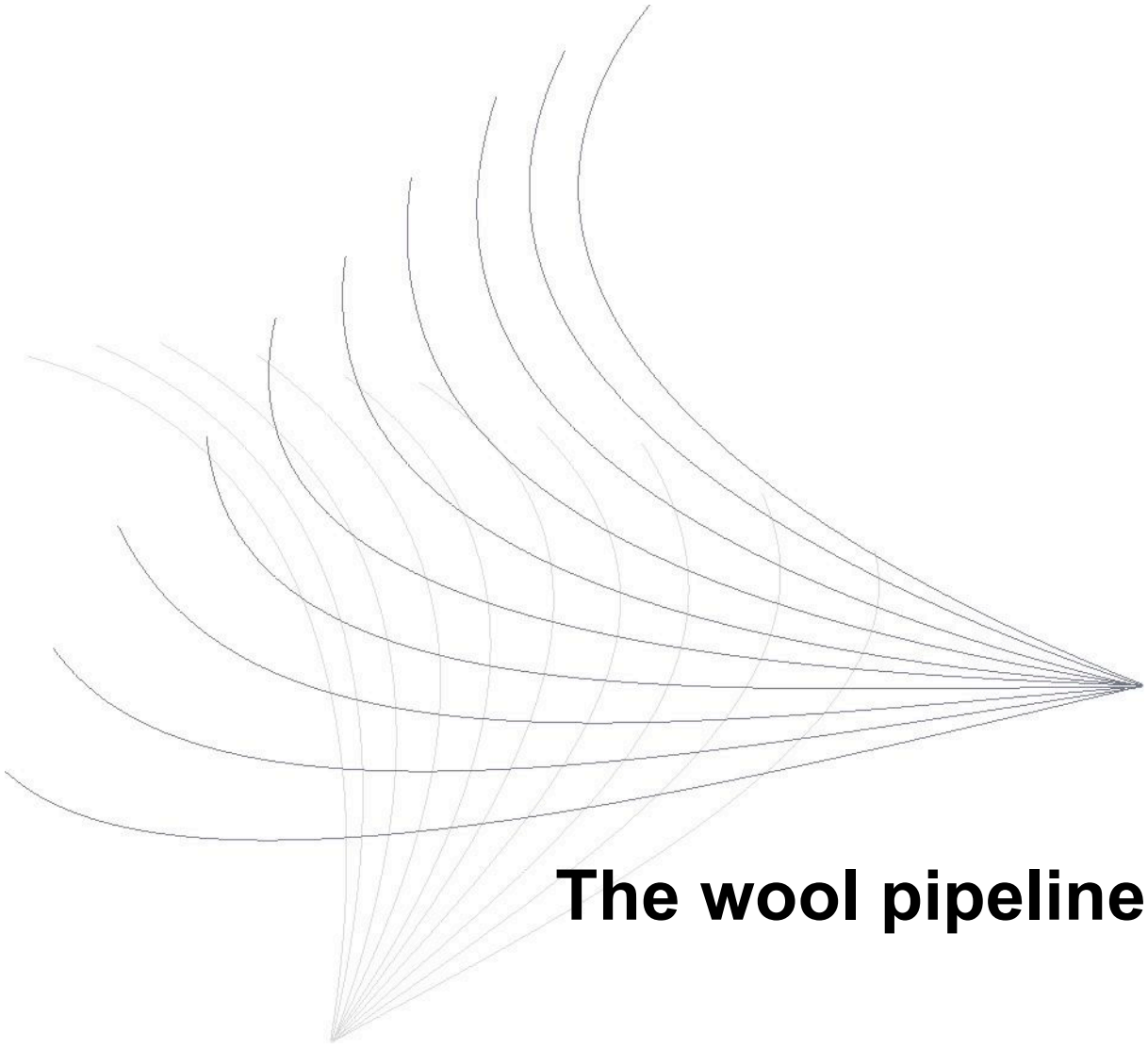

The wool pipeline

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Introduction

This learning resource describes the ways in which wool is sold, purchased and processed and the implications of the needs of processors on harvesting, handling and preparing the wool clip. It discusses:

- wool production and harvesting
- early-stage processing
- spinning
- dyeing
- weaving and knitting
- characteristics that affect processing.

Figure 1 illustrates the stages of the wool pipeline.

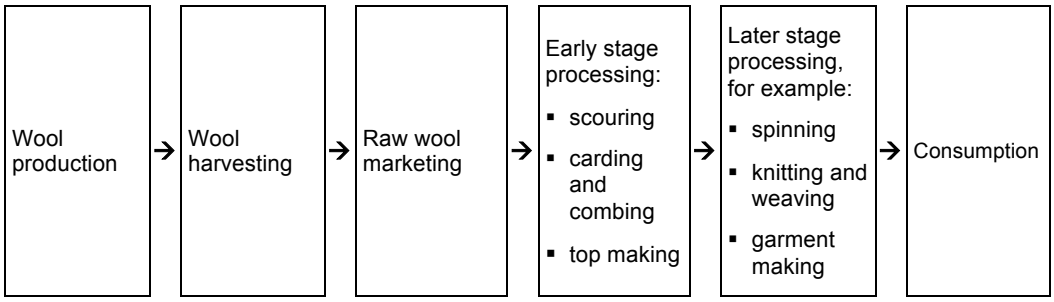


Figure 1: The wool pipeline.

Wool production and harvesting

Wool production and harvesting involves sheep selection and management, shearing, wool preparation and classing, pressing, bale marking, clip documentation and reporting, and delivery of bales to the broker's or private buyer's store.

These activities can all have an influence on the buyer's appraisal of wool and ultimately affect processing performance and output.

Wool harvesting is a vital part of the wool pipeline. It is the only stage at which each fleece is individually inspected by the woolclasser and other members of the wool harvesting team.

Raw wool marketing

Raw wool marketing involves the storage and transfer of ownership of wool, including in-store receival of wool clips, preparation of clips for sale, sale lot appraisal and ownership transfer, and delivery of sale lots to the mill. These activities ensure competition and enable buyers to appraise lots and satisfy the order specifications of their customers.

Processing: early and later stages

The early stage involves processing to the top stage for the worsted sector and the slubbings stage for the woollen sector. Later stages involve spinning, weaving and knitting, mending and finishing.

Consumption

The final step in the wool pipeline is the purchase of the finished product by the consumer. This might be an item of clothing, such as a high quality suit or dress, blankets, tweeds, woollen yarns, knitting wool, rugs, upholstery or carpet.

The objectives of wool preparation

Wool from a large number of sheep is sorted and matched to obtain large, uniform batches suitable for processing.

It is critical that the wool harvesting operation supplies wool of known and predictable characteristics to the wool processing industry. Where wool faults and contaminants occur, they can have serious consequences for processing.

The sorting and matching process begins with the shearing and separation of the belly wool on the floor. It proceeds through the preparation of skirtings, locks, and stains, to the classing of the fleeces. Lines made up in the shed from these components generally become sale lots. These are bought and matched by buyers with other growers' wool to make processing consignments. Processing consignments may be batched by topmakers to make larger processing lots. This may involve combining wool from 2000 to 20,000 sheep from many different locations to obtain a processing batch of 10 to 100 tonnes.

Ensuring a quality product

AWEX Code of Practice

The aim of the *AWEX Code of Practice for the AWEX Quality System, Preparation of Australian Wool Clips: The Woolclasser* is to ensure that raw wool provided to the world's wool trade is of a quality suitable to meet the diverse needs of processors.

The AWEX Code of Practice aims to ensure:

- presentation to the processor of lines of wool that are uniform in visible wool characteristics
- minimal risk of contamination
- accurate documentation.

Importance of the woolclasser's role

The woolclasser is the only person who sees all the skirted fleece wool and is responsible for checking and maintaining uniformity. By doing this task well, the woolclasser can give the buyer confidence in the quality of the wool

displayed in the sample boxes and the test result information that accompanies each sale lot.

Wool must be carefully prepared and classed for sale to ensure:

- the wool broker can achieve the best advantage for the grower
- the wool buyer is able to confidently assess and select the types of wool required by the processing client
- the processor can achieve cost-effectiveness and customer satisfaction.

Wool production and harvesting

The production and harvesting stage covers the on-farm activities from the sheep through to the broker's store. It discusses the progress of wool from the producer to the woolstore, including wool harvesting, handling and preparation practices that contribute to better processing performance.

Pre-shearing

Prior to shearing it is standard practice to crutch sheep to minimise the risk of urine and dung stain. At this time the grower may also cull sheep that display characteristics significantly different from those of the general mob.

Variables such as age, sex, health and the maternal state of ewes will produce variations in wool characteristics between mobs within a flock. As a consequence, wool grown by different mobs of sheep is usually kept separate.

Lambs and rams are often, but not always, shorn separately from the main flock. This helps to reduce the risk of significantly shorter or longer wool contaminating the full-length fleece wool.

During shearing

Normal flocks are managed according to mob principles, which should apply throughout shearing, including the order in which sheep are shorn. (A 'mob' is usually defined as sheep of the same breed, age and sex run together on the same pasture.)

Ideally, an empty pen should separate a new mob entering the shed. This will minimise the risk of mixing mobs that could be different and the risk of contamination.

Shearing

The sequence of shearing aids in keeping different wool types separate. The belly wool is removed first, then wool from the lower legs (shanks), the short pieces around the crutch and the topknot from the head. The belly wool may contain urine and brisket stain and vegetable matter. It will also be shorter and have a different appearance to the fleece wool.

The shank wool is short, matted and may contain kemp. This type of wool is difficult to dye and can create a problems if found in the fleece wool. Short pieces from around the crutch may contain stain or be too short for the pieces line. There will also be locks from second cuts and short pieces trimmed from the body as the shearer removes the rest of the fleece.

All these faults can create processing problems and downgrade the fleece wool.

Shearing board activities

Shed hands working on the shearing board have responsibility for:

- removing stain from bellies (stain-free bellies of a good length and colour are often included in a topmaker's mill batch)

- correctly picking up and throwing the fleece to allow the shed hands and classer to do their job properly
- sweeping the shearing board between sheep and during shearing to minimise the risk of stain getting in the fleeces and wool bins
- picking out any stain in the sweepings
- placing the different types (bellies, stain, locks and topknots) in separate, clearly marked bins or packs.

Wool table activities

The fleece is thrown on the table in a manner that allows the removal of wool that differs significantly from the rest of the fleece; for example, wool from around the crutch, short sweaty edges (fribs), second cuts, clumps of vegetable matter, matted jowls, open backs, stain, dark fibres, skin pieces and blood.

The fleece and skirted pieces are placed into clearly marked bins or packs containing wool of like types. It is normal practice for the classer to check the uniformity of the contents of these bins throughout the shearing of each mob. All these different wool types have an end use and it is important they are uniform. If a lot is not uniform, this may be reflected in the objective measurements and sample of the lot, the confidence of the buyer in that lot and a lower return to the woolgrower.

Pressing and branding

When a mob is completed, if the next mob to be shorn is quite different, it may be necessary to clean out bins, sweep the floors and put in new packs for pieces.

Once each bale is pressed it is labelled according to requirements of the AWEX Code of Practice, with:

- farm brand
- wool description
- bale number
- woolclasser's number.

In the wool book the presser will record the bale number, the wool description placed on the bale and the weight, age and sex of the mob. The classer will mark off breaks in mobs and make any relevant comments regarding lotting in the Remarks column. It is the classer's responsibility to check the wool book entry.

The information in the wool book is used to prepare the Woolclasser's Specification and provide information to the broker regarding lotting and rehandling.

On-farm fibre measurement (OFFM)

OFFM involves taking wool samples for measurement. Mean fibre diameter measurements can assist the woolclasser in creating uniform lines.

Although some classers use individual fleece measurements of fibre diameter to class some of their fleece lines, fleece preparation and classing decisions

are generally subjective. For example, classers use crimp as an indication of fibre fineness, the flick test to assess staple strength, the length of the middle finger to assess length and experience to assess vegetable matter content and yield. However, mills now demand the objective measurement of these important properties.

Raw wool marketing

The second stage of the wool pipeline involves the receival of wool into a broker's store and shipment to a mill, including handling, preparation and selling wool in the broker's and rehandler's wool store. Figure 2 illustrates this process.

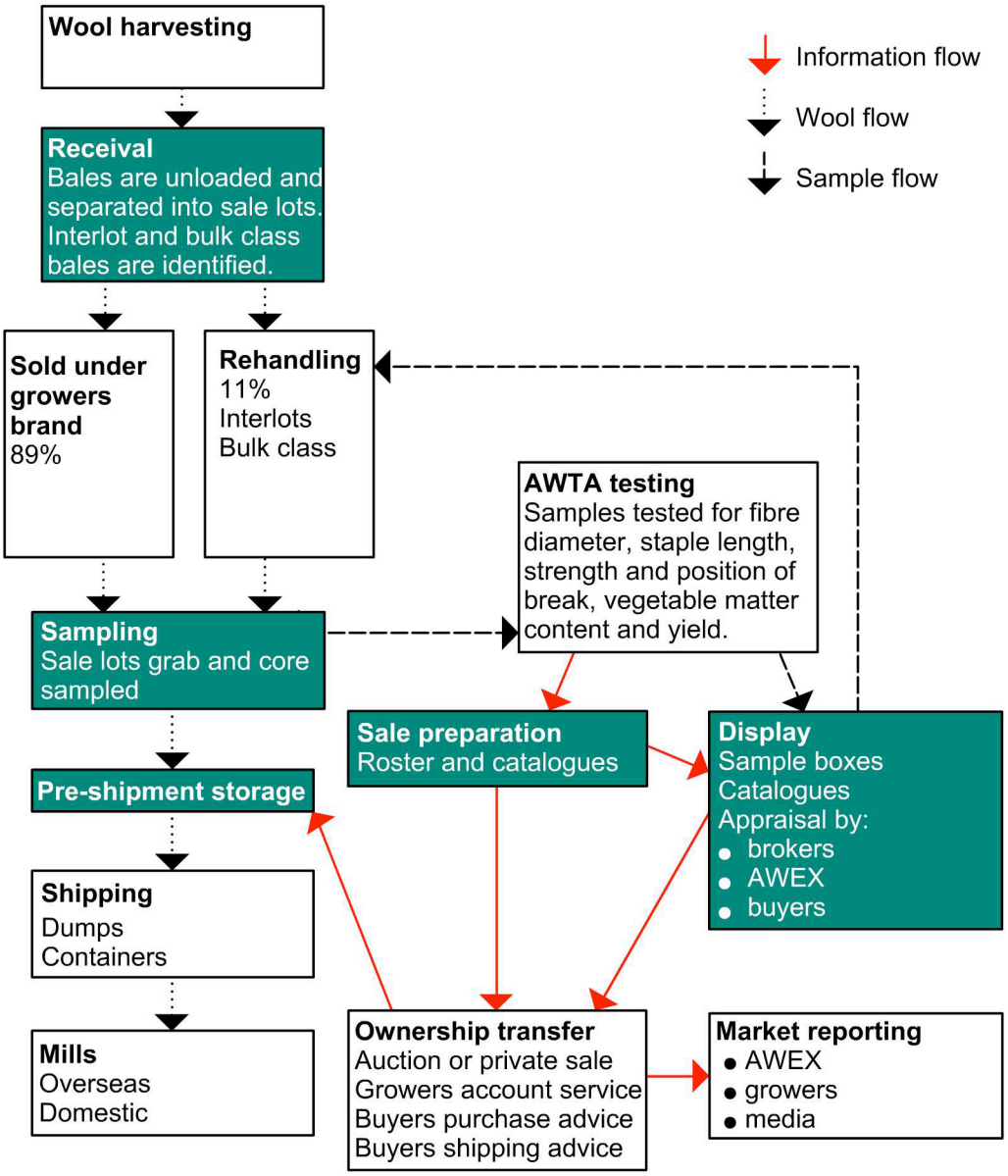


Figure 2: In-store wool, samples and information flows (auction system).

Online market information is increasingly being used in the wool industry.

Methods of sale

Growers have a number of options for selling their wool. The most important of these are:

- the auction system (through which more than 90 per cent of Australia's wool clip is sold)
- negotiation with a private buyer, who may on-sell to a mill or pass it back through the auction system
- sale via an electronic offer board, where a reserve is set and price offered
- sale direct to a mill that processes wool in Australia.

Some have wool processed under their own brand or with a number of other clips of similar type from the same region.

Very little wool is now processed under the grower's account and sold later as a top.

Sales to Australian mills have reduced now that many early-stage topmaking mills have moved off-shore.

Most of the wool goes through the auction system, through either brokers or private buyers.

Receival into store

Wool arrives at the broker's store by rail or road and is stacked in a designated area until the complete clip has been received.

When the complete clip is in the store and all the relevant documentation, including the classer's report, has been received, the clip is ready to be prepared for sale.

The woolclasser is only person who has seen or will see all the fleece wool contained in the main fleece lines and has supervised and monitored the contents of the other non-fleece lines. The brokers, therefore, rely on the classer's level of expertise in preparing the lots for sale and sampling and will only see the wool in the sample boxes prior to sale.

The clip may be divided into two sections of the receival store:

- wool to be sold under the grower's brand
- wool requiring rehandling.

There is usually some wool that will require rehandling; for example, bulk bales that contain wool parcels too small for a bale, that is, less than 110 kilograms (minimum bale weight for Superfine Merino fleece wool (<18.6 micron) is 90 kilograms).

This wool will be sent to the rehandling facility and bulk classed into bins of like wool type. There may also be some one or two-bale lines that may be interlotted with wool from another clip.

Nearly all the small lots of less than four bales are sold with at least a micron, vegetable matter and yield test.

(According to the International Wool Secretariat Australian Wool Compendium, *Wool International*, the average lot size was 7.62 bales in the 1992–93 season, and 5.59 bales according to the *AWEX Wool Statistics Yearbook 2004–05*.) For a 100-tonne processing batch in 1992–93, mills only required 73 farm lots. Now, the mill needs to buy and process 98 lots. This has increased selling and processing costs and may have a negative impact on prices paid for small lots.

Already there is an additional testing cost that could be reduced if more interlotting was adopted.

Lotting

The wool to be sold under the grower's brand is placed into sale lot order according to the classer's report and the accompanying recommendations and instructions. This is done in sale lot order.

Wool is transported to the broker's store by rail or road.

Rehandling

The wool that will be rehandled is usually purchased by the rehandler, then:

- classed into bins to suit the type
- sold in their own catalogue under their house brand by sample and the relevant objective measurement for the type.

The contents of each bin are visually even; however, within each bin the variation could be quite wide, especially for the properties of strength and position of break.

Following the classing of the wool into the bins, the sampling and selling procedures are the same as for the lots sold under the farm brand.

Sampling and testing

Every bale in each lot is grab sampled, weighed and core sampled in that sequence. All wool is sampled and tested prior to sale.

It should be remembered that all the wool sampled, including rehandled wool, has been classed subjectively.

All in-store sampling is carried out in accordance with International Wool Textile Organisation (IWTO) standards.

IWTO regulations cover testing and the IWTO certificate forms the basis of commercial transactions. It specifies the measured and calculated characteristics of a consignment as accurately and fairly as possible.

The IWTO regulations cover:

- sampling requirements
- calculation of various derived values and yields
- requirements for the issuing of IWTO test certificates
- handling of disputed results.

For more information about sampling and testing, refer to the learning resource **Wool sampling and testing**.

Storage

After the bales are sampled, they are returned to the storage area to await the buyer's shipping instructions.

Sale preparation

Once wool has been received, sampled and tested, selling agents acting on the instructions of their grower clients may allocate the wool to be offered for sale at auction. With approximately 50 selling agents and more than 85 wool storage centres throughout Australia, the coordination of the weekly wool auction is vital for an efficient marketplace. The wool roster sets the framework for the sales to take place. The auction selling rules are set by the National Auction Selling Committee, a committee of buyers and sellers.

With the universal adoption of 'sale by sample' it became possible to separate the wool handling and selling functions and effectively offer wool for sale every week from one of five centres in Sydney, Newcastle, Melbourne, Launceston or Fremantle.

Within each selling centre, sale days are set and each broker is allocated a date and the order in which they can offer their own catalogues.

The centre-by-centre sale roster (calendar) is published before the start of the selling season, which commences in July of each year.

Sales are conducted according to a set of selling parameters that have been endorsed by the industry.

Appraisal

Brokers, buyers and AWEX assess the contents of each sale lot using the sample boxes, together with the objective catalogue information.

Buyers

Buyers use the sample box to check the quality of preparation and assess it against the test results and classed structure of the clip. They scan the catalogue and inspect the lots they believe will suit their clients' needs.

The processor (topmaker) will have a set of specifications from a spinner. They use these specifications to purchase a number of individual sale lots, which are blended to create a processing batch. Spinners' specifications will include average fibre diameter, fibre length, strength and amount of vegetable matter. It is these specifications that form the criteria of the basic raw material to provide the required processing performance on the machinery of each scourer, topmaker and spinner.

Buyers inspect the lots they believe will suit their clients' needs.

Ownership transfer

Auction or private sale?

More than 90 per cent of the wool produced in Australia is offered through the auction system, but growers also sell their wool by negotiation with private buyers. Growers are in a stronger bargaining position if the wool is sold subject to the availability of measurements.

A smaller, but growing, percentage of Australian wool is sold privately through electronic offer boards. The electronic offer board is available 24 hours a day, seven days a week, whereas auctions are limited to trading days in any given week.

Some lower lines are purchased privately and rehandled into larger lots for sale through the auction system; for example, smaller lots that do not warrant the cost of testing. These lots are either reclassed into bins in a rehandler's store or interlotted with other bales of similar type and sold through the auction system.

Shipping

As soon as the broker receives overseas shipping instructions from the buyer, they retrieve the lots from storage and send them to the dumping facility, where the bales are compressed for shipping. The process of dumping maximises the efficiency of shipping wool by allowing more wool to be placed into a container. Effectively, three farm bales can be compressed to approximately the size and dimensions of one farm bale.

The dumping of bales can create a problem in the mill because the wool needs to be open and relaxed before it can be scoured. Also, if the weather is cold, the bales may have to be heated to open the wool and reduce the possibility of entanglement and breakage during loader processing.

Early-stage processing

The processing of raw wool into yarn for turning into fabric can be divided into two main systems: worsted and woollen. These systems use raw wool with different characteristics. The worsted system uses longer-staple, wool; the woollen system uses shorter-staple wool, including fellmongered and recycled wool.

Wool used in the worsted system is traditionally termed *combing* wool, while that used in the woollen system is termed *carding* wool.

Worsted fabrics are made from yarns in which the fibres have been laid parallel to each other during manufacture, giving the yarns and the final fabric a neat, smooth appearance.

In producing woollen fabrics, the fibres are crossed rather than parallel and, consequently, have a lofty, more bulky appearance.

Worsted fabrics have a clear, smooth, regular surface and the individuality of the yarn is apparent in the pattern of the weave or knit. Woollen fabrics, on the other hand, are full and bulky.

The knitted products from these two processes also have identifying characteristics – a smooth appearance in a worsted knit and a bulky appearance in a woollen knit.

There are many more processes in the worsted system than in the woollen system.

In both the worsted and woollen systems the initial steps in the process involve blending and scouring.

Table 2 provides a brief summary of the differences between the two systems.

Worsted	Woollen
Yarn characteristics	
Stronger Smoother Finer Lighter weight Cooler handling More durable	Weaker Fuzzier Thicker Heavier weight Warmer handling Less durable
Fibre alignment	
Fibres parallel and twisted slightly to create smooth appearance in yarn.	Fibres not well-aligned and given low twist – fuzzy, bulky yarn.

Worsted	Woollen
End product use	
Suiting, dresses, fine knitting yarns.	Blanket, tweeds, bulky knitting wool, upholstery, wool carpets.
Types of wool	
Combing wool: Longer staple wool with lower vegetable matter (VM).	Carding wool: Shorter staple wool – locks, short lambs, crutchings, stains, pieces, bellies, contaminated with vegetable matter.

Table 2: Summary of differences between the worsted and woollen systems.

Blending

Blending is common to both the worsted and woollen systems.

The processor decides on the combinations of suitable greasy lots of wool to be blended. In the woollen process, this may include both fellmongered and recycled wool.

In the worsted system the mill has purchased the raw wool on the basis of the sale sample and test results and has used these to put a processing batch together. At this stage the grower's identity is lost. Each farm or rehandled lot has been dumped and now needs to be opened and relaxed before scouring. In some countries it may also be heated. This is necessary because the compressed wool may contribute to fibre entanglement as it passes through the scour, creating a problem in the carding and combing operations.

A number of blending systems may be used. Essentially, bales are taken from lots in a programmed fashion and fed into the hopper that feeds the scour.

Blending spreads differences uniformly and randomly through the batch.

In most Western topmaking plants, there are blending operations at every stage. A typical processing batch could be 100 tonnes of greasy wool or 550 bales.

A typical processing batch could be 100 tonnes of greasy wool – the product of many different growing conditions, bloodlines, lengths, fibre strength and other characteristics. To process this wool efficiently, the whole batch must be uniform throughout at the top stage. This is achieved by blending to spread the differences uniformly and randomly throughout the batch.

One hundred tonnes of wool represents approximately 550 bales of fully measured greasy wool. At an average lot size of 5.65 bales, a typical batch might contain wool from more than 90 different locations. All these lots would have been purchased and matched together on the basis that the combination of the measurements will provide the mill with a top that satisfies their client's specifications and yield targets.

Each of these lots would have been tested for Mean Staple Length (SL), Mean Staple Strength, Mean Fibre Diameter (D), Vegetable Matter Content (VM) and the Percent of Staple Mid-Breaks (M).

Scouring

All greasy wool is washed. This involves a combination of water and detergent to remove grease, suint (wool wax) and dirt. Lanolin is a by-product of the scouring operation.

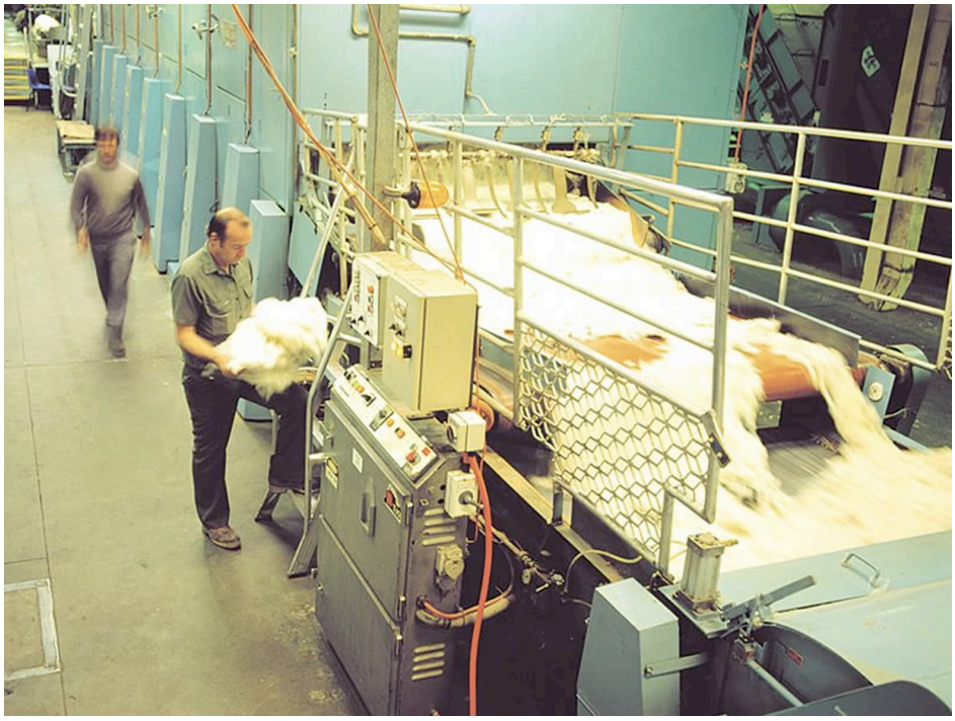
The scouring process is one of the most important parts of the pipeline.

Scouring works through two actions, mechanical and chemical. The mechanical action rakes the wool through the scour, helping to shift the dirt. The chemical action removes grease and suint.

It is possible to damage the fibre while removing the grease, suint and dirt from the wool. Scouring cleans the fibre surface but care should be taken to

avoid excessive fibre entanglement which can lead to subsequent fibre breakage and lower processing yields..

After scouring, the wool is dried. In modern mills this is a sophisticated process, which further blends the product and adds lubricant, before carding.



After scouring the wool is dried before carding.

The dried product is now in a tangled state, so the fibres must be separated into straight parallel formation and removing any entanglement. Vegetable matter is not removed by scouring but must be removed in subsequent processing operations.

Worsted sector

Figure 3 illustrates the flow of wool through the processing pipeline for the worsted sector.

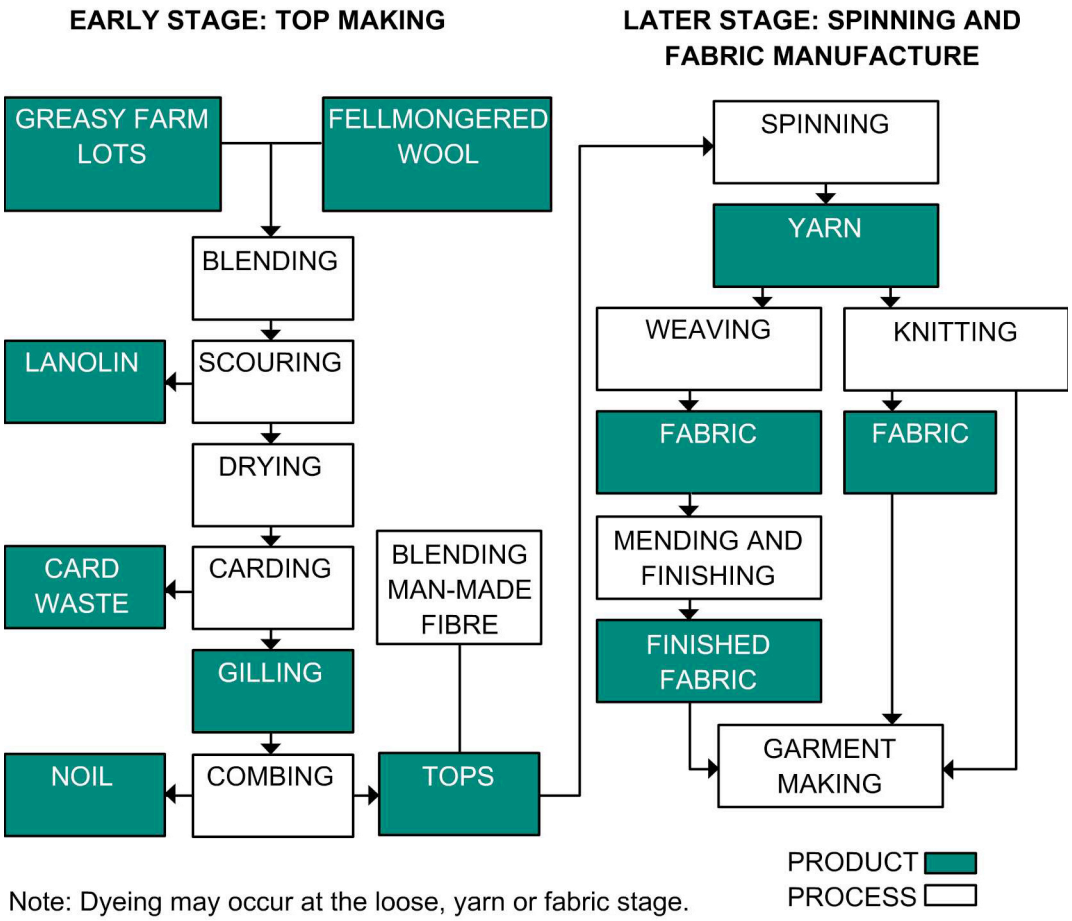


Figure 3: The worsted system.

Carding

Carding has several functions:

- removal of vegetable matter
- separation of entangled fibres after scouring
- blending fibres
- partially aligning fibres into a continuous, bulky rope of fibres called a carded sliver.

Vegetable matter, such as burrs and seeds, can be removed from wool either:

- mechanically – just before or during carding
- chemically – immediately after wool scouring (carbonising).

The stage chosen depends on the type and the quantity of vegetable matter, the method of processing and the resultant fabric. Chemical removal may cause some damage to the fibre surface, resulting in a slightly harsh or brittle handle.

The worsted sector usually prefers mechanical burr removal; in woollen manufacture, both methods are used.

Poor scouring can increase the entangled fibres, leading to greater fibre breakage in carding. Lubricant is added to reduce the amount of breakage.

At each stage of carding, the fibre is taken by pins on the main cylinder (‘the swift’) and transferred through a progression smaller cylinders known as ‘workers’ and ‘strippers’. This action untangles the fibres, either by pulling the fibre out or breaking the entangled fibres. This action puts a hook (or bend) on the fibre that must be removed during the gilling and combing operation prior to spinning.

The beating process, which removes the vegetable matter, may also result in some fibre loss.

At the carding stage, staple strength and the position of break of the wool staple become critical factors.

The vegetable matter that is not removed in carding is removed in combing, together with short fibre.

At the end of the carding process, the sliver of roughly parallel fibres is ready for the next straightening and blending process.

Carded sliver.

Gilling

The gilling process:

- mixes the fibres further
- removes most of the hooks or bends in the fibre
- presents the fibre to the comb with the remaining hooks trailing
- by drafting reduces the sliver weight and thickness ready for combing.

After the three passages of gilling the sliver is ready to be straightened in the combing process to form tops.

Gilling occurs prior to and after combing. For the most effective combing, fibres need to be presented to the comb in parallel alignment at an even density. The gilling machine achieves this by drawing the card sliver through revolving pinned combs at speed ratios in excess of 5:1.

How many times does wool get drafted (blended) to produce one top?

Gilling: three stages

6 x 6 = 36 x 6 = 216 x 6 = 1296

Combing: one stage

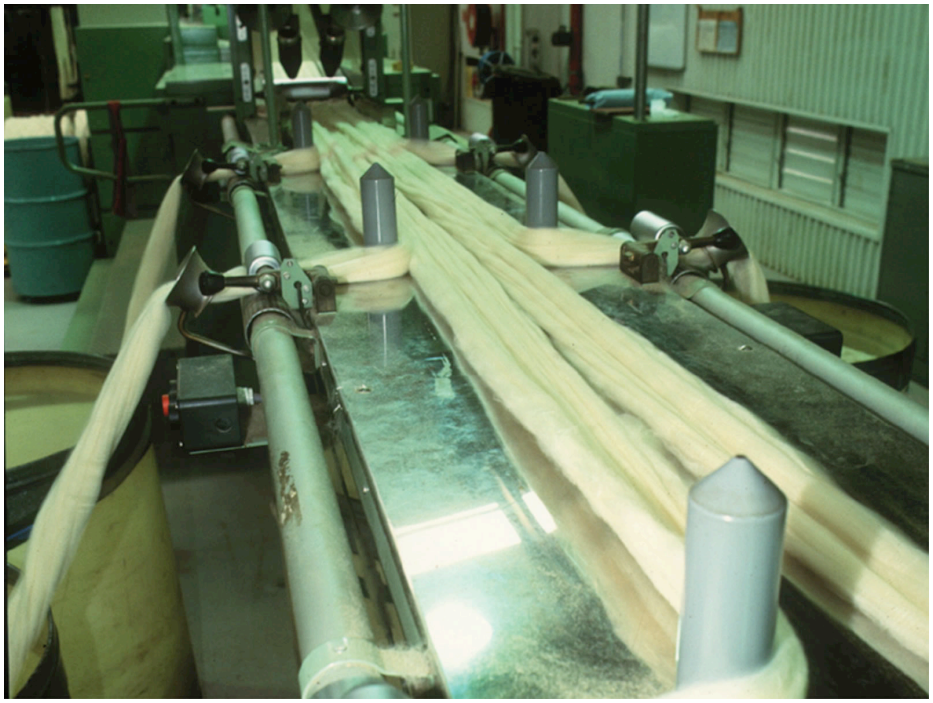
20 into 1 = 1296 x 20 = 25,920

Gilling: up to three stages

3 x 25,920 = 77,760 x 3 = 233,280 x 3

*= **699,840 drafts in total***

This is why even small quantities of fibrous contaminants (for example, 10 grams of black fibre in 10,000 of fleece wool) can cause so much damage.



Six slivers feed into the gill box to be drafted at a rate of 6 to 1.

Combing

The combing operation is the final stage in top making. It involves removing short fibres. These are known as noil. Given their short length, noil can be used in the woollen system as a raw material.

Neps (tightly rolled balls of very short fibres and any remaining vegetable matter) can also be removed.

The major type of combing machine is the rectilinear or Schlumberger comb. In the wool sale catalogue, the Schlumberger dry yield (SCH/DRY) refers to the percentage of top and noil that can be combed from each lot using this machine.

The purpose of combing is to divide the mass of fibres into three parts of differing levels of importance:

- top – the majority of which will consist of clean fibres of a given length
- noil – the shorter fibres and neps formed in carding or gilling
- fly and dust.

A set of Schlumberger combs.

Woollen sector

The significant differences between the woollen, worsted and non-woven sectors are:

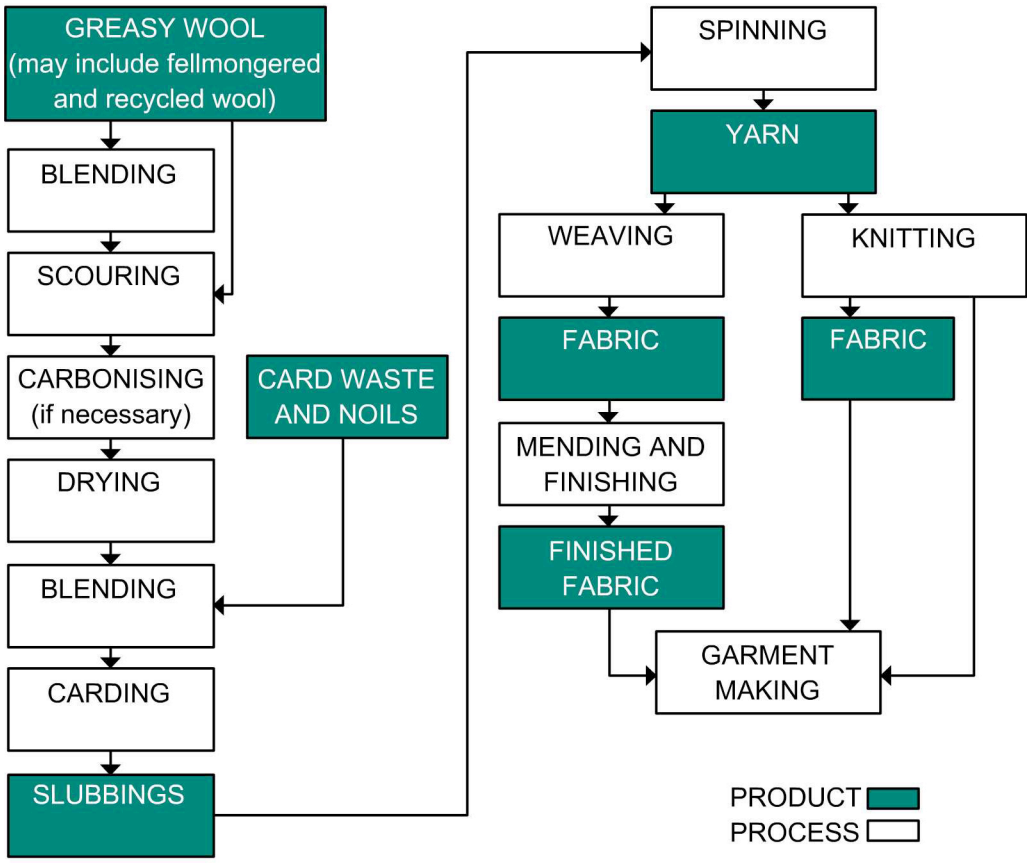
- the types of raw materials used
- the types of yarns produced and used.

The woollen sector uses all shorter types of wool.

In addition to carbonised and scoured wool, the industry will also use by-products and re-manufactured materials, including sample cores, card waste and slivers, broken tops and noils and recycled wool.

The types of yarns produced by the woollen sector are woven and knitted into fabrics and garments and even used in the construction of woven, knitted and tufted carpets.

Figure 4 illustrates the flow of wool through the processing pipeline for the woollen sector.



Note: Dyeing may occur at the loose, yarn or fabric stage.

Figure 4: The woollen system.

Activity 1: Wool processing overview

a. Describe the differences between the types of raw wool used in the worsted and woollen processing systems.

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b. The yarns produced by the woollen and worsted systems differ. Outline the differences.

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c. The following table contains a list of different wool types. Indicate by placing a tick in the column whether the type of wool is suitable for the worsted or woollen system (or both).

Type of wool	Worsted	Woollen
Fleece wool longer than 60 mm		
Fleece wool shorter than 50 mm		
Lambs wool		
Skirtings		
Locks		
Dags		
Bellies with clumpy vegetable matter		
Wool with unscourable stain		

Non-woven products

The non-woven system uses similar types of wool to the woollen system; however, in the non-woven system, fibre is converted directly into fabric in a continuous process rather than the separate steps required in the woollen and worsted systems. These involve converting a web of fibres into an entangled form through the use of mechanical or high pressure water systems.

Non-woven fabrics are substantially less costly to produce than traditional worsted and woollen fabrics, and have the potential to open up markets previously unavailable to wool, including apparel, furnishings, bedding and protective clothing.

As research continues into the production of lighter weight fabrics with better stretching and draping qualities, the non-wool woven system may open up new product possibilities for the wool industry.

Spinning

Both the worsted and woollen systems involve spinning the wool or wool blend into a yarn that is then woven or knitted into a fabric. (Table 2 shows the differences in yarn characteristics for these two systems.)

Spinner specifications

Spinners will have a set of specifications they require. In the case of the worsted sector this will be a set of specifications provided by the spinner to the topmaker. The topmaker will use this set of specifications to purchase a number of sale lots of wool that can be then blended together into a processing batch. A large number of individual sale lots are used to create a processing batch. Wool is not sorted prior to blending so it is critical that the wool has been classed and prepared correctly during the wool harvesting and classing operation.

There is an enormous variety of worsted yarns produced and particular features are required for weaving and knitting. This makes it difficult to be specific about this process. Basically, the spinner requires a clean, spinnable top.

Topmakers place considerable importance on average fibre diameter, fibre length, colour, dark fibres and VM specks. Average fibre diameter is particularly important as the weight and the thickness of the final cloth or knit depends on the fineness of the yarn used in its construction: the finer the yarn, the lighter the fabric. Thickness is a function of the number of fibres in the yarn's cross-section, which is approximately 40 fibres. In combination with the appropriate fibre length, this will ensure efficient spinning.

Once the fibre diameter has been set, the most important factor governing yarn strength and processing efficiencies is fibre length in the processed top – the hauteur or mean fibre length in the top.

Additional characteristics make up the spinner's specification. A typical top specification from a spinner would include the following requirements:

- fibre types and percentages (raw/virgin wool and polyester are generally used in the worsted system. Silk and cashmere may be used in more exclusive fabrics, and Lycra may be used to enhance the comfort and the wearing qualities of the fabric by adding stretch.)
- mean fibre diameter
- minimum fibre length (hauteur) in top
- distribution of fibre length in top (maximum CV% hauteur)
- maximum percentage of fibre under a given length (for example, no more than 5% of fibres greater than 30 microns.
- overall colour as per a standard top
- maximum dark fibre content (for example, 10/100 gram)
- maximum levels of nep and VM specks
- ranges for regain and total fatty matter content.

Regain and fatty matter content

Wool is hydrophilic and hygroscopic, that is, it readily absorbs and discharges moisture. Because of this, the weight of wool can vary; for example, between inland areas and the seaboard, and wool moving from wet areas into dry areas.

Regain is a standard moisture content to which wool is adjusted for trade or processing purposes.

The moisture content will have a major influence on the processing of the fibre. A fibre that is too dry will become electrically charged or subject to static electricity; a fibre that is too wet will cause roller lapping.

Similarly, the correct percentage of fatty matter can ease processing by providing fibre lubrication; too much can cause lapping or sticking from grease residue build-up on the rollers.

Each of the above characteristics will affect the ratio of good, useable fibre (top) to waste (noil and fly). The ratio (top-to-noil) is referred to as tear. The tear ratio is used in wool sale catalogues to express the yield for the IWTO Schlumberger Dry yield. To meet these specifications the topmaker relies on the accuracy of the test results and the skill of the woolclasser and wool harvesting team to produce even and consistent lines of wool.

Any wool suitable for combing that meets certain specifications set by the spinner can pass through the worsted system. Any wool less than 50 mm will generally go through the woollen system. There are no limits to the wool that can be processed through the woollen system.

The spinner requires a clean, spinnable top.

Predicting processing performance

The topmaker will use the spinner's set of specifications to purchase a number of individual sale lots of wool, which will be consolidated into a processing batch. To predict processing performance most mills that process

tops from Australian wool use the sale lot's test results and prices with a formula (called the TEAM formula) to make a prediction about the characteristics of tops produced from the processing batch of wool.

Example

At a Chinese topmaking mill 59 farm lots were combined to form a single processing batch to produce 40 tonnes of top with an average micron of 19.5, a minimum hauteur of 65 mm and no more that 14 per cent of fibres more than 30 mm.

Table 1 shows the details of 15 lots of the 59 lots of wool blended to produce tops. The results of these lines are from the AWTA Test Certificate. In the 15 lots there is a small variation in micron and vegetable matter. There are large variations in length, strength and position of break and small variations in micron and vegetable matter.

Wool fibre diameter is the most important parameter in determining price as it directly affects the fineness of the yarn that can be produced. (The finer the wool, the finer the yarn.)

Raw wool selection will also depend on factors such as tensile strength, position of break and vegetable matter content. These will be specified by the spinner.

Some mills may have much wider variations; for example, they might mix fleeces, pieces and even bellies. However, they will have bought the wool at a price that still meets the customer's specifications.

Topmakers use a formula (TEAM3) to predict the processing performance of each lot. The TEAM3 formula predicts average fibre length of the processed top (hauteur). The TEAM3 formula is presented below.

TEAM3 formula

$$Hauteur = 0.43L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 21.8 + MA$$

**Where mid-breaks are less than 45%, M* = 45%.*

Refer to Table 2. The most important feature of a processing batch is the weighted average of the individual lots which comprise it. Note that a number of lots are below the average minimum hauteur of 65 mm (Lots 2, 3, 4, 8, 12, 13, 14 and 15); however, since other lots exceed the minimum of 65 mm when the 59 lots are bended the weighted average hauteur is greater than 65 mm. This average, and the blending of the greasy wool to physically achieve it, determines how closely the predicted outcome relates to actual results.

If the wool is 70 mm but consists of 'tender' wool with a break in the middle, it is doubtful whether the top would satisfy the spinner's specifications for short fibre content. As it is not commercially possible to test wool that has a staple length of less than 50 mm, buyers would not supply this wool to a topmaker. It would probably be used in the woollen sector.

Heavy, burry wool might need carbonising, which usually weakens the fibre and increases its tendency to break during carding.

For the processor, it is important to have confidence in the test results and the quality of preparation. If the wool has been classed properly, the test results will be accurate and the topmaker is confident to buy and blend various farm lots to produce a top to specification at a price.