INTERNAL PIPELINE ANOMALY ABRADING DEVICE

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INTERNAL PIPELINE ANOMALY ABRADING DEVICE

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BONAFIDE CERTIFICATE

This is to certify that the work contained in this thesis titled "**Internal Pipeline Anomaly Abrading Device**" has been carried out by **Aben Sabu Kuriakose** under my supervision and has not been submitted elsewhere for a degree.

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ABSTRACT

Internal Pipeline Anomaly Abrading Device is a new contribution for maintaining the pipeline integrity. It can abrade projected anomalies inside the pipeline. The unwanted projections inside the pipeline create problems like pig stuck, debris accumulation, decrease in pipeline efficiency etc. To overcome this, the device is conceptualized and it can remove the anomalies without damaging the affected region.

The concept is abrading the projection. The device has a pressure controller, hydraulic motor & a grinding wheel. They are installed within the mandrel of the device.

The removal of the anomaly is done by grinding which is driven by the back pressure. As the projections act as a barrier preventing the device from propelling forward, a back pressure is created. This pressure when reaches above the desired limit activates the pressure controller and thus driving the hydraulic motor. This rotary motion activates the grinding wheel and thus abrades the anomaly.

By implementation of this device factors like time, money, manpower, risk etc. can be reduced to a very low percentage. This thesis shows the conceptualized design of the device and its working in a simple way.

ACKNOWLEDGMENT

In the beginning I praise the Almighty for His blessings without which no task is possible to reach to completion. My sincere gratitude to Mr. Santhosh Kumar Kurre who has been the mentor in this project and without his guidance, expertise and determination; this project could never have taken shape.

My sincere gratitude to my faculties, Mr. A K Aarya & Mr. Ramesh M who have given me immense support and advice on various issues faced by me during the completion of the project report.

Lastly I pay my humble gratitude to my parents, who are the backbone and pillars of support. With their constant motivation and encouragement I haven’t been able to successfully complete my degree.

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TABLE OF CONTENTS

LIST OF FIGURES

NOMENCLATURE

PIG	- Pipeline Inspection Gauge
IPAAD	- Internal Pipeline Anomaly Abrading Device
ILI	- In-Line Inspection
EGP	- Electronic Gauging Pig
CT	- Caliper Tool
DP	- Dynamic Positioning
Rpm	- Rotations per Minute

1. INTRODUCTION

A process which is the act of propelling a properly sized spherical or cylindrical device through the interior of a pipeline by manipulating the pressure & flow of the existing media, or by artificially introduced media or by mechanically pulling the device through the pipeline for the specific purpose of cleaning, inspecting, distributing inhibitor throughout the pipeline or as a plug to isolate a section of the pipeline is known as Pigging. [1]

Other than this a new meaning is to be put to pigging i.e. to clear the obstacle in the pipeline and thus increase the pipeline efficiency. The pig stuck due to many reasons like deformity of pipe, excess debris collection in front valve misplacement etc.

This thesis is giving a new idea to the Pigging i.e. giving the pig a rotational motion in front which helps to propel front more efficiently and grind the pipe anomaly.

What we see in standard pigging operations to clean, dewater, fill, and displace product from pipelines, and the pressures, speeds, and problems incurred, have contributed greatly to the development of instrumented pigs.

The development and improvement of all types of pipeline pigs has been a continuing process, and this trend is set to continue. There are now literally hundreds of different types, some with specific or limited use and others which are standard products. Apart from the main functions of sweeping, drying, wiping, cleaning, scraping, inspection, and integrity monitoring, 'semi-intelligent' pigs now perform additional functions such as alerting and initiating actions involving pumps and valves, and making an input in computerized operations, sometimes by through pipe-wall communications.

There is no doubt that the pigging industry will continue to make full use of new technology as it emerges, in order to meet the challenges of tomorrow.

Pigs can broadly classified into

- **Utility Pigs**: which are used to perform functions such as cleaning, separating, or dewatering.
    1. **Cleaning Pigs**: which are used to remove solid or semi-solid deposits or debris from the pipeline.

2. **Sealing Pigs:** which are used to provide a good seal in order to either sweep liquids from the line, or provide an interface between two dissimilar products within the pipeline.
3. **Mandrel pigs**: which have a central body tube, or mandrel, and various components which can be assembled onto the mandrel to configure a pig for a specific duty.
4. **Foam pigs**: which are molded from polyurethane foam with various configurations of solid polyurethane strips and/or abrasive materials permanently bonded to them.
5. **Solid cast pigs**: which are molded in one piece, usually from polyurethane.
6. **Spherical pigs or spheres:** which are of either a solid composition or inflated to their optimum diameter with glycol and/or water.

- **In Line Inspection Tools**: which provide information on the condition of the line, as well as the extent and location of any problems.
- **Gel Pigs**: which are used in conjunction with conventional pigs to optimize pipeline dewatering, cleaning, and drying tasks.
- **Plugs**: isolate a section of the pipeline. [1]

This thesis is a study of a new tool which can maintain the pipeline integrity by grinding of the anomaly inside the pipeline. Here we see the concept of the tool and conceptualized design in AutoCAD 2010. An animation of what the pig exactly does inside the pipeline

2. LITERATURE REVIEW

2.1 INTRODUCTION

The ability to successfully pig a pipeline is central to the maintenance of the line. This allows operations such as pre-commissioning, removal of wax in crude oil lines, inspection and the ability to swab liquid hold-up from gas lines to take place. With the increase in dual and multi-diameter lines, this is even more critical and pigging should be treated no different to any other offshore or pipeline equipment, with a sufficient level of design, analysis and planning performed.

In dewaxing oil lines, there is an increasing move to use pigs rather than expensive chemicals. The risk of plugging the line must then be considered and aspects such as the type of pig, pigging frequency and scenario planning (for example, change in flow velocity during pigging) employed. Multi-diameter lines are also becoming increasingly popular. The secret is recognising when a pigging application is a special and requires more attention than normal. The cost of a shut-down due to a stuck pig can be very large, especially offshore. Therefore, it is increasingly critical that the pigs negotiate the pipeline successfully and perform well.

This paper is an attempt to summarise the main reasons why pigs become stuck, stalled or damaged in the line and to determine what can be done about it in advance to avoid the problem. The following areas are covered: -

1. Pigs that plug a pipeline and cause a blockage;
2. Build-up of wax in front of pigs causing a wax plug;
3. Unintentional bypass leading to a stuck pig with product flowing past it;
4. Jack-knifing of dual module pig;
5. Excessive wear leading to failure of seals and drive;
6. Mechanical damage;
7. Failure due to the environment, material selection;
8. Other failures that do not fall into the categories above.

This is not intended to be a complete or exhaustive list, but an indication of known problems to use as a starting point. The Figures summaries the main points and can be used to review a pigging operation or pig design, in conjunction with this text. [2]

2.1.1. Pigs Plugging a Pipe

An incorrectly designed or selected pig can plug the line by virtue of the components on-board. In some cases, this can damage the pig and lead to failure. Plugging the line is a case in point. In the worst cases, the more pressure applied to try to move the blockage, then the more jammed the pig becomes. The solution may be a costly pig cut-out and line repair.

A classic example of a jammed pig results from omission or loss of guide bars on receiver outlets when receiving spheres. Figure 1 shows the sphere jammed in the offtake, that results - quite literally - in things going pear-shaped. This can also occur in any line where flow is directed out from such a branch. This can also occur with standard pigs. To overcome the problem, bars need to be fitted to the tee, or in the case of a sphere, a sphere tee or flow tee needs to be considered.

Sphere jammed in Offtake

Sphere jams into a branch line due to flow diversion and causes a jam.

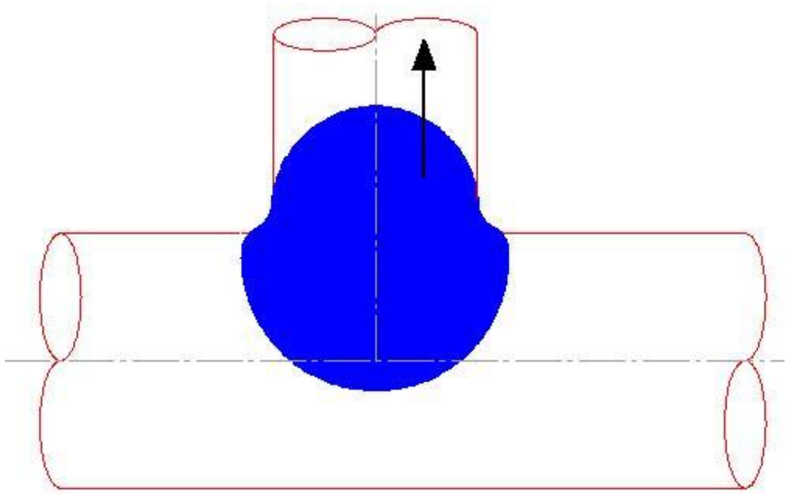


Figure 1 Sphere jammed in Offtake

Require to provide a bar arrangement in receivers or special flow/sphere tees in the pipeline.

This can also occur with standard pigs where there is flow from branch lines. The barring arrangements should be checked. In dual diameter lines, special barring arrangements may be necessary

Bi-directional pigs use guide discs to keep the pig close to the centreline of the pipeline. Guiders really need to be undersized at about 99% of the line Internal Diameter. The guider should be sized in relation to the smallest expected diameter in the line and seals sized to suit accordingly for sealing in all line sizes. If an oversized, hard guider is used, this can cause problems on launching (difficulty in engaging the pig in the reducer) and lead to high differential pressures, or a stuck pig (See Figure 2). It is also important to ensure that the guider and seals do not interfere or lock as this may cause damage to the seals. Generally, all the components on a pig need to be sized correctly with respect to the pipeline.

Incorrect Sized Pig Components

Oversized guiders can cause pigs to misalign and jam in launcher reducer. Pig components should be sized to the actual pipeline with an allowance for wear and other such factors.

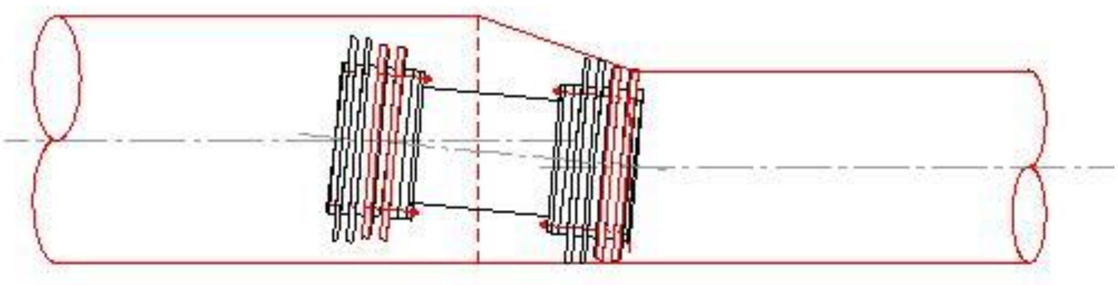


Figure 2 Incorrect Sized Pig Components

Guiders need to be sized correctly to 99% of the smallest line Internal Diameter and then seals sized to suit. Avoid seals locking on guiders as this may lead to rapid wear and seal damage.

Incorrect selection of valves, fixtures and fittings in the line can lead to stuck pigs jamming the line. Incorrect valve selection, such as a gate vale for example can lead to a stuck pig. The valves should ideally be full-bore ball valves (see Figure 3). Allowance should be made for ball valves that are not fully shut. This is especially true in smaller diameter lines where a small intrusion of the valve can lead to a relatively large obstruction, damage to the pig and possible jamming of the line.

Incorrect Valve/Valve not fully open

Use of the incorrect valve in line (valves need to be full bore ball valves or through-conduit gate valves, ideally), or when the valves are not fully opened.

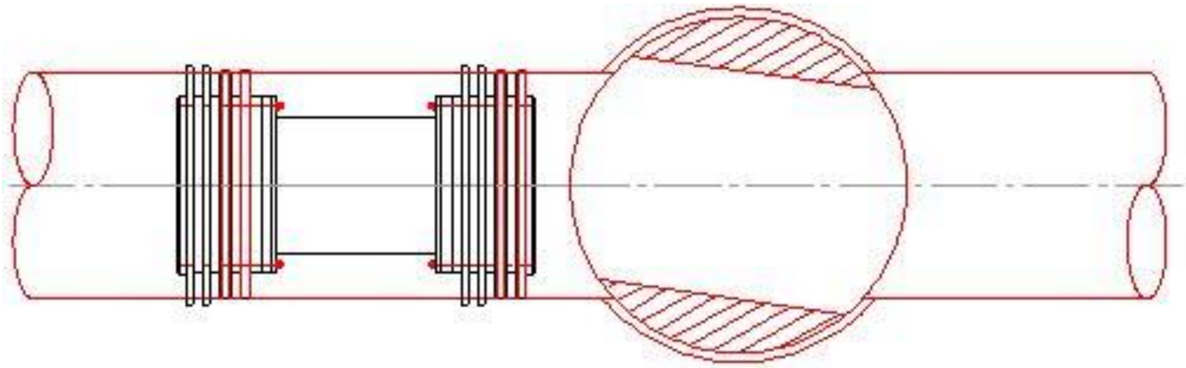


Figure 3 Incorrect Valve/Valve not fully open

This is a problem especially in smaller diameter lines at 12" and smaller and has been known to severely damage the pig.

Checks in the operating procedure should be in place to check the opening of the valves, but the pig design should also consider this eventuality.

The lack of correct information can also be a source of problems. It is common to be informed that all the bends in the pipeline are 5D radius bends, but when the pig is run it is revealed that there were 3D bends in the line! If there is any suspicion of lack of information, then some conservative approach is required. This should be agreed with the client. For example, aim for smaller bend radius, or what every the problem is perceived to be, see Figure 4.

Insufficient Information (Wrong bend radius, for example)

Insufficient information regarding the design of the pipeline can be a problem, especially with older pipelines.

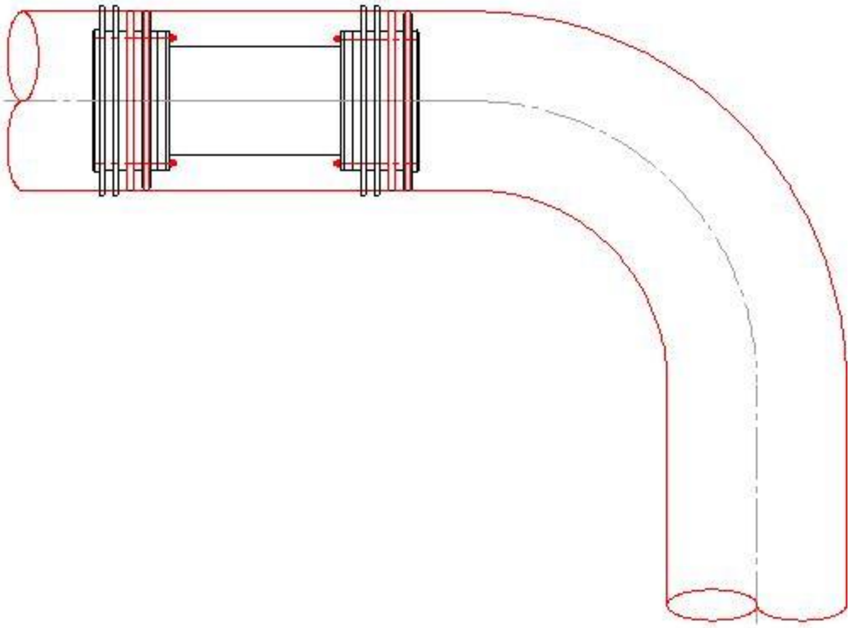


Figure 4 Insufficient Information

For instance, small radius bends can cause problems with longer pigs. The pig must be designed for the line. If such information is unknown, then some conservative assumptions must be made and agreed.

Figure 5 shows another classic situation that can arise when pigs catch up with each other. The rear pig pushes into the back of the pig in front, acts on the seals pushing them harder onto the wall, locking and a plug is formed. In this case, the more force applied to free the pigs then the harder they become lodged in the line, until something gives way. The way to avoid this is to provide suitable bumper noses at design time, front and back of the pig, even if it is not planned to put more than one pig in the line.

Pig pushing on pig in front

When one pig pushes into the rear of another pig, there is a possibility of plugging as it acts on the seals, forcing them harder against the pipe wall and locking: -

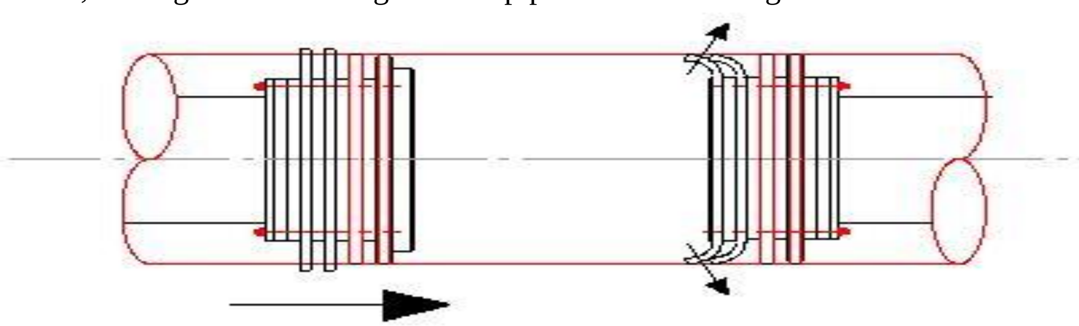


Figure 5 Pig pushing on pig in front

To mitigate against this it is advisable to have bumper noses, both front and rear. This should be provided even if it is only planned to have one pig in the line

The remote possibility of pigs meeting in tees and wyes should be considered in complex lines. Figure 6 shows this occurring when the pig launching sequencing is incorrect. Although this does not often occur, the way around it is to allow one pig to be broken easily by the other. Again, a conservative analysis is required in such a case.

Colliding Pigs

In more complex systems, there is a possibility of pigs meeting at wyes or tees. This can cause a blockage: -

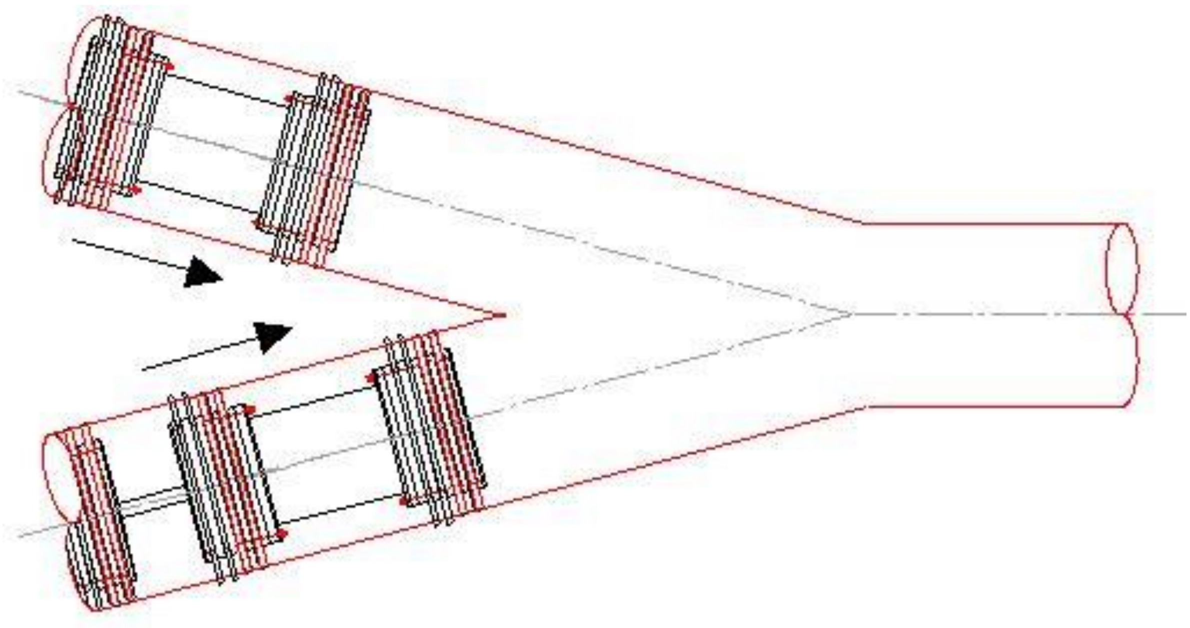


Figure 6 Colliding Pigs

The risk can be reduced by good communications and pigging operating procedures. In addition, one pig may be made sacrificial, i.e. it is broken in two by the main pig, should this occur.

The use of High Friction pigs has become increasingly popular as a means to providing a barrier during repairs in low pressure. Sometimes these pigs are designed to be set at a thinner wall section than where there are launched. This is shown in Figure 7. The result is very high deflections in the seals at the thick walled section, higher differential pressure than planned and subsequent damage to the seals and the pig. In this case, the high friction pig can become a plug (Desirable sometimes perhaps but not in the absence of control!). The result is failure. High Friction pigs need to be designed correctly and tested in a representative facility. [2]

High Friction Pigs

High Friction pigs should be designed to drive in all pipe sections (thick walled included) not just the section where it is planned to set the tool: -

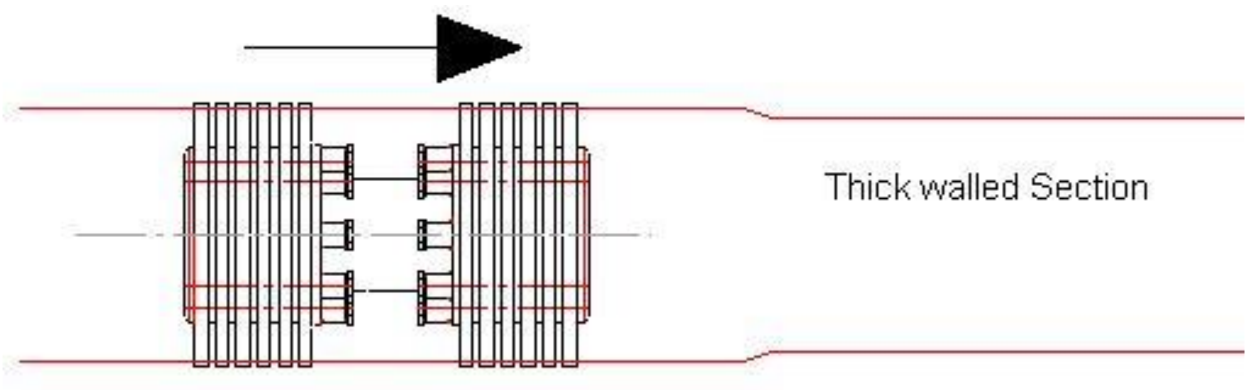


Figure 7 High Friction Pigs

This could lead to serious damage to the pig as seals are torn from boltholes. In general, all pigs should be designed to deal with all the internal diameters of the line and if in doubt, a test performed.

2.1.2. Build-up of wax

An extreme case of plugging a pipeline can arise when dewaxing a line. This is a special case of line plugging which requires attention. Figure 8 shows how the wax plug can arise. Experience suggests that huge pressures can be withstood by the wax plug before yielding (Differential pressures up to 100 bar / 1450 psi have been reported before plugs are either reversed or the line needs to be cut to remove the problem (a costly solution on land never mind subsea!).

The essential model of how the plug occurs is: -

- Pig removes wax from the pipe wall;
- Wax builds up to a critical level;
- Wax immediately in front of the pig hardens as the liquid is squeezed out and the pressure to move the plug increases;
- Eventually, the pig becomes part of the wax movement and it is the wax plug that actually performs the cleaning!
- Finally, the pressure required exceeds what is available or safe, and the line is plugged.

To avoid this possibility, bypass is included through the pig to sweep the wax along ahead of the pig and so avoid the problem in the first place. The rate of bypass must be carefully selected however. If the flow rate is low, then it may be only possible to have a small bypass rate that may not be adequate to carry the wax forward.

Plugging with wax

Wax build up in front of pigs can plug a pipeline. The wax is scraped off the pipe wall, gathers in front of the tool, hardens and eventually plugs the line. The cost of rectifying this situation should it occur is potentially huge, especially offshore: -

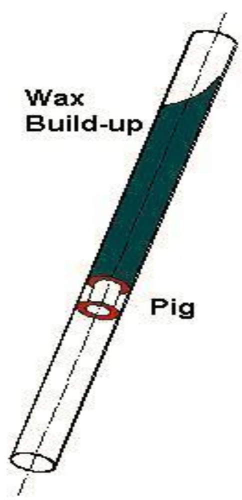


Figure 8 Plugging with wax

This can be avoided by correct selection of pig and the correct bypass rates through the pig to allow the debris to be maintained in suspension downstream of the pig.

Finally, on the subject of debris, other debris types can also jam pigs or cause damage and so again correctly designed bypass is required, see Figure 9. The sand can force the pig upwards and can cause severe wear to the pig. Such dust and debris in the line should be removed by a carefully designed and selected cleaning program. Bypass is one of the best solutions in an overall progressive cleaning program. The correct rate of bypass to overcome the expected volume of debris in the line must be determined. [2]

Debris in the line

Debris such as sand can damage a pig as it can lift the pig up and cause rapid wear to the top of the pig.

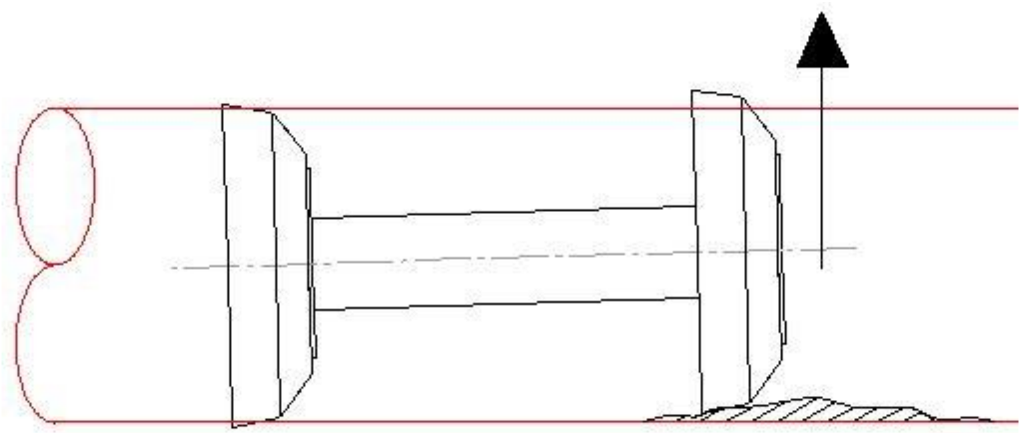


Figure 9 Debris in the line

Again, the most effective way around this is to provide sufficient bypass through the pig. The bypass must be strong enough however, to move the debris along in front of the pig.

2.1.3. Unintentional Bypass

Although bypass is used to aid in the cleaning of lines and removal of unwanted liquid, it is also a source of potential problems. Unintentional bypass is defined as the situation arising when the drive product flows past the pig either due to a breakdown of the seals or because of some line components.

Figure 10 shows a typical example of this. The pig has a bypass system which routes bypass through the pig body and then back again through a jetting head at the front of the pig. At the tee, the low-pressure gas finds a leakage path which results in all the flow being diverted around the front of the pig and so stalling the pig. To avoid this it is necessary to carefully consider the flow conditions and perform the necessary calculations to ensure that the bypass ports are properly sized.

Flow around the Pig

The flow of fluid through or around the pig at pipeline features such as branches and offtakes, wyes etc must be considered.

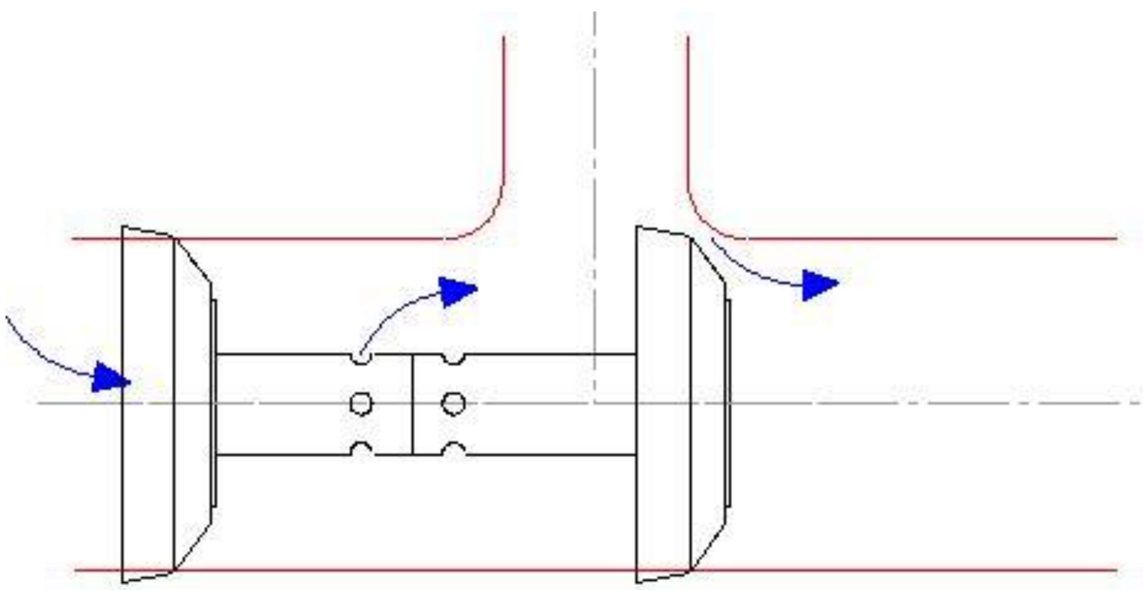


Figure 10 Flow around the Pig

This can lead to a stalled pig if the bypass system is incorrect, too much bypass or too low fluid flow rate. Also, need to consider the position of offtakes

A similar situation is possible with a sphere in a tee or indeed a Y-piece. This is shown in Figure 11. The problem is due to the insufficient seal length of a sphere or any pig that is shorter than the open length of the Y. To overcome this the wye internal diameter should increase slightly, or the wye can be sloped so that the pig rolls and re-engages with the outlet. The problem can also be overcome by careful selection of the internal geometry of the wye, using a profiled internal. This can be used in gas pipelines to "fire" the sphere across the gap. For standard pigs, dual module pigs are frequently employed to span the wye opening length.

Insufficient Sealing Length

At components such as wyes and tees, the sealing length needs to span the branch opening length. If not there is a risk of stalling in this component: -

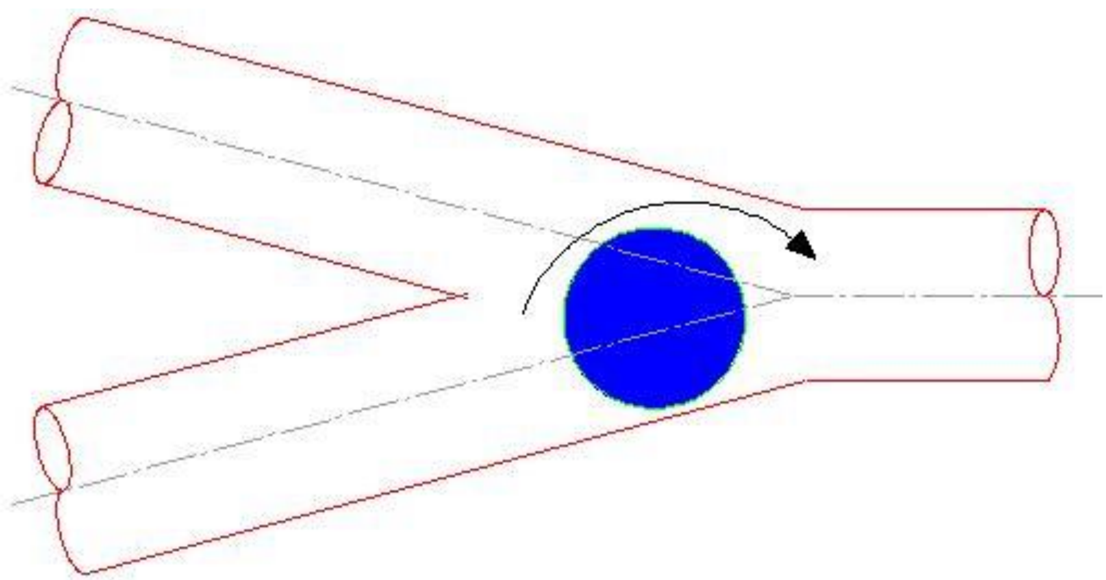


Figure 11 Insufficient Sealing Length

If necessary, a dual module pig should be used to span the component. Spheres can be made to accelerate past the wye (by altering the internal profile of the wye).

Figure 12 shows how a pig can lose drive due to travel nose down. Most pigs travel nose down due to higher friction at the bottom of the pipe compared to the top as a result of pig mass. This is especially relevant in dual diameter pigging where support is difficult. The pig should be designed to maximise the flip pressure of the seals (i.e. the pressure at which the seals blow over as a result of the pressure behind them). The difference between flip pressure and drive pressure is a measure of the safety of driving this pig through the line. This is especially relevant in bends and other line features. Good support systems are available today that can be used to overcome this problem.

Nose down

In dual diameter pigging, in particular, but in all pigs, in general, there is a tendency for pigs to nose down in the large diameter line: -

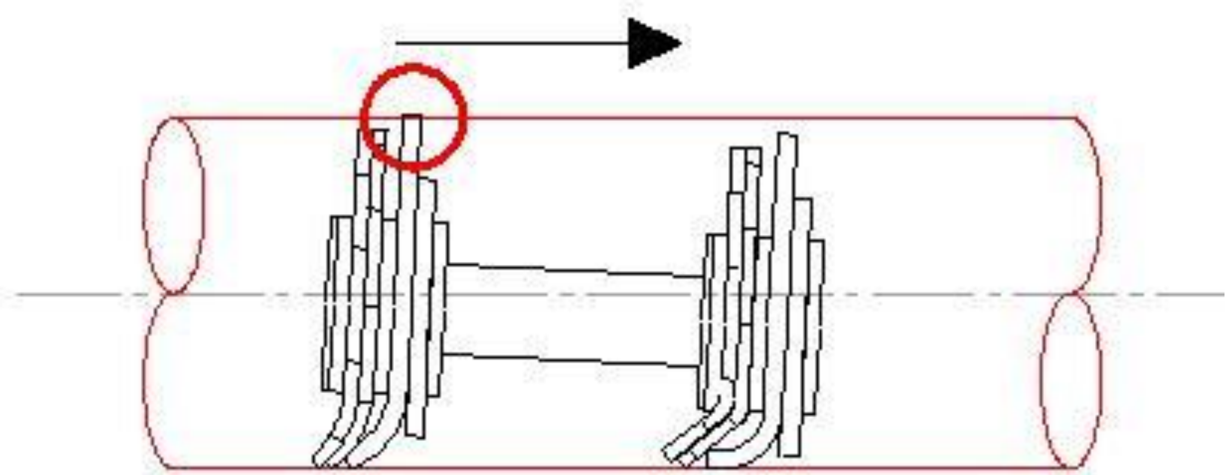


Figure 12 Nose down

This can cause the rear seal to flip (red circle) and product can flow over the off-centre front seal. Modern support techniques should be employed and seals sized appropriately.

Pigs can sometimes fail to reverse when required to do so. Figure 13 shows what can happen when the flow is reversed in the line. There are three possible situations (ignoring the possibility of discs locking on guiders as discussed above): -

1. Pig body moves and the pig seals flip over to allow the pig to move backwards as required;

2. Pig seals do not flip back but the pig judders off in reverse. Although this can be used to reverse the pig, care must be taken as damage to the seals can occur;

3. Finally, there is too much resistance to motion and the flow blows over the seals and bypasses the pig. The pig is therefore stalled.

Reversal

When reversing a pig by reversing the flow in the line, it is important to get the right interaction between the pig seal and the pipe wall: -

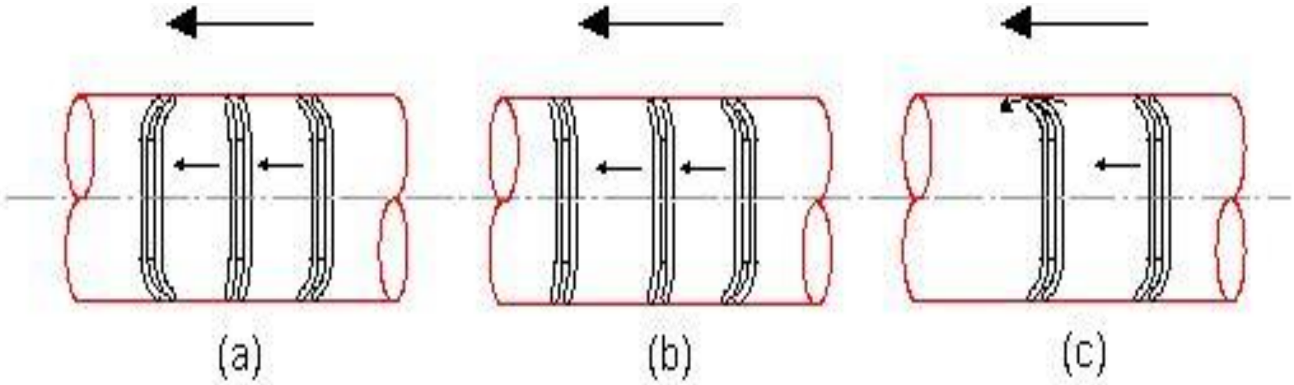


Figure 13 Reversal

In diagram (a), the body of the pig moves first, then the seals reverse and normal drive is resumed. In (b) the seals do not reverse and the pig moves backwards in a juddering motion. Finally, in (c), the seals cannot support the pressure from the front of the pig and collapse, allowing the flow to bypass the pig. The pig stalls. Another aspect to consider in reversing pigs is the interference of pig component such as seals and guide discs.

To overcome this problem, the friction should be minimised and the seals supported such that the pig moves according to situation 2.

Figure 14 shows another important situation that can arise, where a pig stalls due to line components that are in close proximity. In this case, tees are considered but other components such as bends, wyes, valves etc could also cause problems. This is occurring more frequently as space considerations on the topside and on manifolds becomes a premium. To avoid the problem, the location of seals relative to the offtakes must be taken into account and dual module pigs employed if required.

Proximity of components

When line components are too close, there is a risk of bypass as the sealing length is incorrect: -

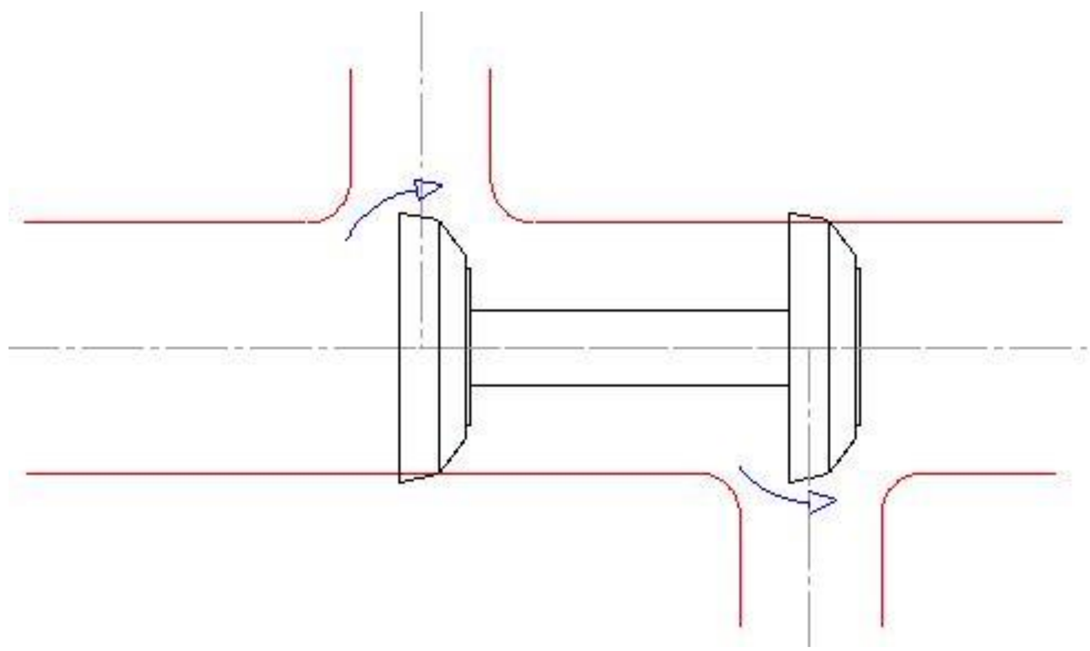


Figure 14 Proximity of components

To avoid this, the configuration of the pig in terms of seal position must be carefully considered. In addition, in the pipeline design, sufficient length between line components should be allowed.

Inappropriate buckling of seals is a problem in dual diameter pigging, but is applicable to normal pigging too. This is shown in Figure 15. The problem can be avoided by correct selection of seal diameter, thickness and flange diameter relative to the pipeline internal diameter. Design methods to achieve this exist that can be used to avoid the problem.

Buckling of Seals

Buckling of sealing discs should be avoided when not required: -

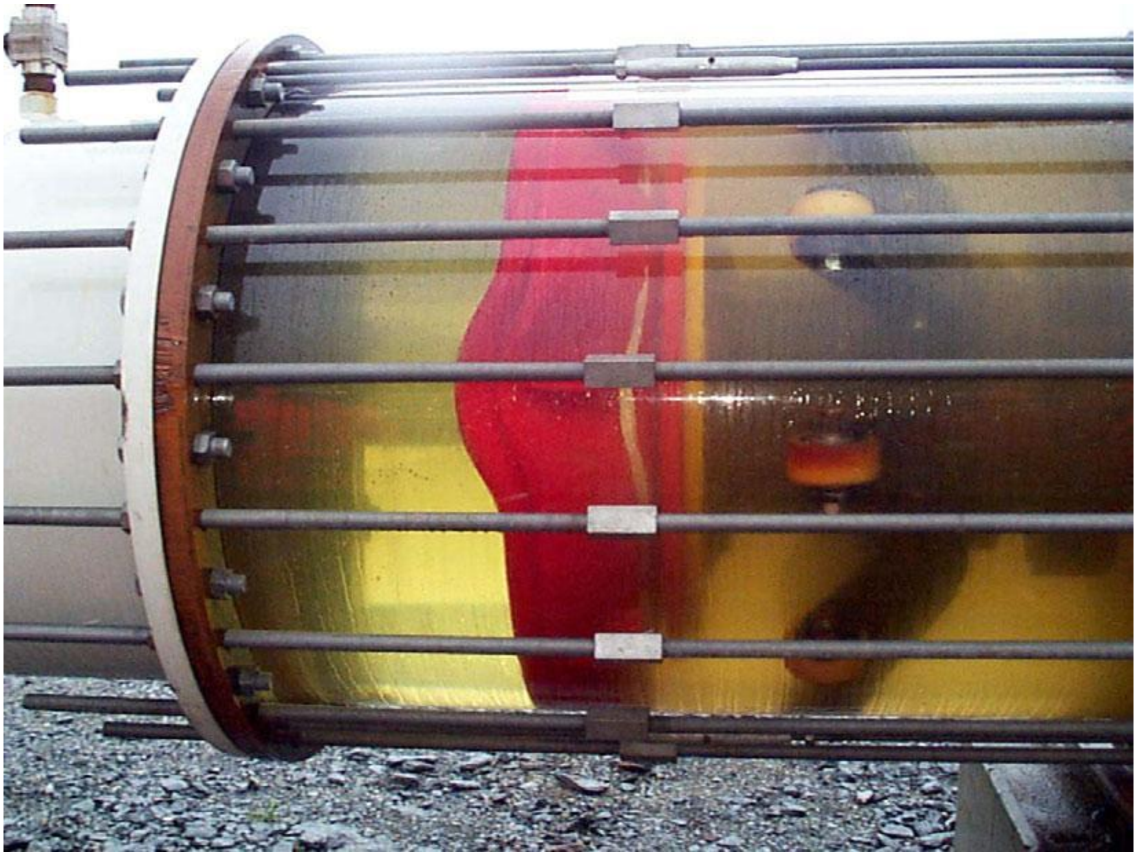


Figure 15 Buckling of Seals

This can now be designed out of the pig by appropriate selection of the seal geometry and flange selection. The problem is particularly important in dual and multidiameter pigging.

Figure 16 shows another potential problem again from dual diameter pigging, but that should also be considered for other applications. The length of a reducer is vital insofar as it affects the location of seals. A Dual diameter pig means just that – it operates in just two diameters (large and small) but not necessarily in the intermediate line sizes. This causes a problem if the reducer is too long and therefore no seal is working effectively. This can cause a conflict between inspection pigging (which requires a long reducer to allow the sensors to work effectively) and conventional pigging (requires a short reducer for the reasons above). The problem is overcome by careful design of the seals and the pig length.

Reducer Length

In dual diameter pigging in particular, the length of the reducer should be carefully considered: -

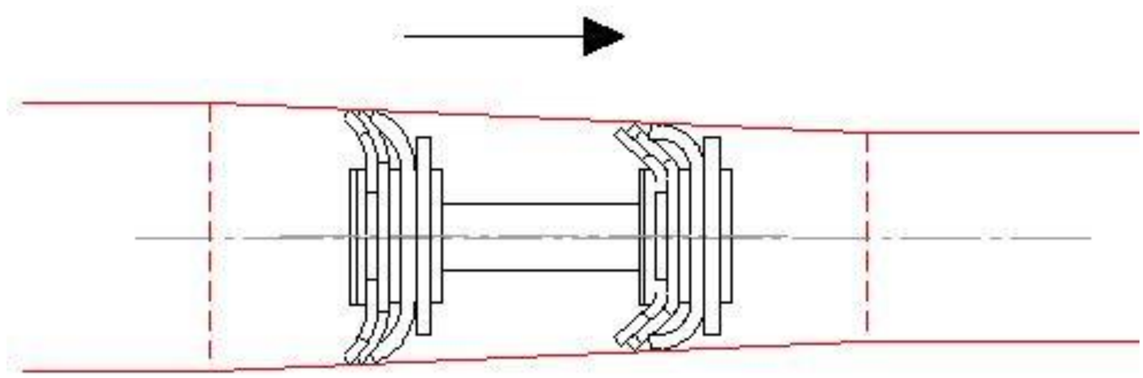


Figure 16 Reducer Length

If not, then there is a risk that no seal is functioning correctly and the pig will stall.

There is a conflict here with inspection pigging where the reducer length should be as long as possible compared with utility pigging where it should be as short as possible.

Figure 17 shows another example where a bypass pig is traveling through a line at normal production flow. Due to a reduction in flowrate, the total flow now passes through the pig and the pig stalls. To rescue the pig, it may be necessary to launch another pig to push it out. The necessary bypass requirements must be met, however. Such possibilities should be considered in the pigging procedure and steps taken to avoid it. [2]

Bypass with reduction in flow

A reduced flow rate means that the full flow of fluid can go through a bypass pig. This can occur when a standard bypass pig is in the pipeline and there is a sudden reduction in fluid flow: -

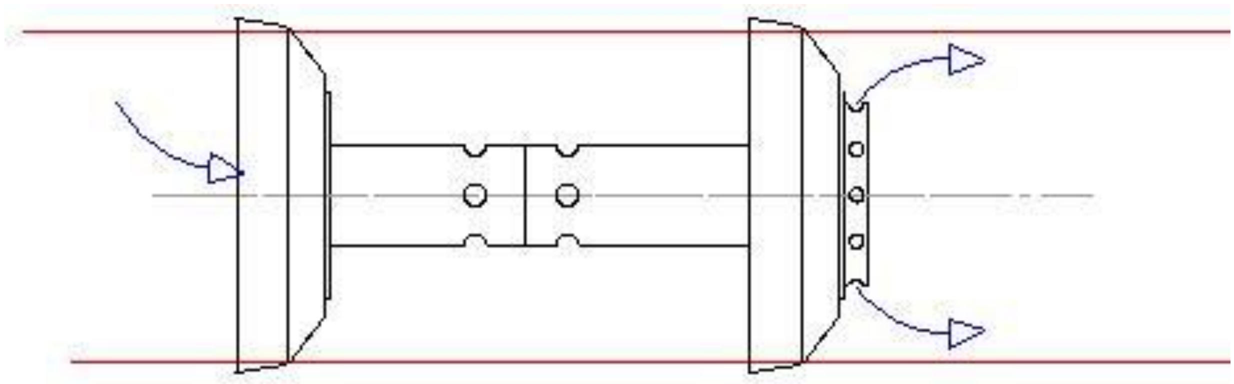


Figure 17 Bypass with reduction in flow

Conversely, an increase in flow rate can mean that there is insufficient percentage bypass through the pig.
For these reasons it is necessary to perform the necessary calculations to allow the correct bypass to be selected.

2.1.4. Jack-knifing

It is often necessary to utilise dual module pigs in order to span wyes while still allowing the pig to negotiate bends. An example is an inspection pig where a number of modules are used for data logging, battery power and housing magnets and sensors. Such pigs consist of a front module, a rear module, and some sort of joint between these modules. These pigs should be driven on the front module to allow it to pull the rear pig along by using open bypass ports on the rear module. Occasionally this is forgotten or circumstances arise that transfer drive onto the rear. This can cause the tool to jack-knife and stall.

Figure 18 shows the effect of driving on the rear module. The pig is pushed laterally by an imbalanced load. The result is that the seals move off the centreline, causing them to flip and the pig stalls. The design should ensure that this cannot happen and drive is always transferred to the front module via suitable pressure bypass ports. Correct controls should be in place to ensure that this is the case before launching.

Driving dual module pig on rear

Dual module pigs driven on the rear tend to move laterally, especially in bends: -

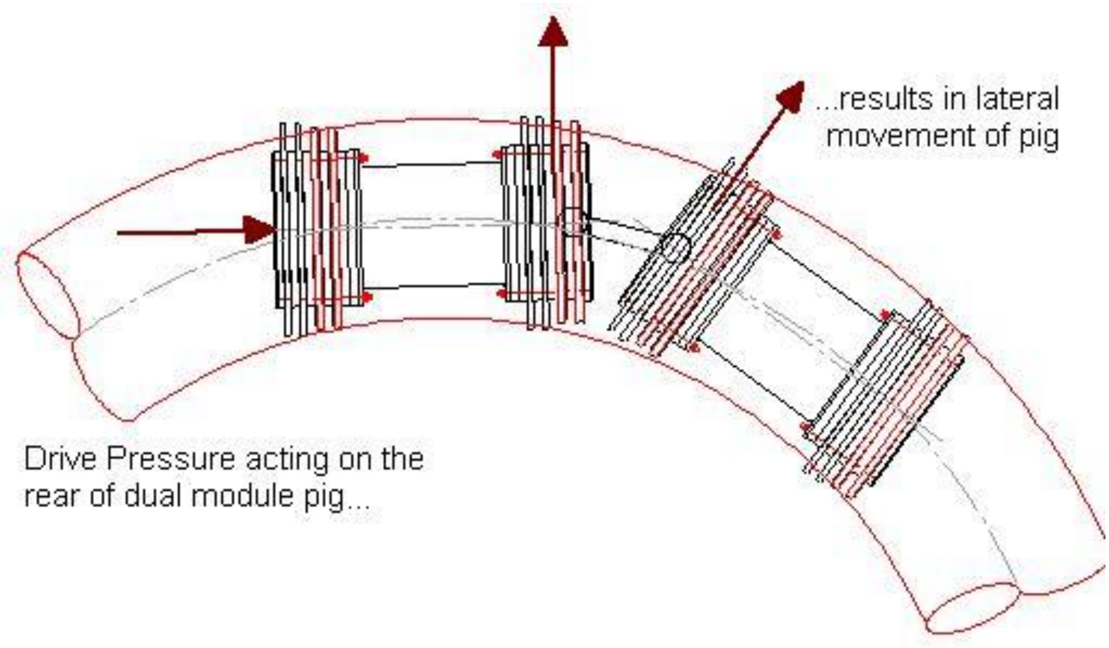


Figure 18 Driving dual module pig on rear

This results in seals flipping and the pig stalls. To avoid this, pressure should be transferred to the front module via bypass ports on the rear. This allows the rear module to be towed and is more stable.

This problem can occur occasionally even with correct bypass to the front module. Figure 19 shows a dual module pig in a bend with low-pressure gas (for example during dewatering). In this instance, gas can find a path around the pig. This in turn sets up a pressure drop across the entire pig that effectively results in the pig being driven from the rear. As a result, the pig is loaded laterally and fails as before. Correct selection of the support system to keep the pig central and correct seal sizing is required to overcome this problem. [2]

2.1.5. Excessive Wear

The pig seals provide a wiping action in the line, but also provide drive, allowing the pig to move forward. If the seals are damaged then it is possible that the pig will stall. One way this can happen is if the seals wear out, then flip forward and allow the product to leak past.

Wear can occur if the system is very abrasive and under a combination of one or more of the following factors: -

- High differential pressure;
- Low Pig Velocity;
- Rough pipeline internal surface;
- Low viscosity fluid;
- Smaller pipeline diameter.

For example, a large diameter line carrying crude oil with a low differential pressure pig can allow pig travel of several thousand kilometers/miles. On the other hand, smaller diameter lines with rough surfaces and drier products can lead to rapid wear and pig failure.

Polyurethane is a highly abrasive resistant material in its own right. Very little can be done to improve on it, but there are ways, and certain additives can be used to improve lubrication etc. There can often be a trade off however, as this can result in lower strength or tear resistance for instance.

Dual Module Pig with leakage

If a low density gas, for example, leaks through a dual module pig, then a differential pressure is set up across the pig and lateral movement can result again: -

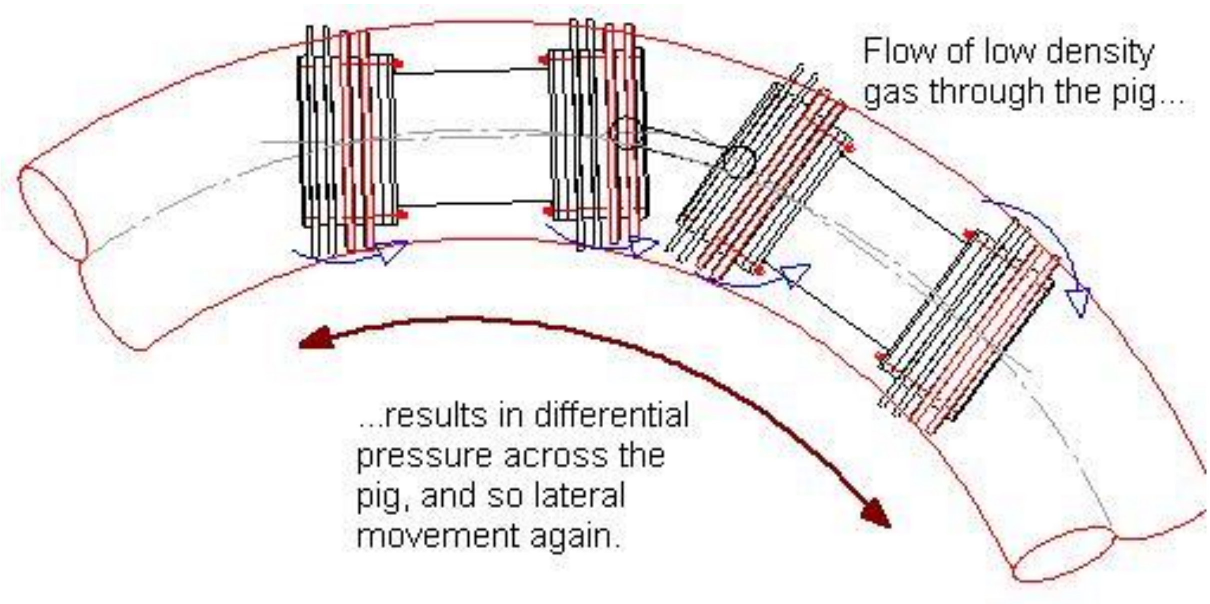


Figure 19 Dual Module Pig with leakage

This can be avoided using better support for the pig and correct sizing of seals

Figure 20 shows a model used to predict how far a pig might be expected to travel in a pipeline under certain conditions. This should be used as a first estimate of piggable distance. If this shows that there is a risk of failure, then methods of wear mitigation need investigating. These include addition of lubricant to the line, reduction in differential pressure, addition of high wear kits or other commonly employed methods. [2]

Wear

Seal wear by abrasion means that there is a maximum piggable distance associated with a given pig and pipeline. Pipeline parameters such as diameter and roughness combine with operational details such as flow velocity, product type to determine the maximum piggable distance.

This can now be estimated given a number of input parameters as shown on the left.

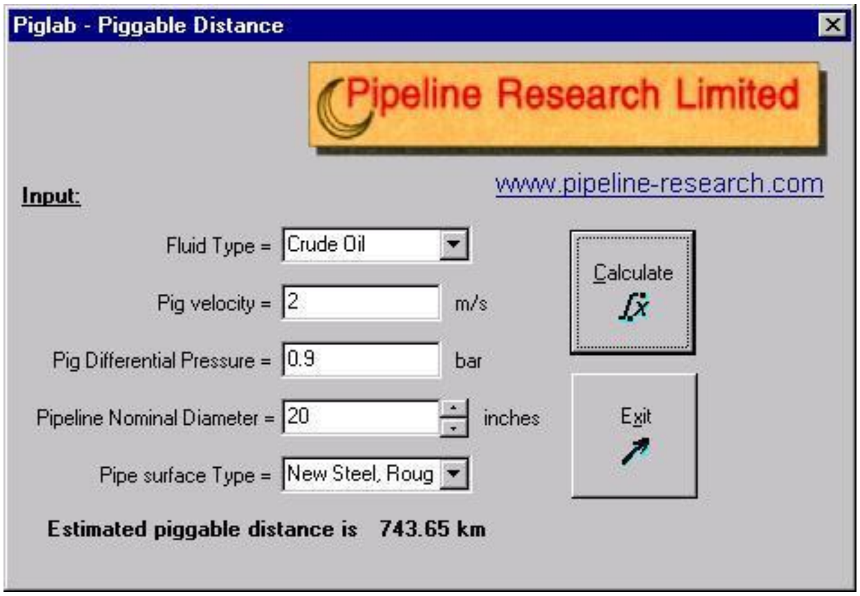


Figure 20 Wear

2.1.6. Mechanical Damage

Mechanical damage, defined as the loss of integrity of structural elements and components on the pig, can lead to loss of drive or usefulness of the pig. This can be because of design problems or unexpected circumstances in the line that leads to damage to the pig.

Velocity Excursions are sudden high accelerations and subsequent high velocities of pipeline pigs usually in lower pressure gas pipelines. This can lead to damage at bends for example (consider at a Z-spool for instance). The problem can be modelled and an example is shown in Figure 21 where a sudden acceleration from thick walled sections during dewatering with Nitrogen results in high loads on the pigs at the bends. Such excursions can lead to the loss of inspection data since these pigs are normally required to operate between 1 and 4m/s.

Velocity Excursions

In gas pipelines, a pig can be subjected to large accelerations and velocities due to the compressibility of the system. This can lead to damage of the pig if accelerated into a bend for example: -

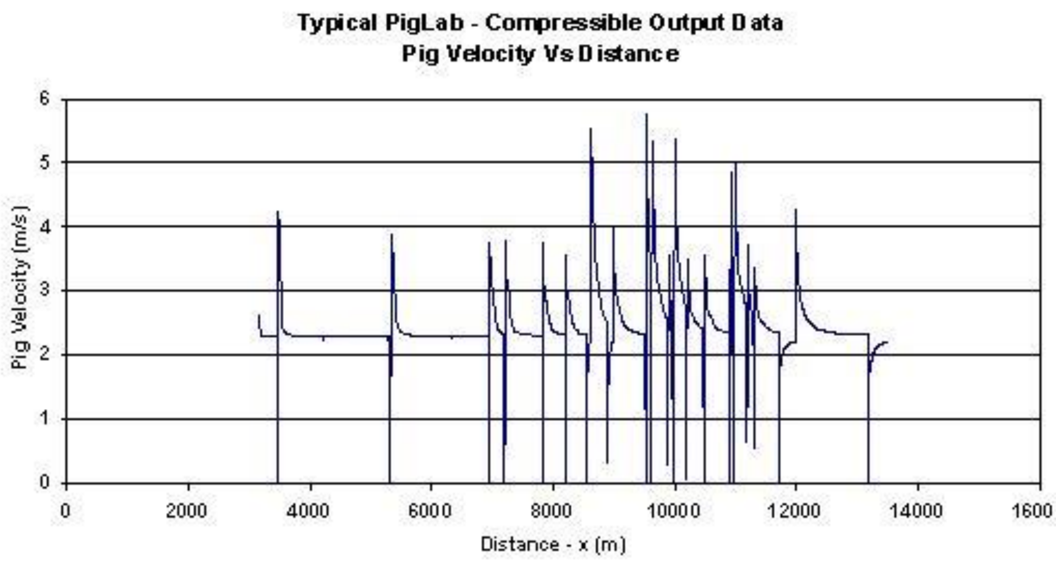


Figure 21 Velocity Excursions

The graph shows pig velocity against distance in a low-pressure pipeline with many changes in internal diameter / wall thickness. The resulting increase or decrease in friction causes the pig to slow or accelerate.

Figure 22 discusses another type of damage to couplings between pig modules due to snatch loads or high compressive/tensile loadings. The type of joint needs careful consideration and strength calculations performed to determine the worst load cases. Stress calculations must be performed to make sure that the joint can withstand such loads. Another possibility is to design out the problem. For example, allowing the joint to swivel can alleviate torsional stress in the component.

Coupling Damage

The coupling between the modules of a dual module pig must be strong enough to take the compressive or tensile, lateral or torsional loads it is subjected to: -

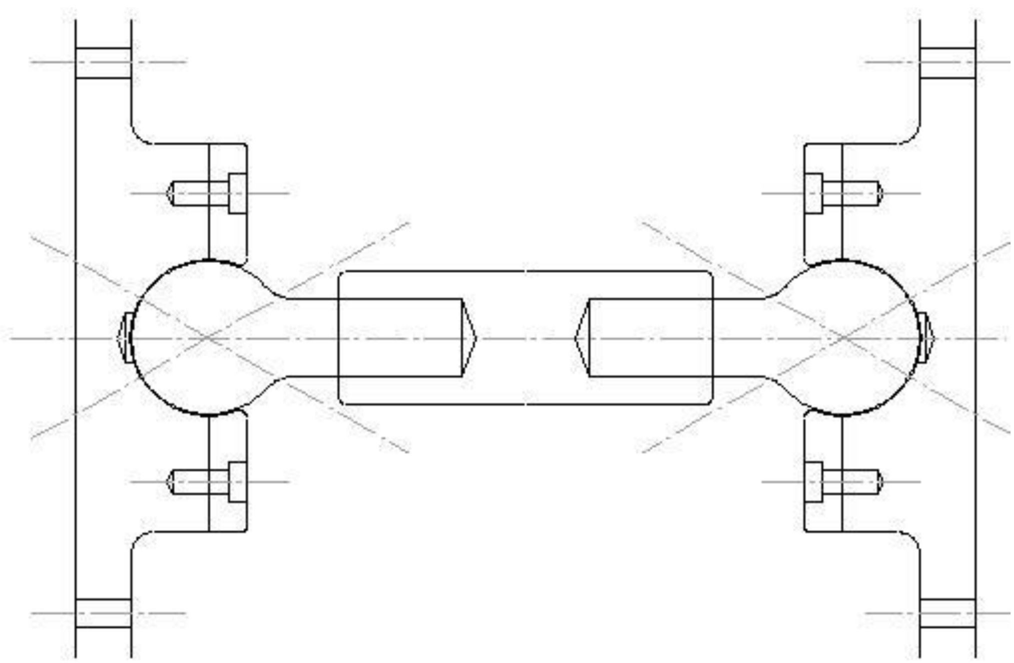


Figure 22 Coupling Damage

The joint must be capable of opening to the correct angle to allow the pig to negotiate the line features.

The limitations of the joint should be carefully understood before use. It is prudent to have some backup in the event of coupling failure to keep both modules together. Only commonly employed joints should be used (U-joints, ball and socket types etc), unless there is no choice and then a high level qualification of the joint is essential. It is useful to set up the pigs such that they can be pushed out by another pig in the event of being left in the line, or at least that the two modules will drive along even if the joint breaks.

Figure 23 shows what excessive line pressure (for example in pressure tests or in deep water) can do to a pig with an isolated cavity inside. Line pressure can cause the pig body to collapse. Such cavities should be avoided altogether if possible or if necessary then they should be subject to careful design, regarded as a vessel in their own right, and tested before deployment.

Trapped Cavities

If there is a trapped cavity on-board a pig, this could collapse under high pipeline pressure. This must be avoided especially in high pressure pipelines or during pressure testing if the pig remains in line

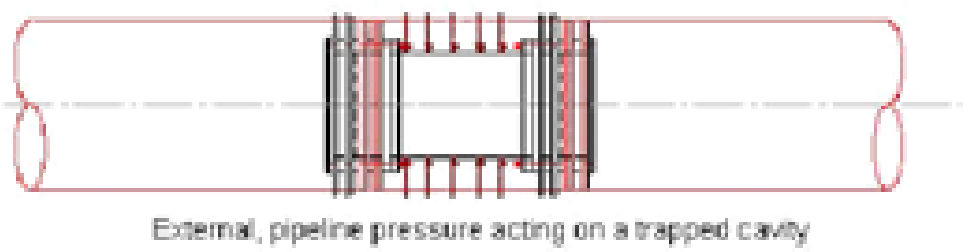


Figure 23 Trapped Cavities

To avoid this all cavities must be pressure balanced. If a cavity is required then it should be designed as an externally pressurised container and subject to qualification.

When seals are oversized too much then there is a risk of tearing the discs out of boltholes. This can rip the discs from the bolt holes and cause failure (See Figure 24). This is generally a seal selection issue and usually occurs with self-acting type seals. The best way to avoid this is to optimise the seal thickness and oversize. Any unnatural seal thicknesses or oversizes should be avoided. The thickness should be somewhere around the nominal linesize of the pipe (20" pipeline with 20mm seal thickness for example). Oversizes greater than 10% are severe.

Tearing seals out of bolt holes

Highly oversized sealing discs are at risk to being pulled out of their boltholes on the pig. This is especially true in dual and multi-diameter pigging: -

Figure 24 Tearing seals out of boltholes

Large diameter pigs have high masses and may freefall down risers. This can lead to damage of the pig and the operation may be affected adversely (for example, during flooding of the line, gas may ingress into the test water during such an event). High velocities can also lead to burning of the polyurethane seals. Two-phase flow can result in damage to the pig in down hill sections, as pigs are accelerated in gas into a liquid column, see Figure 25. [2]

Pigs in Free Fall

Large diameter pigs are heavy and they can free fall in steep sections such as risers: -
This can lead to high velocities and damage to the pig. During flooding of the line for hydrotest, this can also result in gas ingress into the test water

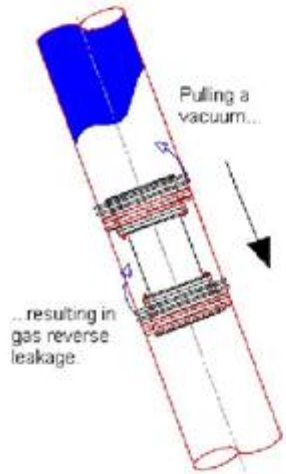


Figure 25 Pigs in Free Fall

There are various methods for slowing the pig down and avoiding this scenario.

2.1.7. Environment

The typical temperature range for standard polyurethane is about 80 degrees C, but this depends on the immersion time. This can be increased by selecting more specialised urethanes of which there are a number on the market. High pressure can cause gas ingress into the seal or pig material that may result in explosive decompression.

Chemicals and their effects on polyurethane are well known. For instance, Methanol degrades Polyurethane at elevated temperatures and renders it soft and toffee-like! At low temperatures, it behaves satisfactorarily. It is therefore necessary to understand the operating conditions and the products in the line. [2]

2.1.8. Others

Figure 26 shows a scenario that occurred while testing a 10” x 16” dual diameter pig. Although a pig generally moves under a nose down moment, it is very difficult to believe that this could have occurred. Given the forces involves, polyurethane offers very little support against pressure forces (for example a 1 bar / 14.5psi differential pressure in 10” pipe is half a tonne / 0.55 tons). The lesson is to “Expect the Unexpected”, but also to appreciate the forces involved and how this can deform the pig.

Unusual Damage to 10” x 16” Pig during testing

As an example of the need to “Expect the Unexpected”, the following photograph shows a 10” x 16” pig stuck in the straight 10” line at a flange and offtake: -

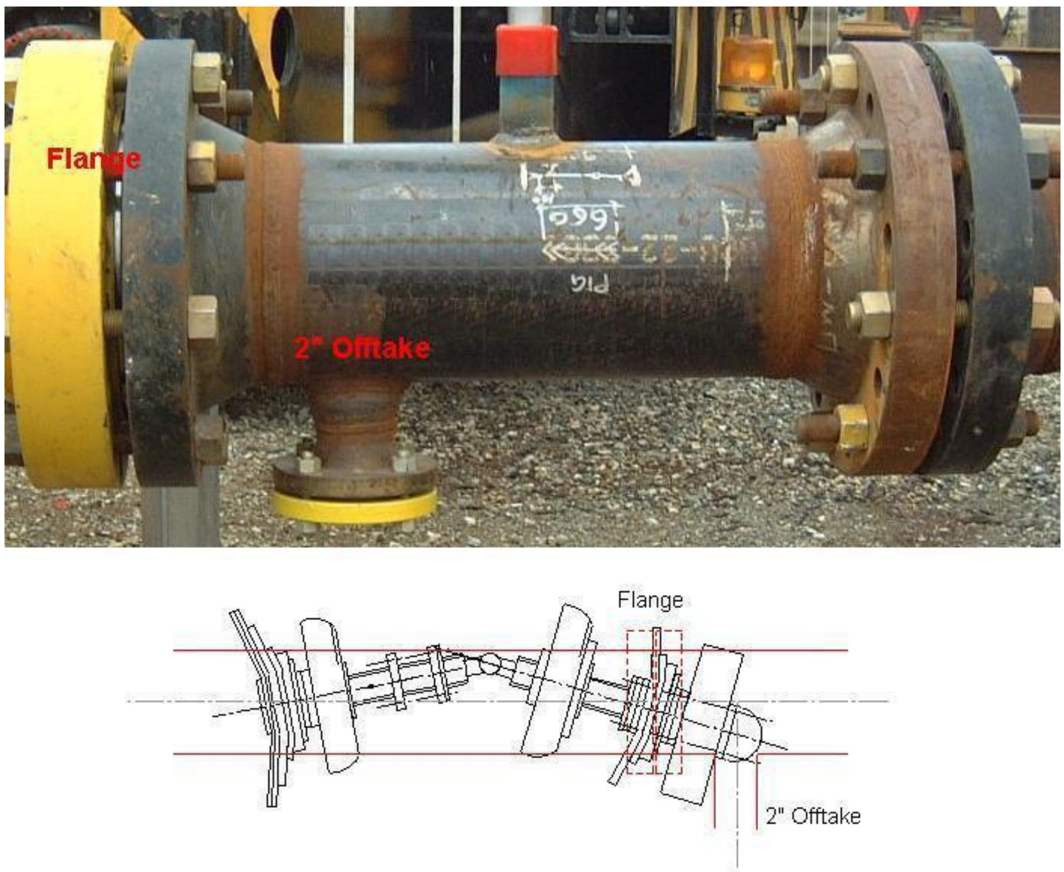


Figure 26 Unusual Damage to 10” x 16” Pig during testing

An imprint of the 2” offtake was observed on the pig nose!

Thorough design and checking of each line feature along with an appreciation of (a) how flexible polyurethane can be and (b) the magnitude of the forces involved can aid in avoiding these problems. In addition, if the line is perceived as being difficult to pig, then good representative tests can show up any such problems.

As a rule, pig differential pressure or friction should be minimised. High differential pressures result in large forces acting on the pig. These forces can either damage the pig or act to pull the pig off-centre and lead to leakage or loss of drive.

The last thing to say on this is to try to avoid any unexpected situations by gathering as much information as possible. Missing information or unknown line components can lead to a stuck pig. If the information is not available then a very conservative analysis should be employed.

2.2 Repair Techniques for Damaged Pipe

Composite repair for damaged pipe low temperature pipe

From minor corrosion to high risk damages, REINFORCEKiT® 4D rehabilitates pipes to their original design characteristics.
3X Engineering has selected advanced materials for the tape, the resin and the putty to provide the industry with a solution for the most high risk cases (critical damages, temperature variation, high pressure...). The use of high quality materials is necessary to ensure the long term integrity of the repair.
The original 3X concept is a combination of Kevlar® tape and specific epoxy resin. It provides the required strength according to the standards such as ASME B31G, ISO24.817, ASME PCC-2. Thanks to this international codes, our clients receive the best guarantee for permanent pipe repair. Repair can be designed for lasting at least 20 years. [3]

Composite pipe repair at high temperature

In accordance with the ISO 24817 and ASME PCC-2, this wrapping composite is very efficient and cost effective. Indeed thanks to our REA software, we are able to design with a great precision, all kind of reinforcement needed while guarantying the quality and time duration.
REINFORCEKiT Hightemp enables to sustain pipe leaking due to internal & external corrosion.

The original 3X concept is a combination of Kevlar® tape and specific epoxy resin, which provides the required strength according to the actual standards such as ASME B31G, ISO24.817, ASME PCC-2. This composite technology reinforces your pipes which had lost up to 80% of their original wall thickness. [3]

Liner assembly for pipeline repair and methods of installing same (Patent US20130312860 A1)

A liner assembly for pipeline repair and methods of installing same. The liner assembly generally comprises an outer tubular liner, an inner malleable inflatable bladder positioned longitudinally within said liner, and a generally non-stretchable strap positioned longitudinally within the malleable inflatable bladder. The generally non-stretchable strap restricts longitudinal over-expansion during positioning and inflation of the liner assembly within a pipeline. [4]

2.3 Conclusions

There are many reasons why a pig can become stuck or damaged, but with the correct planning, design, analysis and testing, this can be avoided. The Figurees presented in the back of this paper can be treated as a preliminary checklist of possible problems and by treating each in turn, they can aid in the process. They can also be added to, based on other experiences.

Generally, pig differential pressure should be minimized. High differential pressures result in large forces acting on the pig. These forces can either damage the pig or act to pull the pig off-center and lead to leakage or loss of drive.

Good analysis where required will provide the necessary missing information, but like everything it is only as good as the input. If it is not known then a conservative approach is required. A very good starting point is to accurately list and describe the Functional Requirements for the pig - in terms of both getting the pig from the launcher to the receiver but also in terms of functionality and getting good performance from the pig along the line.

If there is any doubt at all, then testing is necessary. A well-designed test program can be inexpensive if executed correctly and can answer any remaining questions that might arise, subject to the limitations of the test facility. Nevertheless, in conjunction with the design and analysis, this should ensure that the pig negotiates the line. Judicious design can overcome the seemingly conflicting requirements of the pig and allow a balance to be achieved

It is important that all the information is known or documented at the design stage and is agreed between all involved. A generalized scheme to avoid stuck pigs is as follows: -

- Gather the information;
- Clearly define and agree the Functional Requirements;
- Do the design and the necessary calculations;
- Layout the pig in the line components;
- Select the pig;
- Test and revise the design if necessary (iterate);
- Implement.

It should be remembered that all pipelines are different and also an appreciation of what is a special pipeline and what is not is important. Special pipelines, demanding special attention are Dual diameter; slow pigging, thick wall/deep water, heavy DE waxing/low velocity and many more.

3 THEORETICAL DEVELOPMENT
(Patent : 538/DEL/2015)

3.1 BACKGROUND

Efficiency of the pipeline is often maintained by scheduled pigging. But the pig stuck is one of the major problems which restrict this maintenance activity. This happen because of many reasons, were this invention is to clear the pipeline anomaly problems. Pipeline anomalies like projections inside the pipe or burn through of the weld restricts the pig from advancing front. To clear these sorts of anomalies the pipeline has to be subjected to hot tapping or cutting of and replacement of the damaged piece. Doing such maintenance activities are time consuming and costly. This can be replaced by this invention by grinding off the pipe anomaly.

3.2 SUMMARY

The concept of this invention is a device which can abrade the projections inside the pipeline. This is being done by converting the potential energy into a rotary mechanical energy. When the pig stuck due to pipe anomaly a back pressure is created behind the pig. This back pressure is utilized for the grinding purpose. The device specifications keep changing depending on the type of anomaly.

The back pressure above a limit activates the pressure control valve. This valve pops up and allows the liquid to flow. This flows into a hydraulic motor and drives the motor. The rotational energy is transferred through a shaft to the grinder. This grinder which is in contact with the anomaly grinds of and retains the ovality of the pipeline.

3.3 DESCRIPTION

FIG 27 shows an isometric cross sectional view of the invented device. It is very similar to a bi-directional pig (Pipeline Inspection Gauge) with an extra fitting of a grinding wheel in front. The grinding wheel operates with the help of the components which are installed within the mandrel.

The mandrel has a hollow cylindrical space where the whole instruments can be installed. These are aligned well so that the grinding wheel can be concentric to the device and thus it suits the purpose.

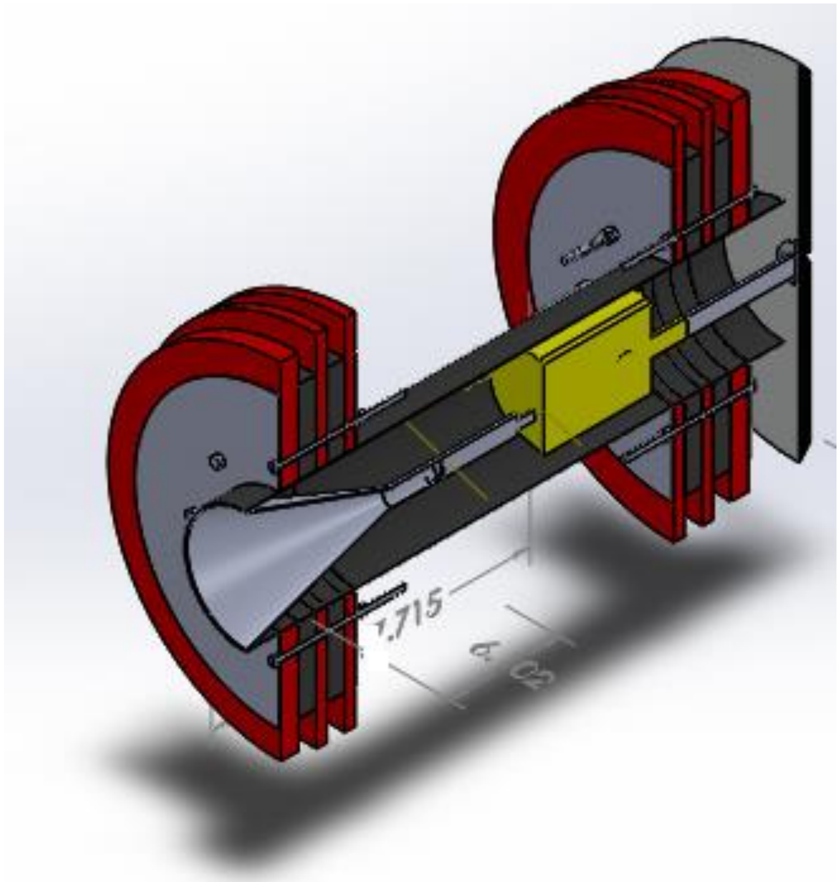


Figure 27 ISOMETRIC VIEW OF TOOL

FIG 28 shows the outer look of the device. It has a Guiding Disc, Sealing Disc, Spacers, Stud bolts and nuts, Mandrel and the Grinding Wheel.

Guiding disc is to increase the area of contact of pressure inside the pipe. So the back pressure acting on the device will be more distributed. It is mostly 95% of the pipe inner diameter. There are 2 sealing discs in device, One in front and one in back.

Sealing Disc seals the inner diameter of the pipeline. Sealing disc is to restrict the liquid from back side of the device to cross the device. It is 102% of the inner diameter of the pipe. Total there are four sealing discs in the device, two in front and two in back.

Spacer discs provide space within the sealing discs and the guiding discs. They can be many according to the requirement.

All the discs are having the same PCD (Pitch Circle Diameter). So they are concentrically arranged and fastened with studs and bolts.

All these discs are being considered as a single part as they are fully fastened to the mandrel. Mandrel is a hollow pipe which is welded by two metal discs, one in front and one in back. The metal disc also has the same PCD and they are well fastened to the polyurethane discs and thus they are joined to the mandrel.

A grinding wheel is protruded out of the body concentric to the device and it is connected to the internal devices. The outer diameter of the grinding wheel varies with the inner diameter of the pipeline.

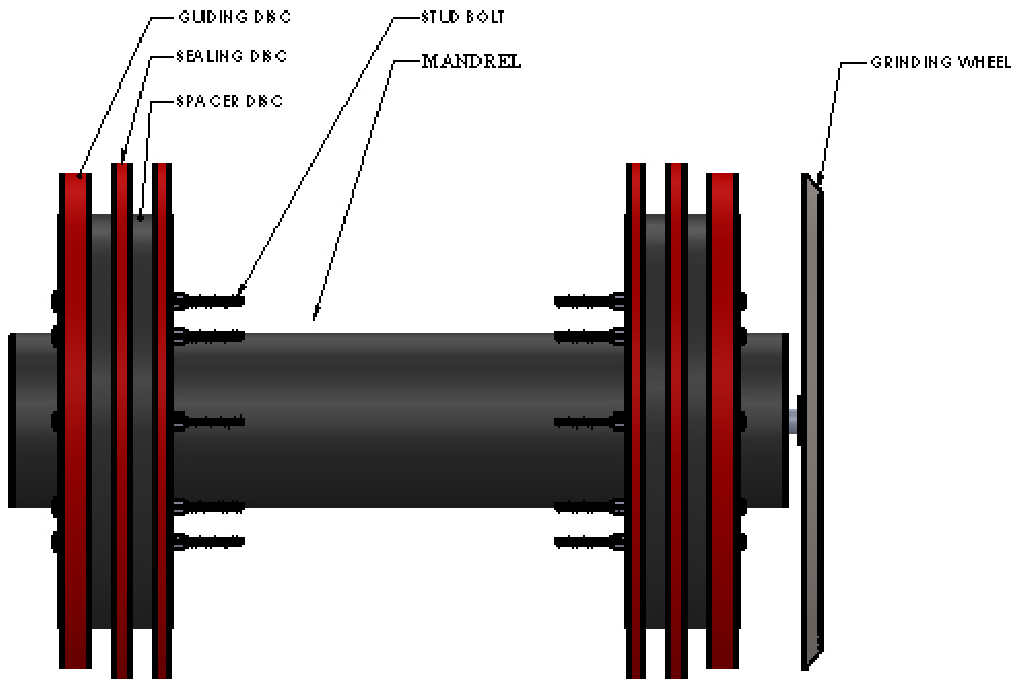


Figure 28 FRONT VIEW OF TOOL

FIG 29 shows the component arrangement in the inner part of the mandrel. It is arranged in such a way that the back pressure created on the device is transferred to the front part and makes the grinding wheel rotate

The components inside the mandrel are Conical Funnel, Pressure Controller, L pipe, Hydraulic motor, shaft & grinding wheel outside.

The conical funnel is to converge the flow into the Pressure controller. The funnel is concentrically welded to the mandrel's inner circle so it doesn't give a chance for water to bypass the device.

The pressure controller is the major part of the device. It varies with the anomaly length and strength. The limit of the Pressure Controller is decided by the resisting capacity of the anomaly. Pressure controller only releases the liquid to pass through if the limit is above the designed pressure. The limit is decided by the initial run of the pigs. The pressure to overcome the stuck would be the releasing pressure of the pig. But the pressure limit to be designed should be less than the releasing pressure. So that the water passes and drives the grinding wheel.

The L pipe is the connecting pipe between the outlet of the pressure controller and the inlet of the hydraulic motor. The L pipe acts as a passage to flow liquid into the inlet of the hydraulic motor.

The hydraulic motor converts the pressure to rotational motion. It intakes the pressure and gives a rotational motion on the grinding wheel

The shaft of the hydraulic motor is connected to a connecting rod. The connecting rod connects the grinding wheel.

The device works by converting the back pressure due to stuck, to a rotational motion that can grind. The removal of the anomaly is done by grinding which is driven by the back pressure. As the projections act as a barrier preventing the device from propelling forward, a back pressure is created. This pressure when reaches above the desired limit activates the pressure controller and thus driving the hydraulic motor. This rotary motion activates the grinding wheel and thus abrades the anomaly.

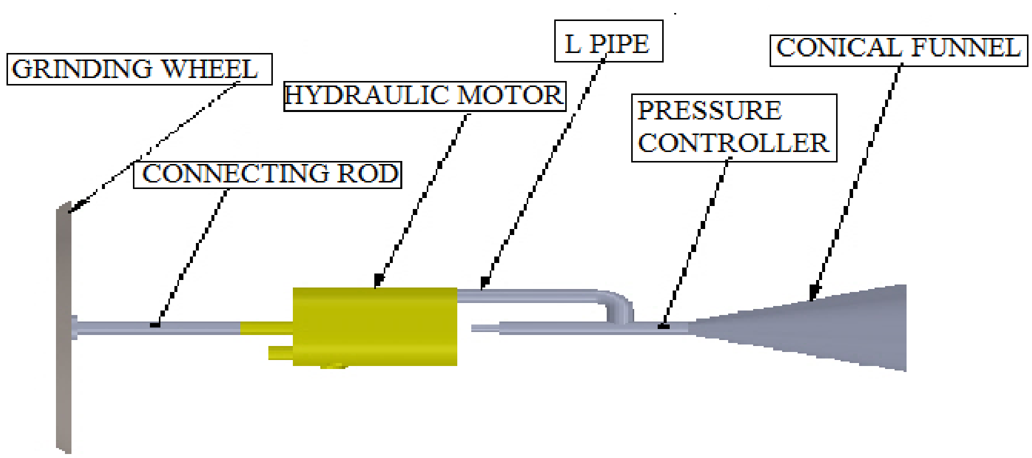


Figure 29 INTERNAL COMPNENTS ARRANGEMENT

3.4 PROCEDURE FOR PIGGING OPERATION

Pigging Operation refers to maintenance practice for pipelines using 'pipeline pigs', for cleaning or inspection of pipeline without stopping operation of the pipeline.
Pipeline pigs are capsule shaped objects which travel through the pipeline, cleaning the inner walls of the pipeline by brushing action.
Pigs get their name from the squealing sound they make while traveling through a pipeline.
Pigging usually means inspection and cleaning of the pipeline.

The pig is inserted into a pig launcher, which is essentially a vessel used to for launching the pig into a pipeline using by creating a pressure differential. [5]

Hazards and risks involved in pigging operation

The following hazards and risks have are typically linked to pigging operations:

- Exposure to high pressure hydrocarbon gas or condensate.
- Physical exertion required to operate manual process valves or handling pig.
- Potential loss of containment of hydrocarbons through leaking flanges or opened valves.
- Risk of igniting released hydrocarbon gas or condensate

Precautions to be taken during pigging operations

- Wear standard Personal Protective Equipment (PPE).
- All personnel should minimize their exposure to the open launcher barrel.
- Never assume that a launcher barrel is depressurized, as pressure can accumulate over time.
- Never attempt to open the barrel unless it is certain that it is at atmospheric pressure.
- Always check that the launcher barrel is completely depressurized before draining to the drain/vent K.O. vessel.
- Use a trolley to assist on the insertion or removal of the pig where possible.
- Follow manual handling requirement to avoid injuries.

For pig launcher

See Figure 30 for references to numbered valves, pressure gauges and pig signals.

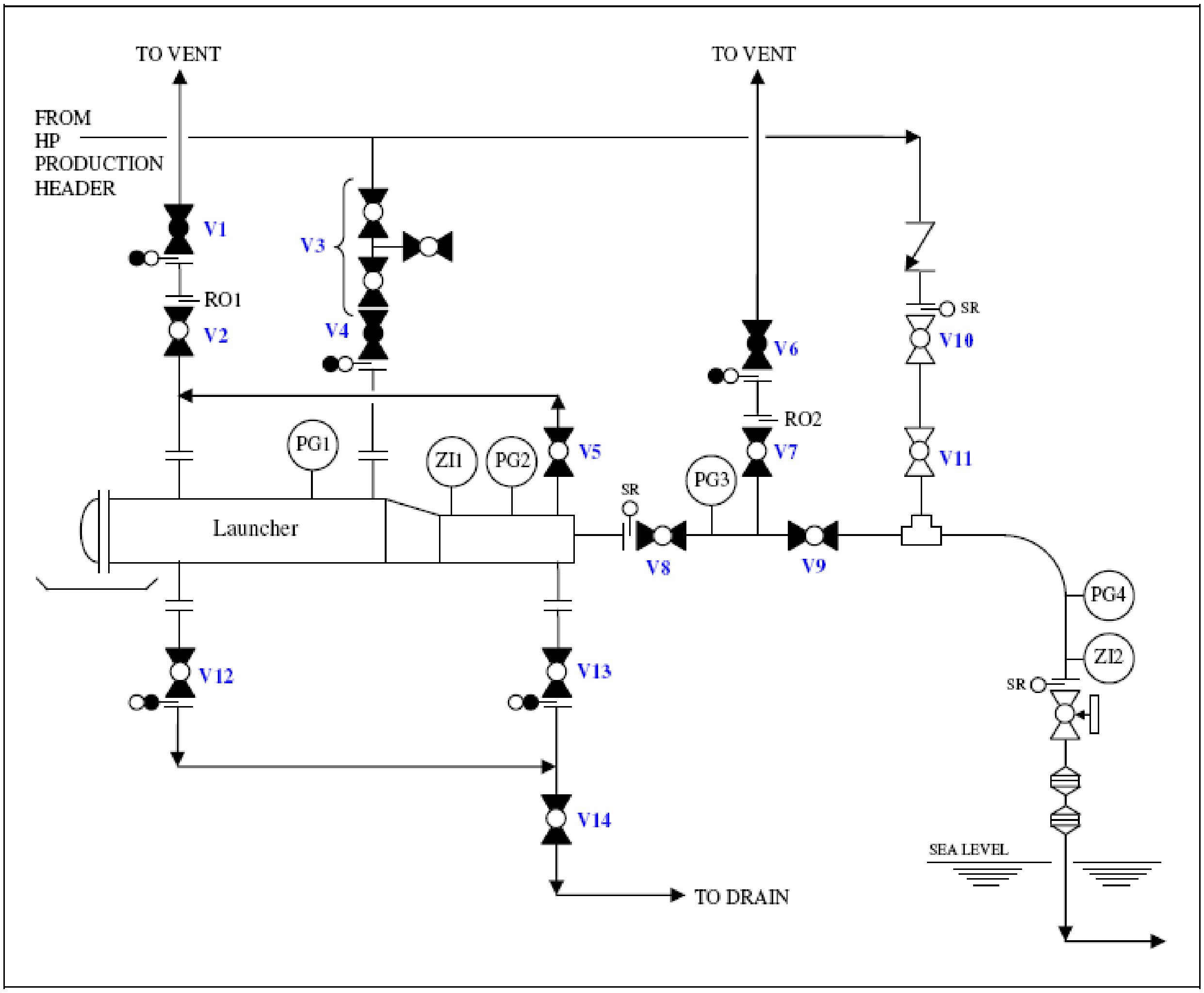


Figure 30 PIG LAUNCHER

Complete the following before attempting to launch a pig:

1. Check that the manual launcher valves V8 and V9 are closed.
2. Check that vent valve V7 and globe valve V6, between the launcher valves V8 and V9, is closed.
3. Check that globe valve V1 and vent valves V2 and V5 on the launcher are closed.
4. Check that integral double block valves V3 and globe valve V4 are closed.
5. Check that drain valves V12, V13 and V14 on the launcher are closed.
6. Check that the electro-magnetic pig signals ZI1 and ZI2 are installed and working correctly with serviceable batteries.

7. Request the personnel at the receiving end of the pipeline to confirm that the pig signals are installed and working correctly with serviceable batteries.
8. Inform the personnel at the other end of the pipeline that a pig is about to be launched. [5]

For pig receiver

See Figure 31 for references to numbered valves, pressure gauges and pig signals. Complete the following to prepare for receiving a pig: [5]

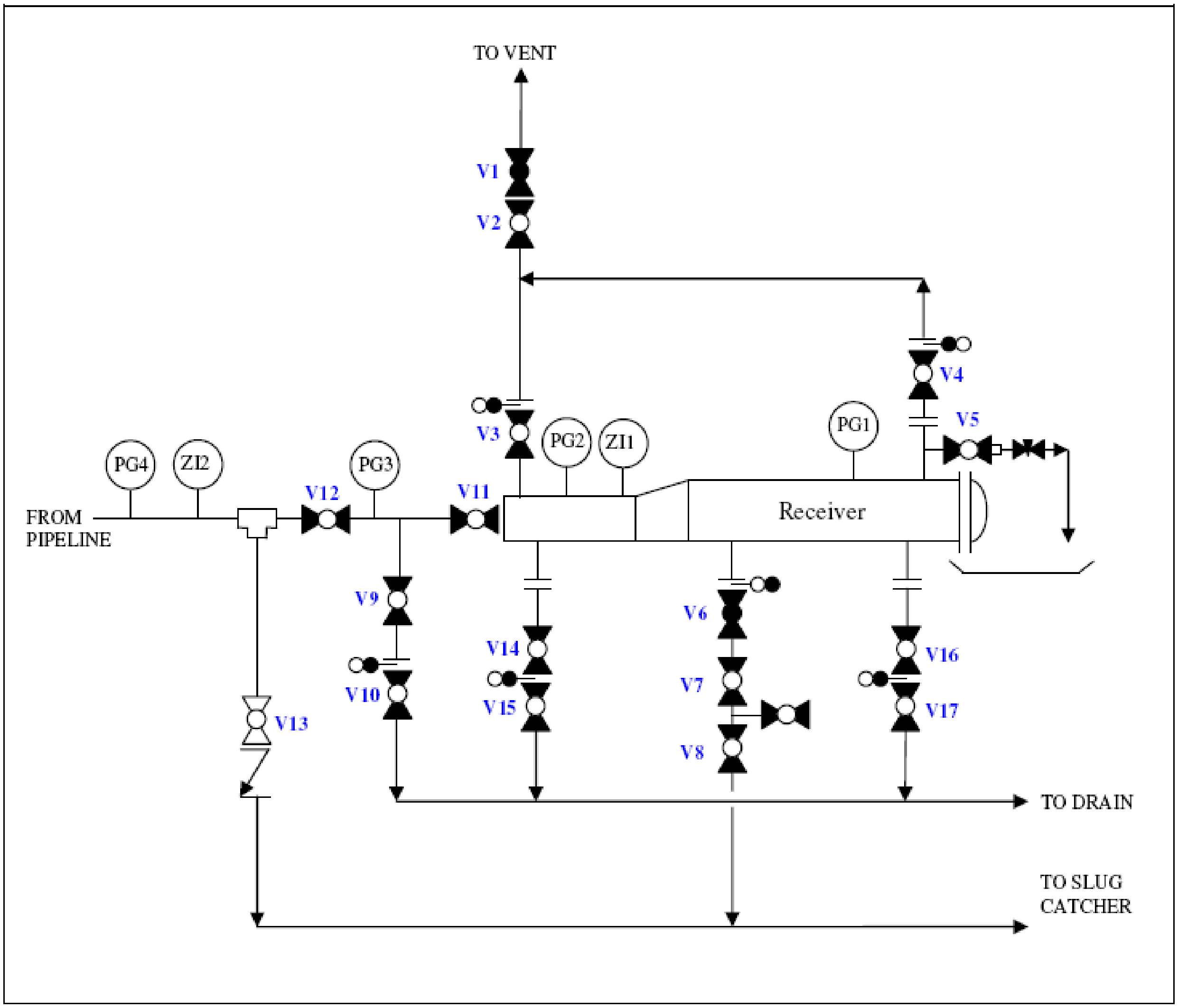


Figure 31 PIG RECEIVER

1. Check that drain valves V14, V15, V16 and V17 on the receiver are closed.
2. Check that vent valves V1, V2, V3, V4 and V5 on the receiver are closed.
3. Check that drain valves V9 and V10 between the receiver valves V11 and V12 are closed.
4. Check that globe valve V6 and double block valves V7 and V8 are closed.
5. Check that valve V13 on the bypass line is opened.
6. Check that the receiver valves V11 and V12 are closed.

Check that the electro-magnetic pig signals ZI1 and ZI2 are installed and working correctly with serviceable batteries.

Typical procedure for pigging

Prior to launching a pig from launcher, complete the following valve line-up procedures at pig receiving end of the pipeline to divert the production through pig receiver barrel via its "kicker line":

1. Open the globe valve V6 and double block valves V7 and V8 in the receiver "kicker line".
2. Open the receiver valves V11 and V12.
3. Close the valve V13 on the bypass line.

Steps to be followed at pig launcher end

Complete the following steps to load and launch a pig from pig launcher. Refer to Figure 1 for all references to numbered valves, pressure gauges and pig signals.

1. Open the globe valve V1 and vent valves V2 and V5 on the launcher. Check that pressure gauges PG1 and PG2 on the launcher barrel are indicating zero pressure.
2. Open the vent valve V7 and globe valve V6, between the launcher valves V8 and V9. Check that pressure gauge PG3 between the launcher valves is also indicating zero pressure.
3. Confirm that the launcher is fully depressurized by opening a small vent valve on the body of the launcher to atmosphere. Check that there is no sound of escaping gas.
4. Open the launcher door.
5. Place the pig into the launcher barrel and push it as far forward as possible.
6. Close the launcher door.
7. Close the globe valve V1 and vent isolation valves V2 and V5 on the launcher.
8. Close the vent valve V7 and globe valve V6.

9. Pressurize the launcher barrel by opening integral double block valves V3 and gradually opening globe valve V4 in the "kicker line". Once the launcher is at the same pressure as the export pipeline, close the valves V3 and V4.
10. Open the launcher valves V8 and V9 at the downstream of the launcher.
11. Open integral double block valves V3 and globe valve V4 in the launcher "kicker line".
12. Close the launcher bypass valves V10 and V11. This will launch the pig into the export line.
13. Check that pig signals ZI1 and ZI2 indicate that the pig has left the launcher barrel.
14. Open the launcher bypass valves V10 and V11.
15. Close integral double block valves V3 and globe valve V4 in the "kicker line" to return all flow to the bypass line.
16. Close the launcher valves V8 and V9.
17. Open valves V2 and V5 and gradually open globe valve V1 to depressurize the launcher.
18. Open vent valve V7 and globe valve V6 to depressurize the pipe spool between valves V8 and V9.
19. Close valves V1, V2, V5, V6 and V7 once the launcher is depressurized.
20. Pig launcher is then isolated once pigging operation is completed.

Steps to be followed at pig receiver end

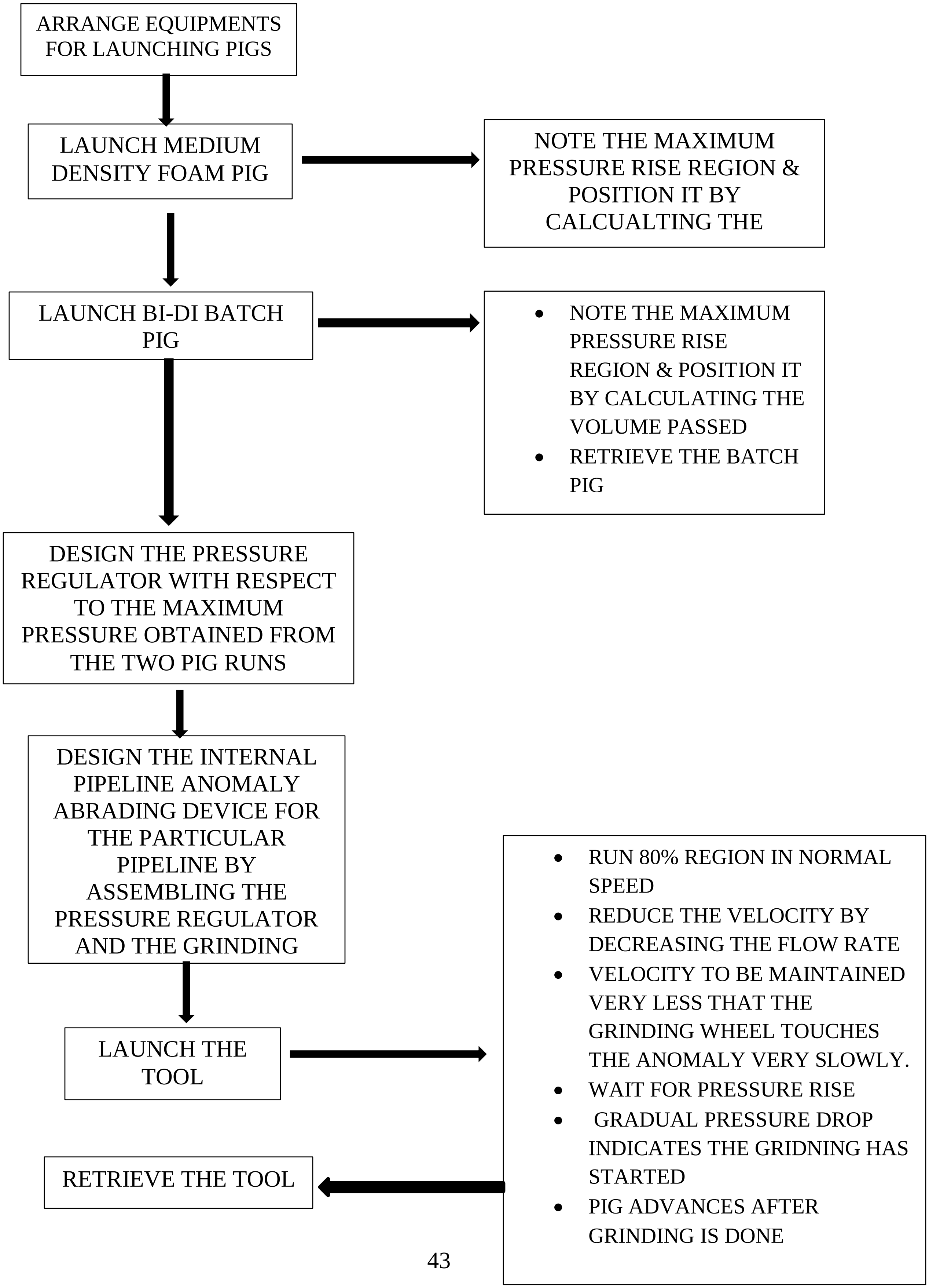
Complete the following steps to receive a pig at pig receiver. Refer to Figure 2 for all references to numbered valves, pressure gauges and pig signals:

1. Once both pig signals ZI1 and ZI2 indicate that the pig has arrived in the receiver, open valve V13.
2. Close globe valve V6 and double block valves V7 and V8 in the receiver "kicker line".
3. Close valve V12 at the upstream of the receiver.
4. Open valves V2, V3 and V4 and gradually open globe valve V1 to depressurize the receiver and the pipe spool between the receiver valves V11 and V12.
5. Close valve V11 at the upstream of the receiver.
6. Once pressure gauges PG1 and PG2 are showing that the receiver is completely depressurized, open drain valves V9, V10, V14, V15, V16 and V17 to drain any liquid from the launcher (and pipe spool between receiver valves) to the drain system.

7. Open valve V5 and the DN15 needle valve on the barrel end vent line to confirm that the receiver is fully depressurized. Check that there is no sound of escaping gas.
8. Open the door on the receiver and retrieve the pig from the barrel.
9. Close and secure the receiver door.
10. Close vent valves V1, V2, V3 and V4.
11. Close drain valves V9, V10, V14, V15, V16 and V17.
12. Pig receiver is then isolated.

The setup of equipment arrangement can be viewed in APPENDIX D

3.5 PROCEDURE FOR LAUNCHING THE DEVICE



4 EXPERIMENTAL OR COMPUTATIONAL

4.1 INTRODUCTION

The project is designed by considering the dimensions of a 20" pipeline with 0.625" thickness. The device is designed for this 20" pipeline considering it has an anomaly in it. The device is also designed with respect to the dimensions of a 20" PIG. The device is the assembly of many components. The main components are:

1. Sealing disc (8 nos)
2. Guiding disc (4 nos)
3. Spacers
4. PIG mandrel
5. Bolts & Nuts (16 nos)
6. Conical Funnel
7. Pressure Regulator
8. L pipe
9. Hydraulic Motor
10. Grinding Wheel
11. Pipe with anomaly

These are the main components which are assembled and aligned. The figures and dimensions are shown in APPENDIX B.

4.2 ANOMALY POSITIONING

The raise in pressure shows the point of stuck. This can be found from the pigging log (refer APPENDIX C). The cumulative volume (V) at that point of stuck is being taken and distance is found.

$$\boldsymbol{V = \pi r^2 L}$$

Here,

V= Volume of liquid passed

r = Radius of the Pipe

L= Distance from the launcher to the anomaly

From the above equation **L**, can be easily calculated and the position of anomaly can be located. Thus the pipeline anomaly can be externally positioned. This helps in finding out the reason for stuck from the pipeline data.

If the stuck is due to some object which can be grinded off, then the device can be set ready for launching.

4.3 GRINDING TIME CALCULATION

This calculation is done by taking some assumptions. The anomaly is assumed as rectangular block protruded within the pipeline.

The volume of the protruded block = **l** x **b** x **h**

Let **Δh** be the thickness of anomaly chopped off in a single rotation of the grinding wheel.

So the chopped off volume would be **lbΔh**

Number of rotations needed for grinding the anomaly completely can be said as

$$N = \frac{lbh}{lb\Delta h}$$

From the hydraulic motor specifications we get the motor rpm '**n**'

Thus the time taken **'T'** for grinding can be calculated from the equation

$$T = \frac{N}{n}$$

4.4 PRESSURE – VOLUME EQUATION

The followings formula can be used to calculate the theoretical volume of water required to raise the pressure in the pipeline: [6]

$$\Delta v / \Delta p = V \times [D / E t \times (1- u^{2}) + 1 / B]$$

Where,

Δv = incremental volume in m3 (Vp)

Δp = incremental pressure in bar

V = pipeline volume in m3

D = pipeline outside diameter in m

t = nominal wall thickness in m

E = Young's elastic modulus of steel = 2.07 x 10 6 bar

u = Poisson's ratio = 0.3 bar

B = Bulk modulus of water in bar

5 RESULTS & DISCUSSION

Internal Pipeline Anomaly Abrading Device is a new device innovated in the Pipeline Maintenance field. It helps in keeping the pipeline integrity well in low cost. This is a very good invention which can drastically decrease the cost and time. Internal Pipeline Anomaly Abrading Device helps in keeping the ovality of the pipeline constant and making the pipeline easily pigable.

Consider a situation of having a PIG stuck in offshore. This creates issues in maintaining the pipeline efficiency. A pipeline has to be easily piggable. This comes as a part of its regular maintenance. If it doesn’t work the pipeline is more exposed to internal corrosion, wax accumulation, pipeline efficiency decreases in short the pipeline life decreases very drastically.

The pipeline thus has to be piggable. So to make this anomaly clear we can use this new device. It can grind of the protruded anomaly and advance forward. Thus it can be made piggable. With the present technique only it can be replaced. For this we have to access the offshore facilities like Barge or DP vessel, Tug vessels, inflating balloons, divers, supporting crew etc.

Thus time and cost and time can be drastically reduced with the implementation of Internal Pipeline Anomaly Abrading Device.

6 CONCLUSION & RECOMMENDATION

The Internal Pipeline Anomaly Abrading Device is a conceptualized design done in Solid Works 2010. This project contains the

1. Design of the Device
2. Animation
3. Patent Application (APPENDIX A)
4. Calculation of time of Abrasion
5. Procedure of launching device
6. Anomaly position detection

The project is fully developed under Solid Works 2010 platform. This new innovation is a contribution to the pipeline maintenance field in maintaining the pipeline integrity. The main advantage of the device is to make the pipeline piggable.

The implementation of this device can reduce the cost drastically, depending on the location of the anomaly. The anomaly can be anywhere beneath earth, onshore, offshore or in golden joints etc. The usage of this device even reduces the cost by mending the same pipe instead of replacing the pipe anomaly part.

Time is also a major factor. The success work of this device changes the time of repair from present repair time to a negligible time of repair. As grinding is a very fast and easy process its takes only minutes to finish the process. It may take 150% extra time of a usual pig runs time.

Thus implementation of this device could be a new contribution to the Pipeline Maintenance field which can save money and time very much. The device is also having a simple working principle which can be easily implemented. The project has to be again carried out in its working by simulation and implementation. The component specifications and its relations has to be identified and thus the implementation design engineering to be developed.

APPENDIX A

PATENT OFFICE
INTELLECTUAL PROPERTY OFFICE BUILDING
Plot No. 32 Sector 14, Dwarka, New Delhi-110078
Tel no. (091)(11)25300200 Fax no. 28034301,02
E-mail: delhi-patent@nic.in
Website: www.ipindia.gov.in

सत्यमेव जयते
GOVERNMENT OF INDIA

INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

Date/Time : 25/02/2015

Docket NO : 6195

Agent Number:

To
ABEN SABU KURIAKOSE
PIPELINE ENGINEERING, IV SEMESTER, UPES, BIDHOLI, PREM NAGAR, DEHRADUN-248001.

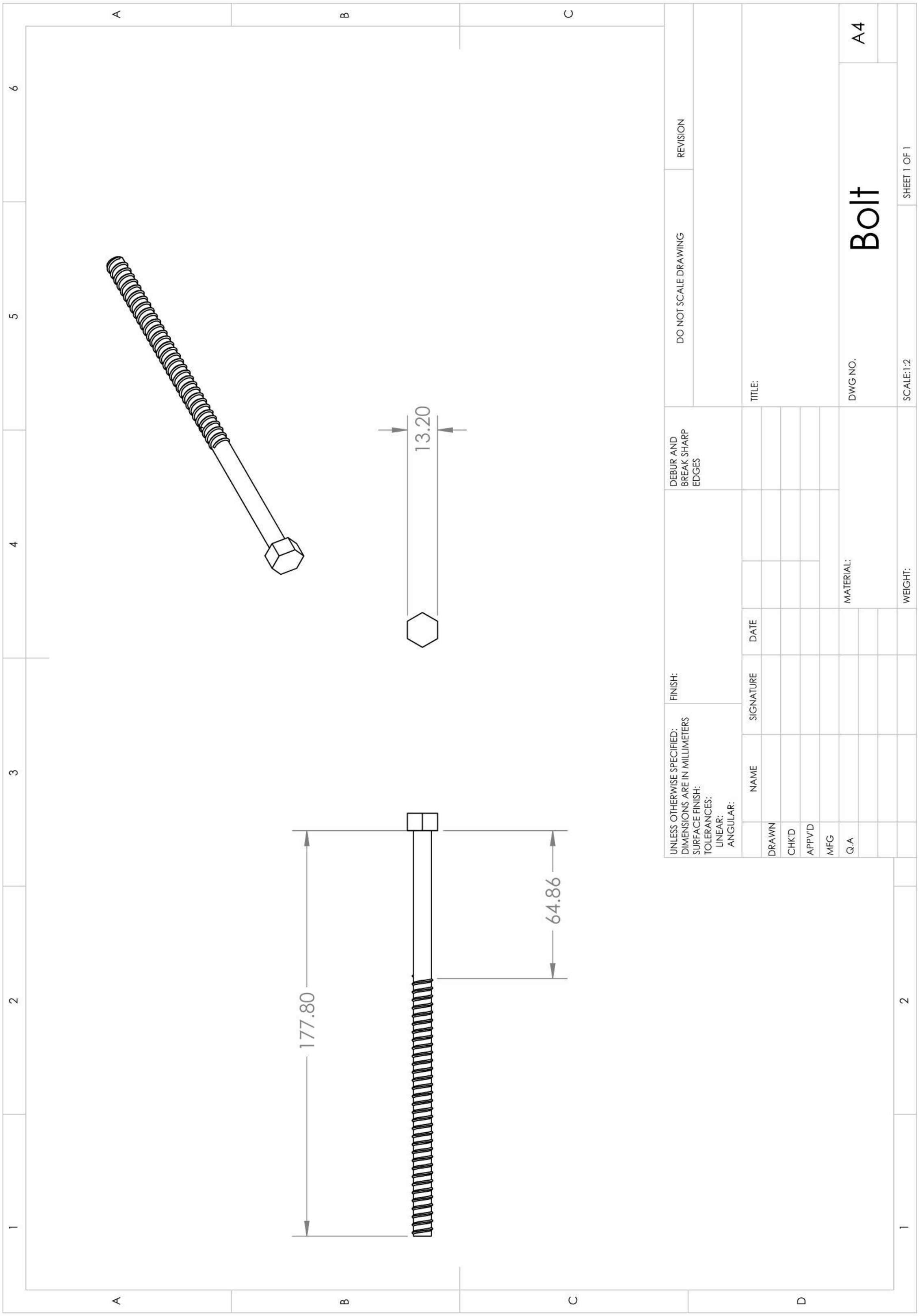
Sr. No.	CBR Number	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid	Amount Computed
1	4181	ORDINARY APPLICATION Pages:-7 , Claims:-8	538/DEL/2015	INTERNAL PIPELINE ANOMALY ABRADING DEVICE	1760	1760
2		E-2/377/2015-DEL	538/DEL/2015	Form2	0	0
Total Amount					**1760**	**1760**

Received a sum of Rs. 1760 (Rupees One Thousand Seven Hundred & Sixty only) as under

Payment Mode	Bank Name	Cheque/Draft Number	Cheque/Draft Date	Amount in Rs
Cash	---	---	---	1760

Note: This is electronically generated receipt hence no signature required.

APPENDIX B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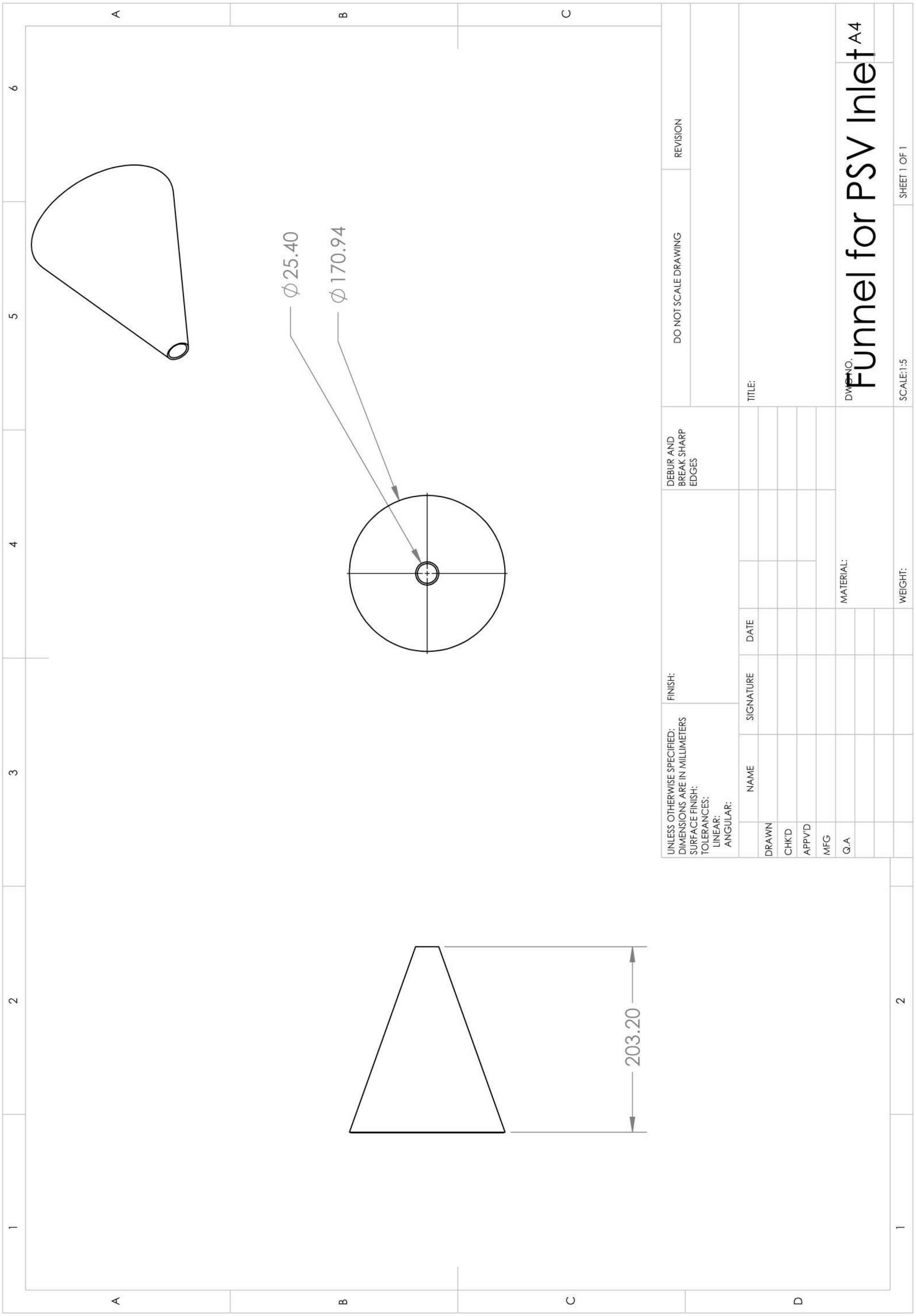
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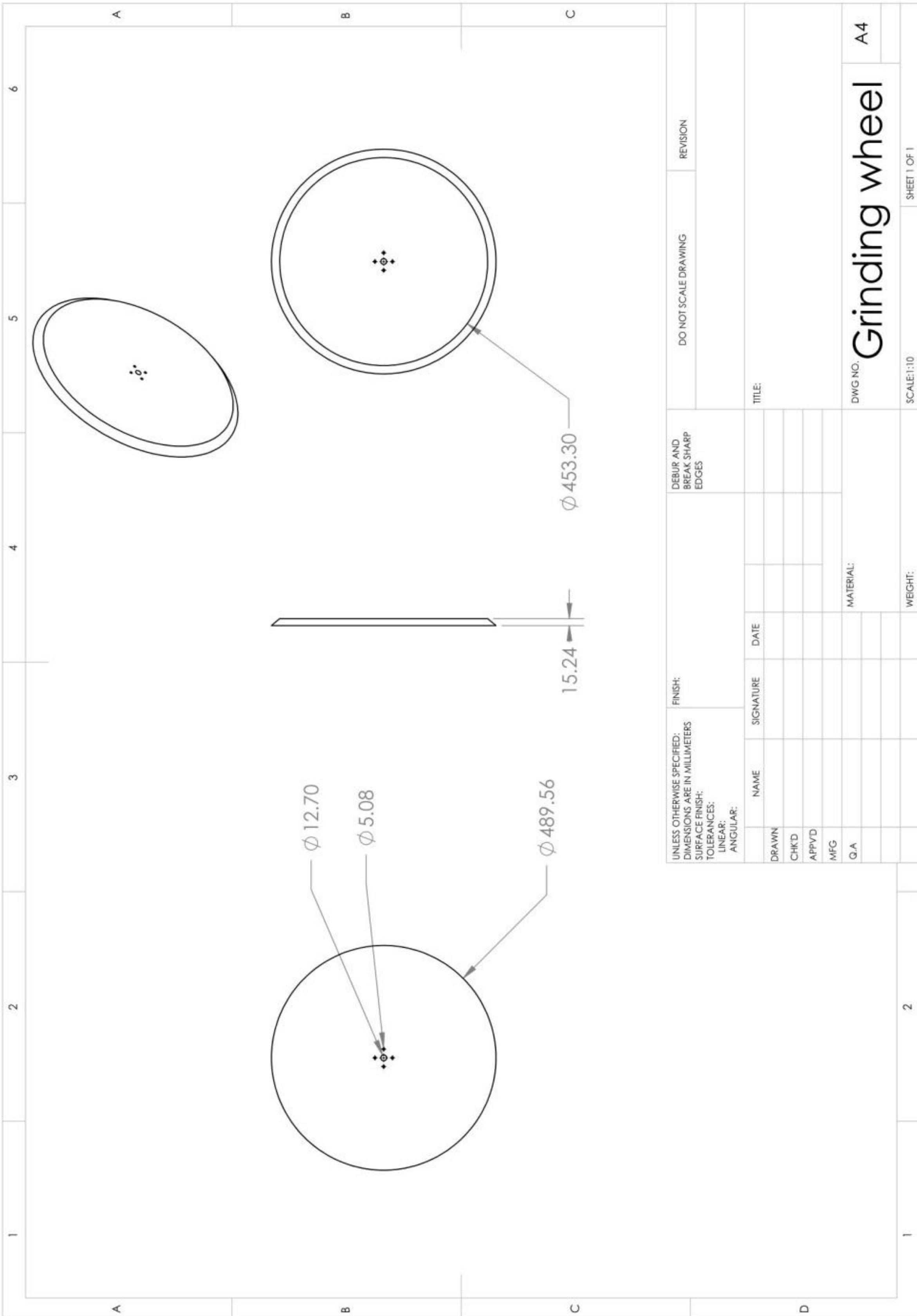
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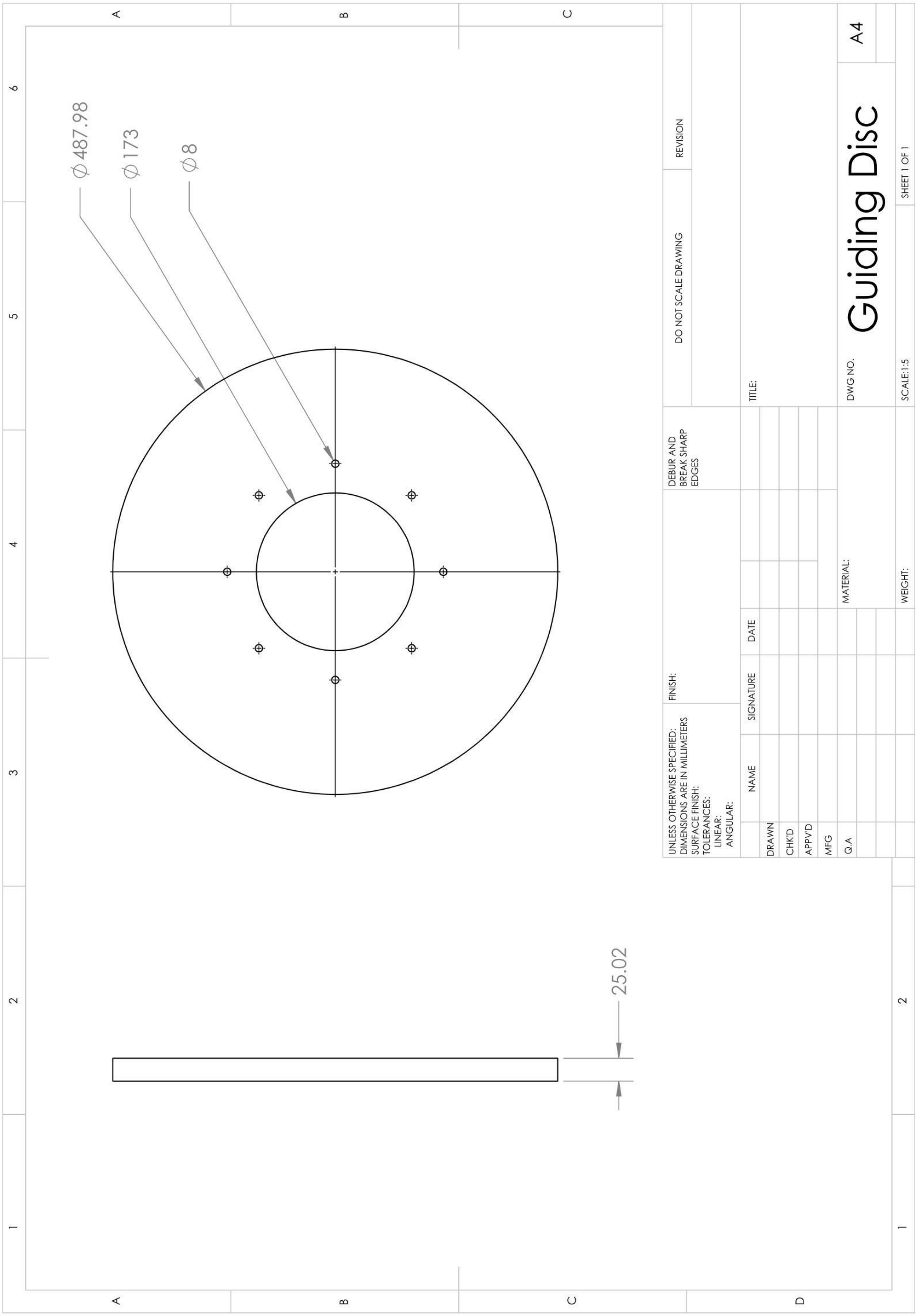
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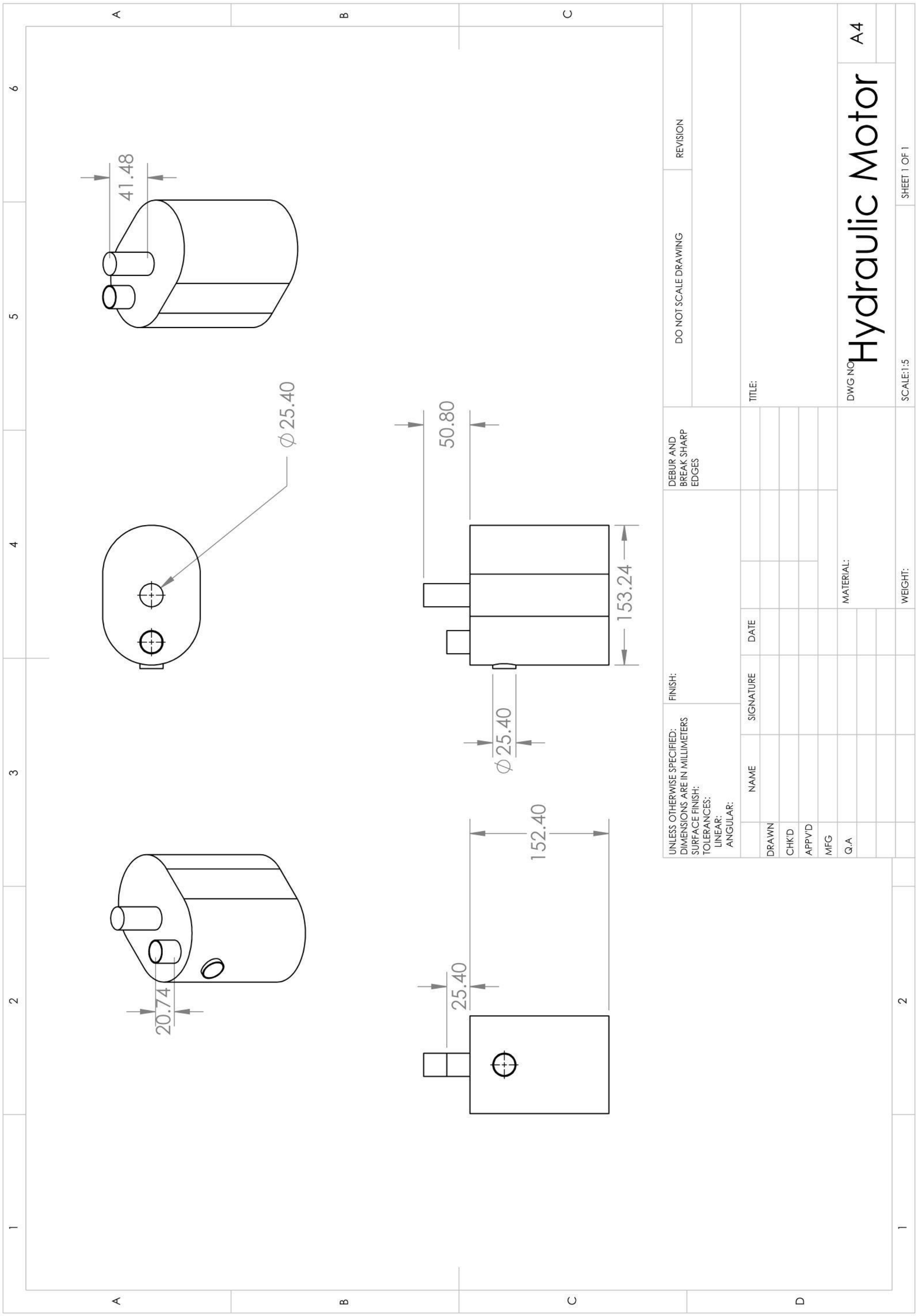
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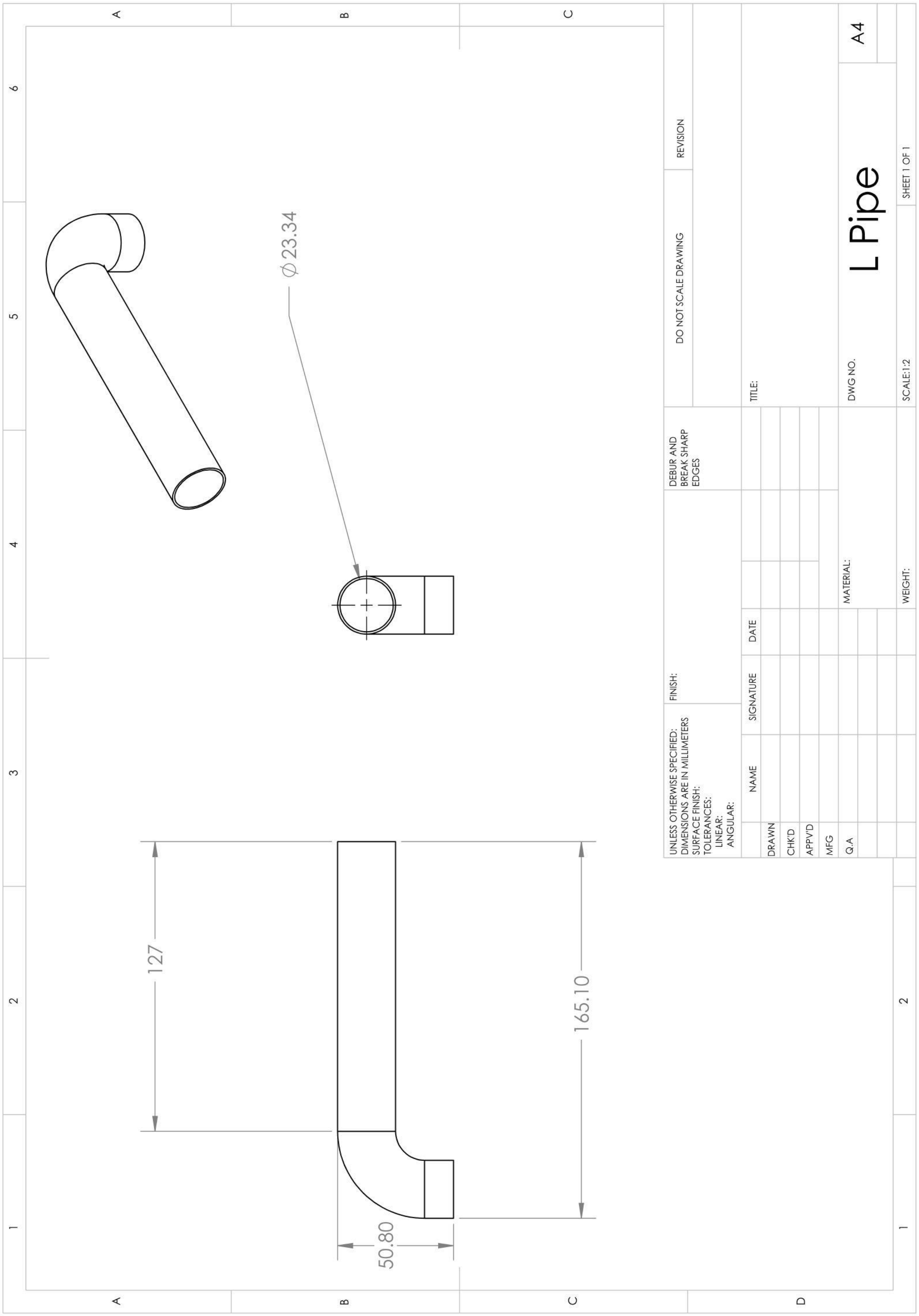
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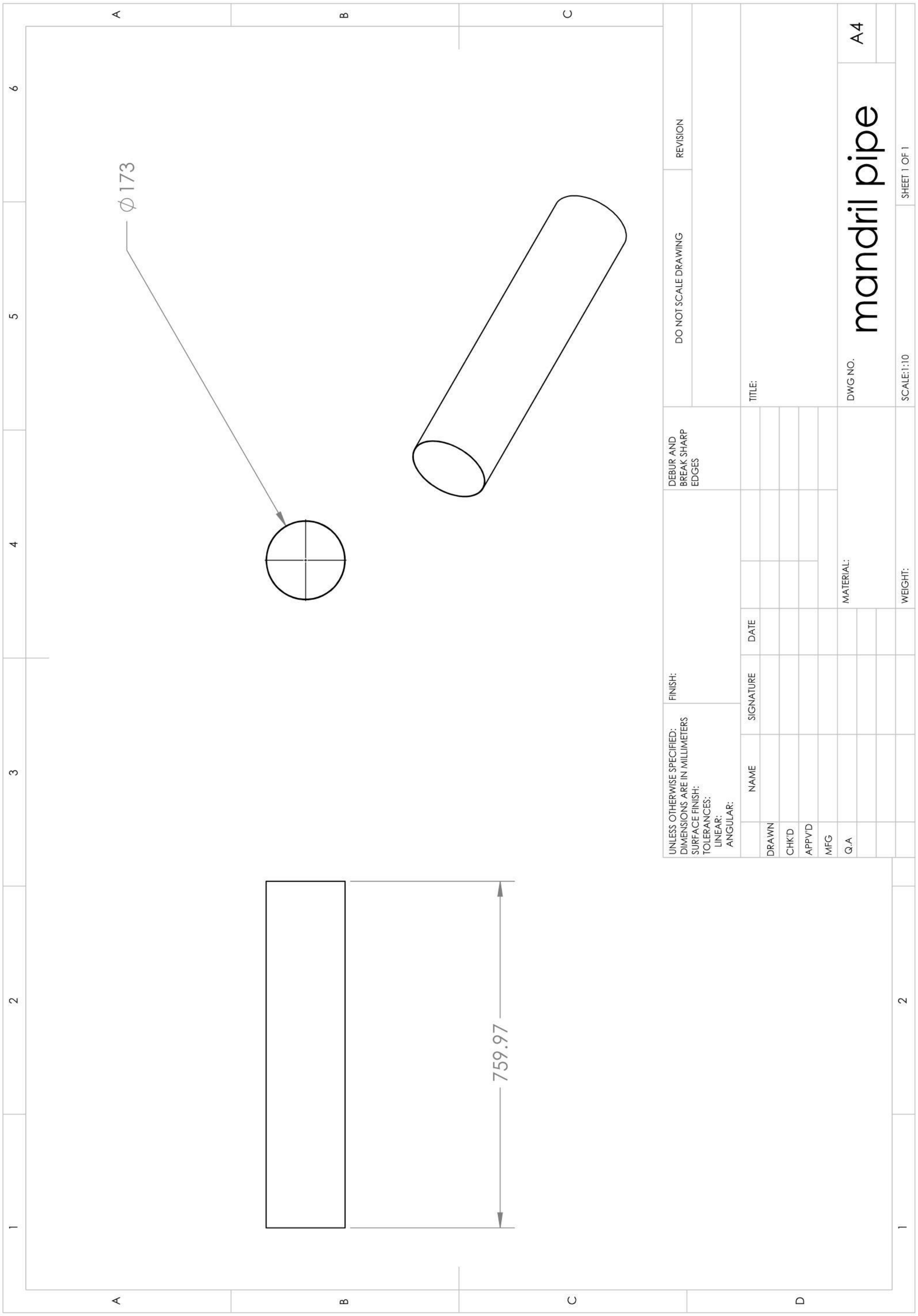
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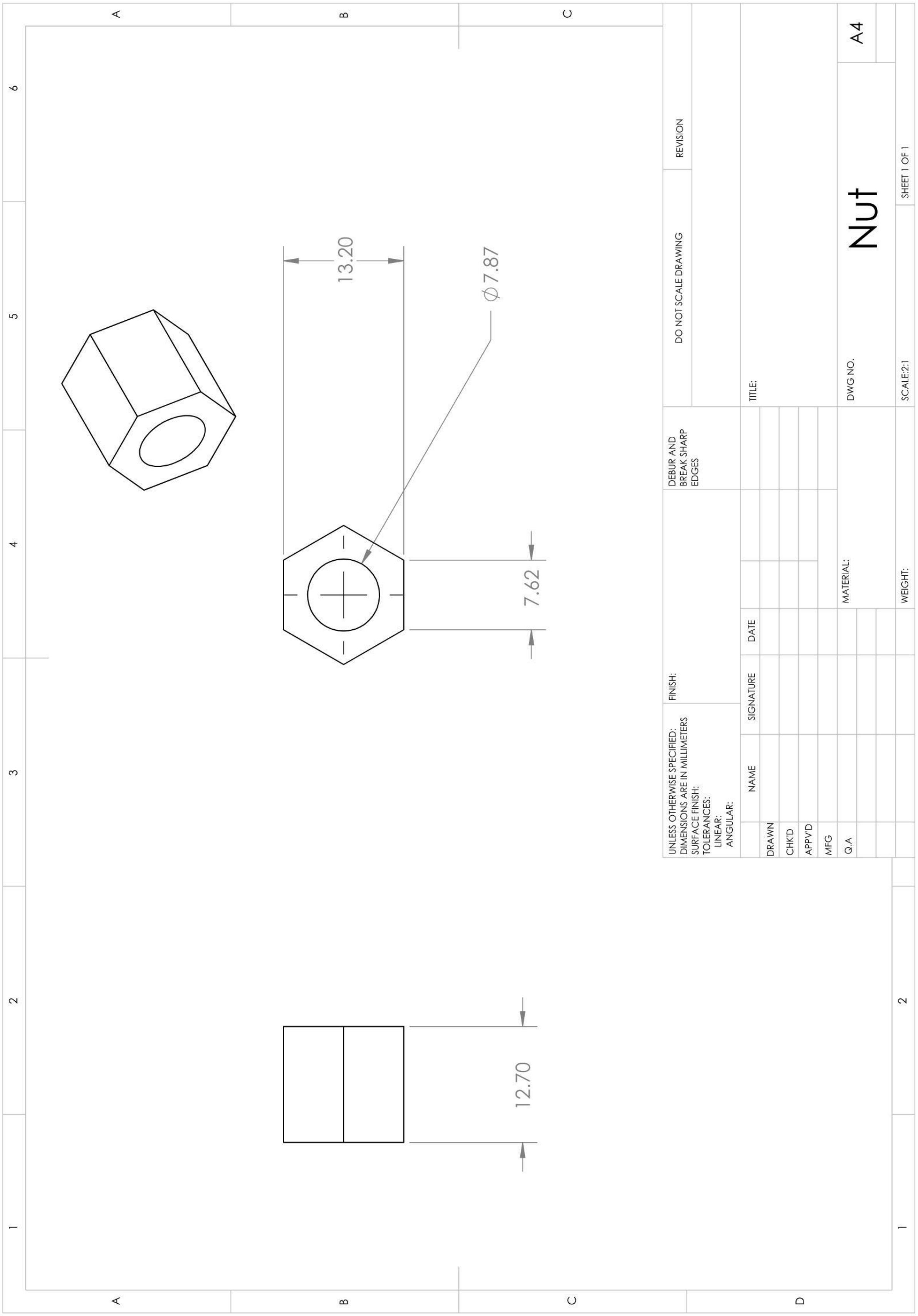
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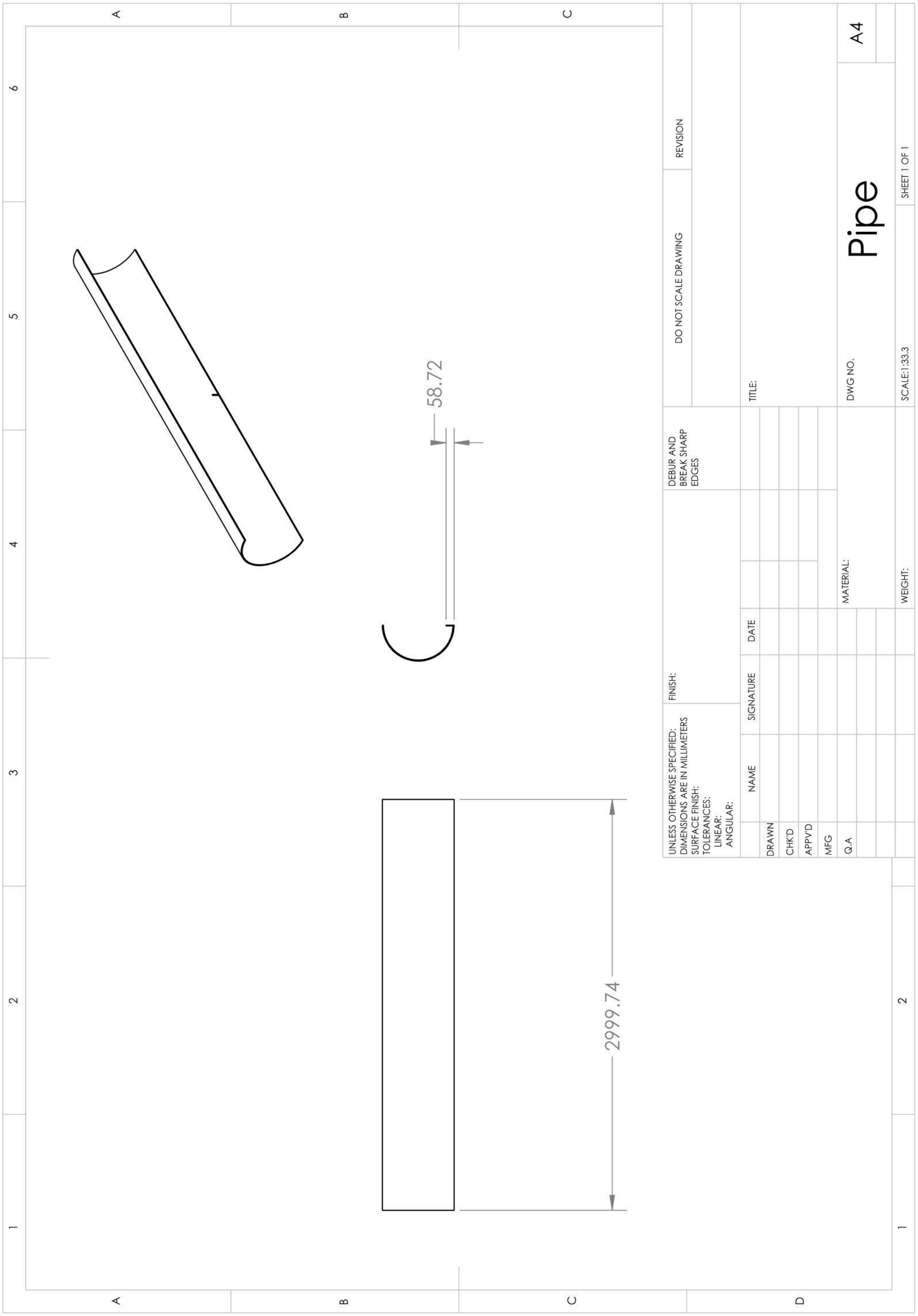

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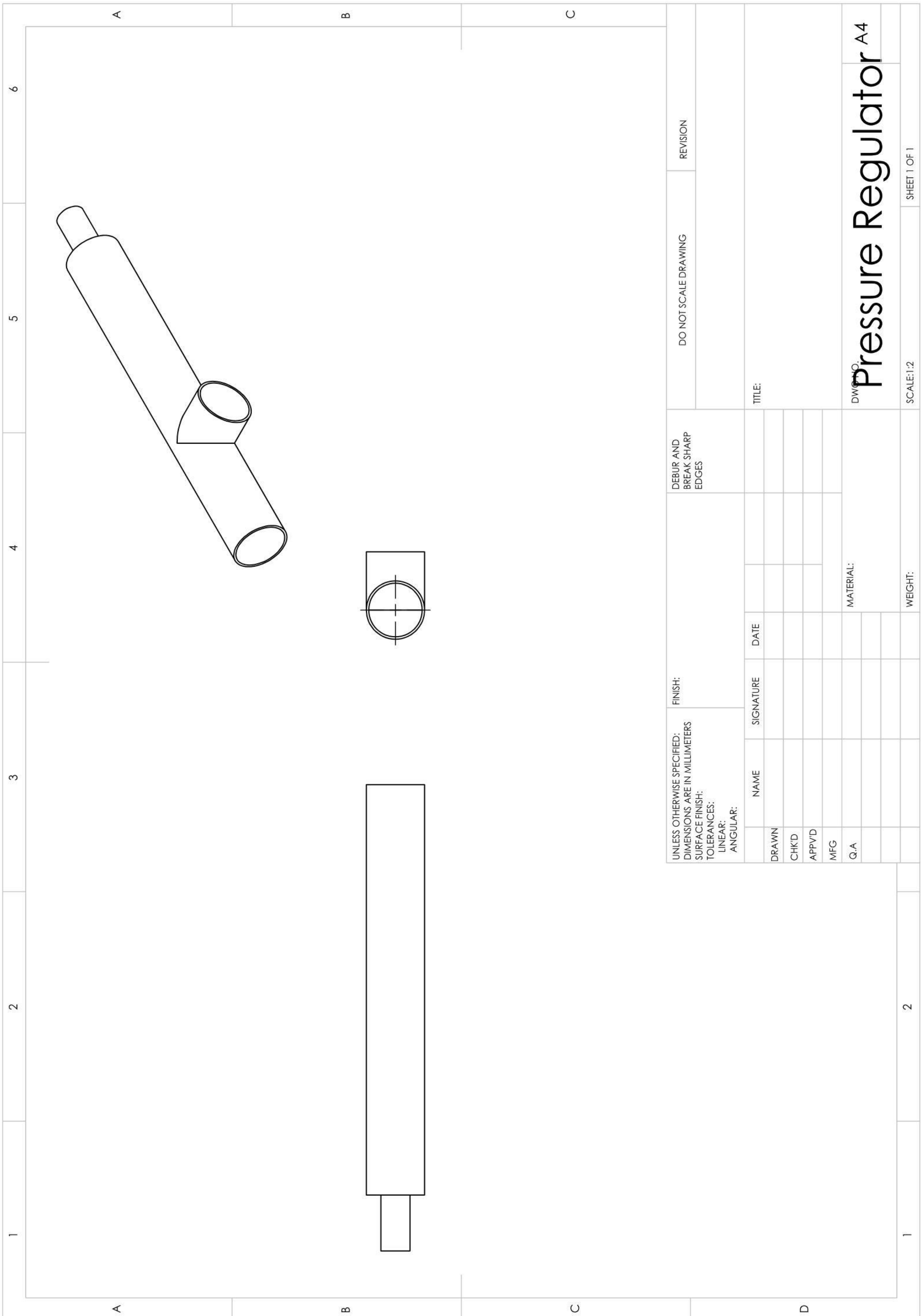
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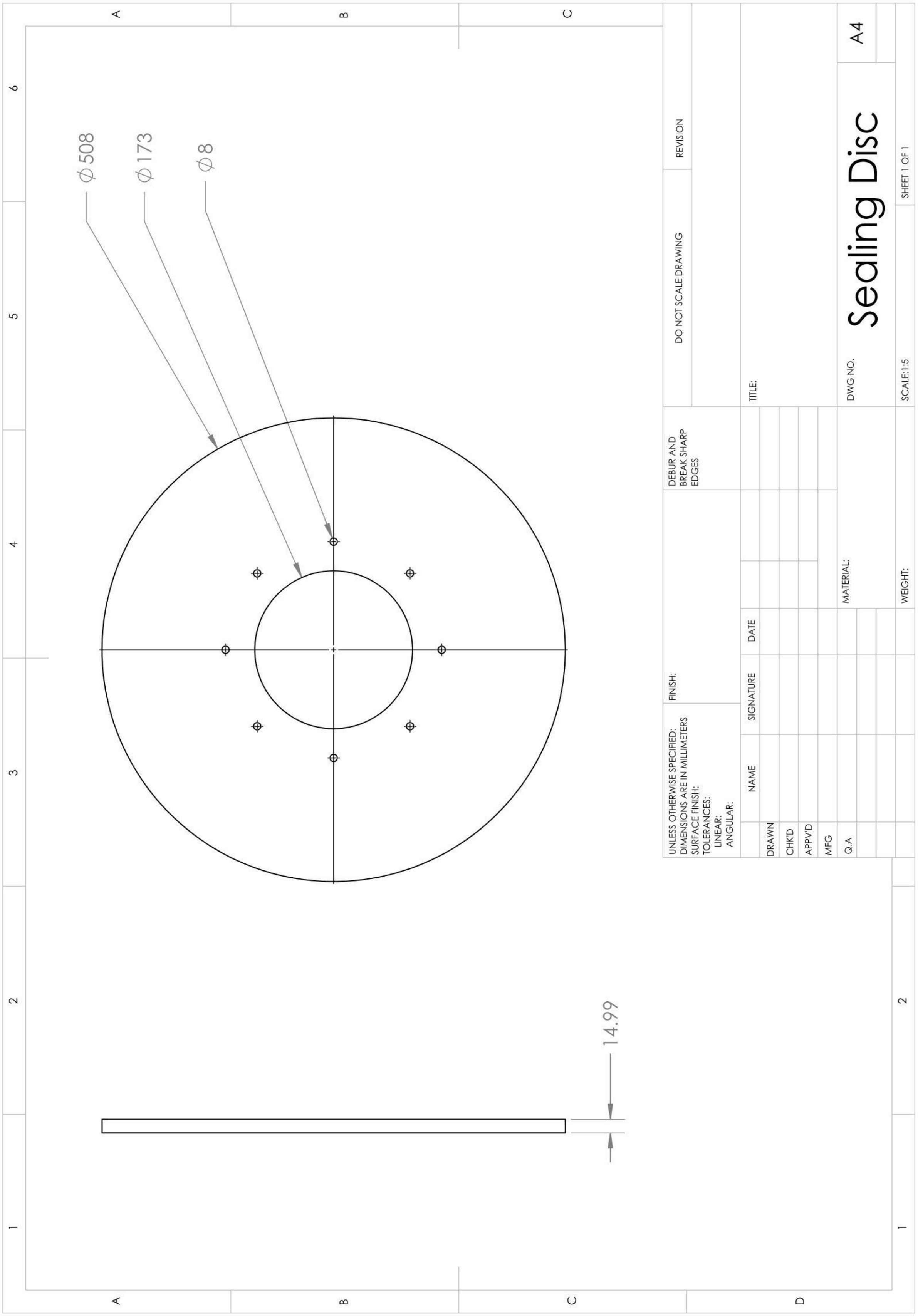
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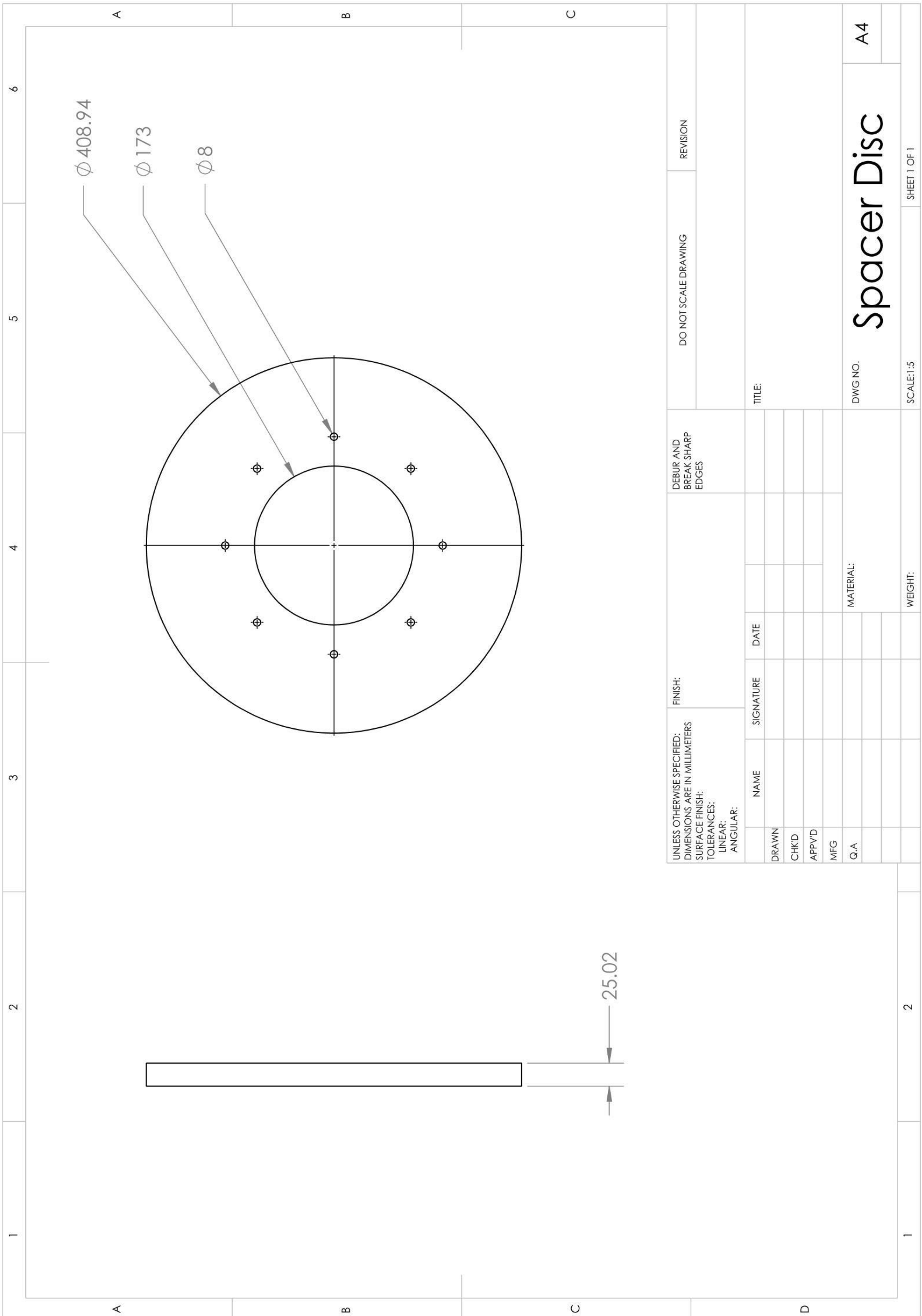

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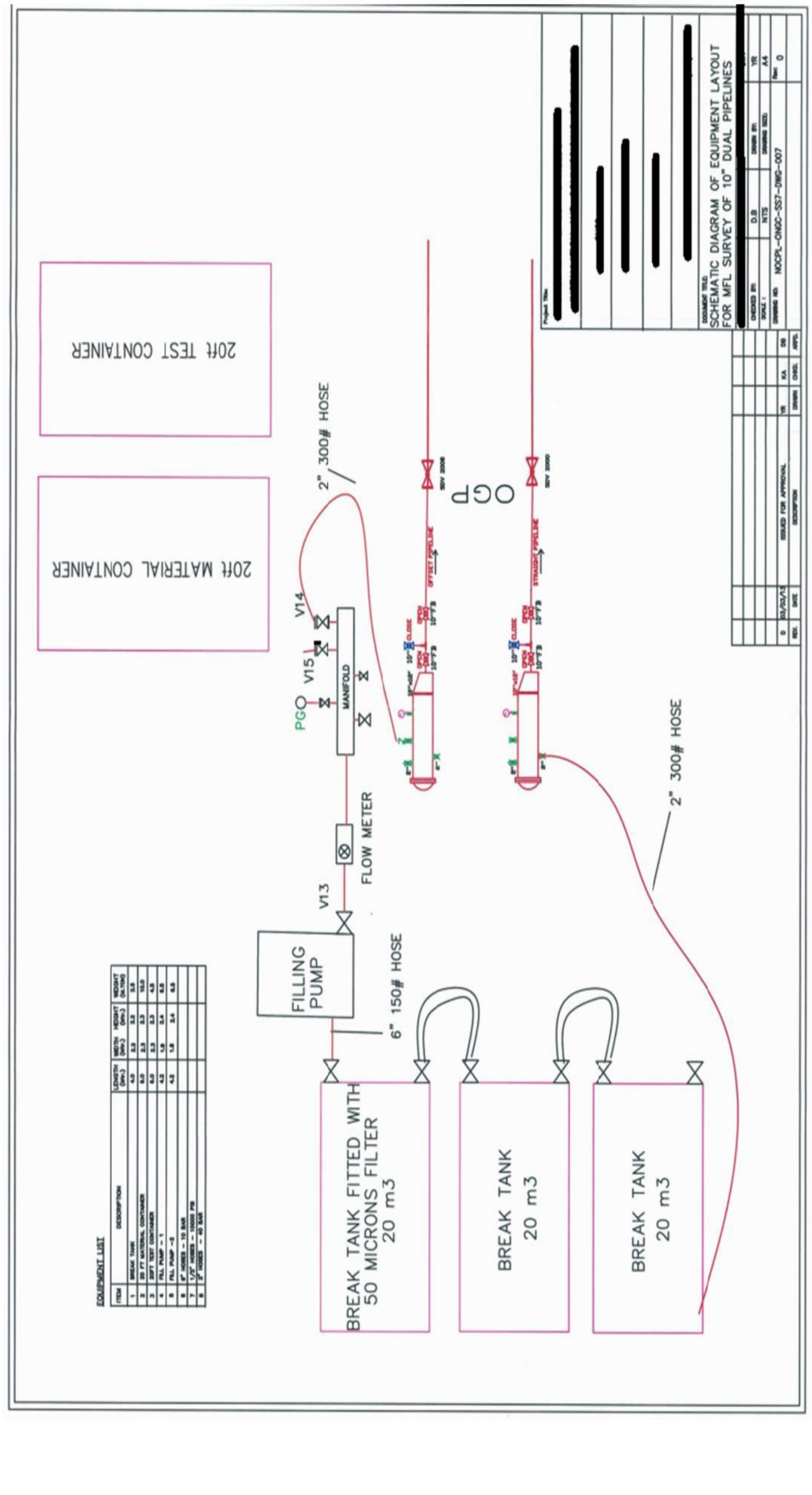
SHEET 1 OF 1

APPENDIX C

DATE	TIME	PRESSURE (BAR)	FLOW METER READING (M3)	DIFFERENTIAL VOLUME(M3)	CUMILATIVE VOLUME(M3)

APPENDIX D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MANIFOLD
PG
V13
V14
V15
FLOW METER
FILLING PUMP
6" 150# HOSE
2" 300# HOSE
BREAK TANK FITTED WITH 50 MICRONS FILTER 20 m3
BREAK TANK 20 m3
BREAK TANK 20 m3

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