I. Executive Summary

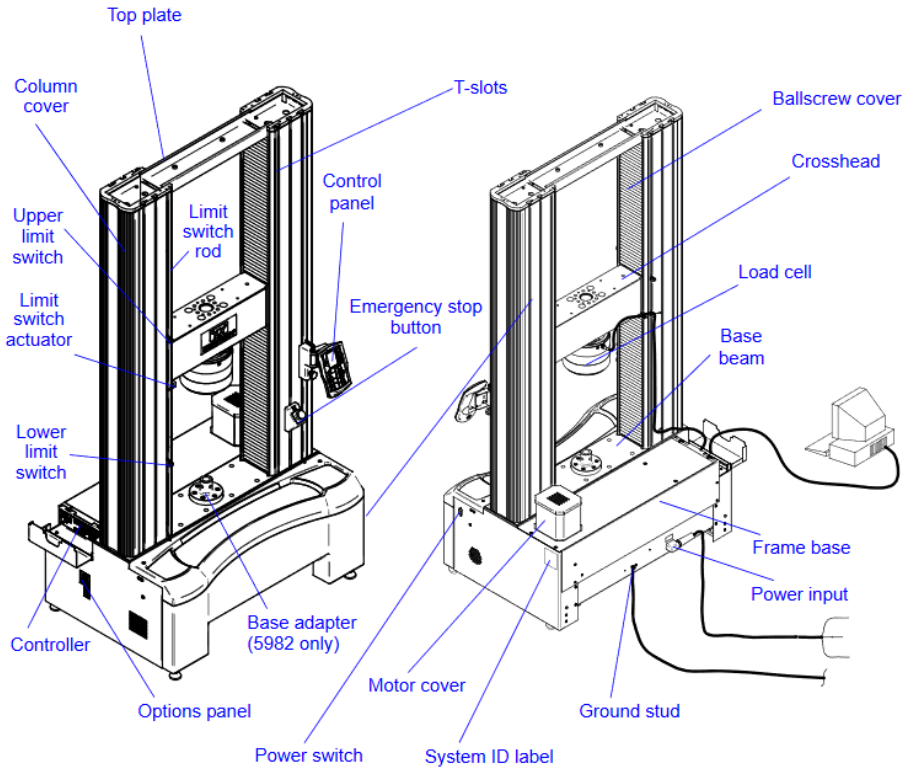
- Instron Universal Testing Machine Series 5982 is recommended
- Machine has a high level of reliability
- Machine has very manageable safety risks
- Machine has a high level of ease of use reducing training costs and safety risks
- Existing laboratory has all of the required components and space for this machine
- PPE requirements are very manageable and inexpensive
- Machine will allow for compression and tensile tests which can be used for research and development, improve product decision making and improve our existing quality insurance processes

II. Introduction

Testing and collecting data about material compression and tension capacities is crucial for engineers to make accurate decisions around their use. The Intron Universal Testing Machine is an instrument that allows engineers and technicians to measure these properties of a material accurately, making it an important tool in an engineer's arsenal.

This report is centralised around the Intron Universal Testing Machine Series 5982 and includes research around the capabilities of the machine, a description, the method of how to use said machine, the limitations, risks, including Personal Protective Equipment required and other laboratory requirements to use the machine. Most of these points will be included in the Method and Discussion sections of this report.

III. Method



(Figure 1)

The above figure shows a labelled drawing for the Instron Universal Testing Machine (5982 Series), a screw-driven testing instrument. The key components of this machine are the following:

- Loadframe (made up of):
    - Crosshead: The vertical moving component of the machine allowing for compression and tension tests
    - Ballscrew columns: Attached to the crosshead and rotate to create vertical movement with high accuracy
    - Guide columns: provide stability, structure, and stiffness to the column to withstand high forces
    - Base: Provides a solid platform for testing materials and withstands forces from the crosshead during testing
    - Top plate: Apart of the structure and stiffness of the entire frame
- Controller: Hardware that controls the frame and any attachments
- Control panel: The hardware panel attached that allows user interaction and assists with performing tests and other software functions
- Power cables and switching
- Cabling to connect to an external PC for viewing and storing test data
- Load cell: Attached to the crosshead, allows for accurate measurement of force
- Specimen to be tested in the instrument
- Vertical testing space: 1930mm (Series 5982)
- Horizontal testing space: 934mm (Series 5982)
- Force capacity: 100kN (Series 5982)
- Machine dimensions (H*W*D): 278cm*149cm*78cm (Series 5982)

When using this model of machine, we also need to include external factors such as:

- Single phase: 200-240 (Vac +- 10%), recommended circuit breaker 20Amp Type C 47-63Hz
- Three phase: 208, 240, 400 or 480 (Vac +- 10%) 47-63Hz
- Instrument storage temperature range (-40 to +66 degrees Celsius)
- Instrument operations temperature range (+10 to +38 degrees Celsius)
- Humidity range (+10 to +90%, non-condensing)

Due to these requirements for the machine, temperature and humidity gauges and the laboratory power sources will also need to be considered when purchasing and implementing this tool.

The procedure of operating this machine is as follows:

1) Collect all specimens together that will make up testing sample
2) Identify each specimen to match results in test report, e.g., with a marking
3) Ensure that correct PPE equipment is worn whilst setting up and operating machine and ensure that surrounding are clear from hazards and risks
4) Turn on machine followed by the computer the machine is attached to
5) Create a sample in Bluehill (software panel)
    a. Click Test on the Home screen
    b. Click New Sample > Select Method in the navigation bar
    c. Select appropriate test method
6) Verify test area and test direction is correct on the Frame Status Indicator in the console area
7) Verify these settings on the control panel

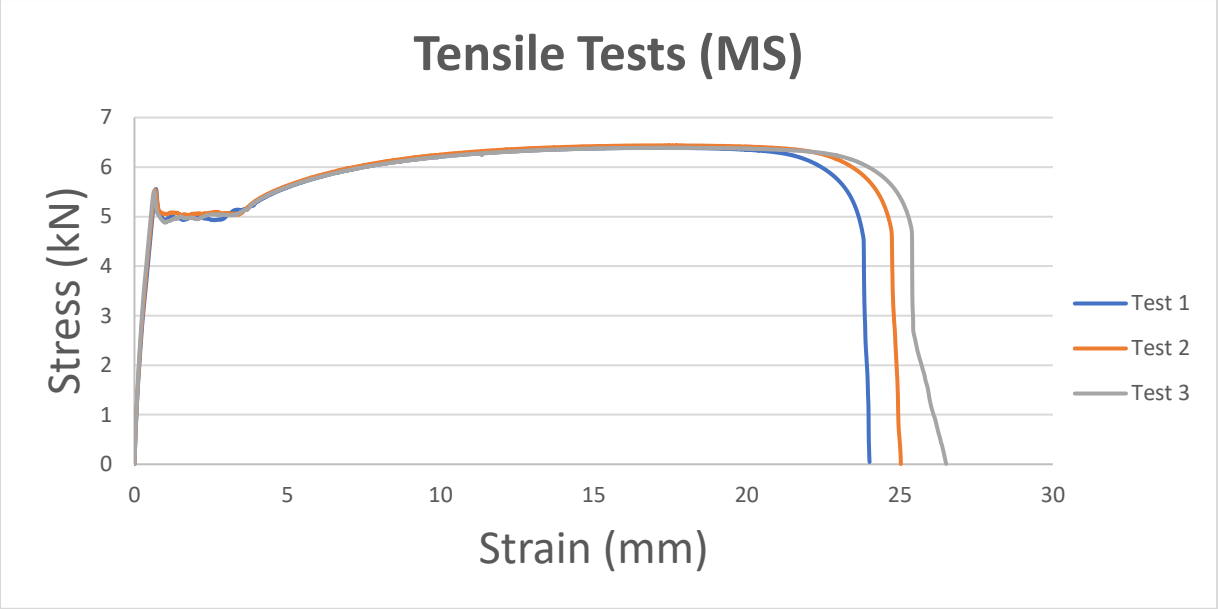
a. Frame Ready indicator illuminates
b. Test Stopped indicator illuminates
c. Start Test indicator illuminates (correct direction of test)
d. At Zero indicator illuminates green if starting from 0 extension

8) If necessary, calibrate the transducer required by test method
   a. Click on the icon for the transducer in the system settings area of the console
   b. Select the transducer configuration in the Transducer Configuration field
   c. Ensure the Calibration Type is set to Automatic
   d. Set transducer to its zero point
   e. Click Calibrate (system will perform the calibration)
   f. Click Done to complete
9) If previously switched off, allow 20 minutes for machine to warm up
10) If specimen includes a specimen protect threshold, select Specimen Protect button on control panel
11) Take measurements of the required specimen dimensions for each specimen and enter values into appropriate fields of the test workspace
12) Complete any additional fields as required
13) Use the job controls to move the crosshead to its starting position for he test and set the zero extension point
14) Ensure that crosshead travel limits are set
15) Ensure that limits are set for each transducer as required by the test method
16) Balance each transducer configuration required by the test method
17) Install specimen into the grips, be sure to avoid finger pinching and do not do so when the machine is in operation or moving to avoid crushing
18) Check the specimen is aligned properly in the grips
19) Start the test by pressing the Start button on the control panel
20) If you need to stop the test before it completes, press the Stop button on the control panel
21) When the test is complete, wait for the machine to finish movement and operation and remove the specimen by releasing the top grip followed by the lower grip
22) After all specimens are tested, click the Finish button in the test workspace
23) Close the Bluehill software
24) Turn off computer followed by turning off the instrument

IV. Results

(Table I) Table of Results from Tensile Tests (MS)

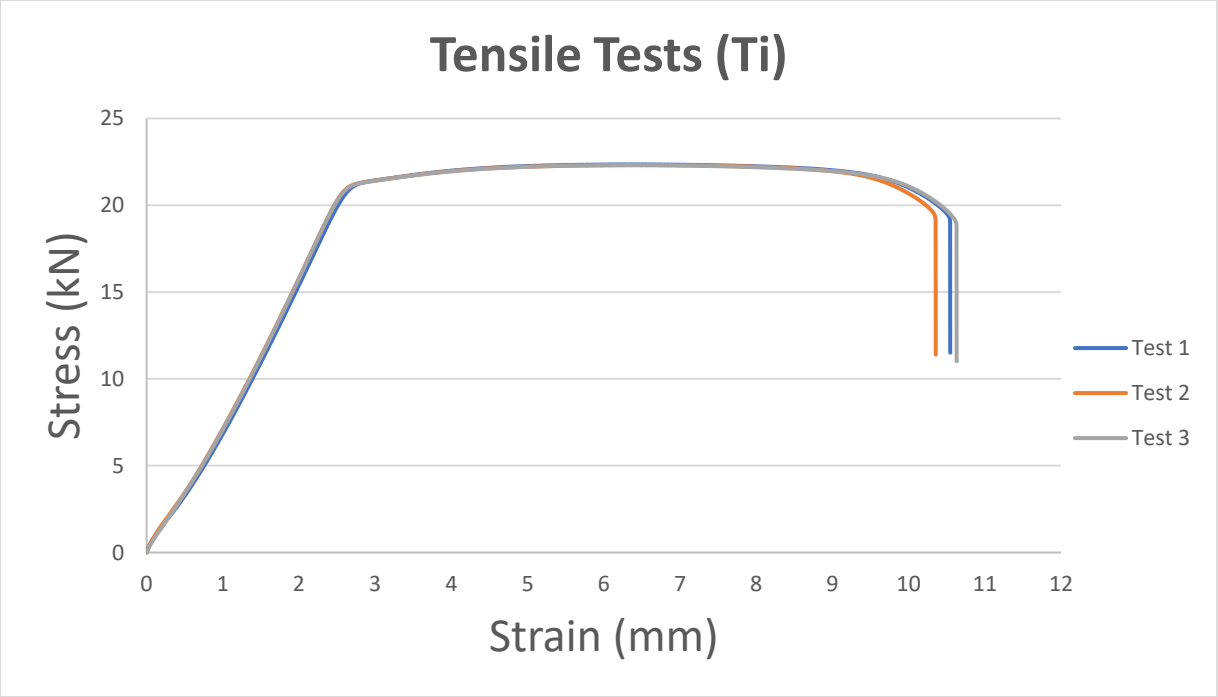
	Area (mm)	**Total Test Time (s)**	**Max Displacement (mm)**	**Max Force (kN)**
Test 1	19.683	180.168	24.0108	6.392
Test 2	19.926	187.835	25.0332	6.4395
Test 3	19.9424	198.961	26.5165	6.3941



(Figure 2)

(Table II) Table of Results from Tensile Tests (Ti)

	Area (mm)	Total Test Time (s)	Max Displacement (mm)	Max Force (kN)
Test 1	24.4	158.299	12.2	22.3558
Test 2	24.36	155.426	12.18	22.3242
Test 3	25.4592	159.54	12.24	22.3157



(Figure 3)

V. Discussion

When observing the results of the test data provided, we can see that the differences between each test respectively are very similar through most of the testing and differences appear towards the end of the tests. When looking at the respective tables, we can see that there is a correlation between the area of each test, width * height, and the maximum displacement. This shows that key changes in area affect the point of fracture with minimal differences in other stages of the test.

When looking at the Ti material test, we can observe that the data from the test stops before reaching 0 strain. This occurs when there is a complete fracture of the material.

When looking at the reliability of the Instron Universal Testing machine we need to consider multiple different factors such as:

- Machine model
- Load cell model
- Performance options chosen if applicable with load cell model
- Professional and frequent calibration of the load cell with the machine (Instron® Load Cell Manufacturing Process, 2019)

We have assumed that we are using an Instron Universal Testing Machine Series 5982 that has been recently calibrated by a professional. Given these assumptions, when looking at the documentation provided about this products reliability, we have found the below.

- Force accuracy: Looking at the Universal Testing Machine 5900 Series by Instron with the variety of load cell data available, the accuracy of the instruments range between either +- 0.4% and +- 0.5% from force reading. This differs when looking at the maximum force reading and ranges between 1/100 to 1/1000 of the load cell capacity (5980 Series | Dual Column Floor Model, 2018)
- Displacement measurement accuracy: +- 0.01mm or 0.05%, whichever is greater (5980 Series | Dual Column Floor Model, 2018)
- Testing speed accuracy: +- 0.1% of set speed (5980 Series | Dual Column Floor Model, 2018)

Given these figures and when looking at the controlled test data that has been provided, we can identify that this machine has a high level of reliability.

Looking into the ease of use of the machine we need to consider the safety and complexity of the machine for potential users. An induction and initial training with a laboratory technician is required before operating this machine. A safety risk assessment and signed documentation showing understanding of safety procedures and risks must be completed by all users. Failure to follow instructions of both the manufacturer and technician can result in damage to instrument and cause major downtime and financial repercussions. These systems have been designed with ease of use in mind and a lower base height that allows the operator to stand closer to the grips and fixtures, reducing the need to hold heavy test specimens away from the body (5980 Series - Dual Column Floor Model). Also, alignment devices can be used to reduce time and adjustment requirements of the grips so that the user can begin quicker.

Some of the key health and safety concerns include the following:

- Compression hazards from the machine, ensure that no body parts are between fixtures of machine whilst in operation

- Finger pinching on pneumatic grip attachments for the instrument (pneumatic foot switch can be used to open and close grips so that operation of grip is hands free and reduces injury risks (Instron Safety: How To Use A Tensile and Compression Testing System Safely, 2018)
- Furthermore, closing speed of this grip can be altered to allow longer time periods for users to move hands if an error does occur (Instron Safety: How To Use A Tensile and Compression Testing System Safely, 2018)
- Clamping devices for small materials to be tested can be used to remove hands and other body parts from the equation and keep them away from moving parts whilst setting up the machine (Instron Safety: How To Use A Tensile and Compression Testing System Safely, 2018)
- Allow only one person to handle machine at all times
- Electrical hazards, ensure that any surrounding cables are protected and cannot be damaged in the instance of a test failure. Flying debris can damage exposed cables and cause additional electrical damage to surrounding equipment and is a potential fire hazard

The Personal Protective Equipment are all included in the below:

- When testing brittle materials, best practise is the use of a safety shield
- Safety glasses must be worn at all times
- Safety glasses should be used by all members within the area / same room as operating machine to prevent injury of any bystanders whilst instrument is in operation
- Loose clothing (such as ties) and long hair must be handled appropriately and either tied back / down or removed
- Enclosed shoes must be worn at all times

VI. Conclusions

Given the research conducted on the Instron Universal Testing Machine, we can conclude that it has a high reliability, very manageable safety risks and PPE requirements, a low level of laboratory requirements such as electricity and a high level of ease of use, this instrument will suit our requirements and will enable staff to complete the tasks required with high efficiency and reliability.

VII. References

Instron.com. 2018. *5980 Series | Dual Column Floor Model*. [online] Available at: <https://www.instron.com/-/media/literature-library/products/2013/02/5980-series-dual-column-floor-model-100kn--600kn.pdf> [Accessed 24 October 2021].

Youtube.com. 2019. *Instron® Load Cell Manufacturing Process*. [online] Available at: <https://www.youtube.com/watch?v=20AZR2kYEu0> [Accessed 24 October 2021].

Youtube.com. 2018. *Instron Safety: How To Use A Tensile and Compression Testing System Safely*. [online] Available at: <https://www.youtube.com/watch?v=gnigdDyXCYE> [Accessed 24 October 2021].

VIII. Appendix

Figure 1: Labelled illustration of the Instron Universal Testing Machine Series 5982
Figure 2: Graph of 3 tensile tests results from Intron Universal Testing Machine Series 5982 with material (MS)
Figure 3: Graph of 3 tensile tests results from Intron Universal Testing Machine Series 5982 with material (Ti)