside diameter 110.0mm, wall thickness 2.2mm, internal diameter 105.6mm. Possible supplier GF Piping Systems Search for project code 192017039 Link to GFPS website (for reference only) Note to teams: you can download a CAD model of a sample section of pipe from this website.</p> <p>Note to university supervisors: you will need to shop around to get the best price for the pipe. Pay particular attention to the wall thickness and inside diameter before ordering to avoid ending up with a smaller inside diameter than specified.</p>	<p>£225 inc. VAT for 2.5m</p>
	<p>Chain: 2.5m long, weight of 0.265kg for the 2.5m length (0.106kg/m). Link thickness is 2.5mm. Possible supplier B & Q Search for product code 1520639 Link to B&Q website (for reference only)</p>	<p>£8.10 inc. VAT</p>

Appendix 2 – Challenge Scoring Examples

Recorded Run Time	Calculated Score	Rounded Score
01:22	18.67	18
00:37	29.52	29
01:58	10.00	10
00:35	30.00	30
01:02	23.49	23
01:00	23.98	23