TALLINNA TEHNIKAÜLIKOOL
INSENERITEADUSKOND

Simplified Fluid Sampling Device for Oil Terminals

Industrial Engineering and Management
Master Thesis

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Curriculum: Industrial Engineering and Management

Tallinn 2019

AUTHOR'S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material. All works, major viewpoints and data of the other authors used in this thesis have been referenced.

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Author: .....

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Thesis is in accordance with terms and requirements

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Supervisor: …….....

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Accepted for defense

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Chairman of theses defense commission: .....

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Department of Engineering

THESIS TASK

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Thesis topic:

(in English) SIMPLIFIED FLUID SAMPLING DEVICE FOR TERMINALS

(in Estonian) LIHTSUSTATUD VEDELIKU PROOVIVÕTUSEADE TERMINALIDELE

Thesis main objectives:

1. Explain how terminals work and the basics of the sampling process.

2. Show the downsides of the current sampling process

3. Propose a possible solution with 3D model and production process description

Thesis tasks and schedule:

No	Task description	Deadline
1.	Presentation of the topic with broken down chapters	15.04.2019
2.	Presentation of the work with the 3D model and the drawings	05.04.2019
3.	Presentation of the complete work	25.05.2019

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CONTENT

PREFACE

Current paper was written by author who has visited Paldiski Terminal and worked as an operator at Sillamäe Terminal. Additionally, has seen the sampling process up-close, with both light and dark oil products, with a worker of a sampling company called SAYBOLT. Thanks to the working time at Sillamäe Terminal and the time spent with SAYBOLT the author has now a good understanding of how oil terminals work and of the sampling process. The paper proposes a possible solution to the problem of lack of simple tool which simplifies the actions taken by the worker during the sampling process.

The author would like to thank immensely Tiit Pikk, a project manager at SAYBOLT, for providing all the necessary information about the sampling process and the tools and equipment used for it.

LIST OF ABREVIATIONS AND SYMBOLS

KKT – Kiviõli keemiatööstus

CNC – Computer numerical control

HQ – Headquarters

ANSYS - Simulation Driven Product Development

INTRODUCTION

At the very base of the world's economy lies commodity trading. Commodities are crucial raw materials that we require for our day to day lives, the food we eat, the fuel that powers our vehicles, the energy that makes our homes warm and metals that are at the base of all construction. Physical commodities come in all shapes and sizes. They divide mainly into two forms: primary commodities and secondary commodities.

- Primary commodities are ones that are extracted directly from natural resources, as for example crude oil or coal. Their characteristics vary largely.

- Secondary commodities are ones that are produced from primary commodities and have more specific characteristics depending on the market demand. Secondary commodities are for example diesel, bitumen or LPG

All commodities are being traded and therefore transported and stored in locations built specifically to suit their characteristics. Current paper will be more focused on the liquid commodities and more precisely on oil commodities, which are usually stored in oil terminals (also called tank farms and oil depots). Oil terminals are used to store oil and petroleum goods until the buyer organizes its pick up, either by sea with a tanker or by ground with a train or a vehicle. It's also used to mix different products, or same products, with different characteristics to get a new product as a result. In our case different oil products are required to create different everyday products, for example tires, shampoo, lipstick, chewing gum, tooth paste etc. As we can see oil allows us not to just create fuel for our transport and energy for our houses, it also is used to create an immense variety of products for our daily needs.

Furthermore, there is even larger amount of different trading and non-trading companies that constantly search, buy and sell those oil and petroleum goods. In that manner, the content in the oil terminals is constantly changing. Due to the extreme variety of the products, sellers and buyers are always very careful about the parameters of the products, for example there is a huge difference if the Sulphur content in the oil is 0.9% or 1.0%, even if all other parameters are the same. Therefore, to ensure that the product corresponds to the numbers indicated in the contract, companies hire other companies, which specialize in sampling the products. Usually they are based directly in the oil terminal, so that any company that stores its products in it can order sampling and product quality check. Likewise, there is such a company in Estonian Terminals, which are

located in Sillamäe and Paldiski. The company is called SAYBOLT and it specializes in oil and chemicals inspection.

Although, we live in a time of innovation and simplification of certain tasks and work, some still remain primitive and therefore more time consuming than they should be. One of those tasks is acquiring the needed samples from the top of the tanks. Multiple solutions do exist, although they are not particularly the cheapest. Therefore, the task of the current paper is to develop a device simple enough to not cost a fortune and that will simplify the task of fishing multiple number of samples throughout the day. More to that, when a product like crude oil is involved the whole process tends to get very messy and takes extra time to keep the working place clean and during extreme weather conditions, it gets very unpleasant for the worker. So additionally, the device needs to be able to solve that issue too.

[1] Figure 1. Horizon Terminal in Dubai

Saybolt
A CORE LABORATORIES COMPANY

[2] Figure 2. SAYBOLT logo

1 THE NECESSITY OF THE SAMPLING DEVICE

As described above, oil and petroleum products vary very widely and trading firms would not be able to close deals without the papers proving the quality of the product. Therefore, companies, like SAYBOLT, who specialize in inspection of those products, have to gather samples and analyze them in their laboratories. Logically, they will not acquire those samples with their bare hands but by using special sampling tool.

1.1 Current sampling method and it's variations

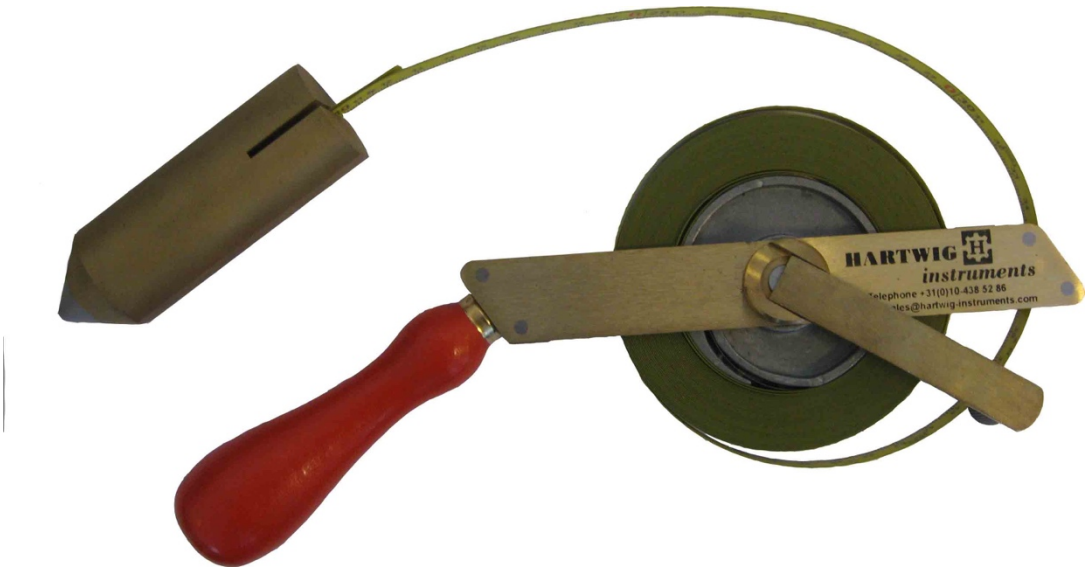
The method currently at use by SAYBOLT in Estonian Terminals, located in Sillamäe and Paldiski, doesn't actually involve any specific device and relies more on pure skills and experience of the worker. The tools used by the worker are simply a bucket with a rope in it (figure 3), bottle-holder (figure 4), a ThermoProbe TP-7 thermometer (figure 6), a Hartwig dipping tape (figure 7) and a basket for the sample bottles (figure 5).

Figure 3. Bucket with rope and a bottle-holder for samples

Figure 4. Bottle-holder for sampling

Figure 5. Sample bottle for all liquid products

[3] Figure 6. ThermoProbe TP-7 thermometer



[4] Figure 7. Hartwig dipping tape

The sampling process starts with the order email, received from a company (a client) that wishes to receive accurate information about some product that it either wishes to buy or sell. It usually says in the order how many samples need to be taken and tested. Logically, the more samples the more precise the result. Further on, a worker takes all the necessary tools and drives to the tank that contains the product interesting their client. Thereafter, the worker takes all the tools with him to the top of the tank. First, the actual level in the tank needs to be calculated. It is necessary due to products volume variation depending on the temperature. The worker uses the Hartwig dipping tape for that. There are two ways of measuring the actual level:

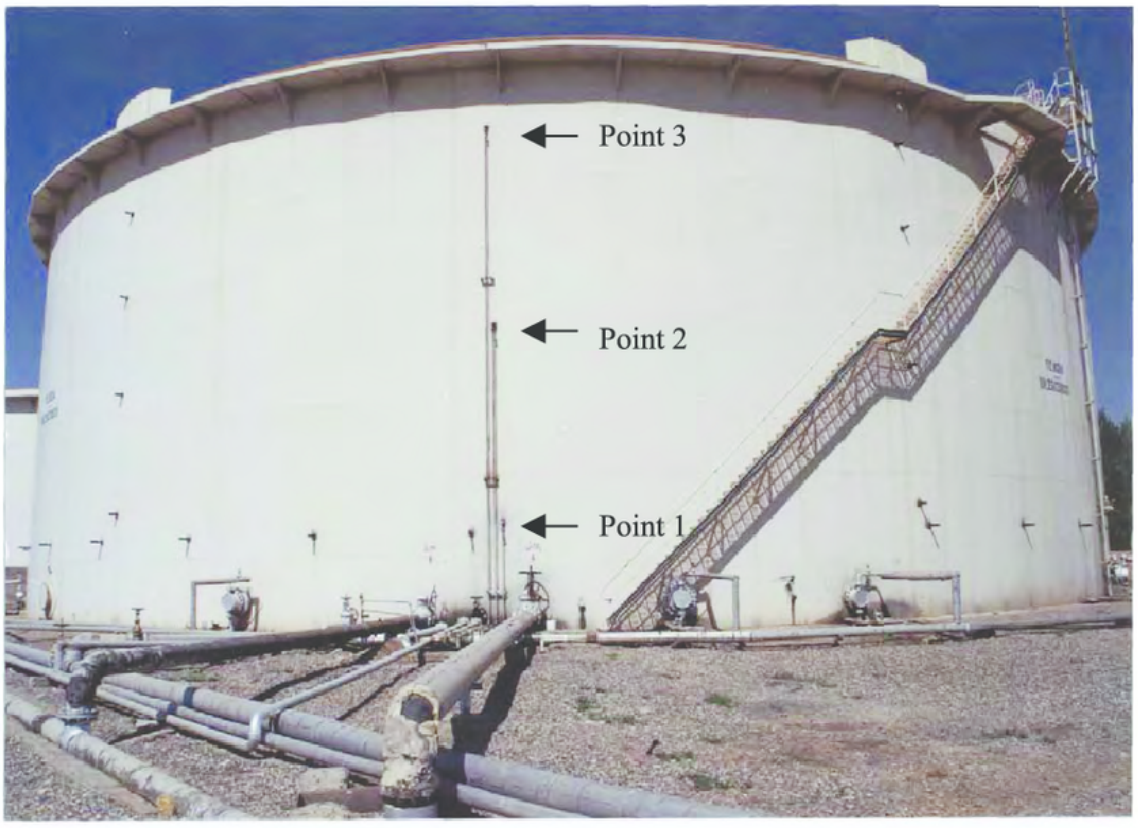
- If the product is a dirty one like, shale oil or naphtha for example, then the worker (for the sake of keeping the tool clean) just dips the point of the dipping tape and looks at the numbers indicated on the tape.

- If the product is clean, like petrol or kerosene for example, the worker descends the tip of the dipping tape into the product and then marks the approximate area on the tape with chalk. Further-on, he lets the tip of the tape hit the bottom of the tank. When he spins the tip back up, there will be a clear mark on the chalk, indicating the actual product level in the tank.

From there on, the worker measures the product temperature in the tank with a special thermometer, ThermoProbe TP-7, and compares it with the ones indicated in the office. Again, the tanks are all equipped with sensors showing all the necessary information, but it's still required to double check them every time manually, to avoid unpleasant situations caused by numerous factors, like temperature for example.

All checks completed, now the worker can start acquiring the samples. Their quantity is usually indicated by the client but usually there will be at least three. Samples have to be taken at 3 different levels (figure 8). Because of the different densities of the same product (depending on its quality) the parameters might actually vary on different levels. For example, gasoline with a density of 0.75 kg/L will be heavier and thus on a lower level in the tank than the gasoline with a density of 0,72 kg/L. Consequently, at least three samples have to be taken to calculate the average. To take a sample from the top of the tank, the worker has to place the bottle in the bottle-holder and lock it, so that the bottle won't fall off in the tank. Then, using a rope, he descends the bottle into the product and waits until it's

filled from the top and then lifts it up, cleans the bottle and places it into the basket (figure 9). After that, to take samples from the middle and the bottom of the tank, it's the same procedure, except now the worker closes the sample-bottle with a cap that has a small hole on top. This gives the worker enough time to lower the bottle deeper into the product and therefore acquire the sample at the required level. Although there exists another method to take samples from the deeper levels of the tank without letting the product flow into the bottle form the start. The worker can close the bottle with a bung, which is also attached to the rope, but in a way, that when pulled hard on the rope, the bung comes out and lets the product flow in only from required level. This method is usually used if a more precise result is needed. After all the samples have been taken, the worker cleans up the tools, closes the tank and descends with all the equipment and samples back to the car. The samples are taken to the lab to be analyzed. Usually they check for example the density, viscosity, boiling point, flashpoint or nitrogen percentage. As soon as the results are calculated, a full report is composed and sent to the client.



[5] Figure 8. 3 different levels from which samples have to be taken

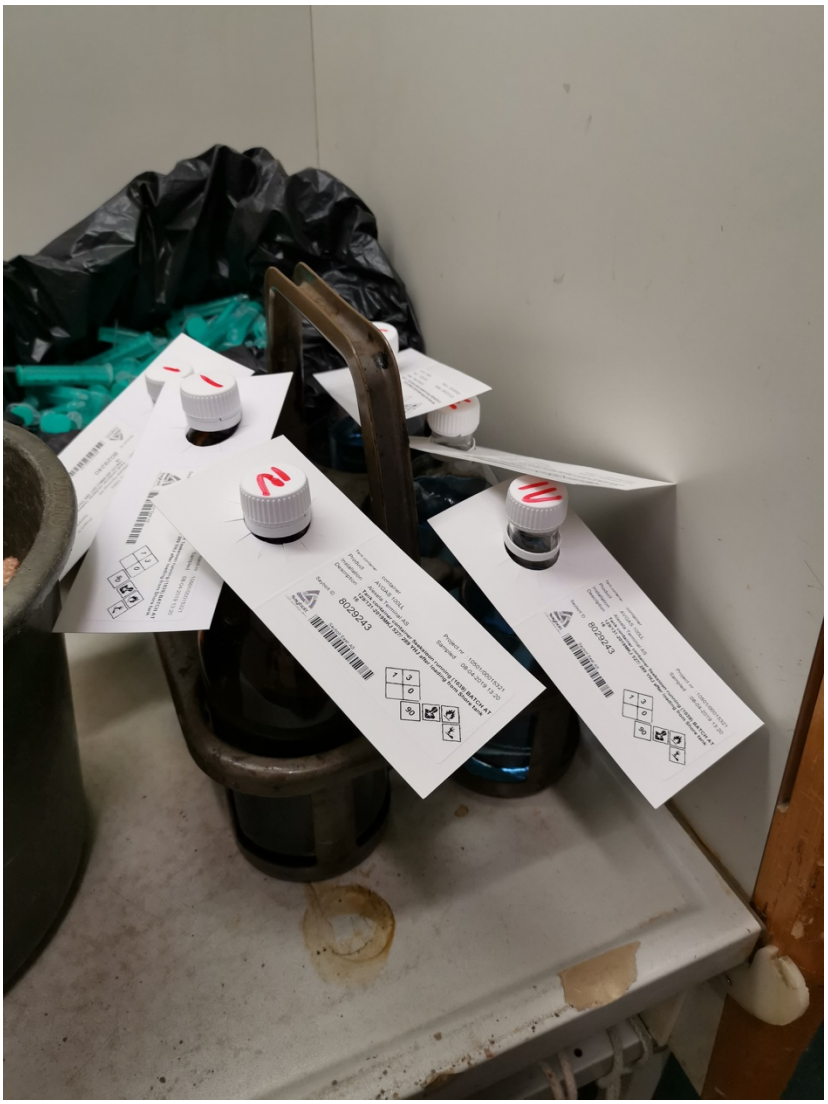


Figure 9. Basket for sample bottles

Sampling method described above is only the one used to gather samples from the top of the tanks. Alternatively, special lines can be constructed in the tanks which permit to take samples from the bottom of them, simply by turning the corresponding tap (figure 10). While this method is a lot simpler it is far too costly to be installed on every tank in all the terminals. In other cases, samples are taken even from the lines, train wagons, truck wagons or even straight from the tankers (marine vessels used to transport oil and petroleum goods). Whilst taking samples from wagons is the same as with tanks and from the lines, it's usually through a special tap, then to take it from a tanker a special tool is used, that allows to gather a sample without opening the hermetically sealed tanker volume. The tool used is HERMetic UTImeter (figure 11). It also is capable to measure the temperature of the product and the level of the product in the tanker.

[6] Figure 10. different taps corresponding to different levels in the tank

Figure 11. HERMetic UTImeter

1.2 The downsides of the current sampling method

Now we have a clearer understanding on what are the SAYBOLT inspector's tasks when an inspection is ordered and which methods and tools are used. But even though those methods are used widely not just by SAYBOLT and not just in Estonia, there are quite a few downsides to them.

The problem itself lies not in the method or the technique used for sampling but rather in the tools. Unfortunately, their simplicity, is what brings a few bottlenecks into the process. Using just a bucket with a rope and a bottle-holder seems quite alright for acquiring the samples of the light products, but when it's being done with the dark ones the worker has to clean the rope at the same time while he is pulling it up. Moreover, he has to clean every bottle too, before placing it into the basket. He has to repeat the process over and over again for each sample taken. It's might seem okay if only three samples have to be taken, but if that number rises to around 30-40, it gets very difficult physically. One sample weighs around 2 kilograms and the worker has to pull it up from up to 30 meters deep (in case if the sample is taken from the bottom of the tank). One worker can only carry so much, so in cases where 30 or more samples are ordered, he would have to descend the samples to the car and then get back up on the tank to continue the sampling.

Logically, this process takes quite some time, but there is also other factors like the weather and rules for the wellbeing of the workers. Terminals are usually close to the port and therefore close to the sea. Due to this, weather conditions can be pretty harsh, in winter as in summer. It's not safe for the workers to work more than one hour in -20 degrees with violent winds or under a burning sun. They are allowed and advised to rest after each hour of work in those conditions. This means that in freezing cold for example, the worker will have to take a break before he can finish acquiring all the samples. Consequently, the tools used is what slows the whole process down. Autosamplers and more complex tools exist but, as described before, they are far too expensive for the terminals and usually are heavy to run with them up and down from the tanks.

1.3 Requirements for the simplified sampling device

The goal of the current thesis is to develop a simplified sampling device that will save the overall time used to acquire samples and keep the working space cleaner at the same time.

The device will have to be built from light materials, which also have to be non-static due to safety reasons. The vapor from the products can be easily lit if something around it has static electricity in it. That is the reason why mobile phones are not allowed near the tanks and all the clothes and equipment used by the workers in the terminal are non-static. Moreover, it has to be compact and easy to carry around since, the worker also has to take the thermometer, the dipping tape and the basket with the sample bottles with him.

The device will have to be fast to use, to save time needed to get the bottle down and back up again. A blocking mechanism will be needed, so that the worker won't have to hold it and have only one free hand. This will allow him to either rest or do multiple thing at the same time (if necessary). A measuring possibility should also be present, as the worker always has to know at which height the sample bottle is currently hanging.

In short, the key tasks of the current device will be to save time and speed up the process of sampling while also making it physically easier for the worker.

2 CONCEPT GENERATION OF THE SIMPLIFIED SAMPLING DEVICE

Following the previous point, the author will generate a couple of prototypes, while considering the characteristics and requirements elaborated in the table 1. This will set approximate margins for the device which author will use to imagine possible solutions and designs for the simplified sampling device.

Characteristic	Requirement
Size	The size of the device will not have to exceed the size of the ThermoProbe TP-7 Thermometer (figure 6). It is necessary for the worker to be able to easily carry it around and not take a significant amount of space.
Weight	The weight of the device will have to be adequate so that carrying it to the top and back to the bottom of the tank wouldn't tire off the worker and make him sweat (very important, during winter). A mass of approximately 2-3 kilos should be acceptable.
Material	The material used absolutely has to be non-sparking or non-static. Preferably to satisfy the weight requirements, will be copper-aluminum alloy or plastic. It is necessary, due to highly flammable gases which exit the tank as soon as it is opened.
	The device has to facilitate the process of acquiring the sample although will not need to complicate it. The easier it is to use, the less time is needed to train a worker to use

Easiness of use	it. This will keep inconvenient situations from happening like for example a worker calling the head of department because he forgot how does the device work.
Sampling time	One of the core purposes of the device is to make the sampling process faster and therefore require less time to fulfill large orders. The cleaning part will most probably wear-off due to friction and needs to be replaceable.
Cleaning function	Especially when dark products (naphtha, shale oil) are sampled, the rope gets soaked with it and the worker has to manually press the product off it while lifting the sample. Therefore, the device will have to have a way of cleaning the product off it without considerable effort.
Price	A lot of oil terminals have a very aggressive save-up strategy. Most of them have special workshops where most of the tools can be repaired and all the necessary parts for the oil terminal can be built. A new tool or part are usually purchased out of extreme necessity. Therefore, the price of the current device can’t be excessive.

Table 1. Characteristics and requirements of the sampling device.

2.1 Generation and drawing of different concepts

The following concepts were drawn, while considering the requirements for the device described in the table 1.

Concept 1: The tripod sampling device

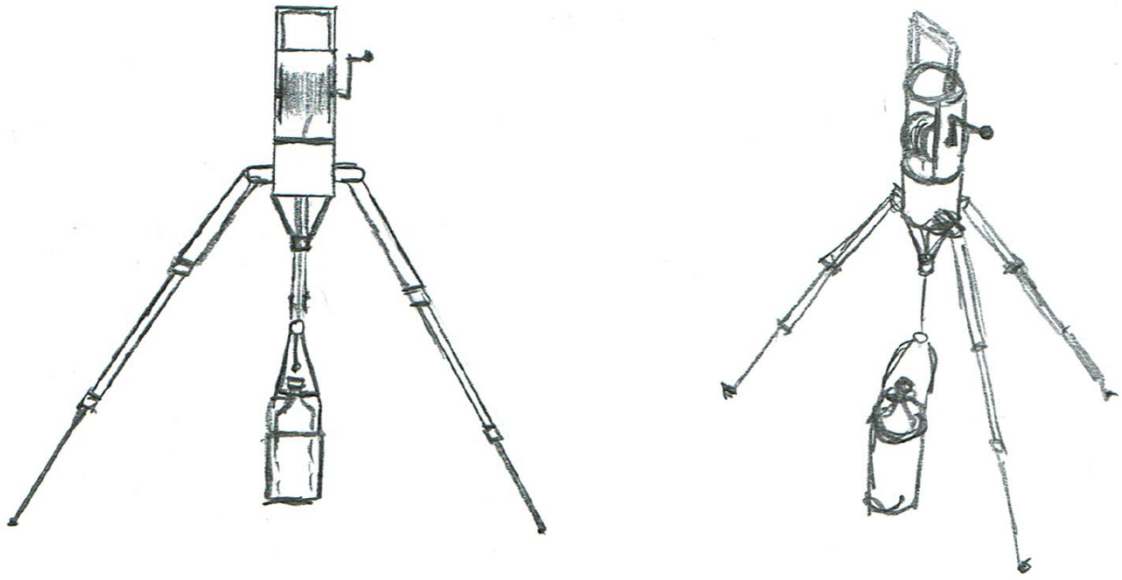


Figure 12. Concept 1 of the simplified fluid sampling device.

Concept 1 is slightly longer due to the tripod system, which (identically to the camera tripods) can be slid in and folded upwards to save up space. The material used in the current device would probably be mostly plastic with some elements of aluminum alloy. Tripod legs for example would need to be from aluminum alloy to make them as thin as possible while conserving the strength and eliminating the possibility of them breaking if wrongly placed. The rest is a plastic structure, holding in a plastic spool with a plastic handle and a rope attached. The lower part will be used for a higher stability of the rope and at the same time hold a rubber part that will clean the rope from the product. The sampling time will be decreased due to a simpler action than descending and ascending the sample by hand while at the same time cleaning the rope. The price of the current device could be slightly higher due to the tripod system.

The strongest plus of the Concept 1 is that, thanks to the tripod, the device is placed high enough for the worker not to bend over while using it. Therefore, the worker contains a more natural, relaxed posture and this could eliminate work trauma.

Concept 2: The hole-based sampling device

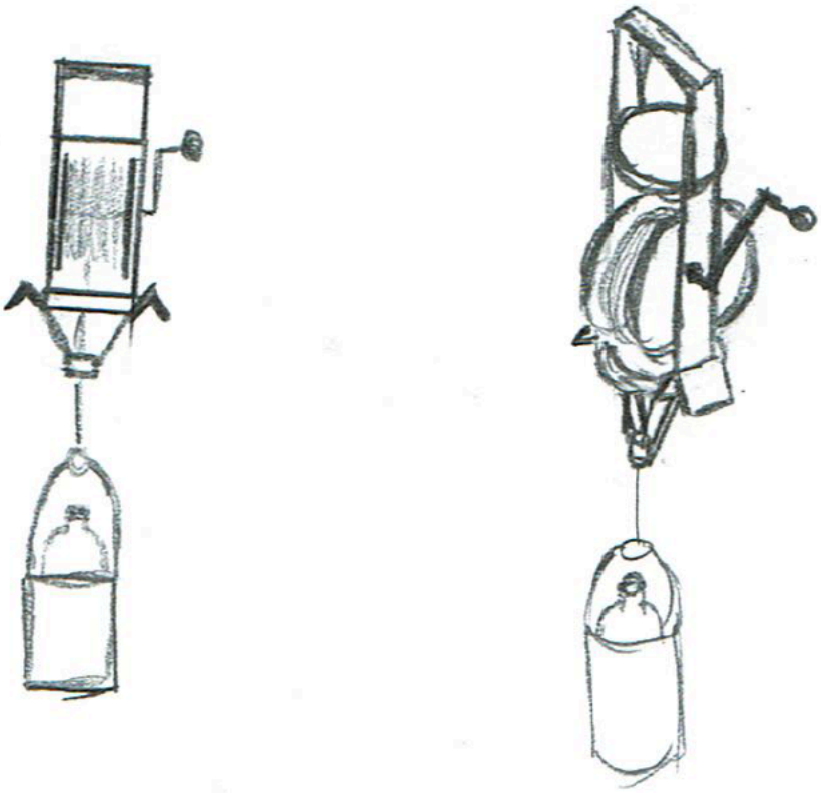


Figure 13. Concept 2 of the simplified fluid sampling device.

The upper part and the rope cleaning solution of the concept 2 is the same as with the concept 1. In this case though, the difference is in the stabilization of the device. While with concept 1 the worker would set up the height of the tripod in the best position, the concept 2 is more focused on the sampling hole itself. In fact, all sampling holes, on every tank, in every terminal are the same. They come as a slight extension to the roof of the tank and are all measured at a diameter of 150 mm as standard. Therefore, all this device needs are a small pair of extensions on the bottom sides to stabilize its position directly on the hole itself. The worker could place the bottle in the bottle-holder, then carefully place the device on the hole and proceed with acquirement of the samples.

The strongest side of the concept 2 is the simpler design, lower price and lesser time used to set up the device for the sampling process.

Concept 3: The electric sampling device

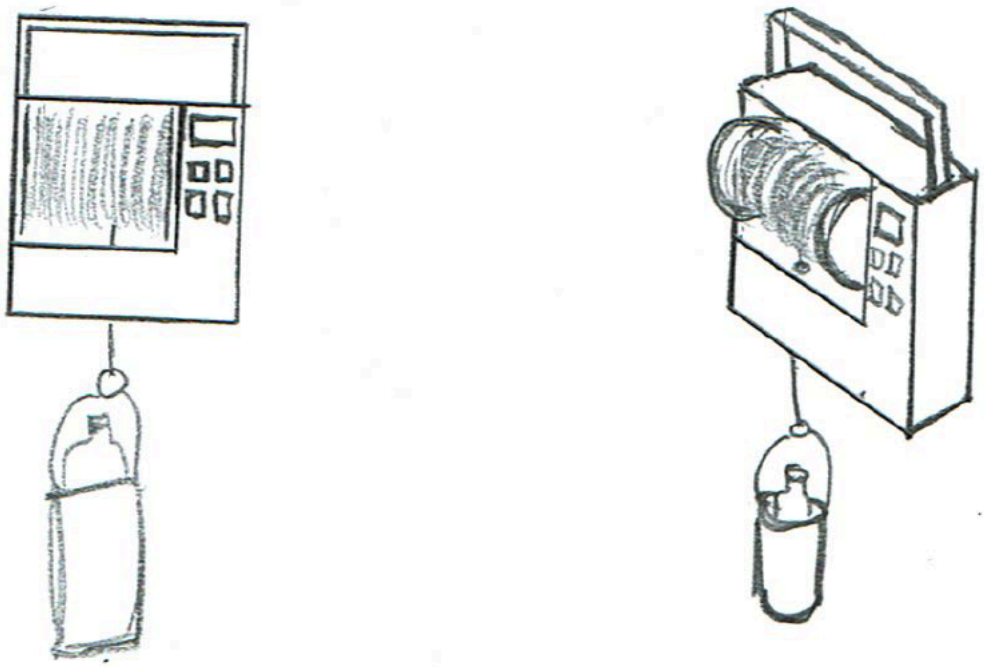


Figure 14. Concept 3 of the simplified fluid sampling device.

Concept 3 represents a completely different approach to the sampling process. Its goal is to replace the thermometer while at the same time making the sampling process effortless. The device would have an ability to show the temperature of the product on the small display, more to that, would be able to show the length of the descended cord and be equipped with an electrical winch to acquire samples with a simple press of a button. The materials used for this would probably be a plastic casing and would had to be equipped with a grounding cable.

The strongest side of the concept 3 is the multifunctionality and the elimination of use of physical strength in the sampling process.

2.2 Concept evaluation and selection of the most suitable one

All three different concepts were introduced in accordance with the chosen criteria but will now have to be evaluated. The evaluation is necessary to be able to pick the optimal device and start developing the 3D prototype with all the concerning calculations.

To evaluate the concepts, a table will be used and each concept will receive a grade from 1-5 in the specific criteria (1 being the worst grade and 5 being the best grade). At the end all the grades will be summed up and the concept with the most points will be chosen as the most optimal one.

	Concept 1	Concept 2	Concept 3	Explanation of the grade
Size	3	5	4	The concept 2 is the smallest, due to lack of the tripod system and electronic parts like battery, electric winch etc.
Weight	3	5	4	The concept 2 has the lowest weight due to lack of the tripod system and electronic parts like batter, electric winch etc.
Material	4	5	1	The material used in concept 1, 2 is mostly plastic and therefore are safer than the electronic, static materials used in concept 3.
Easiness of use	4	5	3	Concept 1, 2 are very simple to use and require no extra training whilst concept 3 needs some time to get used to.
Sampling time	4	4	5	The concept 3, thanks to the electric winch, would be the fastest device to get the samples up or down.
Cleaning time	4	4	5	Cleaning time is also reduced thanks to the speed of the electric winch of the concept 3.
Price	4	5	2	With the simplest design and lack of electronic parts the concept 2 remains the less costly version of the devices.
SUM	26	33	24	

Table 2. Evaluation of the concepts with explanations.

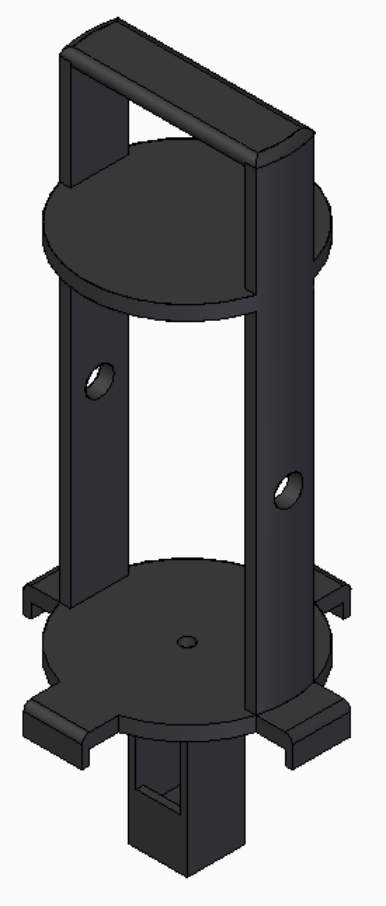
With a score of 33 points the concept number 2 remains ahead of the other two concepts. Although the concept number 3's multifunctionality would be of great help to the workers at oil terminals, the production price of such a device would be a lot higher than for the concept 1 and 2 and consequently the sale's price would be less interesting to the terminals. Moreover, worker safety remains one of the most important issues in the tank fields and due to that it is always better to not take any chances by using devices with electronic, static components on top of the reservoirs. This is the reason why such basic tools like a rope and a bucket are used during sampling in the first place. Concept 2, is the safest and the simplest option permitting the workers to save time during sampling and carry the device easily around.

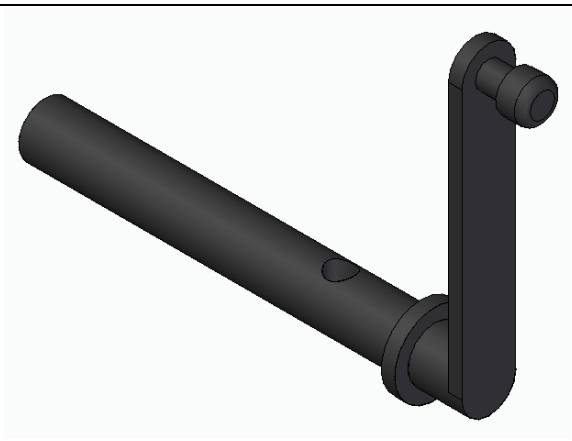
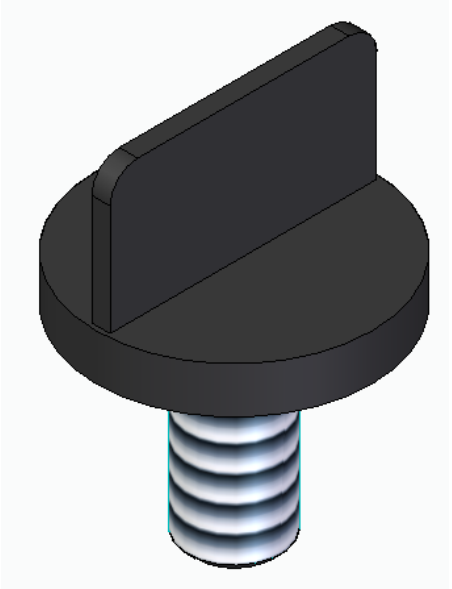
3 SIMPLIFIED FLUID SAMPLING DEVICE 3D MODELLING

To model and design the prototype the author will use Solid Edge ST9 software. The chosen Concept 2 will be used as a base. Although, the design of the prototype will be slightly modified according to authors judgements. Following that, the author shall choose the material for the device's parts, which will give a slight idea on how those parts should be machined and produced. Therefore, an analysis will be conducted

3.1 3D model and design explanation

The table 3 contains all the parts of the completed 3D model of the sampling device with the explanations of the choice of design and the function the parts are fulfilling.

Part	Explanation
	The current part is the base frame of the whole device. The handle on top makes it easier to carry and at the same time stabilize it while in use during sampling. Middle part is meant for the spool which will hold the rope. The 4 stabilization legs have been modified since they will improve the stability even more by supporting the device from 4 corners and not let it fall inside the tank or move during the sampling process. The bottom part is meant for increased stability of the rope and also hold the rope cleaner.

	A simple spool that will hold and store the rope. A hole in the center part is made as a place where a rope can be attached. It's been chosen as a solution so that workers at the terminal could use their own rope if needed. That way, the device can be sold without the rope at a lower price if needed.
	Current part is a handle which goes through the base and the spool. Also has hole to simply connect the spool using rope itself. The maximum mass of a sample is not going to exceed 2 kilograms so this sort of connection should be acceptable.
	This part is responsible for securing the other side of the handle once it's through the spool and the device's base frame. It's a simple method of screwing it in and securing its movement, allowing the system to work.

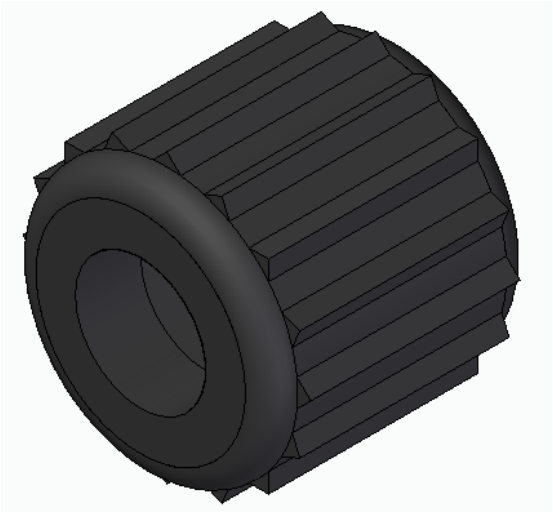
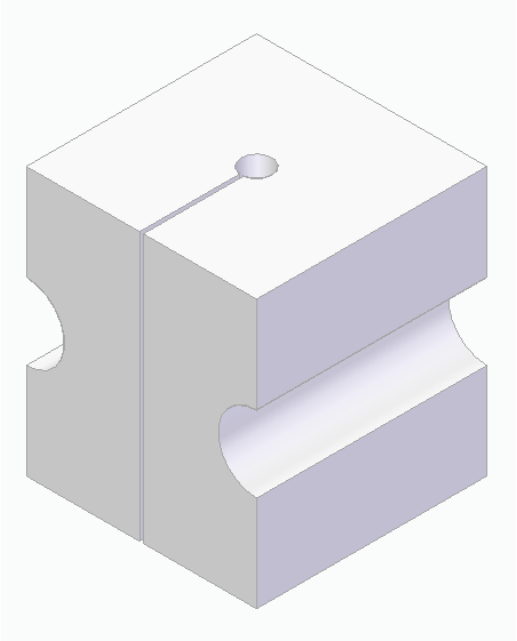
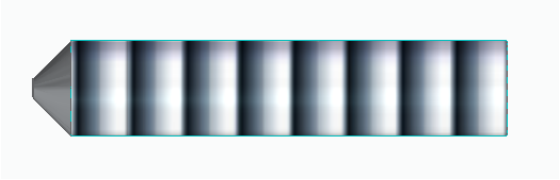
	A handle wheel, which will be a clip-on part for the handle's end where the worker's hand goes. Its rotation allows the worker to use the device a lot quicker. The edges are designed so that the worker won't lose grip no matter which gloves is he wearing or which weather conditions are currently outside.
	The current part will be used to clean the rope. It will be made out of elastic, non-static material permitting it to enfold the rope and squeeze a considerable amount of product out of it. The hole in the center is meant for the rope and logically the cut is made to easily slide rope into it and place it in the device. The round cutouts on the sides serve as a binding that won't allow the cleaner to slip out from its place while the rope is moving up or down.
	A small fixator used to secure the spool and the handle together. This will allow to lock their rotational movement.

Table 3. Simplified fluid sampling device parts description.

The parts shown above, except the rope and the bottle holder is everything the simplified sampling device consists of. Figure 15 shows us an assembled version of the device.

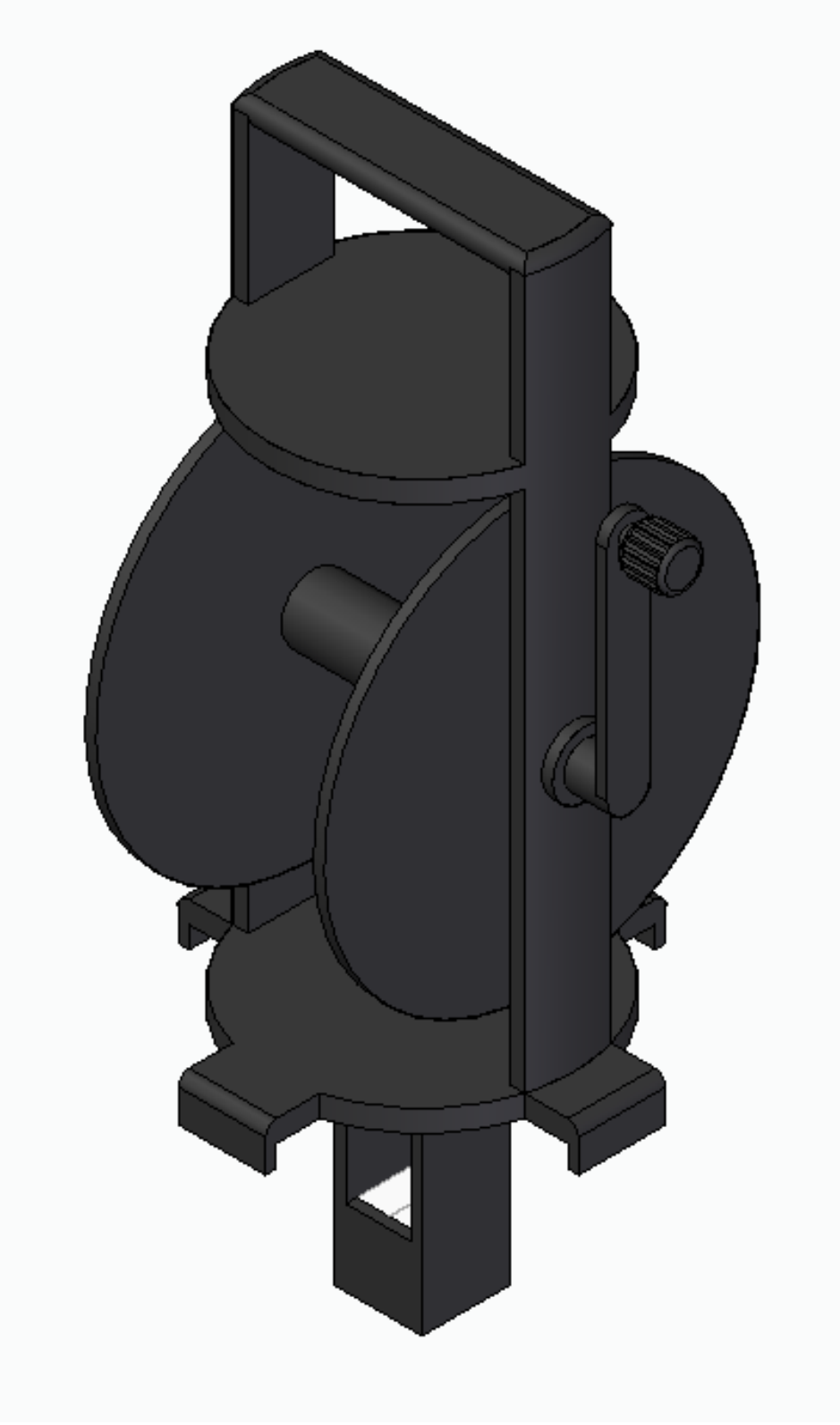


Figure 15. Assembled simplified fluid sampling device.

3.2 Choice of material and necessary changes

To choose the material we have to keep in mind that it is extremely important to use non-sparking materials for the device. This is crucial to eliminate any possibility of creating dangerous situations for human lives and the terminal itself. Horrifying cases have been witnessed which started exactly due to a small spark, one of which, involved 1 death and an explosion of a whole tank. One small electrostatic charge is enough to create a spark that can light up the gases coming up from light products.

As noted before, the choice of material for the device stands between bronze, aluminum and nickel alloys, plastics and wood. All of those materials are non-sparking and therefore, acceptable for use for the sampling device. At the same time, we need to take into consideration the requirement of low weight, higher sturdiness, easy machining and low cost. Bearing in mind that we live in a time of quick technological advancement and that base frame is 10mm thick the author decided to choose plastics as the most suitable material. It will allow an easy machining process and give a strong structure to the device while maintaining low weight and anti-static characteristic. The plastic suitable for this kind of work is polyoxymethylene (POM). Necessary parts can be either machined molded.

Unfortunately, when we think about price, then some of the elements of the current device prototype will be either too hard or too expensive to create. This problem is present with the support legs of the device, and the cleaner part holder. Both of them are part of the main frame and this makes it very difficult produce. The rope cleaner holder is square whilst the frame is round shaped. The support legs are connected to a junction of the frame pillar and the bottom of the frame. Both of these elements complicate things too much, by adding a large amount of time to the production process (different tools have to be used and the part has to be machined on multiple machines). Additionally, the spool and handle parts would add extra production cost, since those elements have to be molded or machined, Since the production quantity of the device's parts won't be in millions, the overall production price shoots up way too high.

As a solution to the problems stated above, the author has made according changes to the prototype of the device.

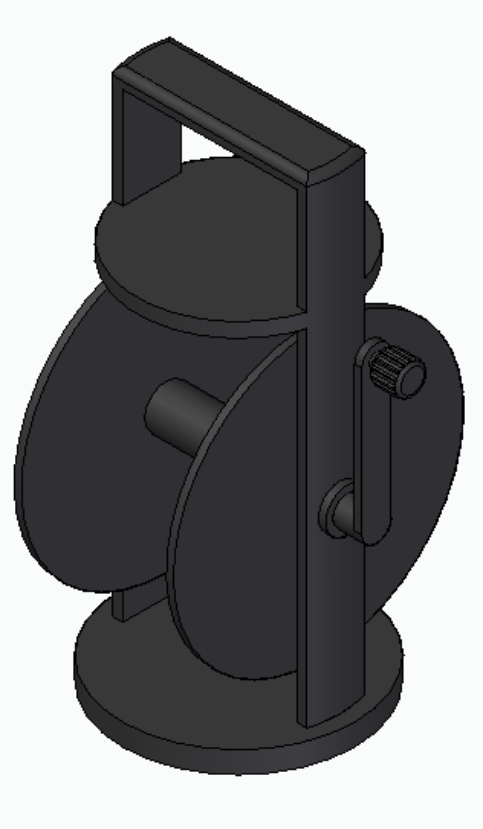


Figure 16. New device design.

Figure 17. modifications to the bottom of the device.

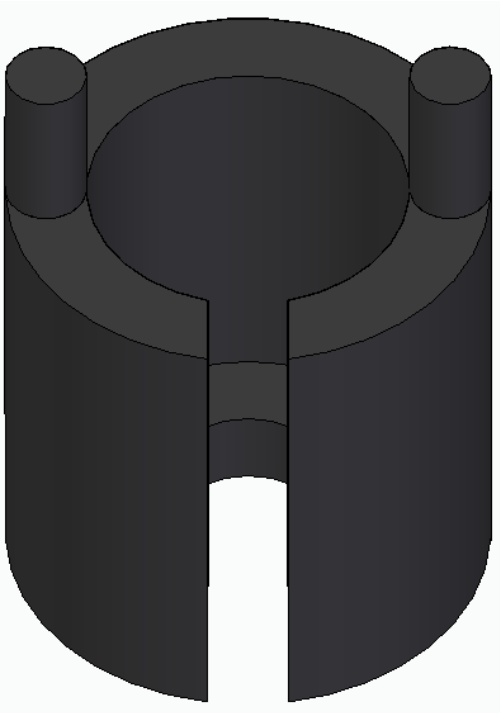


Figure 18. Rope cleaner holder

Figure 19. Silicone rope cleaning part.

As a solution for the support legs, the new model has an increased round bottom with higher edges (figure 16, figure 17), so that stability of the device is still maintained. The cleaner and the cleaner holder are now round too with a different connection method (figure 18, figure 19). The cleaner holder is a separate part now which should simplify the machining process of the frame. As a solution to the high price of the spool, handle and knob, perhaps it would be wiser to use standardized parts and simply buy it in for the assembly of the whole device. Different companies are dealing with production of plastic spools and other parts. It would be cheaper to find such a company and negotiate a deal with it since they already have the tools and experience needed to produce the exact part we should need. With that done, buying those parts in, ready for assembly, this leaves us with just production of the main frame, and the rope cleaner holder with the rope cleaner part itself. As a result, an important business relation has been created, which could be useful in the upcoming new projects and which could bring important discounts with the long-term deals, and the overall production time and price has been reduced. The reduced sales price will also attract more clients since, in our world, everyone is constantly in search of the best and cheapest option.

3.3 Calculations

The device model is completed and now a couple of calculations need to be done. Through Solid Works software the author checks if the main frame and the handle could handle the stress.

For the main frame the bottom part is locked in (figure 20) and the we simulate the situation if somebody would apply a force of 1000N to from the top. In other words, if somebody with a mass of approximately 100 kilos would completely lean on the part. As we can see from the figure 21 we notice that there aren't any major changes to the structure of the device and it withstands the force easily. Figure 1 illustrates the effect of the applied force in a scale 18,625 to 1 so it would be clearer which part of the main frame gets more affected.

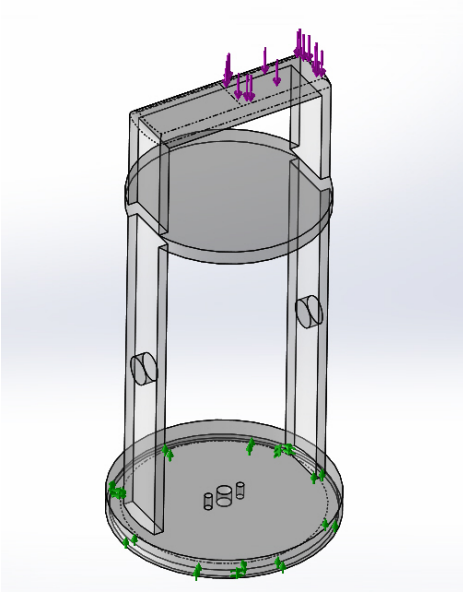


Figure 20. Part locked in in the bottom and force applied from the top

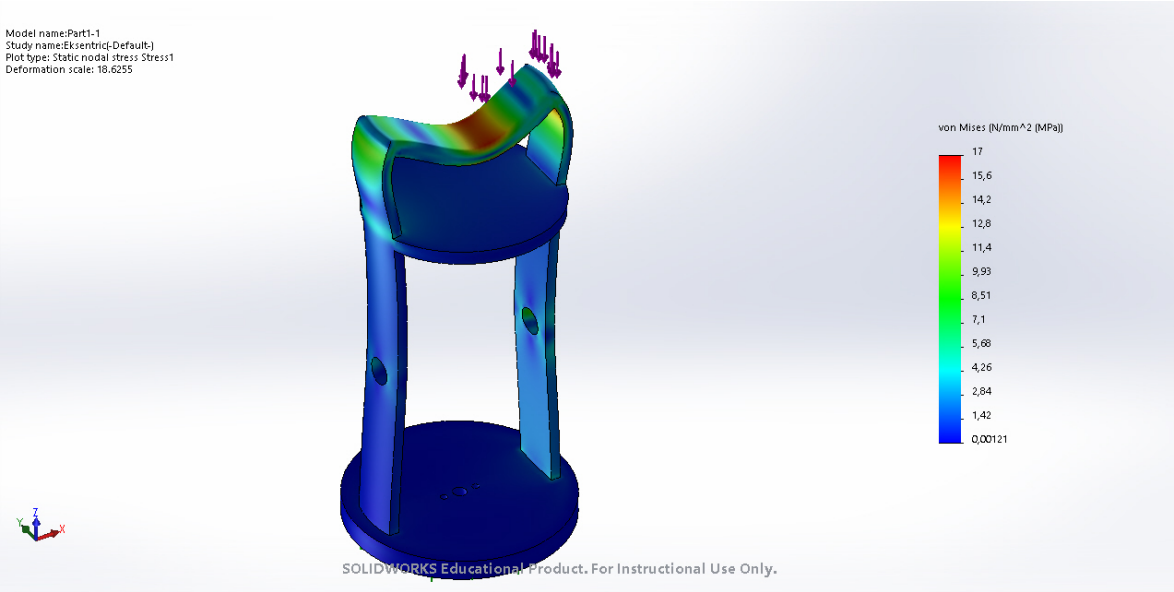


Figure. 21 Static nodal stress illustration with a scale 18,625 to 1.

The same calculation is done to the handle. The simulation considers, that the handle would get stuck and somebody would apply force of 50N (or approximately 5kg) on the knob part. Therefore, the part gets locked in the spool part and the force is applied to the knob part of the handle (figure 22). The result is also satisfying since the part withstands the stress (figure 23).

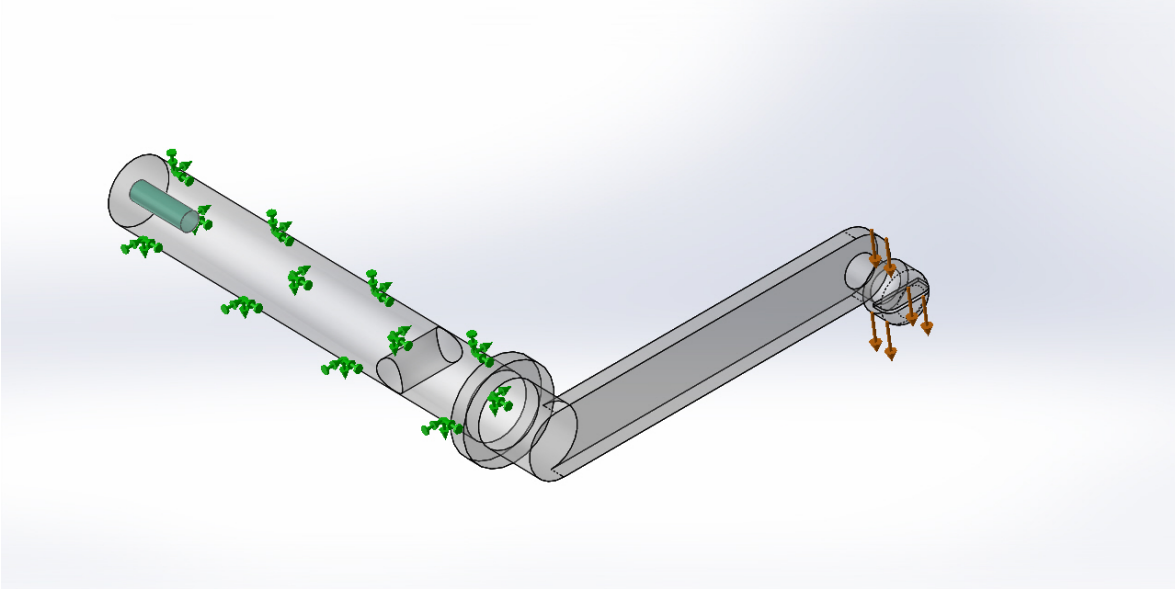


Figure 22. Handle locked in and the force is applied to the knob part.

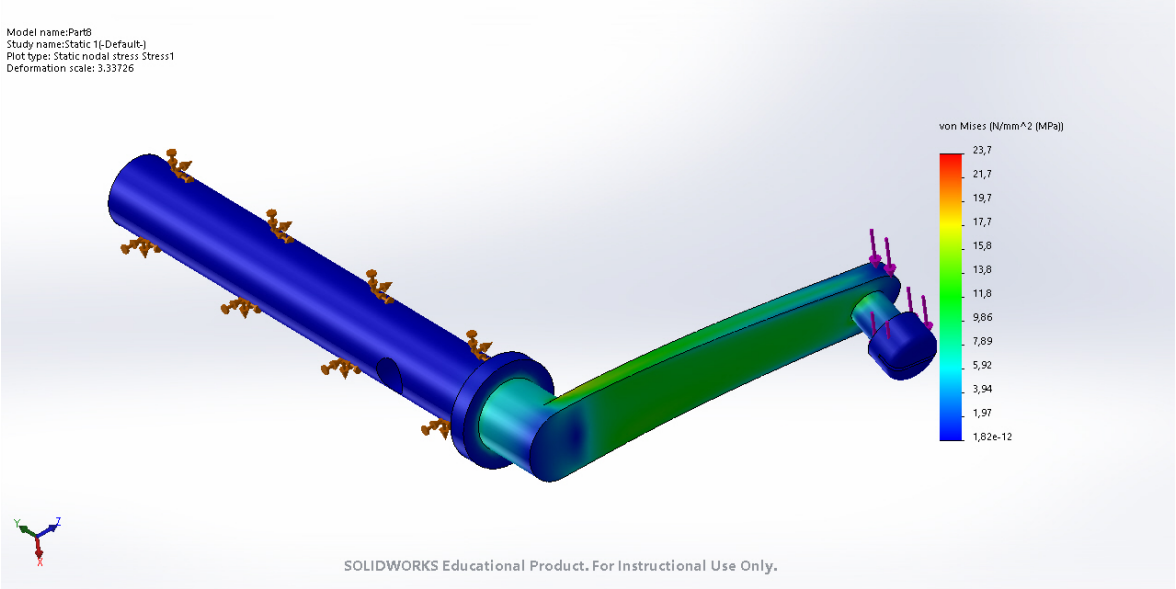


Figure 23. Static nodal stress on the handle with a scale 3,337 to 1.

Following that we need to calculate the stress applied to the handles support places, considering that the spool with a rope are present and there is 2kg mass hanging on the end of the rope.

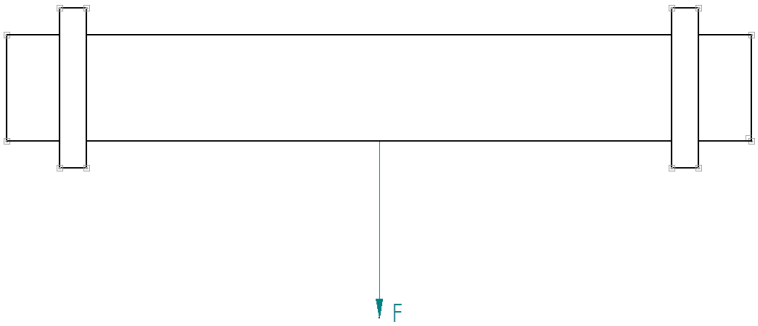


Figure 24. Force applied to the middle of the handle.

The figure 24 illustrates the calculation. First, we will have to calculate the applied force. The mass on the end of the rope is 2 kilos. We will make it 5 kilos to check what would be the result if the mass would suddenly be more than expected.

$$F = m \times 9{,}81$$

$$F = 5 \times 9{,}81 = 49{,}05\ N$$

Now we have to calculate the stress in the handle under explained conditions.

$$\tau = \frac{F}{2 \times A} = \frac{49{,}05}{2 \times \frac{\pi \times 20^2}{4}} = \frac{49{,}05}{628{,}32} \approx 0{,}078\ MPa$$

As the calculation shows the stress present in the handle with the mass of even 5 kilos is negligible. In fact, the part can withstand more than that.

Finally, we have to calculate how many turns of the handle would it take the worker to descend the sample bottle by 1 meter. We calculate the circumference and then the rotations.

$$C = \pi \times d = \pi \times 20 \approx 62{,}83mm = 6{,}283cm$$

$$Rotations = \frac{100}{6{,}283} \approx 15{,}92\ turns$$

It would take at least 15 rotations by the worker to descend the sample bottle by 1 meter.

4 PRODUCT MARKETING

With the prototype design set and necessary solutions created to reduce the production time and price, we have to choose now, how exactly are the parts of the device going to be produced, which machines and tools will be used, where will the production plant be located, which ways and methods will be used for marketing and sales of the product and who will be the main clients.

4.1 Production method and location

As slightly mentioned before, the production scale cannot be as large as millions of products since there won't be enough clients to sell it to. Therefore, the production quantity will probably be in thousands.

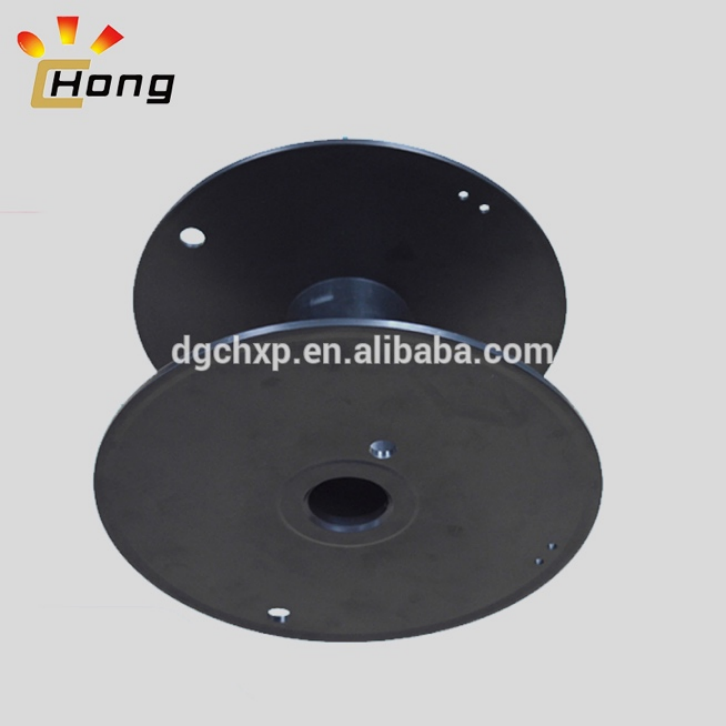
The point 3.2 gave us an understanding that some parts have to be produced in the HQ of the company or purchased as service from the companies which already have the equipment for such production. At this point it really depends on the precise calculation between purchasing the equipment with hire of the necessary workforce and the quota proposed by the other companies on production of such parts. In long term it would be perhaps still better to own the equipment and the workers who know how to operate it since, in the long term, the company could be dealing not only with the current sampling device production, but also the development of new models which will be improved and with more functions.

It could work closely with the terminals and the sampling companies like SAYBOLT to create and supply them even more equipment for different tasks they are performing. That is why the company with the factory should probably located in the country which has terminals and ports that are part of large international trade deals. Therefore, Estonia is a very good place to create a business in this field. Estonia already serves as a bridge between the Russian federation, a country which is a home to an enormous number of commodities and consequently commodity trading, and European Union, with at least two important ports and terminals in Sillamäe and Paldiski. Multi-billion international companies like Trafigura uses this strategic placement to conduct deals with Russian suppliers. Trafigura has offices in 36 countries and conducts business all over the globe (figure 25). This underlines the importance of Estonia as part of international trade. Additionally, there are other important

terminals locate not too far from Estonia. Russian, Finnish, Lithuanian ports for example are of the equal importance. The conclusion is therefore, that the company and the factory will be situated in Estonia.

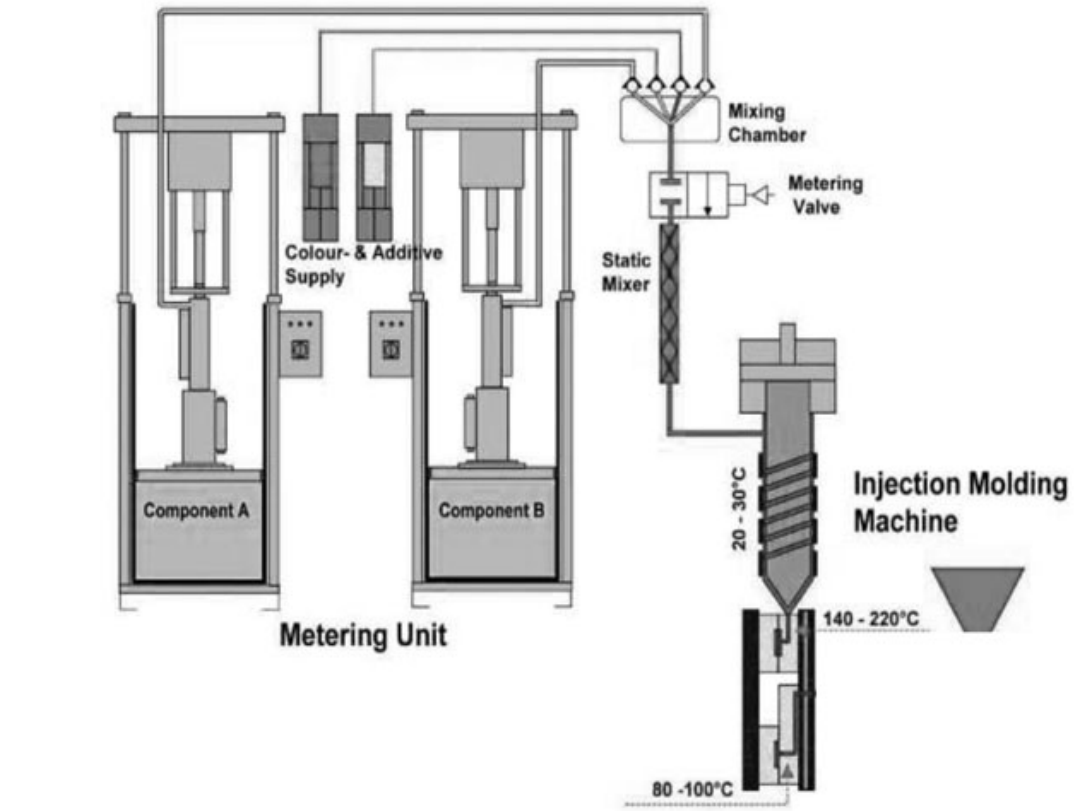
[7] Figure 25. Trafigura's presence in the world.

Spool, handle and rope cleaner have to be purchased from the companies who specialize in production of the plastic products and in our case spools and parts that go with it. With a simple research on internet the author has been able to find a plastic spool (figure 26) with similar dimensions that are designed by the author. The company is called Dongguan Changhong Bobbin Co., Ltd. and it is situated in Guangdong, China. The price market for the current product is 2 dollars per piece with the minimal order of 120 pieces. The goal here is to negotiate with the company a long term deal for the similar spool with custom dimensions and a custom handle. Even if the price per piece for both will remain under 10 dollars it will still be very good, considering that producing those parts by ourselves would cost probably thousands of euros per piece. The company is also very experienced in working internationally with companies located in Europe and therefore shipping probably won't be the problem either.



[8] Figure 26. Plastic rope spool produced by a company in China.

What concerns the the silicone rope cleaning part, it is probably not necessary to purchase a mold injection machine just to produce one part and therefore, should also be bought in from a company that knows what it's doing. As an example the company named Simtech Silicone Parts which specialises in liquid silicon rubber injection molidng (figure 27), who are also present in Europe. Perhaps it would be better to, similarly to Dongguan Changhong Bobbin company, negociate a deal with them to produce necessary silicone rope clening parts for the current sampling device.



[9] Figure 27. Liquid silicone rubber injection molding process

Parts like the main frame and rope cleaner holder have to be produced in the main factory and in this case the company could use a few machines and tools for this. The purchase of these machines should drop the price of the end product and keeping them allows production of future projects as well. To produce the main frame and the rope cleaner holder of the sampling device a company could use a turning machine and a CNC-Milling machine. For the turning machine, a Colchester & Harrison V350 (figure 28) would be perfect since it allows to turn parts with the length of up to 350 mm and in our case the frame is 345mm. Regarding the milling part of the part production process, Euromod MP45 CNC-Milling machine (figure 29) would work perfectly since it's travel ranges are 650x450x250. The dimensions fit perfectly to work on the main frame and moreover the machine should definitely be kept for the future projects. Euromod MP45 can work with materials like aluminium, plastics, plate materials, brass and foams.

[10] Figure 28. Colchester & Harrison V350

[11] Figure 29. Euromod MP45 CNC-Milling Machine

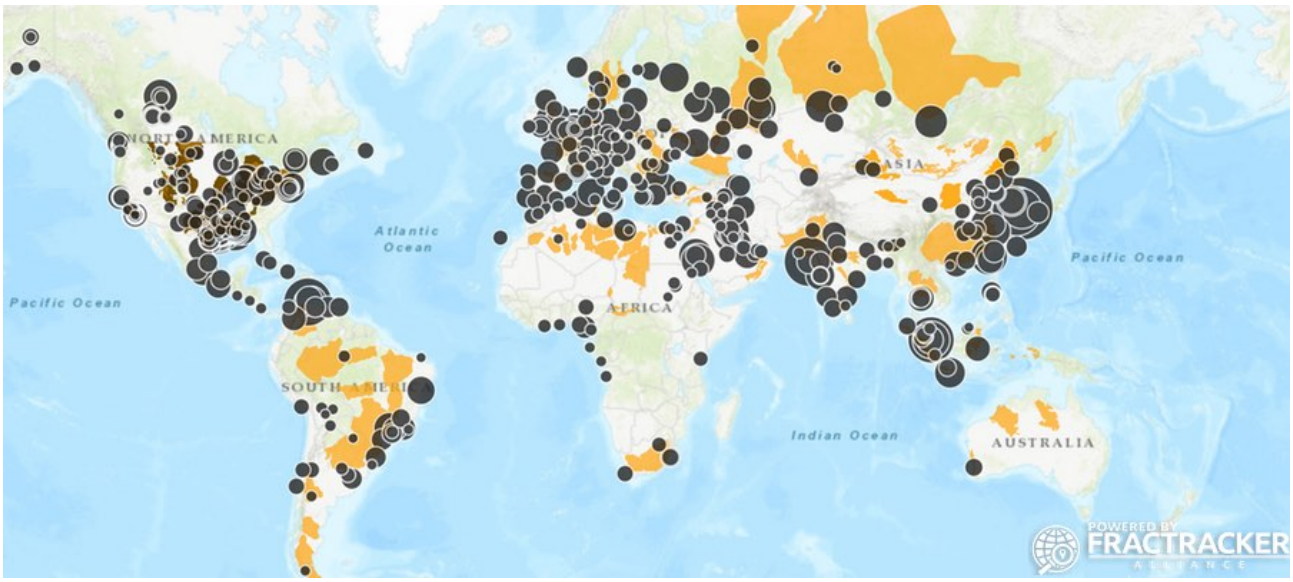
4.2 Clients and sales method

According to the www.tankterminals.com, a site which specializes in listing all the terminals in the world, there are approximately 4916 oil & petroleum terminals in the world (figure 30) and this number keeps on growing. Probably each one of them contains at least one sampling company in them. The main focus with the sales of the simplified fluid sampling device will be these terminals. They will require at least around 1-10 of those devices depending on their size. Some terminals have 10 tanks and some have 55. There are terminals with a lot more work required to take samples continuously throughout the day and consequently 1 device per terminal might not be enough. Having a special team who will responsible for advertisement and proposition of the sampling devices to these terminals is crucial. Although, with the sites like www.tankterminals.com it will be a lot easier since there is a clear list that the ad-team can work with. More to that, in this field of business connections are very important and therefore, it is important to start working very closely with terminals located close and companies like SAYBOLT, because they communicate with other companies and terminals in this line of work and will be spreading the word about the new device themselves.

Following that, there are 536 global oil refineries in the world. The next focus will be on them. Like the Kiviõli Keemia Tööstus in Kiviõli, refineries also own tanks where they store the produced oil, in KKT's case the shale oil. They also have to check its quality to know how it turned out. Therefore, the next target would be to propose the device to all the refineries in the world (figure 31).

Finally, there are a lot of different independent sampling companies, terminals and other oil and petroleum related facilities that can always contact the company and order the device for themselves. Moreover, other liquid goods, like coconut oil for example, are also stored in similar terminals. Thus, the device can be used to acquire samples of not strictly oil and petroleum goods but also other liquid products.

[12] Figure 30. Quantity and location of terminals in the world.



[13] Figure 31. Quantity and location of refineries in the world

CONCLUSION

Oil terminals are important storage facilities in the chain of all commodity trading. More specifically oil terminals are facilities that provide storage possibilities for other commodity trading firms no matter if the product is liquid, gas or solid. The current paper concerns the terminals that store oil and petroleum goods and the companies that deal every day with sampling those goods. To be more precise this paper targets a certain inconvenience caused by the lack of a simple tool for the sampling process. At the moment everything SAYBOLT uses, at smaller terminals is a simple bucket with a rope. It is a simple set but it brings some inconvenience to the worker while acquiring the samples, especially when dark products and harsh weather conditions are in the equation. Current paper proposes a solution to this problem, by introducing a new simplified fluid sampling device that allows the worker to acquire samples faster and with less actions needed, preserving his health. In this paper, the author creates a 3D model of a prototype while carefully following the requirements created for a device in such field of work. A production plant location is chosen alongside with the production process. Some parts are outsourced through companies which specify in the field of production of those type of products. The long-term agreements allow to reduce the production price of the device and allows to use the same supplier for the upcoming new projects. Other parts are produced in the HQ with machines and tools on place. Machines remain for the upcoming projects so their purchase is logical. The clients for whom the device was meant will be all the storying facilities with tank parks and liquid products, though mainly terminals with oil and petroleum goods. Apart from them device will be interesting for the oil production factories and other independent companies working in the same field.

KOKKUVÕTE

Naftaterminalid on olulised ladustamisrajatised kaubavahetuse ahelas. Täpsemalt on naftaterminalid rajatised, mis pakuvad teistele kaubandusettevõtjatele ladustamise võimalusi, olenemata sellest, kas toode on vedelik, gaas või tahke. Käesolev dokument puudutab nafta- ja naftatoodete terminale ning ettevõtteid, kes tegelevad iga päev nende kaupade proovide võtmisega. Täpsemalt on see dokument suunatud teatud ebamugavustele, mis on põhjustatud lihtsa vahendi puudumisest proovi võtmise protsessis. Praegu kõik, mida SAYBOLT kasutab, väiksemates terminalides, on ämber ja nöör. See on lihtne komplekt, kuid see pakub töötajale proovide hankimisel ebamugavusi, eriti tumedate tootede puhul ja karmides ilmastikutingimustes. Antud töö pakub sellele probleemile lahendust, võttes kasutusele uue lihtsustatud vedeliku proovivõtuseadme, mis võimaldab töötajatel proove kiiremini ja vähemate liigutustega hankida, säilitades samas oma tervise. Selles töös koostab autor prototüübi 3D mudeli, jälgides hoolikalt välja kirjutatud nõudeid, mida peaks sellises valdkonnas hoolikalt järgima. Tootmisettevõtte asukoht valitakse koos tootmisprotsessiga. Mõned seadme osad ostetakse teiste ettevõtete kaudu, mis spetsialiseeruvad nende toodete tootmise valdkonnas. Pikaajalised kokkulepped vähendavad seadme tootmishinda ja võimaldavad kasutada samat tarnijat ka uute projektide puhul. Muud osad toodetakse koha peal olevate masinate- ja tööriistadega. Masinad jäävad tulevaste projektide tootmise jaoks, nii et nende omandamine on loogiline. Kliendid, kellele seade on mõeldud, on kõik mahutiparkide ja vedelate toodetega, kuid peamiselt on need nafta- ja naftatoodete terminalid. Peale selle on seade huvitav naftatootmisettevõtetele ja teistele samas valdkonnas töötavatele ettevõtetele.

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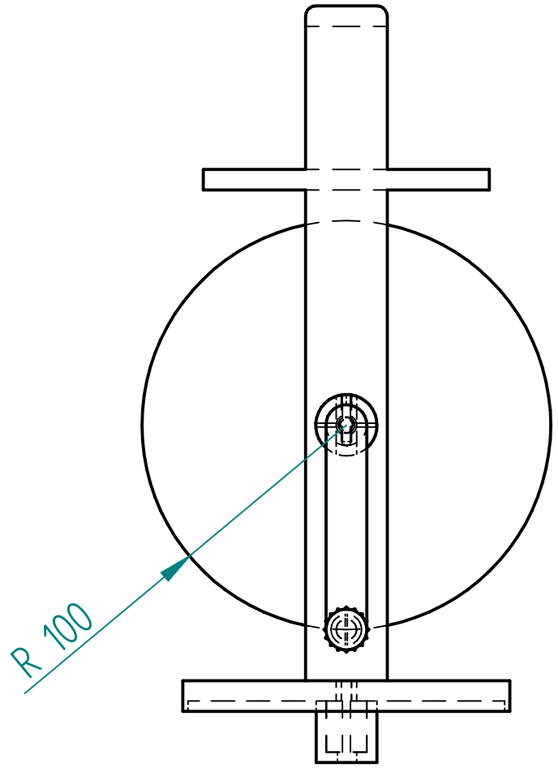
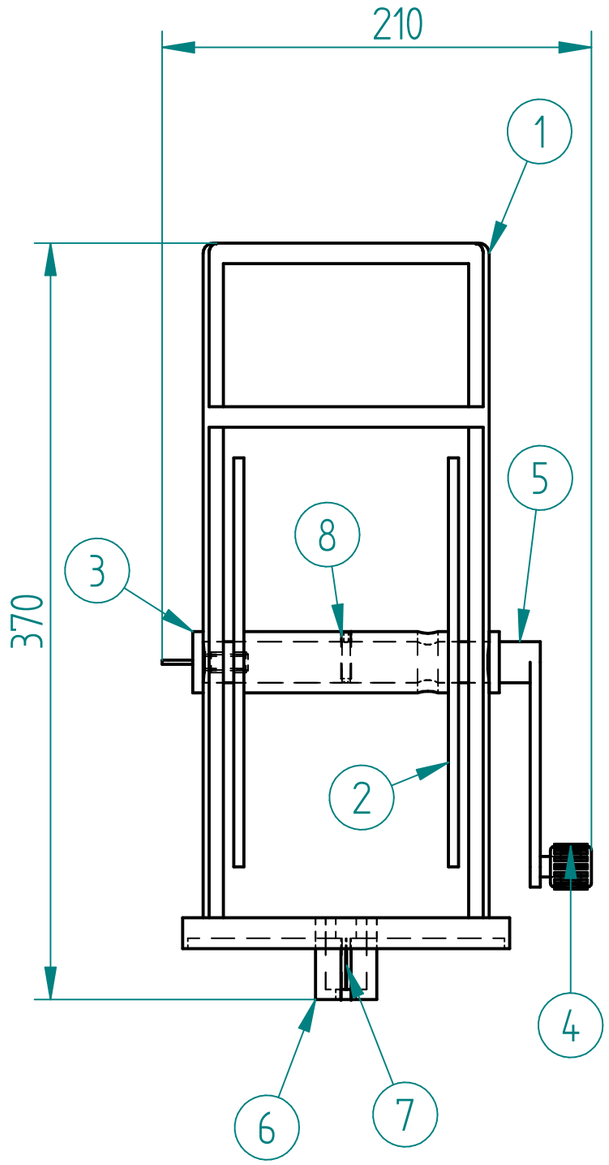
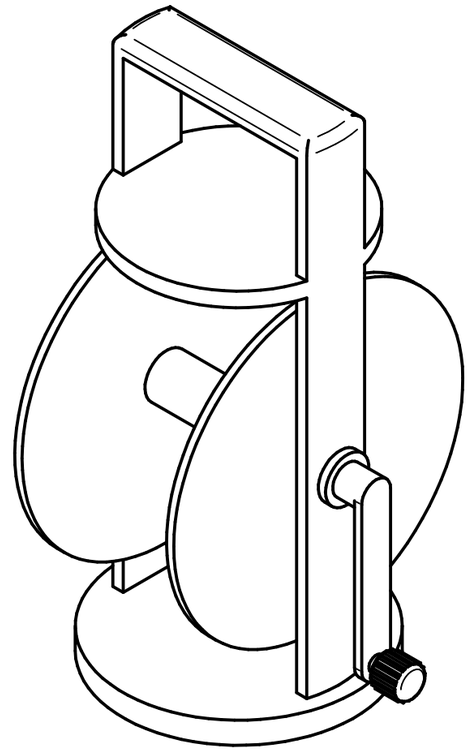
APPENDICES

1) CAD.01.00.00, Simplified Fluid Sampling Device
2) CAD.01.01.00, Main Frame
3) CAD.01.02.00, Spool
4) CAD.01.03.00, Handle Fixator
5) CAD.01.04.00, Handle Knob
6) CAD.01.05.00, Handle
7) CAD.01.06.00, Rope Cleaner Holder
8) CAD.01.07.00, Rope Cleaner
9) CAD.01.08.00, Spool Fixator







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7	CAD.01.07.00	Silicone	1
8	CAD.01.08.00	Steel	1

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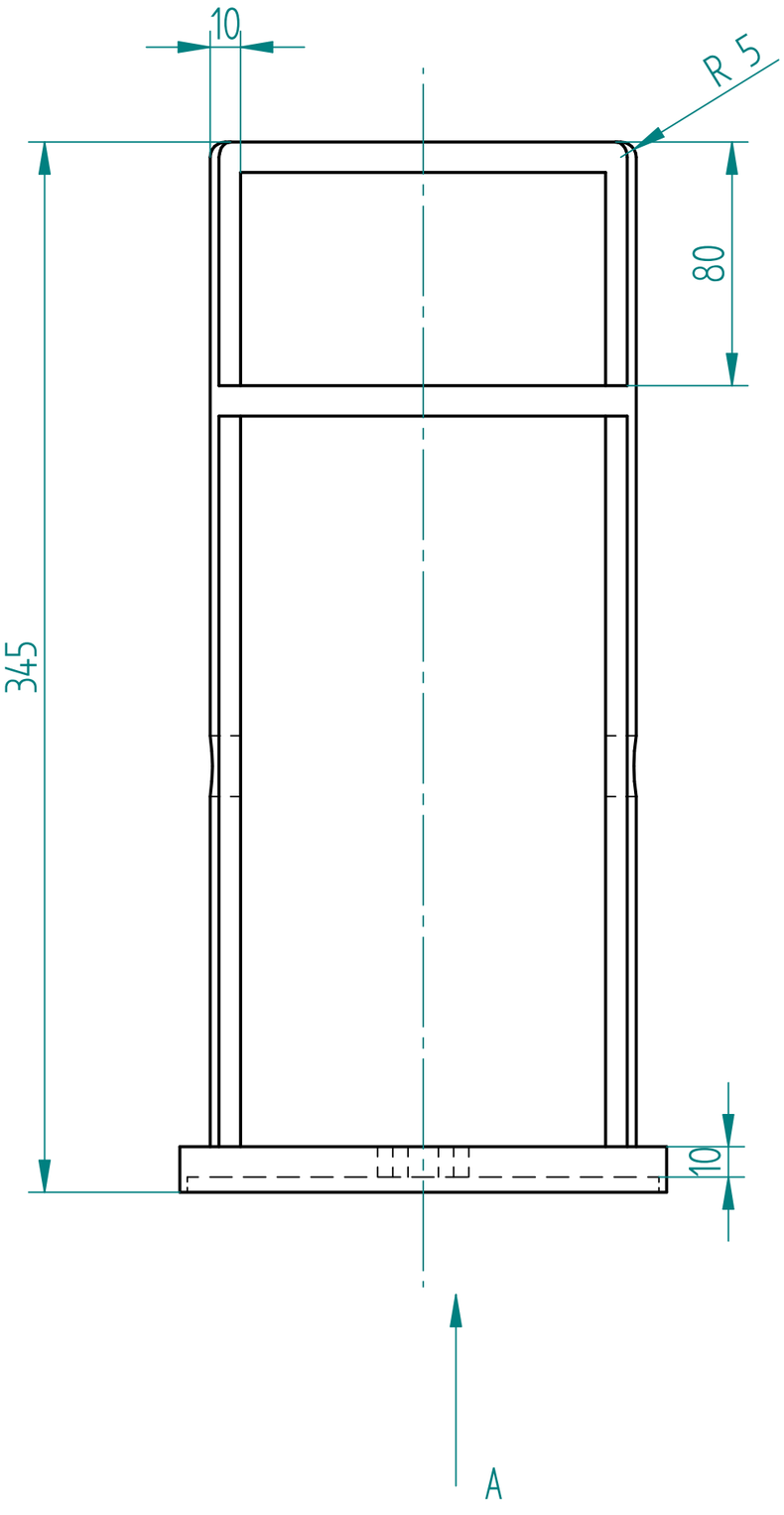

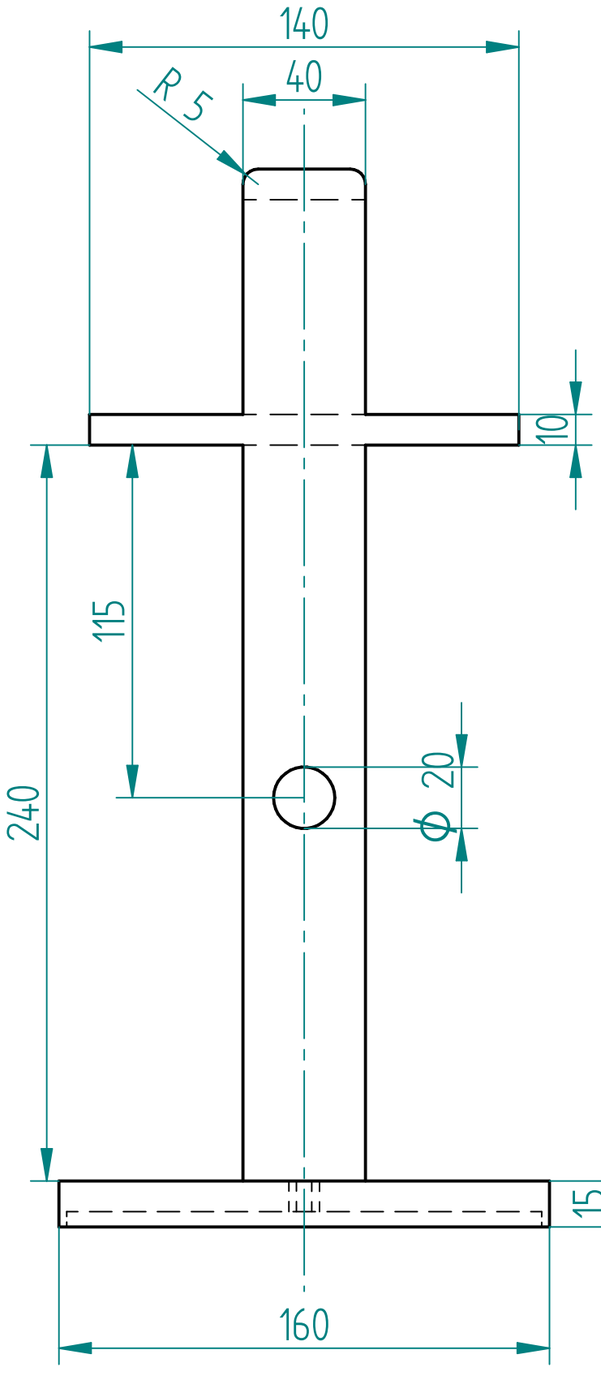

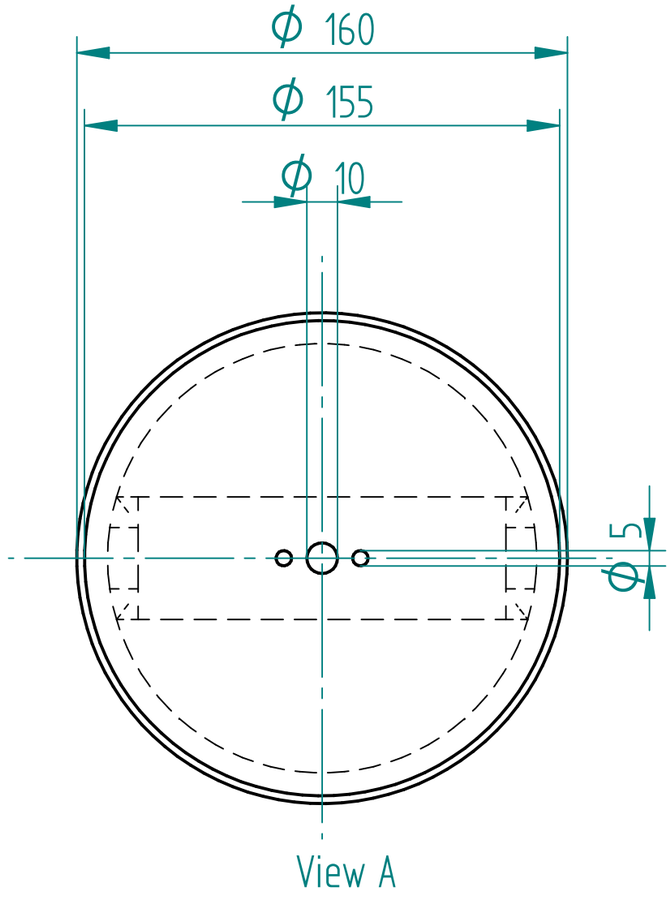

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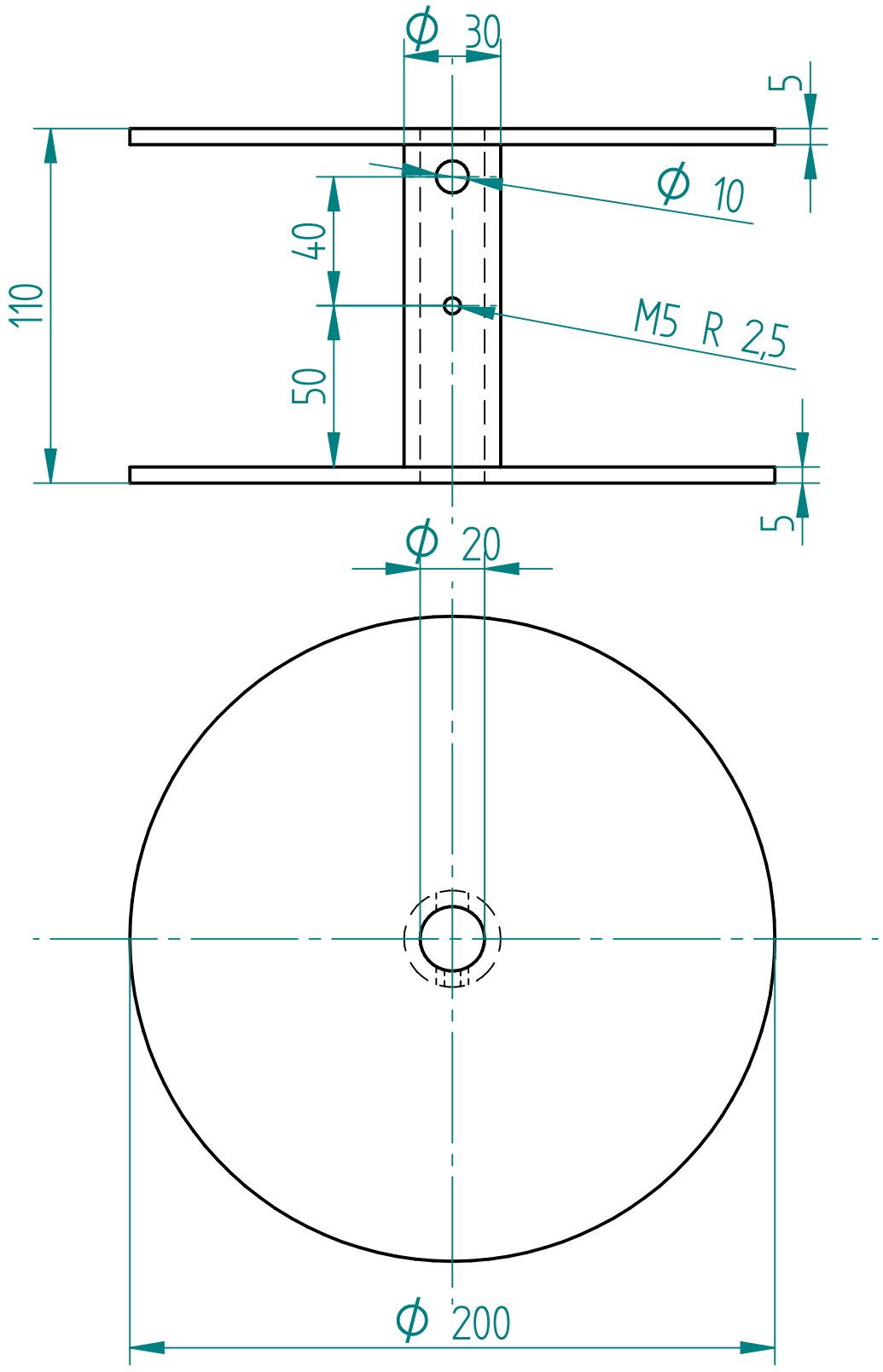

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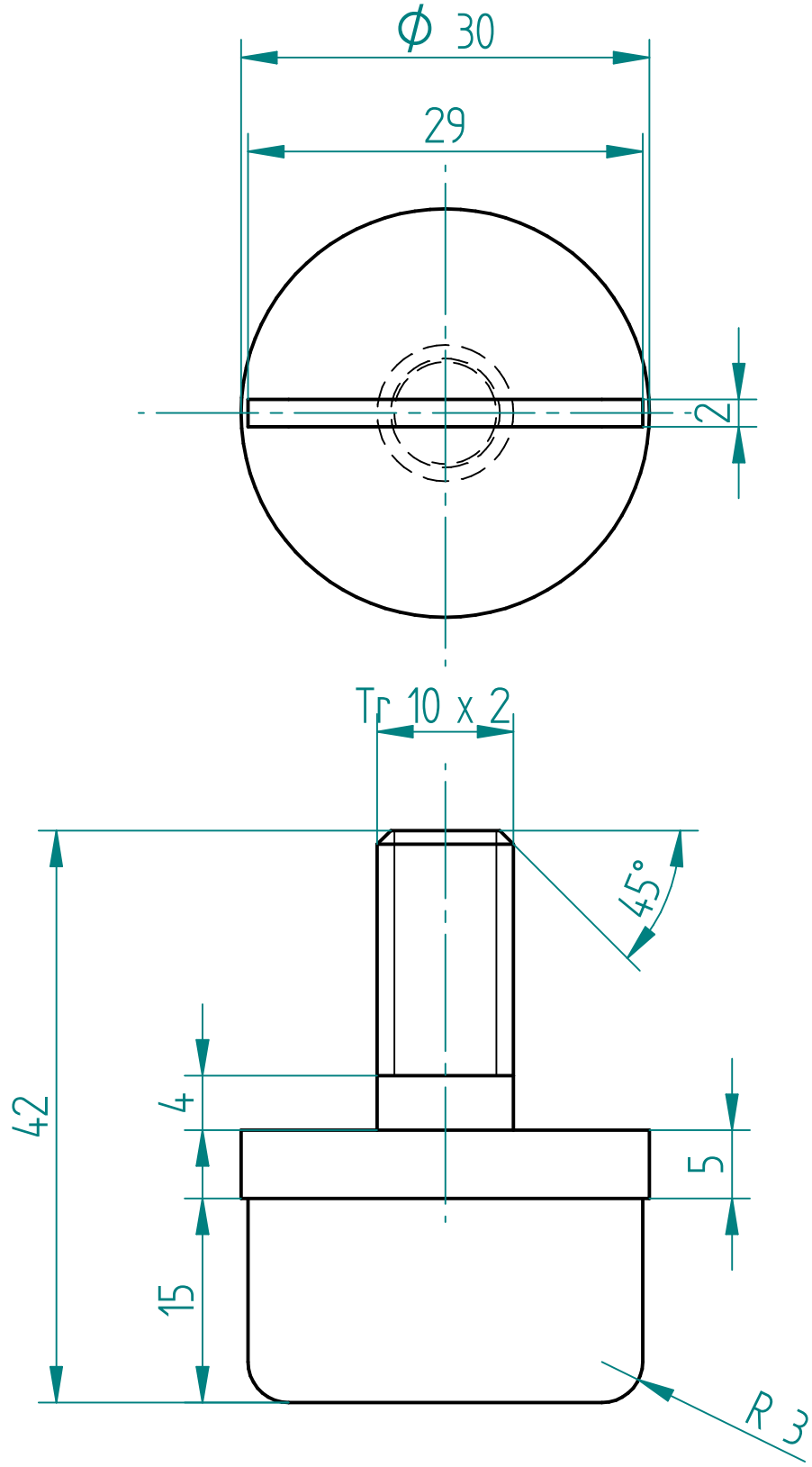

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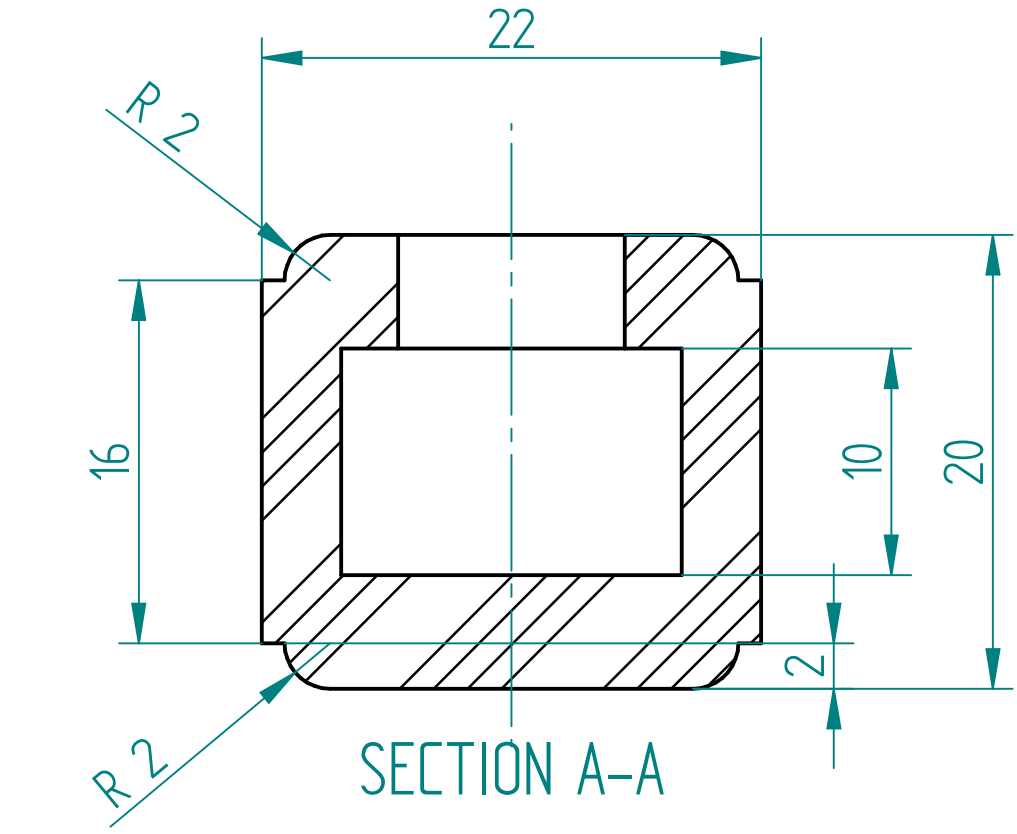
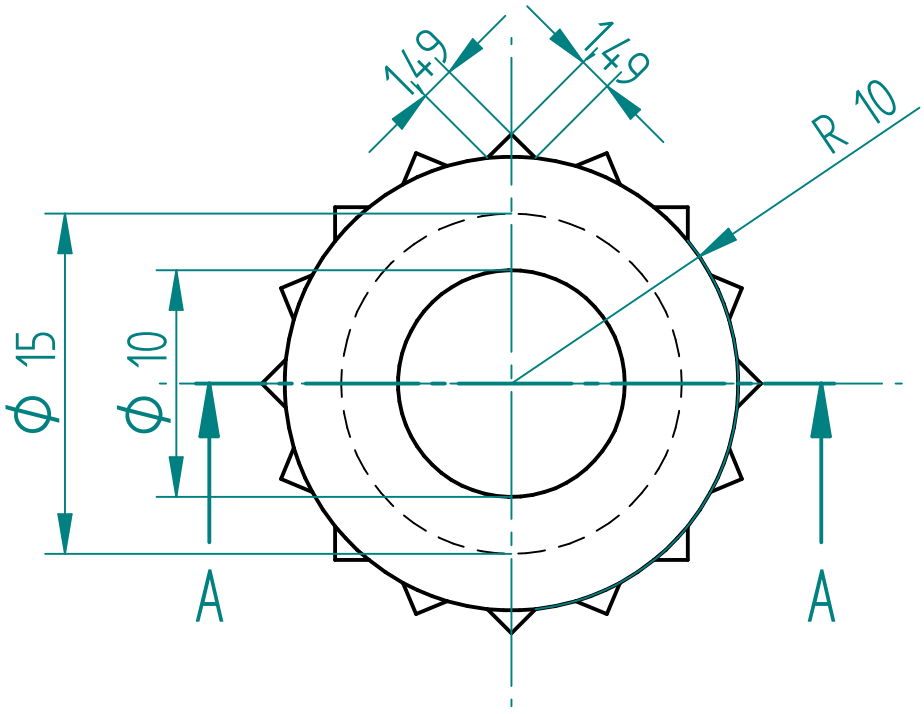
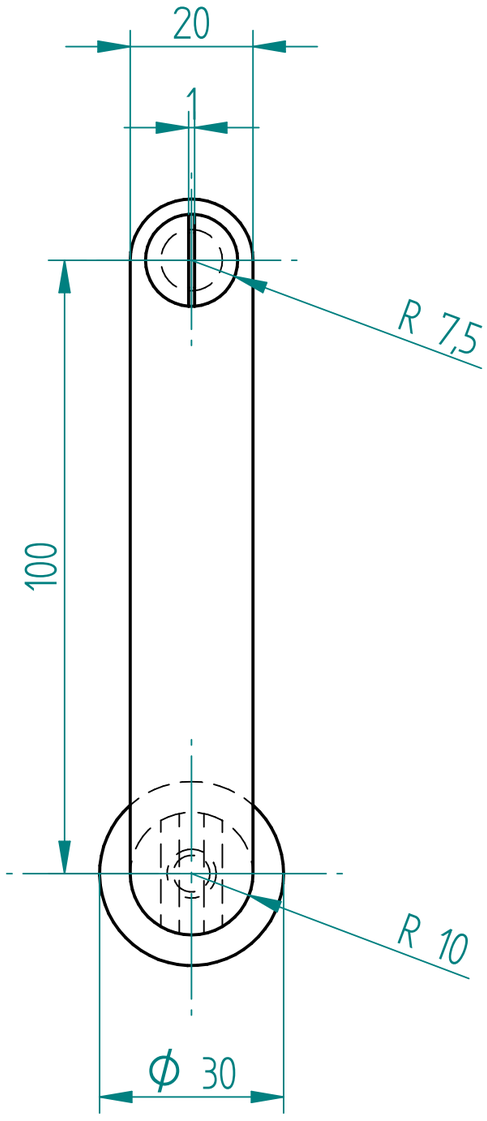
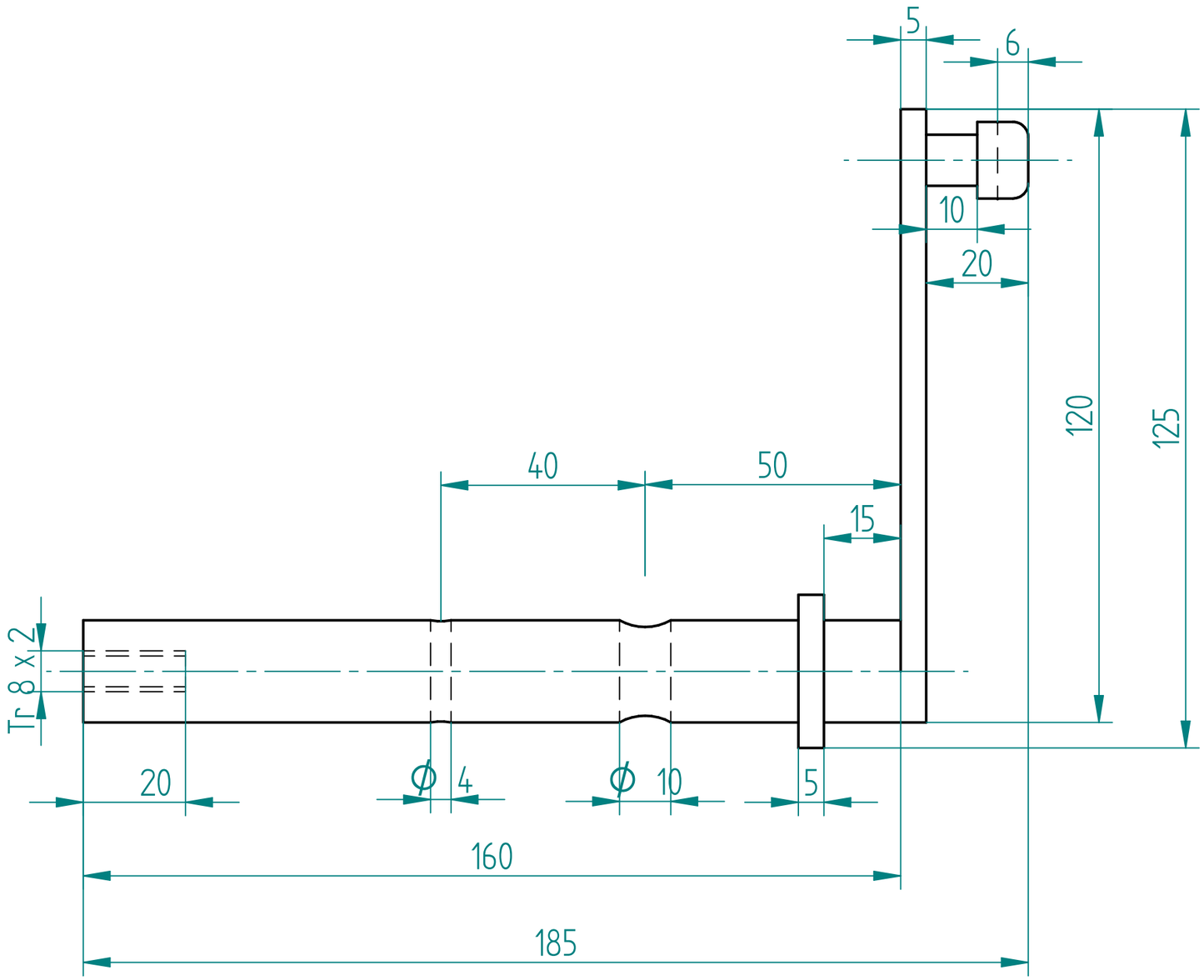


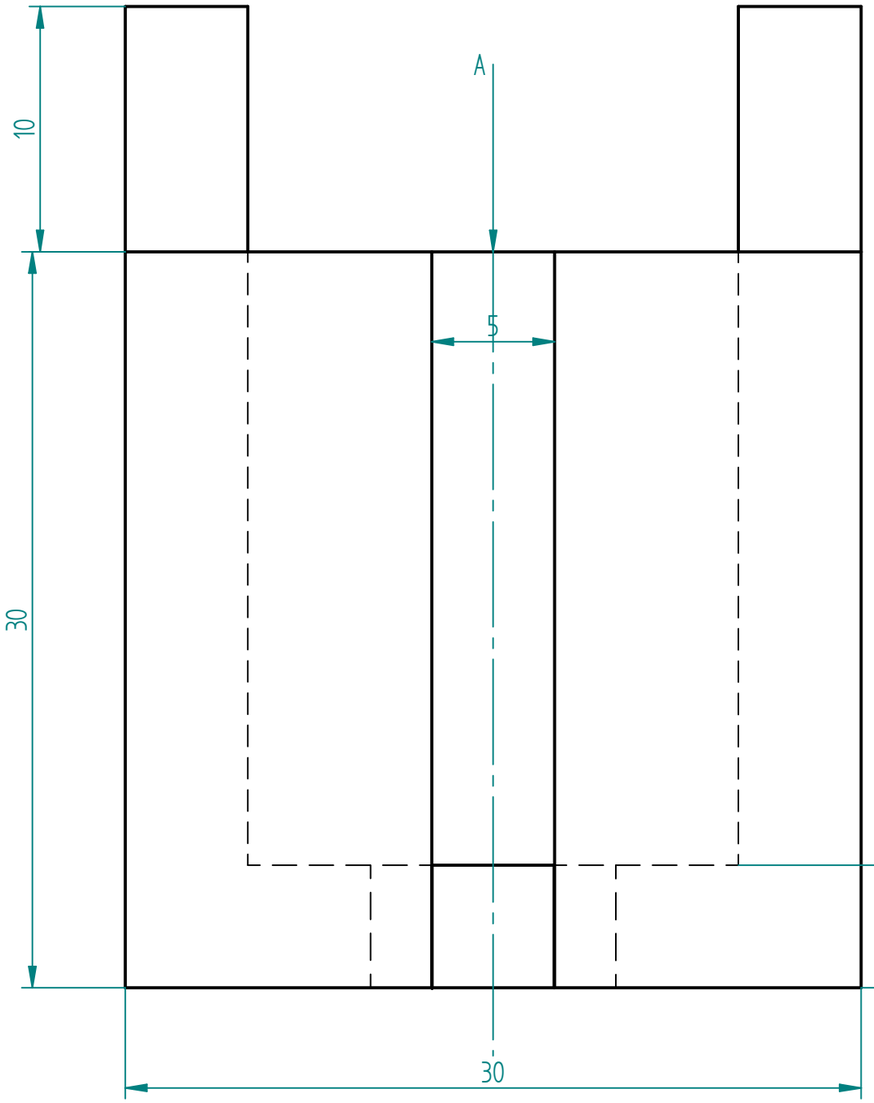


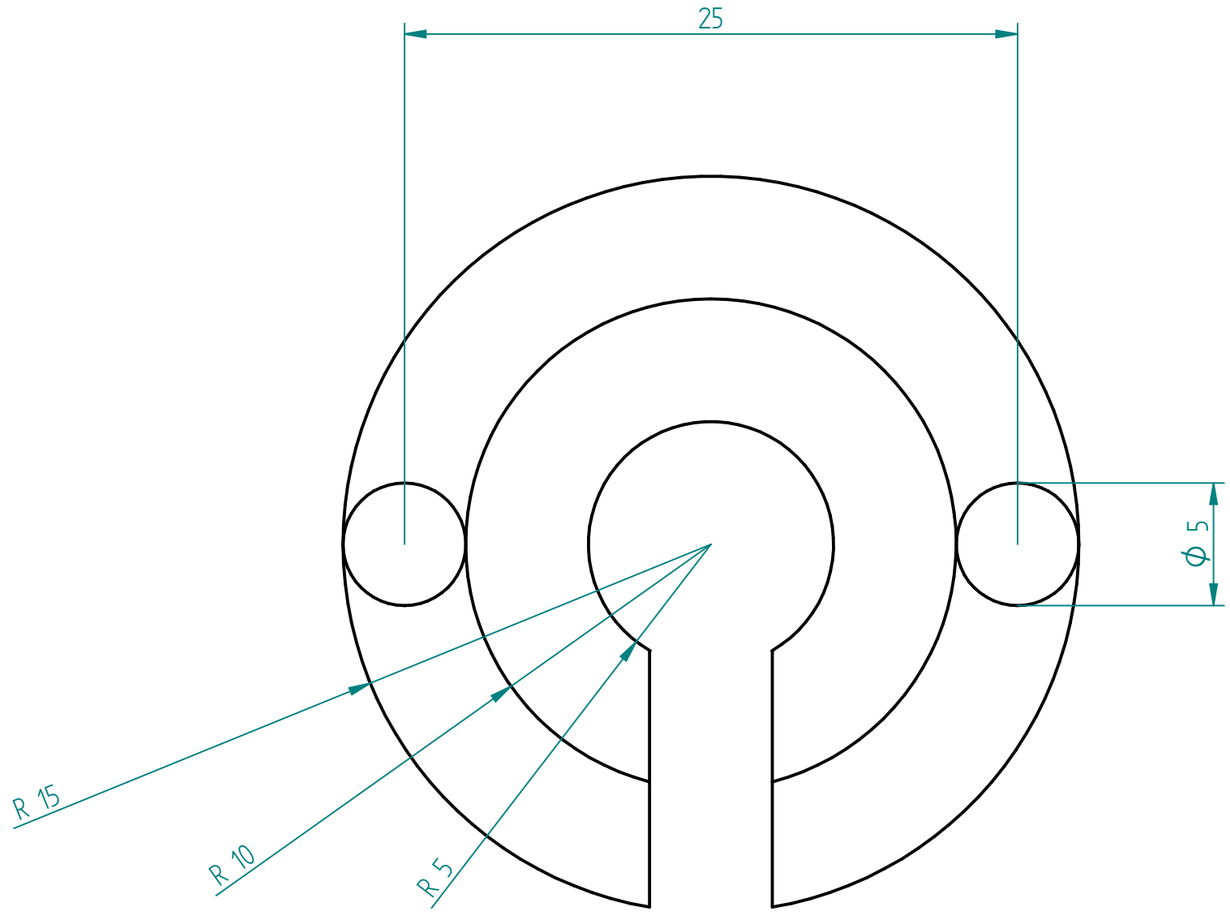
	Material: Polyoximethylene	Unmarked permissible deviations: H12, h12, ±IT12/2	Scale: 3:1
Composed	Georg Huban	Name: *Simplified Fluid Sampling Device*	
Checked	Martin Eerme		
Approved	Martin Eerme		
TalTech School of Engineering Industrial Engineering and Management		Page: 5/9	Annotation: CAD.01.04.00
			Format: A4





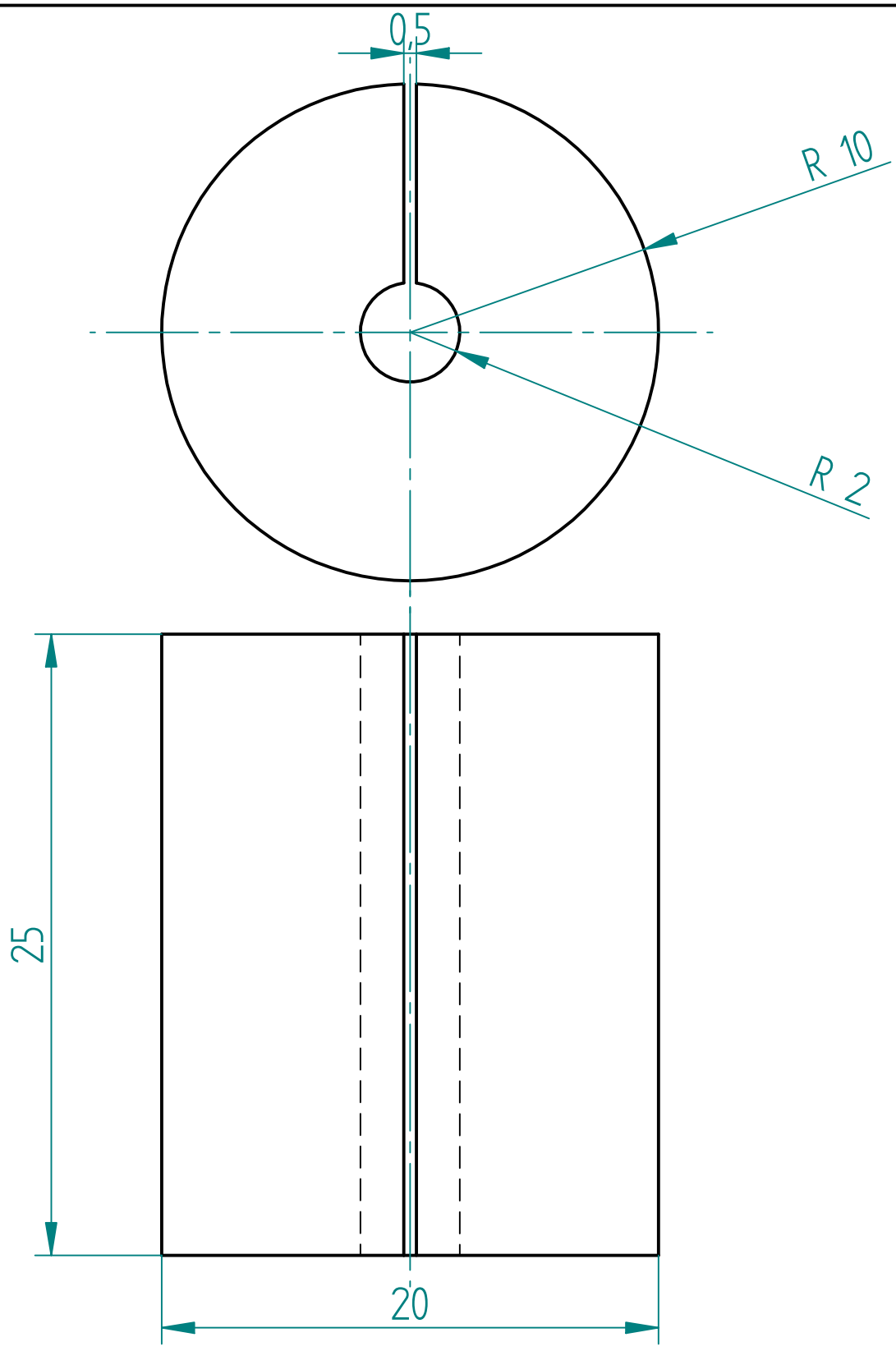
Material: Polyoxipropylene		Unmarked permissible deviations: H12, h12, ±IT12/2	Scale: 1:1
Composed	Georg Huban	Name: *Simplified Fluid Sampling Device*	
Checked	Martin Eerme		
Approved	Martin Eerme		
TalTech School of Engineering Industrial Engineering and Management		Page: 6/9	Annotation: CAD.01.05.00 / Format: A3



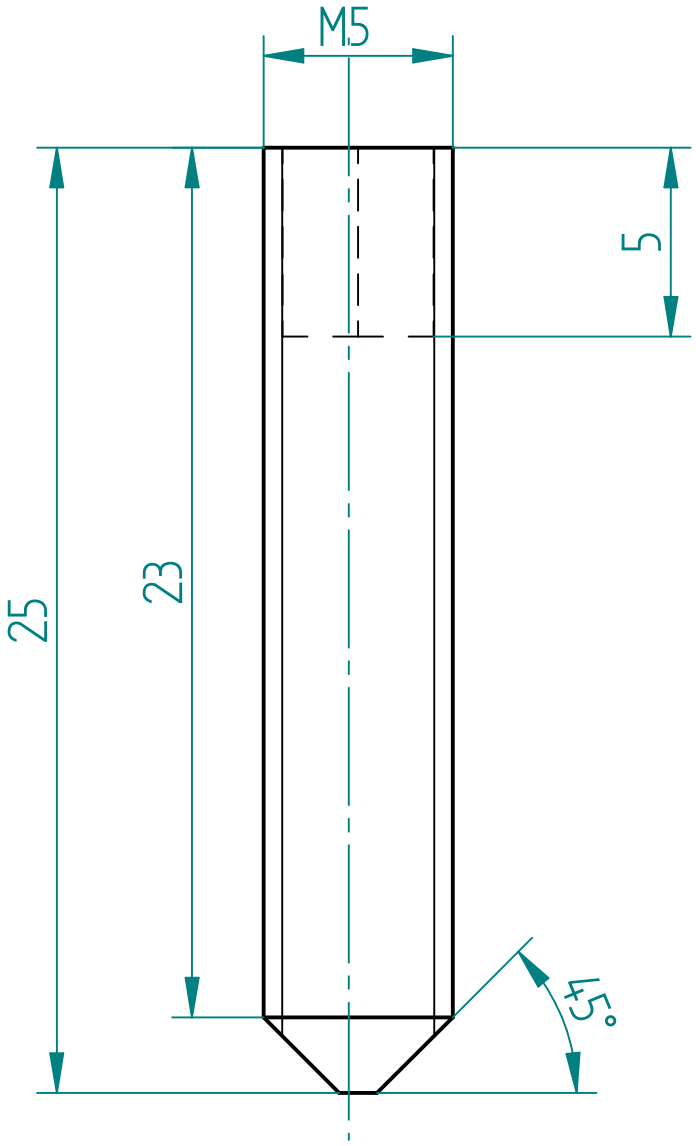


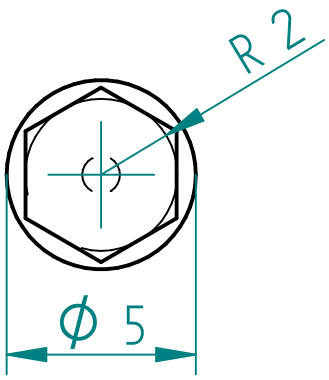
View A

Material: Polyoxymethylene		Unmarked permissible deviations: H12, h12, ±IT12/2	Scale: 4:1
Composed	Georg Huban	*Name:* *Simplified Fluid Sampling Device*	
Checked	Martin Eerme		
Approved	Martin Eerme		
TalTech School of Engineering Industrial Engineering and Management		Page: 7/9	Annotation: CAD.01.06.00 / Format: A3



	Material: Silicone	Unmarked permissible deviations: H12, h12, ±IT12/2	Scale: 4:1
Composed	Georg Huban	Name: *Simplified Fluid Sampling Device*	
Checked	Martin Eerme		
Approved	Martin Eerme		
TalTech School of Engineering Industrial Engineering and Management		Page: 8/9	Annotation: CAD.01.07.00 / Format: A4





Material: Steel		Unmarked permissible deviations: H12, h12, ±IT12/2	Scale: 5:1
Composed	Georg Huban	Name: *Simplified Fluid Sampling Device*	
Checked	Martin Eerme		
Approved	Martin Eerme		
TalTech School of Engineering Industrial Engineering and Management		Page: 9/9	Annotation: CAD.01.08.00 / Format: A4