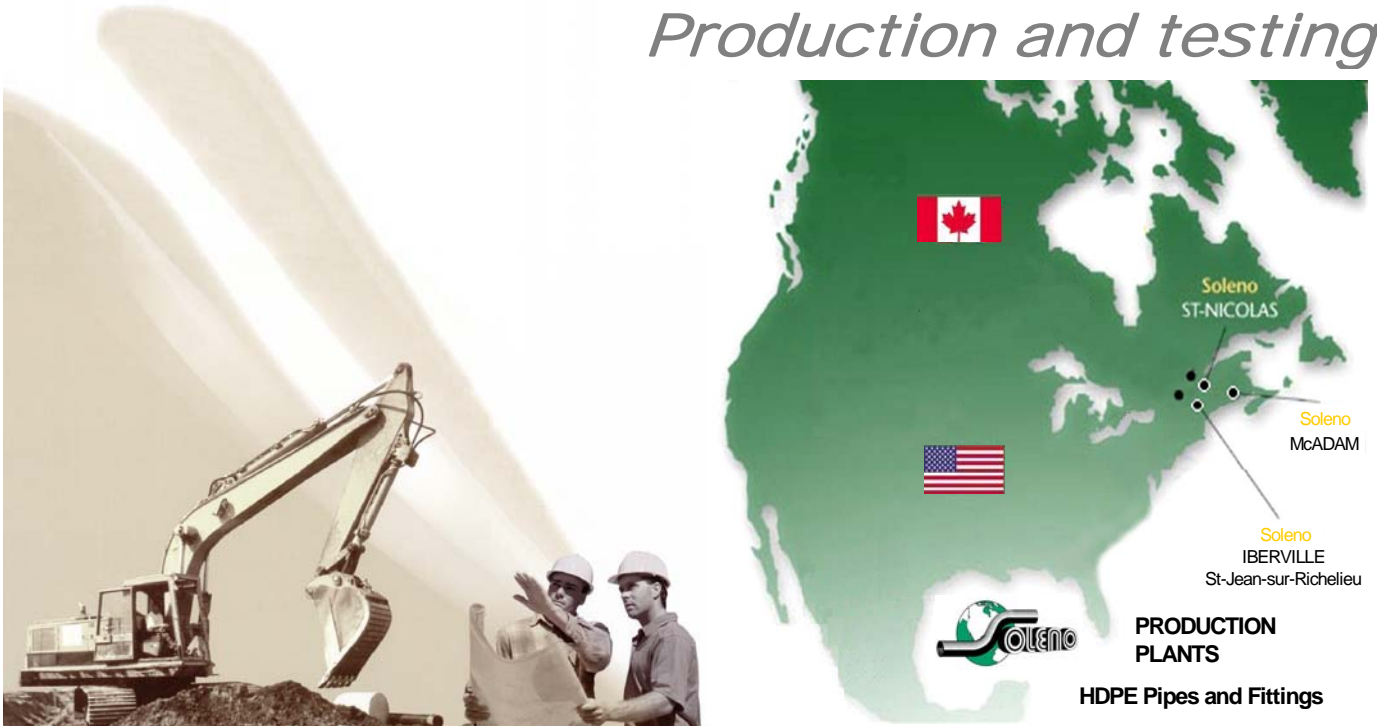


Chapter
3

SECTION 1

Production and testing



HDPE Pipes and Fittings

Technical Manual

Characteristics of

CORRUGATED HDPE PIPE



TECHNICAL MANUAL

SECTION 1

Characteristics of CORRUGATED HDPE PIPE

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CHAPTER 3

SECTION 1

PRODUCTION AND TESTING

Solen has established a reputation as an innovator in the field of the production of **HDPE** pipe and accessories. **Solen** was one of the first companies to commercialize corrugated pipe manufactured by a vacuum process in a wide range of diameters, as well as accessories by a process of injection with extruded resin.

Pipes such as **SOLFLO MAX**[®], **SOLFLO**[®] and **DRAIN** as well as accessories and sumps are all manufactured using the latest technology in **Solen** plants and meet quality and performance criteria related to product standards as indicated in chapter 2 of section 1. The entire manufacturing process is controlled and documented in conformity with **Solen**'s Quality System.

Manufacturing process

The industry of corrugated **HDPE** pipe is advancing rapidly in terms of technological developments in the manufacturing process and controls during the manufacturing process. A continual extrusion manufacturing process is used. The sequence of manufacturing is comprised of five phases critical to the success of the company's mission. The mission is articulated below and the five basic phases of all the manufacturing processes for corrugated **HDPE** pipe are illustrated in Figure 3.1.

*The management of **Solen** Inc. is committed to supplying clients with products compliant with or superior to the applicable standards when used in applications for which they were designed.*

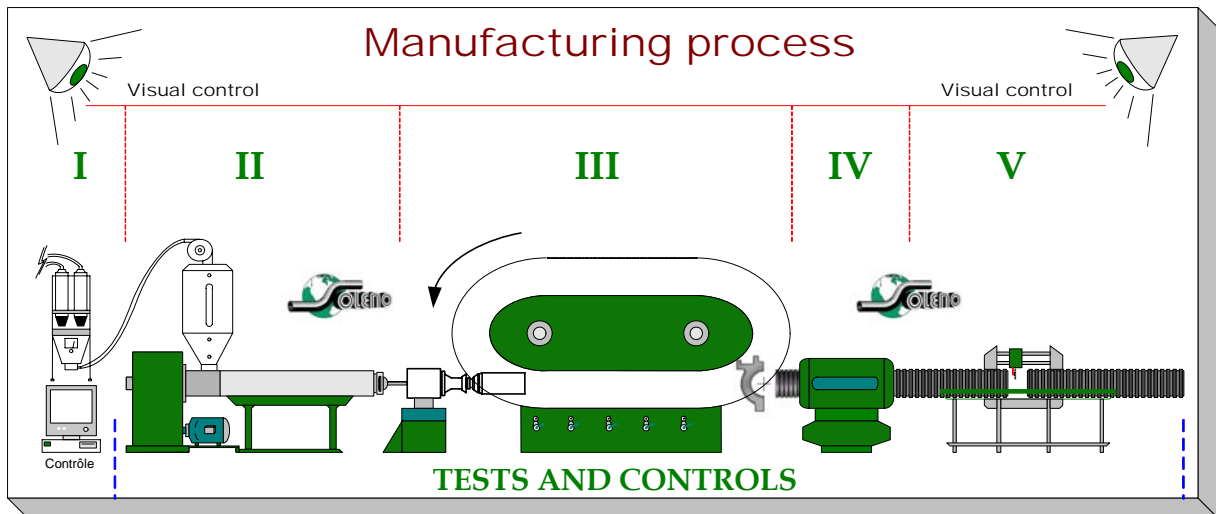


Figure 3.1 : Tests and controls

The phases are: preparation of raw material, extrusion (pasty consistency), corrugating, calibration and finishing and packaging so that throughout phases II to V, there is a constant verification of the product by tests and controls.

Phase I

Preparation of raw material (RM)

This is a critical phase of the manufacturing process because it requires the involvement of personnel at several different levels. The preparation of raw material begins with the raw material purchase order and ends after the preparation of the mixture (see Figure 3.2), and its transfer to the hopper of the extruder to be transformed.

This phase includes steps of monitoring and control. It is directly linked to the production plan or schedule. The steps of this phase are:

- Purchase order**
- Receiving / Storage**
- Mixture**



Figure 3.2: Preparation of mixture

Approval of RM for purchase order

Raw materials (RM) used in the manufacturing process are approved by our personnel in the operation group known as Production / Quality Assurance / Purchasing, based on the following criteria: technical record of the RM (classification by properties for **HDPE**), the criteria required by product standards, the reliability of the supplier and the manufacturing tests and Quality Control on the RM and, in the case of a **HDPE** resin, when transformed into the final product. If the RM meets the requirements, it can be incorporated into our procedure and be ordered. Figure 3.3 outlines these steps.

Receiving / Storage

RMs are controlled at receiving by the quality controller, by means of the extraction of a sample and the verification of the factors included in the analysis certificate, the bill of lading and the purchase order slip. The quality controller carries out standardized tests on the sample to determine the compliance of the lot and to record the result in a report:

If the lot is not compliant, the load is returned and a report of non-compliance is opened.

If the lot is compliant, it is stored and registered.

Mixture

Depending on the type of corrugated **HDPE** pipe and the product standard, our mixtures may vary. On the other hand, the quality of **HDPE** resin remains constant. During the mixing process, we add a minimum of 2% and a maximum of 5% of the UV inhibitor, carbon black.

The Quality Controller (QC) carries out tests on the mixture to verify if it is compliant with the characteristics of product mixture to be manufactured and if the UV inhibitor is at the right percentage.

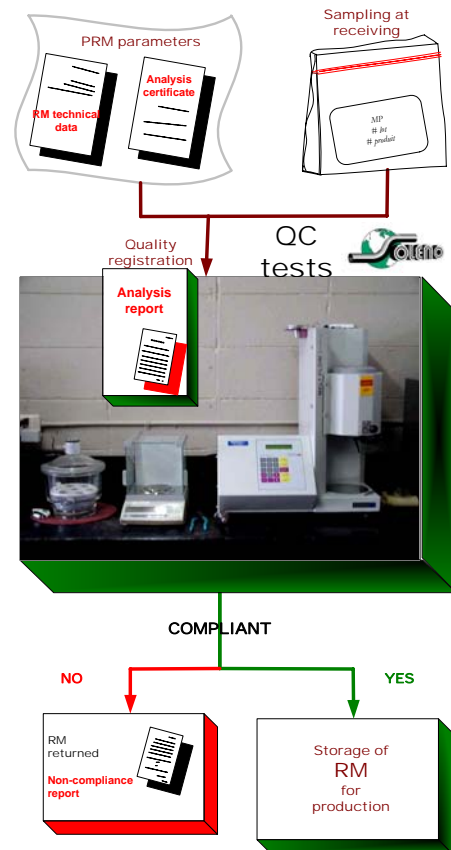


Figure 3.3: Control at receiving

In Phase I, **Solen** carries out a minimum of four controls, six Quality Control tests and four registrations. All of these verifications are necessary in order to guarantee the highest quality of **HDPE** resins, both virgin and post-consumer recycled. **Solen** was the first company to request recognition of recycled **HDPE** resins in the standards, providing they are compliant with the properties of their classification as required by product standards.

Phase II

Extrusion

The extrusion phase (see figure 3.4) for thermoplastics is the stage where **HEAT** is used to fuse the polymer. Heat is produced by heating elements or bands in conjunction with the rotation of the screw. **Solen** uses screws specially designed for a minimum of molecular splitting and a maximum of mix in order to reduce the possibility of deterioration of the resin to a minimum. In this way, the level of fluidity of the mixture required in order to pass through the matrix is attained, as well as the creation of pressure, enabling the **HDPE** to exit the die lips in a consistent manner.

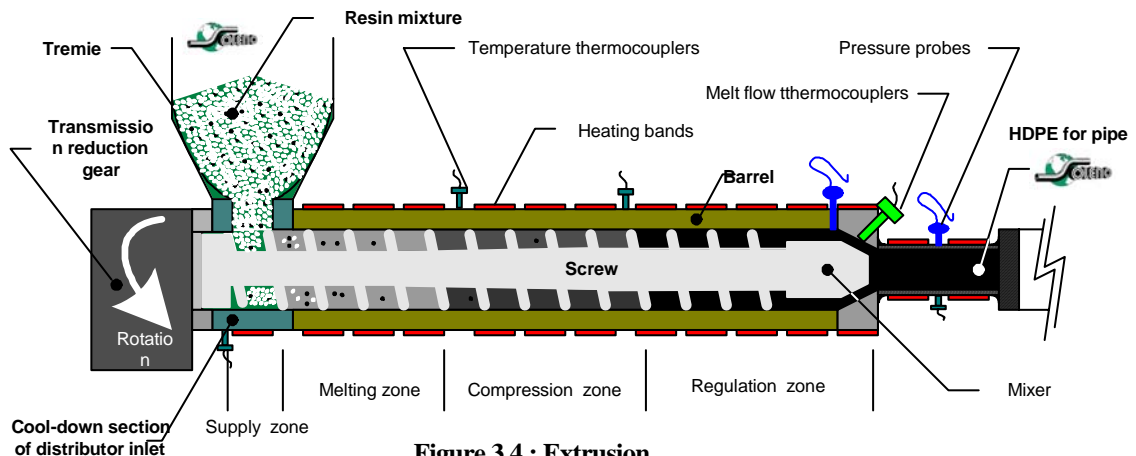


Figure 3.4 : Extrusion

The melting of the **HDPE** resin is controlled by a precise adjustment of the temperature curve of the various work areas for the type of resin and therefore optimizing the pressure at the die lips. This task is performed by our production personnel (Adjuster and Operators) according to the procedures outlined in the Quality Assurance Manual and the Job Instructions Manual. For more details concerning our Quality System, please refer to Section 1, Chapter 2.

Phase III

Corrugation

This phase is important because it is the first step in the production of a *Solen* pipe. Following the extrusion, the **HDPE** moves through the die where it is shaped into a tube at the exit of the die. The tube is reshaped using heat into a corrugated exterior profile by a vacuum process (it could be done by forced air). The molding stage is carried out using a rotating molding corrugator's. The process is a continuous one. It might also include a second smooth interior wall (dual wall). New technologies enable the addition of a third smooth exterior wall—the product is known as a triple-wall pipe. This recent technology is under study.

Depending on the type of pipe to be molded, the Adjuster prepares and installs the necessary tools on the production line as well as verifying the functioning of all the components. The tools include the die, the moulds and the surrounding hardware. *Solen* uses tools for pipe measuring 38mm to 1200mm in interior diameter on different types of corrugators.

The adjuster makes the initial adjustment (thickness, distribution) and assists the operator in optimizing the adjustments during production (weight, speed and temperatures). The Quality Controller conducts controls on the finished product to insure it meets quality and performance criteria.

Figures 3.5 and 3.6 illustrate the dies for **SOLFLO MAX**[®] dual wall pipe and **SOLFLO**[®] and **DRAIN** single-wall pipe. The wall or walls may be produced by co-extrusion or single extrusion. The dies have a lips for the formation of a tube that is molded to the corrugated shape of the mould by vacuum lines tooled in moulds conveyed by the corrugator's or in certain cases by forced air, moved directly through the inside of the die (See Figure 3.7).

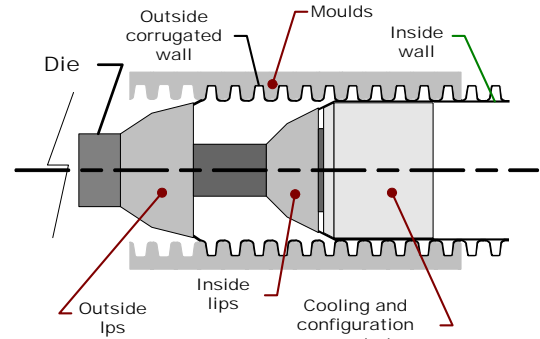


Figure 3.5 : Dual wall die

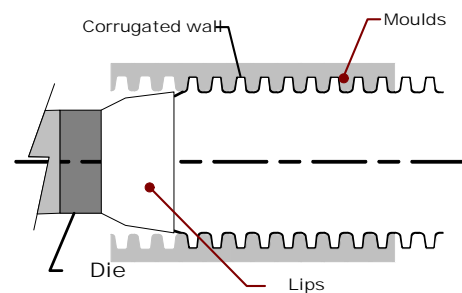


Figure 3.6 : Single wall die

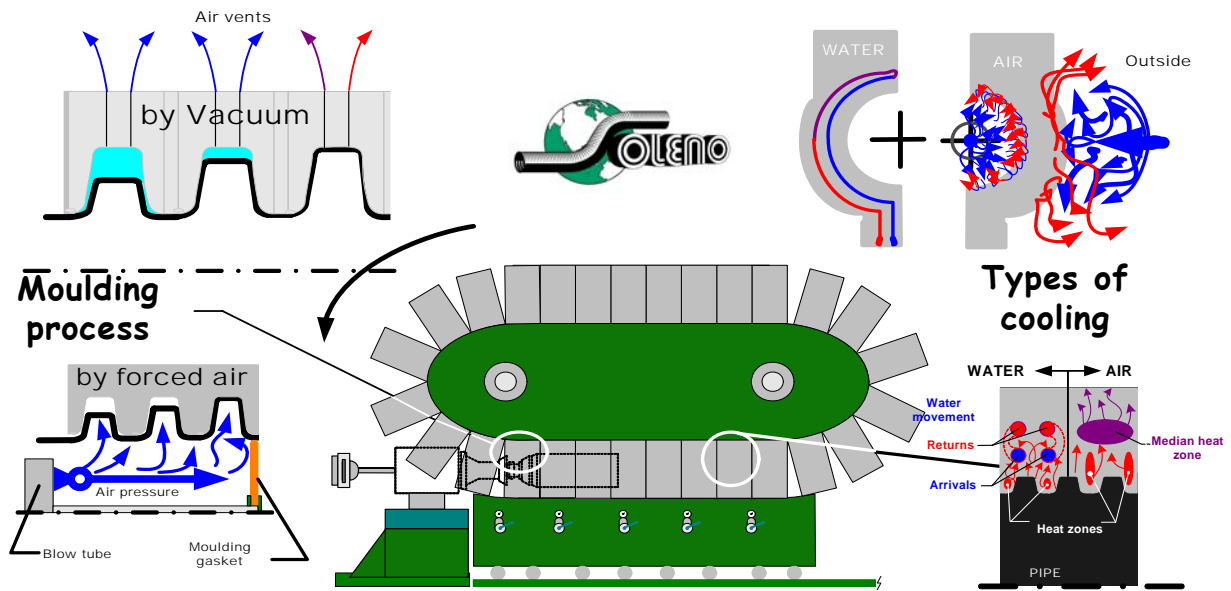


Figure 3.7 : Corrugator

To enable a proper corrugation of the pipe, the moulds must be cooled down. Most tools use an air-cooling system. This technology requires the force of a large volume of air and high velocity over the surfaces of the mould using a forced air turbine.

A second technology uses water to cool down the moulds. Both types of cooling target the rapid dispersion of the heat given off by the **HDPE** on the surfaces of the molding. This step is crucial to the proper formation of the corrugated profile. A good cool down will benefit the calibration of the pipe in Phase IV.

Phase IV

Calibration

In the production of plastic pipe, there is a cooling stage necessary in order to meet dimensional requirements. This step is the calibration and varies in length depending on the thickness to be cooled and the speed of the line. The cooling is done using water nozzles spread around the circumference and along the length of the calibrator (see Figure 3.8). A cooling unit and a treatment component control the temperature of the water.

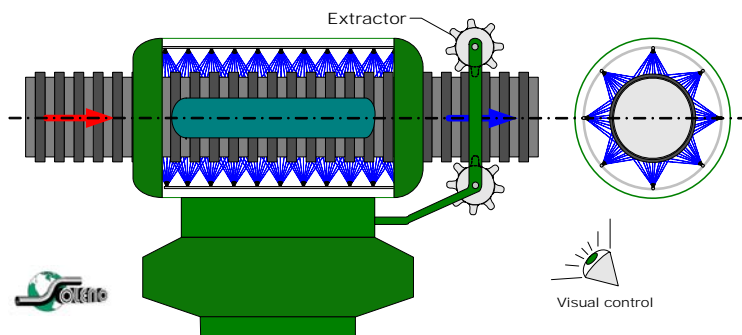


Figure 3.8 : Calibration

Phase V

Finishing and Packaging

In the final stage of the manufacturing process, samples are extracted from the corrugated **HDPE** pipe by the Operator and the Quality Control service to conduct a series of in-house tests to determine the compliance during the manufacturing process and the optimization of the adjustments.

The finishing applied to the product varies according to the type of pipe: **SOLFLO MAX**[®] with smooth interior wall, or **SOLFLO**[®] and **DRAIN** with corrugated interior and exterior. **SOLFLO MAX**[®] and certain **SOLFLO**[®] and **DRAIN** are finished lengthwise, known as straight (see Figure 3.9). The **DRAIN** and some **SOLFLO**[®] are finished lengthwise rolled, commonly known as roll or flexible (see Figure 3.10). The products can be finished lengthwise and packaged according to **Solen** standards or the customer's specifications, by special order approved by **Solen**.

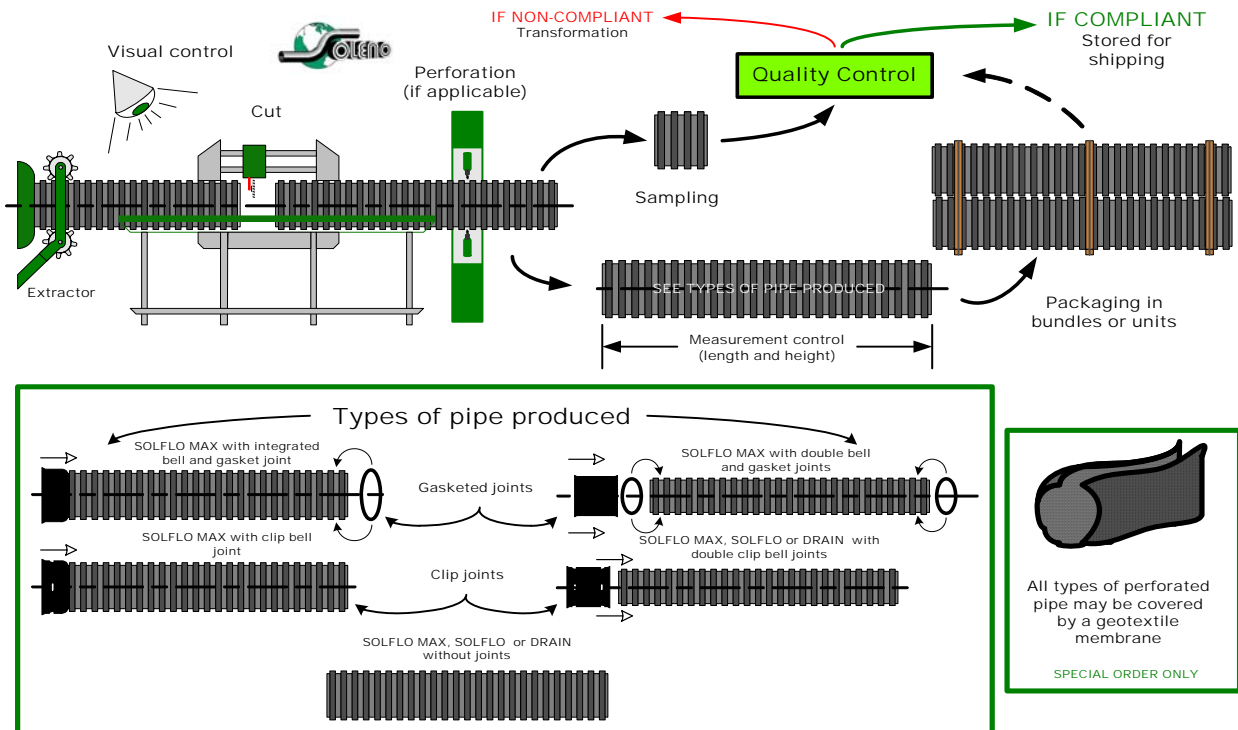


Figure 3.9: Dual wall and single wall finishing and packaging of sections

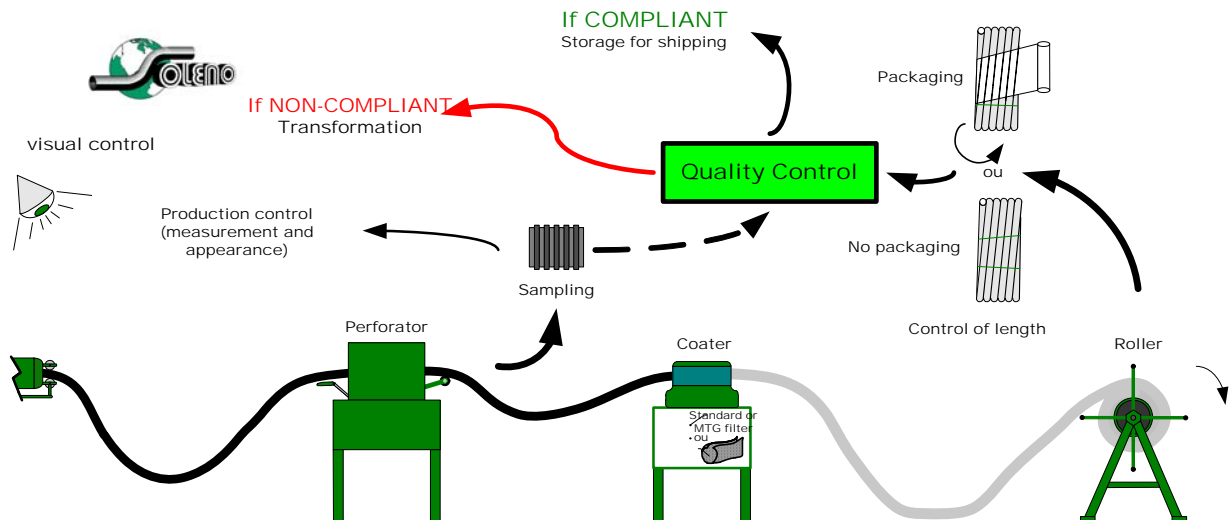


Figure 3.10: Single Wall Finishing and packaging rolls

Controls and Tests

Throughout the production cycle, from Phase I to Phase V, the production is controlled by the production personnel and the Quality Controller. A lot is defined at the total daily production. A number or the date of manufacture identifies the lot. The lot number is recorded on the pipe or on a label in compliance with the applicable standard. *Solen* conducts a series of controls and tests to determine conformity. In order to accept a production lot, the Quality Control service extracts samples from the product according to the testing protocol established by product standards. The following characteristics are evaluated:

Characteristics of HDPE of pipe:
Properties of mixture - % carbon black

Dimensional characteristics:
Diameter interior/exterior – Thickness of wall - Lengths - Perforations - Distribution (dual wall)

Mechanical characteristics:
Quality of wall joints (SOLFLO MAX®) - Shock resistance - Rigidity - Flexion and elongation (SOLFLO® and DRAIN)

Physical characteristics:
Appearance - Water resistance of joints (SOLFLO MAX®) - Quality of joint welding of adaptors - Resistance of joints to separation - Resistance of joints to crushing

The test and control methods are outlined in the the product standards and follow the testing method standardized by the ASTM test standards. You will find the numbers and descriptions of the principal standards adhered to by **Solen** in Appendix A.

*For every lot period, **Solen** conducts a minimum of 75 to 90 controls and tests, depending on the type of product, in order to guarantee the best possible quality of HDPE **Solen** pipe.*

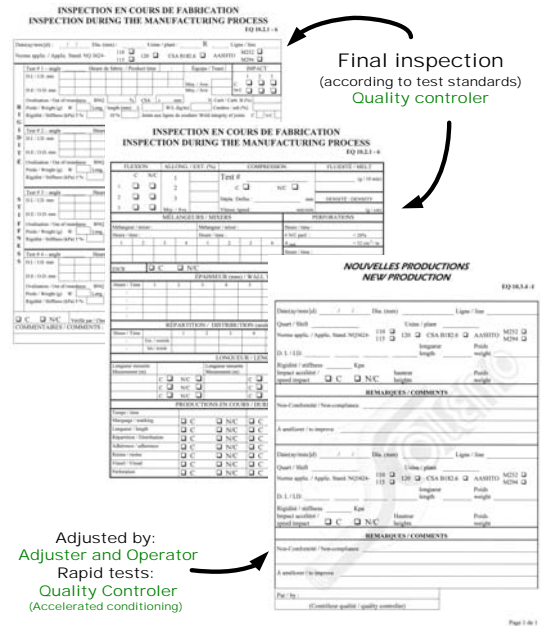
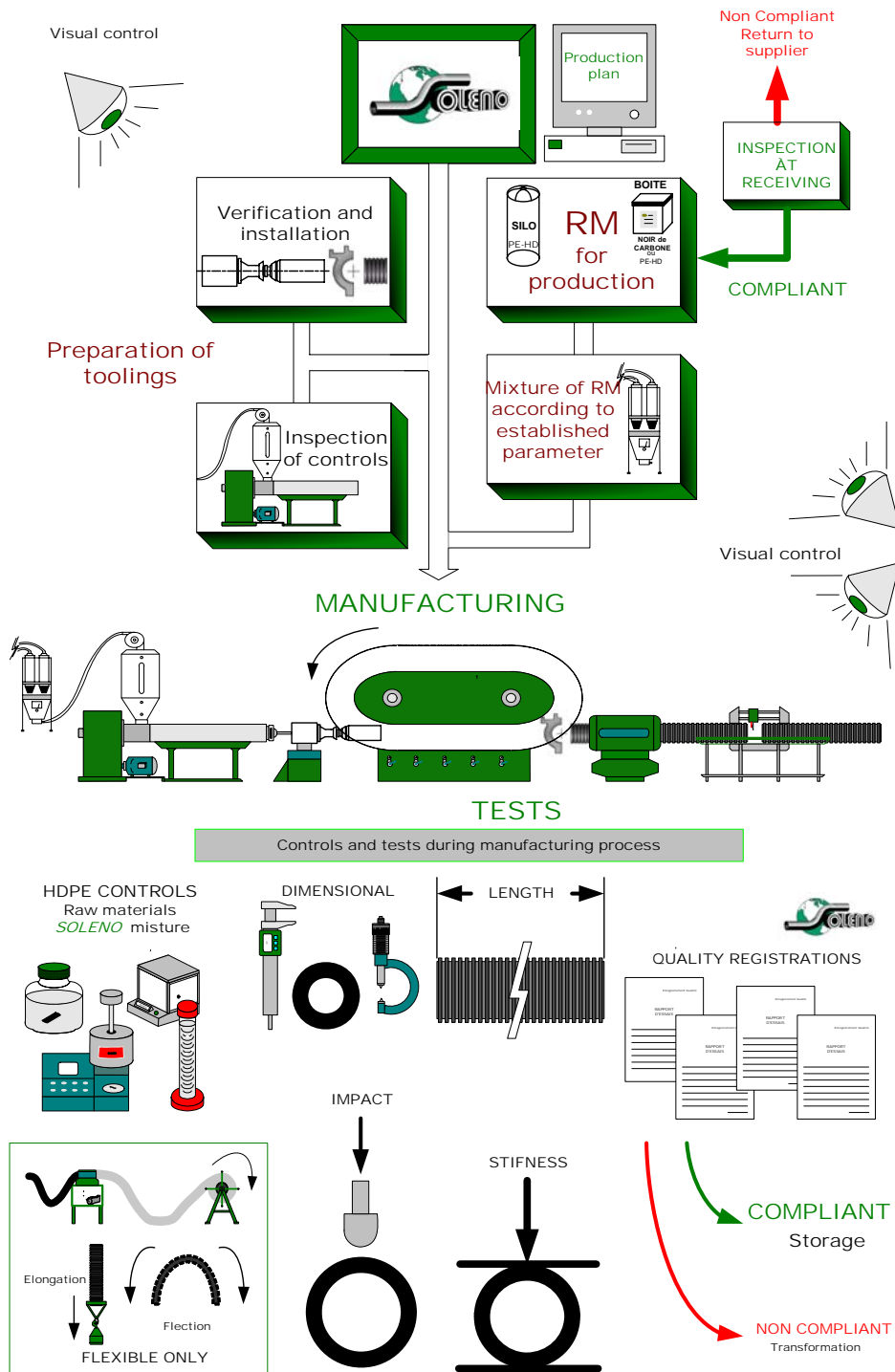
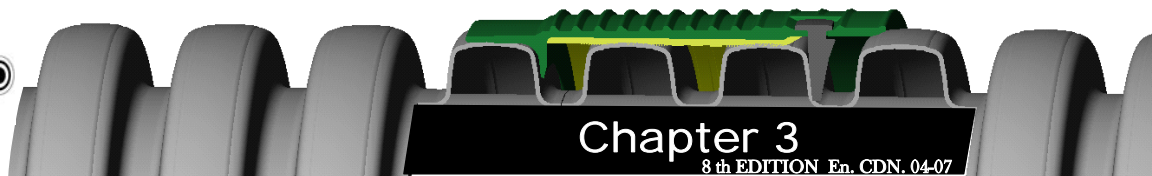


Figure 3.11: Inspection during manufacturing process

All tests and controls are recorded (see Figure 3.11). In this way, every product, if there is more than one type or more than one size, is inspected and recorded during the manufacturing process. In the case of a new product, extra tests are conducted until all the necessary adjustments are made to insure a product compliant with **Solen** criteria, in accordance with performance standards. For more details concerning the Quality System of **Solen**, please consult Section 1, Chapter 2.

Summary of PRODUCTION AND TESTING, Chapter 3, Section 1 of the Technical Information Manual.





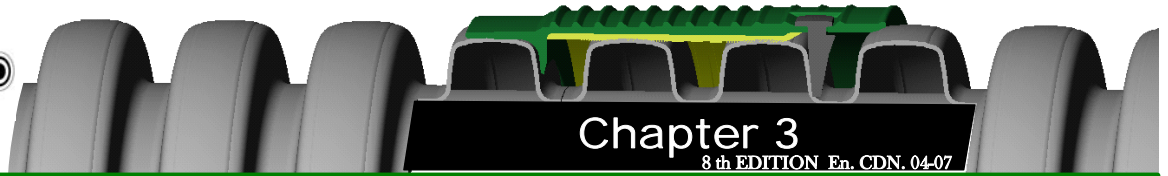
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Product standards and testing and control method standards

APPENDIX A

Numbers	Descriptions
NQ 3624-001	<i>Tuyauteries de plastique – Définitions, désignations et dimensions.</i>
NQ 3624-110	<i>Tuyaux et raccords en polyéthylène (PE)- Tuyaux semi-rigides ou flexibles pour l'évacuation des eaux de ruissellement, le drainage des sols et les ponceaux - caractéristiques et méthodes d'essais</i>
NQ 3624-115	<i>Tuyaux et raccords en polyéthylène (PE)- Tuyaux annelés flexibles pour le drainage - caractéristiques et méthodes d'essais</i>
NQ 3624-120	<i>Tuyaux et raccords en polyéthylène (PE)- Tuyaux à profil ouvert ou fermé à paroi intérieure lisse pour l'égout pluvial et le drainage des sols - caractéristiques et méthodes d'essais</i>
CSA B 181.1	<i>Tuyaux de plastique pour drainage et égout et accessoires</i>
CSA B 182.6	<i>Tuyaux d'égout à paroi profilée et raccords Polyéthylène.</i>
CSA B 182.8	<i>Tuyaux d'égout pluvial et de drainage à paroi profilée et raccords Polyéthylène.</i>
AASHTO M252	<i>Corrugated Polyethylene Drainage Pipe</i>
AASHTO M294	<i>Corrugated Polyethylene Pipe, 300- to 1200-mm Diameter</i>
ASTM D 618	<i>Conditioning Plastics and Electrical Insulating Materials for Testing</i>
ASTM D 1693	<i>Test Method - Environmental Stress Cracking of Ethylene Plastics</i>
ASTM D 2122	<i>Test Method - Determining Dimensions of Thermoplastic Pipe and Fittings</i>
ASTM D 2412	<i>Test Method – Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading</i>
ASTM D 2444	<i>Test Method – Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)</i>
ASTM D 3350	<i>Standard Specification for Polyethylene Plastics Pipe and Fittings Materials</i>
ASTM D 4218	<i>Test Method – Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique</i>



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APPENDIX B



FABRICANT DE TUYAUX ET D'ACCESSOIRES EN POLYÉTHYLÈNE
POLYETHYLENE PIPE AND FITTINGS MANUFACTURER

ATTESTATION DE CONFORMITÉ / COMPLIANCE CERTIFICATE

Client / Customer	
# Bon de livraison / Bill of lading #	
Lot	
Description	
Type	
Catégorie/Category	
Diamètre nominal / Nominal diameter	
Norme applicable / Applicable standard	

Diamètres intérieurs moyens Average inside diameters (mm)	Rigidité Rigidity (kpa)	Protection Ultraviolet Protection (%)	Surface de perforation Perforation area (cm²/m)

Résistance aux chocs : conform/e
Impact resistance : non-conform/e

Ce lot est : conform/e
This lot is : non-conform/e

Remarque/Remark : _____

Signature : _____
 Chantal Hébert
Contrôleur Qualité / Quality controller

Date : _____

04/07/03
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 • <http://www.solen.com> • solen@solen.com •



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