E-CFW MANUFACTURING HANDBOOK

TOPFIBRA
EFFECTIVE FILAMENT WINDING® PIONEERS

MANUFACTURING HANDBOOK

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RECOMMENDED PERSONNEL AND ORGANIZATION FOR EFW LINE

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1. PERSONNEL ORGANIGRAM

On the next page, you will find an organization chart of the factory managing staff, which is provided in order to help you organize the work at your factory in the most efficient way.

2. PRODUCTION MANAGEMENT

2.1. Technology

TOPFIBRA clients and any factory proprietor, has to remember that all the technologies used in the pipe production, are significant for the proper and beneficial functioning of the factory. The factory management must have processes under control and efficiently direct the staff. Studying all the Handbooks will help with that, because you also have to understand the processes that you don't control, for example testing the raw materials and the QC tests done on the products.

All descriptions of the tasks and responsibilities listed in the next sections, are managed by you. You have to study and know them.

2.2. Planning

The Production Manager must make plans in co-operation with other staff on the team, for example: managers and supervisors, sales, procurement, maintenance, logistics and so forth. For this purpose, meetings with the relevant departments and staff should be organized on a regular basis.

2.2.1. Yearly plan

The Production Manager needs to have a clear plan, in order to see if it is possible to produce the diameters and the types of scheduled products. If the production plan is not carried out, a thorough consideration should be made to understand its reasons. If the set requirements are not met due to under production or the faults in production, the manager should advise his seniors to buy the equipment from TOPFIBRA.

2.2.2. Quarterly plan

A quarterly plan is important for the Managers because it allows to plan and manage the amount of personnel needed for the factory. It may be necessary to employ and train a higher number of personnel, if you intend to arrange the production on a 3-shifts or even 4-shift schedule basis, or if the factory will operate on weekends and in overtime, to meet the production needs.

2.2.3. Monthly plan

A monthly plan is important to prepare a schedule of the tooling and schedule staff for the production, especially after production has been stopped or a product has been changed. If it is prepared well, the time needed to change the diameter is reduced and the operation is a lot more efficient, when each participant knows exactly what their function is and is able to perform it correctly. Moreover, in some cases, tooling has to be repaired and it has to be considered in the plan, amongst other contingencies.

2.2.4. Weekly plan

Weekly plan serves to get all the tools, machines and equipment ready for the next job. Create an area near the machine, and out of the way, for tools or machine parts which will be used for the next diameter. As soon as you know which is the next diameter that will be produced, you or the Production Supervisor must personally inspect all the tooling to make sure it is in good condition and ready to use. The same should be done for tools that have just been removed. Repair broken sections or parts and store neatly store the tools, so that they are ready to be used next time.

The Production Manager must not forget to update the post shift schedules. Make sure everybody knows what they must do.

2.2.5. Daily plan

If the factory operates on a 3- or 4-shift basis, it is the Production Manager's task to create a plan which will ensure the work during the late and night shifts will proceed at the same rate, effectiveness and quantity, as during the shifts when the Production Manager is present.

The plan must be communicated to all shift Supervisors. In most cases, the Manager will not see 2 or 3 of the shift Supervisors during his 8-hour shift. Therefore, a system must be made that ensures the instructions and feedback are communicated every day. This must be formalized by signatures on receiving and returning end of the communication.

For a factory to function properly, it is vital to make sure everybody has work to do. The manager must ensure the work related to the production is done. Very often, people will not do anything and present their excuses in the morning. To combat this behaviour, it is recommended to provide a list of “stop jobs” (explanation provided in section 2.2.7.1).

2.2.6. Shift plan

The production plan must be split into parts which are relevant to the goals that can be achieved by each shift.

If the diameter is changed, the Manager must assist with planning all aspects of the task, so that it can be completed in record time. The Production Supervisor will be tasked with controlling that this plan is carried out correctly. Every minute the machine does not produce, the company loses money.

The plan with instructions for other activities has to be prepared as well, such as clean-up of the factory building and its premises, regularly and thoroughly, updating the documentation, and product rectification.

It is advisable to add the “Stop jobs” to this list and make sure the workers are busy all the time.

2.2.7. Hourly plan

If you have new staff on the job or a high priority work has to be completed in a short period of time, like a diameter change, the Manager must assist the Production Supervisor in planning every single step of the work. At this level, when the work is being carried out, there will be many parallel tasks. Using a Gantt chart or spreadsheet makes all tasks, operations and staff jobs very clear.

2.2.7.1. Stop jobs, part of the daily plan

Post a list of jobs the factory staff can do, if their regular work cannot be done for whatever reason. This list should include clean-up and maintenance tasks, such as sweeping, mopping, lubricating the machine parts, and cleaning tools with acetone. It is important to be firm with this task list. It will ensure that the staff wants to do their regular jobs rather than the ones on the list. Staff will have initiative and plans to do their regular jobs if the alternative jobs on the list are less pleasant, like cleaning.

2.2.7.2. Scrap and Waste Handling

Scrap should be stored, disposed carefully and closely controlled in the following way, because the materials are hazardous:

1. scrap pipes must be stored orderly, just like good the pipes. Scrap pipes must be cut up and removed every week. Tip: Make sure the staff who produced the scrap are the ones cutting it into pieces. This will help reduce faults in production;
2. scrap uncured resin must be put in drums which are half-filled with water, in order to absorb the exothermic heat of the curing. The drum must be clearly marked;
3. scrap catalyst must be put in drums which are half-filled with water and soap. This allows the active chemicals to degrade and become non-hazardous. The drum must be clearly marked;
4. empty catalyst containers must be rinsed with soap water and damaged by making a hole in the bottom. This prevents people from using them for other purposes;
5. a plan must be made in conjunction with local authorities regarding the disposal of the waste materials.

3. PRODUCTION MANAGER

3.1. Safety

Safety must always be a priority and on constantly your mind, because your staff works with machinery in the factory. People are the company's biggest asset. They are in your care and under your supervision. It is the duty of the Production Manager to ensure their safety.

Safety and clean-up operations go hand in hand. A dirty and untidy place is normally unsafe simply because the dirt could be slippery and present a tripping hazard, a fire hazard or an array of other dangers. An unsafe workplace will affect the output of the people and the machines.

Here are several tips that will help you ensure a safer workplace:

1. perform a daily walk with your staff, who are responsible for each work area and inspect it for cleanliness, stacking methods, obstacles and whatever you notice that is out of place;

2. randomly check the cupboards to see if they are tidy of if there are any objects that do not belong there;
3. make sure everything that is stacked up on top of the cupboards and cases is removed;
4. randomly check the electrical equipment, ladders and scaffolding to make sure they are noted in the register and that they are checked for safety every month;
5. ensure every shift has a person responsible for the medical first aid on the team;
6. make sure the first aid kit is stocked and sealed;
7. make sure the fire extinguishers are present and ready to use;
8. do not allow and also discourage all practical jokes and horseplay;
9. make sure you have a safety representative on the safety committee (one of your staff). Help this person to perform their duties by giving him/her the time to do the inspections. Take note of recommendations and implement the necessary improvements as soon as possible. Rotate the representative post at least once a year in order to subject all your staff to that level of safety awareness;
10. organize regular safety talks on various topics, which shouldn't take longer than 15 minutes. Let each person who attends the safety talk sign a register of attendance. This is for future reference;
11. encourage safety in the homes of your staff. Home accidents also impact work, because if a person is absent from his/her position you will have to work with a less trained person.

Let the staff sign the register to confirm the performance of the training. Add the training notes to the register when you file it. If somebody gets injured, you may have to provide proof that the person was trained and prepared, as well as provide the content of the training. The accident investigator will need this information. If the accident resulted in death of a worker, the court would use this information as well.

3.2. Management tips

3.2.1. Manage the KPI and demand results

The Production Manager is responsible for the complete pipe manufacturing process. In order to produce quality pipes, you have people and machines at your service. These will fail you if left on their own. You can wait for the end of every day, week or month to see how they have performed and get very angry at the factory results, or you can influence the results of each machine, process and the people before they perform their tasks. The latter approach guarantees results. The use of KPI helps for corrective actions.

3.2.1.1. Advantages of "Managing the results"

1. gets the worker to study what he/she must do to start the process, which will provide the desired result and result in having control of the process
2. monitoring the execution of results while they happen;
3. ability to forecast the results if the Manager keeps statistics over a long period of time;
4. requiring daily reports or reports that are made in very short intervals and making immediate adjustments to the type or the frequency of KPI;
5. enables a timely assistance when the Manager sees that help is needed;
6. experts can list the expected results to achieve results for complex work.

3.2.1.2. Disadvantages of "Managing the results"

1. by the time the results are obtained, there is absolutely nothing the Manager can do to change them;
2. most people start looking for excuses to explain the result if the results are undesired;
3. the staff will start blaming each other for the poor results (if they are poor);
4. seniors will demand to keep repeating the good results even if you do not know how to achieve them;
5. when you are unaware of the job specifics, you can be misled as to why the results were not achieved;
6. the Manager can end up threatening your staff to produce better results without any guarantees that they will do it the next time.

3.3. Meetings

Many types of meetings are organized for the factory staff. These are formal boardroom meetings, stand-up meetings, passage meetings and everything in-between. Their effectiveness is rarely determined by the method of the meeting but rather by the agenda and the way the agenda is managed. Think carefully what you want to achieve with the meeting and plan the agenda carefully:

1. devote what you think is the right amount of time for each topic and stick to it;
2. establish some ground rules and follow them as much as possible;
3. schedule the time for the meeting;
4. during the discussions, keep a record of what must be said/presented. Do not write essays but note down what must be done by who and in what time frame. Number each item and add a new number for each new item. Cancel one by one the already presented items. This numbering system will highlight the points that are old, and it will also be a visible measurement of the completed work and the progress that has been made;
5. before the meeting, ask if anybody wants to add something to the agenda, otherwise your staff will come unprepared, sit there and think of all issues to discuss. If a new matter arises during the meeting and it is not really urgent, tell the person it will be added to the next meeting's agenda. This will mean your staff will be prepared for the meeting.

Do not fall into the same trap as many managers before you have fallen into. This is called the "history traps" where people give reports of what happened yesterday and blame others for what did not happen. Try your best to concentrate on what must be done that day or the next day in order to affect the results in your area. Get all your staff to discuss the challenges they are faced with next. What's done is done and no amount of discussing the past topic can change it. You can be almost 100% sure, that the discussions of old issues will end up as a mud throwing and blaming each other. If the production results of the previous day have to be reported, they can be added to a board before the meeting by each responsible person. The targets and achievements must be clearly marked for all to see. This way the Manager does not have to waste time talking about it. You can then talk about what to do today and the following days, to make sure the staff will improve the results. It is extremely important to focus the discussions on the plans and actions. Each person has to present how he/she will ensure that they will be productive today and tomorrow. People in meeting can then contribute and you will achieve a benefits for the group.

Do not use the meeting to manage your staff. To manage your staff, meet on a daily basis with each member responsible for certain tasks directly at their working place and ask everything you need to know. Then help them by giving advice and planning further steps together. The meeting is not a place to learn from your staff what happened yesterday. Your staff deserves to go to a meeting without their time being wasted, while you do your work.

3.4. Communication

The Production Manager has some responsibilities regarding the communication as well:

1. find out what kind of formal communications are expected from you by the General Manager;
2. find out what kind of formal communications must be passed to your staff;
3. use notice boards. Write the date the notice was posted and the date it will be removed. If your notice boards look the same every week, nobody will be aware of them;
4. have regular feedback meetings. Keep them short and stick to the rules described in section 8.2.2. "Meetings";
5. keep them daily informed. Do not wait for the meeting you have once a month. You can talk to your staff while they are working. They need to be regularly informed and updated;
6. feedback concerning the performance versus the production targets is very important. If you link bonuses to performance, you can use this to your advantage to keep the staff motivated to take up the challenge;
7. in some cases, you must have confidential discussions. Make sure there is a room, office or place for this, where the worker will feel comfortable. If a discussion was confidential make sure it remains as such;
8. establish a communication channel from your workers to you and encourage open and frank communications. Make sure to reply and follow upon every raised point.

3.5. Production supervisor

3.5.1. Technology

3.5.1.1. Know-how

You should remember that all the technologies used in the pipe production important in order to obtain a high-quality product, and ensure that the equipment lasts long and functions properly. The Production Supervisor must have processes under control and efficiently direct the staff. Studying all the Handbooks will help with that, because you also have to understand the processes that you don't control, for example testing the raw materials and the QC tests done on the products.

All the descriptions of tasks and responsibilities mentioned in this section are to be managed by the Supervisor, who should study and know them.

3.5.1.2. Cross training of all staff

To ensure continuous operation of the plant without stoppages it is crucial, that in a case an employee, for example the winder operator, is absent from a critical position, you need to appoint someone else to do the work. This is the reason we advise you train all the machine-operating staff on the Winder, then the Hydro-tester, followed by training on other machines. You can also train staff from other areas so that they are available for this job, which is one of the most important jobs in the production process and requires special skill.

3.5.2. Production

There are many aspects in the pipe production process. The Production Supervisor must be in control of all of them, even if not all steps are performed. They are described in the next sub-sections.

3.5.2.1. Raw material preparation

The resin premixing tanks must be prepared in advance and the resin mixture, which will be used in the production, must be tested and approved by the laboratory. The gel time of each tank must be used to set the percentage catalyst in order to adjust to the optimal requirements the curing and exothermic peak.

3.5.2.2. Pipes production

Different materials and process variables have to be regularly monitored and controlled to ensure a correct laminate performance.

Make sure that every process setting change is noted in a machine's register book. The Operator must write the time, pipe number in processing, the reason for the change, and the setting before and after. Then the Supervisor must approve this change, if necessary, for example when the catalyst % setting is modified, the heater lamps are changed, resin quantity, resin temperature and so on.

3.5.2.3. Cutting and testing sleeve couplings on the Grooving Machine and Sleeve Coupling Hydrotester

Every produced pipe must be fitted with a tested fibreglass sleeve coupling. To do this, the grinding and testing of sleeve couplings must be done first.

Make sure the QC documentation is filled out for each sleeve.

3.5.2.4. Hydrotesting of pipes

Every pipe must be tested to two times the nominal pressure for two minutes or as long as a specific standard requires. To reduce the risk of making scrap, there should never be more than 4 untested pipes. If a pipe is bad, the Hydrotester Operator must immediately inform the Winding Operator and the Supervisor, so they can correct the winder if the origin of the problem is the winding machine.

Make sure the QC documentation is filled out for each tested pipe.

3.5.2.5. Sleeve Coupling Pipe joining

Make sure that every pipe is fitted with a QC passed sleeve. If possible, make a mark on the interface to indicate that it was fitted by the factory. This will differentiate it from a poorly fitted customer's pipe and sleeve and help determine whose fault it is if there is a problem.

3.5.3. Quality inspections

Producing quality products is the responsibility of all production staff. The verification of the quality at any stage of the production is the responsibility of the QC department. Allow the QC Laboratory to inspect the products and react fast if they find something wrong. Try to have the same team repair the pipes that made them incorrectly before the end of the shift, so that faulty pipes do not accumulate while they wait for a rework.

Make sure the QC documentation is filled out for each reworked pipe.

3.5.4. Raw material supply and ordering

The raw materials needed during the after-hours shifts, must be ordered from the stores during the normal working hours, when the stores staff are present. It has to be ordered early in the day to be accepted in the afternoon and next morning. This will give the Logistics Supervisor time to prepare the materials.

3.5.5. Maintenance: planned, unplanned and breakdowns

The responsibility for each machine lies with its Operator, as well as the Production and Maintenance Supervisors. In case of disfunction, the maintenance staff must be called as early as possible to take urgent steps in order to minimize the downtime.

Planned shutdowns and maintenance will be carried out by the Maintenance Supervisor, who must be assisted by the Operator who can perform lubrication and other tasks. That is the reason why the Production Supervisor should collaborate with the Maintenance Supervisor to do planned maintenance during job changes, if they are close to the time of the regular maintenance operations.

3.5.5.1. Repairs

During the production process, pipes with visual or other small defects can be produced. These defects can be repaired, returning the faulty pipe to a normal state. It can then be used for normal applications or at least for gravity line applications.

The list of typical defects and the approved repair methods is found in the Quality Control Handbook and in the Installation Handbook. The workers must refer to these handbooks when making repairs. If non-standard repairs have to be carried out, a repair procedure must be drawn up for the worker to follow.

Each repair must be approved, noted in the pipe documentation and signed off.

3.5.5.2. Non routine tasks

- Diameter changes must be planned in advance, with every activity listed and the responsibilities assigned to the staff. Draw up a statistic for every diameter change in order to plan the next one and make improvements to it;
- clean-up: keep the production area clean. Dirt or other materials must not be allowed to accumulate from one to the next;
- removing the cured resin below the machine: place a plastic material below the machine to catch the resin. Clean it every few hours. A priority is to reduce the dripping of the resin by adjusting the iuts. Resin dripping on the floor must be cleaned every week.

3.6. MAINTENANCE SUPERVISOR

3.6.1. Maintenance Planning

3.6.1.1. Spare parts

The maintenance person must evaluate the machine parts, see if they are reliable and what state they are in. If they are likely to break down or wear out, the maintenance person has to decide:

1. whether the state of the part is critical;
2. whether it is important;
3. how long it will take to find a replacement.

Some important parts are very expensive. If a part is easy to find, meaning it will only take a day to locate a new piece, it may be better to not have it in stock. While if it is an item which will take 4 weeks to replace, it must be kept in stock.

3.6.1.2. Typical important or critical parts

- chains;
- belts;
- bearings;
- valves;
- spare PC completely set up for a quick change;
- PLC modules;
- resin mixers;
- catalyst pump spares;
- encoders;
- motors;
- heat sensors;
- switches;
- o-rings and seals;
- oils for gearboxes and hydraulic power packs.

3.6.2. Daily inspections

3.6.2.1. Maintenance Supervisor

Regardless of schedules and formal programs, the Supervisor must walk past every machine every day and ask the operator if anything has changed, like the sound of the motor, the movement of parts, vibrations, the way to operate and if he/she knows of any problems or possible failures. It is important to take notes of this. The Maintenance Supervisor must add the reported faults to his plans for that day or the next maintenance shut down, and make sure they are fixed. If problems are reported and not fixed, the staff will stop informing the Supervisor of what is wrong and watch with interest when a breakdown occurs and you run to the problem.

3.6.2.2. Maintenance staff members

Allocate an area of the factory to each maintenance person. Usually, the maintenance staff consists of one Mechanical Maintenance and one Electric/Electronic Maintenance person, who are up to date with the mechanical and electrical/electronic services of all the machines in the factory. However, when the production rate is high, the plant is big and there is a lot of machinery, more personnel can be employed. They must take the responsibility for all the machines in the assigned area. After an "adaptation" period, they will soon know the operators and the machines very well.

An informal early warning method and breakdown prevention consists of the maintenance staff walking past every machine every day, early in the morning. They confirm the functionality of the machines with their operator, if there are any changes or disorders, or potential and actual problems. The maintenance staff must report to the Maintenance Supervisor and provide the collected data. The Supervisor must add the reported problems to his/her work plans for that day or schedule them for the next maintenance shutdowns to ensure the problems are fixed.

3.6.3. Night Reports

The Supervisor must provide one notebook for the Engineering staff and one notebook for the Production staff. They use the notebooks to write down the problems as well as the solutions. Both departments must provide signatures and comments in the notebooks. Be careful not to allow blaming between the departments to occur.

Read and sign the notebooks every day. Leave questions and notes for the night shift. Note the problems and add them to your plans for that day or to the next maintenance shutdowns, make sure the problems are fixed.

3.6.4. Breakdowns

There will be less unplanned breakdowns when the machines are being taken care of and when new sounds and problems are detected early. If the breakdowns happen, it is important to follow all the safety rules while resolving the problem as quickly and efficiently as possible.

All breakdowns must be reflected in the shift report.

Determine if this breakdown can be prevented in the future, if the section of the machine that broke down and particularly the broken parts, are checked during the routine planned maintenance operations. If so, add this task to the plan.

3.6.5. Maintenance schedules

Regardless of all your good planning, the production will overrule your plans because of the delivery schedules, machine stoppages, workforce factor and other circumstances. Make sure you do not overrun the schedule too much. It is advisable to do the maintenance during job changes in order to not reduce the production time. If the job changes are short, do the winder first, then other machines during the next job changes.

Draw up weekly, monthly, quarterly and yearly schedules for each machine. This is profitable for oil changes, inspections where you have to strip parts of the machine, some bearings that are overworked, etc.

As you notice the trends in breakdowns, plan a service before the next expected breakdown.

3.6.6. Records

The Supervisor can use software or a book for each machine, which will allow them to perform a regular control of the state and functioning of the equipment. Records are handy but do little more than help you predict the future problems with a less than 60% accuracy.

However, make sure you keep a note of who provided specific solutions and who did which repairs, so that if a problem arises the same person or another person can attend.

3.6.7. Staff

The Maintenance Supervisor needs a person to do electrical and electronic control, fault finding and fixing of equipment.

For mechanical maintenance, the Supervisor needs a person to do mechanical fault finding and fix the machinery.

However, in a large factory with big production areas and output, more people can be employed who work together or are divided in shifts, so that there are 2 maintenance personnel per shift.

If there are not enough maintenance personnel for each shift, they must be on standby to be called when needed.

3.6.8. Maintenance Workshop

The workshop should be ca. 100 square meters in size, fitted with compressed air outlets, several single and 3 phase outlets for welders, hand tools, etc.

3.6.9. Tools

Software: we recommend using the Maintenance Software to record and plan the maintenance. However, keep in mind that you will need extra staff to maintain the software.

Workshop tools include: lath, milling machine, grinders, standing drilling machine with 16 mm chuck and work benches with vices.

3.6.10. Modifications

It is common practice to modify a machine if you think there is a problem. Please note that this can only be done with the authorization of the TOPFIBRA company and if our engineers see this modification as an improvement. In most cases, modifications do not consider the whole solution of the issue and must be avoided. It is recommended you contact TOPFIBRA for assistance, before modifying the machine.

NEVER do the following:

- weld on the main shaft of the winding machine. Weld induced stress will cause fatigue and the shaft will break;
- weld the machine, or weld parts on the machine, while the machine power is on. If you have to weld on the machine, switch the machine's power off and put the welder earth connection as close as possible to the weld.

3.6.11. Production maintenance

The production maintenance is related to the running of the machine and must be done by the machine operator. The operator needs to be trained to do this work.

The typical production maintenance problems are:

- chopper blades and rubber rollers;
- resin mixer;
- troughs;
- cleaning of the machines;
- cam followers on the aluminium beams;
- bearings in the aluminium beams;
- job changes (shafts, discs, machine adjustments);
- replacement of worn parts (wheels, brass on the aluminium beams and diamond cutting tools).

4. TECHNICAL MANAGER

The design and specification of the pipe, the needs of the client, the pricing of a project, the ability of the machines and the staff are all dependent on each other. The Technical Manager is the senior who has to understand this dependency. He/she must coordinate all Technical Office activities, follow the research and development of the company, and study, prepare and plan the project. The manager is responsible for the project activities as well as the pre- and post-sale technical assistance.

4.1. Pipe designs

The pipe design software supplied with the machines will design all standard pipes ranges that can be manufactured with the TOPFIBRA machine. It is important to understand different elements of the designs in order to advise the client on the right choice of the pipe for a particular set of conditions, environment and application.

4.2. Resin selection

A number of standard resins are used in the production of pipes for the most common applications. However, if a client has special product characteristics requirements, other resins should be considered and chosen, as for example if pipes have to be designed to withstand acid or heat. At this point, the Technical Manager can ask the resin suppliers, as well as TOPFIBRA Laboratories, for advice.

4.3. Design and drawings of specials and fittings

Every pipeline project has bends, elbows, T-joint and air valves. Which means the customer needs fittings. Our Engineering Handbook, chapter "GRP Fitting Design" explains various methods of producing fittings. The customer's task is to specify the detail and size of every fitting.

4.4. Research and development

To fit the customer's needs, a study and development can be performed for making non-standard products. Before supplying such products, the pipe producer needs to be sure that the product is made according the relevant standards and that it is tested and proven to be good. This may require a special R&D program. If the producer's Technical Office and the Quality Control Laboratory are unable to achieve a desired result, TOPFIBRA d.o.o., its laboratories and related companies offer this service.

4.5. Installation support

Special care has to be taking during the GRP pipe installation, if the contractor who is laying the pipes has no knowledge or experience with this product. In this case, the pipe manufacturer's Technical Manager can offer assistance and send a qualified person to the customer. This person will train personnel and assist the contractor.

If there are problems, this person will investigate the problem, together with the Technical Manager if needed, depending on the gravity of the problem.

Contractors frequently need help with butt & strap joints on site, the installation of fittings and joining the pipeline to the 3rd party products like steel valves, steel pipes and other.

5. QUALITY CONTROL MANAGER

It is the responsibility of the production staff to manufacture good products which correspond to the existing norms and requirements of the client. In the same way, it is the responsibility of the Logistics Department to purchase high quality raw materials. The Quality Control Department plays an important role in this case, influencing the production and purchase.

It is good practice to have a 2nd or 3rd party quality control, because the output **quantity** is frequently substituted for **quality**, if one party controls both.

5.1. Raw material qualification

5.1.1. Raw material rejection and release for production

No material can be accepted simply based on words or documents of the supplier. All raw materials used in the pipe production need to be tested in order to make sure that they are exactly as ordered. This is critical to the manufacturing process to guarantee a good quality of the final product. The manual procedures for the test and the actions in case of a failure must be followed.

5.1.2. Qualify suppliers for raw materials

The raw material suppliers must be carefully selected to ensure you receive quality materials with right properties.

To see if a supplier qualifies, the raw materials offered by their company must be used to produce a test pipe. This pipe should then be thoroughly tested by various methods such as HDB, burst test, tensile test, etc.

It is useful to have a list of approved suppliers to select from. Such list is initially provided by TOPFIBRA. If this list is not provided, the Quality Control Manager should contact TOPFIBRA.

Materials offered by a new supplier must undergo the same testing in order to qualify. In case of any doubts, please contact the TOPFIBRA laboratory.

5.2. Production quality control

5.2.1. 3 hourly PVIs (Process Variable Inspections)

The raw materials, used for the pipe production, must comply with the pipe design. This includes the number of hoop roving, number of chopped roving, amount of resin needed for each layer, amount of sand and more. The winding machine Operator must make sure that the materials are applied correctly. The Quality Control Supervisor must verify the state of these materials approximately every 3 hours and at the start of every new production.

5.2.2. Pipe and sleeve inspections

Inspect the outside of the pipe for visual defects. Pay special attention to cracks and air bubbles in the liner. For sleeve couplings it is important that the rubber gaskets are properly inserted in the grooves.

Cross-check the measurements taken during the production, measurements of the outside diameter, length and thickness.

5.2.3. Hydro tests controls

It is important to perform this test on pipes and sleeve couplings for a specific duration and pressure. Attend these tests regularly to verify that they are correctly performed by the machine operator.

5.2.4. Standard Tangential Initial Stiffness (STIS) test

This test must be performed minimally once per shift, or according to the applied standard specifications.

5.2.5. Gel time tests and the results

The resin in the daily mixers must be gel time tested after different materials are well mixed.

The gel time test has to be performed on the resins which are ready to be used for the production and the ones that might be required during the production.

The gel time must be reported to the Production Supervisor so that the process is constantly monitored or adjusted, if necessary.

5.2.6. Repairs acceptance

The Quality Control manager has to verify the state of the repaired pipes and the state of the pipes with small defects. If a visual defect does not threaten the integrity of the pipe or if a reported defect was fixed by abrasion and additive lamination, the product can still be qualified as acceptable, after a series of test. If it does not fit the pressure pipe service standards, the pipe can sometimes still be used for gravity service. For this purpose, additional tests on the product should be performed.

5.3. Documentation

Every pipe must have a unique number and a document associated with it. All material batch numbers must be recorded, as well the team that manufactured the product. The hydrostatic test results and measurement results must also be recorded. The document must be signed by the production and QC staff.

A list of typical defects and the approved repair methods are given in the TOPFIBRA Know-How Handbooks. They must serve as guidelines for the workers who perform the repairs and for their Supervisors. Repair instructions for the non-standard repair procedure must be provided so the workers can follow them.

Each repair must be approved by the Quality Control Manager, noted in the pipe documentation and signed.

5.4. Final inspection

Pipes can be damaged during transportation from the machine to the yard and from the stack to the truck. Pipes must be inspected on the truck after they have been loaded. It is good practice to take a photo of every load to assist with investigations when the customers claim that the pipes were damaged upon arrival.

5.5. Marking the pipe

It is important to provide pipe identification, because all pipes look the same. Mark different pressure and stiffness pipes with a colour code rings or a sticker.

Mark COD (constant outside diameter) pipes so that the contractor can use them for the installation of short pieces.

5.6. Report results

All defects must be reported to reduce possible problems. Keeping a record is very useful. When dealing with a problem, notify the person who can correct the problem first and then notify the management staff if necessary.

6. LOGISTICS SUPERVISOR

The Logistics supervisor is responsible for the raw materials, machine spare parts and for dispatching the pipes. This function encompasses the treatment of all materials that are necessary for the factory to function properly (equipment, machine pieces and details and the materials from which the fibreglass products are manufactured). The main tasks of the Logistics Supervisor are the pick-up of all materials, checking if they are in a good state and in order, arranging the storage and handling of the materials and pieces before and after the application.

The Logistics Supervisor’s duties for the produced pipes include: handling, storage and loading to ensure the product is undamaged and in good state.

6.1. Yard Space

The yard space must be analysed and planned to store the pipes in such a way that the transporting and operating vehicles do not crash into them. The first in - first out principle has to be used.

Allocate an area for scrap pipes and make sure that the scrap does not accumulate for more than one week before it is cut into pieces and moved to the landfill. You will need a permit from the landfill owner for the scrap disposal.

Remember to plan enough space for the trucks to turn and for the loading vehicles to manoeuvre around the yard.

6.2. Stacking the Pipes

Produced and stocked pipes may present a danger because they can roll if they are not secured and fixed. When storing them, it is important to determine the maximum stack height. Always use planks between the rows of pipes and use wedges at the ends. The wedges must be nailed so they are secured.

Make sure the pipe ends are in the same plane so they are not damaged by passing vehicles.

If the sleeve couplings are fitted on the pipes, the pipes be arranged in such a way, that their ends alternate. Allow enough yard space for the vehicle to freely turn the pipes, without risking damaging the product or injuring people present on-site.

6.3. Effect of the Sunlight, Hot and Cold temperatures on the Pipes

Long term exposure of produced pipes to the extreme weather conditions reduces their quality if the outer surface of the pipes, especially the resin layer, is not UV protected.

6.4. Loading Methods and Securing the Pipes

For more details, see the Installation Handbook, chapter "Installation of Pipes". The handling, loading/unloading techniques and transportation at the installation site follow same rules that are used at the pipe production plant.

6.4.1. Types of loading vehicles

Side loaders are the most widely method to move long objects. Some side loaders have multi-function wheels and can move in any direction.

Front loaders with special fork attachments can also be used for loading pipes.

Forklift trucks must be used for raw materials.

When selecting the vehicles, make sure they will be able to handle the pipe diameter and weight.

6.4.2. Security

Trucks leaving the yard loaded with pipes need correct documentation (invoices, delivery notes, road police permit, etc.)

Photograph each load with a date stamp for the load proof. This will be helpful if the customer claims the pipes were damaged upon their arrival.

SPECIFICATION AND MANUFACTURING OF GRP PIPES ON TOPFIBRA'S E-CFW MACHINE

SPECIFICATION AND MANUFACTURING OF GRP/BRP PIPES ON TOPFIBRA'S EFFECTIVE CONTINUOUS FILAMENT WINDING MACHINE

TABLE OF CONTENTS

1. GENERAL PROVISIONS

This specification is applicable to all pipes produced on TOPFIBRA's Effective Continuous Filament Winding Machine (EFW Machine).

The pipes are produced with a controlled proportioning of raw materials on and around a rotating mandrel and with a controlled curing system, to ensure uniform pipe properties from section to section.

No difference is made between the pressure or non-pressure pipes, since the manufacturing process is identical. Pressure pipes differ from non-pressure pipe in a different selection of the resin, different content and arrangement of the reinforcement, different curing systems and different testing requirement. The GRP pipe made for the gravity application is simply a variant of the GRP pressure pipe, characterized by less severe resistance requirements for the internal hydraulic pressure.

Any GRP pipe, manufactured on the TOPFIBRA EFW Machine, will have a pressure resistance of several bar (for example, 6 bar actual Nominal Pressure for the lower stiffness class).

2. DIAMETERS

The sizes and dimensions of the TOPFIBRA GRP pipes are standardized on the basis of the outside diameter in order to use the standard couplings.

Nominal Diameter (ND) and Outside Diameter at the machined spigot end (OD) are taken from the International Standards: AWWA C-950 (Table 5), ASTM D3517/3754 (International Standard) and ISO 10467/10639 (Series B1):

Nominal Size	**Pipe Spigot Diameter**	**Tolerance** (*mm*)	
ND *mm*	**OD** *mm*	Upper Limit	Lower Limit
300	310	+1.0	-1.0
350	361	+1.0	-1.2
400	412	+1.0	-1.4
450	463	+1.0	-1.6
500	514	+1.0	-1.8
600	616	+1.0	-2.0

700	718	+1.0	-2.2
800	820	+1.0	-2.4
900	924	+1.0	-2.6
1000	1026	+2.0	-2.6
1100	1128	+2.0	-2.6
1200	1229	+2.0	-2.6
1300	1332	+2.0	-2.6
1400	1434	+2.0	-2.8
1500	1536	+2.0	-2.8
1600	1638	+2.0	-2.8
1700	1740	+2.0	-2.8
1800	1842	+2.0	-3.0
1900	1944	+2.0	-3.0
2000	2046	+2.0	-3.0
2100	2148	+2.0	-3.0
2200	2250	+2.0	-3.2
2300	2351	+2.0	-3.2
2400	2453	+2.0	-3.4
2500	2556	+2.0	-3.4
2600	2658	+2.0	-3.6

Notes on the Standard Sizes and OD:

1. As OD we always mean the Outer Diameter at the machined spigot end. The outer diameter in any other part of the pipe section will be a few tenths of mm larger.
2. Last revision of the AWWA Standards (in 2007) conformed to the ISO Standards as well as the ASTM Standards (in 2006).
3. For information: the previous ASTM OD International Standard Series was according to the formula: OD = 1.02x ND + 4 mm.
4. The nominal sizes above ND 1000, including odd numbers (1100, 1300, etc.), are non-preferred sizes (not in the AWWA tables), and the OD is interpolated.

Warning: Any pipe diameter can be produced, depending on the purchased set of the mandrel disks, beams and shims. The manufacturer has to be aware that testing a pipe with non-standard external diameter on the Hydrotesting Machine could be impossible.

Warning: The CFW Pipe Design Program also allows the pipe to be designed for the old OD series and other special series, as well as for the fixed ID, equal to the Nominal Diameter.

2.1. Tolerances

The AWWA/ISO/ASTM tolerances mean that the pipe of a certain nominal size can be supplied in that size range.

The pipe manufacturing tolerances are ±0.5 mm for all sizes.

The coupling ID tolerances are ±0.5 mm for all sizes. The coupling ID shall be determined according to the actual pipe spigot OD or vice versa. The common practice is to manufacture in advance the pipe for sleeve couplings, and then to adjust the spigot OD to the sleeve ID. Change in the mandrel diameter for the production of the pipe may be required.

3. PRESSURE CLASSES

The Pressure Class is generally defined as of the short-term pipe failure pressure or of the estimated long term failure pressure.

For more details about the definition of the Pressure Class, please see the Engineering Handbook, chapter "General Design Specification".

The Pressure Class is generally referred to the normal ambient temperature and service conditions, and the actual working pressure shall be of the Pressure Class.

When designing a pipe, the designer will select the Pressure Class based on the working pressure and all other service and environmental conditions.

The preferred Pressure Classes for the GRP pipes produced on the TOPFIBRA EFW Machine are:

PN 6 PN 10 PN 16 PN 20 PN 25 PN 32.

Gravity pipes that have a several bars pressure resistance, are classified as PN 1 bar and are tested at 2 bar.

Pipes with an intermediate Pressure Classes can be manufactured if the customer or the project require them, since the TOPFIBRA EFW Machine has no limitations in the production of varied thicknesses or structures in the reinforcements, except for those that are caused by the physical limitations of the machines, and/or testing equipment, and/or joints sealing capacity.

4. STIFFNESS CLASSES

The specific stiffness (STIS or S) of a GRP pipe is defined as:

$$S = \frac{EI}{D^3}$$

Where:

E = the ring flexural modulus of elasticity;

I = the second moment of inertia of the pipe wall;

D = the mean diameter.

Stiffness class measures the capacity to resist the loads that tend to deform or compress and implode the pipe in the section transversal to the pipe axis.

For more details about the definition of the Stiffness Class, please see the Engineering Handbook, chapter "General Design Specification".

The preferred Stiffness Classes are:

SN 1250 SN 2500 SN 5000 SN 10000.

The unit used to measure the Stiffness is N/m2 (or Pa – Pascal).

The flexibility of the manufacturing process allows production of pipes with the intermediate values of S, with certain limitations due to the physical capacities of the EFW machine.

Available PN and SN pairs of are given in the EFW Pipe Design Program, as well as the limitations for the larger diameter pipes. The EFW Pipe Design Program gives limitations and warnings for any non-valid pipe and pressure stiffness couples.

Pressure Class limitations may also result in the Hydrotester Machine capacity, and from the Client Specifications, which can be different from the AWWA Specification. The tables and the design program take into account a testing pressure of 2x PN.

5. PRODUCT RANGE

Available Pressure Class and Stiffness Class pairs are given in the Machine Specifications and in the CFW Pipe Design Program for different types of the TOPFIBRA CFW Machines. The limitations for the larger diameters and higher pressure/stiffness pairs are due to the structural capacity of the machines, to the sealing capacity of the gasket sleeve coupling, and due to the capacity of the Hydrotester Machine.

Gravity pipes actually have a Pressure Class of several bar, depending on the Stiffness Class. They differ from the pressure pipes only in the requirements for the hydraulic leak tightness test, which is made at a minimum test pressure (for example, 1.5 bar, according to the BS or ISO Standards). In other words, a "G" pipe is equal to a PN6 pipe, but for the designation and the less severe testing requirements.

6. PRESSURE LIMITATIONS

Pressure Class bar	***Up to Diameter mm***
PN 32	ND 600
PN 25	ND 1200
PN 20	ND 1600
PN 16	ND 2400
PN 10	ND 2600

7. PIPE WALL STRUCTURE

The pipe wall, manufactured on the TOPFIBRA EFW Machine consists of several layers. Starting from the inner side they are:

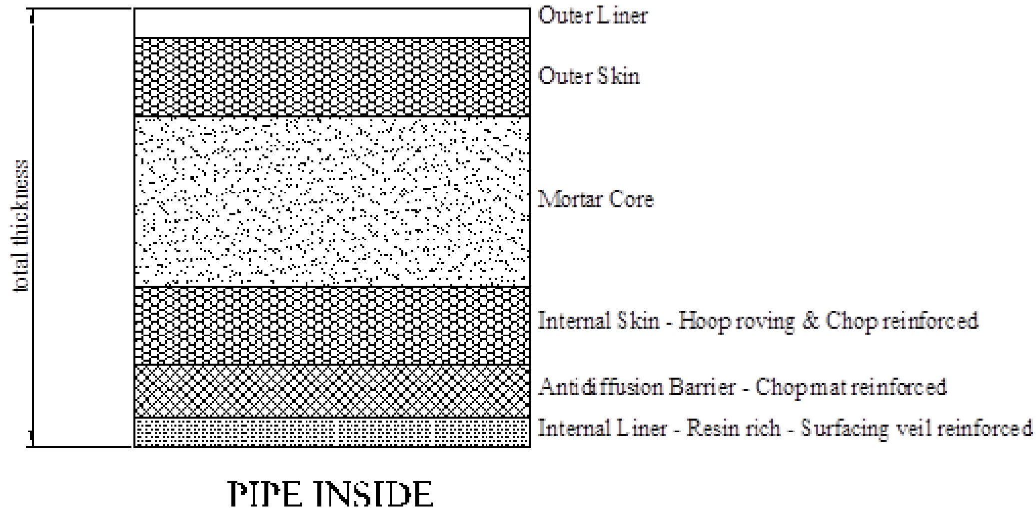


Figure 1

7.1. Internal Liner

It is the layer which is directly in contact with the internal fluid. It is rich in resin (approx. 90% by weight) and reinforced with a “surfacing veil” made of the “C” glass (chemical resistant very light fibreglass mat) or a polyester veil.

The thickness is approximately 0.2 mm for 1 surfacing veil, but it can be doubled.

NOTE: For the characteristics and specifications of the resin and of all the fibreglass reinforcements, please see the relevant chapters in the Raw Materials Handbook.

7.2. Anti-diffusion barrier

It is part of the internal liner, is resin rich (approx. 70% by weight) and is reinforced with chopped roving of the “E” glass. Its function is to stop the propagation of the micro-cracks from the mechanical layer (inner skin) to the internal liner.

The thickness of the diffusion barrier can be from 0.8 mm to 2 mm or more, depending on the Project Specification. The standard thickness is 0.8 mm.

7.3. Inner High-Strength Skin

It forms the mechanical resistant layer together with the core and the outer skin.

It is reinforced with a high strength hoop wound fibreglass roving (50÷60% by weight), and chopped roving (10÷20% by weight). The resin content is 25÷30% by weight.

7.4. Mortar Core

Mortar core serves to increase the thickness and the stiffness of the pipe without using a lot of valuable raw materials. The main constituent of the Mortar Core is silica sand, with a few hoop and chop roving, which is as low in resin as possible.

The TOPFIBRA pipes can also be manufactured without the mortar core, when a very high pressure is required or for special Client Specification requirements. In this case, the Inner and Outer Skins are a unique layer. The Pipe Design program allows the selection of this option, or selects it automatically when designing a high pressure pipe with low stiffness requirement, or if the mortar core is too thin.

7.5. Outer High-Strength Skin

Same as the Inner Skin. Generally, it has the same thickness as the Inner Skin, but it can be different.

7.6. Outer Liner

The outer liner can be simply made of pure resin, but can be also reinforced with a surfacing veil in order to increase the finishing and the chemical resistance to the environment.

COUPLINGS FOR THE TOPFIBRA CONTINUOUS FILAMENT WINDING MACHINE

COUPLINGS FOR THE TOPFIBRA CONTINUOUS FILAMENT WINDING MACHINE

TABLE OF CONTENTS

The EFW Pipe Design Program (PDP) allows you to calculate the pipe dimensions, coupling dimensions and gaskets dimensions for any spigot OD or Reka series, as well for the pipe designed for fixed ID, equal to the Nominal Diameter.

1. SLEEVE COUPLINGS

GRP pipes, manufactured on the continuous filament winding machine (EFW Type), are joined with sleeve couplings made of a lip-type elastomeric profile, which is inserted into the grooves of the GRP sleeve and covers the pipe spigot ends.

The hydraulic sealing of the pipe-sleeve system is achieved with:

4. the pressure of the conveyed fluid against the profile lips;
5. the compression of the elastomeric profile between the pipe's external surface.

This document applies to pipes with a 300 mm nominal diameter and larger.

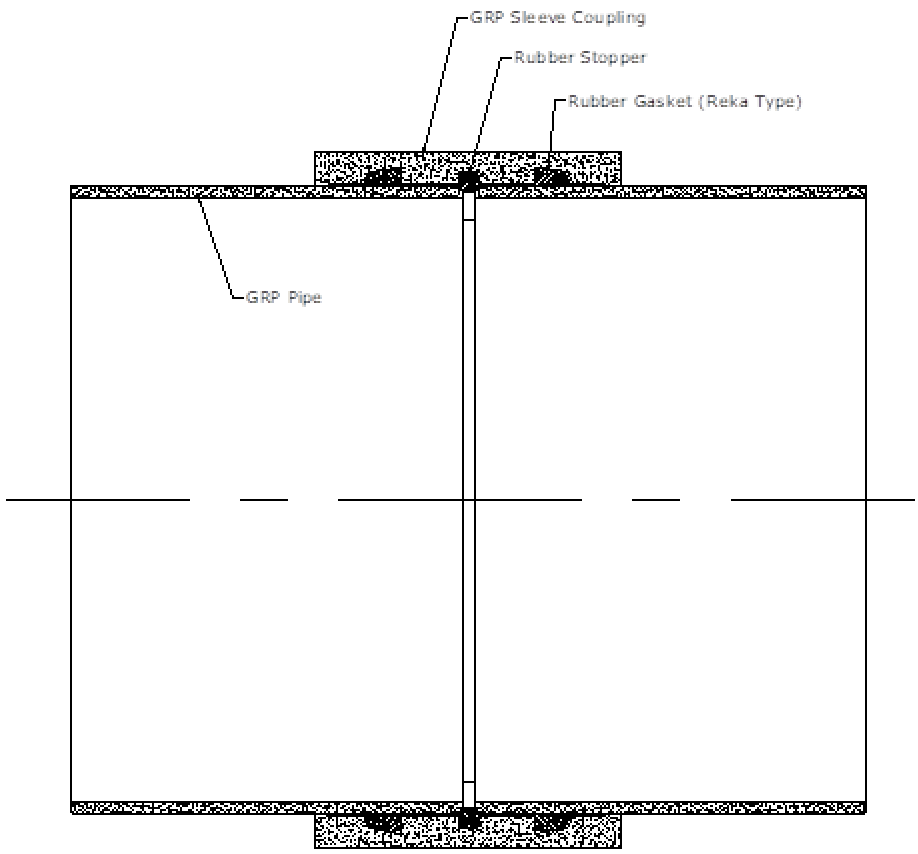


Figure 2

2. CONSTRUCTION

Sleeve couplings are manufactured from a specially manufactured pipe piece, which has specific physical and dimensional characteristics. They are worked by the Sleeve Grooving Machine according to the specifications and the figure in the next section.

2.1. Dimensioning of Sleeve Coupling with the Reka Ring Gaskets

The couplings dimensions are calculated in order to maintain the Radial Compression Ratio (RCR) greater than 22%, when the sleeve coupling expands due to the internal pressure.

The undeformed outer diameter of the sealing ring is calculated in order to have an optimum 4.5% circumferential compression at the assembly.

The thickness of the sleeve collar is calculated in order to have a RCR > 18% at a nominal pressure.

The construction of the sleeve collar is demonstrated by the following drawing:

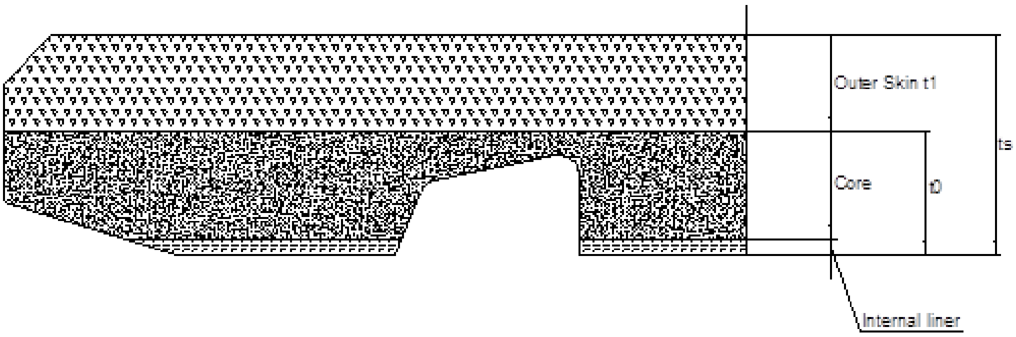


Figure 3: Sleeve collar structure

The composition and the thickness of the different sleeve layers are given in the EFW Pipe Design Program for each pipe diameter and pressure class, as well as the sleeve internal diameter.

The thickness of the sleeve collar is calculated while considering the pressure resistance of the core.

All machined surfaces must be coated with the resin.

3. CLASSIFICATION

Sleeve couplings vary according to their width:

- **type 250** have the width of 250 mm and Reka sealing rings, applicable to pipes with the 300 mm to and including the 700 mm nominal diameter;
- **type 300** have the width of 300 mm and Reka sealing rings, applicable to pipes with the 800 mm and to and including the 4000 mm nominal diameter.

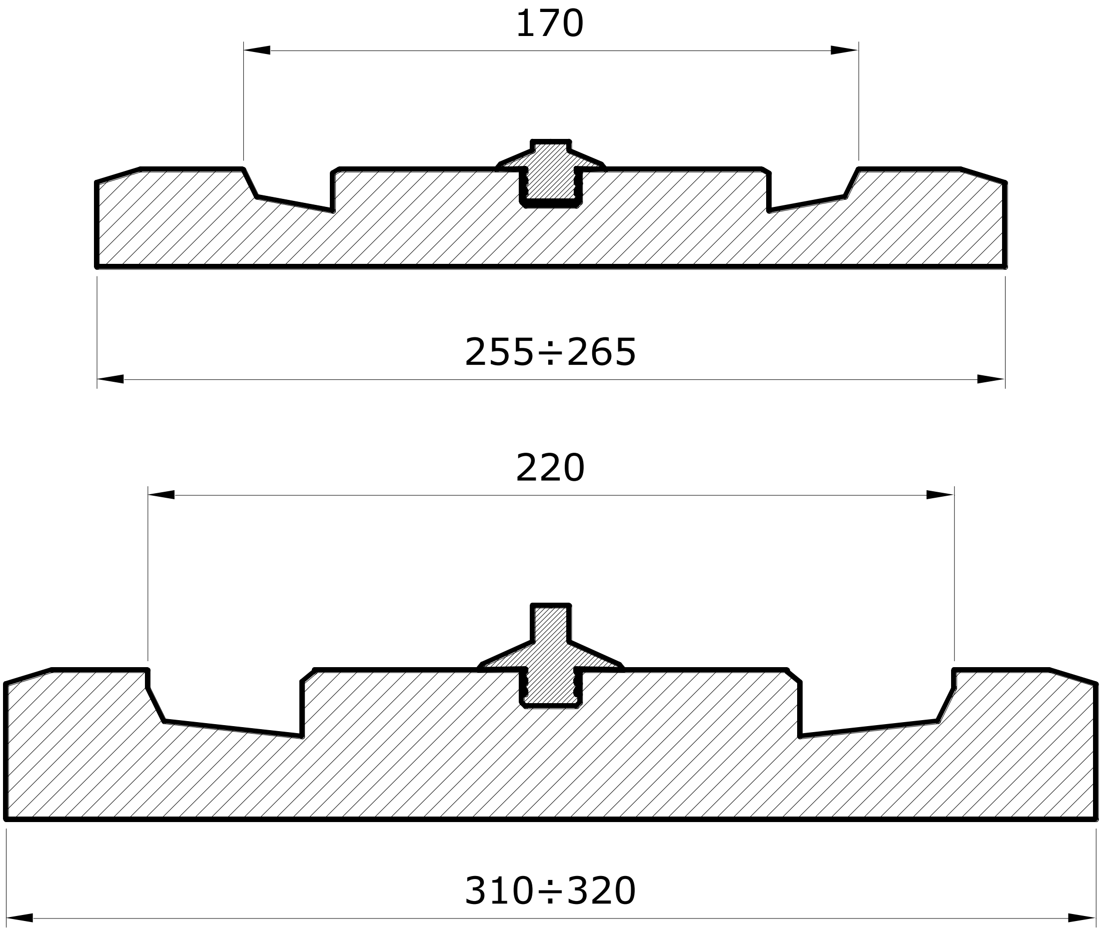
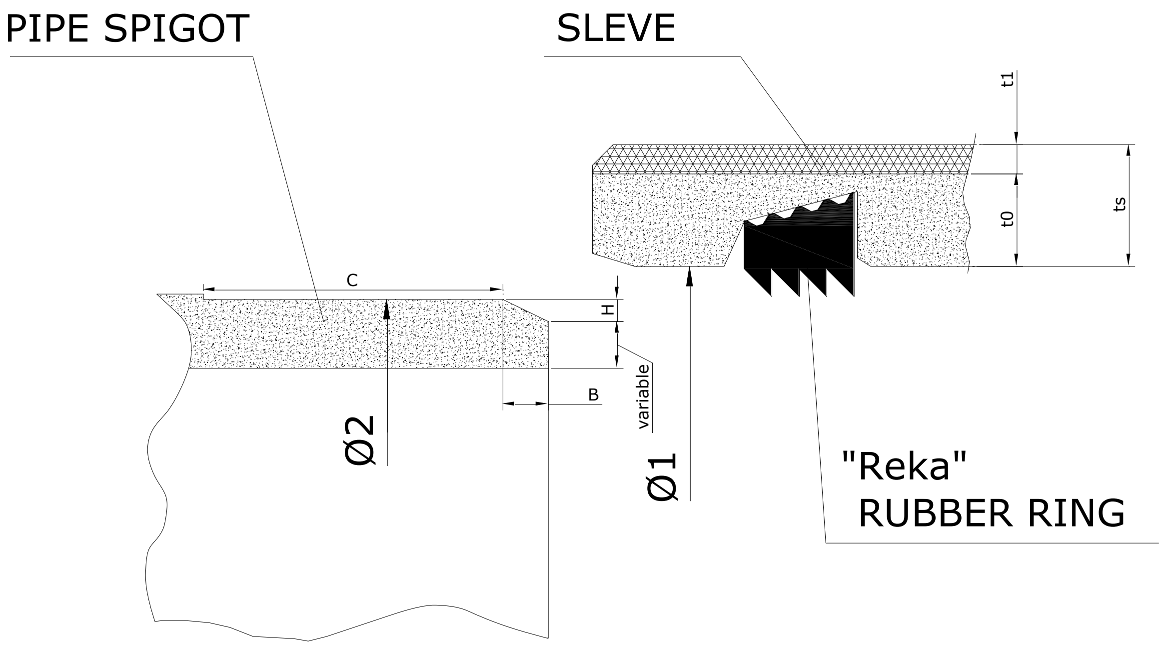


Figure 4: Type 250 and Type 300 sleeve

The meaning of the symbols and the joint parts dimensions are shown in the Figure 5.

DIMENSIONS OF JOINT PARTS



Ø1 = Sleeve ID
Ø2 = Spigot OD
t0 = liner+core
t1 = out skin
ts = total thick.
see CFW-Pipe Design Program

C = 163 mm
B= 17 mm for DN>=600
B= 10 mm for DN<600
H= 5 mm for DN>=600
H= 4 mm for DN<600

Figure 5: Coupling dimensions

All machined surfaces must be coated with the resin.

4. DIMENSIONS FOR THE GROOVE DEPTH AND SEALING RINGS

4.1. Grooving depth

Figure 6 demonstrates the millings profiles for different diameters:

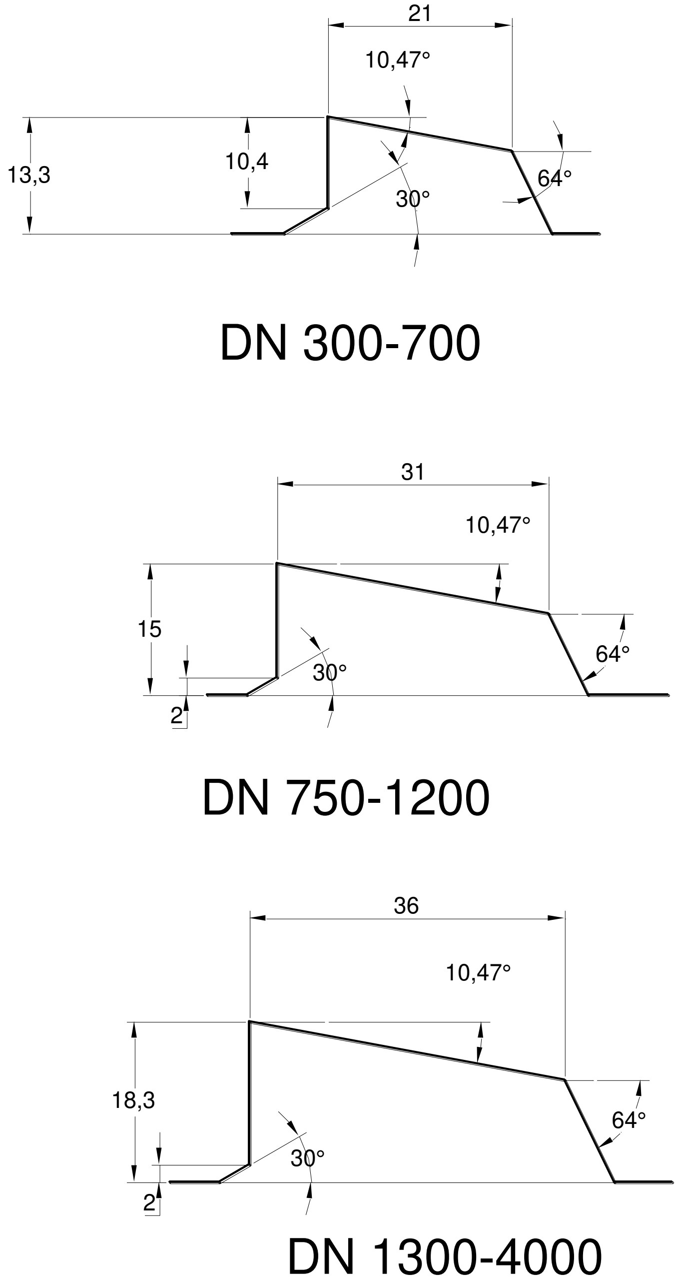


Figure 6: Groove profile

Reka ring and groove dimensions are given in this table and in the CFW Pipe Design Program. Dimensions are also given for the non-standard pipe OD. The grinding wheel sets, which are supplied with the Sleeve Grooving Machine, are designed to give the exact chamber. The spigot OD, sleeve ID and chamber ID may be different if the pipe is not produced according to the standard AWWA OD (for instance if the Client Specification requires an exact ISO ID).

Groove Dimensions (New Reka 2010 Series - International Unified Spigot OD Series)									
				Reka Ring		Chamber			
ND	Spigot OD	Sleeve ID	ID-OD gap	Thickness eg	Width lg	Width c +1-0	Internal Diameter d1	Depth	Chamfer
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
300	310	312	2	18	20,0	21,0	338,6	13,3	2,9
350	361	363	2	18	20,0	21,0	389,6	13,3	2,9
400	412	414	2	18	20,0	21,0	440,6	13,3	2,9
450	463	465	2	18	20,0	21,0	491,6	13,3	2,9
500	514	516	2	18	20,0	21,0	542,6	13,3	2,9
600	616	618	2	18	20,0	21,0	644,6	13,3	2,9
700	718	720	2	18	20,0	21,0	746,6	13,3	2,9
750	769	773	4	22	30,0	31,0	803,0	15,0	2,0
800	820	824	4	22	30,0	31,0	854,0	15,0	2,0
900	924	928	4	22	30,0	31,0	958,0	15,0	2,0
1000	1026	1030	4	22	30,0	31,0	1060,0	15,0	2,0
1050	1075	1079	4	22	30,0	31,0	1109,0	15,0	2,0
1100	1128	1132	4	22	30,0	31,0	1162,0	15,0	2,0
1200	1229	1233	4	22	30,0	31,0	1263,0	15,0	2,0
1300	1332	1336	4	26	35,0	36,0	1372,6	18,3	2,0
1400	1434	1438	4	26	35,0	36,0	1474,6	18,3	2,0
1500	1536	1540	4	26	35,0	36,0	1576,6	18,3	2,0
1600	1638	1642	4	26	35,0	36,0	1678,6	18,3	2,0
1700	1740	1744	4	26	35,0	36,0	1780,6	18,3	2,0
1800	1842	1846	4	26	35,0	36,0	1882,6	18,3	2,0
1900	1944	1948	4	26	35,0	36,0	1984,6	18,3	2,0
2000	2046	2050	4	26	35,0	36,0	2086,6	18,3	2,0
2100	2148	2152	4	26	35,0	36,0	2188,6	18,3	2,0
2200	2250	2254	4	26	35,0	36,0	2290,6	18,3	2,0
2300	2351	2355	4	26	35,0	36,0	2391,6	18,3	2,0
2400	2453	2457	4	26	35,0	36,0	2493,6	18,3	2,0
2500	2556	2560	4	26	35,0	36,0	2596,6	18,3	2,0
2600	2658	2662	4	26	35,0	36,0	2698,6	18,3	2,0
2800	2861	2865	4	26	35,0	36,0	2901,6	18,3	2,0
3000	3066	3070	4	26	35,0	36,0	3106,6	18,3	2,0
3200	3270	3274	4	26	35,0	36,0	3310,6	18,3	2,0
3400	3474	3478	4	26	35,0	36,0	3514,6	18,3	2,0
3600	3678	3682	4	26	35,0	36,0	3718,6	18,3	2,0
3800	3882	3886	4	26	35,0	36,0	3922,6	18,3	2,0
4000	4086	4090	4	26	35,0	36,0	4126,6	18,3	2,0

Groove Dimensions (New Reka 2010 Series - International Unified Spigot OD Series)									
				Reka Ring		Chamber			
ND	Spigot OD	Sleeve ID	ID-OD gap	Thickness eg	Width lg	Width c *+1-0*	Internal Diameter *d1*	Depth	Chamfer
mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
300	310	312	2	18	20,0	21,0	338,6	13,3	2,9
350	361	363	2	18	20,0	21,0	389,6	13,3	2,9
400	412	414	2	18	20,0	21,0	440,6	13,3	2,9
450	463	465	2	18	20,0	21,0	491,6	13,3	2,9
500	514	516	2	18	20,0	21,0	542,6	13,3	2,9
600	616	618	2	18	20,0	21,0	644,6	13,3	2,9
700	718	720	2	18	20,0	21,0	746,6	13,3	2,9
750	769	773	4	22	30,0	31,0	803,0	15,0	2,0
800	820	824	4	22	30,0	31,0	854,0	15,0	2,0
900	924	928	4	22	30,0	31,0	958,0	15,0	2,0
1000	1026	1030	4	22	30,0	31,0	1060,0	15,0	2,0
1050	1075	1079	4	22	30,0	31,0	1109,0	15,0	2,0
1100	1128	1132	4	22	30,0	31,0	1162,0	15,0	2,0
1200	1229	1233	4	22	30,0	31,0	1263,0	15,0	2,0
1300	1332	1336	4	26	35,0	36,0	1372,6	18,3	2,0
1400	1434	1438	4	26	35,0	36,0	1474,6	18,3	2,0
1500	1536	1540	4	26	35,0	36,0	1576,6	18,3	2,0
1600	1638	1642	4	26	35,0	36,0	1678,6	18,3	2,0
1700	1740	1744	4	26	35,0	36,0	1780,6	18,3	2,0
1800	1842	1846	4	26	35,0	36,0	1882,6	18,3	2,0
1900	1944	1948	4	26	35,0	36,0	1984,6	18,3	2,0
2000	2046	2050	4	26	35,0	36,0	2086,6	18,3	2,0
2100	2148	2152	4	26	35,0	36,0	2188,6	18,3	2,0
2200	2250	2254	4	26	35,0	36,0	2290,6	18,3	2,0
2300	2351	2355	4	26	35,0	36,0	2391,6	18,3	2,0
2400	2453	2457	4	26	35,0	36,0	2493,6	18,3	2,0
2500	2556	2560	4	26	35,0	36,0	2596,6	18,3	2,0
2600	2658	2662	4	26	35,0	36,0	2698,6	18,3	2,0
2800	2861	2865	4	26	35,0	36,0	2901,6	18,3	2,0
3000	3066	3070	4	26	35,0	36,0	3106,6	18,3	2,0
3200	3270	3274	4	26	35,0	36,0	3310,6	18,3	2,0
3400	3474	3478	4	26	35,0	36,0	3514,6	18,3	2,0
3600	3678	3682	4	26	35,0	36,0	3718,6	18,3	2,0
3800	3882	3886	4	26	35,0	36,0	3922,6	18,3	2,0
4000	4086	4090	4	26	35,0	36,0	4126,6	18,3	2,0

4.2. Tolerances

The machined spigot OD is given in the chapter "GRP Pipe Specification and Manufacturing", according to the AWWA/ISO/ASTM Tables, Metric Series International OD.

The AWWA/ISO/ASTM tolerances mean that the pipe with a certain nominal size can be supplied in that size range.

The manufacturing tolerances are ±0.5 mm for all sizes.

For example, a batch of ND 1000 pipes may be manufactured and supplied with an average 1024 mm spigot OD of instead of 1026mm (i.e. the batch will pass the inspection), but all pipes of the batch must be the same, with a 1024.5 mm ÷ 1023.5 mm spigot OD range.

The same applies to the sleeve ID. The sleeve ID shall be determined according to the actual pipe spigot OD or vice versa. The common practice is to first manufacture the pipes for sleeves, and then to adjust the spigot OD to the sleeve ID, according to the gap foreseen by the design.

4.3. Sealing Rings

The dimensions, which are relevant to the sealing rings profiles for the different types of sleeve couplings, are given in this table and drawings:

Reka Ring Dimensions (New Reka 2010 Series) (International Unified Spigot OD Series)					
ND	**Cutting Length** *mm*	**Ring OD** ***dag*** *mm*	**Ring ID** ***dig*** *mm*	**eg ±0.4** *mm*	**lg ±0.4** *mm*
300	*(1.059)*	355	319	18	20
350	*(1.225)*	408	372	18	20
400	*(1.392)*	461	425	18	20
450	*(1.561)*	515	479	18	20
500	*(1.728)*	568	532	18	20
600	*(2.064)*	675	639	18	20
700	*(2.400)*	782	746	18	20
750	*(2.573)*	841	797	22	30
800	*(2.739)*	894	850	22	30
900	*(3.082)*	1003	959	22	30
1000	*(3.418)*	1110	1066	22	30
1050	*(3.578)*	1161	1117	22	30
1100	*(3.754)*	1217	1173	22	30
1200	*(4.087)*	1323	1279	22	30
1300	4433	1437	1385	26	35
1400	4769	1544	1492	26	35
1500	5105	1651	1599	26	35
1600	5441	1758	1706	26	35
1700	5777	1865	1813	26	35
1800	6110	1971	1919	26	35
1900	6447	2078	2026	26	35
2000	6783	2185	2133	26	35
2100	7119	2292	2240	26	35
2200	7455	2399	2347	26	35
2300	7785	2504	2452	26	35
2400	8121	2611	2559	26	35
2500	8460	2719	2667	26	35
2600	8796	2826	2774	26	35
2800	9462	3038	2986	26	35
3000	10138	3253	3201	26	35
3200	10810	3467	3415	26	35
3400	11479	3680	3628	26	35
3600	12152	3894	3842	26	35
3800	12821	4107	4055	26	35
4000	13493	4321	4269	26	35

Tolerance on ring OD – ID: ±0.5%.

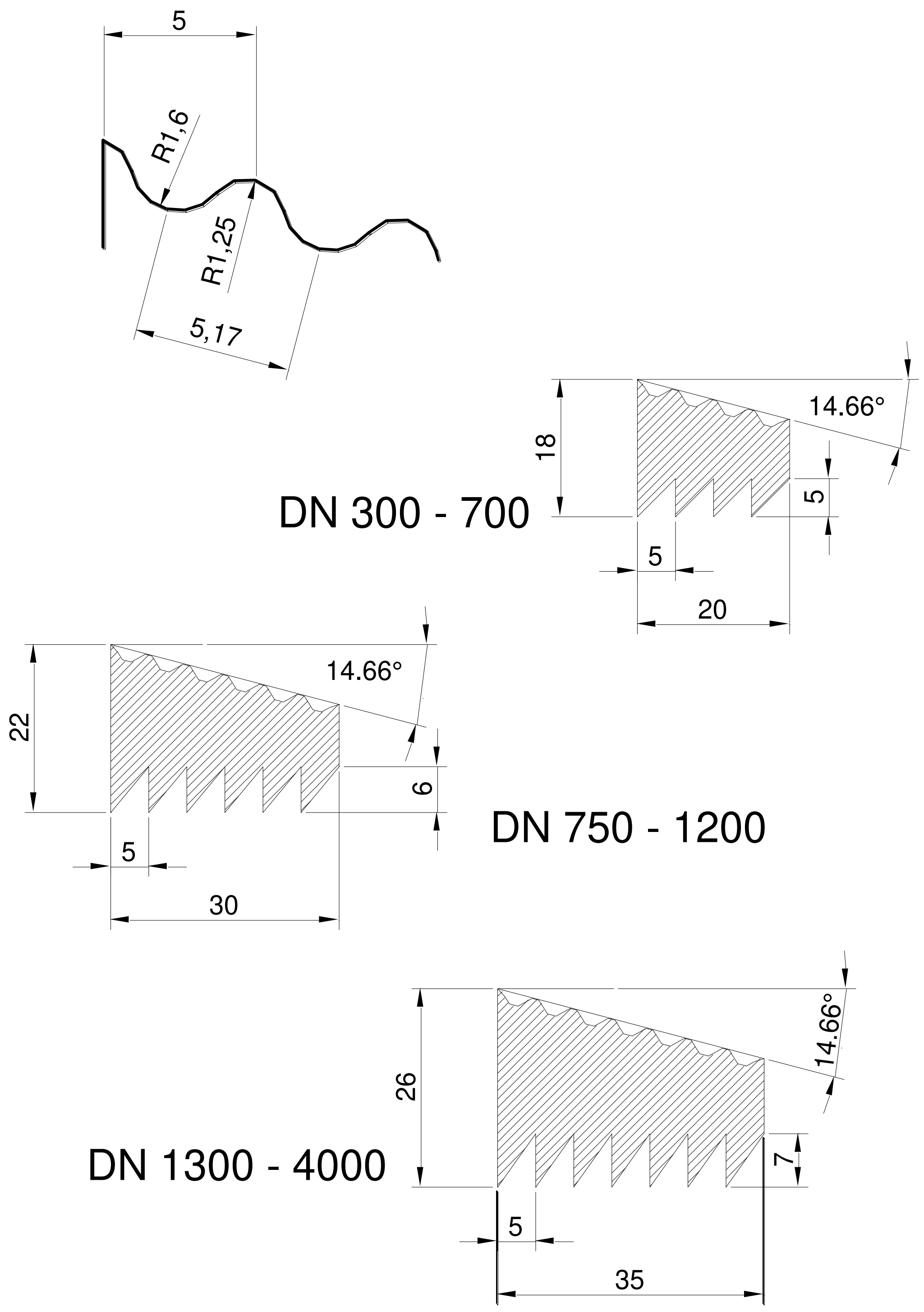


Figure 7: Reka Ring sections

5. MATERIAL FOR SEALING RINGS

Extrusion is not suitable and is not suggested for this type of lip-gasket.

The recommended material for sealing rings is EPDM – Ethylene Propylene Copolymer and Thermopolymer, which is resistant to animal and vegetable oils, ozone, and strong and oxidizing chemicals. It is vulnerable to mineral oils, solvents and aromatic hydrocarbons.

The recommended EPDM rubber properties for sealing rings are given in the following table, while no prescription is foreseen for the forming rings.

5.1. Table 4A – Standard EPDM Rubber

Property	**Unit**	**Standard**	**Value**
Cured 20' at 170°C			
Density	kg/dm3		1.18±0.02
Hardness	Shore A	ISO 48	55±5
Tensile strength	MPa	ISO 37	>9
Elongation at break	%	ISO 37	>250
Compression set		ISO 815	
after 22h at 23°C ± 2°C	%		<20
after 22h at 70°C ±1°C	%		<25
After hot air ageing 70h at 70°C±1°C		ISO 188	
Hardness change	Shore A	ISO 48	max +5
Elongation change	%	ISO 37	max -20
Tensile strength change	%	ISO 37	max -30
Ozone resistance		ISO 1431-1	No cracks

5.2. Table 4B –EPDM Rubber for Potable Water

Property	**Unit**	**Standard**	**Value**
Cured 20' at 170°C			

Density	kg/dm3		1.10±0.2
Hardness	Shore A	ISO 48	70 ± 5
Tensile strength	MPa	ISO 37	>9
Elongation at break	%	ISO 37	>200
Compression set		ISO 815	
after 72h at 23°C ±2°C	%		<15
after 24h at 70°C ±1°C	%		<20
after 72h at -10°C ±1°C	%		<50
Hot air ageing 70h at 70°C ±1°C		ISO 188	
Hardness change (max)	Shore A	ISO 48	max +8
Elongation change (max)	%	ISO 37	max -20
Tensile strength change (max)	%	ISO 37	max -30
Distilled Water Aging at 70°C		ISO 1817	
Volume change	%		-5/+8
Ozone resistance		ISO 1431-1	No cracks

5.3. Table 4C –NBR Rubber – Oil Resistant

Property	**Unit**	**Standard**	**Value**
Cured 20' at 170°C			
Density	kg/dm3		1.27±0.02
Hardness	Shore A	ISO 48	70 ± 5
Tensile strength	MPa	ISO 37	> 10
Elongation at break	%	ISO 37	> 250
Compression set		ISO 815	
after 22h at 23°C ±2°C	%		< 20
after 22h at 70°C ±1°C	%		< 25
Hot air ageing 168h at 70°C		ISO 188	

Hardness change	Shore A	ISO 48	max +8
Elongation change	%	ISO 37	max -10
Tensile strength change	%	ISO 37	max -30
ASTM Oil N 1 Aging 72h at 70°C		ISO 1817	
Volume change	%		±15
ASTM Oil N 3 Aging 72h at 70°C		ISO 1817	
Volume change	%		max +50
Ozone resistance		ISO 1431-1	No crack

5.4. Ring Joint Strength

Large size ring gaskets can be produced by joining sections obtained by cutting smaller gaskets or the discontinuously molded ones.

The joint is obtained by the injection molding and the fusion of rubber material.

The joint must be subjected to the tensile test and the tensile strength of the joint should be 1000 N (100 kg) for lg =25 mm and below or 1500 N (150 kg) for greater sizes.

5.5. Elastomer Quality Control

The pipe manufacturer should make a visual inspection of sealing rings to check that no extrusion defects and burrs are present. Special care should be taken of the dimensional check of the sealing rings for each previously defined type.

Visual inspection and dimensional control of the profiles is performed on the strips about 50 mm wide, cut at a right angle off the sealing rings.

6. APPLICATION OF SLEEVE COUPLINGS

Sleeve couplings are applied to one end of the pipes before delivering on site. The joining is performed by means of special equipment (the Sleeve Coupling Joining Machine). This operation is performed in compliance with the following steps:

1. Visual inspection of the pipe end to assure that the cut section has not suffered damages during handling and that the rectified part as well as the cut section have been protected with an outer layer of pure resin.
2. Control of the bevel dimensions and their uniformity all around the circumference of the pipe.
3. Clean carefully the rectified surface of the pipe with a rag and then run over the hand to assure the absence of any residual grit.
4. Mark the insertion limit on the pipe circumference using a measuring tape, a marker and a strip of flexible material such as PVC.
5. Clean carefully the internal surface of the sleeve coupling with a rag and then run a hand over to assure that no residual grit, dirt, sagging or resin drops are present.
6. Lubricate the surfaces to be coupled by running over the rectified zone of the pipe and the inside of the sleeve coupling with a rag impregnated with liquid soap with sodium, the content of the latter lower than 5%. Do not use grease.
7. Slowly put the sleeve coupling on the pipe with the Sleeve Joining Machine up to the insertion limit. At the end of the operation check the alignment between the pipe and sleeve, thus, assure that the edge of the pipe is placed uniformly against the retainer of the sealing ring, without gaps or super-impositions.

The Sleeve Joining Machine guaranties perfect alignment of the sleeve coupling with the pipe axis. Unlike the sleeve coupling applied in the factory, in case of field installation the sleeve coupling allows a certain misalignment of the joined elements, without leakage in the joint.

The maximum allowed pipe to pipe angular deviation and the allowed bending radius for the pipeline are shown per classes of diameters in the following table:

Pipe diameter	**Pipe to Pipe Angular Deflection**	**Bending Radius**	
		L = 6 m	**L = 12 m**
300≤DN ≤ 600	4.0°	86	172
600<DN ≤ 750	3.5°	98	196
750 < DN ≤ 900	3.0°	115	229
900 < DN ≤ 1100	2.5°	138	275
1100 < DN ≤ 1400	2.0°	172	344
1400 < DN ≤ 1900	1.5°	229	458
1900 < DN ≤ 2800	1.0°	344	688
2800 < DN ≤ 3800	0.75°	458	917
3800 < DN ≤ 4000	0.5°	688	1375

Bending radius depends on the section length of the pipe. This table shows the standard 6 m and 12 m section lengths, but the bending radius can be easily calculated since it is in inverse relation to the section length (3 m section length will have half the radius of the 6 m section length).

E-CONTINUOUS FILAMENT WINDING MACHINE DESCRIPTION

E-CONTINUOUS FILAMENT WINDING MACHINE DESCRIPTION

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1. E-CFW MACHINE

EFW machine produces GRP pipes using the continuous winding technology without stopping. The machine includes online pipe chamfering, rectifying and cutting.

The machine is composed of three principal parts:

- Winding station (**Error! Reference source not found.**, zone 1);
- Curing station (Figure 8, zone 2);
- Cutting and unloading station (Figure 8, zone 3).

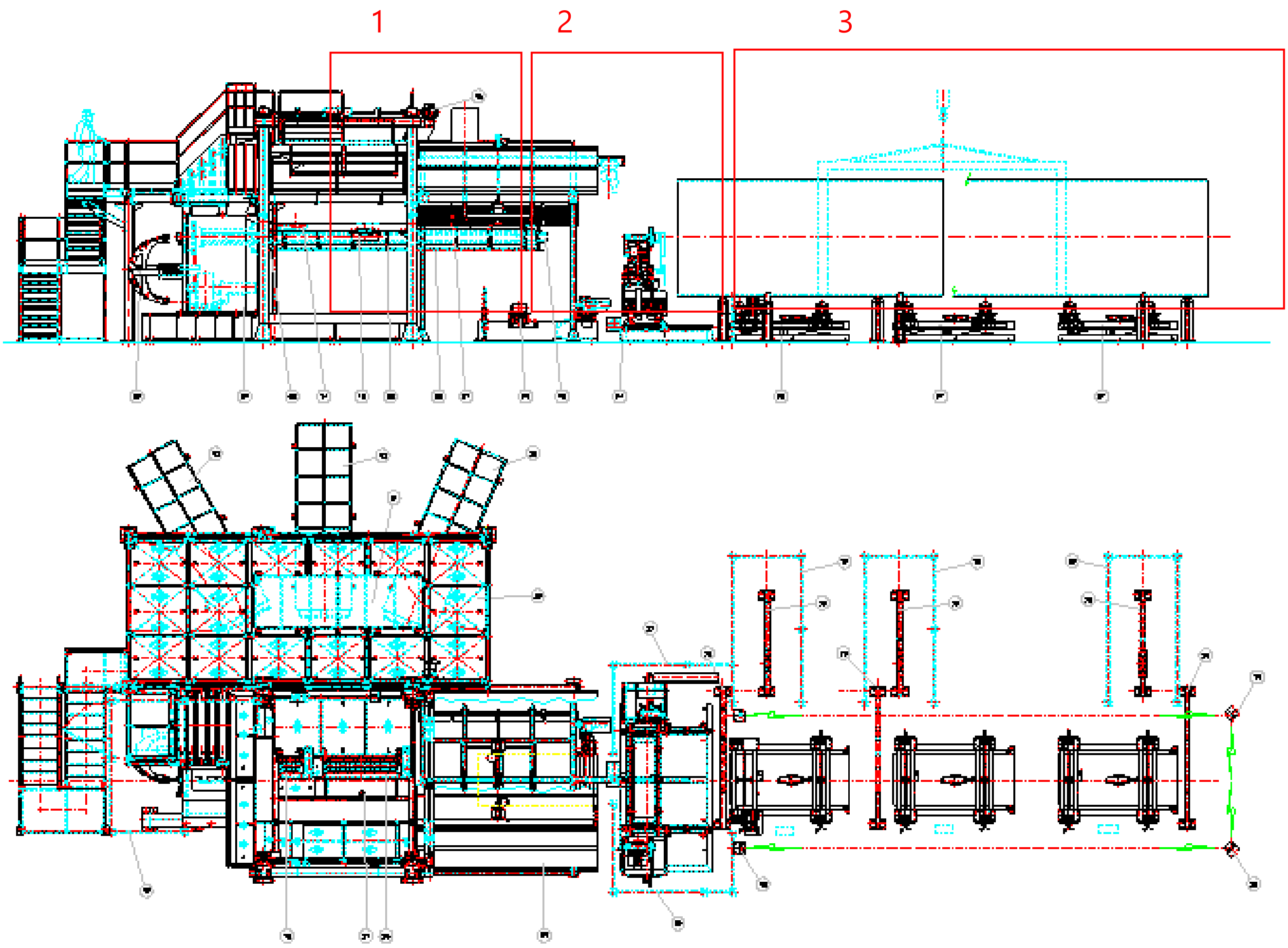

Figure 8: Continuous filament winding machine, general assembly

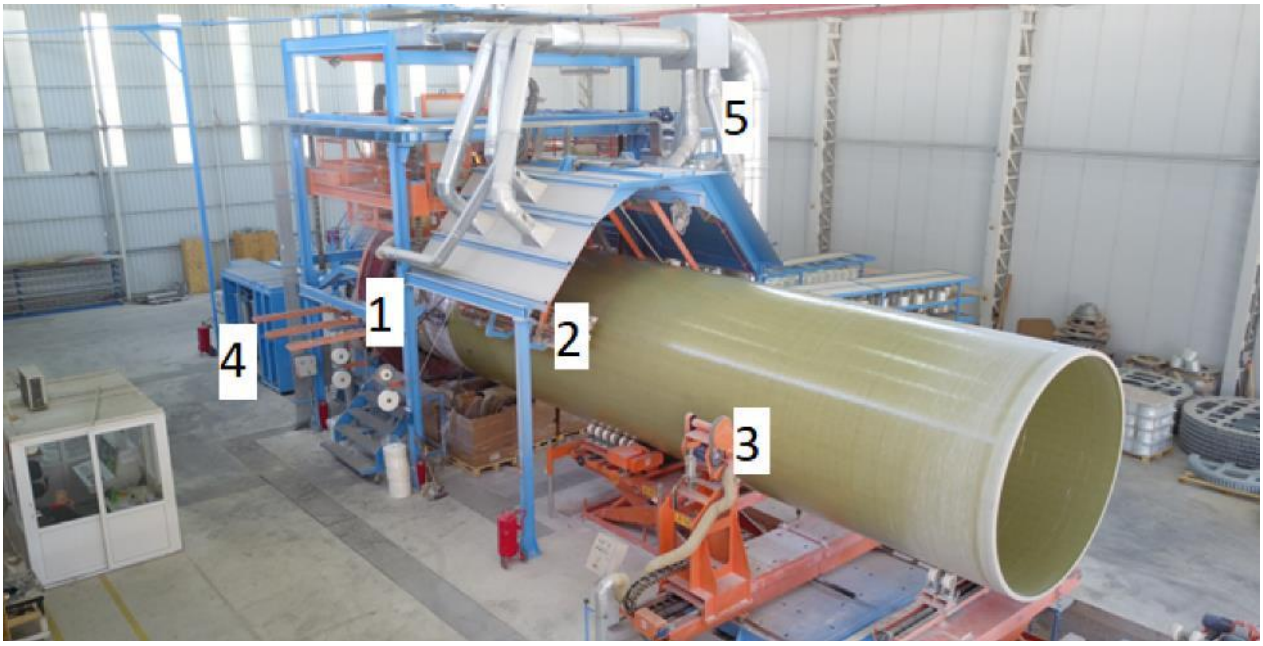

Figure 9: The general view of Continuous filament winding machine: winding station (1), curing station (2), cutting and rectifying unit (3), resin feeding system (4), and styrene aspiration duct from the top (5)

Figure 10: Continuous filament winding machine during the production.

2. WINDING STATION

In this area the pipe is produced by winding fibreglass in various forms (tissues, continuous roving, chopped roving) plus silica sand filler. At the same time, they are impregnated with the liquid resin. All of this combined, makes up the pipe wall.

The liner station is first, because it manufactures and partially cures the inner liner, before the structural part of the pipe wall is made.

Figure 11: EFW winding area (with marked liner and structure winding areas)

The liner manufacturing devices are:

- Mylar winder, which covers and protects the mandrel;
- C-veil winders, which create the inner skin of the liner;
- Chopper, which cuts glass fibers in 50.6mm long pieces;
- Resin dispenser, including the static mixer for mixing the resin and catalyst.

Figure 12: Mylar unwinder with Mylar detection sensor, and veil unwinder

The structure manufacturing devices are:

- Hoop roving guide, hoop tensioner and combs
- Structure chopper, which cuts the fibers in 53.3 mm long pieces;
- Resin dispenser, including the static mixer for mixing the resin and catalyst;
- Sand dispenser, which feeds sand to the core to increase the thickness of the structural pipe wall
- Surface veil winders, which provide a better finish of the outer pipe surface;
- Compaction rollers, which compact the applied materials during the manufacturing and Finishing Rollers which help obtain a good pipe surface

Figure 13: Hoop roving guide, hoop tensioner and combs

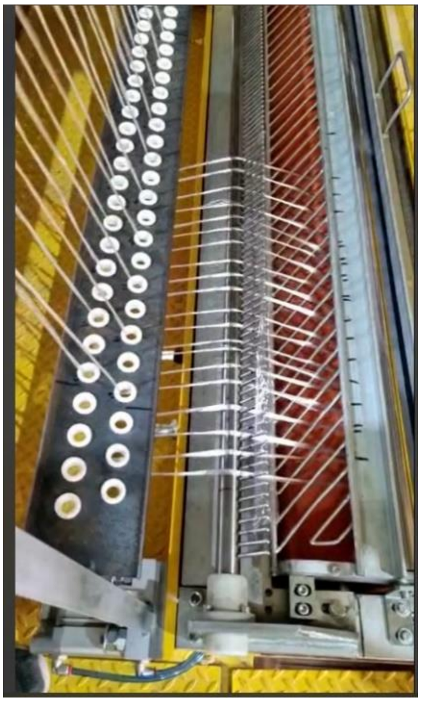

Figure 14: Structure Choppers

Figure 15: Resin dispensers

Figure 16: Sand dispenser

Figure 17: Compaction roller, finishing roller, surface veil unwinder

3. CURING STATION

In this the area, the manufactured pipe is hardened after winding. The curing station consists of four infrared lamps batteries, independent of each other. They allow you to set different temperatures for the polymerization of the resin. In order to measure the pipe's temperature during the cure, ten pyrometers are located along the length of the lamps.

Figure 18: Curing station with IR lamps

4. CUTTING AND UNLOADING STATION

In this area, the manufactured pipe is grinded, chamfered and cut to the correct length. During the grinding operations, the pipe end is worked and the spigot is manufactured.

The grinding, chamfering and cutting are online and automatic, so there is no need to stop the production of the pipe for working its end.

After the pipe has been cut, it is unloaded by four lifting tables discharging beams with load cells

Figure 19: Cutting (a) and grinding (b) unit

Figure 20: Weighing station

SETTING THE EFW MACHINE BEFORE START-UP

SETTING THE EFW MACHINE BEFORE START-UP

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1. MAIN SHAFT INSTALLATION/ CHANGE

To remove or insert the main shaft please follow the procedure:

Shaft insertion and extraction procedure & tool rev00 of the E-CFW operation manual

2. INSTALLING DISKS AND SPACERS

The first operation is the assembly of the mandrel, according to the produced pipe diameter. The operations for the two different shafts differ:

- Shaft 200 for Pipe diameters 300-500
- Shaft 360 for Pipe Diameters 600-2600

2.1. Mandrel on 360 mm Shaft - Assembly

360 mm shaft is used for the production of the pipe with ND600-2600 diameter range. The step is to install the disks and spacers. The following sequence demonstrates the right way to assemble these devices:

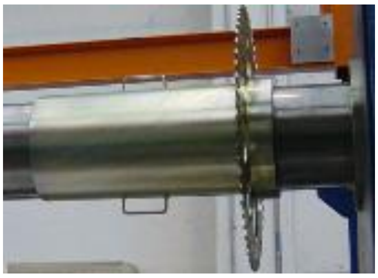

Figure 21: Step 1

Figure 22: Step 2

Figure 23: Step 3

The disks shall be positioned by a keyway. Be sure to use the right groove on the disk to fix it to the keyway.

The last spacer is shorter than the others. The head flange shall be used to fix the spacer and the disks. The internal series of screw will fix the flange to the shaft, the external screws will push on the last spacer to compact all the systems.

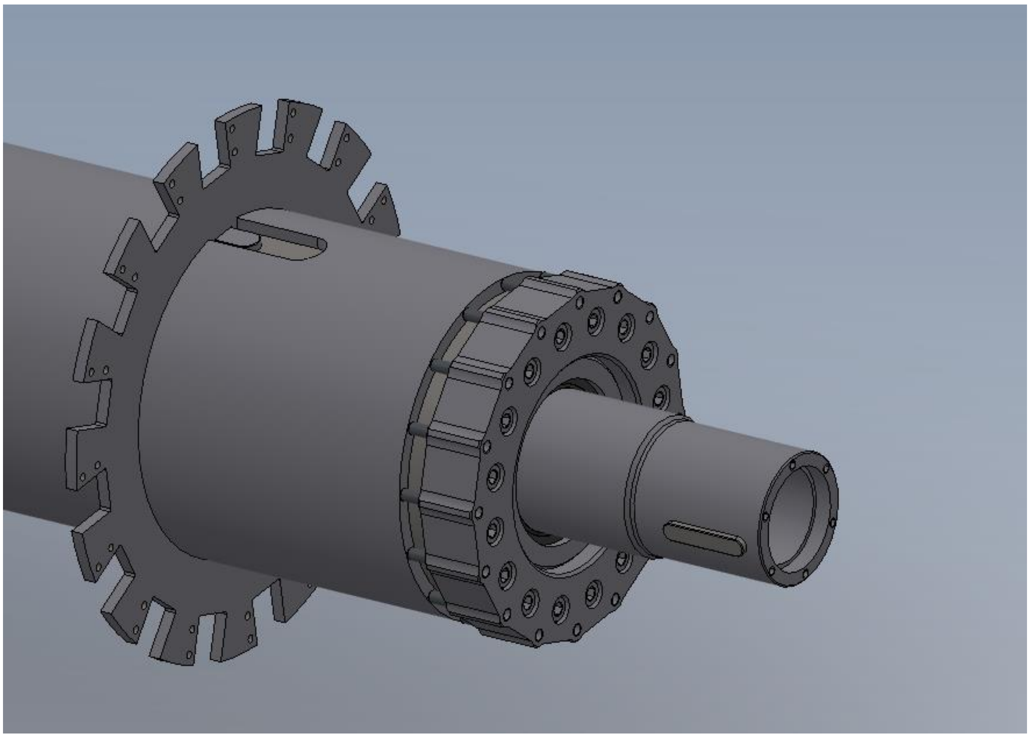

Figure 24

The last step is to fix the spacer beams (where foreseen). Insert the spacers and the beam in the disk holes, as shown in the picture, and fix them with bolts on the ends.

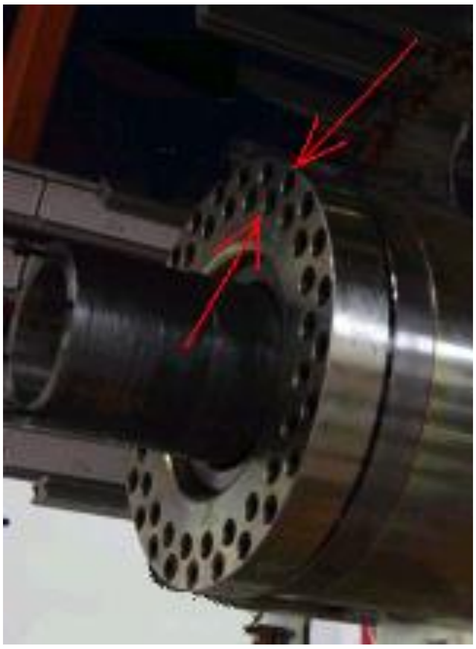

Figure 25: Head flange

Figure 26: Spacers beams

2.2. Mandrel on 200 mm Shaft - Assembly

The 200 mm shaft is used to produce pipes from 300-500 diameter range. The assembly sequence mostly the same as for the 360 mm shaft, with some difference. The cam must be installed first and the plate must be fixed to the big cam of the machine.

Figure 27

After that, the disks and the spacer can be installed. The principle is the same as for the 360 mm shaft but in this case some intermediary disks have to be installed.

Make sure to use the right disk groove to fix it in the keyway.

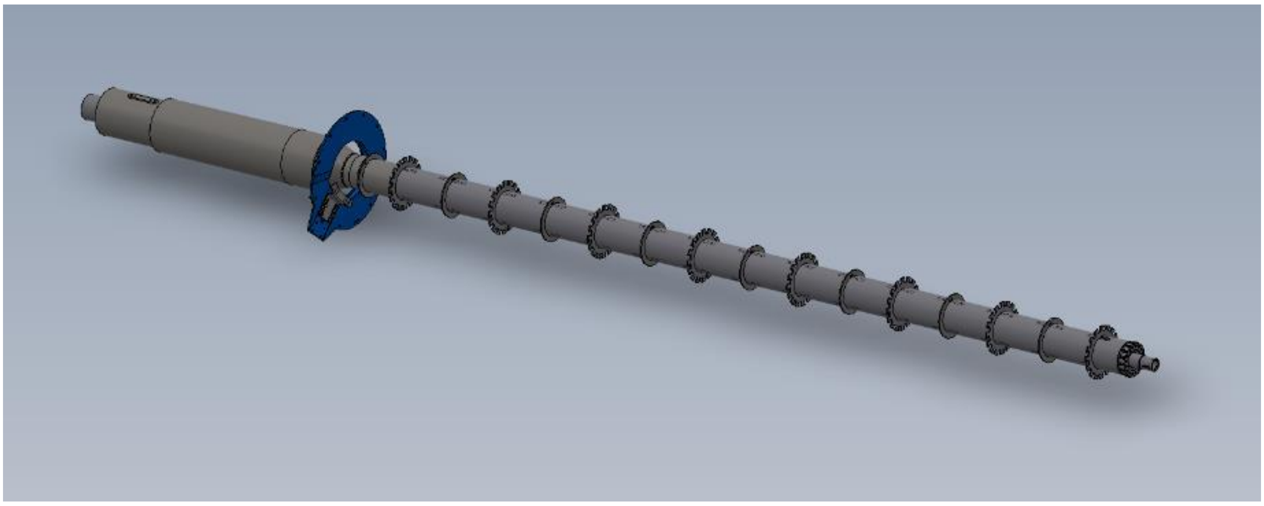

Figure 28

The head flange shall be used to compact all the systems.

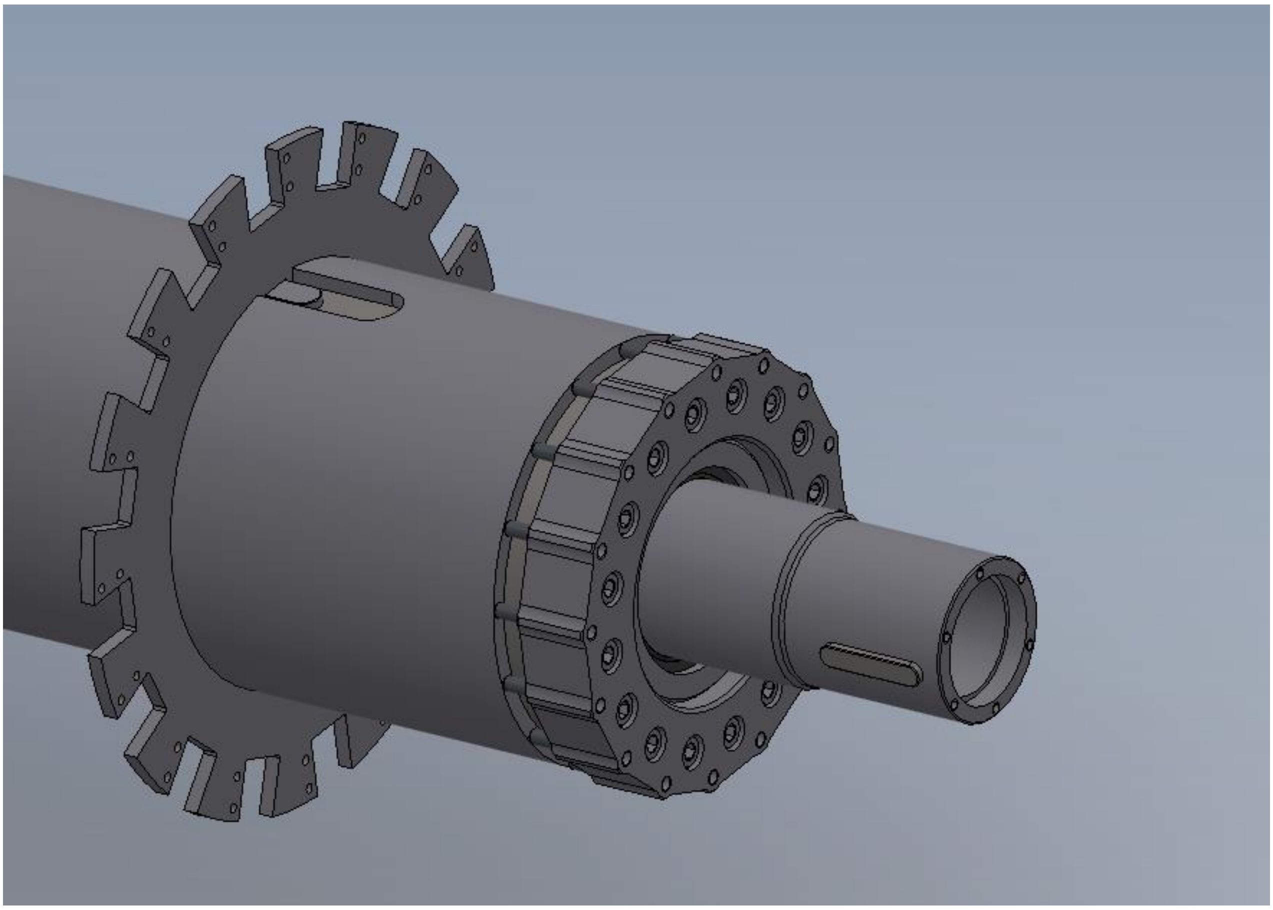

Figure 29

3. ALUMINIUM BEAMS CALIBRATION

Beams with different thickness and shapes are available to adjust the mandrel diameter, depending on the thickness of the pipe which will be produced.

Figure 30: Low beams *Figure 31: Medium beams*

When dealing with thin beams, the fixing clamp is screwed around the beam itself.

3.1. Medium height beams

A regulation device is available to adjust the heights of the beams. The device must be calibrated so it corresponds to the height of the beam. After that, the shim has to be inserted in the groove at the back side of the beam. Then, using the calibrator, the spacer screw of the shim has to be regulated with an Allen key. Once the spacer screw has been regulated, it has to be fixed with the lateral socket set screw.

4. LOW BEAMS

Thin beams are used exclusively for the production of the small 12" 14" diameter pipes and couplings. The calibration is performed by fixing the low beam spacer and regulate the height with the regulation screw.

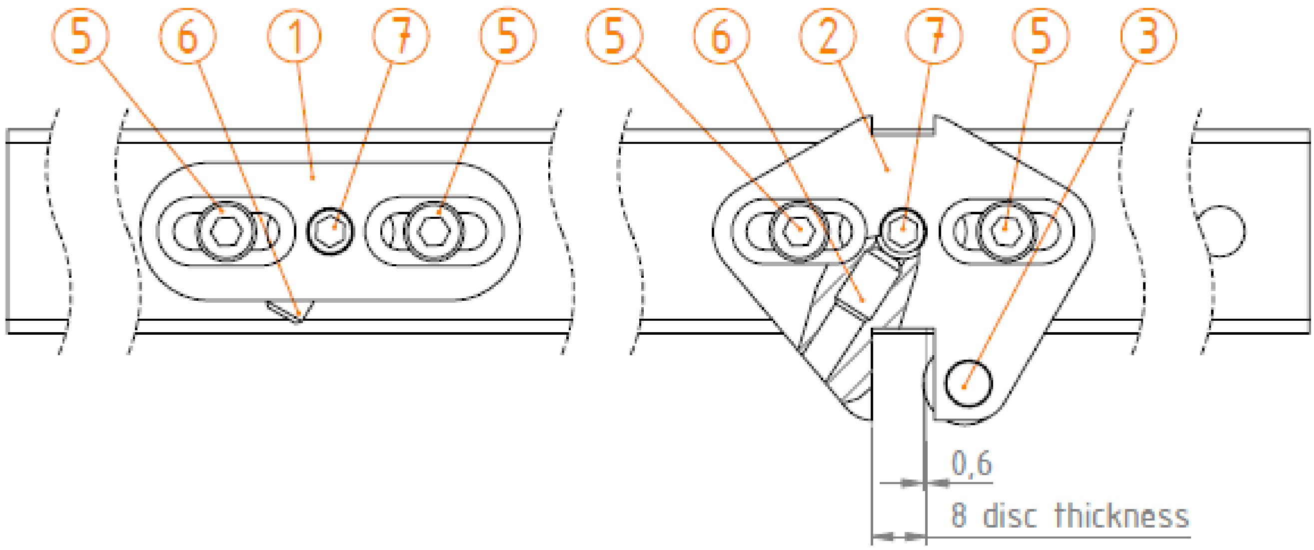

Figure 32

5. ALUMINIUM BEAMS INSTALLATION

5.1. Medium height beams

Insert the beam in the disks grooves. Pay close attention, because the deeper grooves are for the pipe production; and the shallow groves are for the sleeve production. Once the beam is in grooves, fix it to the disks with the shim screws. Make sure that the spacer shim screw touches the bottom of the groove. During assembly, alternate the beams with pushers, with the beams without pushers (see Figure 33).

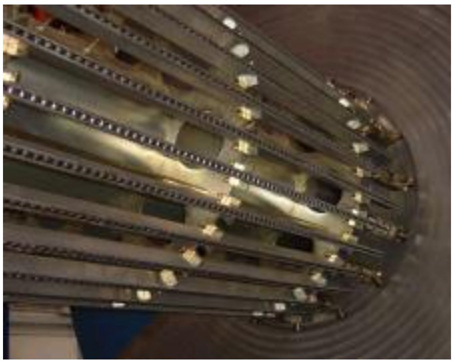

Figure 33: Aluminium beam assembly

5.2. Low beams

Insert the beam in the disks grooves. Once the beam is in grooves, fix it to the disks with the shim screws. Make sure that the spacer shim screw touches the bottom of the groove.

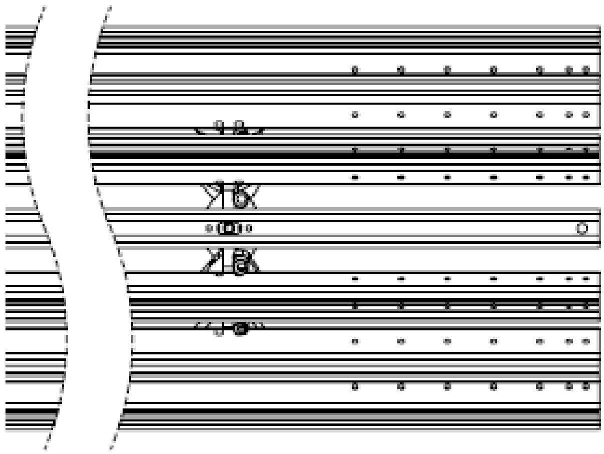

Figure 34

6. RETURNING DEVICE INSTALLATION

Once the assembly of the beams has been finished, the returning device shall be installed. Fix it on the extremity of the mandrel and regulate the height of the bearings supporting arms in order to achieve a perfect alignment with the beams.

Figure 35: Mandrel extremity

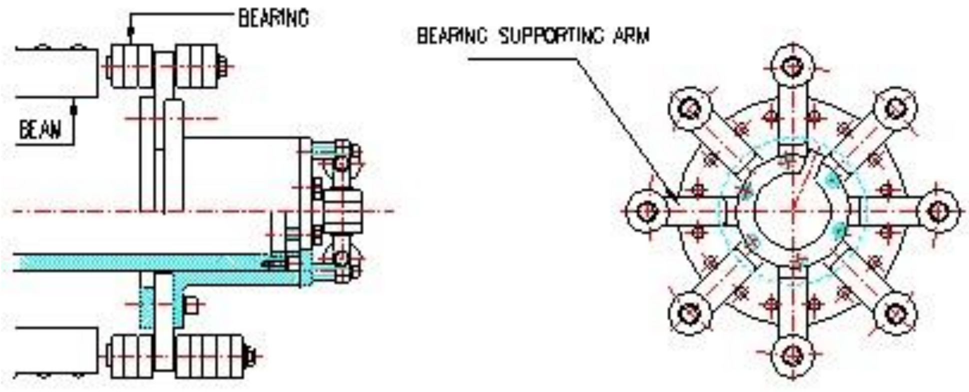

Figure 36: Returning device scheme

The beams should be as close as possible to the radial bearings of the returning device. In any case, this distance should not be more than 1 cm. Adjust the position of the returning device by releasing the blocking flange in the back of the machine.

Figure 37

7. STEEL BAND

7.1. Installation Steel Band

Start to install the steel band close to the machine's cam plate. Fix the steel band by adhesive tape or a clamp. Wind the band along the whole length of the mandrel to the exit head. Then release the tape, or a clamp fixing the steel band, and guide it through the guiding bearings of the exit head. The exit of the steel band should be on the upper side of the mandrel, slightly to the left of the vertical diameter. When the steel band exits from the back of the machine, guide it through the tensioning device and prepare it for welding.

Figure 38: Steel band winding

Figure 39: Steel band exit

Figure 40: Tensioning device

7.2. Welding Steel Band

Using the shear of the welding machine, cut the extremities of the steel band to make them fit perfectly.

Establish a value for the "Welding Path" and use the welder's switch to set it. Then put the two steel band extremities between the clamps, ensure the joint is perfectly in the middle of the welding path, and clamp the two steel band extremities.

For the welding procedure please refer to:

WELDING MACHINE KN 41 USER MANUAL

Figure 41

During welding, sparks will be produced. Use protecting glass and gloves.

7.3. Annealing Steel Band

The annealing procedure is automatic already programmed in the welding machine.

8. RETURN GUIDING BEAM

In order to avoid the steel band overlaps, the guiding beam, which is close to the pushers and near the cam plate, should be perfectly regulated. It is very important to position the movable support in such a way, that it allows the steel band to rest on the aluminium beams before it is pushed.

The guiding beam should be positioned in such a way that it has the right winding angle.

Once the calibration has been done, fix all the devices.

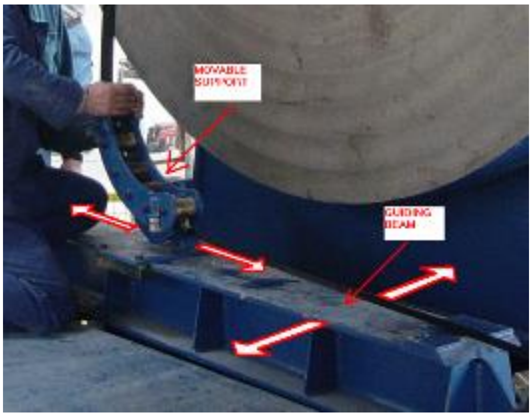

Figure 42: Guiding beam adjustment

9. TENSIONING DEVICE AND EXTRA-STROKE SENSORS

Once the steel band has been welded and the returning device has been regulated, the system can be tensioned and, finally, put in motion.

Use the console to regulate the pressure of the tensioning device. The suggested values are 1.1 - 1.2 bars for a thicker steel band and 0.8 - 1.0 bars for a thinner steel band.

After putting pressure to the tensioning device, the position of the tensioning piston has to be checked. The piston should have enough stroke to compensate for the steel band elongation due to heating. To achieve this, regulate the tensing arm mechanically.

Then position the sensors for detecting the steel band damages so the cam is between the two sensors.

During production, the steel band will elongate. Check the position of the sensor n.1 to avoid that the machine stops for no apparent reason. If the sensor is too close to the cam, move it back. Repeat this operation until the steel band achieves its complete elongation.

SETTING THE CONTINUOUS FILAMENT WINDING MACHINE PROCESS

SETTING THE CONTINUOUS FILAMENT WINDING MACHINE PROCESS

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1. REFERENCES

When starting the machine preparation phase for a new production, all equipment and raw materials must be arranged in an appropriate way, following the general layout scheme, as illustrated in Figure 43.

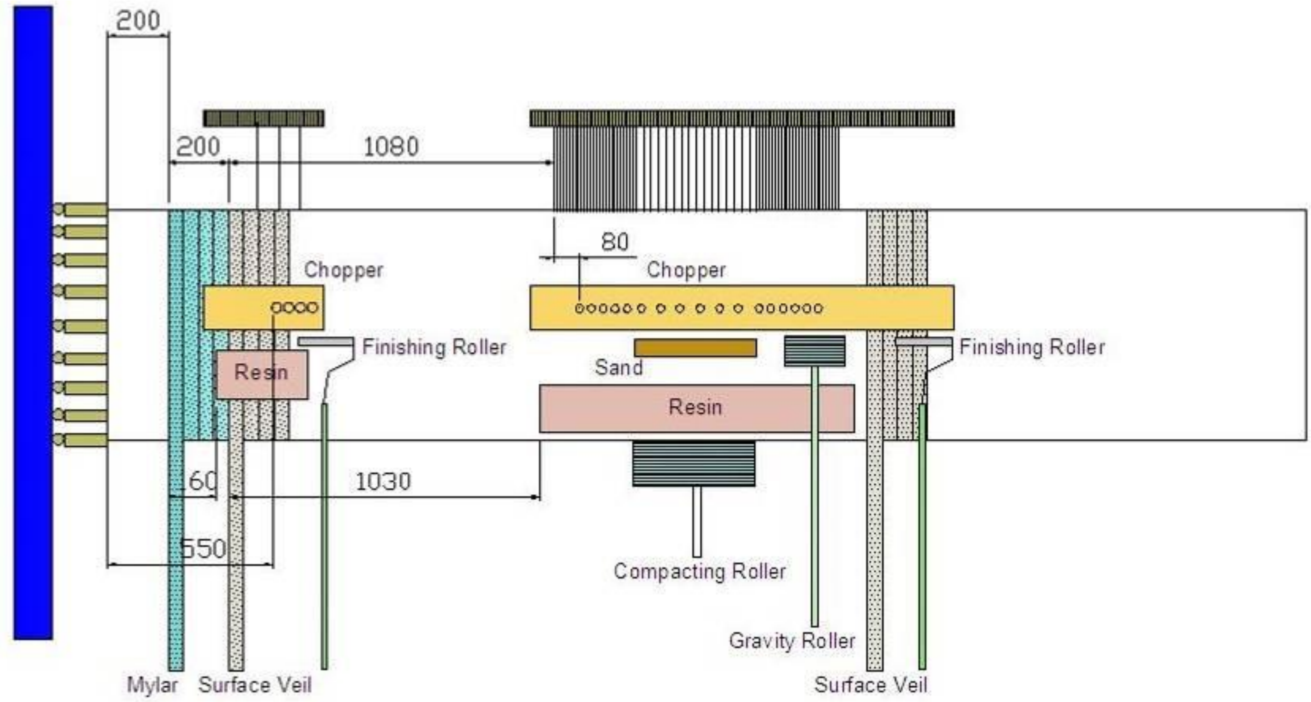


Figure 43: General plant arrangement

2. RESIN SET UP FOR THE CONTINUOUS FILAMENT WINDING PROCESS

This chapter presents the correct resin formulation set up for the continuous filament winding process. Having the correct resin formulation is important because of different factors, such as the environment, plant conditions, type of the pipe that will be produced, as well as the resin properties: its temperature, viscosity and reactivity. Resin properties must be set up before starting the production and closely controlled during the production, so the filament winding machine can be run at the highest allowed production rate.

Please see the Raw Materials Handbook for more details on the raw materials terminology and application.

Resin Temperature

The temperature of the resin is the most important factor to pay attention to, because it has an immediate effect on the resin viscosity and reactivity.

Increase in the temperature provokes a decrease of the resin viscosity, as well as an increase of the reactivity of the resin.

Note: the resin temperature can be also influenced by the environmental conditions produced by the winding machine. Furthermore, the resin can be subjected to seasonal and other weather temperature variations.

Because of that, it is highly recommended to thermo-stabilise the resin by:

- using the air-conditioning systems in the daily mixers room in order to maintain the temperature of the resin at 20 ± 3° C;
- using the heat-exchangers to stabilise the temperature of the resin, which is fed to the machine at 28 ± 2° C.

2.1. Resin Viscosity Set Up

Viscosity is the resin's most important property and should be considered in the continuous winding process, since it influences the correct wetting of the used reinforcements, such as glass fibres and sand. In this way, it ensures the composite product is free of delamination defects.

A pure liquid resin can be theoretically considered a Newtonian fluid. Its viscosity is inversely related to its temperature as shown by the Arrhenius-type equation:

$$\eta(T) = \eta_0 \cdot e^{\left(\frac{T_b}{T}\right)}$$

where ▪0 and Tb are characteristics of different types of resin. For narrow temperature ranges, such as 15-40° C, the viscosity can be considered linearly inversely dependent on the temperature (Figure 44).

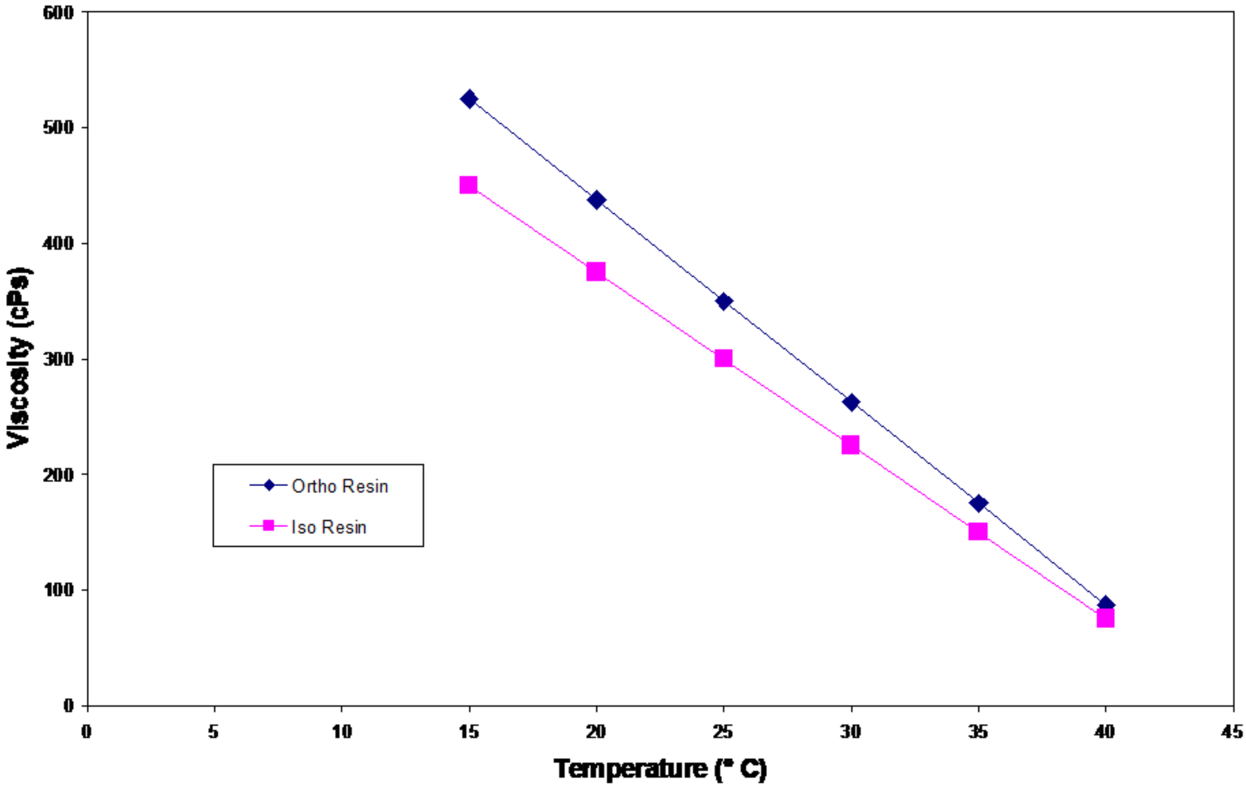


Figure 44: Viscosity versus Temperature plot for one type of the orthophthalic and isophthalic liquid resin

A suitable viscosity range for the unsaturated polyesters and vinylesters is between 250 and 400 cPs (mPa·s) at 25° C for the continuous filament winding process.

If the temperature of the resin, which is fed to the FW machine, is 25° C, the Quality Control Laboratory has to measure the viscosity of the liner resin and structural resin, before starting the production and during the production. These measurements are taken with a Brookfield viscosimeter or the Ford cup method (for the description of the procedures, see Quality Control Handbook, section: "Testing the Resin").

If the resin, which has just been received from the supplier, or after it has been in the storage for some time, shows a viscosity higher than 400 cPs, a certain amount of styrene may be added to the unsaturated polyesters and vinylesters, in order to adjust the viscosity to a suitable value. The maximum permitted amount of styrene which can be added to the resin depends on the resin specification 5-10 % by weight. An example of how styrene effects the viscosity of an isophtalic resin is shown in Table 1:

Amount of styrene (%)	Viscosity (cPs) @ 25° C
0	480
4	340

Table 1 – Styrene concentration effect on the resin viscosity.

Higher amount of styrene could reduce the resin elasticity when cured and provoke composite brittleness. Elasticity is an important characteristic, especially for the liner resin, because its barrier properties are strictly related to the carried fluid during its working life.

2.2. Resin Reactivity Set Up

Liquid unsaturated resins, such as polyesters and vinylesters, become reactive when adding:

- accelerators, such as cobalt salts;
- promoters, such as amines;
- initiators, such as organic peroxides.

The reactivity has to be set up by adjusting the correct amount of reactants in the resin.

As described in the Quality Control Handbook, Section "Testing the Resin", the most useful and practical way to determine the resin reactivity is by measuring its gel time and its "time to peak" temperature. This test is used to verify the quality of the supplier's resin and to set up the correct formulation for each type of the pipe in order to guarantee the highest production rates.

Since different organic peroxides are available on the market and inside a single family of the organic peroxides, like methyl-ethyl-ketone peroxide (MEKP), the active oxygen content can vary. Due to its reactivity, it is absolutely necessary that the quality control laboratory does different gel time tests in order to practice with the products before they are used.

The resin reactivity is also influenced by the temperature variations due to the kinetic reaction. Curing of the unsaturated resins follows the radical mechanism and the temperature increase provokes an increase of the reaction rate.

The gel time test can be carried out on one kind of resin, while varying the amount of reactants each time. The test temperature must always be the same for all tests. When possible, the temperature must be 25° C, if this is the temperature of the resin, which will be fed to FW machine.

The typical amounts of reactants used for the resin formulations are:

- cobalt salt (6 % Co solution*): 0.1÷0.2 phr (per hundred resin - by weight);
- peroxide: 1÷2 phr;
- secondary promoter: 0.3÷1 phr.

(*) Cobalt salt solutions are available in different concentrations: typical values are 1%, 6% and 10% - the above phr refer to the 6% Co salt solution.

The gel time test is useful when comparing the reactivity between resins from different suppliers, as shown in Figure 45, where two resins from different suppliers have been tested. In this case, when the cobalt salt concentration is a maintained constant and the peroxide content is varied, the received information concerns different "sensibility" of the resins to the peroxide.

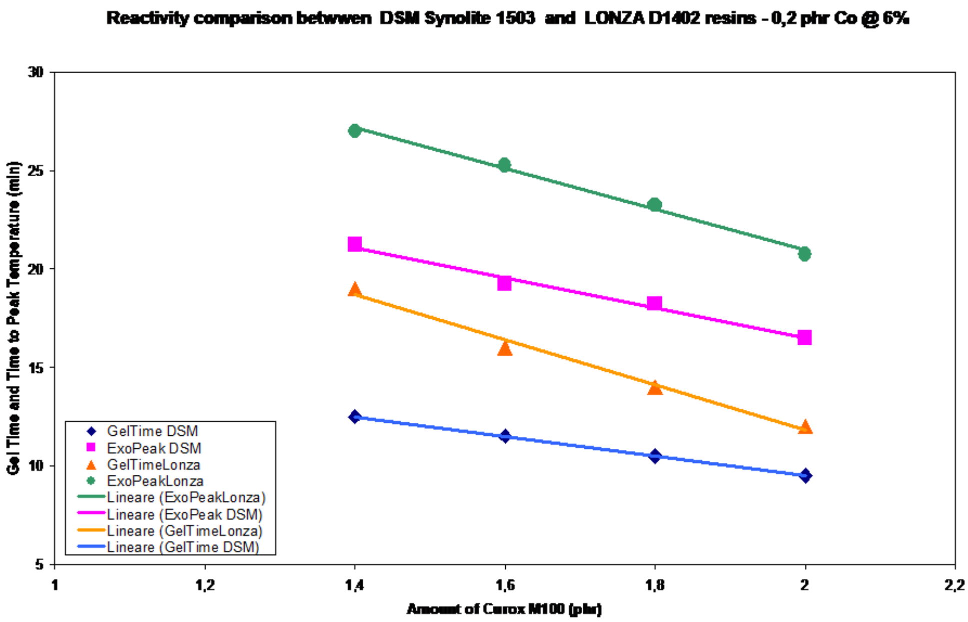


Figure 45: Comparison of reactivity between the two Ortophthalic resins when cured with the MEKP Curox M100

In Figure 46, the reactivity data for one kind of the resin is reported as a function of the peroxide type and its amount. So, maintaining a constant cobalt salt concentration, the strength evaluation for different peroxides for the same resin can been proven.

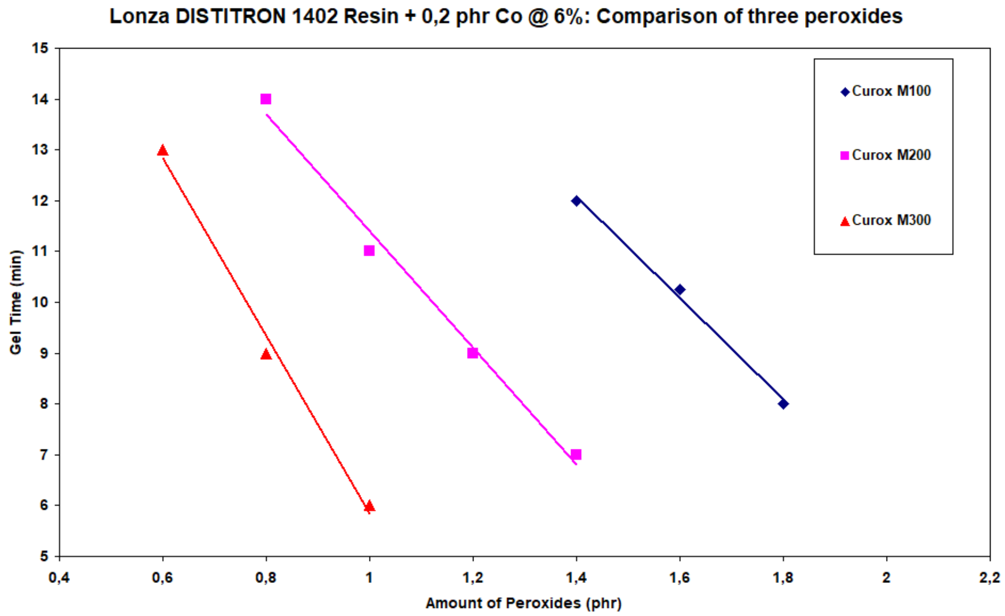


Figure 46: Comparison of reactivity between the MEKPs Curox M100, M200, M300 with the orthophthalic resin

The liner and structural resins setup for the EFW process is based on the following assumptions:

- resins temperature must be 25° C, when applied on the machine mandrel;
- at this temperature, the resin must have 250÷400 cPs viscosity, with or without styrene addition;
- gel time of the liner resin must be shorter than the gel time of the structural layer to avoid delamination;
- distance between the beginning of the liner winding and the structural layer winding on the machine is about 1 m (see Figure 47 - liner displacement);
- liner resin gelation must occur before the structural layer winding, at about 0.6 - 1 m from the beginning (see Figure 47 - liner resin gel time position);
- structural layer gelation must occur between the beginning of the infrared oven zone and the end of the first infrared lamp, at about 1.8÷2 m from the beginning of the liner winding (see Figure 47 - structure resin gel time position);
- structural resin exothermal peak must take place between the third and the fourth infrared lamp, at about 3 m from the beginning of the liner winding (see Figure 47 - structure resin time-to-peak position);

- four infrared lamps are set at the following temperatures:
  1. first lamp: 50÷60° C;
  2. second lamp: 70÷80° C
  3. third lamp: 100÷105° C
  4. fourth lamp: 110÷120° C.

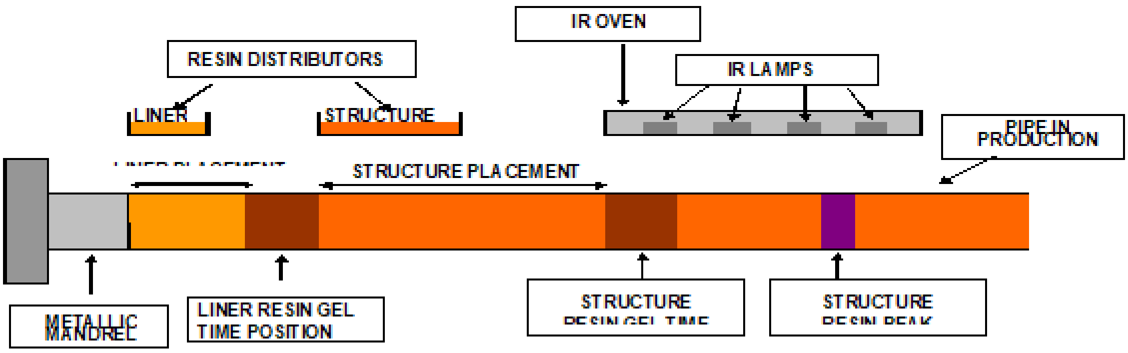


Figure 47: Schematic representation of the EFW pipe production

The choice of a correct liner and structural resins formulation is done by:

- calculating the needed gel times for the pipe structures which will be manufactured with an empirical model for the resin, liner and the structural layer;
- determining the suitable amount of reactants (cobalt salt, peroxide and if necessary, promoter) in the Laboratory to get the correct gel times.

Calculation can be done by the Production Manager, while the second part is carried out by the Quality Control Laboratory.

Example 1

Resins formulation set up for the production of the DN 1600 PN 16 SN 10.000 pipe with maximum 9 m/h production speed.

Resins gel times are calculated to produce the pipe at the maximum 9 m/h = 0.15 m/min production rate.

The structural resin gelation must occur 1.8÷2 m from the structure winding starting point, hence, the gel time must be 12÷13.3 min, according to the following formula:

$$gel-time=\frac{1.8\div 2}{0.15}=12\div 13.3$$

The structural resin gel time (unlike the peak time) is not supposed to be largely influenced by the oven radiation. So, if the 25°C resin temperature is considered feasible, the Quality Control Laboratory must set up a formulation of the structural resin, performing the gel time tests at 25°C to find a suitable resin composition with the 12÷13 min gel time.

Since the calculated gel time (from the above equation) is referred to the maximum production speed, the gel time must be set using a concentration of peroxide (e.g. MEKP type) between 1.5÷1.8 phr, in order to stay below the maximum concentration limit of 2.0 phr. Typical cobalt salt solution concentrations range between 0.1÷0.2 phr (for 6% Co solution). If the gel time is not obtained experimentally, using those cobalt salt and peroxide concentrations, it is necessary to add a promoter to speed up the reaction (0.3÷0.8 phr).

When a suitable structural resin gel time is found in the Laboratory, the formulation can be used during the production. The machine operator must control the point of the structural resin gelation on the pipe during the production and, eventually, vary the peroxide concentration from the machine console in order to maintain the gel time point in the correct position (see Figure 47).

The liner resin gel time is not influenced by the oven radiation, but it is in direct contact with the steel band of the mandrel, which after 1÷2 hours of production may reach 70÷80° C. So, even if the resin is fed to the machine at 25° C, it is quickly heated by the steel band.

When a stable working temperature is reached, the liner resin gel time must occur 0.6÷1 m from the liner winding starting point, hence, the gel time must be 4÷6.5 min, according to the same formula:

$$gel-time=\frac{0.6\div 1}{0.15}=4\div 6.5$$

In TOPFIBRA's experience, in order to obtain the liner resin gelation after 0.6÷1 m from the liner winding starting point, when the steel band reaches a stable temperature, the liner gel time must be calculated after at least 3÷3.2 m, while considering that the steel band is at a room temperature (at the very beginning of production) and the resin at 25° C. In this case, the liner resin gel time range is:

$$Liner - gel - time = \frac{3 \div 3.2}{0.15} = 20 \div 21 \min$$

The Quality Control Laboratory must set up the formulation of the liner resin by performing the gel time tests at 25° C, to find a gel time in the 20-21 min range.

As for the structural resin, the experimental liner resin gel time must be set up using a concentration of peroxide (e.g. MEKP type) between 1.5÷1.8 phr, in order to stay below the maximum 2.0 phr concentration limit. Typical cobalt salt solution concentrations range between 0.1÷0.2 phr (for 6% Co solution). If the gel time is not obtained experimentally using those cobalt salt and peroxide concentrations, it is necessary to add a promoter to accelerate the resin (0.3÷0.8 phr).

When a suitable liner resin gel time is found, the formulation can be used during the production. The machine operator must control the point of the liner resin gelation on the pipe, first at the beginning of the production, at 3÷3.2 m from the liner beginning (when the production starts, it is recommended to produce at least 5 m of the liner only), and during the production, at 0.6÷1 m, before the structural winding begins.

Example 2

Resins formulation set up for the production of the DN 800 PN 16 SN 10.000 pipe with maximum 26 m/h production speed.

Resins gel times are calculated to produce the pipe at the maximum 26 m/h = 0.44 m/min production rate.

The structural resin gelation must occur 1.8÷2 m from the structure winding starting point, hence, the gel time must be 4.15÷4.6 min.

The liner resin gel time must occur 0.6÷1 m from the liner winding starting point, hence, the gel time must be 1.4÷2.3 min, while considering that the FW machine is running in constant conditions (warm steel band).

The liner resin gel time set in the laboratory, which considers 3÷3.2 m of displacement, must be 7÷7.6 min.

3. DAILY MIXERS ROOM SET UP

The daily mixers are the resin vessels containing prepared resin. The formulation of resins is composed of various chemical components, following the laboratory indications. From these vessels the resin is sent directly to the machine during the production process, through a system of pumps and pipes.

Correctly using these mixers is fundamental for securing the polymerization process by making it as homogenous as possible and so it corresponds to the specifications of the laboratory.

It is important to mix the components in the vessels in such a way, that a good homogenization of the resin and other chemical components is reached during the mixing. The raw materials fed to the daily mixers are:

- resin;
- accelerator;
- promoter;
- styrene.

Commonly used accelerators are cobalt salts, while promoters are the composites used in specific ambient conditions or for the specific production needs to further accelerate the polymerization process. A certain quantity of styrene (less than 10%) is added to the resin if viscosity is too high.

The mixer preparation procedure starts with loading a 50% of the total resin amount, which is intended to be used. After that, a 100% of the total additional chemical components amount are inserted and the mixer is started. After about 30-45 min of mixing, the remaining 50% of the resin is added and mixing is performed for another 15 min. At the end of this operation, it is important to perform the control of the mixture properties by taking a sample directly from the vessel. Checking viscosity and the gel time is done by the QC Laboratory. If these properties do not conform to the specifications, the necessary elements are added and a simultaneous mixing is done for no less than 15 min, followed by another check of the mixture properties. This procedure is performed until the indicated specifications are achieved.

4. RESIN TROUGH SET UP

The resin trough allows for the distribution of the correct resin quantity in various layers for the pipe in production. The device is a basin with holes in the bottom, which are arranged in a row and spaced 12mm (11,55) from each other.

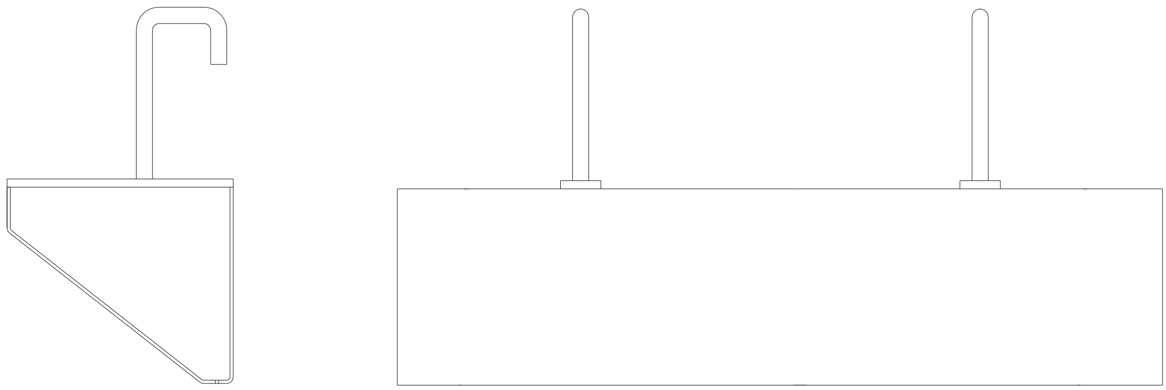


Figure 48: Resin trough

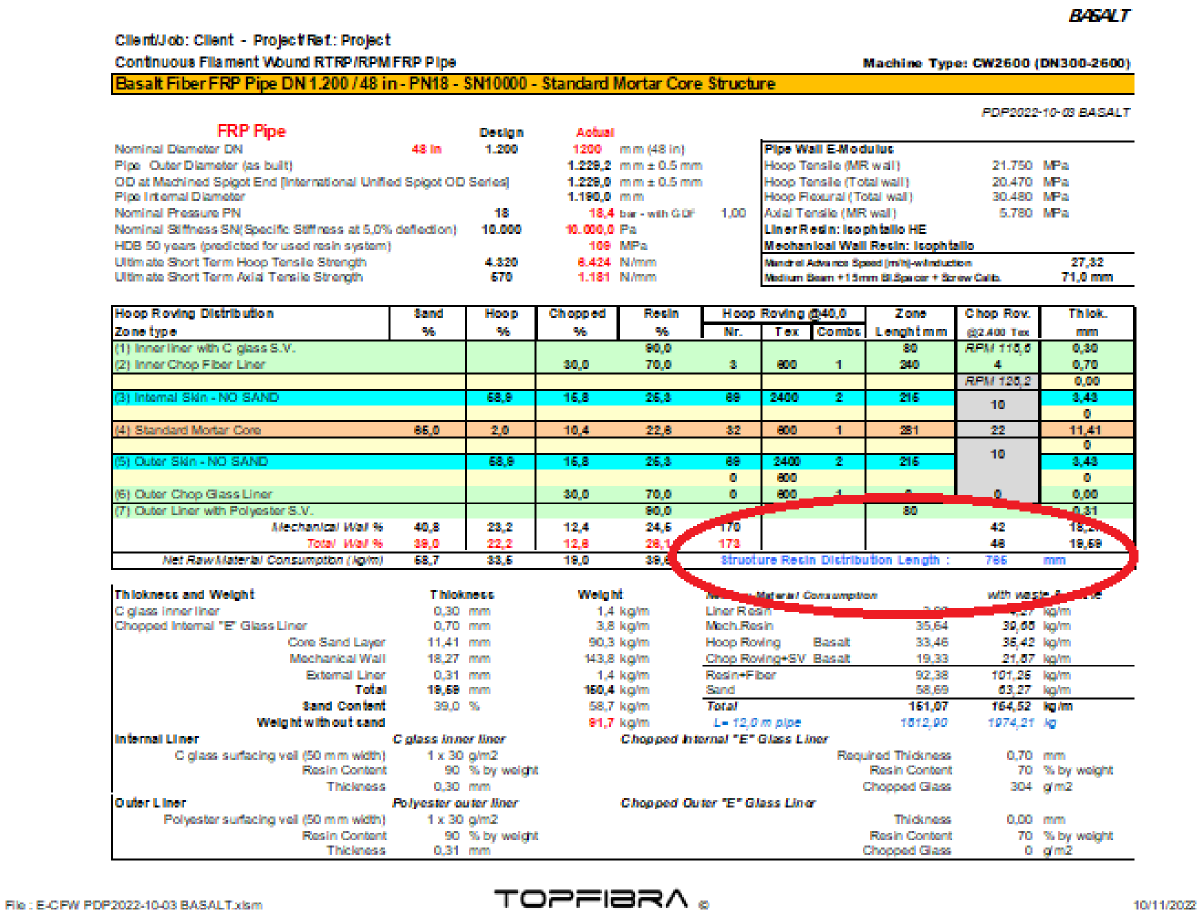
Choosing a correct trough is based on the two principal parameters:

- its length;
- diameter of the holes.

For the liner resin, TOPFIBRA recommends using a 30 cm long basin for the production of the ND up to 1200 pipes, and a 40 cm long basin for the production of the pipes with larger diameters.

For HPUSA the trough has been customised.

The trough length for the structural part depends on the pipe design and in particular, on the length of the continuous roving band, which is used for winding the pipe. Such dimensions make part of the software data output for the pipe design (see Figure 49). A general recommendation is to use a 10-15 cm longer trough than the nominal length. This allows the impregnation before the winding starts (which provides a better adhesion between the liner and the structure) and after the winding (to achieve a better finish of the external pipe surface).



BASALT

Client/Job: Client - Project/Ref.: Project
Continuous Filament Wound RTRP/RPM FRP Pipe — Machine Type: CW2600 (DN300-2600)
Basalt Fiber FRP Pipe DN 1.200 / 48 in - PN18 - SN10000 - Standard Mortar Core Structure

PDP2022-10-03 BASALT

FRP Pipe		Design	Actual	
Nominal Diameter DN	48 in	1.200	1200	mm (48 in)
Pipe Outer Diameter (as built)			1.229,2	mm ± 0.5 mm
OD at Machined Spigot End [International Unified Spigot OD Series]			1.229,0	mm ± 0.5 mm
Pipe Internal Diameter			1.190,0	mm
Nominal Pressure PN		18	18,4	bar - with GDF 1,00
Nominal Stiffness SN(Specific Stiffness at 5,0% deflection)		10.000	10.000,0	Pa
HDB 50 years (predicted for used resin system)			109	MPa
Ultimate Short Term Hoop Tensile Strength		4.320	6.424	N/mm
Ultimate Short Term Axial Tensile Strength		570	1.181	N/mm

Pipe Wall E-Modulus		
Hoop Tensile (MR wall)	21.750	MPa
Hoop Tensile (Total wall)	20.470	MPa
Hoop Flexural (Total wall)	30.480	MPa
Axial Tensile (MR wall)	5.780	MPa
Liner Resin: Isophtalic HE		
Mechanical Wall Resin: Isophtalic		
Mandrel Advance Speed [m/h]-w/induction	27,32	
Medium Beam +15mm Bl.Spacer + Screw Calib.	71,0 mm	

Hoop Roving Distribution Zone type	Sand %	Hoop %	Chopped %	Resin %	Hoop Roving @40,0 Nr.	Tex	Combs	Zone Lenght mm	Chop Rov. @2.400 Tex	Thick. mm
(1) Inner liner with C glass S.V.				90,0				80	RPM 115,6	0,30
(2) Inner Chop Fiber Liner			30,0	70,0	3	600	1	240	4	0,70
									RPM 125,2	0,00
(3) Internal Skin - NO SAND		58,9	15,8	25,3	69	2400	2	215	10	3,43
										0
(4) Standard Mortar Core	65,0	2,0	10,4	22,6	32	600	1	281	22	11,41
									10	0
(5) Outer Skin - NO SAND		58,9	15,8	25,3	69	2400	2	215		3,43
					0	600				0
(6) Outer Chop Glass Liner			30,0	70,0	0	600	1	0	0	0,00
(7) Outer Liner with Polyester S.V.				90,0				80		0,31
Mechanical Wall %	40,8	23,2	12,4	24,5	170				42	18,2[illegible]
Total Wall %	39,0	22,2	12,8	26,1	173				48	19,58
Net Raw Material Consumption (kg/m)	58,7	33,5	19,0	39,6	Structure Resin Distribution Length :				765	mm

Thickness and Weight	Thickness	Weight
C glass inner liner	0,30 mm	1,4 kg/m
Chopped Internal "E" Glass Liner	0,70 mm	3,8 kg/m
Core Sand Layer	11,41 mm	90,3 kg/m
Mechanical Wall	18,27 mm	143,8 kg/m
External Liner	0,31 mm	1,4 kg/m
Total	19,69 mm	160,4 kg/m
Sand Content	39,0 %	58,7 kg/m
Weight without sand		91,7 kg/m

Material Consumption			with waste	
Liner Resin		[illegible]	[illegible]	kg/m
Mech.Resin		35,64	39,65	kg/m
Hoop Roving	Basalt	33,46	35,42	kg/m
Chop Roving+SV	Basalt	19,33	21,87	kg/m
Resin+Fiber		92,38	101,26	kg/m
Sand		58,69	63,27	kg/m
Total		151,07	164,52	kg/m
L= 12,0 m pipe		1812,90	1974,21	kg

Internal Liner	C glass inner liner	Chopped Internal "E" Glass Liner	
C glass surfacing veil (50 mm width)	1 x 30 g/m2	Required Thickness	0,70 mm
Resin Content	90 % by weight	Resin Content	70 % by weight
Thickness	0,30 mm	Chopped Glass	304 g/m2
Outer Liner	**Polyester outer liner**	**Chopped Outer "E" Glass Liner**	
Polyester surfacing veil (50 mm width)	1 x 30 g/m2	Thickness	0,00 mm
Resin Content	90 % by weight	Resin Content	70 % by weight
Thickness	0,31 mm	Chopped Glass	0 g/m2

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Figure 49: Resin trough length, calculated by the pipe design software program

Once the trough length is specified, it is important to define the diameter of the holes which allow the device to operate correctly.

Choosing the hole diameter depends on a range of parameters, such as:

- resin viscosity;
- resin flow volume;
- trough length.

Resin viscosity can be determined with laboratory test for the quantity of material spilt from the vessel in use. The flow is recorded once the record of the machine production speed is made. The indications, concerning the trough length, are provided by the design software.

5. HOOP ROVING SET UP

The arrangement of the continuous fibreglass roving is one of the most delicate operations of the machine set-up. During the production of the pipes or couplings with big dimensions, the number of roving strands can be very high, and thus, a correct and reasonable arrangement of this material is crucial in order to avoid problems during the production.

The roving strands unwind from the internal part of the bobbin arranged on the creel and are guided to the pipe, which is being produced, across series of guiding and tensioning stations. These are (see Figure 50):

- fibre guiding panel;
- fibre guiding panel;
- fibre guiding panel;
- tensioning device;
- comb + tensioning device.
-

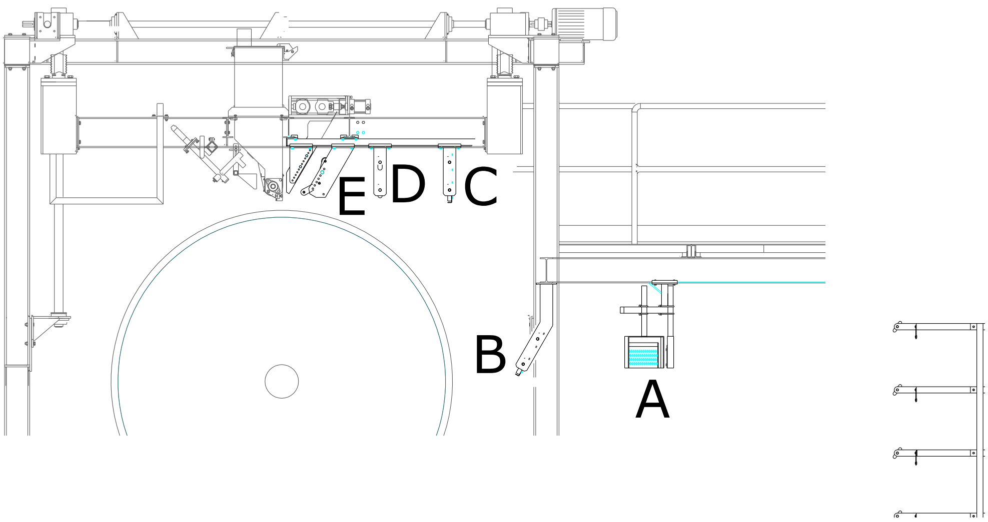

Figure 50: Hoop roving distribution system

When performing the continuous roving arrangement operations, it is important to consider two fundamental concepts:

- on the way from the bobbins to the pipe, various roving strands should be arranged in a way that they do not come in contact with each other;
- the fibers feeding path should be as straight as possible and avoid abrupt direction changes, which could damage the roving strands.

It is extremely important to properly arrange the bobbins on the creel. Figure 51 illustrates the optimal arrangement of the fibreglass bobbins. Each position has a bobbin in the working phase W and a reserve bobbin S. The internal side of the operating bobbin is inserted in the filament guides, while the external side is connected to the reserve bobbin, which substitutes the first one once it is finished. The arrangement method for the operating and reserve bobbin is illustrated in the figure below.

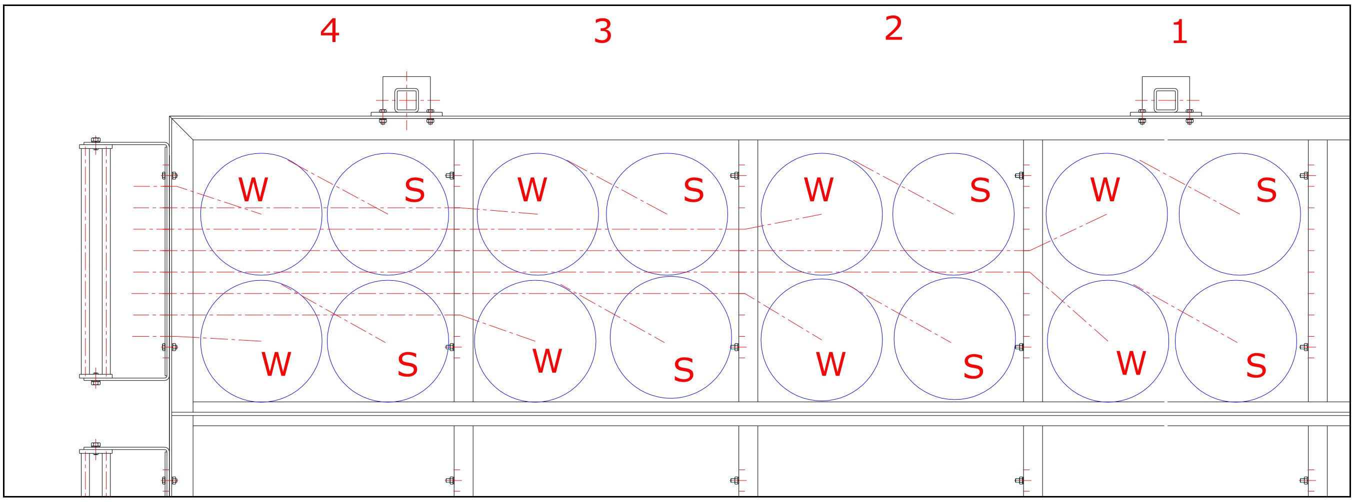

Figure 51: The arrangement of the hoop roving bobbins on the creel (plan)

Each creel level has 16 exit roving strands, distributed between two filament guides: the right one and the left one. Thus, while considering all levels (5 in total – see Figure 52), there should be 16*5 = 80 rovings.

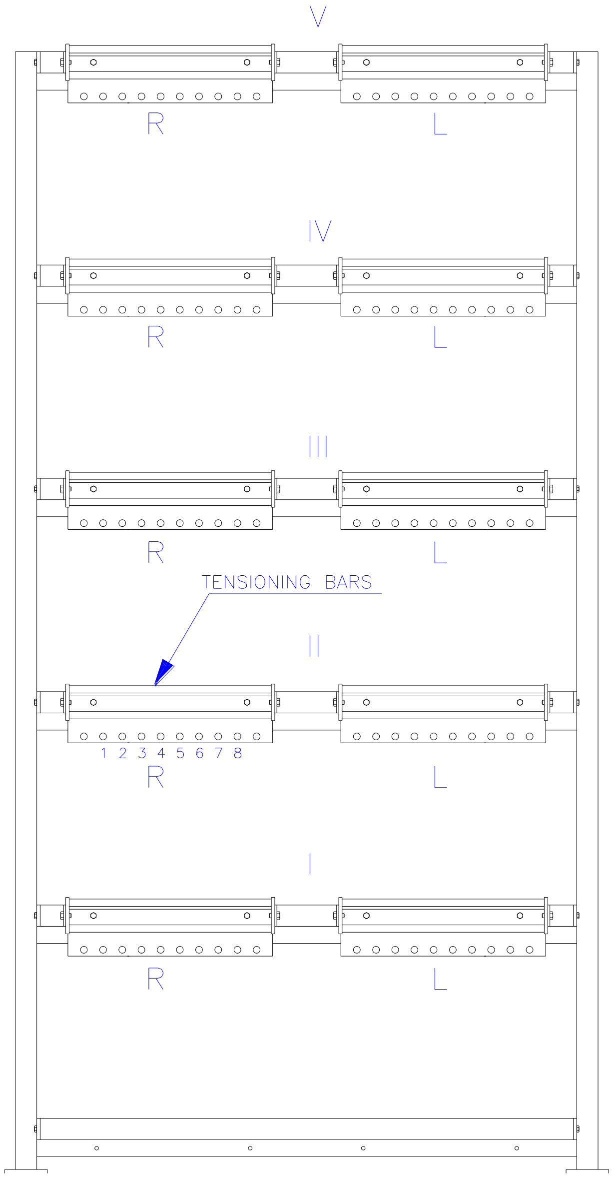

Figure 52: The arrangement of the hoop roving bobbins on the creel (front view)

After groups of roving strands have been inserted between the bars of the tensioning devices, each group should be put through a guiding panel in position A. TOPFIBRA recommends that the distribution of the roving strands follows the diagonal plates in which the ceramic eyelets of the guiding devices are found. The panel with the recommended arrangement is illustrated in Figure 53.

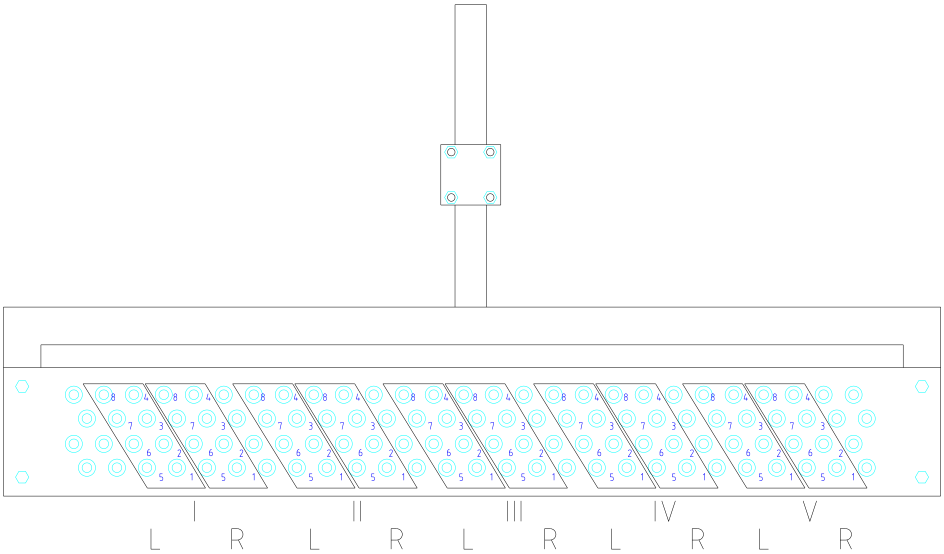

Figure 53: Guiding device scheme: diagonal plates with eyelets

The roving stands, arranged in this way in the guiding panel in the position A (as per Figure 50), are guided towards the panels in the positions B and C. This structure is shown in Figure 54. In this case, the arrangement of the roving strands should follow the diagonals of the ceramic eyelets. In this case, the only difference is that all the diagonal plates should be adjacent one to another, without leaving any of them apart. This will allow the subsequent passage of the roving strands to the comb teeth. The distance between two diagonal plate eyelets is 6.15 mm, which corresponds to the distance between the comb teeth.

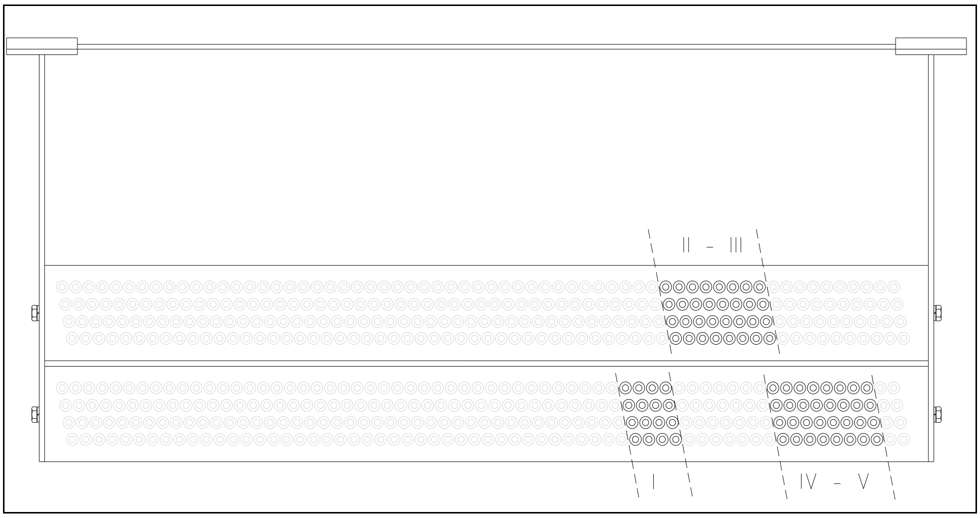

Figure 54: Ceramic eyelets of the guiding device

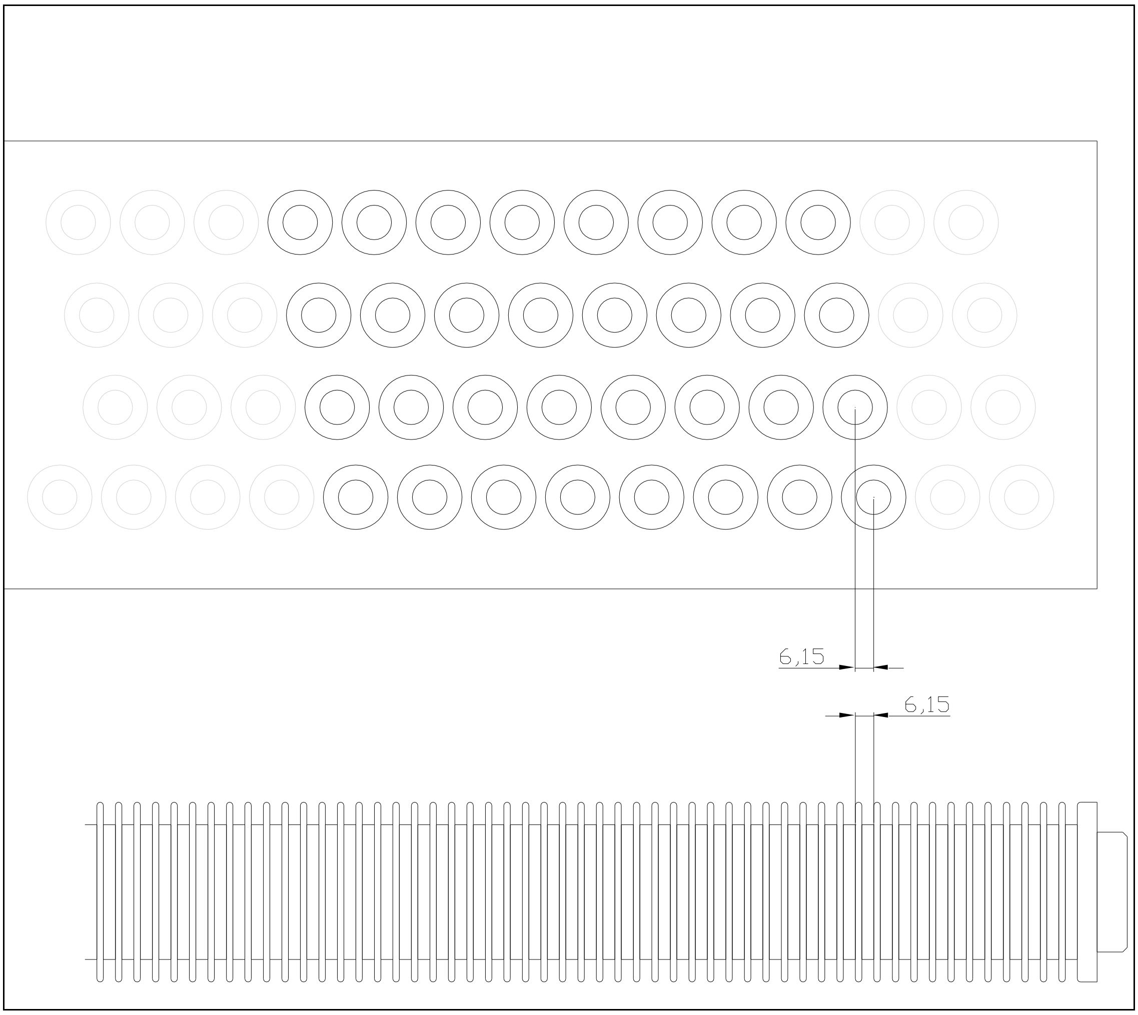

Figure 55: Ceramic eyelets of the guiding device – detailed view

B and C panels are arranged in two levels, in order to allow the rovings to be more easily distributed. It is recommended to divide the roving strands in groups of 32 pieces and alternate the positioning between the levels. This will facilitate the interventions in the roving feeding system during the production in case of breaks, blocks, bobbin change, etc.

Figure 56 demonstrates an example of the distribution in groups: from the panel A, the roving fibres are directed into panel B, divided in groups and alternating between the high and the low level of the same panel.

Figure 56: Roving groups distribution

The roving strands, located on the higher levels of the guiding panels, are placed in the higher comb, while the roving strands of lower levels go to the lower comb. The tensioning bar, installed in the group of combs, must be used for regulating the inclination of the roving strands in respect to the pipe surface. The suggested position is illustrated in a schematic way in Figure 57, where an angle is created between the pipe radius and the tangent at the contact point of the roving strands and the pipe. This angle should be about 20°.

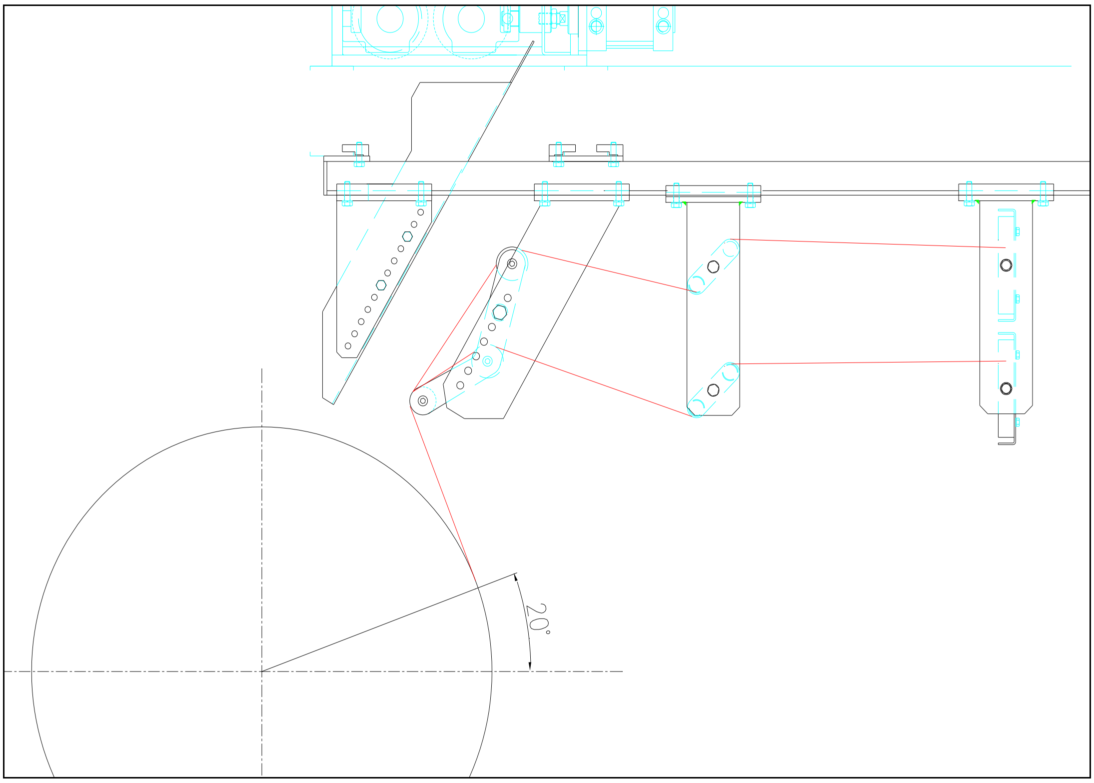

Figure 57: Schematic of the tensioning device and the winding angle regulation

6. CHOPPED ROVING SET UP

The number and positioning of the roving strands for the copping is given in the Pipe Design Program, in the "Summary" page (Figure 58) and in the "Process Setup" (Figure 59) page for the liner, as well as for each layer of the structural wall.

Hoop Roving Distribution	**Chop Rov.**	**Thick.**
Zone type	**Number**	**mm**
(1) Inner liner with Surf.Veil		**0,24**
(2) Chopped "'E" Glass Liner	**3,0**	**0,76**
(3) Internal Skin - NO SAND	**8,1**	**2,04**
(4) Standard Mortar Core	**3,9**	**3,13**
(5) Outer Skin - NO SAND	**9,1**	**2,25**
(6E) Outer "E" glass Liner *	**0,0**	**0,00**
(6C) Outer "C" glass Liner *		**0,25**
Mechanical Wall %	**21,0**	**7,43**
Total Wall %	**24,0**	**8,68**
Net Raw Material Consumption (kg/m)	**640**	**mm**

Figure 58: The Pipe Design Program, the "Summary" page

CHOP ROVING @ 67,0 RPM			Hole #		Hole #	
Inner Skin 2.400 tex	45,0	45,0	1	246,2	15	201,2
Mortar Core (Standard)		275,9	16	396,5	30	120,6
Outer Skin 2400 tex		396,5	31	625,8	48	229,3

				Roving Strands Spacing on the Cutting Roller
	8,1	1,22	0,82	25,0 mm roving spacing
	3,9	0,59	0,39	31,0 mm roving spacing
	9,1	1,37	0,91	25,3 mm roving spacing
	21,0	*3,18*	*2,12*	

Figure 59: The Pipe Design Program, the "Process Setup" page.

6.1. Internal Liner

In the internal liner, the number of roving strands is fixed (3). Only when the liner is extra thick and/or if a very high advancing speed could be necessary, the number of the roving strands is increased in order to reduce the linear speed of the roving strand and the rotational speed of the chopper. In this (rare) case, an error advice is given by the Pipe Design Program and the number of roving strands can be modified by the operator in the "IutAdv" page, where the definition of the liner structure can be found (Figure 60). The number of roving strands for chop can also be increased (or reduced) to better adjust the distribution of the chop glass and minimize the fall down.

Internal liner						
Type of S.V. (1="C" glass; 2=Polyester)		1				
Surfacing Veil (S.V.) weight	g/m^2			**30**		30
Resin content by weight for S.V.	%			**90**		90
Number of veils	Nr.	1				
Roll width	mm			**50**		50
Total liner thickness (S.V. & chop)	mm	1,00				
Resin content by weight for chop liner	%	70				
Number of Roving Strands for Chopper	Nr.	3				
Liner Hoop Roving Tex	Tex	600				
Liner Hoop Roving Number	Nr.	3				

Figure 60: Liner definition in the "IutAdv" page

6.2. Structural wall

In the structural wall, the total number of roving strands (21 in the above Figure 58 and Figure 59) is spread between the skins and the internal core (if any), according to the proportions and the spacing shown in the figures.

The sequence in the example (8.1 – 3.9 – 9.1) does not mean that the roving stands shall be divided, but that the density in the core shall be a little less than 4 and, in the skins, a little more than 8 and 9. It means, in particular, that a couple of strands will be between one zone and the other. The theoretical spacing between the roving stands is shown in the last column of Figure 59. It is up to the operator to choose the groves where the roving strands will be placed in compliance with the PDP directions.

6.3. Placement of the roving strands

The distribution and feeding scheme for the chopped roving is illustrated in the Figure 61. The whole process is shown on the Figure 71, from the fibreglass bobbins to their application by chopped filaments dispersion onto the pipe in production, which takes place on the winding machine.

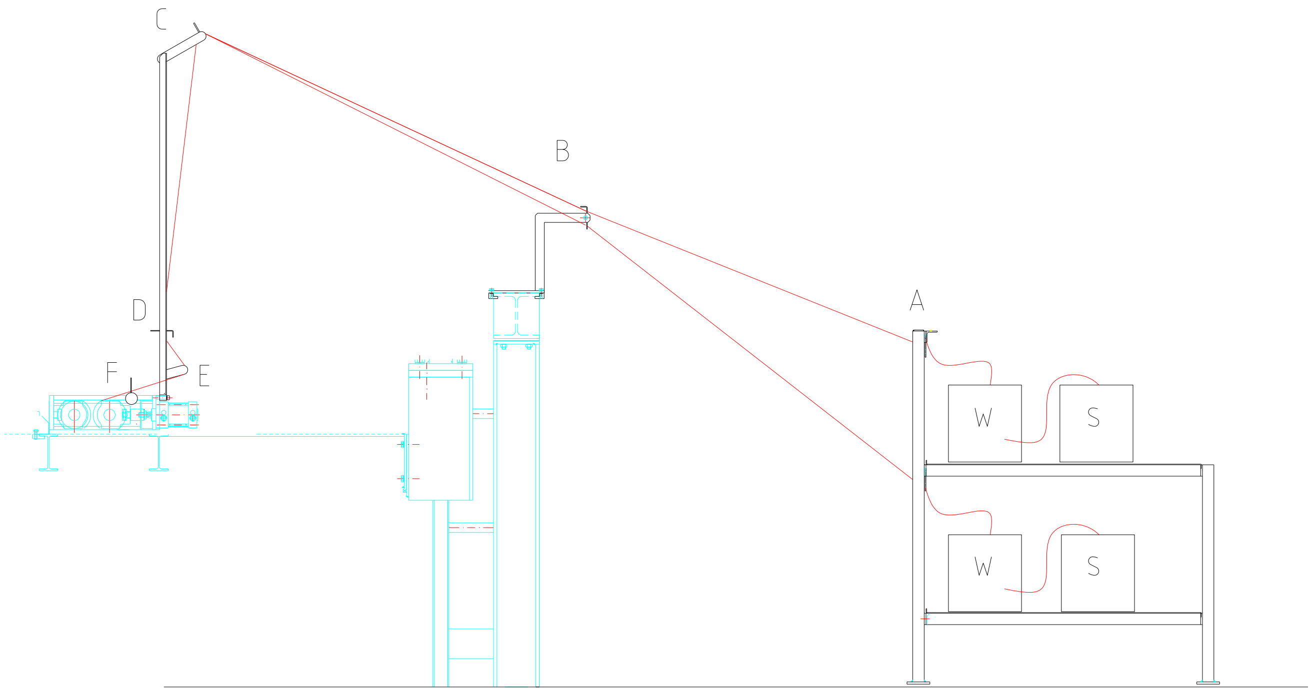

Figure 61: Chopped roving distribution system

The devices in use are:

- Bobbin creel;
- Filament guide;
- Comb;
- Filament guide;
- Tensioning device;
- Comb.

The creel is divided in two levels, two shelves. Each of them is equipped with a proper filament guide plate. In this case, it is also advisable to put 2 sets of bobbins on the creel, so that one set will be the working bobbins and the other set will be in reserve, with its bobbins connected to the working ones. (see Figure 62).

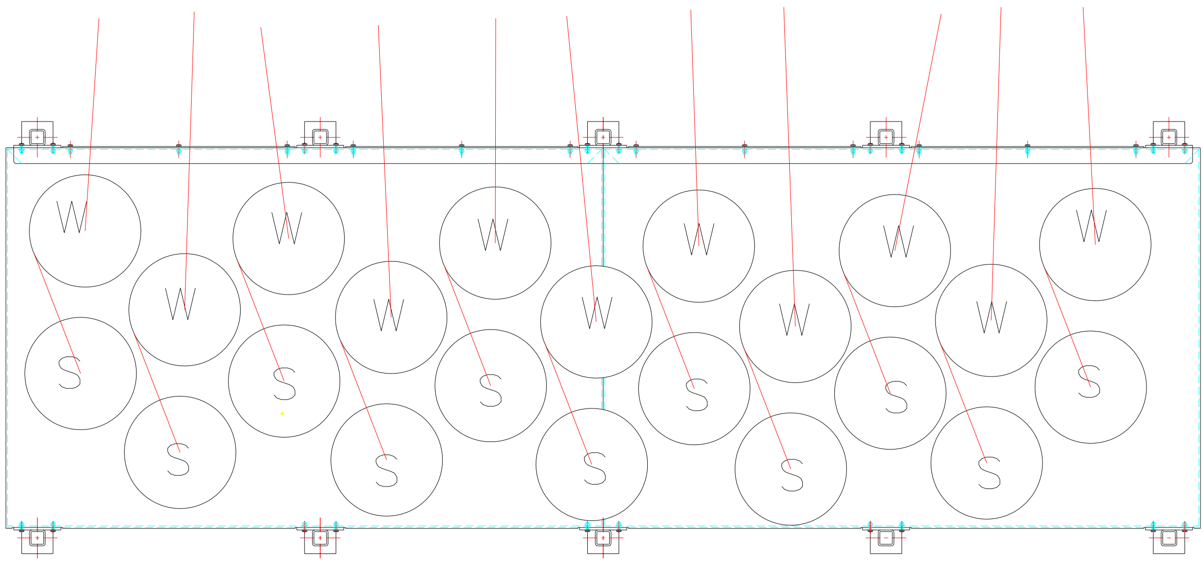

Figure 62: The arrangement of the chop roving bobbins on the creel

The roving strands, which exit from the creel, are guided towards the filament guiding panel B, equipped with two lines of openings with ceramic eyelets. The upper line of the openings is used for positioning the roving from the upper creel shelf, while the lower line is used for positioning the roving from the lower creel shelf.

From here, the roving strands are guided to the first comb C. To avoid tangling of the roving, which may damage the integrity of the filaments, it is recommended to position in the openings of the panel B an upper filament (from the upper shelf), which alternates with the lower filament (from the lower shelf), as illustrated in the Figure 63. Repeat this model of distribution in the filament guide D and the comb F, which passes the roving strands under the tensioning device E.

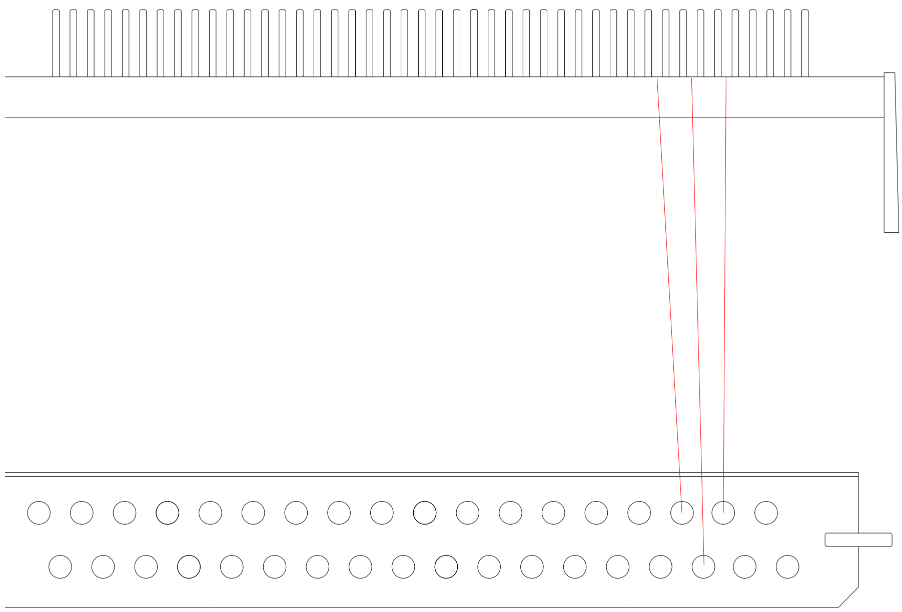

Figure 63: Correct placement of the filaments to avoid tangling

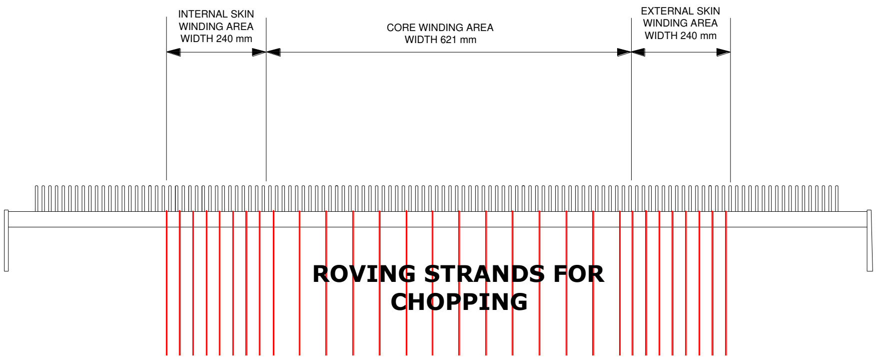

Figure 64: Chopped roving placement on the comb

7. SAND DOSER SET UP

The sand is distributed on the mandrel with a hopper, fixed on the elevator in the correct correspondence with the superior quadrant of the mandrel.

The right quantity of sand is obtained by regulating the distribution length and the rotation speed of the dosing roller, that has on its surface numerous calibrated cavities to feed the sand.

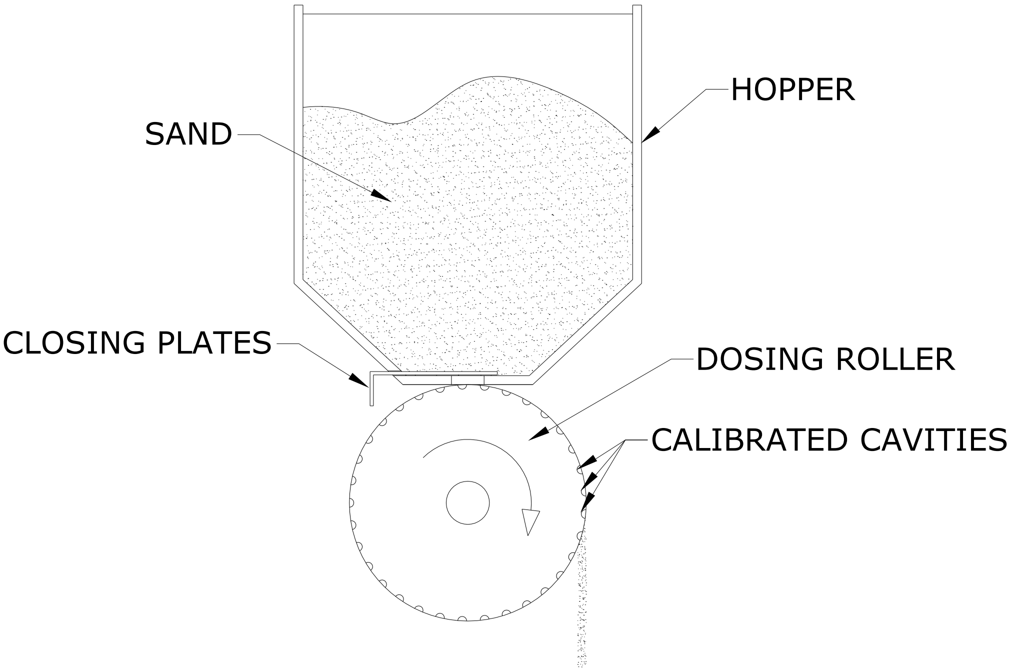

Figure 65: Sand dispenser

The rotation speed of the roller is controlled by the machine software.

The hopper is automatically filled with sand via system that transports sand from the main silos. The lower part of the hopper contains a longitudinal slot and a set of closing plates which are 40 mm wide each (or as defined for each machine). Closing plates are used to set the position and the width of the open area in the hopper slot. The length and position of the opening and number of open slots are obtained from the Pipe Design Program.

Hoop Roving Distribution	Hoop Roving			Distribution	Chop Rov.	Thick.
Zone type	Nr.	Tex	Combs	Lenght mm	Number	mm
(1) Inner liner with Surf.Veil				80		0,24
(2) Chopped "'E" Glass Liner	3	600		80	3,0	0,76
(3) Internal Skin - NO SAND	39	2400	1	246	8,1	2,04
(4) Standard Mortar Core	9	600	1	121	3,9	3,13
(5) Outer Skin - NO SAND	43	2400	1	271	9,1	2,25
(6E) Outer "E" glass Liner *	0	600		0	0,0	0,00
(6C) Outer "C" glass Liner *				80		0,25
Mechanical Wall %	91			637	21,0	7,43
Total Wall %					24,0	8,68
Net Raw Material Consumption (kg/m)	Structure Resin Distribution Lenght :				640	mm

Figure 66: Sand dispenser length calculated by the Pipe Design Program ("Summary" page)

STRUCTURAL WALL	Offset	Start		End	
MORTAR CORE	mm	mm	Slot #	mm	Slot #
Mortar Core (Standard)	75,0	275,9	6	396,5	8

Width	Qty	Qty	Qty		
mm	nr	kg/m	kg/min	Other	Description /Note
120,6		7,67	5,11	42,42	g/mm min

Figure 67: Starting point and slots ("Process Setup" page)

Before starting a new production, TOPFIBRA recommends that the calibration of the sand dispenser is performed, in accordance with the project volume values.

8. MYLAR SET UP

Mylar is a plastic material film that is wound on the mandrel before the raw materials are wound and layered. It is used to protect the mandrel and to ensure the pipe detaches from it at the end of the production cycle. It is fundamentally important. The misuse of Mylar may result in a faulty production.

Two Mylar bobbins are placed on the support in such a way that one of them is in the working position and the other one is ready to substitute it as soon the first one is finished. After the Mylar band unwinds from the bobbin, it passes through a special device, which is equipped with a sensor. The sensor sends signals to the machine operator in case the Mylar is missing. The following figures demonstrate the correct positioning of the bobbins and a detailed view of the safety device.

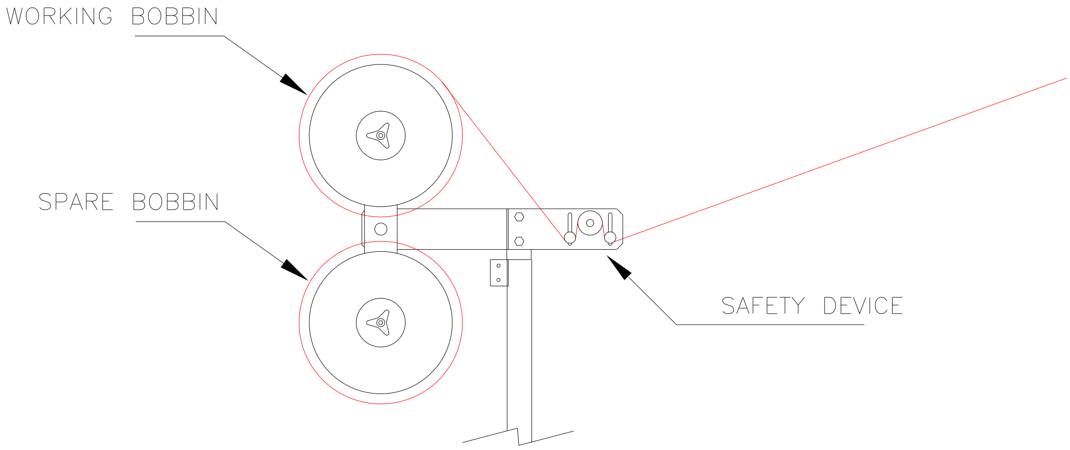

Figure 68: Mylar bobbins arrangement and safety device with a sensor

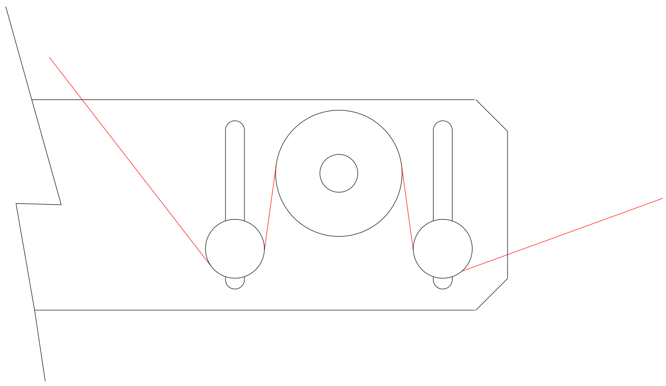

Figure 69: Safety device with a sensor (detailed view)

Mylar must be wound on the mandrel with extreme care, to avoid that Mylar gets drawn by the steel band into the returning device at the exit of the pipe. For this purpose, it is recommended to give special attention to the following parameters:

- tension of the Mylar during the winding;
- relative position of the Mylar in regard to the mandrel steel band.

The Mylar tension is regulated with the support brake. It is important to adjust the tension in such a way that the Mylar is perfectly adherent to the mandrel, leaving no chance that it laterally slips.

The relative position of Mylar depends on the steel band and its width.

For the 50 mm wide bobbins it is necessary to make the right edge of Mylar correspond to the right edge of the steel band spiral on which the Mylar is wound.

For the 60 mm wide bobbins, Mylar is applied on the steel band coil allowing it to overlap 1 cm on each side.

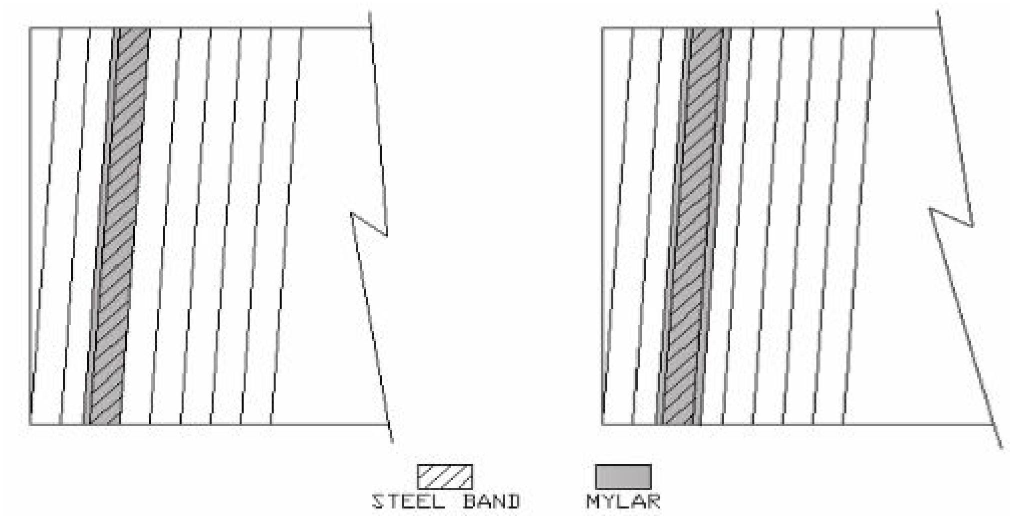

Figure 70: Mylar application on the steel band, depending on its width

9. C-VEIL SET UP

Surface veil bobbins are used in different ways in the production of pipes with the continuous filament winding technology.

The surface veil is used for the formation of the liner's internal layer, the one which is in direct contact with the conveyed fluid. It is wound on the mandrel at the beginning, immediately after the protective polyester film (Mylar) has been wound on the mandrel.

The veil is also used on the external surface of the pipe, to guarantee the finish of the outer surface.

The veil bobbins are placed on their supports in such way that one bobbin is being used and the other waits in reserve for an immediate substitution after the first bobbin ends. The supports are equipped with a mechanical brake, which allows the veil to have a certain tensional level during the winding.

Figure 71: Inner and outer C-veil application

10. COMPACTION ROLLERS

Compaction rollers are used to eliminate the air which is entrapped in the laminate and to get rid of the excess resin that may occur in the laminate. On the winding machine, two types of compaction rollers are used:

- pneumatic compaction roller: it is equipped with a pneumatic piston which allows the compaction pressure to be regulated;
- gravity compaction roller: it is equipped with a weight that can be placed in different intermediary positions of the roller arm and in this way provide different degrees of compaction.

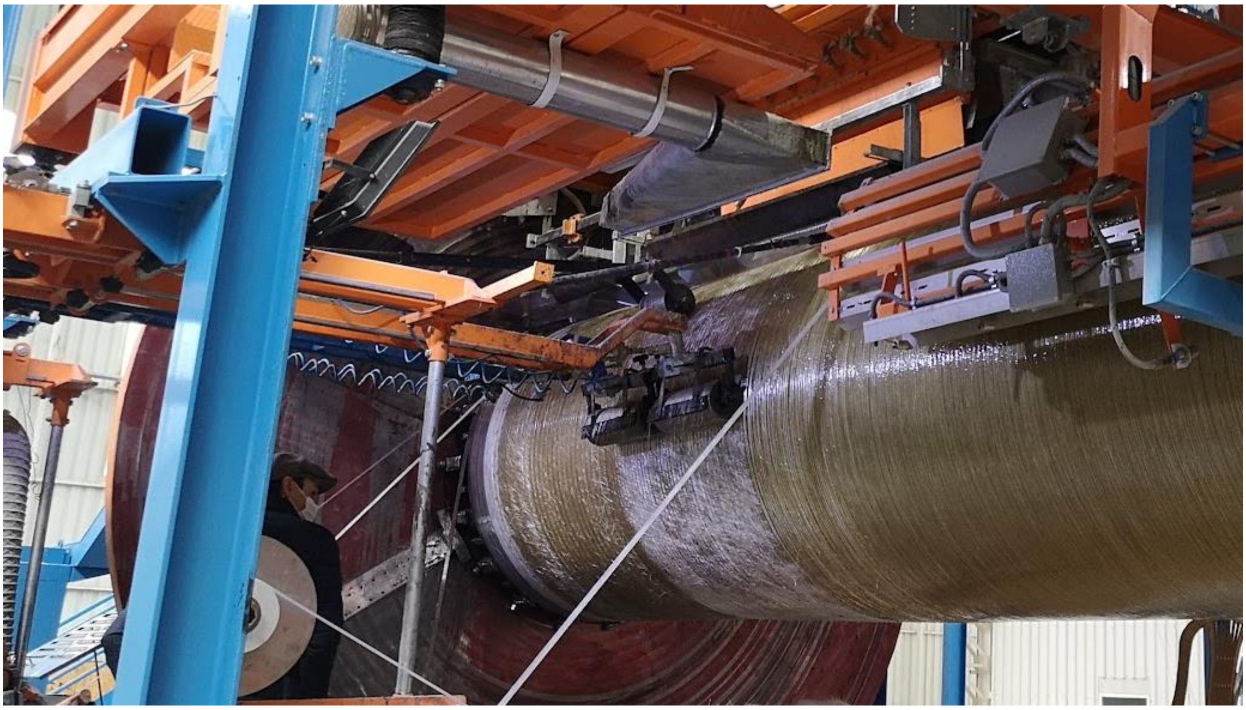

Figure 72: Pneumatic and gravity compaction rollers

Pneumatic roller comes in two lengths: 400 mm and 600 mm. It is positioned so it corresponds to the central part of the structural wall building zone, which ensures that the roller remains in contact with the laminate all along its length. For this purpose, the roller inclination is regulated with two side loops found in the structure, which support the axis of the roller on sides in such a way that they allow the roller to rest on the pipe, following the laminate thickness variations.

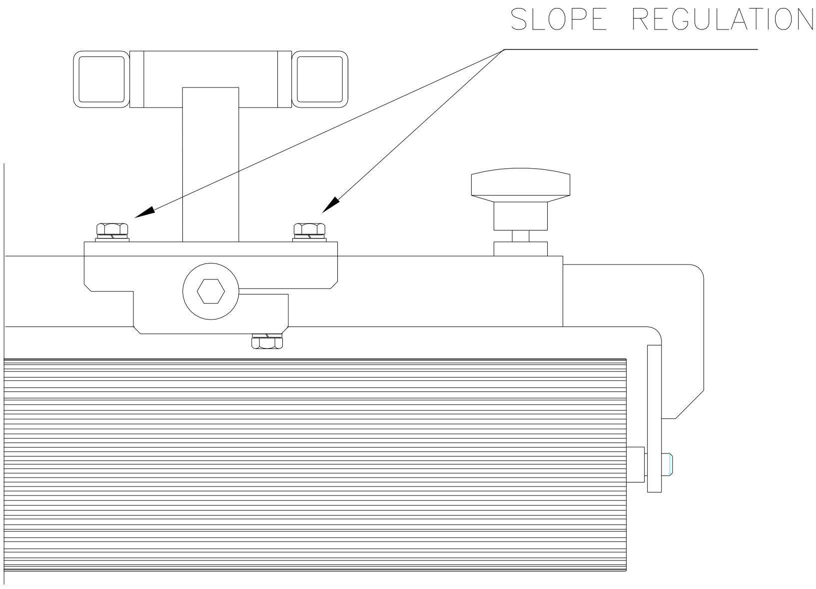

Figure 73: Pneumatic compaction roller, detailed view

Pressure from the compressed air may vary. It depends on the length of the roller and the laminate thickness, from minimum 2 bar to maximum 4.5 bar.

The gravity compaction roller and the finishing roller are positioned correspondingly to the lamination of the external pipe skin. Its arm length can be regulated with a telescopic lever in such a way, that is places the roller on the superior part of the mandrel, see Figure 72.

11. FINISHING ROLLERS

Finishing rollers make the surface they are applied to as smooth as possible. During the pipe production, finishing rollers are used in two positions:

- immediately after the liner build-up;
- immediately after the structural layer build-up, on the external pipe surface.

The finishing roller for the external surface is positioned in such way, that it corresponds to the winding of the superficial C-veil. It is advisable to have some excess resin under the roller, which allows for a good impregnation of the veil and helps avoid the dryness of the external pipe surface.

12. OVEN SET-UP

VERY IMPORTANT NOTE:

The pipe laminate cures because of the cross linking of the various chemicals, not because of the temperature. Temperature is a result of the chemical reactions. The pipe must be able to cure 100% with only its own reaction temperature. However, this is a slow process and the machine will not be cost effective if it operates at this speed. To increase the effectiveness of the production, heat is introduced to speed up the curing. This extra heat must be controlled and understood in order to produce quality pipes at fast speeds.

12.1. Exotherm

The amount of chemicals, for example accelerators and catalysts, will affect the temperature of the reaction.

This temperature will be absorbed by the laminate in another position on the mandrel.

12.2. Induction Heater

The function of the induction heater is to heat the steel band for approximately 20º C in order to activate the curing from the inside. It is very important to cure the laminate from the inside out in order to cure faster, without trapping gasses. The exotherm of the liner already adds heat to the first skin, but it is not enough if the production speed is very fast.

The normal energy, which has to be added to the first skin, is around 3kW if the ambient temperature is 25º C, a receiving steel band has around 65º C and the production speed is high. The induction heater moves the peak exotherm forward or moves it away. In other words, the induction heater changes the angle of the cure.

In the diagram 12.2 (Figure 74), it is possible to see the induction heater line; such line is not visible on the machine or the control screen:

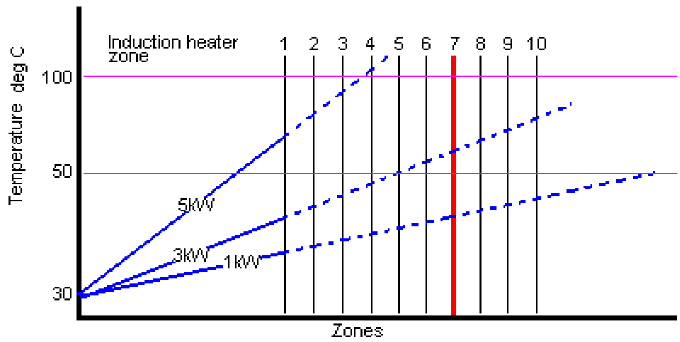

Figure 74: Diagram 12.2

The effect of this heat can be measured in zones 1 – 3.

12.3. Infrared Ovens

The infrared heater adds heat to the outside layers of the laminate to ensure curing is complete by the time the pipe exits the mandrel.

The laminate must reach its highest temperature at the position indicated in the process diagram or schematic. This is called the "peak exotherm".

The machine contains 4 infrared ovens.

The first and second oven are the most important ones. By adding heat at those two points, you effect the zones 3, 4, 5 and beyond. If you look at the same curve as in the diagram 12.2 (Figure 74), you can add the effect of this zone. Refer to diagram 12.4 (Figure 75). For practical purposes, the effect is indicated only on the 3kw curve and for high speed with the line that shows double from zones 3 – 7 to indicate that more lamps are switched on to change the angle of the curve. The effect is shown and the extra temperature can be seen, after the oven 1 and 2 are switched on.

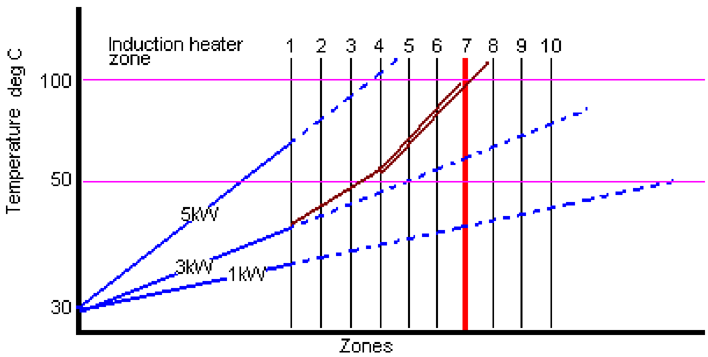

Figure 75: Diagram 12.4

12.4. Managing the temperature curve

Diagram 12.4 (Figure 75) shows the ideal curve for a small diameter pipes.

Examples for the curve in the 12.4 (Figure 75) diagram:

- If the machine runs faster, the peak position moves away from the cam plate or "out". This is normal. In order to bring the curve back so that the peak exotherm is on position 7, it is possible to do the following:
    1. add a catalyst. This is a priority if the catalyst percentage is low;
    2. increase the output of the induction heater, but limit it to 3 kW unless the pipe is large or the production speed is on maximum;
    3. add more lamps in ovens 1 and 2;
    4. reduce speed.

Do NOT just switch on the heaters in ovens 3 and 4 without considering these 4 points.

- If the peak exotherm is in zone 6, 5, and even 4, it is possible to do the following:
    1. increase the production speed;
    2. switch off or reduce the % power for some heater lamps if they are on high;
    3. decrease the induction heater output;
    4. decrease the catalyst.

Important note:

Always record the changes that were made so that other operators will know what was done and react accordingly.

13. LIFTING TABLES SET UP

Setting the EFW Machine lifting tables for the pipe is based on two main distances, which have to be adjusted in order to give a firm and even support to the advancing pipe without excess uplift force:

- height (H);
- distance between the support rollers

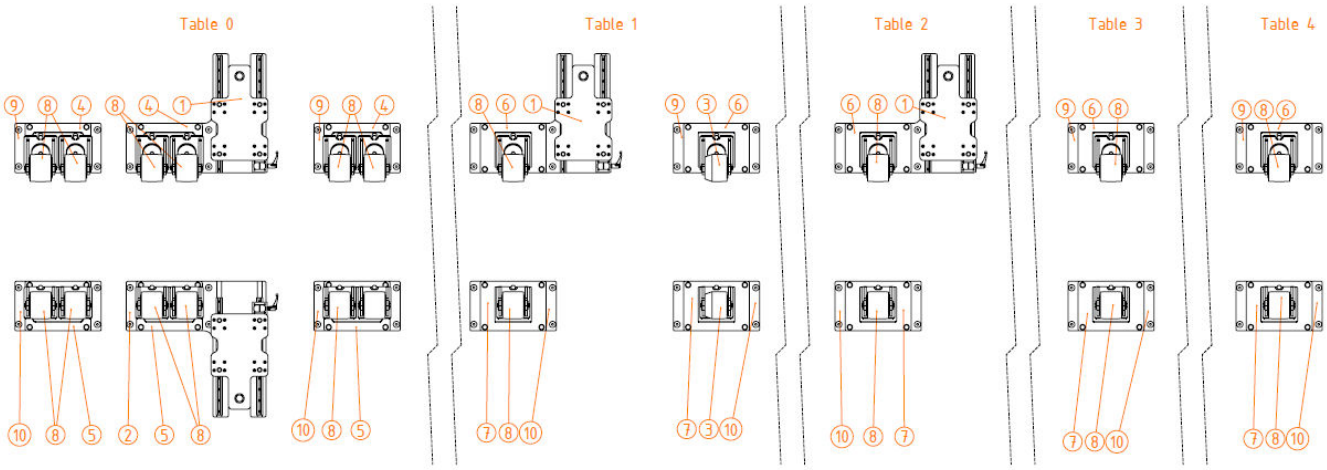

Figure 76

EFW MACHINE START-UP AND PRODUCTION CHECK LIST

EFW MACHINE START-UP AND PRODUCTION CHECK LIST

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1. BEFORE START

Before the machine starts running, the following operations must be performed:

1. ensure you have all the necessary raw materials for the production, in particular:
2. resin in the daily mixers, with the necessary amount of cobalt to get the desired Gel time.
3. liner catalyst in the tank;
4. structure catalyst in the tank;
5. enough chop roving and hoop glass bobbins;
6. enough Mylar and C-veil bobbins;
7. enough sand in the silos;
8. clean acetone (TOPFIBRA suggests you always have a small bucket with clean acetone close to the operators).
9. set the machine control to the pipe design which will be produced;
10. if necessary, check the calibration of every device (pumps, choppers, sand unit);
11. make sure that each part of the machine works perfectly:
12. chopper devices (blades, rollers, skids, roving guides);
13. check the correct pressure values in the choppers (max 2 bars for rollers, 4 bars for the moving comb);
14. be sure that catalyst is properly delivered to the static mixers from the Liner and the Structure pumps;
15. check the diameter of the static mixers;
16. ensure that the static mixers are properly assembled;
17. make sure that the sand hopper is full of sand;
18. check the pneumatic compacting roller pressure (max 4.5 bars);
19. prepare and test the resin feeder for the liner and the structure;
20. Verify that you have an appropriate number of spare rollers, to make it faster during production, mainly:
21. compacting rollers: 200 mm, 400 mm and 600 mm for the Structure Mortar core (Horizontal grooves);

22. surface finishing rollers - Vertical grooves.

2. MYLAR BOBBIN

1. Position the bobbin so it perfectly covers the steel band. The 50 mm wide Mylar should be positioned with the left tape border corresponding to the left border of the steel band. make sure that chopped glass, falling from the top, does not fall directly on the steel band;
2. regulate the Mylar tension with the regulator. Mylar should not move once it is wound on the mandrel;
3. make sure that chopped glass falling from the top does not fall directly on the steel band;
4. during the production keep spare bobbins ready, so they can be quickly and efficiently changed when necessary.

3. LINER C-VEIL

1. Position the bobbin so it perfectly covers the Mylar
2. Tension the veil with the regulator, but pay attention you do not break it;
3. During the production keep spare bobbins ready, so they can be quickly and efficiently changed when necessary.

4. LINER CHOPPER

Before the start and during the production, we suggest you follow the next steps:

1. verify that each part of the device is perfectly clean;
2. check the device calibration before you start the production. If necessary, calibrate it again;
3. adjust the positions of the roving so they will not fall between the Mylar and the C-veil after they have been chopped;
4. regulate the metal roller position in the chop cutter unit, to ensure that it is parallel to the rubber roller;

5. verify the rubber roller pressure, which must be maximum 2 bar so that the chop strands are approximately 45-65mm long. Increase the pressure when the blades or rubber are worn out;
6. verify the pneumatic control pressure of the moving comb, to ensure an adequate distribution of the roving. Slow movement is better.

5. STRUCTURE CHOPPER

1. Verify that each part of the device is perfectly clean;
2. adjust the distribution of the rovings according to the pipe design indications.
3. regulate the metal roller position in the chop cutter unit, to assure that it is parallel to the rubber roller;
4. gradually increase the rubber roller pressure so that the roving strands are chopped in the appropriate length (45÷65mm). Increase the pressure when the blades or rubber are worn out. This causes the roving strands to slip and when they are cut, they are longer. When the pressure reaches 2 bar and the length cannot be controlled anymore, the rubber and or blades must be replaced;
5. verify the pneumatic control pressure of the moving comb, to ensure an adequate distribution of the roving. Slow movement is better;
6. during cutting, check that it works smoothly;
7. check the device's calibration before starting the production. If necessary, calibrate it again.

6. SAND DOSING

1. Verify the correct opening of the sand distribution unit;
2. before starting the production, check the calibration. If necessary, calibrate the device again;

7. LINER RESIN

1. Before starting the production, verify that the resin and catalyst flow to the machine; if necessary, remove air from the piping;

2. position the trough so that NO resin falls directly on the Mylar. Wet the C-veil from the top only;
3. adjust the size of the holes and the width of the bath to obtain the required distribution length as per the Design Program. Check that the level of resin inside the bath does not exceed 2 cm in the middle and 1 cm at the extremities. Test the bath before starting the production at a flow, which corresponds to the production speed.

8. STRUCTURE RESIN

1. Before starting, verify that the resin and catalyst flow to the machine. If necessary, remove air from the piping;
2. position the trough so that resin falls directly on the liner, about 3 cm before starting the structure winding, to wet the surface before the structure starts winding;
3. adjust the hole sizes and the width of the bath according to the EFW Pipe Design Program. Check that the level of resin inside the bath does not exceed 4 cm in the middle and 0.5 cm at the extremities. Test the bath before starting the production at a flow, which corresponds to the production speed;
4. if the resin in the bath does not reach the extremities, reduce the diameter of the holes and use another resin bath. Make sure all raw materials are well wetted to avoid delamination.

9. HOOP ROVINGS

1. The hoop roving should not cross on their path between the bobbin and the mandrel. The path should be as smooth as possible, without big direction changes, to avoid breaking during the production;
2. set the correct tension of the roving.

10. STATIC MIXERS

1. If the design of the holes in the resin bath is symmetrical, position the mixer in the middle of the resin bath. Otherwise, move the mixer, to have the right level of resin in the bath;
2. check the size of the static mixer and choose the size depending on the flow range.

11. COMPACTION ROLLER

1. The pneumatic compaction roller should be positioned in the core sand area and should be well oriented, so it touches the pipe uniformly;
2. set the pneumatic cylinder pressure to achieve a force of 15-20 kg on the roller face (about 4 bars);
3. during the production keep spare rollers ready, so they can be quickly and efficiently changed when necessary.

12. FINISHING ROLLER

1. Position a vertical groove surface roller after the end of the structure winding, pressing on the external surface veil to distribute the resin for a good wet-out of the surface tissue;
2. during the production keep spare rollers ready, so they can be quickly and efficiently changed when necessary.

13. SURFACE C-VEIL

1. Position the bobbin so that the veil winds on the pipe's external surface, which has already been manufactured;
2. regulate the surface veil tension with the regulator, but pay attention you do not break it;
3. during the production keep spare bobbins ready, so they can be quickly and efficiently changed when necessary.

14. ANTITORQUE SYSTEM

1. The antitorque device must be used for pipes with diameters over 1600;
2. turn on the antitorque motor on the console, before the pipe, which is coming out of the machine, becomes too long;

MAINTENANCE PLANNING

MAINTENANCE PLANNING

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1. FOREWORD

These indications refer to the technical servicing of the Continuous Filament Winding machine. The machine is an essential and integral part of a production plant for manufacturing of the glass reinforced polyester (GRP) pipes.

In the first part of this chapter, basic and general rules for maintenance are described in respect to the main working units.

In the second part of the chapter, you will find specifics rules for the main Effective Continuous Filament Winding Machine units.

Note: "Use and Maintenance Handbook" often referred to, stands for the equipment handbooks (Mechanical Brochures and Electrical Brochures) when the equipment is supplied by TOPFIBRA; or to the Instructions of the Supplier if the Customer acquires their own equipment.

2. GENERAL MAINTENANCE RULES

2.1. General Rules

To keep the plant operating and in good condition, it is important to follow these instructions for general maintenance of the plant:

2.1.1. Supports

Grease them every 500 working hours.

2.1.2. Belts

- Check their tension every 500 working hours;
- ensure that pulley's supports are strictly fastened to avoid axis misalignments;
- check the wear on rear, sides and teeth;
- check the wear on rear and sides of the flat belts.

2.1.3.Reducers

Follow manufacturer's instructions and those included in the Use and Maintenance handbook.

2.1.4.Conveying chain

During and after work, control any axial torsion or any other stresses, which could impair the good operation of the conveying chain.

2.1.5.Rack

Clean and grease the rack teeth every week and check teeth wear.

2.1.6.Three phase motors

Follow the manufacturer's instructions included in the Use and Maintenance handbook.

2.1.7.Sliding guides

After each working shift, remove any eventual scale and/or dust.

2.1.8.Cables

Check the cables, which were not part of the machine supply, every week.

2.1.9.Hydraulic cylinder

Check sealing and scraper rings every 500 working hours.

2.1.10. Hydraulic unit

Oleodynamic unit for the hydraulic actuators: please refer to the manufacturer's manual and check the equipment.

2.1.11. Oil tank

Check the level and temperature of the oil tank every day, during the working operation.

2.1.12. Pressure valves

Check leakage every day while they are functioning.

2.1.13. Pipeline

Check friction areas of the flexible pipeline every day, during the working time.

Check gaskets sealing every day, during the working time.

2.1.14. Filters

Check the filter clogging indicator every day, whilst operating.

2.1.15. Pump, motor, coupling

Control pump noise every day, during the working time.

Check pump structure temperature every day, whilst operating.

2.1.16. By-pass valves

Check valves closure every month, whilst operating.

2.2. General Maintenance Operations

The main general maintenance operations should be performed by the maintenance personnel and supervised by the Maintenance Supervisor in cooperation with the Production Manager:

- spherical ball bearings are mounted on supports that have lubricators: the lubrication is performed with a standard grease for normal applications (lithium base), approximately every 1÷3 months. It depends on the quantity of the dust accumulated on the bearings. As a general rule, apply grease on the moving bearings up to the exit between the external ring and the periphery of the protection schemes;
- keep clean all the external surfaces of the rotation rollers coated with polyurethane and keep clean the external surface of the GRP pipe in work, in order to avoid damages;
- keep all the working devices clean from dust (which results from cutting or from the sand transportation units), rust and roving residues.

3. GENERAL EFW MACHINE MAINTENANCE

See Paragraph 2 for ordinary maintenance of standard components.

3.1. Steel Band

Maintenance of the steel band:

- check the steel band wear on every shift;
- check the consistency of the steel band welding on every shift;
- replace the steel band when the damaged parts are visible, or at least every 500 working hours.

3.2. Chopper Unit

Maintenance of the chopping unit:

- check chopper blades on every shift, replace damaged blades before machine start-up;
- check wear of the rubber roller on every shift;
- check the integrity of the pneumatic unit (cylinders, valves, flexible pipes);
- clean all units with compressed air on every shift (to remove the roving residues).

3.3. Sand Unit and Distribution Pipeline

Maintenance of the sand unit:

- check and clean sand unit filters before machine start-up;
- clean all units with compressed air on every shift (to removing the roving residues or sand dust);
- check the level sensors integrity and clean them on every shift.

3.4. Cutting and Grinding Unit

Maintenance of the cutting and grinding unit:

- check and clean all diamond tools before start-up;
- check the integrity of the pneumatic unit (cylinders, valves, flexible pipes) on every shift;
- clean the dust off of all units on every shift.

3.5. Static Mixers and Resin Baths

Maintenance of the static mixers:

- check all static mixers before start-up and clean the resin on them;
- check the integrity of the flexible pipes for resin and catalyst on every shift.

Maintenance of the resin baths:

- check all baths before start-up and clean the resin in them;
- replace and clean each resin bath when the resin reaches gel state during the production.

3.6. Rollers

Maintenance of the rollers (compaction, finishing and others):

- check all rollers before start-up and clean the resin on them;
- replace and clean each roller when the resin reaches gel state during the production.

3.7. Lifting Tables

Maintenance of the lifting tables:

- check and clean the pipe supporting rollers before start-up every 500 working hours;
- check the integrity of the pneumatic unit (valves, flexible pipes) every 500 working hours.

3.8. Electrical Plant

Maintenance of the electrical plant:

- check all electrical cables and machine sensors and clean them of resin, sand and glass dust (coming from the grinding and cutting unit) every 500 working hours;
- check the integrity of the electrical signal. Check buttons and cables every 500 working hours.

3.9. Cam Plate and Pushers

Maintenance of the cam plate and pushers:

- check all cam plates and pushers and clean them of resin, sand and glass dust (if any) before start-up or at least every 500 working hours;
- check cam plate and pushers wear every 500 working hours and replace them when necessary.

3.10. Beams

Maintenance of the beams:

- check all beams and clean them of resin, sand and glass dust (if any) before start-up, or at least every 500 working hours;
- check the integrity of the beam bearings every time a production diameter changes, or at least every 500 working hours.

For more information, contact us writing at

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or

visit our page

www.topfibra.eu

To learn more of the EFW technology visit our blog

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