THE WOOLMARK COMPANY

WOOL SCIENCE, TECHNOLOGY AND DESIGN EDUCATION PROGRAM

FACILITATOR GUIDE
WORSTED TOP-MAKING

CONTENTS

THE WOOLMARK COMPANY | AUSTRALIAN WOOL INNOVATION

The Woolmark Company (TWC) is a subsidiary of Australian Wool Innovation (AWI) and is the global authority on Merino wool. With a network that spans the entire global wool supply chain, The Woolmark Company builds awareness and promotes the unique traits of nature's finest fibre.

Australian Wool Innovation (AWI) is the research, development and marketing body for the Australian wool industry. More than 60,000 Australian woolgrowers co-invest with the Australian government to support the activities carried out by AWI and TWC along the global wool supply chain.

The Woolmark Company supports and connects global supply chain participants through initiatives such as The Wool Lab and Wool Lab Sport. These internationally renowned wool-sourcing tools provide designers, retailers and brands with the latest trends in wool yarns, fabrics and technologies, while promoting Australian Merino wool as the ultimate fibre of choice for apparel.

Marketing activities focus on education and awareness raising to ensure consumers, manufacturers and designers are aware of Australian wool's benefits and qualities, can capitalise on wool's inherent properties, and can successfully integrate wool into their product lines.

THE WOOL SCIENCE, TECHNOLOGY AND DESIGN EDUCATION PROGRAM OVERVIEW

The *Wool Science, Technology and Design Education Program* combines a series of introductory and advanced courses of study developed to meet the needs of tertiary-level participants studying within the fields of: textile science and engineering, fashion and textile design and/or textile manufacturing. Individual courses within the series may also be of interest to participants studying sheep and wool science, and those working in the wool production, raw wool processing, textile manufacturing and textile sales and marketing industries.

Introductory level courses are suitable for participants studying at first or second-year tertiary levels, while the advanced courses are aimed at participants in their more senior years of study. The extension courses can be used for specific course requirements.

INTRODUCTORY COURSES

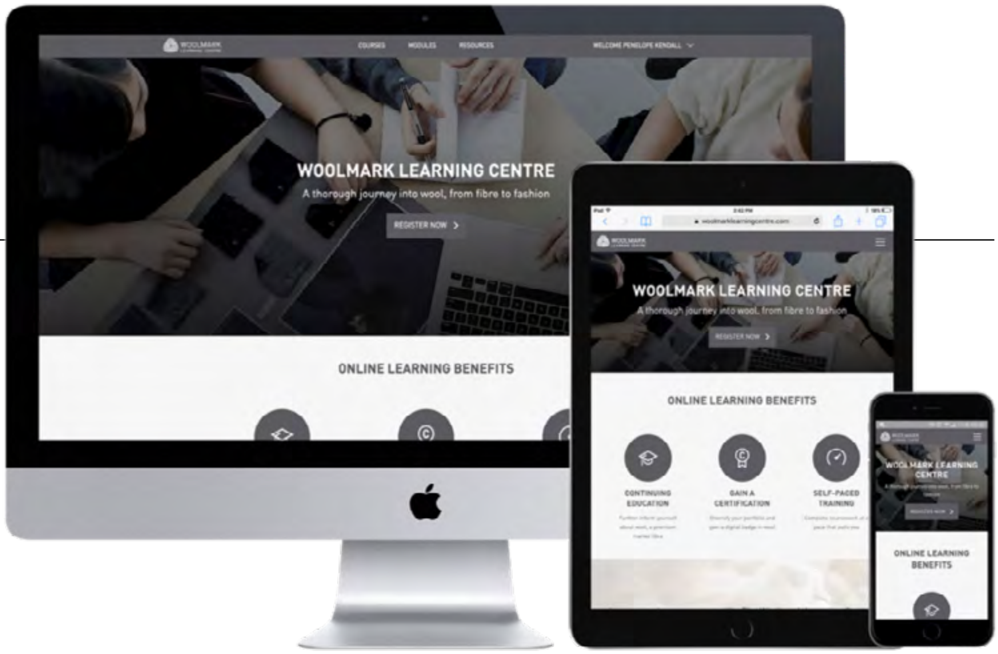
- Wool fibre science
- Introduction to wool processing

ADVANCED COURSES

- Raw wool scouring
- **Worsted top-making**
- Worsted and woollen spinning
- The dyeing of wool
- Wool fabric finishing

EXTENSION COURSES (IN DEVELOPMENT)

- Finishing of wool knitwear
- Wastewater management
- Wool product quality
- Methods of wool fabric formation



THE WOOLMARK LEARNING CENTRE

The *Woolmark Learning Centre* is a freely accessible, online learning platform, which supports The Woolmark Company's commitment to education and awareness raising with regard to wool, wool processing and product innovation.

Make sure you have completed the *Wool Appreciation Course* online before delivering any courses of the *Wool Science, Technology and Design Education Program* to familiarise yourself with The Woolmark Company's approach and core messages about wool production and the wool supply chain.

It is also important to encourage all participants to explore the online *Woolmark Learning Centre* to reinforce and build on the knowledge they have gained by attending this advanced level course.

The W*oolmark Learning Centre* can be accessed at: https://www.woolmarklearningcentre.com/

INTRODUCTION TO THIS FACILITATOR GUIDE

This Facilitator Guide covers the *Worsted top-making* course of the *Wool Science, Technology and Design Education Program*.

This information in this Guide will support you to:

- deliver the technical content across a series of face-to-face lectures in an engaging and easy-to-follow way
- carry out a range of practical demonstrations and interactive discussions to support participant learning.

This Facilitator Guide provides:

- an overview of the *Wool Science, Technology and Design Education Program* courses
- the target audience for the *Worsted top-making* course
- the pre-requisites for the course
- an overview and learning objectives for *Worsted top-making*
- a suggested agenda for delivering *Worsted top-making*
- an overview and the learning objectives for each module within *Worsted top-making*
- course materials and resources required to deliver *Worsted top-making*
- administrative requirements and institutional responsibilities when delivering *Worsted top-making*
- guidelines and processes regarding participant recognition upon completing *Worsted top-making*
- links to participant and facilitator feedback and evaluation questionnaires
- a facilitator checklist to enable successful planning and preparation leading up to, during and following delivery
- recommended room layout for small venues or groups
- a guideline for the effective and engaging delivery of the course content.

INTRODUCTION TO THIS COURSE

Worsted top-making is an advanced-level course, which provides participants with an understanding of:

- the process of worsted top-making
- the aims and objectives of worsted top-making
- the machinery used to make wool top
- the issues affecting product quality.

The course structure and module plan contained in this Facilitator Guide indicate the technical content to be addressed, however it's important to adapt the focus of your training in line with participants' existing understanding and specific target audience requirements.

TARGET AUDIENCE

The *Worsted top-making* course is primarily aimed at senior-level tertiary students studying textile science and engineering, and staff and managers from wool processing companies.

The course is designed to be delivered face to face, in groups of 6 – 50 people, although the ideal number of participants who can attend course lectures depends on the resources available to support the delivery.

COURSE PREREQUISITES

As an advanced course, *Worsted top-making* is suitable for participants with sound knowledge of wool or the wool industry, or participants who have undertaken the introductory courses of the *Wool Science, Technology and Design Education Program (e.g. Wool fibre science* and *Introduction to wool processing)*.

If this is the first *Wool Science, Technology and Design Education Program* course being delivered to these participants, start the initial lecture with an *Introduction to The Woolmark Company*.

This presentation is included in the *Worsted top-making* facilitator slides as an optional introductory module.

COURSE LEARNING OBJECTIVES

By the end of the *Worsted top-making* course, participants are expected to be able to:

- describe in detail the key fibre properties important in top-making
- describe the role of the top-maker
- describe the operations that make up 'early-stage processing'
- describe the aims, functions and the operation of the machines used for converting scoured wool to top (carding, gilling, combing)
- outline the reasons for the sequence of operations used during top-making
- describe the components of cards, gills and combs and their function
- outline some of the latest developments in worsted carding
- describe the effect of processing conditions on top-making
- describe the quality attributes of the output material (top) and the role of quality assurance in the top-making process
- outline some of chemical treatments conducted on top.

COURSE AGENDA

The *Worsted top-making* course consists of eight lectures, of approximately one hour each, supported by a set of PowerPoint slides, videos and recommended demonstrations, as outlined in the table below.

NOTE: Indicated slide numbers for Module 1 take into account the introductory Woolmark Company slides as outlined in the following facilitator notes.

MODULE | SLIDE NUMBER	VIDEOS AND PRACTICAL DEMONSTRATIONS
Module 1: The role of the top-maker | 25 slides	Slide 15: Staple length (demonstration) Slide 16: Staple strength (demonstration) Slide 17: Vegetable matter in card waste (demonstration)
Module 2: Early-stage processes in top-making | 14 slides	Slide 11: Bin blending (video) Slide 12: De-dusting (video)
Module 3: Worsted carding | 36 slides	Slide 5: Worsted carding (video) Slide 5: Card sliver and top (handout) Slide 6: Hand cards (demonstration) Slide 7: Card clothing (reference) Slide 11: Card action | Working (demonstration) Slide 12: Card action | Stripping (demonstration) Slide 23: Lubricants (reference) Slide 30: Card clothing comparison (reference)
Module 4: Drafting and gilling | 23 slides	Slide 4: Drafting theory (demonstration) Slide 5: Gilling (video) Slide 5: Gilled sliver and worsted top (handout) Slide 7: Drafting and doubling (demonstration) Slide 8: Faller bar (handout)
Module 5: Combing | 20 slides	Slide 4: Combing (video) Slide 4: Combed sliver and worsted top (handout) Slide 6: Combing the beard (demonstration) Slide 7: Combing the beard (animation) Slide 8: Drawing out the beard (demonstration) Slide 9: Combing noil (handout) Slide 11: Combed sliver and worsted top comparison (handout)
Module 6: Predicting top from raw wool properties (TEAM) | 16 slides	No videos or recommended demonstrations
Module 7: Quality assurance of wool top | 25 slides	Slide 15: Strength of wool fibres (demonstration)
Module 8: Treatment of top | 23 slides	Slide 3: Comparison of ecru, dyed top and re-combed dyed top (handout) Slide 8: Backwashing (video) Slide 10: Mélange top (handout) Slide 11: Gill blending (video) Slide 13: Felt-resist treated top and untreated top comparison (handout) Slide 14: Felt-resist treatment (video) Slide 17: Mercerised top and untreated top comparison (handout) Slide 18: Stretched treated top and untreated top comparison (handout) Slide 21: Contamination risk (video)

MODULE OVERVIEW AND LEARNING OBJECTIVES

Module 1 —The role of the top-maker starts off this 8-module course by reviewing the participant's knowledge about the properties of the wool fibre and introducing the role of the top-maker. This will ensure all participants are at the same starting level of understanding and will confirm the use of any technical terms required during this course.

By the end of this module participants are expected to be able to:

- describe in detail the key raw fibre properties important during top-making
- name and describe the key properties to specify raw wool for top-making
- name and describe the key specifications of top
- describe the role and aims of the top-maker.

Module 2 —Early -stage processes in top-making will review participants' knowledge about the wool fibre and the early-stage processes that occur before the operations of carding, gilling and combing to bring all participants to the same starting level of knowledge and confirm the use of any technical terms required.

By the end of this module participants are expected to be able to describe the operations that make up the 'early-stage processes' in top-making, explain the aims of blending and scouring and their impact on the final top.

Module 3 —Worsted carding will cover the process of carding in the context of worsted top-making. It will explore the equipment used in the carding process, the impact of the raw fibre properties on the carding process and the form and quality attributes of the fibre following carding. Some of the latest developments in carding technology will also be covered.

At the end of this module participants are expected to be able to:

- describe the objectives of a worsted carding operation in the context of a worsted top-making operation
- describe the quality attributes of the input material that impact the carding process
- describe the components of a card and their function
- describe the conditions that affect card productivity and their impact on top quality
- describe the quality attributes of the output material from the carding process
- outline some of the latest developments in worsted carding.

Module 4 —Drafting and gilling covers the aims and practice of gilling operations. It also explains:

- the theory and mechanics of drafting wool in sliver form
- the types of gilling operations
- the mechanics of gilling using rollers and faller bars
- the issues associate with gilling
- before combing and re-combing (preparer gilling)
- after combing (finisher gilling).

At the end of this module participants are expected to be able to describe the aims of gilling, describe the theory and mechanics of the drafting operation, list the different types of gilling operations, describe the mechanics of gilling using rollers and faller bars and list the range of issues associated with gilling.

Module 5 —Combing investigates the aims of combing and the factors that affect the combing operation. It also explains the important settings and maintenance issues to ensure high-quality combing including:

- pinning of the combs
- fibre loading
- combing speed

The aims of finisher gilling are also covered in this module.

At the end of this module, participants are expected to be able to describe the aims of combing and operation of the comb, outline the key factors affecting the operation of the comb and describe the impact of the combing conditions on top quality. They will also be able to outline the role of finisher gilling.

Module 6 —Predicting top from raw wool properties (TEAM) investigates the principles of predicting top properties from raw wool measurements, the TEAM equations and their application, boundaries and understandings required when applying the formulae and the influence of some fibre properties on hauteur and romaine predictions.

At the end of this module, participants should be able to describe the TEAM equations and their function and describe the use of the equations in wool purchasing and processing. They should also be able to explain the role of the mill factor and describe the use of the TEAM equations in quality assurance (QA) programs.

Module 7 —Quality assurance of wool top covers the key features that define top quality, and how these features can be monitored, measured and managed.

By the end of this module participants will be able to describe the key features of wool top that define its quality and indicate the measurements and instruments used to evaluate the key quality attributes. They will also be able to outline the rationale for sampling and testing and describe the key features of a quality assurance program for top.

Module 8 —Treatment of top explores the processes that can be applied to modify wool top. It investigates the advantages and disadvantages of each of these processes and explains that management of top following various modifications depends on the impacts of the treatment process.

At the end of this module, participants should be able to describe the common treatments used on top to improve processing, impart both colour and functional properties. They will also be able to understand the methods used to impart these properties, the impact on the subsequent processing of wool and the procedures adopted to maximise subsequent spinning efficiency.

COURSE MATERIALS AND RESOURCES

To deliver the *Worsted top-making* series of lectures, you will need the following materials:

Provided in each course Facilitator Pack

- Facilitator Guide (PDF provided via DropBox link)
- Facilitator slides (PowerPoint files for each module provided via DropBox link)
- participant sign-on sheet (Word template provided via DropBox link)
- Participant Guide (PDF provided via DropBox link)
- Demonstration kit (see details below)
- Certificates of Participation (supplied by the regional Woolmark Company office on confirmation of student numbers).

To be sourced by facilitators

- speakers (for listening to the videos)
- laptop, data projector and overhead screen
- participant name tags (e.g. sticky labels or equivalent and a black marker to write participant names)
- flipchart and paper or access to a whiteboard
- markers for the flipchart or whiteboard where available

NOTE: The WST&DEP materials are designed to be delivered on a Microsoft 365 platform, on a 64bit hard drive. Please contact the regional Woolmark office if you do not have access to adequate technology.

THE WORSTED TOP-MAKING DEMONSTRATION KIT

A range of practical demonstrations, group activities, handouts and samples is recommended to be used throughout this course to support participant learning and complement the content delivered in the lectures.

Recommended resources are listed at the start of each module in the *Worsted top-making* Facilitator Guide.

The following samples and resources for demonstrations are provided in the *Worsted top-making* Demonstration kit (resources not supplied in the kit will need to be supplied by the facilitator as specified at the start of each module):

Module 1:
- sample of greasy (raw) wool
- sample of scoured wool
- sample of card waste with vegetable matter
- sample of worsted top

Module 3:
- sample of worsted top
- sample of card sliver
- sample of scoured wool
- samples of card clothing

Module 4:
- several lengths (1m) of card sliver
- sample of gilled sliver
- sample of worsted top

Module 5:
- sample of combed sliver
- sample of worsted top
- coarse comb
- fine comb
- bag of combed noil

Module 7:
- sample of worsted top

Module 8:
- sample of ecru (untreated and undyed) top
- sample of dyed top
- sample of re-combed dyed top
- sample of mélange top
- sample of felt-resist treated top
- sample of mercerised top
- sample of stretched top

ADMINISTRATIVE DETAILS

ORGANISATIONAL RESPONSIBILITIES

Institutions delivering the *Wool Science, Technology and Design Education Program* course *Worsted top-making* will be responsible for:

- ensuring all facilitators have completed the online *Wool Appreciation Course* prior to delivering their first course
- providing the venue and equipment required to support the program (i.e. lecture theatre, data projector, data screen, flip chart, whiteboard and markers)
- enrolling the participants in the course
- ensuring all participants have undertaken the prerequisite courses of study or have sufficient industry knowledge to complete this advanced course of study
- administrative paperwork (i.e. participant sign-in sheets, name tags etc.)
- providing administrative support for communication between the facilitator and the participants
- ensuring both the participants and the facilitator have the required access to external sites required to support participant learning
- providing supporting services, as required. (e.g. interpreter, transport to or from external sites)
- providing The Woolmark Company with participant numbers, and participant and facilitator feedback and course evaluation post delivery.

The Woolmark Company will be responsible for providing:

- Facilitator Guide (PDF provided via DropBox link)
- Facilitator slides (PowerPoint files for each module provided via DropBox link)
- Participant sign-on sheet (Word template provided via DropBox link)
- Participant Guide (PDF provided via DropBox link)
- Demonstration kit
- Certificates of Participation (printed copies will be provided by the local TWC office upon request).

NOTE: Course materials are provided in English. If translation to the local language is required, this is the responsibility of the delivering institution.

PARTICIPANT RECOGNITION

At the conclusion of the eight *Worsted top-making* lectures,each participant who has attended all lectures is eligible to receive a Woolmark Company-endorsed Certificate of Participation.

PROGRAM EVALUATION

Feedback from those attending the *Worsted top-making* course must be collected by way of an online survey link. This feedback will be used to adapt the course on an annual basis, if and where necessary, to ensure it achieves the desired objectives in the most effective way.

Feedback from those delivering the *Worsted top-making* course also must be submitted at the completion of the course.

Facilitator survey:
www.woolmarklearningcentre.com/wstd-surveyfacilitator

Participant survey:
www.woolmarklearningcentre.com/wstd-surveyparticipant

FACILITATOR CHECKLIST

The following list outlines the actions required before, during and after delivery of the *Worsted top-making* course.

One month before:

- ☐ Fully familiarise yourself with the course materials.
- ☐ Check you have all the materials required to deliver the course (including the facilitator materials and the wool demonstration kit).
- ☐ If you are an external facilitator, obtain contact details for your key point of contact at the host institution. Make contact, introduce yourself and arrange regular meetings leading up to the delivery dates.
- ☐ Confirm the number of participants attending, along with the year level and any previous studies relevant to the course.
- ☐ Confirm any specific needs for the target audience in consultation with the institution.
- ☐ Familiarise yourself with the venue and facilities that will be available for the lectures including room size and potential room layout options (see following notes regarding room layout). This may be via site maps or discussions with your key contact.
- ☐ Confirm equipment available at the venue (e.g. data projector, screen, speakers, laboratory equipment).
- ☐ Adapt the program (if required) to meet the needs of the participants and venue facilities.
- ☐ Check the availability of participant materials in sufficient quantity.
- ☐ Ensure you have reviewed the delivery material and have checked videos for the upcoming lectures work on the available equipment.

One week before:

- ☐ Confirm shipping details of the course materials and equipment (If required)
- ☐ Confirm transport between the institution and any external site visits. (if required).
- ☐ Confirm names of the participants attending the course.
- ☐ Ensure you have ordered a sufficient number of the 'Certificates of Participation' to be distributed to the appropriate participants following the completion of the final lecture.
- ☐ Ensure your wardrobe contains various wool garments. In order to demonstrate the benefits and versatility of wool and wool products, facilitators are encouraged to wear as much wool as possible, across a range of garment types. For example:
    - wool trousers or skirt
    - wool t-shirt or undershirt, long-sleeved shirt, sweater or jacket
    - wool socks.

One day before:

- ☐ Arrange to meet your key institution contacts face to face and any key contacts at external sites (if required).
- ☐ Familiarise yourself with the venue's emergency procedures.
- ☐ Tour the facility. Visit the rooms you will be using.
- ☐ Check the equipment you need is available in working order and you know how to use it (including lighting, heating and cooling).
- ☐ Ensure you have reviewed the delivery material and have checked any videos for the upcoming lectures will work on the available equipment
- ☐ Familiarise yourself with the rest rooms available at the venue.
- ☐ Take note of any challenges associated with each room (e.g. noise, heat, lighting). Identify strategies to minimise these challenges.
- ☐ Prepare the participant materials you will need to distribute at the first lecture (e.g. participant name tags and sign-in sheets).
- ☐ Check you have all the materials you need to deliver the course (including the Participant Guides).
- ☐ Distribute the PDF (soft copy) of the Participant Guide to participants prior to the first lecture if possible, to allow them to become familiar with the course materials and content.

Prior to each lecture:

- ☐ Ensure you are wearing a variety of wool garments that reflect the benefits and versatility of wool and wool products
- ☐ Arrive 30 minutes before each lecture to check the equipment is available and working.

At commencement of the first lecture:

- ☐ Distribute the hard copy of the Participant Guide to each participant.
- ☐ Distribute name tags to each participant.
- ☐ Record those who are present.

After each lecture:

- ☐ Stay to answer any questions the participants may have about the course content.

Prior to the final lecture:

- ☐ Ensure you have received a sufficient number of the 'Certificates of Participation' to be distributed to the appropriate participants following the completion of the final lecture.

At the completion of the course:

- ☐ Provide participants with the online feedback and evaluation survey link.
- ☐ Complete and submit your own online evaluation survey.
- ☐ Provide feedback to the institution regarding the successful completion of the course.
- ☐ Explore future delivery opportunities and liaise with The Woolmark Company regional office.

Post-course survey links:

Facilitator survey:
www.woolmarklearningcentre.com/wstd-surveyfacilitator

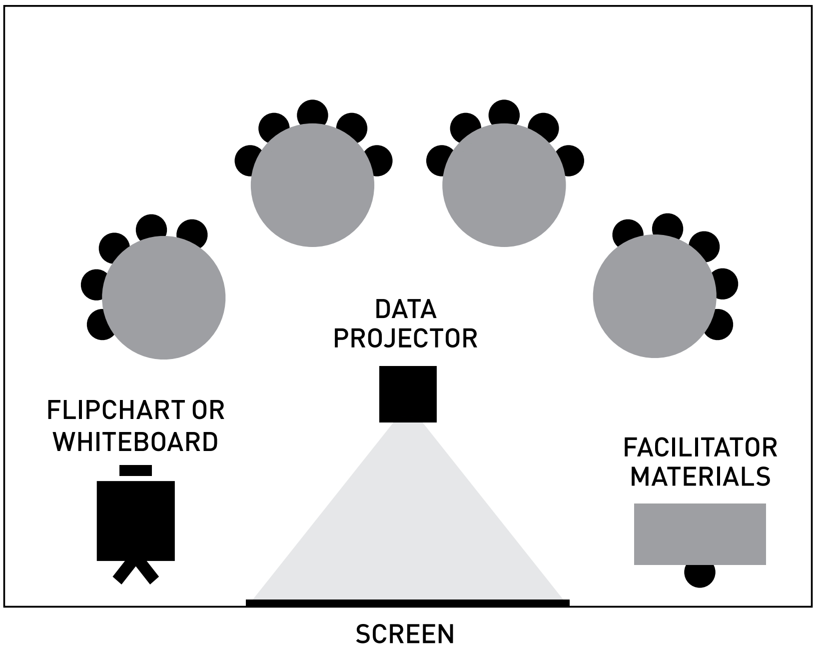
Participant survey:
www.woolmarklearningcentre.com/wstd-surveyparticipant

ROOM LAYOUT

The *Worsted top-making* course is designed to be delivered face-to-face, in groups of 6 – 50 people. In many cases this will mean delivery occurs in a large lecture theatre and there will not be an opportunity to influence the physical learning environment.

In smaller groups and settings where the learning environment can be influenced:

- arrange tables in a cabaret style (see diagram below) facing a flipchart or whiteboard and a data projector/screen
- allow for small group discussion in groups of three or four.



A GUIDELINE FOR THE EFFECTIVE AND ENGAGING DELIVERY OF THE COURSE CONTENT.

The course materials are designed to achieve a Gunning Fog Index of 8–10, with the exclusion of technical terms specific to the course.

The Gunning Fog Index formula implies short sentences written in plain English achieve a better score than long sentences written in complicated language.

Materials with a Gunning Fog Index of 8 have a readability equivalent to a Grade 8 reading level for English speaking students. It is considered the ideal score for readability. Anything above 12 is too hard for most people to read[1].

Information is provided in Appendix A for facilitators who wish to enhance their skills in facilitation by acknowledging the different learning styles of participants.

Research has shown each person has a preferred way of learning[2]. As adults, we tend to adopt the learning style with which we are most comfortable and ignore learning styles with which we are unfamiliar or uncomfortable. This means learning is most effective when a student can process information and solve problems in a way that is meets their preferred learning style.

When you know a person's learning style, you can present information to them so they can grasp it quickly and easily. If information is presented in a way that is at odds with their preferred learning style, the student will find it more difficult to learn. Sometimes this means, as a facilitator, you may have to present information to a student in a way that will engage them, although that may not be your preferred method. If you do not accommodate the students preferred learning style, you make it harder to get the message across, which may lead to frustration on your part, as well as a lack of commitment from the student.

Honey & Mumford have developed a questionnaire, included in Appendix A, which helps you identify your students' preferred learning styles.

For those who are interested, you could provide this questionnaire to your student one month out from delivery. Using the results from this survey you can cater to your students' preferred learning styles more effectively.

1 http://www.usingenglish.com/glossary/fog-index.html, http://juicystudio.com/services/readability.php
2 Kolb D. A. (1984). Experiential Learning experience as a source of learning and development, New Jersey: Prentice Hall.

APPENDIX A:
LEARNING STYLES QUESTIONNAIRE

NAME: ____________________________

This questionnaire is designed to find out your preferred learning style(s). Over the years you have probably developed learning "habits" that help you benefit more from some experiences than from others. Since you are probably unaware of this, this questionnaire will help you pinpoint your learning preferences so that you are in a better position to select learning experiences that suit your style and having a greater understanding of those that suit the style of others.

This is an internationally proven tool designed by Peter Honey and Alan Mumford.

There is no time limit to this questionnaire. It will probably take you 10-15 minutes. The accuracy of the results depends on how honest you can be. There are no right or wrong answers.

If you agree more than you disagree with a statement put a tick by it.

If you disagree more than you agree put a cross by it.

Be sure to mark each item with either a tick or cross.

□ 1. I have strong beliefs about what is right and wrong, good and bad

□ 2. I often act without considering the possible consequences

□ 3. I tend to solve problems using a step-by-step approach

□ 4. I believe that formal procedures and policies restrict people

□ 5. I have a reputation for saying what I think, simply and directly

□ 6. I often find that actions based on feelings are as sound as those based on careful thought and analysis

□ 7. I like the sort of work where I have time for thorough preparation and implementation

□ 8. I regularly question people about their basic assumptions

□ 9. What matters most is whether something works in practice

□ 10. I actively seek out new experiences

□ 11. When I hear about a new idea or approach I immediately start working out how to apply it in practice

□ 12. I am keen on self discipline such as watching my diet, taking regular exercise, sticking to a fixed routine, etc

□ 13. I take pride in doing a thorough job

□ 14. I get on best with logical, analytical people and less well with spontaneous, 'irrational' people

□ 15. I take care over the interpretation of data available to me and avoid jumping to conclusions

□ 16. I like to reach a decision carefully after weighing up many alternatives

□ 17. I'm attracted more to novel, unusual ideas than to practical ones

□ 18. I don't like disorganised things and prefer to fit things into a coherent pattern

□ 19. I accept and stick to laid down procedures and policies so long as I regard them as an efficient way of getting the job done

□ 20. I like to relate my actions to a general principle

□ 21. In discussions I like to get straight to the point

□ 22. I tend to have distant, rather formal relationships with people at work

□ 23. I thrive on the challenge of tackling something new and different

□ 24. I enjoy fun-loving, spontaneous people

□ 25. I pay meticulous attention to detail before coming to a conclusion

□ 26. I find it difficult to produce ideas on impulse

□ 27. I believe in coming to the point immediately

□ 28. I am careful not to jump to conclusions too quickly

□ 29. I prefer to have as many resources of information as possible – the more data to think over the better

□ 30. Flippant people who don't take things seriously enough usually irritate me

□ 31. I listen to other people's points of view before putting my own forward

□ 32. I tend to be open about how I'm feeling

□ 33. In discussions I enjoy watching the manoeuvrings of the other participants

□ 34. I prefer to respond to events on a spontaneous, flexible basis rather than plan things out in advance

- ☐ 35. I tend to be attracted to techniques such as network analysis, flow charts, branching programs, contingency planning, etc
- ☐ 36. It worries me if I have to rush out a piece of work to meet a tight deadline
- ☐ 37. I tend to judge people's ideas on their practical merits
- ☐ 38. Quiet, thoughtful people tend to make me feel uneasy
- ☐ 39. I often get irritated by people who want to rush things
- ☐ 40. It is more important to enjoy the present moment than to think about the past or future
- ☐ 41. I think that decisions based on a thorough analysis of all the information are sounder than those based on intuition
- ☐ 42. I tend to be a perfectionist
- ☐ 43. In discussions I usually produce lots of spontaneous ideas
- ☐ 44. In meetings I put forward practical realistic ideas
- ☐ 45. More often than not, rules are there to be broken
- ☐ 46. I prefer to stand back from a situation
- ☐ 47. I can often see inconsistencies and weaknesses in other people's arguments
- ☐ 48. On balance I talk more than I listen
- ☐ 49. I can often see better, more practical ways to get things done
- ☐ 50. I think written reports should be short and to the point
- ☐ 51. I believe that rational, logical thinking should win the day
- ☐ 52. I tend to discuss specific things with people rather than engaging in social discussion
- ☐ 53. I like people who approach things realistically rather than theoretically
- ☐ 54. In discussions I get impatient with irrelevancies and digressions
- ☐ 55. If I have a report to write I tend to produce lots of drafts before settling on the final version
- ☐ 56. I am keen to try things out to see if they work in practice
- ☐ 57. I am keen to reach answers via a logical approach
- ☐ 58. I enjoy being the one that talks a lot
- ☐ 59. In discussions I often find I am the realist, keeping people to the point and avoiding wild speculations
- ☐ 60. I like to ponder many alternatives before making up my mind
- ☐ 61. In discussions with people I often find I am the most dispassionate and objective
- ☐ 62. In discussions I'm more likely to adopt a "low profile" than to take the lead and do most of the talking
- ☐ 63. I like to be able to relate current actions to a longer term bigger picture
- ☐ 64. When things go wrong I am happy to shrug it off and "put it down to experience"
- ☐ 65. I tend to reject wild, spontaneous ideas as being impractical
- ☐ 66. It's best to think carefully before taking action
- ☐ 67. On balance I do the listening rather than the talking
- ☐ 68. I tend to be tough on people who find it difficult to adopt a logical approach
- ☐ 69. Most times I believe the end justifies the means
- ☐ 70. I don't mind hurting people's feelings so long as the job gets done
- ☐ 71. I find the formality of having specific objectives and plans stifling
- ☐ 72. I'm usually one of the people who puts life into a party
- ☐ 73. I do whatever is expedient to get the job done
- ☐ 74. I quickly get bored with methodical, detailed work
- ☐ 75. I am keen on exploring the basic assumptions, principles and theories underpinning things and events
- ☐ 76. I'm always interested to find out what people think
- ☐ 77. I like meetings to be run on methodical lines, sticking to laid down agenda, etc.
- ☐ 78. I steer clear of subjective or ambiguous topics
- ☐ 79. I enjoy the drama and excitement of a crisis situation
- ☐ 80. People often find me insensitive to their feelings

SCORING AND INTERPRETING THE LEARNING STYLES QUESTIONNAIRE

The Questionnaire is scored by awarding one point for each ticked item. There are no points for crossed items. Simply indicate on the lists below which items were ticked by circling the appropriate question number.

	2	7	1	5
	4	13	3	9
	6	15	8	11
	10	16	12	19
	17	25	14	21
	23	28	18	27
	24	29	20	35
	32	31	22	37
	34	33	26	44
	38	36	30	49
	40	39	42	50
	43	41	47	53
	45	46	51	54
	48	52	57	56
	58	55	61	59
	64	60	63	65
	71	62	68	69
	72	66	75	70
	74	67	77	73
	79	76	78	80
TOTALS	____________	____________	____________	____________
	Activist	**Reflector**	**Theorist**	**Pragmatist**

LEARNING STYLES QUESTIONNAIRE PROFILE BASED ON GENERAL NORMS FOR 1302 PEOPLE

ACTIVIST	REFLECTOR	THEORIST	PRAGMATIST	
20	20	20	20	Very strong preference
19				
18		19	19	
17				
16		18		
15		17	18	
14				
13	18	16	17	
12	17	15	16	Strong preference
	16			
11	15	14	15	
10	14	13	14	Moderate
9	13	12	13	
8				
7	12	11	12	
6	11	10	11	Low preference
5	10	9	10	
4	9	8	9	
3	8	7	8	Very low preference
	7	6	7	
	6	5	6	
2	5	4	4	
	4	3	3	
	3			
1	2	2	2	
	1	1	1	
0	0	0	0	

LEARNING STYLES – GENERAL DESCRIPTIONS

Activists

Activists involve themselves fully and without bias in new experiences. They enjoy the here and now and are happy to be dominated by immediate experiences. They are open-minded, not sceptical, and this tends to make them enthusiastic about anything new. Their philosophy is: "I'll try anything once". They tend to act first and consider the consequences afterwards. Their days are filled with activity. They tackle problems by brainstorming. As soon as the excitement from one activity has died down they are busy looking for the next. They tend to thrive on the challenge of new experiences but are bored with implementation and longer-term consolidation. They are gregarious people constantly involving themselves with others but in doing so they seek to centre all activities on themselves.

Reflectors

Reflectors like to stand back to ponder experiences and observe them from many different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to any conclusion. The thorough collection and analysis of data about experiences and events is what counts so they tend to postpone reaching definitive conclusions for as long as possible. Their philosophy is to be cautious. They are thoughtful people who like to consider all possible angles and implications before making a move. They prefer to take a back seat in meetings and discussions. They enjoy observing other people in action. They listen to others and get the drift of the discussion before making their own points. They tend to adopt a low profile and have a slightly distant, tolerant unruffled air about them. When they act it is part of a wide picture which includes the past as well as the present and others' observations as well as their own.

Theorists

Theorists adapt and integrate observations into complex but logically sound theories. They think problems through in a vertical, step-by-step logical way. They assimilate disparate facts into coherent theories. They tend to be perfectionists who won't rest easy until things are tidy and fit into a rational scheme. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories models and systems thinking. Their philosophy prizes rationality and logic. "If it's logical it's good". Questions they frequently ask are: "Does it make sense?" "How does this fit with that?" "What are the basic assumptions?" They tend to be detached, analytical and dedicated to rational objectivity rather than anything subjective or ambiguous. Their approach to problems is consistently logical. This is their "mental set" and they rigidly reject anything that doesn't fit with it. They prefer to maximise certainty and feel uncomfortable with subjective judgments, lateral thinking and anything flippant.

Pragmatists

Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications. They are the sorts of people who return from management courses brimming with new ideas that they want to try out in practice. They like to get on with things and act quickly and confidently on ideas that attract them. They tend to be impatient with ruminating and open-ended discussions. They are essentially practical, down to earth people who like making practical decisions and solving problems. They respond to problems and opportunities "as a challenge". Their philosophy is: "There is always a better way" and "if it works it's good".

In descending order of likelihood, the most common combinations are:

1st Reflector/Theorist
2nd Theorist/Pragmatist
3rd Reflector/Pragmatist
4th Activist/Pragmatist

LEARNING STYLES – A FURTHER PERSPECTIVE

ACTIVISTS:

Activists *learn best from activities where:*

- There are new experiences/problems/opportunities from which to learn.
- They can engross themselves in short "here and now" activities such as business games, competitive teamwork tasks, role-playing exercises.
- There is excitement/drama/crisis and things chop and change with a range of diverse activities to tackle
- They have a lot of the limelight/high visibility, i.e. they can "chair" meetings, lead discussions, and give presentations.
- They are allowed to generate ideas without constraints of policy or structure or feasibility.
- They are thrown in at the deep end with a task they think is difficult, i.e. when set a challenge with inadequate resources and adverse conditions.
- They are involved with other people, i.e. bouncing ideas off them, solving problems as part of a team.
- It is appropriate to "have a go".

Activists *learn least from, and may react against, activities where:*

- Learning involves a passive role, i.e. listening to lectures, monologues, explanations, statements of how things should be done, reading, watching.
- They are asked to stand back and not be involved.
- They are required to assimilate, analyse and interpret lots of "messy" data.
- They are required to engage in solitary work, i.e. reading, writing, thinking on their own.
- They are asked to assess beforehand what they will learn, and to appraise afterwards what they have learned.
- They are offered statements they see as "theoretical", i.e. explanation of cause or background
- They are asked to repeat essentially the same activity over and over again, i.e. when practicing.
- They have precise instructions to follow with little room for manoeuvre.
- They are asked to do a thorough job, i.e. attend to detail, tie up loose ends, dot the i's, cross t's.

Summary of strengths

- Flexible and open minded.
- Happy to have a go.
- Happy to be exposed to new situations.
- Optimistic about anything new and therefore unlikely to resist change.

Summary of weaknesses:

- Tendency to take the immediately obvious action without thinking.
- Often take unnecessary risks.
- Tendency to do too much themselves and hog the limelight.
- Rush into action without sufficient preparation.
- Get bored with implementation/consolidation.
- Key questions for activists:
- Shall I learn something new, i.e. that I didn't know/ couldn't do before?
- Will there be a wide variety of different activities? (I don't want to sit and listen for more than an hour at a stretch!)
- Will it be OK to have a go/let my hair down/make mistakes/have fun?
- Shall I encounter some tough problems and challenges?
- Will there be other like-minded people to mix with?

REFLECTORS:

Reflectors *learn best from activities where:*

- They are allowed or encouraged to watch/think/chew over activities.
- They are able to stand back from events and listen/ observe, i.e. observing a group at work, taking a back seat in a meeting, watching a film or video.
- They are allowed to think before acting, to assimilate before commencing, i.e. time to prepare, a chance to read in advance a brief giving background data.
- They can carry out some painstaking research, i.e. investigate, assemble information, and probe to get to the bottom of things.
- They have the opportunity to review what has happened, what they have learned.
- They are asked to produce carefully considered analyses and reports.

- They are helped to exchange views with other people without danger, i.e. by prior agreement, within a structured learning experience.
- They can reach a decision in their own time without pressure and tight deadlines.

Reflectors *learn least from, and may react against, activities where:*

- They are "forced" into the limelight, i.e. to act as leader/chairman, to role-play in front of on-lookers.
- They are involved in situations which require action without planning.
- They are pitched into doing something without warning, i.e. to produce an instant reaction, to produce an off-the-top-of-the-head idea.
- They are given insufficient data on which to base a conclusion.
- They are given cut and dried instructions of how things should be done.
- They are worried by time pressures or rushed from one activity to another.
- In the interests of expediency they have to make short cuts or do a superficial job.

Summary of strengths:

- Careful.
- Thorough and methodical
- Thoughtful
- Good at listening to others and assimilating information.
- Rarely jump to conclusions.

Summary of weaknesses:

- Tendency to hold back from direct participation.
- Slow to make up their minds and reach a decision.
- Tendency to be too cautious and not take enough risks.
- Not assertive - they aren't particularly forthcoming and have no "small talk".

Key questions for reflectors:

- Shall I be given adequate time to consider, assimilate and prepare?
- Will there be opportunities/facilities to assemble relevant information?
- Will there be opportunities to listen to other people's points of view – preferably a wide cross section of people with a variety of views?
- Shall I be under pressure to be slapdash or to extemporise?

THEORISTS:

Theorists *learn best from activities where:*

- What is being offered is part of a system, model, concept, or theory.
- The have time to explore methodically the associations and inter-relationships between ideas, events and situations.
- They have the chance to question and probe the basic methodology, assumptions or logic behind something, i.e. by taking part in a question and answer session, by checking a paper for inconsistencies.
- They are intellectually stretched, i.e. by analysing a complex situation, being tested in a tutorial session, by teaching high calibre people who ask searching questions.
- They are in structured situations with a clear purpose.
- They can listen to or read about ideas and concepts that emphasise rationality or logic and are well argued/elegant/watertight.
- They can analyse and then generalise the reasons for success or failure.
- They are offered interesting ideas and concepts even though they are not immediately relevant.
- They are required to understand and participate in complex situations.

Theorists *learn least from, and may react against, activities where:*

- They are pitch-forked into doing something without a context or apparent purpose.
- They have to participate in situations emphasising emotions and feelings.
- They are involved in unstructured activities where ambiguity and uncertainty are high, i.e. with open¬ended problems, on sensitivity training.
- They are asked to act or decide without a basis in policy, principle or concept.
- They are faced with a hotchpotch of alternative/ contradictory techniques/methods without exploring any in depth, i.e. as on a "once over lightly" course.
- They find the subject matter platitudinous, shallow or gimmicky.
- They feel themselves out of tune with other participants, i.e. when with lots of Activists or people of lower intellectual calibre.

Summary of strengths:

- Logical "vertical" thinkers.
- Rational and objective.
- Good at asking probing questions.
- Disciplined approach.

Summary of weaknesses:

- Restricted in lateral thinking.
- low tolerance for uncertainty, disorder and ambiguity
- Intolerant of anything subjective or intuitive.
- Full of "shoulds, oughts and musts".

Key questions for theorists:

- Will there be lots of opportunities to question?
- Do the objectives and program of events indicate a clear structure and purpose?
- Shall I encounter complex ideas and concepts that are likely to stretch me?
- Are the approaches to be used and concepts to be explored "respectable", i.e. sound and valid?
- Shall I be with people of similar calibre to myself?

PRAGMATIST:

Pragmatists *learn best from activities where:*

- There is an obvious link between the subject matter and a problem or opportunity on the job.
- They are shown techniques for doing things with obvious practical advantages, i.e. how to save time, how to make a good first impression, how to deal with awkward people.
- They have the chance to try out and practice techniques with coaching/feedback from a credible expert, i.e. someone who is successful and can do the techniques themselves.
- They are exposed to a model they can emulate, i.e. a respected boss, a demonstration from someone with a proven track record, lots of examples/anecdotes, and a film showing how it's done.
- They are given techniques currently applicable to their own job.
- They are given immediate opportunities to implement what they have learned.
- There is a high face validity in the learning activity, i.e. a good simulation, "real" problems.
- They can concentrate on practical issues, i.e. drawing up action plans with an obvious end product, suggesting short cuts, giving tips.

Pragmatists *learn least from, and may react against, activities where:*

- The learning is not related to an immediate need they recognise/they cannot see, an immediate relevance/ practical benefit.
- Organisers of the learning, or the event itself, seems distant from reality, i.e. "ivory towered", all theory and general principles, pure "chalk and talk".
- There is no practice or clear guidelines on how to do it.
- They feel that people are going round in circles and not getting anywhere fast enough.
- There are political, managerial or personal obstacles to implementation.
- There is no apparent reward from the learning activity, i.e. more sales, shorter meetings, higher bonus, promotion.

Summary of strengths:

- Keen to test things out in practice.
- Practical, down to earth, realistic.
- Businesslike – gets straight to the point.
- Technique oriented.

Summary of weaknesses:

- Tendency to reject anything without an obvious application.
- Not very interested in theory or basic principles.
- Tendency to seize on the first expedient solution to a problem.
- Impatient with waffle.
- On balance, task oriented not people oriented.

Key questions for pragmatists:

- Will there be ample opportunities to practice and experiment?
- Will there be lots of practical tips and techniques?
- Shall we be addressing real problems and will it result in action plans to tackle some of my current problems?
- Shall we be exposed to experts who know how to/can do it themselves?

GLOSSARY

ACRONYMS, ABBREVIATIONS AND UNITS OF MEASUREMENT

ASTM	American Society for Testing and Materials
ATLAS	Automatic Tester of Length and Strength
AWI	Australian Wool Innovation
AWTA	Australian Wool Testing Authority
CEN	European Committee for Standardisation
CIE	Commission International de l'Eclairage
CSIRO	Commonwealth Scientific and Industrial Research Organisation; Australia's national science agency
CVB	The coefficient of variation of fibre length based on the barbe measurement.
CVD	The coefficient of variation in fibre diameter.
CVH	The coefficient of variation of fibre length based on the hauteur measurement.
FFD	Fresh fibre density, the amount of fibre entering the card.
ISO	International Organisation for Standardisation
MFD	Mean fibre diameter
N/ktex	Units of staple strength: newtons per kilotex, the breaking load of a staple divided by the linear density.
Nm	Newton metre, a unit of torque, also called a moment.
NZWTA	New Zealand Wool Testing Authority
OFDA	Optical Fibre Distribution Analyser, which measures the fibre diameter distribution.
POB	Position of break, zone of weakness in the wool staple.
QA	Quality assurance
QC	Quality control
RF dryers	Radio frequency dryers, used for top drying following backwashing.
SOP	Standard operating procedure
TEAM	Trials Evaluating Additional Measurements, used to predict top quality from raw wool properties.
TWC	The Woolmark Company
VM	Vegetable matter content
WHS	Workplace health and safety
WTBSA	Wool Testing Bureau of South Africa

GLOSSARY

Term	Definition
Almeter	An electronic apparatus for determining the fibre length distribution parameters on top (and sliver).
back ratch	The distance from the nip of the delivery rolls to the entry of the faller bars.
barbe	The mean fibre length of the fibres determined from the length and weight of the fibres in the sample.
beard	The fringe of wool formed during the early combing process and combed by the circular comb.
bi-axial pressing	Compressing pressing bales in two different directions.
card	Worsted carding machine.
card clothing	The wires, sometimes held in a backing material wrapped around the various components of the card, and the points of which are used to separate the wool fibres.
card sliver	The product of the worsted or semi-worsted carding machine: see also 'sliver'.
carding	The process of disentangling and aligning fibres, while partially removing any vegetable matter (VM) contamination.
combing	A process used to straighten and align the fibres, remove short fibres along with neps (small fibre entanglements), and remove any remaining vegetable matter.
draft (noun)	The ratio of the front roller speed to the back or feed roller speed in the gill box.
draft (verb)	The process of drawing out slivers or top to reduce linear density (the weight per unit length).
fettling	The cleaning of the card.
fibre bundle tenacity	The force required to break a fibre bundle divided by the bundle weight per unit length.
finisher gilling	A process where the combed sliver is gilled to improve the regularity of the top, further align the fibres, adjust the moisture content of the wool and produce a top ready for drawing.
front ratch	The distance from the nip of the front delivery roll to the exit or delivery point of draft control mechanism.
gilling	A process used to better align the fibres and help mix and further blend the wool.
hauteur	The average (or mean) length of the fibres determined from the total length and number of the fibres in the sample.

Term	Definition
heather	Yarns formed from fibres of different shade or depth of colour.
hook	A 180 degree a bend in the fibre, which is created during carding by the action of the card clothing wire on the wool fibre mass.
K value	A measure of the short fibre content of the top.
L value	The length reached by a certain percentage of the fibres in a top.
labile	Easily broken down or displaced.
Laserscan	An instrument used to measure fibre diameter distribution.
mélange	Yarns formed from fibres of different shade or depth of colour (often black and white).
mercerisation	A process that improves the lustre and handle of treated top, also known as soft lustre.
mill factor	Also known as the mill correction, is determined from the average difference between the predicted and actual results for a specific mill over a number of batches.
neps	A small accumulation of entangled fibres having a distinct central core.
oleines	Mixed fatty acids derived from tallow and bone grease, traditional processing aids used for woollen carding and spinning.
opening	Processes in which the wool fleeces (and pieces) are broken into locks or clumps of fibre that are not heavily entangled before carding.
Optim	A process in which wool fibres in top form are stretched. This process reduces the fibre diameter and changes the cross-sectional shape of the fibre, in turn improving the handle and lustre of the fibre.
raising	Describes the lifting of the fibres on a cylinder to improve transfer.
romaine	The amount of noil produced during combing expressed as a percentage of the weight of total top and noil.
sliver	A continuous strand of loosely assembled wool fibres, which may contain variable amounts of vegetable matter (VM) and is approximately uniform in cross-sectional area and with none or very low levels of twist.
slub	An abruptly thick place in a yarn usually with a diameter in excess of 2.5mm, does not contain an entangled core of fibres.

Term	Definition
solvent extractable material	Non-fibrous solvent-soluble material in or on a sliver
spectrophotometer	An instrument for measuring the colour of wool by determining the reflectivity of a surface within the visible spectrum.
stripping	Describes the movement transfer of the wool from one roller to another.
working	Describes the separation of the individual fibres from the fibre clumps usually between the worker rollers and the swift.

COURSE
INTRODUCTION

THE WOOLMARK COMPANY

WORSTED TOP-MAKING

WELCOME participants as they arrive, ensuring they collect their pre-prepared name tags or ask them to write their name on a tag as they arrive.

ENSURE each participant takes a copy of the Participant Guide and records their attendance.

INTRODUCE yourself and provide a brief (maximum three-minute) overview of your role, experience and broad objectives in delivering this series of lectures.

After introducing yourself, if you have a group of 20 participants or less, ask each participant to provide a brief introduction (name, role and organisation, or area of study) and share three things they wish to achieve by attending this series of lectures.

NOTE: If you have 20 participants and they each take about 30 seconds to introduce themselves and their objectives, this exercise will require 10 minutes.

Keep it brief. You may need to modify your approach, based on the number of participants in the room. For example, in a large group (20+ participants select a small sample of participants to introduce themselves and share their expectations).

RECORD AND group participants' responses regarding their own learning objectives on the flipchart or whiteboard.

This introduction will expand upon your understanding of each participant's needs and attitude towards their participation in the program and will give them the opportunity to build rapport with you as the facilitator and other participants in the group.

EXPLAIN TO participants you will revisit these objectives throughout the course to ensure each objective has been covered or participants are directed to additional resources that will help them meet their own learning objectives.

Endeavour to draw on these participant objectives as you progress through the course.

SET UP guidelines for participant interaction by stating that if you ask a question of the audience, the correct answer is acceptable, the incorrect answer also is acceptable, however silence is unacceptable.

ENCOURAGE participants to ask questions by reassuring them that all questions are valuable.

SPEND a few moments exploring participants current understanding of wool. Establishing how much individuals, or the group as a whole, already know about wool will allow you to acknowledge and leverage the experience of those in the room and tailor the content and delivery of the course appropriately to either dispel misperceptions or build on current understanding.

ALLOW about 5–10 minutes for a group discussion prompted by a questioning approach outlined below.

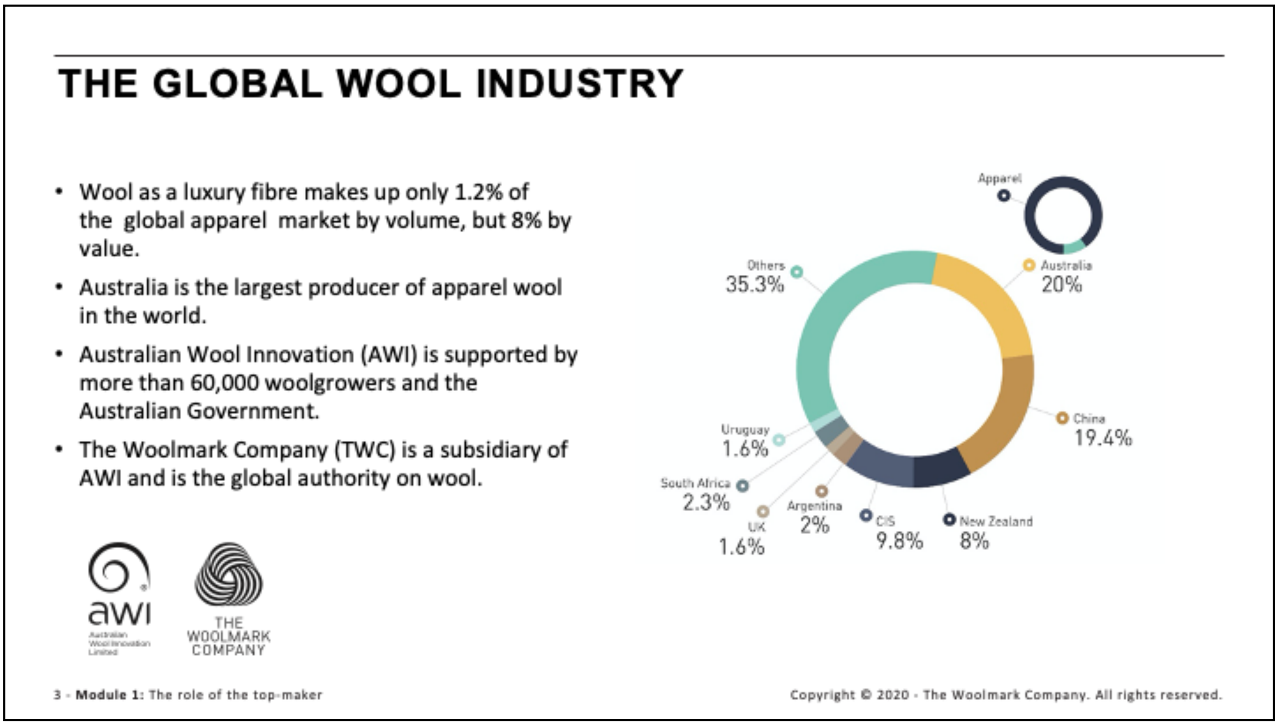
ASK *participants to share what they already know about wool.*

Examples of questions you might ask to encourage participation include:

- *What are some key properties of raw wool?*
- *What are the key processes wool has undergone before top-making takes place?*
- *What is wool top?*

RECORD *responses to the above questions on a flipchart or whiteboard and explain that you will re-visit the responses at the end of this module and the course to reflect upon what participants may have learnt during the course.*

NOTE: *If participants have not already been introduced to Australian Wool Innovation (AWI) and The Woolmark Company (TWC) insert this short presentation here, before continuing with* Module 1 — Role of the top-maker



REFER TO the slide as you indicate that Australian woolgrowers produce 90% of the world's fine apparel wool as part of Australia's $2.5 billion wool export industry*.

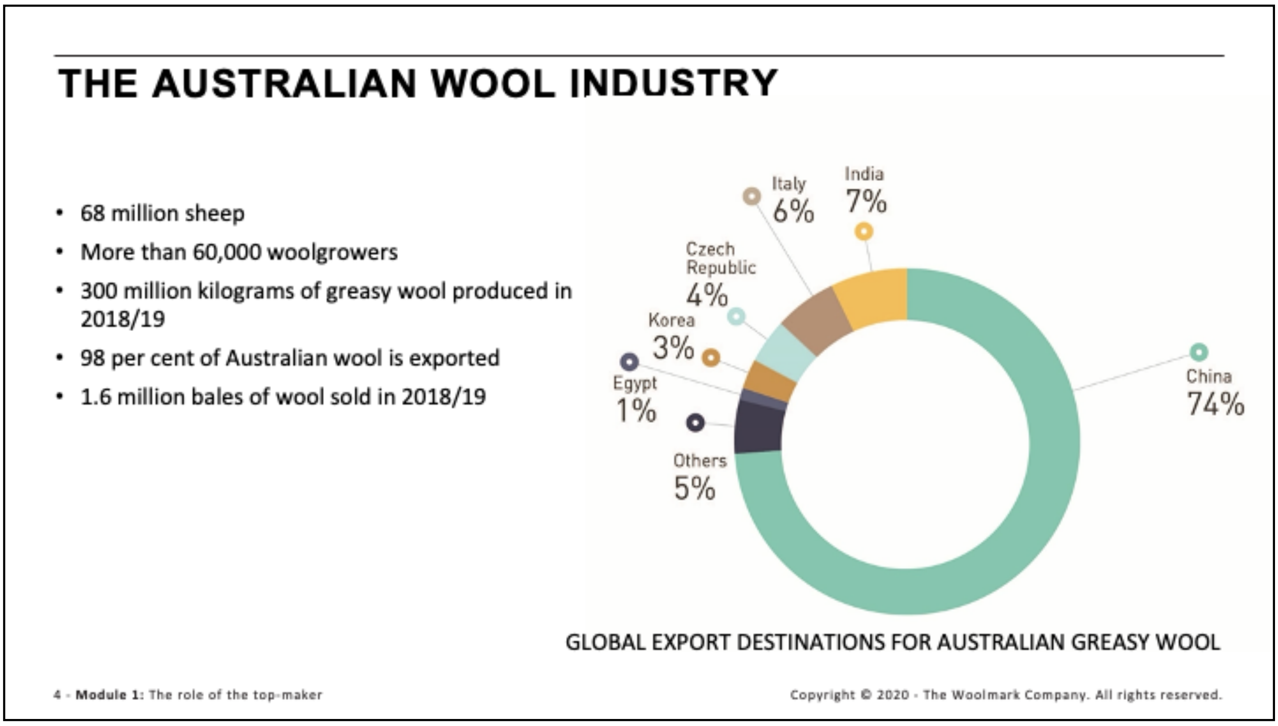
**Source ABARES Agricultural Commodities, March 2020 quarter.*

EXPLAIN THAT Australian Wool Innovation (AWI) is the research, development and marketing body for the Australian wool industry, supported by more than 60,000 Australian woolgrowers, who co-invest with the Australian government to support the activities carried out by AWI and TWC along the global wool supply chain.

EXPLAIN THAT The Woolmark Company is a subsidiary of Australian Wool Innovation and is a global authority on Merino wool. With a network that spans the entire global wool supply chain The Woolmark Company builds awareness and promotes the unique traits of nature's finest fibre.

REINFORCE THAT The Woolmark Company collaborates with global experts on all aspects of wool science, technology and design to develop and deliver educational materials, such as the course you are about to deliver.

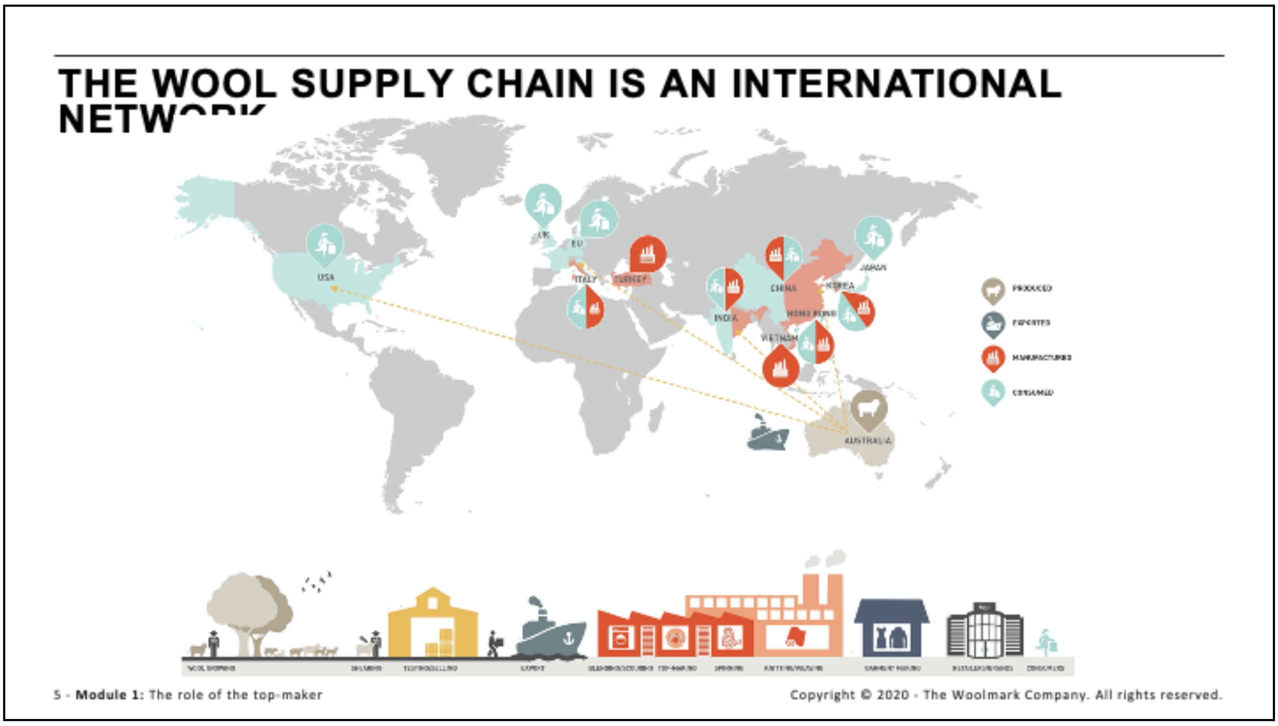
NOTE THAT you will provide a brief overview of the Australian wool industry and global supply chain, and elaborate on the role of The Woolmark Company in the global context before commencing the technical components of the course



EXPLAIN THAT there are more than 68 million sheep in Australia, carefully managed by more than 60,000 woolgrowers.

INDICATE THAT in 2018/19 Australia's woolgrowers produced 300 million kilograms of greasy wool and sold 1.6 million bales of wool.

POINT OUT that 98 per cent of Australia's wool is exported to other countries for further processing into a diverse range of products.



REFER TO the slide as you explain that it offers a snapshot of the global dynamics of the Australian wool industry, illustrating where the key export markets are for Australian wool, where most wool is processed from its raw state into yarn and fabrics and where the fashion and trend influencers and wool consumers are located.

NOTE THAT countries such as China, India and Italy are major manufacturers and consumers of wool products.

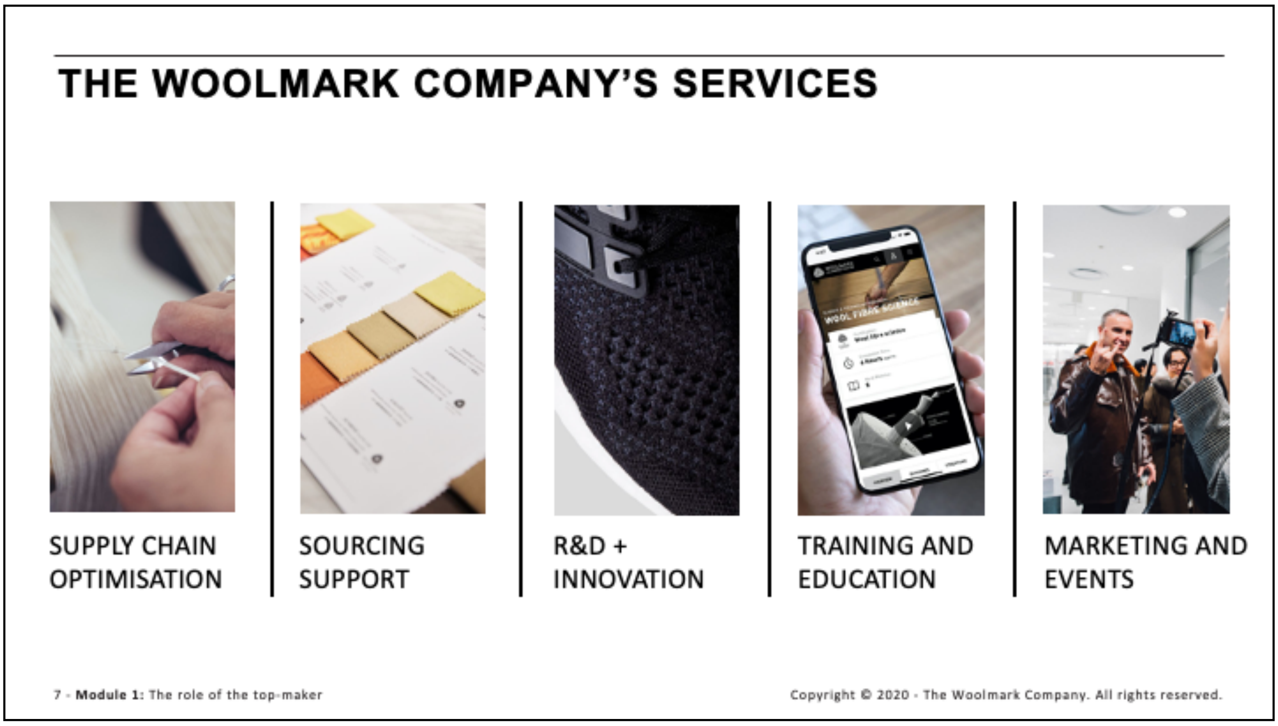
EXPLAIN THAT in line with these global dynamics, The Woolmark Company head office in Sydney, Australia is supported by a growing number of regional offices globally. Through this support The Woolmark Company invests in innovation along the global wool supply chain.

REINFORCE THAT The Woolmark Company works on behalf of Australia's 60,000+ woolgrowers, who are responsible for producing 90 per cent of the world's fine apparel wool.

EXPLAIN THAT The Woolmark Company's parent body — Australian Wool Innovation — invests in on-farm research and development to deliver new knowledge to woolgrowers to increase the profitability and sustainability of the growing wool business.

NOTE THAT The Woolmark Company strives to deliver tangible solutions across the global wool textile industry through process and product research and development.

EXPLAIN THAT the Woolmark Company builds industry confidence through communication, collaboration and a range of educational programs across the industry.



EXPLAIN THAT The Woolmark Company partners with designers, brands and retailers worldwide, offering support with quality assurance, product innovation and supply chain assistance.

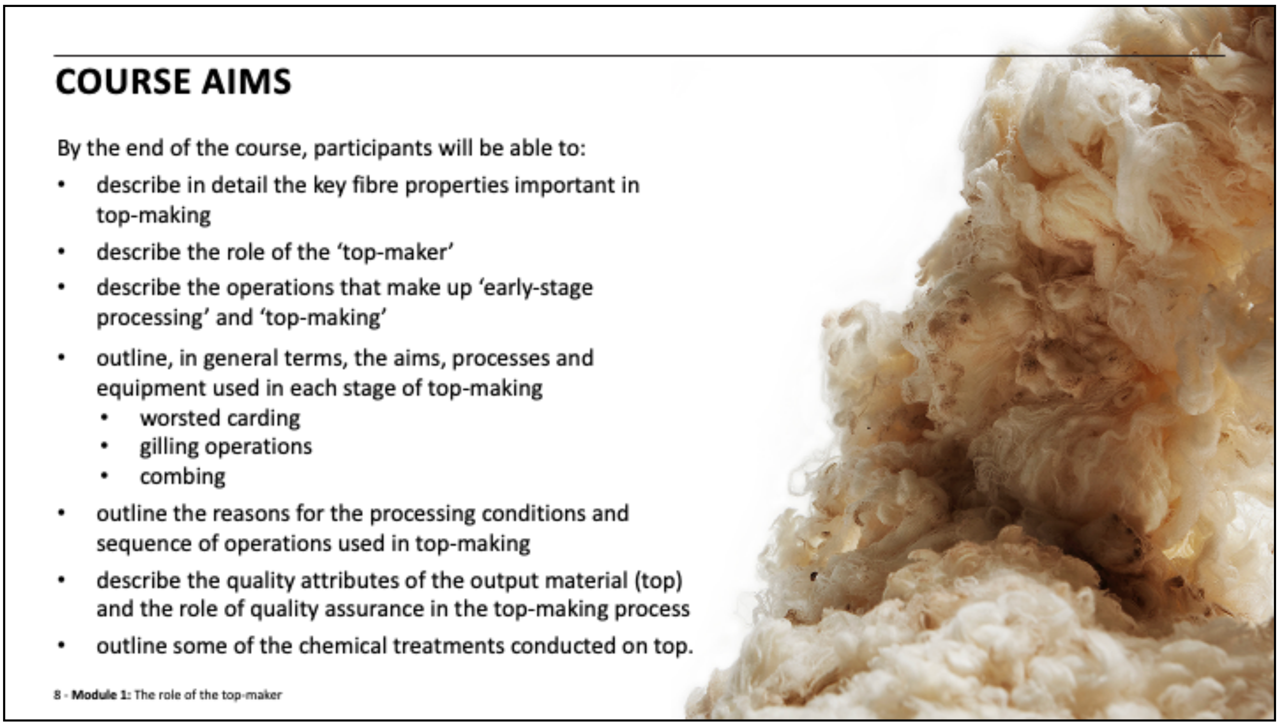
INDICATE THAT The Woolmark Company provides sourcing support through direct access to the global wool manufacturing industry through The Wool Lab. A seasonal guide to the latest innovations in wool, fabrics are sourced from the world's best spinners and weavers in the global supply network.

REINFORCE THAT The Woolmark Company takes secures funding and delivers research to improve wool production and processing through fibre science, traceability and fibre advocacy.

EXPLAIN THAT The Woolmark Company offers a range of online and face-to-face training programs to educate the industry. During 2019, The Woolmark Company launched the Woolmark Learning Centre, an online educational hub for industry professionals.

POINT OUT that The Woolmark Company markets the performance and environmental benefits of the fibre to ensure industry and consumers are informed and inspired to make better purchasing choices.

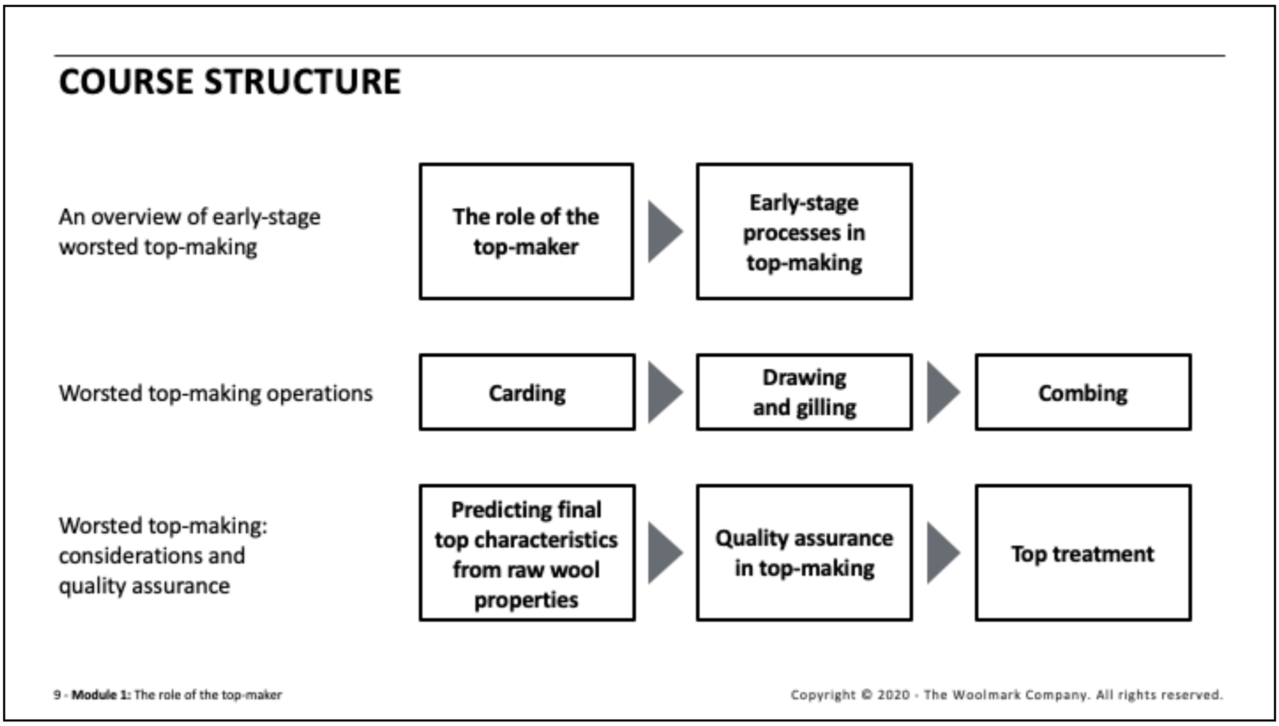
ASK PARTICIPANTS if they have any questions about the Woolmark Company before you proceed with the course aims.



EXPLAIN THAT the aim of this course is to introduce participants to the aim, operations and equipment involved in worsted top-making.

INFORM participants that by the end of this course they will be able to:

- describe in detail the key fibre properties important in top-making
- describe the role of the top-maker
- describe the operations that make up 'early-stage processing'
- describe the aims, functions and the operation of the machines used for converting scoured wool to top (carding, gilling, combing)
- outline the reasons for the sequence of operations used during top-making
- describe the components of cards, gills and combs and their function
- outline some of the latest developments in worsted carding
- describe the effect of processing conditions on top-making
- describe the quality attributes of the output material (top) and the role of quality assurance in the top-making process
- outline some of chemical treatments conducted on top.



NOTE: The sequence of the following information may differ from the actual presentation to allow for differences in venue and participant prior knowledge and experience.

EXPLAIN THAT this course takes an in-depth look at the worsted top-making process, its aims, the processes and equipment involved, and the factors affecting the final top characteristics and quality. It is easier to appreciate and understand the subsequent processing of worsted top, and the performance of the resulting knitted and woven wool products, if you understand the factors involved in early-stage worsted processing.

NOTE THAT this course:

- explores the role of the top-maker
- provides an overview early-stage processes of scouring and blending
- investigates the key worsted top-making operations, including:
    - carding
    - drawing and gilling
    - combing
- discusses key considerations during worsted top-making, including:
    - how the properties of the raw wool fibre impact on the final top characteristics
    - implications of the structure, physics and chemistry of the fibre, including:
        - quality assurance during the top-making process
        - top treatment.

MODULE 1

THE WOOLMARK COMPANY

THE ROLE OF THE TOP-MAKER

RESOURCES — MODULE 1: THE ROLE OF THE TOP-MAKER

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 1: The role of the top-maker**:

- sample of greasy (raw) samples
- sample of card waste

Additional resources to be sourced by the facilitator include:

- ruler

WELCOME participants to Module 1 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making —The role of the top-maker*.

***ASK** participants if they can describe what a top-maker does.*

***COLLECT** responses from two or three participants from across the room.*

***RECORD** responses on whiteboard or flip chart.*

NOTE: This module will review the participants' knowledge about the properties of the wool fibre and introduce the role of the top-maker. This will ensure all participants are at the same starting level of understanding and will confirm the use of any technical terms required during this course.

EXPLAIN THAT by the end of this module participants will be able to:

- describe in detail the key raw fibre properties important during top-making
- name and describe the key properties to specify raw wool for top-making
- name and describe the key specifications of top
- describe the role and aims of the top-maker.

RESOURCES REQUIRED FOR THS MODULE:

- *sample of raw wool*
- *ruler (facilitator to provide)*
- *sample of card waste with vegetable matter*

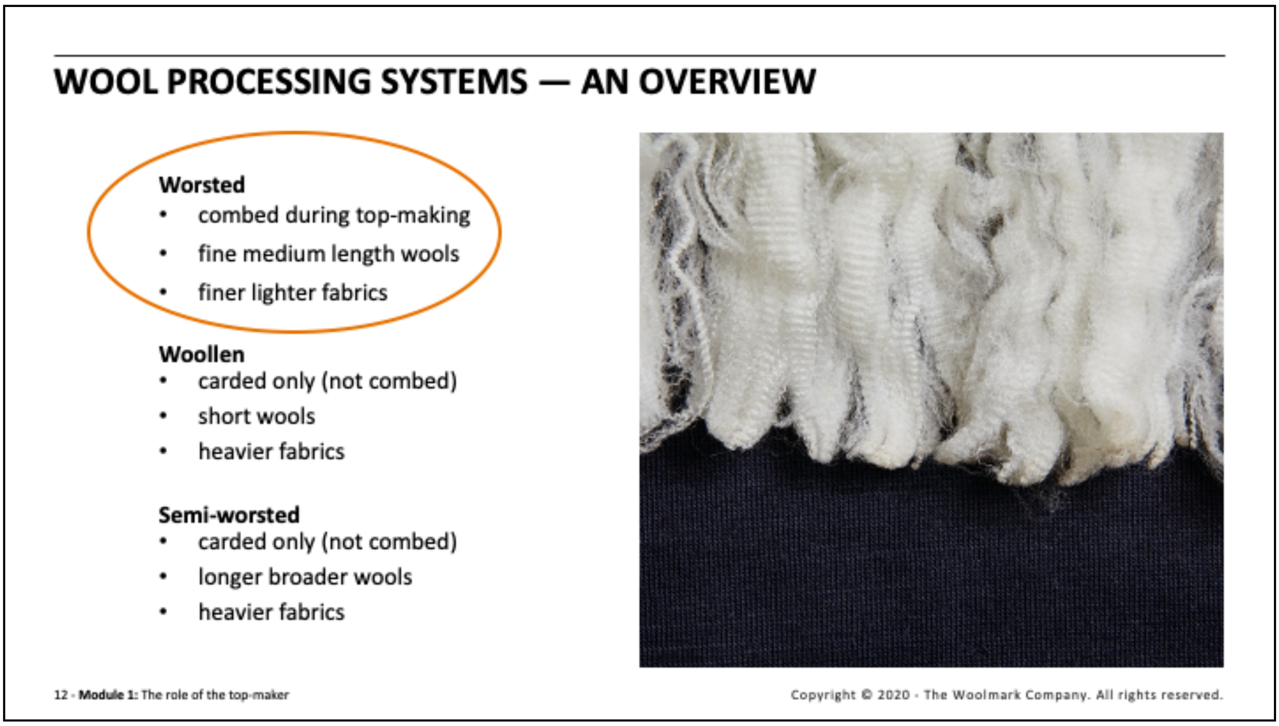
***BEFORE PROCEEDING** to the next slide, ask participants where they think the demand for wool comes from.*

***COLLECT** and acknowledge responses from two or three participants before proceeding to the next slide.*

INDICATE THAT the global market for wool products is driven by consumer demand and the fashion cycle.

- Fashion designers create wool garments to meet the ever-changing needs and desires of consumers.
- Textile manufacturers produce woven and knitted fabrics to meet the demands of fashion designers.
- Worsted and woollen spinners produce yarn that meets the needs of weavers and knitters.
- Top-makers process raw (greasy) wool fibre to meet the specifications required by worsted and woollen spinners.
- Woolgrowers use breeding (genetics) and management to produce a raw fibre that meets the specifications required to allow top-makers to deliver a product that, if handled effectively at each stage of the the wool supply chain, will meet the needs of consumers and maintain a strong long-term demand for wool.

EXPLAIN THAT this module will explore key raw fibre properties important for successful top-making, the key specifications of raw wool and worsted top, and the role of the top-maker in delivering a suitable product for the following stages of the wool supply chain.



INDICATE THAT as has been covered in an earlier course of Wool Science, Technology and Design Education Program — *Introduction to wool processing* — there are three routes by which raw wool can be processed into yarn for woven or knitted fabric production — worsted, woollen or semi-worsted processing.

The worsted process:

- uses fine long wools and is the subject of this course
- includes a combing operation, also referred to as 'top-making'. The combed material or 'top' is the feed stock for worsted yarn production.

The woollen process:

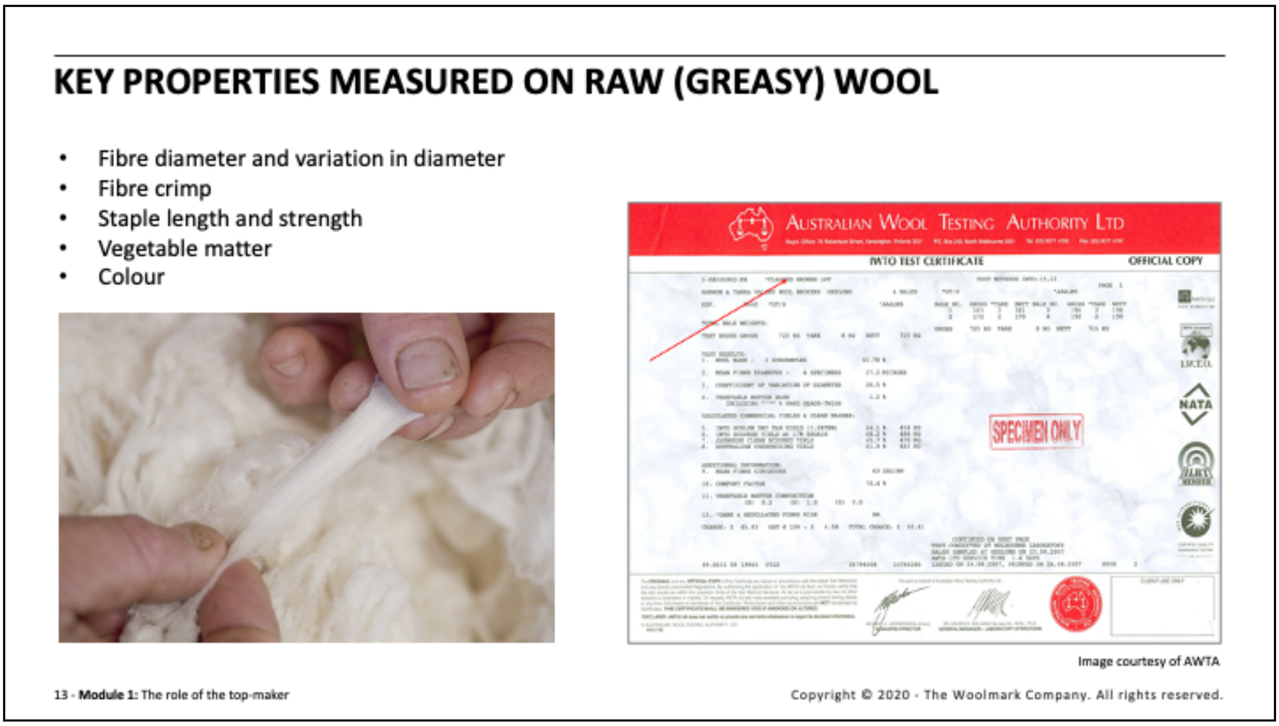
- is a flexible alternative method of yarn production
- is designed to process short wools, or with a slightly different design, long broad wools. The production of woollen yarn is the subject of another course of the Wool Science, Technology and Design Education Program— *Worsted and woollen spinning.*

The semi-worsted process:

- generally uses similar machinery to the worsted system, but combing is excluded
- is not a cheap alternative to worsted processing as semi-worsted yarns are different in character from worsted yarns.

REMIND participants that materials used in the semi-worsted system must be as clean as possible and virtually free of vegetable matter. Wools used in semi-worsted spinning are generally broad wools (e.g. those produced in New-Zealand and United Kingdom)

NOTE: Only the worsted process will be studied in this course.



EXPLAIN THAT the characteristics of the raw (greasy) fibre vary from one wool type to another. These characteristics determine the choice of processing route, the type of machinery used and ultimately the product manufactured.

EXPLAIN THAT for the top-maker, the key properties of interest in the raw fibre include:

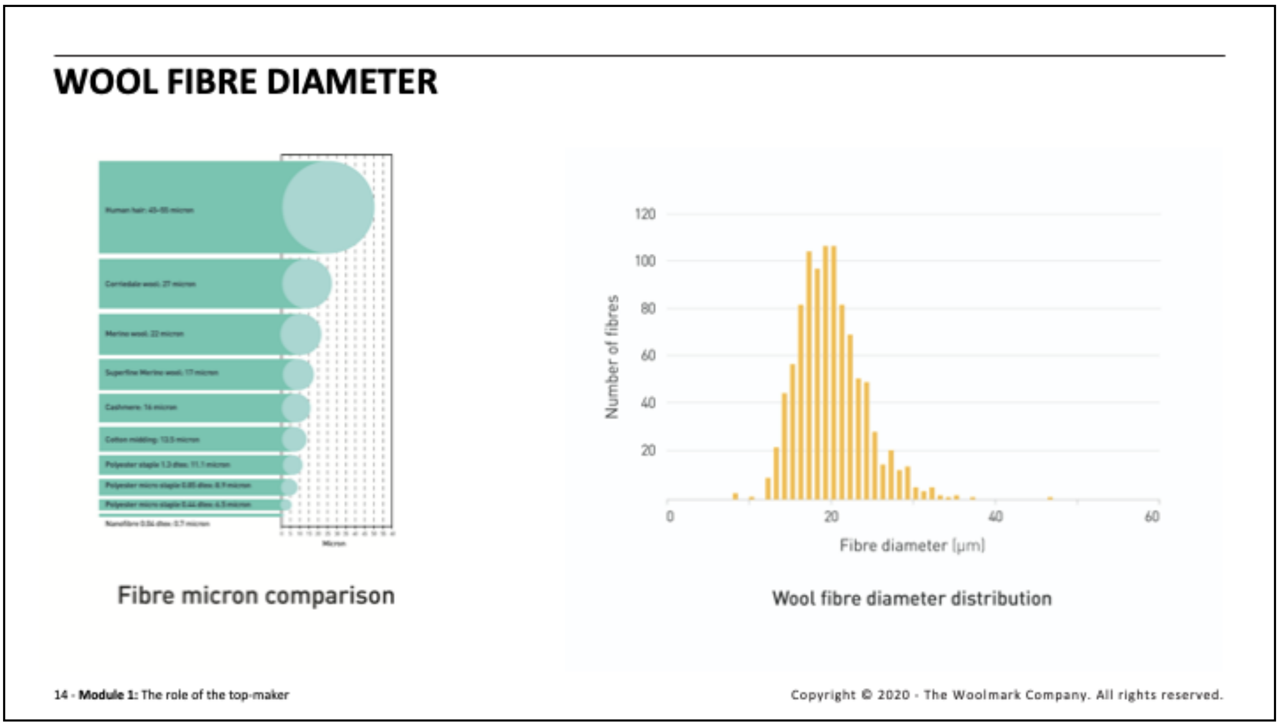
- mean fibre diameter (MFD)
- variation in fibre diameter (CVD)
- fibre crimp
- average staple length (SL)
- variation in staple length
- average staple strength
- variation in staple strength
- vegetable matter content (VM)
- colour.

The surface properties of the fibre (e.g. friction) also impact on processing and depend on the moisture content of the fibre.

EXPLAIN THAT in Australia, these properties are tested by the Australian Wool Testing Authority (AWTA) using International Wool Textile Organization (IWTO) standard methods for sampling and testing. Other global testing organisations include the New Zealand Wool Testing Authority (NZWTA) and the Wool Testing Bureau South Africa (WTBSA).

INDICATE THAT the results of the tests carried out by the AWTA are issued on a certificate like the one shown on the slide.

EXPLAIN to participants that we will briefly recap the key points about each of these above fibre characteristics in the following slides. The objective measurement of raw wool is the covered in detail in the Wool Science, Technology and Design Education Program course *Introduction to wool processing*.



INDICATE THAT fibre diameter is the most important fibre property as it determines:

- the fineness of the yarns that can be spun from a particular wool
- the final weight of a fabric.

NOTE THAT fibre diameter is also a major contributor to the softness and handle of a wool product or garment.

EXPLAIN THAT the major drivers for wool to become finer, which has influenced breeding programs across Australia, are:

- the trend for lighter-weight fabrics in garments
- an increasing trend for softness and next-to-skin garments
- the move to higher processing speeds and an associated demand for higher labour productivity.

NOTE: Not all fibres have the same diameter even on a single sheep. Within every fleece (and every sale lot) there will be a variety of fibre diameters as illustrated by the graph on the right-hand side of the slide. The size of the variation is important in processing.

EXPLAIN THAT crimp refers to the undulations or waves that appear along the wool fibre. Crimp frequency is normally measured:

- subjectively (i.e. visually)
- in crimps per centimetre.

Crimp can also be measured as fibre curvature, as an additional measured when determining fibre diameter characteristics, using Laserscan or OFDA.

NOTE: Crimp is most commonly observed in fine wool.

INDICATE THAT crimp levels impact the final product. For the same fibre diameter, higher-crimp wools :

- improve top yield
- produce bulkier yarns (favoured for knitted products) and fabrics
- form yarns that are less smooth than low-crimp wool in woven products
- entangle more during processing
- result in lower pilling in the final fabric, because the fibres interact more with each other
- tend to shrink a little more in fabric relaxation tests.

STAPLE LENGTH AND VARIATION IN LENGTH

Staple length is measured in raw wool and recorded on the AWTA certificate

16 - **Module 1:** The role of the top-maker

EXPLAIN TO participants that as with fibre diameter, in a single consignment of wool, fibre length (measured as staple length in raw wool) varies from a minimum to a maximum, so the definition of length is not straight forward.

INDICATE THAT staple length is measured in raw wool with the ATLAS staple length and strength tester and is recorded on the AWTA certificate.

NOTE THAT staple length influences the average fibre length of the wool after processing.

DEMONSTRATION: STAPLE LENGTH

Resources required:

- *sample of greasy (raw) wool*
- *ruler*

SHOW *participants a greasy wool staple and measure its length using a ruler.*

EXPLAIN THAT the influence of fibre length in processing and product manufacture can be summarised as follows:

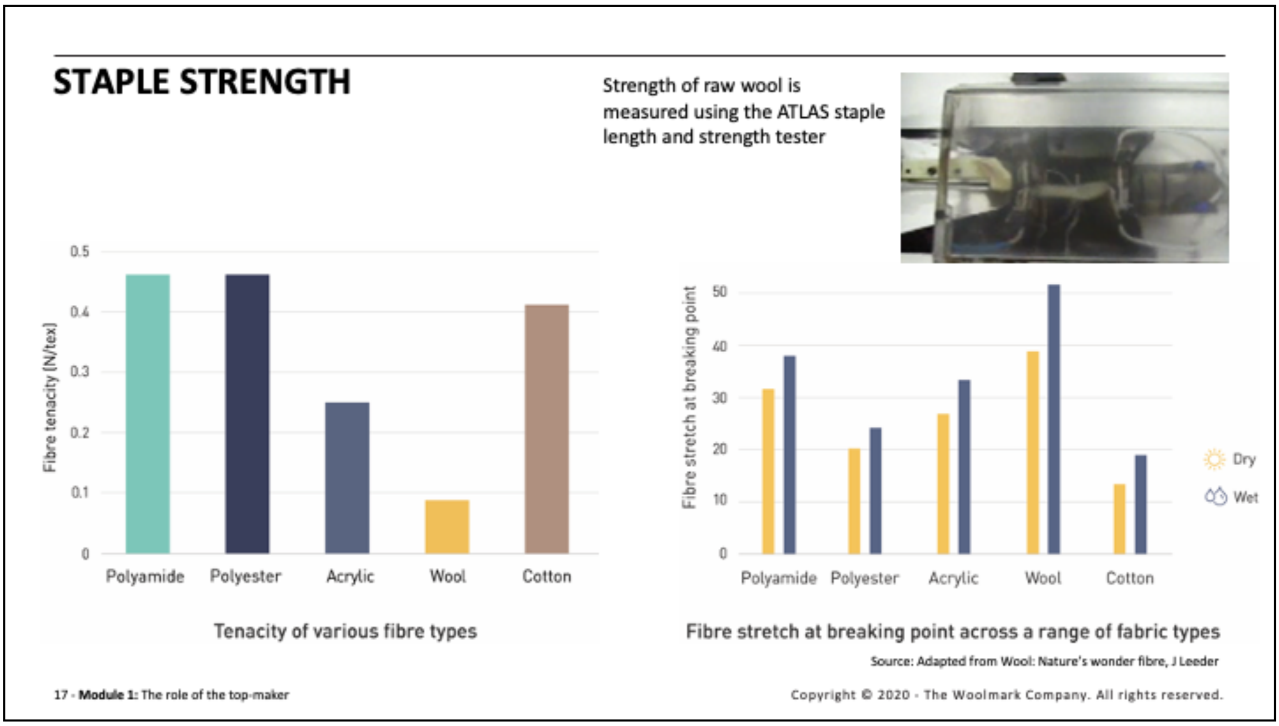
- An increase in length generally improves worsted yarn tensile properties, the effect being more marked for shorter-length wools.
- An increase in fibre length reduces the short-term irregularity of the yarn, again the effect decreases as the fibre length increases.
- Longer fibres lead to substantially fewer yarn breaks in spinning. This will be discussed in later modules. Results indicate the improvement continues out to at least 90mm of fibre length.

NOTE THAT recent research in this field, (1996 – 2003) has indicated that an increase in 10mm of average fibre length is equivalent to:

- a 10% reduction in twist
- a 7% increase in spinning speed

EXPLAIN THAT longer wool can give the user the ability to use a more cost-effective (e.g. 1µm broader) wool.
An increase in fibre length also greatly reduces the number of yarn faults that have to be removed during winding (after spinning) and generally reduces yarn 'hairiness'.

EXPLAIN further, the longer the fibre the better security the fibre will have in the yarn (more anchoring points), which reduces the tendency in the fabric to 'face up', which eventually leads to pilling.



INDICATE THAT staple strength is also a key measurement made on raw wool with the ATLAS staple length and strength tester (see image on right) and is recorded on the AWTA certificate.

POINT OUT that as seen in the illustrations on the left, wool is not as strong as many other fibres, but has a high extension to break, particularly when wet.

EXPLAIN THAT staple strength affects the breakage of fibres during processing and thus the length characteristics of the final top.

DEMONSTRATION: STAPLE STRENGTH

Resources required:

- *sample of greasy (raw) wool*

***ASK FOR** a volunteer to help demonstrate staple strength.*

***GIVE THE** sample of greasy wool to the volunteer and ask them to try and break it while describing the level of effort required.*

VEGETABLE MATTER

Vegetable matter depends on

- type of sheep
- type of pasture
- type of wool (fleece, skirtings etc)

Types include

- seeds, shive, burrs
- skin pieces

Impact of processing

- reduced yield – Increased waste
- reduced processing efficiency

Vegetable matter includes seeds, shive and burrs

18 - **Module 1:** The role of the top-maker

NOTE THAT vegetable matter (plant material) in wool is a problem; its removal during processing can be costly.

DEMONSTRATION: VEGETABLE MATTER

Resources required:

- *card waste with significant levels of vegetable matter*

SHOW *participants the vegetable matter in card waste.*

ASK *participants if they can identify any of the vegetable matter components.*

ACKNOWLEDGE *responses before proceeding.*

INDICATE THAT vegetable matter depends on:

- type of sheep
- type of pasture
- type of wool (fleece, skirtings etc).

EXPLAIN THAT vegetable matter content can vary by:

- type — some types of vegetable matter (e.g. burrs) are harder to remove than others
- quantity — the more vegetable matter, the lower the value of wool.

EXPLAIN THAT examples of vegetable matter commonly found in raw wool include:

- plant seeds and shive
- hard heads and twigs
- spiral burr
- pieces of skin
- other organic materials.

COLOUR

Measured using

- CIE tristimulus values (X, Y, and Z)
- under a D65/10 illuminant.

The inherent colour of wool can be:

- white (Y-Z ~ 7)
- creamy
- yellow (Y-Z ~ 14)

Base colour of raw wool is measured

- on core samples
- after a standard scour.

The yellowness of wool is specified as Y–Z

Image Courtesy of AWTA Ltd

19 - **Module 1:** The role of the top-maker

EXPLAIN THAT greasy colour is important to processors as only white product can be dyed to pastel shades, whereas off-coloured wool is restricted to darker colours. There generally is a price premium for whiter wools.

INDICATE THAT the colour of raw wool can be influenced by climate (high rainfall and humidity levels), diet, animal health and external parasites. The colour of wool is determined by its inherent colour as well as by the presence of dirt, wool wax, suint and other impurities.

EXPLAIN THAT the colour of raw wool may be measured as-is or, more often, the base colour of raw wool is measured after the specimen has been scoured under prescribed conditions and carded to remove as much contamination as possible.

NOTE: Wool colour is measured spectrophotometrically.

INDICATE THAT the colour is specified using CIE tristimulus values (X, Y, and Z) under a D65/10 illuminant. The yellowness is specified as Y-Z.

- Very white = 7
- White = 9
- Creamy = 11

EXPLAIN THAT the major steps in the conversion of raw wool to worsted top are:

- Purchase of a selection of raw wool sale lots
- Processing batch preparation (compilation of a suitable number and type of sale lots)
- Opening — to break up the clumps of wool into a more fibrous form.
- Scouring — to remove dirt, grease and suint salts while minimising any entangling of the fibres.
- Blending — to mix the various components of the batch before and/or after scouring
- Carding — to disentangle and align fibres, while partially removing any vegetable matter (VM) contamination.
- Gilling — to better align the fibres and help mix and further blend the wool.
- Combing — to straighten and align the fibres, remove short fibres along with neps (small fibre entanglements), and remove any remaining vegetable matter.
- Finisher gilling — the combed sliver is gilled twice more to better align the fibres in the sliver and produce a final sliver ready for spinning.

INDICATE THAT subsequent modules in this course will discuss carding, gilling and combing in detail.

NOTE: the final product is known as combed top.

The operation of scouring is covered in detail in the Wool Science, Technology and Design Education Program course *Raw wool scouring.*

SPECIFICATION OF THE TOP

Dependent on raw wool properties and processing

- Fibre diameter (average and variation — CVD)
- Fibre length (hauteur and barbe)
  - variation in fibre length (%)
  - tolerance — % fibres < say 30mm
- Vegetable matter (and straw)
  - frequency and size per 100g
- Solvent extractable material
- Color — Y-Z

Dependent on processing

- Sliver weight (average and variation along the sliver — Uster CV%)
- Total fatty matter (%)
- Neps – frequency and size per 100g
- Moisture content (regain) (%)
- Fibre modification (e.g. felt-resist finish)

There are tolerance levels for each of the specifications listed.

21 - **Module 1:** The role of the top-maker

EXPLAIN THAT the 'top' is the feedstock the spinner uses to produce a yarn that meets the specifications of the knitter or weaver. As such, the spinner generates a top specification to ensure they source top that meets the technical specifications of the next stage of production at a reasonable cost to their business.

INDICATE THAT the number of top properties the spinner must consider is reasonably wide and are listed on the slide:

- fibre diameter — both average fibre diameter and variation in fibre diameter (CVD)
- fibre length — this includes average fibre length, variation in length (CVH and/or CVB) and maximum or minimum tolerances (this may vary with the spinner).
- vegetable matter and straw — frequency and size per 100g
- solvent extractable material
- colour — Y-Z
- sliver weight — measured in grams per metre (g/m)
- regularity of mass — the variation of weight along the sliver (Uster CV%)
- total fatty matter — measured as a percentage (%)
- neps — frequency and size per 100g
- moisture content (regain) — measured as a percentage (%)
- fibre modification — for example felt-resist treatment.

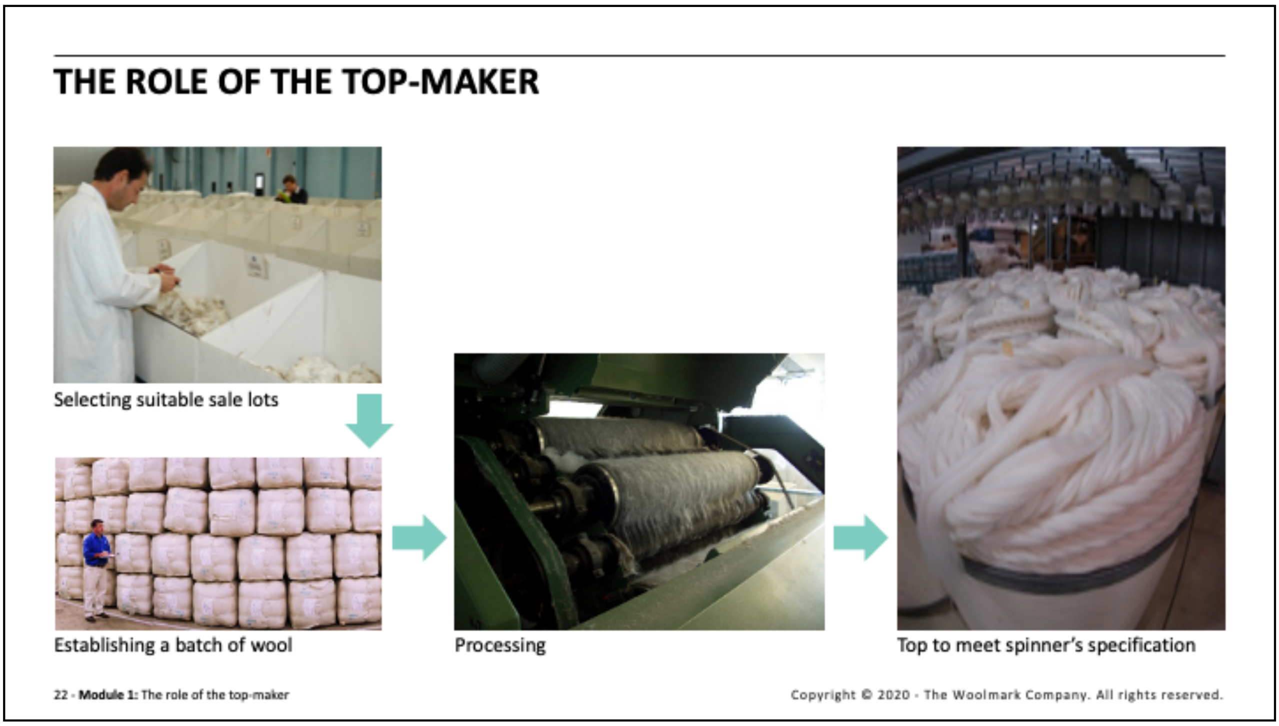
EXPLAIN THAT the top-maker is responsible for delivering a top that meets the specifications set out by the spinner, which greatly affects their choice of raw wool.

Definitions

Hauteur is the average (or mean) length of the fibres determined from the total length and number of the fibres in the sample.

The coefficient of variation of fibre length based on the hauteur measurement is represented as CVH as a percentage.

Barbe is the mean fibre length of the fibres determined from the length *and weight* of the fibres in the sample. The coefficient of variation of fibre length based on the barbe measurement is represented as CVB as a percentage.



EXPLAIN THAT the 'top-maker' is the person whose role it is to purchase sale lots of raw (greasy) wool to establish a 'processing batch' of wool that, when converted to combed top, will meet the specifications set down by the spinner.

NOTE THAT the term 'blend engineering' is sometimes applied to the process of choosing a selection of suitable sale lots — engineering the properties of the raw wool blend to meet the specifications of the top.

INDICATE THAT in this context the top-maker may:

- be the wool buyer
- be the wool 'processor' (or comber)
- be the wool exporter
- be an agent who sources and exports the raw wool, which is subsequently converted to top under commission by the comber.
- commission a processor to undertake the top-making role in whole or in part.

THE OBJECTIVES OF THE TOP-MAKER

The overall objectives of the top-maker are:

- quality – to meet the customer's requirements
- price – to meet the customer's price
- profitability – to produce the best product for the lowest price.

Plant	Reduction of 1% romaine	Plant efficiency (%)	Product value (USD)	Potential gain (USD/year)
Greasy to top (1000kg/hr)	+10kg/hr	80	8.00 (10.00 – 2.00)	0.67M
Vertical – greasy to fabric (350kg/hr)	+3.5kg/hr	70	15/linear metre (3m/kg)	1.32M

23 - **Module 1:** The role of the top-maker

EXPLAIN THAT it is the responsibility of the top-maker to accept and manage the financial risk associated with combining a range of sale lots of raw wool into a larger batch that meets the top specifications.

NOTE THAT in establishing a suitable batch of wool, the top-maker must consider:

- the characteristics of the raw fibre that will impact the top specifications set by the spinner (which will be covered shortly)
- the issues of physically blending sale lots (which will be covered in the next module)
- uniformity of supply (year-round continuity)
- costs associated with buying the raw raw material and those associated with the top-making process.

Keeping these considerations in mind the overall objectives of the top-maker are:

- quality – to meet the customer's requirements
- price – to meet the customer's price
- profitability – to produce the best product for the lowest price.

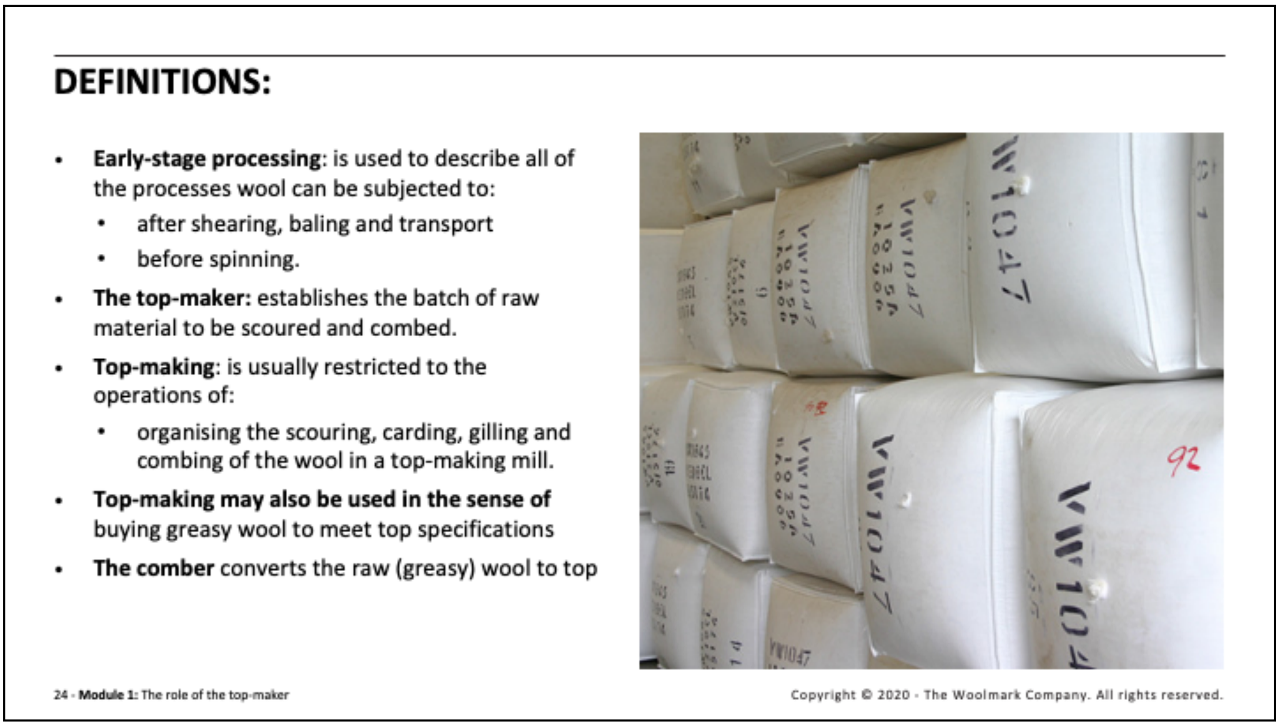
EXPLAIN THAT to make a profit, the top-maker must select wool required to meet the specifications of the particular top at minimum cost. An experienced and skilled 'top-maker' can save (or lose) a considerable sum of money by the decisions they make.

EXPLAIN THAT for example, a reduction in the romaine (a form of waste) associated with the production of a specific top can result in the difference of many thousands of dollars in the ultimate value of the top as outlined in the table on the slide.

- In a factory processing greasy wool to top, the correct choice of raw wool can affect the wastage in processing. As shown in the table on the slide, for a factory processing 1000kg/hr, the gain from a 1% saving in waste (romaine) (i.e. 10kg/hr) can be as high as US~0.67M per year.
- For a vertical plant processing raw wool to garment the saving is even higher (more than US1M per year).

Consequently**,** to be a successful top-maker it is vital to have a sound understanding of the consequences of optimised processing practises in early-stage processes.

INDICATE THAT the following course aims to present a better understanding of the technical variables the top-maker can control to increase profit of the business, starting with the establishment of a batch of raw wool with suitable fibre characteristics.



INDICATE THAT understanding the following definitions and terminology will be useful in understanding the processes involved in early-stage processing and top-making.

The term 'early-stage processing' is used to describe all of the processes wool can be subjected to:

- after shearing, baling and transport
- before spinning.

The term 'top-maker' is applied to the person whose role is to establish a batch of raw wool which, when converted to combed top, will meet the specifications required by the spinner.

The term top-making is used in two ways:

- Top-making can be used to describe the conversion of raw wool to top, usually restricted to the operations of organising the scouring, blending, carding, gilling and combing of the wool in a top-making mill.
- Top-making can also be used to describe buying greasy wool to meet top specifications.

NOTE: The term 'comber' is also sometimes applied to the mill that converts the greasy wool to top.

SUMMARY — MODULE 1

The aim of top-making is to convert raw wool into a specified top ready for yarn production

Key measured fibre properties:

- fibre diameter and variation in diameter
- fibre crimp
- staple length and variation in length
- staple strength and variation in strength
- colour.

Fibre surface properties (e.g. friction) also impact on top-making.

Key specifications of top

- fibre diameter
- fibre length
- vegetable matter and straw
- colour
- sliver weight
- regularity of mass
- total fatty matter
- neps
- moisture content (regain)
- fibre modification.

The role of *the top-maker is to obtain suitable sale lots to process that will result on a top meeting the customer specification while sustaining a profitable top-making business.*

25 - **Module 1:** The role of the top-maker

EXPLAIN THAT the overall aim of top-making is to convert an assembly of greasy wool sale lots (in bales) into combed wool or top to meet a required set of spinner specifications for a price. Blend engineering, with specification and price in mind, is a key objective of the top-maker.

NOTE the key fibre properties for raw wool important for specification and in top-making

- fibre diameter and variation in diameter
- fibre crimp
- staple length and variation in length
- staple strength and variation in strength
- colour.

These raw fibre properties are measured by global wool testing authorities such as AWTA, NZWTA, SAWTA.

INDICATE THAT the surface properties of the fibre (e.g. friction) also impact on processing and depend on the moisture content of the fibre.

EXPLAIN THAT the operations that make up ‘early stage processing’ and ‘top-making’ are:

- opening
- scouring
- blending
- gilling
- combing.

Carding, gilling and combing will be discussed in detail in this course.

EXPLAIN THAT the number of top properties the spinner must consider is reasonably wide, including:

- fibre diameter — both average fibre diameter and variation in fibre diameter (CVD)
- fibre length — this includes average fibre length, variation in length (CVH and/or CVB) and maximum or minimum tolerances (this may vary with the spinner).
- vegetable matter and straw — frequency and size per 100g
- colour — Y-Z
- sliver weight — measured in grams per metre (g/m)
- regularity of mass — the variation of weight along the sliver (Uster CV%)
- total fatty matter — measured as a percentage (%)
- neps — frequency and size per 100g
- moisture content (regain) — measured as a percentage (%)
- fibre modification — for example felt-resist treatment.

NOTE THAT the role of the top-maker is vitally important in the wool manufacturing pipeline.

INFORM participants of the time and location for the next lecture in the *Worsted top-making* course — *Module 2: Early-stage processes in top-making*— and ensure they read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

MODULE 2

EARLY-STAGE PROCESSES IN TOP-MAKING

RESOURCES — MODULE 2: EARLY-STAGE PROCESSES IN TOP-MAKING

No additional resources are required to deliver **Module 2: Early-stage processes in top-making**.

WELCOME participants to Module 2 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making —Early stage processes in top-making*.

EXPLAIN THAT this module will review participants' knowledge about the wool fibre and the early-stage processes that occur before the operations of carding, gilling and combing to bring all participants to the same starting level of knowledge and confirm the use of any technical terms required.

INDICATE THAT by the end of this module participants will be able to:

- describe the operations that make up the 'early-stage processes' in top-making
- explain the aims of blending and its impact on the final top
- explain the aims of scouring and its impact on the final top.

NO RESOURCES REQUIRED

NOTE TO FACILITATOR: *The following slide is animated.*

BEFORE *revealing the next slide, ask participants to indicate whether they have studied the Woolmark Wool Science, Technology and Design Education Program course* Raw wool scouring.

ACKNOWLEDGE *responses.*

REINFORCE THAT there are three important early-stage processes carried out at the start of 'top-making' before the wool enters the carding and combing processes — blending, opening and scouring.

ASK *participants who have completed* Raw wool scouring *to explain the process of blending.*

ALLOW *participants sufficient time to respond before proceeding to the next slide and revealing the answer.*

EARLY-STAGE PROCESSES

Blending:

- Mixing of the components of the blend.

Opening:

- Breaking the mass of wool into a fibrous form.
- Opening the staples of wool into a fibrous form.

Scouring:

- Washing wool in a detergent solution.
- Rinsing the fibres.
- Drying the clean wool.

2 - **Module 2:** Early-stage processes in top-making

REINFORCE THAT blending involves mixing of the components of the blend.

ASK *participants who have completed* Raw wool scouring *to explain the process of opening.*

ALLOW *participants sufficient time to respond before revealing the answer.*

REINFORCE THAT opening involves:

- breaking the mass of wool into a fibrous form
- opening the staples of wool into a fibrous form.

ASK *participants who have completed* Raw wool scouring *to explain the process of scouring.*

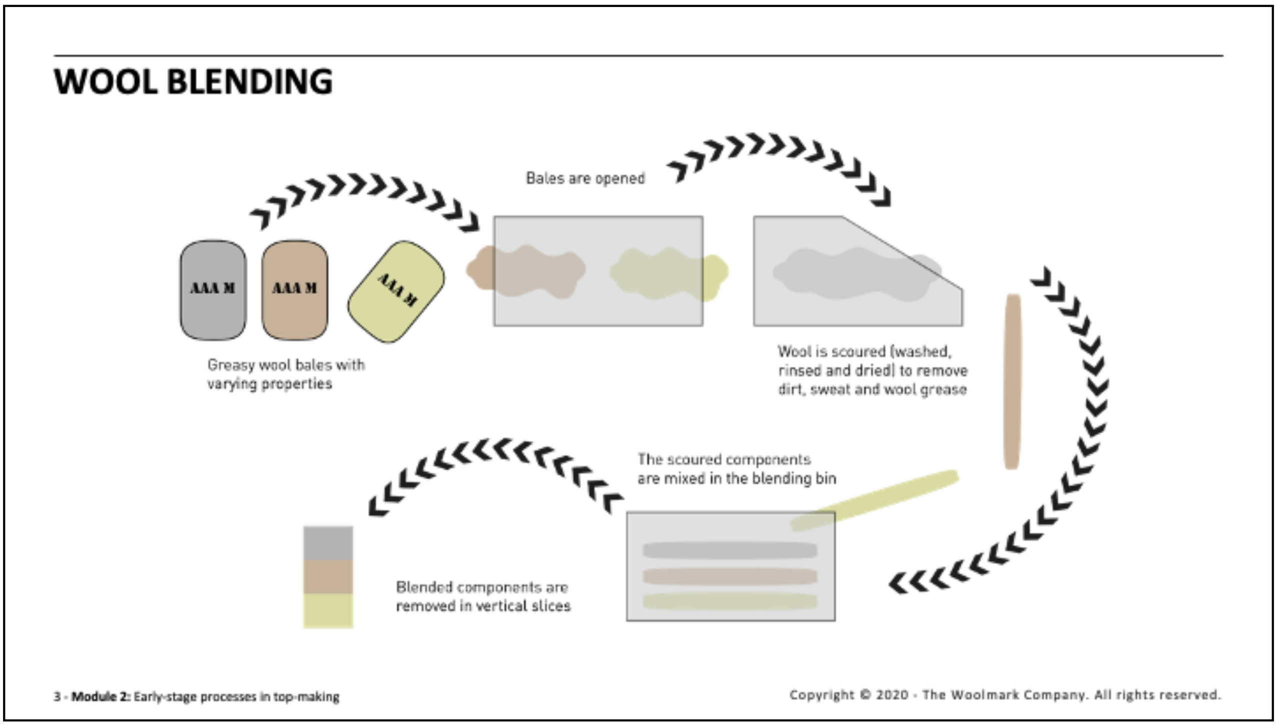
ALLOW *participants sufficient time to respond before revealing the answer.*

REINFORCE THAT scouring involves:

- washing wool in a detergent solution
- rinsing the fibres
- drying the clean wool.

NOTE THAT each process can affect the success of any subsequent top-making operation.

INDICATE THAT the details of these topics are not directly part of this course but are covered in detail in other courses in the Wool Science, Technology and Design Education Program.



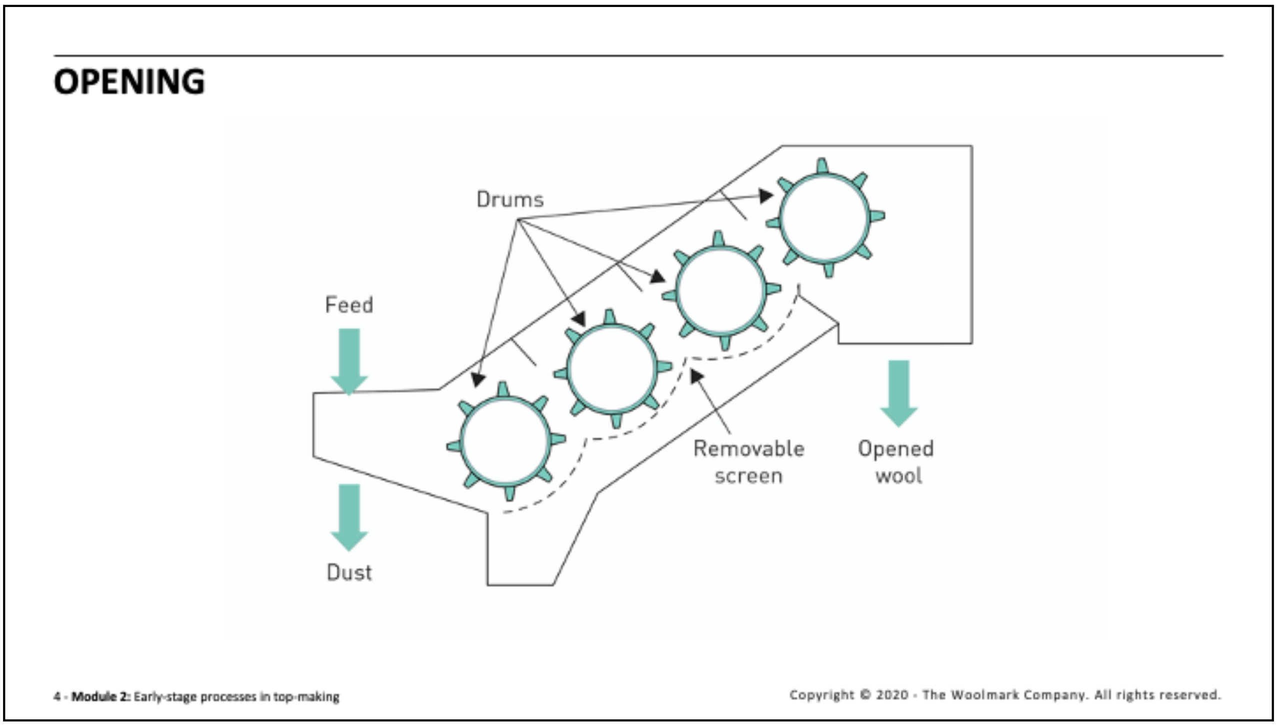
EXPLAIN THAT the aim of blending is to ensure the resultant top is as even and uniform as possible across all characteristics throughout its entire length.

INDICATE THAT blending can occur at several points during early-stage processing.

EXPLAIN THAT consignments, in bales of greasy wool assembled for scouring, are arranged in order so the component lots are randomised before the bales are opened.

NOTE THAT the bales are fed to the opening line with the homogeneity of final top properties in mind. The bales are opened in a bale-breaker. This is usually followed by more opening, such as double drum machines, to break the wool into approximately staple courses and remove some of the dirt. Many opening machines are also designed to ensure some mixing of the components of the blend.

EXPLAIN THAT most commonly the entire lot is re-blended as a course in scoured form in a blending bin. The output of the scour is loaded into the bin in horizontal layers and then removed in vertical slices.



INDICATE THAT bales of wool are often dumped or compressed for transport. This compacts the wool and makes separation into tufts more difficult.

EXPLAIN THAT the opening machine starts the process of opening the tufts of wool that have been removed from the bales so the wool may be more evenly scoured.

NOTE THAT opening of superfine wool, (which has been stored at farm bale densities), during greasy blending or scoured wool blending, should be kept to a minimum to reduce the risk of entanglement in the scour or during further processing.

ASK *participants to explain what happens during the scouring process.*

IF NECESSARY *reinforce that scouring involves removing some of the contaminants from raw wool by:*

- *washing wool in a detergent solution*
- *rinsing the fibres*
- *drying the clean wool.*

ASK *participants to explain the outcomes of scouring that can affect top making.*

ACKNOWLEDGE *responses before moving to the next slide.*

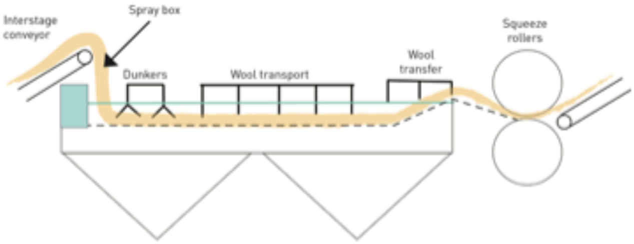
SCOURING

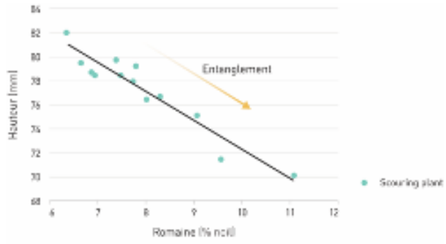
Raw wool is scoured to remove:

- dirt
- wool wax
- salts from suint (sweat)
- non-wool protein material
- skin pieces.

Scouring involves:

- washing wool in a detergent solution
- rinsing the fibres
- drying the clean wool.





Scouring plant comparison

5 - **Module 2:** Early-stage processes in top-making

EXPLAIN THAT scouring is designed to remove of some of the contaminants from raw wool including:

- dirt
- wool wax
- salts from suint (sweat)
- non-wool protein material
- skin pieces.

REINFORCE THAT scouring involves:

- washing wool in a detergent solution
- rinsing the fibres
- drying the clean wool.

MENTION THAT the scouring process affects subsequent processes and the properties of the resultant top.

EXPLAIN THAT the four main features of scoured wool that affect its subsequent processing performance are the:

- extent of fibre entanglement
- moisture content of the fibre
- pH of the fibre
- levels of residual contaminants (dirt and grease) remaining in the wool batch.

INDICATE THAT fibre entanglement during scouring increases fibre breakage in subsequent processing stages and the fibre length of resultant top as well as the production of waste. The threat of entanglement starts as wool enters the first scouring bowl and continues until it is held in a relatively immobile state in the dryer.

EXPLAIN THAT as outlined in the course on scouring, the method of feeding the wool to each bowl, dunkers, the transport mechanism in the bowls, the way in which the wool flows out of each bowl, the means used to assist this, the squeeze rollers, the conveyors between the bowls, and, if present, the wet opening process, all potentially contribute to fibre entanglement.

A number of effective scouring systems have been developed to clean wool without excessive entanglement. These are described in the Wool Science, Technology and Design Education Program course *Raw wool scouring*.

NOTE THAT it is essential the scouring, carding and combing plants work together to optimise manufacturing outcomes.

REFER participants to the diagram on the right, which shows the results for 13 different scouring plants processing the same greasy wool. All scoured products were carded and combed on the same machinery in the one plant. The results highlight the range of practises existing across the wool processing industry and the colossal lost production of usable wool that exists within the industry.

TESTING OF SCOURED WOOL

IWTO tests for scoured wool include:

- Oven dry mass — moisture content (IWTO-33, 41, DTM-63)
- Residual fatty matter (IWTO-10, 43, DTM-61)
- Diameter distribution characteristics (IWTO-08, 12, 28, 27)
- Colour (IWTO-56)

6 - **Module 2:** Early-stage processes in top-making

EXPLAIN THAT after some form of initial scouring a number of objective tests are carried out on scoured wool while it is still in fibre form. This is common where the top-maker commissions the wool to be scoured by another organisation. These tests provide a form of quality control on scouring and ensure the wool can be processed to meet the top specifications set at the start of the process.

INDICATE THAT the tests carried out at this stage of processing are used to determine:

- the moisture content and oven dry mass of the wool in the consignment
- the amount of non-wool residuals on the fibres (i.e. residual contaminants)
- the fibre diameter characteristics of the scoured fibre
- the colour as a measure of cleaning and yellowing of the fibre during scouring.

NOTE THAT scouring performance is often assessed using the solvent extractables and/or colour as a measure.

Fibre diameter is measured using the same methods as for greasy wool:

- projection microscope
- airflow
- Laserscan
- OFDA.

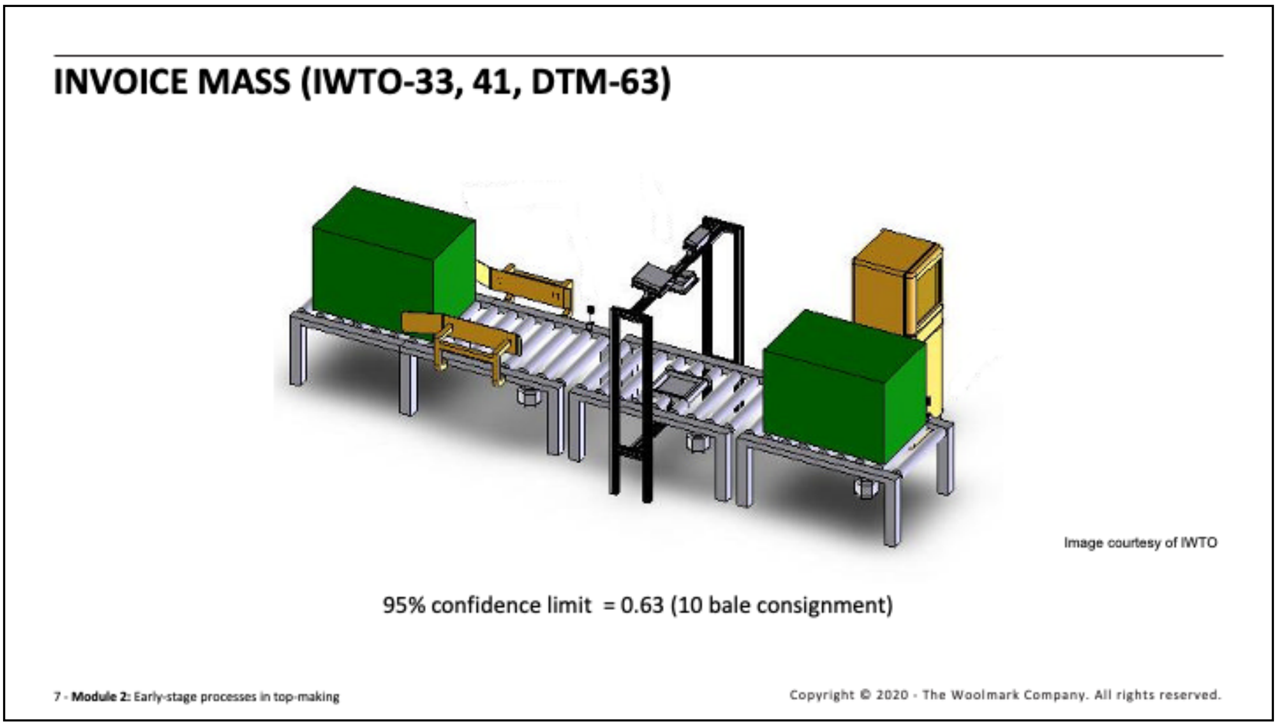
EXPLAIN THAT no pre-scouring of the sample is required, except where the base colour of the fibre is to be measured.

These tests were covered fully in the Wool Science, Technology and Design Education Program course *Introduction to wool processing* and *Raw wool scouring*.

Colour measurement of raw and scoured wool is also described in the Wool Science, Technology and Design Education Program course *Introduction to wool processing*.

NOTE: IWTO regulations for testing scoured wool apply to:

- weighing the lot
- sampling
- determining oven dry mass (IWTO-33)
- condition testing.



EXPLAIN THAT following are the three methods published by International Wool Textile Organisation (IWTO) for measuring oven dry mass (and thus moisture content) of the scoured wool consignment.

Invoice mass (also referred to as oven dry mass) (IWTO-33)
This relatively simple method involves:
- determining the mass of the consignment of wool
- core sampling the consignment (>500g)
- determining the mass of the sample
- weighing and then drying a specimen at 105ºC until 'oven dry' to determine the moisture content
- determining the oven dry mass of the lot from the average moisture content of the specimens.

Invoice mass (IWTO-41) capacitance method
This method uses a capacitance measuring system to determine the moisture content of the wool in a bale.
- Each bale in the lot can be tested.
- The method must be calibrated against IWTO-33.
- The measured between-laboratory variance is 0.152%.

Malcam microwave method (DTM-63)
This test uses the difference in the adsorption of microwaves by wool (~0.001) and water (0.5) to measure the moisture content of scoured wool while still in the bale (where the wool has been re-baled after scouring).
- Malcam's MMA-2020 system is used.
- The method must be calibrated against IWTO-33.
- The calibration is sensitive to the form in which the wool is packed.
- Malcam claims the system can be used to measure the moisture in wool bales online.

RESIDUAL FATTY MATTER (IWTO-10, DTM-43, DTM-61)

IWTO-10
- Scoured wool
- Combed top
- Using extraction with dichlormethane

DTM-43
- Scoured wool
- Sliver (top)
- Using NIR

DTM-61
- Using petroleum ether

Near Infrared spectrophotometer

Image courtesy of B and W Tek (USA)

8 - **Module 2:** Early-stage processes in top-making

INDICATE THAT following are the three methods commonly used to measure residual fatty matter of the scoured wool consignment.

EXPLAIN THAT after scouring, wool can contain residual or trace amounts of materials, which can affect the subsequent processing of the wool, such as:
- wool wax
- suint
- dirt
- non-wool proteins
- faecal matter and urine
- detergent (used in scouring)
- salts used as builders or water conditioners in scouring.

EXPLAIN THAT the following three methods are used to measure residual fatty matter in scoured wool:

Extraction with dichloromethane (IWTO-10)
All the materials listed above cannot be extracted by a single solvent. Dichloromethane is used to extract wool wax, other fatty materials and many detergents in the wool.

This test is widely applied as a quality control tool in scouring to determine:
- effectiveness of scouring
- effectiveness of rinsing.

A Soxhlet extract of an oven-dried (at 150^{o}C) wool specimen is conducted for at least 10 siphonings over 90 minutes. The extracted matter is weighed after evaporation of the solvent at 106^{o}C.

Near Infra-red method (DTM-43)
This method is calibrated against extraction with dichloromethane using regression techniques.

DTM-61
Where dichloromethane cannot be used for health and safety reasons, petroleum ether can be used (DTM-61).This solvent is highly flammable and must be used with care.

BALING OF SCOURED WOOL

- Storing to 12mths reduces fibre length (hauteur) by 2–3mm.
- Bi-axial pressing worse than mono-axial pressing.
- Packing density has little effect on fibre length after processing.
- Regain during pressing not significant.
- Losses are negated if scoured wool is relaxed above its glass transition temperature (Tg).

Image courtesy of CSIRO (Australia)

9 - **Module 2:** Early-stage processes in top-making

EXPLAIN THAT scoured wool is often stored in bales for varying lengths of time — from a few days to several months. Long-term storage can impact on the ultimate fibre length of the fibres after processing.

NOTE THAT storing for 12 months reduces fibre length by 2–3mm.

EXPLAIN THAT bi-axial pressing (pressing bales in two different directions) is worse than mono-axial pressing (pressing in one direction) in encouraging fibre entanglement. Packing density has little effect on fibre length.

MENTION THAT the moisture content (regain) during pressing does not affect subsequent processing.

INDICATE THAT losses in fibre length are negated if scoured wool is 'relaxed' in steam before further processing.

ASK *participants to describe what is meant by the term 'relaxed'.*

ALLOW *participants sufficient time to respond before proceeding.*

REINFORCE THAT 'relaxation' is the term used to describe the recovery of deformation in previously strained material. As discussed in the Wool Science, Technology and Design Education Program course *Wool fibre science,* relaxation occurs more rapidly above the glass transition temperature (Tg) of the fibre. The glass transition temperature is the temperature at which polymeric materials, such as wool, soften more rapidly. The glass transition temperature of wool is reduced as moisture content (regain) increases.

BALING SCOURED WOOL:
TENSILE PROPERTIES OF CREASED WOOL BUNDLES

	BREAKING TENACITY (cN/tex)	BUNDLE MASS RATIO
Not creased	1.75	1.05
Creased (48 hours)	1.56	0.68
Creased (42 days)	1.38	
Creased (42 days) — relaxed in steam	1.67	

10 - **Module 2:** Early-stage processes in top-making

INDICATE THAT the impact of bale pressing and storage can be simulated by creasing the wool fibres

EXPLAIN THAT creasing the wool fibre significantly reduces fibre bundle tenacity (force to break a fibre bundle divided by the bundle weight per course length).

NOTE THAT the position of the break shifts in sympathy with the presence of the crease. This demonstrates that wool fibres are weakened due to the presence of deformation, which has been temporarily set into the fibre. This weakening occurs almost immediately – within 48 hours – and continues to deteriorate with time.

EXPLAIN THAT this is the most likely reason for the loss of fibre strength due to extended storage of wool in bales especially fine wool.

INDICATE THAT the loss in tenacity is temporary and the strength of the bundle can be restored at any time by suitable relaxation processes. This explains the observation that, if wool held in a bale for a long time is relaxed in some way before opening or processing, the loss of strength can be reversed as outlined in the table on the slide.

EXPLAIN TO participants that this Woolmark Company video shows the use of a blending bin to blend wool after scouring.

PLAY *video (18 seconds)*

AS THE *video plays, reinforce that the aim of blending is to mix the wool. This is done in bins, as shown in the video.*

NOTE THAT *the blower ensures even spreading of the incoming wool. (7:20 seconds)*

NOTE THE *wool in this blending bin has been scoured (14:00 seconds). Explain that this can also be done before blending.*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

EXPLAIN TO participants that from the blending bin the wool can then pass to a de-dusting plant, which shakes all the remaining dust from the wool and adds the carding lubricant in preparation for the next operation.

PLAY *video (57 seconds)*

INDICATE THAT *machines are used to remove dust from scoured wool by opening and shaking the wool.*

MENTION THAT *this machine is often used to add lubricant to the wool (38 seconds).*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

SUMMARY — MODULE 2

The operations that precede top-making include:

- blending
- opening
- scouring

Tests carried out on scoured wool include:

- moisture content
- colour
- residual fatty matter
- fibre diameter distribution

Baling and storage of scoured wool affects:

- fibre strength and then ultimately fibre length

Storage issues can be resolved with relaxation.

13 - **Module 2:** Early-stage processes in top-making

SUMMARISE THAT the operations that make up ‘early-stage’ processes in top-making are:

- blending — to mix the various components of the blend
- opening — to break up the clumps of wool into a more fibrous form
- scouring — to remove dirt, grease and suint salts with minimum entangling of the fibres.

REMIND participants that these processes were briefly reviewed as they are discussed in detail in the Wool Science, Technology and Design Education Program courses *Introduction to wool processing* and *Raw wool scouring*.

REINFORCE THAT the IWTO tests used to assure the quality of scoured wool and the efficacy of the scouring operation include testing of:

- invoice mass (oven dry mass/moisture content)
- colour
- residual fatty matter
- fibre diameter characteristics.

REMIND participants that long-term baling of scoured wool affects:

- fibre strength, which will in turn impact on fibre length in the processed wool.

REINFORCE THAT the process of relaxation (steaming the fibre to raise it above the glass transition temperature) resolves the issues of long-term storage of scoured wool.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

THE WOOLMARK COMPANY

THANK YOU

 AWI gratefully acknowledges the funding provided by Australian woolgrowers and the Australian government to support the research, development and marketing of Australian wool. GD2891

INFORM participants of the time and location for the next lecture — *Module 3 Worsted carding* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

MODULE 3

THE WOOLMARK COMPANY

WORSTED CARDING

RESOURCES — MODULE 3: WORSTED CARDING

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 3: Worsted carding**:

- sample of worsted top
- sample of card sliver
- sample of scoured wool
- samples of card clothing

Additional resources to be sourced by the facilitator include:

- hand cards
- lubricant samples

WELCOME participants to Module 3 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making — Worsted carding*.

EXPLAIN THAT this module will cover the process of carding in the context of worsted top-making. It will explore the equipment used in the carding process, the impact of the raw fibre properties on the carding process and the form and quality attributes of the fibre following carding. Some of the latest developments in carding technology will also be covered.

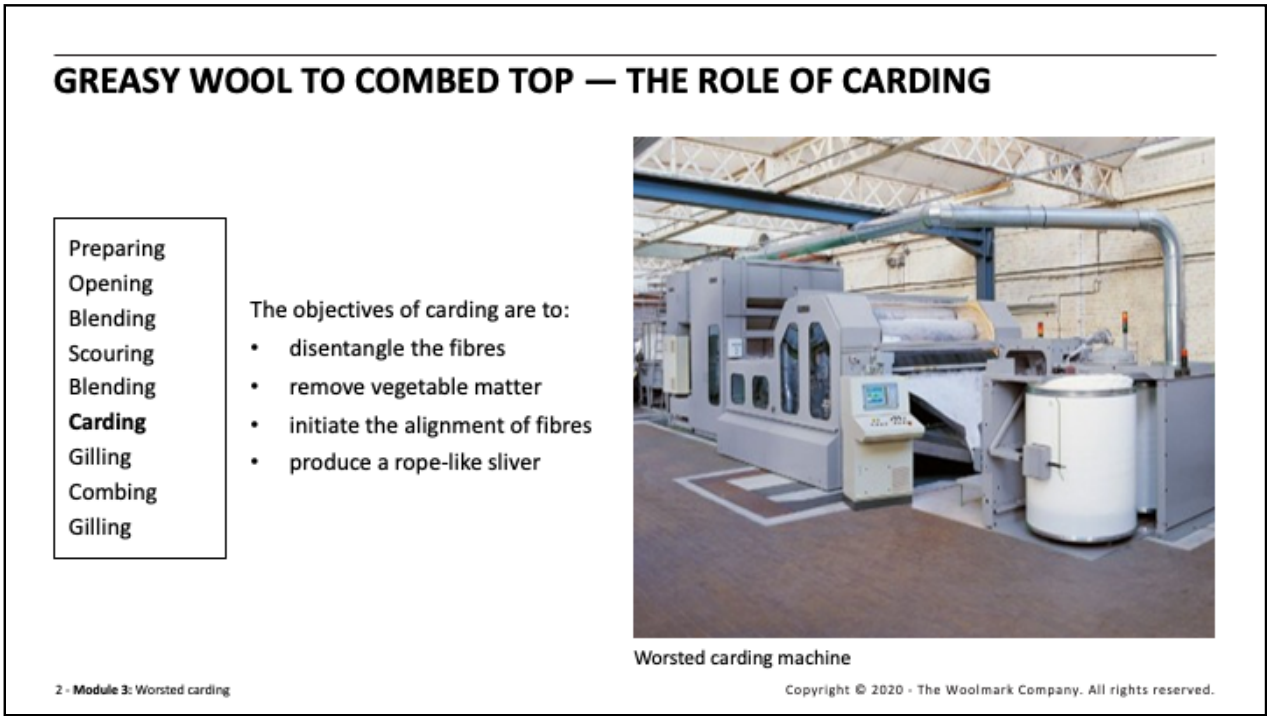
INFORM participants that by the end of this module they will be able to:

- describe the objectives of a worsted carding operation in the context of a worsted top-making operation
- describe the quality attributes of the input material that impact the carding process
- describe the components of a card and their function
- describe the conditions that affect card productivity and their impact on top quality
- describe the quality attributes of the output material from the carding process
- outline some of the latest developments in worsted carding.

NOTE: In the worsted industry, wool is always carded in the white undyed state.

RESOURCES REQUIRED FOR THIS MODULE:

- *sample of card sliver*
- *sample of worsted top*
- *hand cards (to be supplied by facilitator)*
- *sample of scoured wool*
- *samples of card clothing*
- *samples of lubricants (to be supplied by facilitator).*



EXPLAIN THAT the word 'carding' is derived from the Latin *carduus*, meaning 'teasel', because dried vegetable teasels (flower heads or burrs) were originally used to comb raw wool.

INDICATE THAT the carding operation aims to disentangle and align fibres, while removing vegetable matter (VM) contaminants.

EXPLAIN THAT the worsted carding machine (or 'card') has the task of:

- disentangling the locks of scoured wool and separate the fibres one from another, (i.e. individualising the fibres)
- intimately mixing individual fibres together
- removing as much vegetable matter as possible
- starting the process of aligning the fibres
- reassembling the fibres into a rope-like strand called a 'sliver' for further processing.
- packaging the sliver for the next processing operation.

EXPLAIN THAT the processing conditions during carding are designed to :

- minimise the inevitable fibre breakage, which occurs as the scoured wool is disentangled
- minimise the frequency of fibre faults and nep (a small entanglement of fibre)
- maximise carding efficiency and profitability, while meeting product quality parameters.

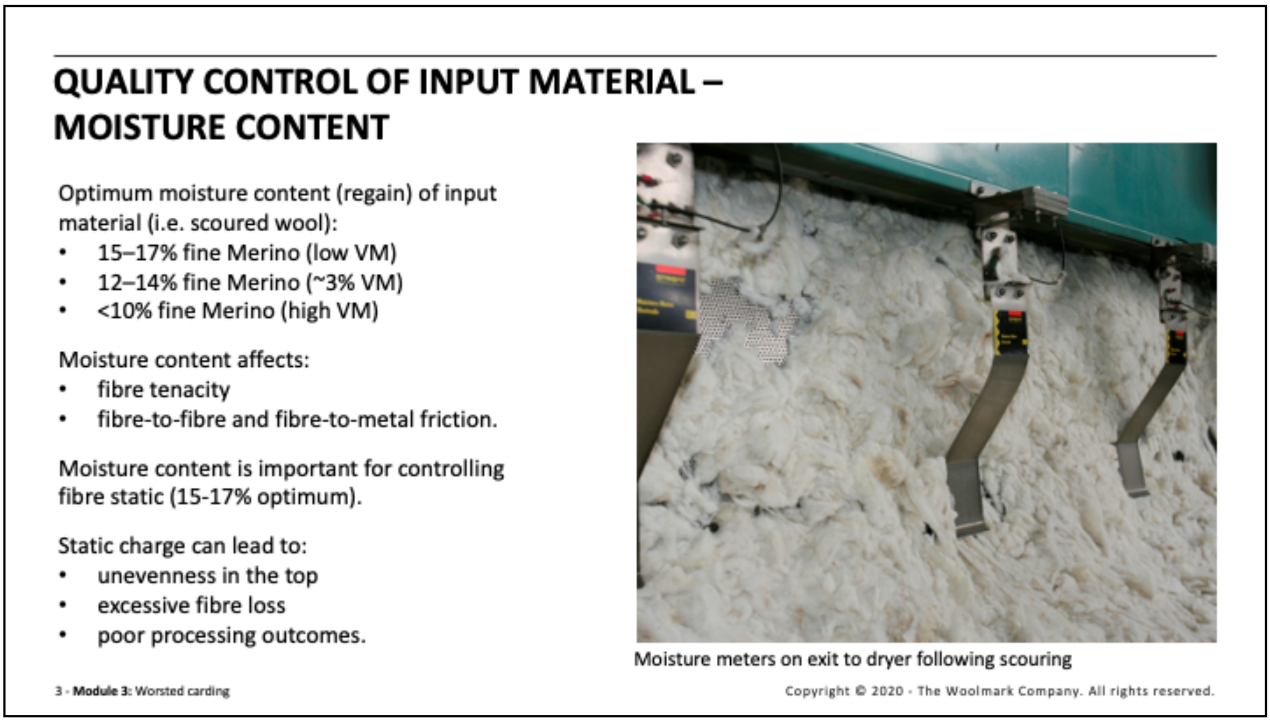
MENTION THAT the worsted card is expected to process scoured, dried, non-felted, well-open wools, with a normal amount of residual grease, containing up to 8% of vegetable impurities.

'Opened' implies the wool fleeces (and pieces) are broken into locks or clumps of fibre that are not heavily entangled.

Many different types of worsted carding machines have been developed but operate on the same basic principles.

INDICATE THAT the number and configuration of the rollers used on a card may vary on the different types of carding machine, and vegetable matter removal systems differ in design, but the objectives of the various machines remain the same.

NOTE: All the aims listed should be achieved with the least possible fibre breakage and loss.



EXPLAIN THAT the moisture content (regain) of scoured wool can affect carding performance and later processes. After scouring and drying, the moisture content of the fibre should typically be 14–18%.

INDICATE THAT the optimum moisture content of wool for the removal of vegetable matter (VM) during carding depends on the amount of vegetable matter.

Vegetable matter content	Moisture
• Low (<3%)	15–17%
• Medium (~3%)	12–14%
• High (5–8%)	8–10% (dryer is better)

EXPLAIN THAT at lower levels of moisture content, vegetable matter tends break into smaller pieces. At higher moisture content, certain types of burrs tend to unravel, forming 'monkey's eyelashes', which are difficult for the combing machine to remove.

INDICATE THAT fibres that are wet or over conditioned also may cause problems in later processing. Roller and coiler laps during gilling and combing lead to excessive waste. Beyond about 20–25% moisture content, nep formation increases due to a rapid decrease in fibre rigidity (due to the glass transition effect). These problems may come about from irregularity in moisture distribution.

Fibre tenacity

It is essential for the wool fibre to be pliable, or capable of recovery from extension, to reduce fibre breakage. The moisture content of the fibre affects its tensile properties (i.e. load at break and extensibility).

The higher the fibre moisture content, the lower the modulus (stiffness) and breaking strength of the fibre. However, if the fibres are dry (e.g. less than 10% moisture content), they will be more brittle and more liable to break than when they are at the correct moisture content (in the order of 15–17%).

NOTE THAT increased fibre moisture content increases fibre extension at break and improves recovery.

Fibre-to-fibre and fibre-to-metal friction

The coefficient of friction between wool fibres and between wool fibres and metal increases with fibre moisture content.

When fibres come into frictional contact with each other, or pass over machine surfaces or rollers in carding, they develop a static electric charge, making the fibres difficult to process. This causes unevenness in the resultant tops, excessive fibre waste and low machine efficiencies.

EXPLAIN THAT increasing the moisture content of the material lowers the electrical resistance of the fibre, reducing the static charge. A moisture content for wool fibres of 15–17% can reduce static charge to an acceptable level.

NOTE: The moisture meters in the slide are measuring the moisture content of the scoured wool as it leaves the dryer.

QUALITY CONTROL OF INPUT MATERIAL: RESIDUAL CONTAMINANTS

Recommended levels of residual contaminants in scoured wool:

- total fatty matter (TFM): (solvent extractable) content after scouring — 0.3 - 0.5%
- dirt content after scouring (e.g. ash) — 0.4 - 0.6%

Soxhlet apparatus to extract residual contaminants

4 - **Module 3:** Worsted carding

EXPLAIN THAT because of the desire to have high production rates and efficiency in carding, wool processors want the input material (scoured wool) to be as clean as possible, with minimal levels of residual contaminants, such as wool wax, suint etc.

INDICATE THAT current thinking is that the optimum level of residual wool wax after scouring should be close to nil. The currently-accepted level for solvent extractable materials (determined using IWTO-10 and DTM-61) is 0.4–0.5%.

NOTE THAT the effects of residual contaminants on processing performance are difficult to quantify, because they manifest further down the worsted processing route, for example, during the roving and spinning stages.

POINT OUT some of the negative effects attributed to excessive residual contaminants include:

- inferior colour of scoured wool
- accumulation and premature wear in processing equipment
- changed properties of processing additives (lubricants and antistats)
- poor drafting performance during gilling
- poor dyeing performance
- excessive dust in the work environment.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the carding process. Following the video we will look at the carding process step by step.

PLAY *video (1:40 minutes)*

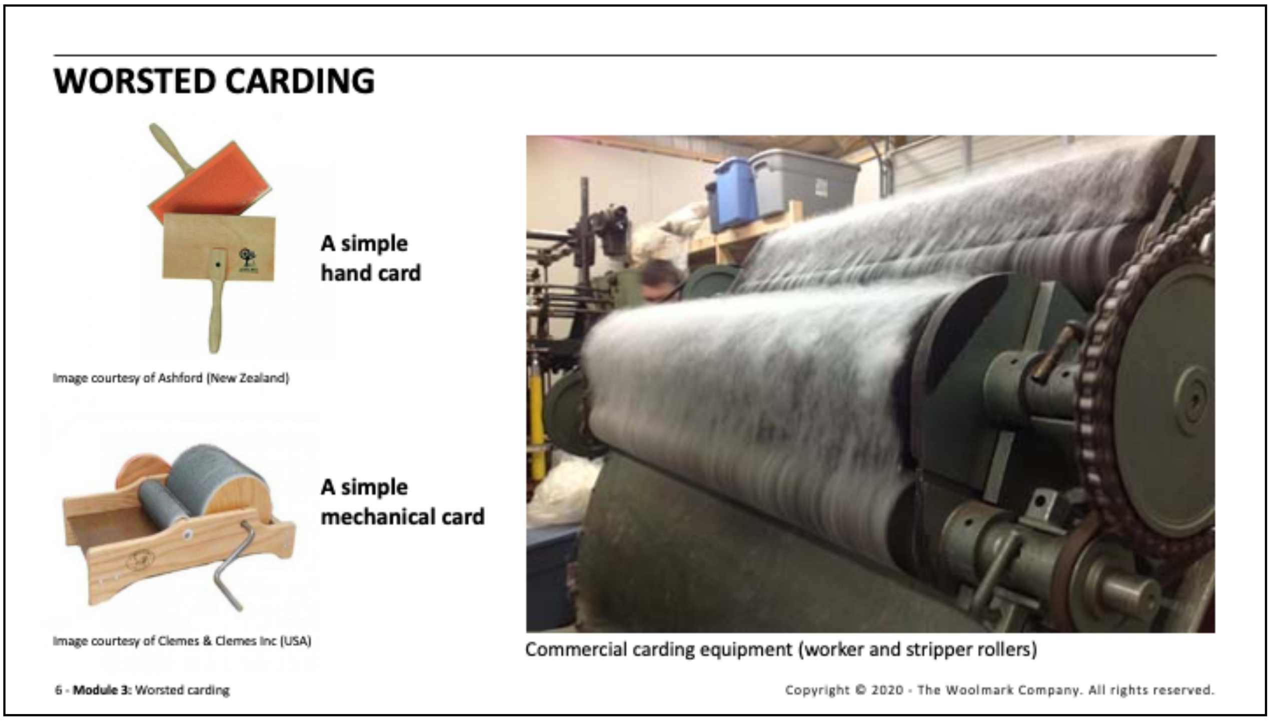
AS THE *video plays, note the following points:*

- *The scoured wool is fed into the carding machine.*
- *Some additional opening occurs in the feed lattice (10.58 seconds).*
- *The weigh belt ensures an even feed of wool (18.71 seconds).*
- *Burrs are crushed by rollers, called morels, and removed from the wool (29.00 seconds).*
- *The staples are separated into individual fibres using workers and strippers (42.67 seconds). Note that the action of these rollers will be discussed further shortly.*
- *Note there are several workers and strippers.*
- *The doffer and doffer comb remove the wool from the card (50.94 seconds).*
- *The animation shows the path of the wool (1:00 minute).*
- *The separated fibres are gathered into a continuous stream called a sliver (1:18 minutes).*
- *In this machine the slivers are fed directly into a gilling machine (1:31 minutes).*
- *NOTE that alternatively, they can be fed into a can or cans.*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

HAND OUT *samples of card sliver and top as you explain that the card sliver is the result of the worsted carding process and the top is the final result from top-making.*



EXPLAIN THAT the complexity of the carding process depends on the scale of the operation. For example, small-scale spinners have long been using simple hand and mechanical cards similar to those shown on the slide. Commercial carding equipment is far more complex, but the primary aims and outcomes (separating the fibres) remain the same.

NOTE THAT after scouring, despite advances in design and operating procedures, the wool is presented to the carding machine in a lightly entangled state.
The commercial carding machine achieves its various tasks through working, stripping and raising actions.

- Working — describes the separation of the fibre clumps and the fibres within these clumps.
- Stripping — describes the movement of the wool from one roller to another.
- Raising — describes the lifting of the fibres on a cylinder to improve transfer.

DEMONSTRATION: HAND CARDS

Resources required:

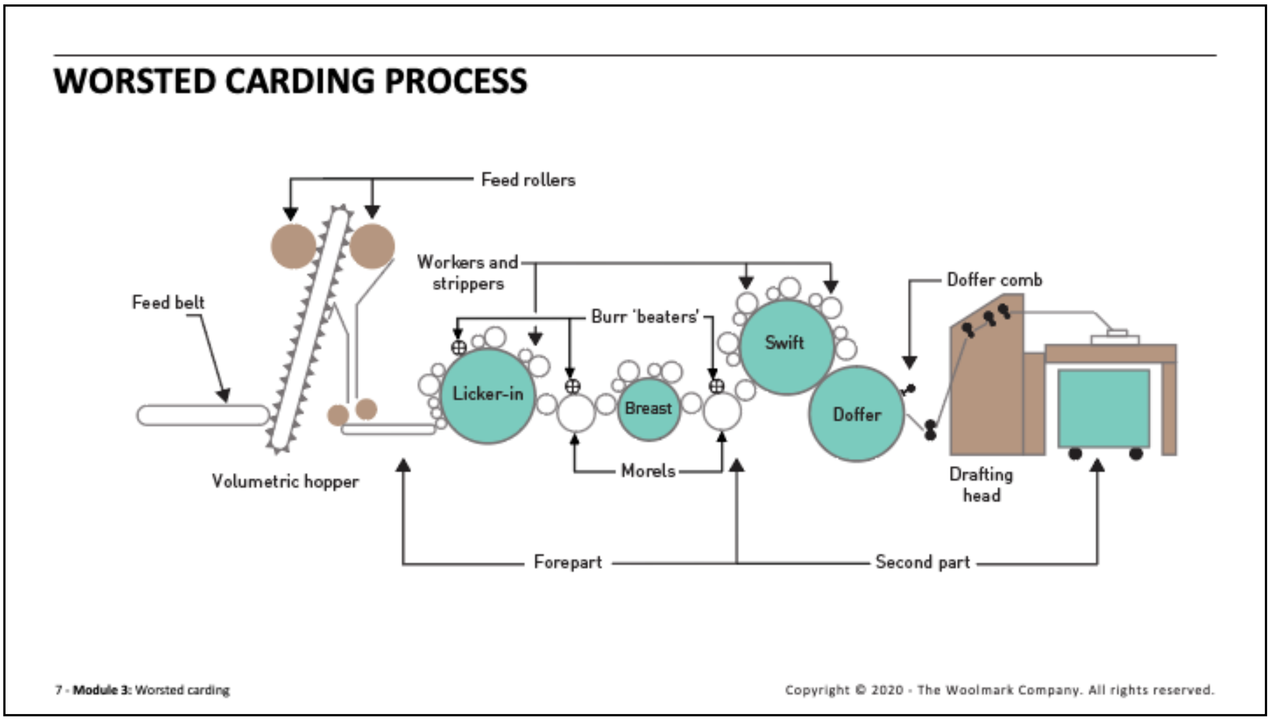
- *hand cards*
- *sample of scoured wool*

TAKE *a scoured wool sample and demonstrate the carding action using hand cards.*

INDICATE THAT the various rollers of the carding machine, which are covered with metallic or fillet wire clothing, separate the wool staples into individual fibres in a manner similar to the simple hand and mechanical cards.

EXPLAIN THAT wool is gradually disentangled as it passes through the carding machine. First the wool is subjected to coarsely clothed rollers set at relatively open settings, then, as the wool is disentangled, the spacing between the rollers decreases and the pinning of the card clothing teeth increases.

NOTE THAT in this manner, it is possible to minimise fibre breakage and to disentangle the fibres to a fairly open state.



EXPLAIN THAT the worsted card is a large machine with many types of rollers. It can be roughly divided into two parts as illustrated on the slide — the licker-in, morels and breast rollers form the forepart of the card and the swift, with its workers and strippers, form the latter part of the card.

REFER participants to the diagram on the slide as each component is explained.

Forepart

Fibre is presented to the feed rollers of the carding machine in a well opened, uniform sheet but still largely in staples or locks.

From the feed rollers, the fibre passes onto the licker-in, the first of four main rollers, which have pairs of smaller rollers (worker and strippers) around their circumference. The aim of the licker-in is to gradually tease open the entangled locks of scoured wool.

From the licker-in, the fibre passes through the first morel course. The aim of the morel is to present the fibre web in such a way as to make removal of vegetable matter more effective.

From the first morel the wool moves onto the breast. The breast is another roller with pairs of workers and strippers around its circumference to open the wool.
From the breast the wool moves to a second morel.

Second part

The wool then moves to the swift, which is normally the largest roller in the carding machine, which also has pairs of workers and strippers. The aim of the swift is to complete the opening of the fibres.

After being worked, stripped, raised and transferred between rollers, the fibre is then transferred onto the doffer. The aim of the doffer is to remove the wool web from the swift.

The wool in the form of a web is removed from the doffer by a swiftly oscillating comb or, in some machines by a directed air blast. The doffer comb removes the web from the doffer so that it can be formed into a sliver.

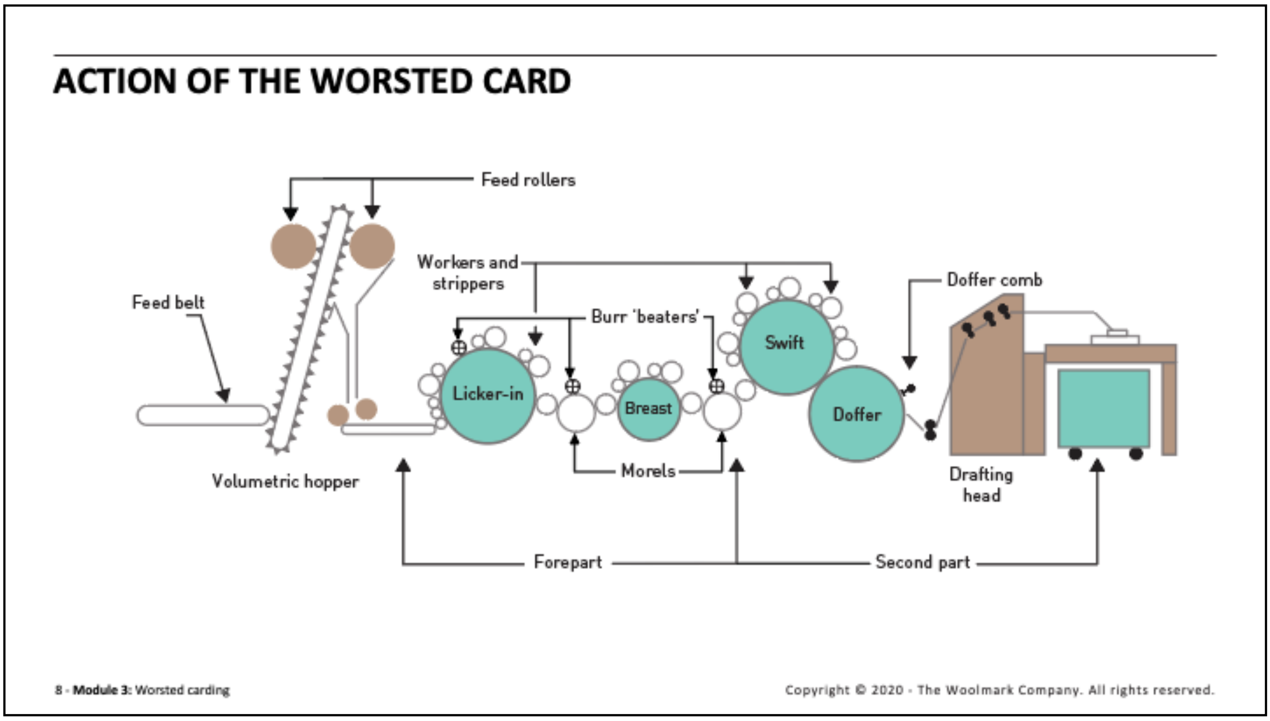
The web is collated to form a sliver, which is packaged for transport to the next processing stage.

____

SHOW *participants samples of card clothing.*

ENSURE *all participants can observe these clearly.*

____

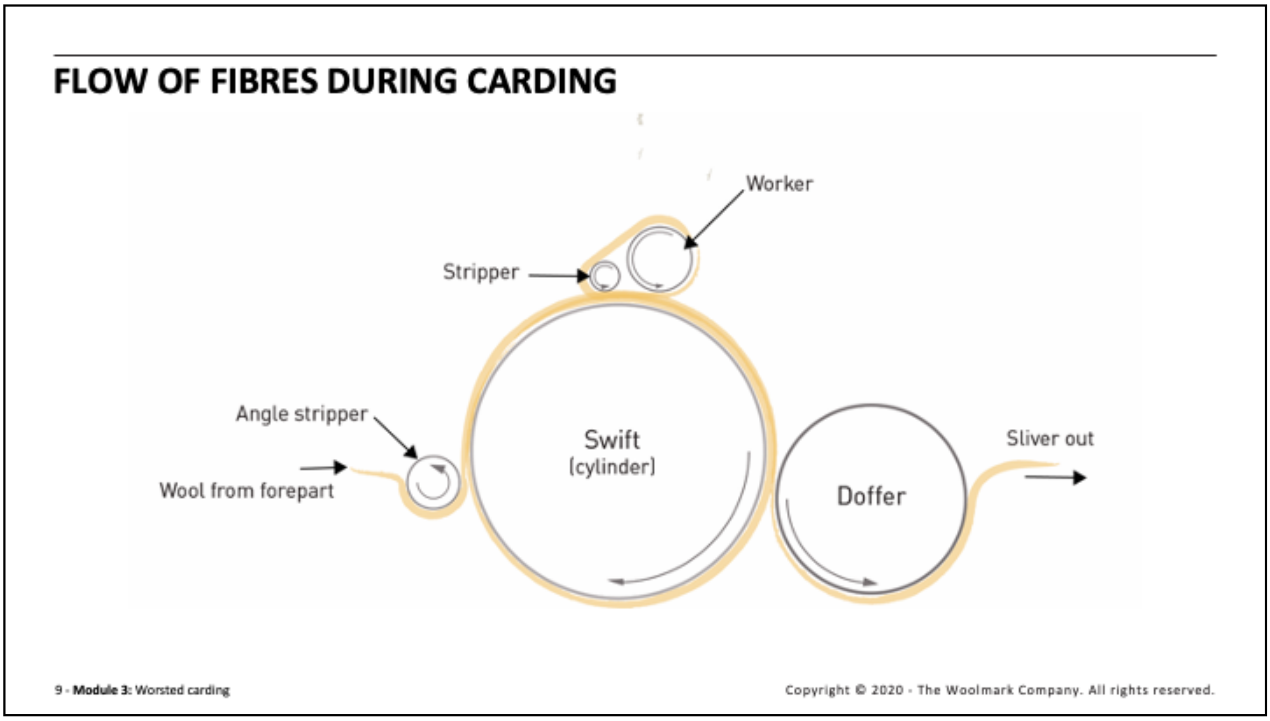


INDICATE THAT as the wool fibres progress through the carding machine, the pinning of the card clothing on each roller becomes denser and the speed of the rollers increases.

POINT OUT that the relative speeds, directions of revolution and inclination of the card clothing wires, together with the distance from the adjacent rollers, determine the degree of opening and mixing given to the fibres.

NOTE THAT other contributory factors are:

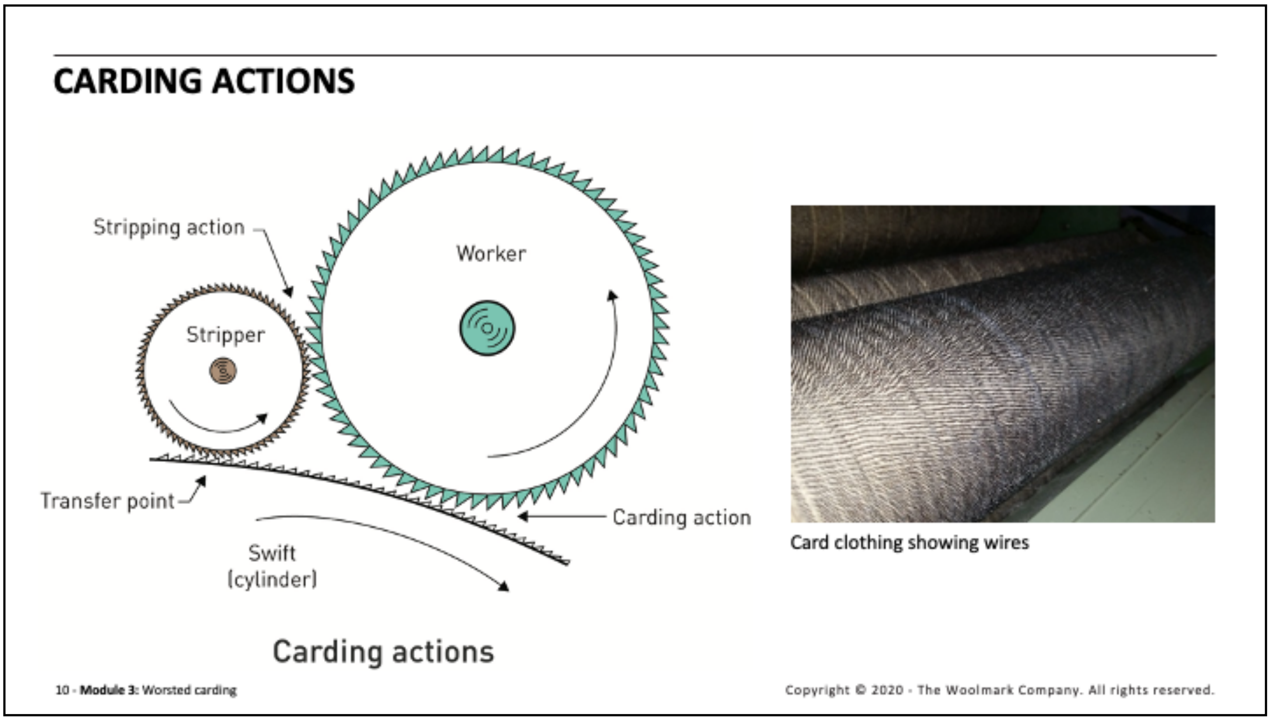
- the sharpness of the wire or pin teeth of the card clothing
- the wire diameter
- the density of pinning in the card clothing for the particular type of wool.



EXPLAIN THAT fibre movement throughout card is complex. Wool is not necessarily transferred at every point at which rollers approach as illustrated by the diagram on the slide.

INDICATE THAT the probability of fibres transferring (or not transferring) at any point depends on the fibre properties, speed ratios, the distance between various elements, wire geometry, fibre density at that point and the general condition of the wire.

REFER participants to the diagram where only one worker and stripper are shown for simplicity. In a commercial card there are a number of these worker-stripper pairs, depending on the size of the swift.



EXPLAIN THAT depending on the type of clothing, the card rollers can contain metal wire or teeth to hold and move the fibre between the rollers.

NOTE: Card clothing is discussed later in this module.

EXPLAIN THAT the wire point direction of the card clothing, roller speeds and their direction of rotation achieve three main types of carding actions in the worsted card — working, stripping and raising.

Working opens the tufts (i.e. locks and clumps) of wool and separates the fibres, the workers are the rollers with the slowest surface speed.

***POINT OUT** to participants the working point (carding action) on the diagram, as shown on the slide.*

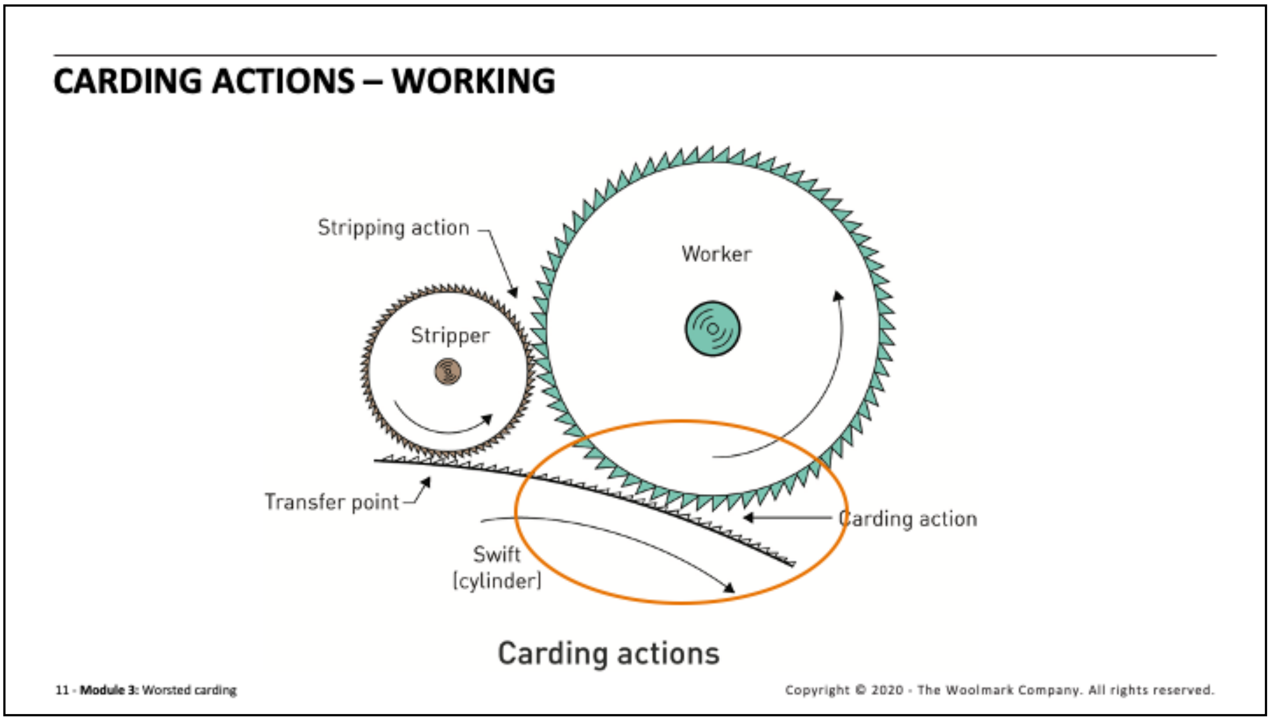
Stripping transfers wool from the worker to the cylinder or swift. The stripper moves faster than worker but slower than the swift.

***POINT OUT** to participants the stripping points (transfer points) on the diagram, as shown on the slide.*

Raising lifts the fibres on a swift (cylinder) to improve transfer efficiency at the next stage. In this instance (i.e. the process of raising) the wires are mounted back to back.

POINT OUT that as shown in the illustration on the slide, in many places on the carding machine, two or more rollers lie close to each other. The pairs of adjacent rollers do not actually touch each other, but are 'set' according to the particular type, quality and condition of the wool fibre being processed. Thin metal gauges are used to set rollers a known distance apart.

INDICATE THAT the recommended settings for a specific type of wool are usually given by the machine manufacturer or are gained through experience within the processing plant.



EXPLAIN THAT in the carding machine, where adjacent rollers are operating *with their teeth point to point*, an opening action occurs, or in technical language 'working' is carried out as indicated in the diagram on the slide.

DEMONSTRATION: CARD ACTION | WORKING

Resources required:

- *scoured wool*
- *hand cards*

***DEMONSTRATE** card actions, working with the hand cards (point to point).*

***ENSURE** all participants can observe this action clearly. If possible, allow participants to use the hand cards.*

INDICATE THAT the two rollers (worker and swift) effectively compete for possession of the wool; any fibre held momentarily by either roller is combed through by the teeth of the opposing roller. Clusters of fibres are disentangled, teased out or straightened.

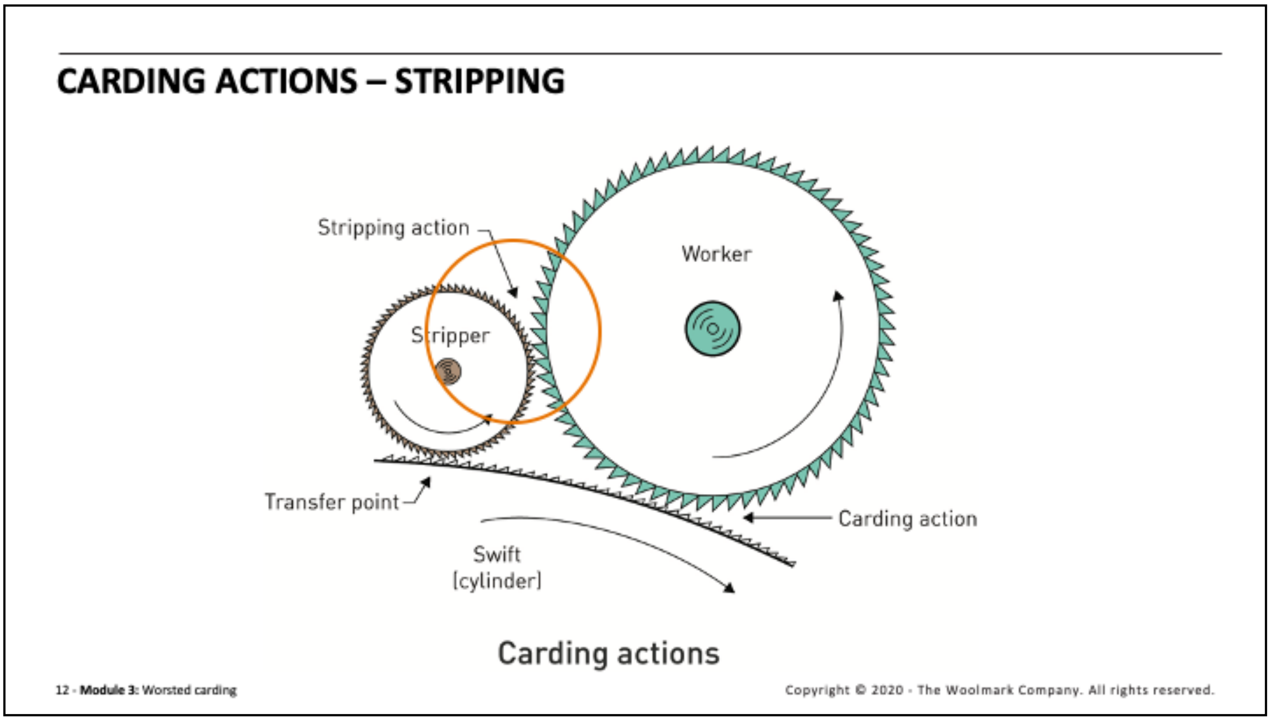
NOTE THAT there are two types of working action in the card, between :

- the swift and a slower revolving worker
- the swift and a slower moving doffer.

In both cases, the fibre on the swift is shared by the two rollers:

- swift and worker
- swift and doffer

EXPLAIN THAT working points along the carding machine have progressively faster roller speeds or denser pinning (or both) with the rollers usually set nearer to each other. This method of operation ensures a gentle and progressive opening of fibrous mass with minimum effect on fibre breakage and longer life of the card clothing.



NOTE THAT the 'stripping' action is the point at which the tips of the card clothing teeth of the stripper roller approach and pass the backs of the worker card clothing teeth. This removes much of the wool from the worker to the stripper.

DEMONSTRATION: CARD ACTION | STRIPPING

Resources required:

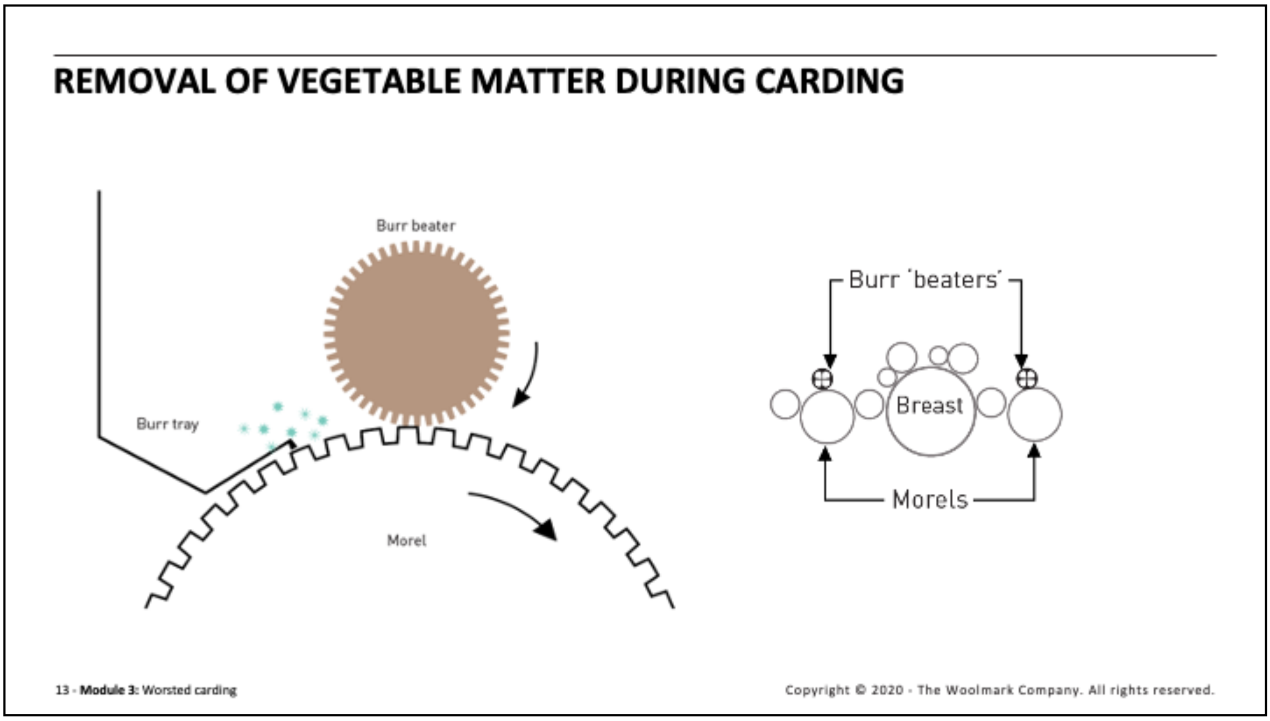
- *scoured wool*
- *hand cards*

DEMONSTRATE *the stripping with the hand cards (points face in the same direction).*

ENSURE *all participants can observe this action clearly. If possible, allow participants to use the hand cards.*

EXPLAIN THAT a similar action takes place when the points of the card clothing teeth of the faster-moving swift approach and pass the backs of the card clothing teeth of the slower-moving stripper roller. This removes most of the wool from the stripper to the swift.

POINT OUT that in both cases, when wool fibre is present, the faster-moving roller strips the fibres held by teeth of the card clothing on the slower-moving roller.



EXPLAIN THAT the principal mechanism for the removal of vegetable matter (VM) on the wool worsted carding machine is the burr beater. The most important burr-beating points are those on the morel rollers.

EXPLAIN THAT the flat-topped profile of the wire teeth used on the morel rollers and the spaces between the teeth are designed to allow wool fibres to be carried underneath the beater while exposing vegetable matter particles to the impacts of the beater blades.

NOTE THAT the closer the burr beater is to the morel, the better the vegetable matter removal efficiency, but the greater the fibre loss carried with the burr. Vegetable matter type will also play a role in the settings used for the burr beater.

POINT OUT that burr beaters need to be sharp for best effect, and should be rotated on a regular basis to keep the edges worn at an even rate.

INDICATE THAT burr removal efficiency on a single-swift (continental) card is less than that of the two-swift card, and can be increased by the use of tandem morel rollers in the forepart of the card.

VEGETABLE MATTER AND FABRIC FAULTS

WOOL QUALITY	VM TYPE	VM IN TOP PER KG		HOLES IN FABRIC PER KG	
		>3mm	>10mm	>3mm	>10mm
AAAA	Burr	14	1	2.4	0
Pieces	Burr	83	13.2	4.5	1
AAA	Seed/shive	5.2	0.4	0.7	0
Pieces	Seed/shive	5.8	0.6	3.9	0.1

14 - **Module 3:** Worsted carding

INDICATE THAT removal of vegetable matter is vital to avoid expensive problems during later stages of fabric manufacture.

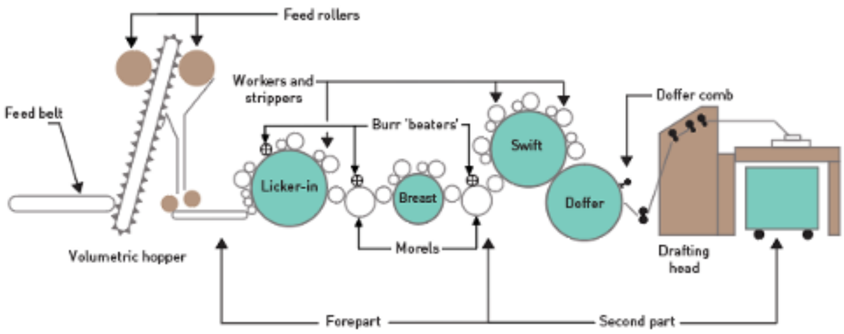
NOTE THAT burr (B) is worse than seed/shive (K) for retention of vegetable matter (VM) fault.

EXPLAIN THAT the effect of holes in the final product due to the presence of various types of vegetable matter can be seen in the table on the slide. One hole per kilogram of fabric is about one hole for every 3–5m of fabric (depending on fabric weight).

NOTE: The lower the vegetable matter content the fewer the holes.

CARD SETTINGS

- Forepart settings, while important for gentle opening, are less important than final swift settings.
- Swift-to-doffer and final worker-to-swift settings are the most important settings.



EXPLAIN THAT settings within a carding machine are varied and complex, and have a lesser or greater impact on the result depending upon the nature of the setting.

NOTE THAT burr beaters should be run at maximum speeds and be set close to the morels.

Worker–stripper pairs should be set closer to the swift as the clumps of fibre are progressively opened.

The loading of the carding machine (the card), in terms of the amount of fibre on the various rollers at any given time, is critical and has a bearing on:

- the amount of fibre breakage (and hence hauteur of the top)
- the amount of noil produced at the combing machine
- the overall productivity and economics of the carding process.

The amount of fibre entering the card, and thus loading the card rollers, is called fresh fibre density (FFD).

EXPLAIN THAT fresh fibre density is measured in grams per square metre and calculated by dividing the production rate of the card (measured in kilograms of wool processed per hour) by the width of the card multiplied by the surface speed (metres per minute) of the main cylinder (swift).

$$\text{FFD (g/m}^2\text{)} = \frac{\text{Production rate (kg/h) x 1000}}{\text{60 x swift speed (m/min) x card width (m)}}$$

As an indication, fine wool should be set at an FFD of 0.50–0.75 g/m^2 and coarser wool types at 1.20–1.50 g/m^2.

NOTE THAT loadings above these ranges will result in excessive fibre breakage and increased production of noil (waste).

INDICATE THAT across a wide range of fibre diameters, the effects of altering the settings in the forepart of the card in terms of fibre neps (small fibre entanglements), changes in hauteur (fibre length) or combing noil are small.

POINT OUT that the changes in the back part of the card, have some influence. However, the influence of these changes is smaller than those caused by manipulating the card production rate.

IMPACT OF CARD PRODUCTION RATE

CARD PRODUCTION RATE (kg/h/1.8m)	HAUTEUR (mm)	COMBING NOIL (%)
15.0	71.3	4.5
23.9	70.8	4.8
27.0	69.7	5.0
35.0	69.6	5.7
48.0	68.4	5.9
57.0	67.2	6.2

16 - **Module 3:** Worsted carding

EXPLAIN THAT card production can be increased by increasing the rate at which the fibre is processed through the card. A higher production rate per card (kilograms of fibre per hour across a given width of card) means fewer cards (an expensive machine) are required to produce a given amount of sliver (reducing capital expenditure).

POINT OUT however, as outlined in the table on the slide, increasing the production rate per card can negatively impact the quality of the resultant top — as more fibre is introduced into the carding elements per course of time, there is a steady reduction in hauteur (fibre length) and an increase in noil (comb waste).

INDICATE THAT alternatively, the top-maker can increase card production by keeping the amount of fibre being carded per course width constant, but increasing the total width of the card. This is the option machinery manufacturers took in the 1980s, increasing widths from 1500/1800mm (the historical width for many decades) to 3500mm. The increase in card width kept the cost of wool carding reasonably competitive, but this came at a significant increase to the capital cost of the card.

ASK *participants if they can describe a nep.*

ALLOW *sufficient time for participants to respond.*

IF NECESSARY *confirm that a nep is a small entanglement of fibre before proceeding.*

NEP FORMATION DURING CARDING

It is generally accepted that nep formation is affected by.....

- the degree of entanglement from scouring
- the stripper settings
- the doffer settings
- the swift speed – fibre density
- swift to doffer speed ratio (SDSR)
- the type of card clothing and its condition
- moisture content (regain) of the fibre.

17 - **Module 3:** Worsted carding

EXPLAIN THAT the formation of neps (small fibre entanglements) is one of the unwanted side effects of carding. It is generally accepted that nep formation is affected by the following factors:

The degree of entanglement from scouring
More entanglement during scouring leads to:

- higher fibre breakage during disentangling of the fibres
- tight fibre entanglements, which the card struggles to separate.

The stripper settings
Wider settings may preserve fibre length, but at the expense of considerably increased fibre entanglements.

The doffer settings
Like stripper settings, wider doffer settings preserve fibre length at the expense of increased fibre entanglements.

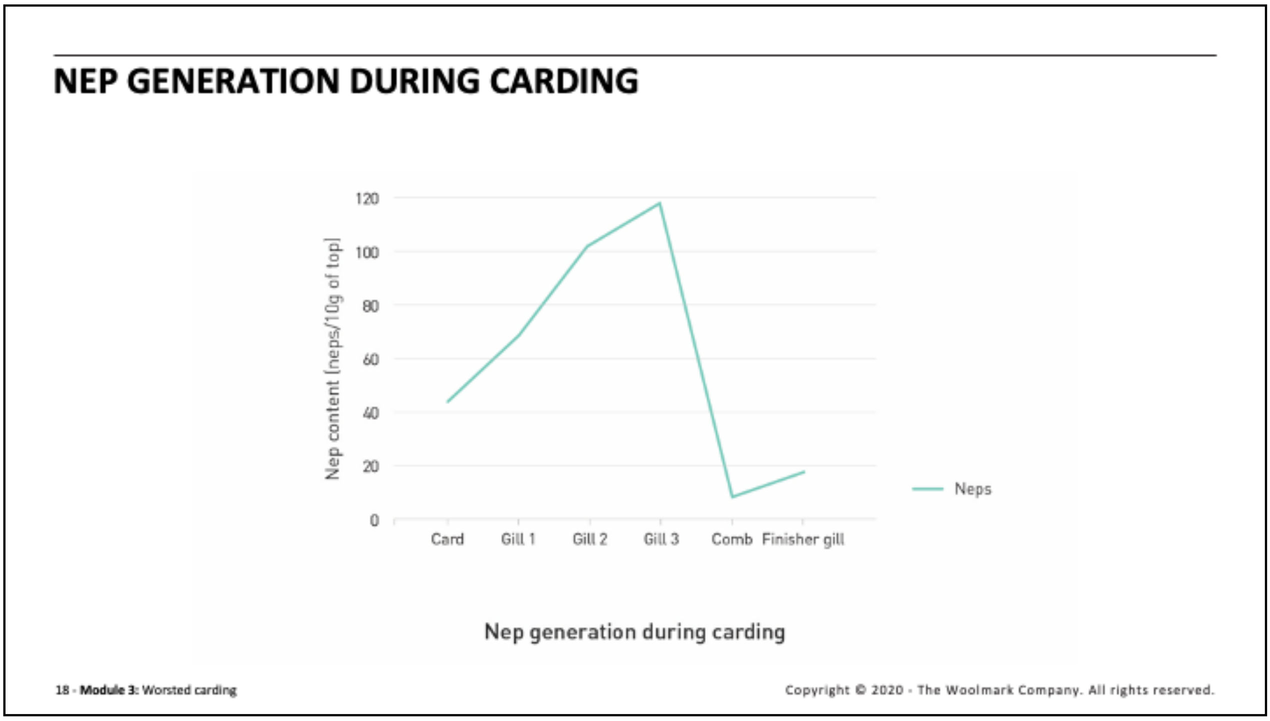
The swift speed and fibre density
Reduced fibre density (higher swift speed) improves the fibre length, reduces neps and minimises carding waste,

Swift to doffer speed ratio (SDSR)
Increasing the SDSR improves fibre length while reducing combing waste.

The type of card clothing and its condition
Finer clothing tends to assist better disentanglement of fibre.
Clean polished wire reduces faults.

NOTE THAT between any worker or stripper and the cylinder, there are four influencing factors:

- Geometry — diameter and direction of rotation
- Speed — individual and differential
- Gauge — separation distances between rollers
- Clothing — type and condition.

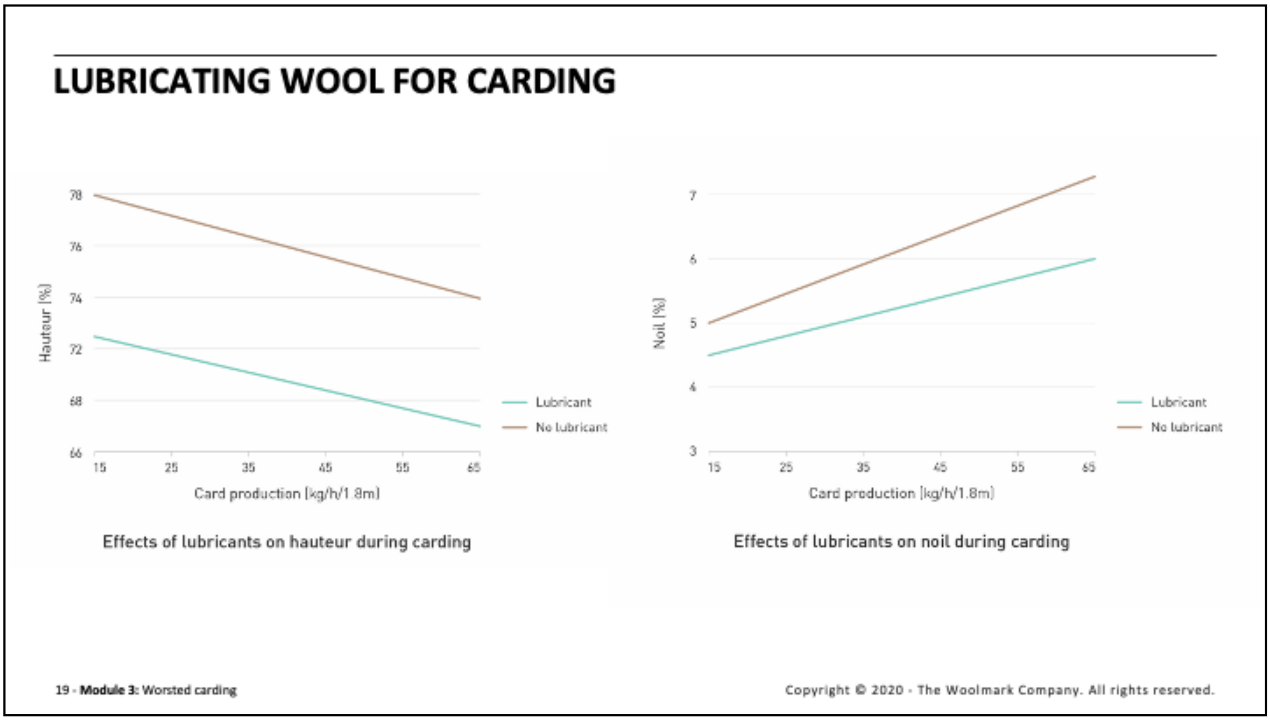


POINT OUT that neps are generated during the carding process as fibres entangle.

Subsequent gilling operations, designed to straighten the fibres, increase the number of neps.

NOTE the increase in neps with each gilling operation.

EXPLAIN THAT only during combing are neps removed (see reduction in graph). The more neps formed during carding, the greater the waste formed during comb.



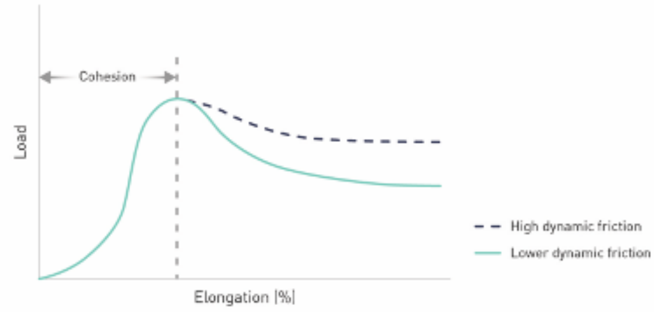
POINT OUT that fibre processing aids (lubricants) are generally added to scoured wool during the blending process to reduce fibre-to fibre and fibre-to-metal friction and static.

INDICATE THAT as illustrated in the figures on the slide, adding lubricants during carding increases the length (hauteur) of the wool after combing and reduces noil (waste).

NOTE also the increase in noil and reduction in fibre length with increasing card production rate as discussed earlier

EXPLAIN THAT a wide variety of fibre processing aids can be used when processing scoured wool fibre into worsted tops. The types of aids used and the considerations when selecting a suitable aid will be covered shortly.

CARDING LUBRICANTS — FIBRE-TO-FIBRE FRICTION AND STATIC



The frictional behaviour of the fibre processing aid

Antistatic effect

- Lubricants reduce frictional forces and inhibit initial generation of static.
- Lubricants are applied dissolved or dispersed in water.
- Water itself is an excellent antistatic.

20 - **Module 3:** Worsted carding

Fibre-to-fibre friction

EXPLAIN THAT considerable force is required to separate unlubricated wool fibres because of the roughness of the wool fibre's scaly surface.

INDICATE THAT the energy required to operate a card would be extremely high without the lubricating properties of a suitable fibre processing aid, and some of this energy would break fibres.

However, the role of a lubricant is not solely to reduce friction, but also to improve cohesion (the way fibres remain together in web or sliver form).

NOTE THAT there are two quite different aspects of fibre-to-fibre friction:

- static friction, which affect sliver cohesion
- dynamic friction, which affects the forces required to separate fibres.

Static and dynamic friction are both important in carding.

Fibre processing aids may affect cohesion (and static fiction) and dynamic friction in different ways.

EXPLAIN THAT cohesion of the fibre web is required if high card sliver yields are to be achieved in carding, and if slivers are to support themselves (i.e. do not break during handling).

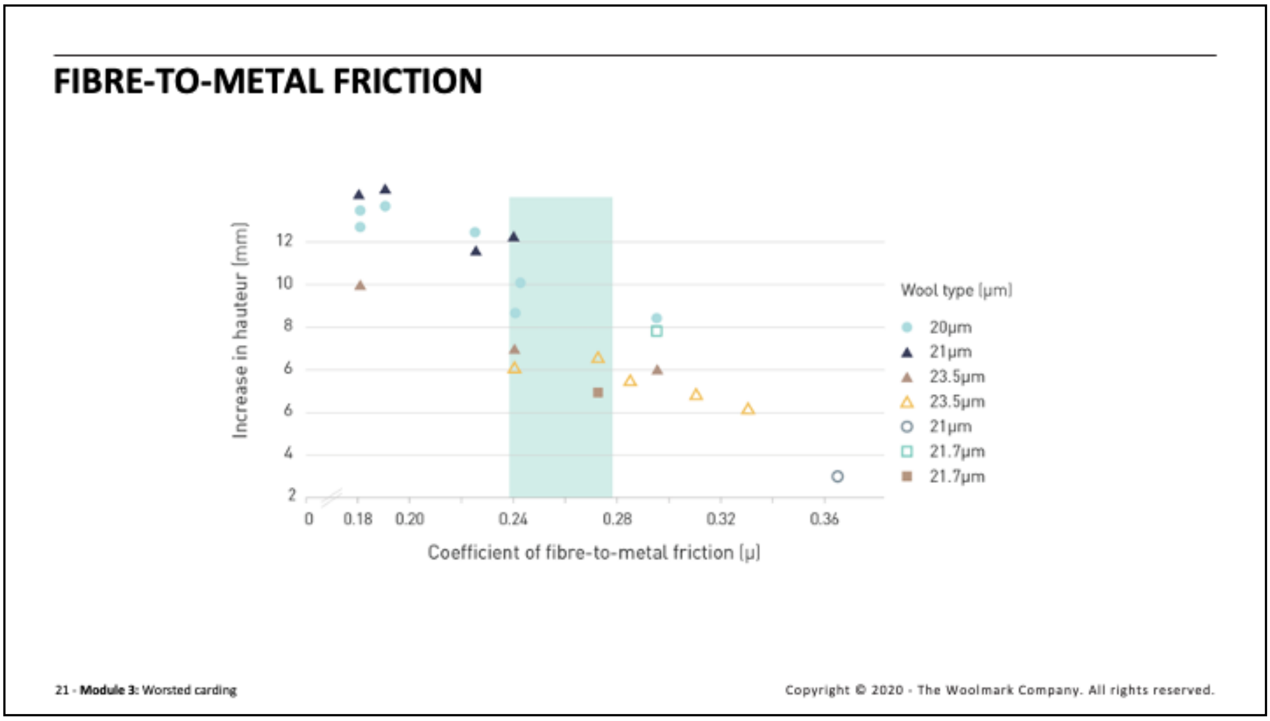
INDICATE THAT fibre length, fineness and crimp also contribute positively to cohesion of card web and slivers. If these fibre properties are lacking, they must be compensated by the cohesive behaviour of the fibre processing aid.

For example, if short lustrous fibre is to be processed, a fibre processing aid with high cohesive properties is required.

EXPLAIN THAT fibre processing aids also reduce dynamic fibre-to-fibre friction. The frictional behaviour of the fibre processing aid can be assessed from the slope of the right-hand side of the curve in the figure in the slide (i.e. less force is required to pull apart the fibres where there is lower dynamic friction).

Antistatic effect

Another primary purpose of the fibre processing aid is to dispel static forces, or prevent their initial generation. Fibre processing aids are often applied dissolved or dispersed in water, and water itself is an excellent antistatic.



EXPLAIN THAT as well as reducing fibre-to-fibre friction, the application of a fibre processing aid lowers dynamic fibre-to-metal friction, which in turn reduces the energy required for carding and minimises fibre breakage.

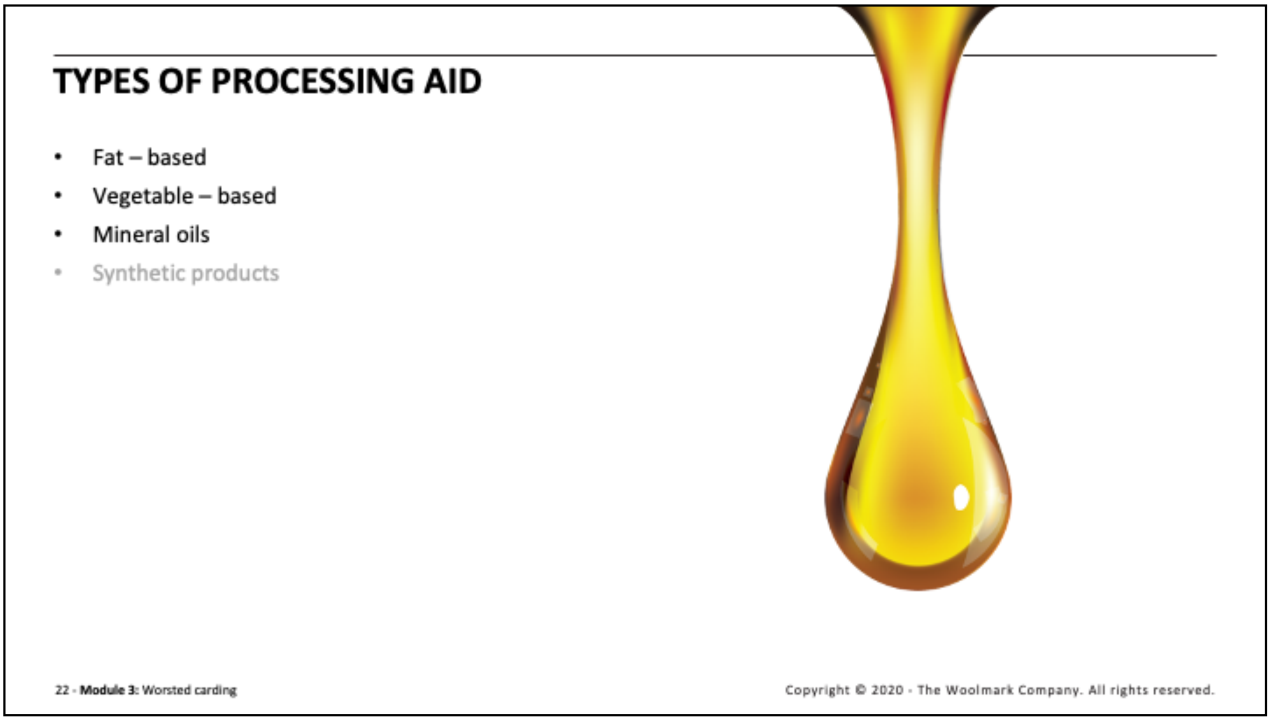
INDICATE THAT CSIRO studies have confirmed that reducing fibre-to-metal forces is critical to reducing fibre breakage during wool processing.

POINT OUT the diagram on the slide illustrates the relationship between the fibre-to-metal friction for a range of different lubricants on seven different wool types (with varying fibre diameters) and the gain in average fibre length (hauteur) of the top.

NOTE THAT it can be seen that lubricants that reduce the fibre-to-metal frictional forces result in an increase in the hauteur (length).

REFER participants to the shaded area of the graph , which indicates the range covered by commercial lubricants available at the time of these studies. Those outside the range were developmental products, which were not commercially-available at this time.

EXPLAIN THAT reducing fibre-to-metal friction also improves the yield of top by reducing the amount of noil (combing waste).



EXPLAIN THAT historically a wide and diverse range of products, with diverse chemistry, has been used to lubricate wool during processing. The following product types are recorded here for information purposes only as the processing aid market is now dominated by synthetic products.

Fat-based products

Oleines (mixed fatty acids derived from tallow and bone grease) were the traditional processing aids used for woollen spinning. The oleic acid content of these products can be 30–95% with the balance comprising neutral oils or mineral oils. Such products also contain emulsifying agents, oxidation stabilisers and antistats.

Oleines are used at application rates of 6–8% per wool weight, and support effective cohesion. They are removed during scouring using sodium carbonate to turn the fat into soap. The soap generated gives thorough scouring, risks alkali-yellowing of the wool.

NOTE THAT although oleines are still used to produce woollen knitting yarns, other products have proved to be more convenient, economical and environmentally acceptable. Modern variants (blended fatty oils) are now available for woollen spinning, but are not widely used in top-making.

Vegetable-based products

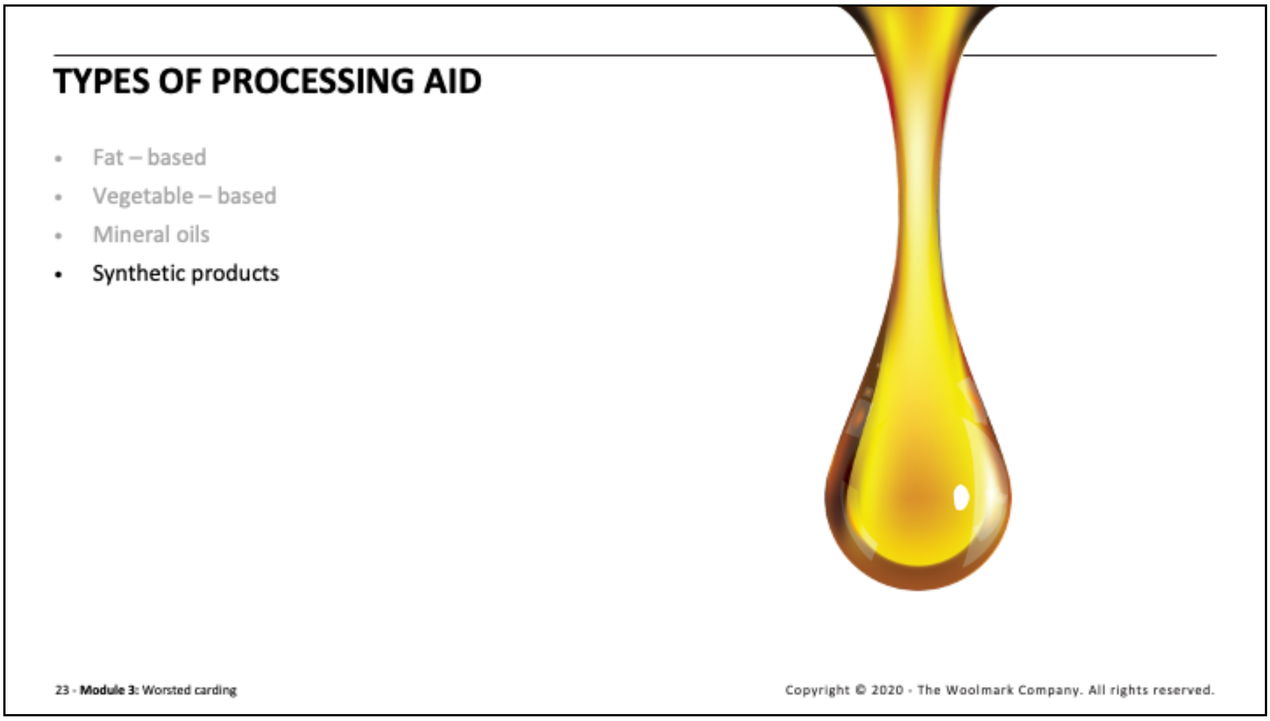
Vegetable oils are not used in top-making because they do not satisfy the industry requirement for soluble products that can be removed in the dyebath.

Mineral oils

Compared with oleines, mineral-based products:

- are paler in colour
- are more stable to oxidation (reducing the risk of fire)
- give off less odour.
- are insoluble in water, so are blended with surfactants to facilitate emulsification during subsequent scouring
- vary in scourability.

POINT OUT that mineral oils must be removed thoroughly following top-making because residues promote soiling and can lead to uneven dyeing. These oils were the traditional aid used in top-making and spinning until the mid-1980s.



Synthetic products
There are several different synthetic products used as fibre processing aids (e.g. polyalkylene glycols, ethoxylated esters, fatty esters, complex phosphoric esters). These products can be tailored during manufacture to achieve particular outcomes.

Synthetic products tend to be more expensive than mineral-based products as they are used at application rates of 0.25–0.50% per wool weight.

Synthetic lubricants are effective antistats and cohesive agents, and in the quantities used are generally less lubricative than oily fibre processing aids.

EXPLAIN THAT the outstanding advantages of synthetic lubricants are their versatility, greater stability and easy scourability. Mild pre-scouring conditions may be used or they may be removed by a rinse in the dyeing machine before dyeing. Finally, they can be dissolved in the dyebath itself.

NOTE THAT increasingly, stringent regulations on effluent disposal have encouraged the development of biodegradable processing aids.

***SHOW** participants a range of lubricant samples.*

SELECTION OF LUBRICANTS

- Technical performance
- Scourability
- Solubility
- Stability
- Storage
- Toxicity
- Effects on materials
- Compatibility with dyes/auxiliaries

Lubricant formulation	Coefficient of friction (μ)	Standard deviation	Static charging propensity	Deviation
A	0.299	0.013	0.7	0.2
B	0.271	0.023	0.8	0.1
C	0.209	0.022	6.0	1.1
D	0.233	0.017	1.4	0.4

Lubricant formulation	Card waste (% ± 0.2)	Fibre length after carding (mean mm ± 2)
A	5.0	93
B	5.5	98
E	5.3	100

Source: CSIRO

EXPLAIN THAT when selecting a fibre processing aid (lubricant) the following features are important to consider:

Optimal technical performance of the processing aid during carding and combing (e.g. minimum fibre breakage). The tables shown on the slide illustrate the variation in technical performance of a range of lubricants across a range of factors.

Scourability: During subsequent manufacturing stages, tops, yarns and fabrics are mostly wet-processed and the fibre processing aid is removed during those stages. However some fibre processing aids require a dedicated scouring treatment, whereas others are easily removed in warm water (e.g. in a rinse before dyeing). The latter reduce the need for an additional scouring process. However, the quantity and acceptability of the fibre processing aid in the scouring effluent must also be considered.

Solubility: As it is applied as a water spray, the product needs to be soluble or emulsifiable in cold water. In many mills, the available water is unsoftened, so the lubricant for some processing plants needs to be unaffected by hard water.

Stability: It may be necessary to store emulsions of the fibre processing aid in water. Ensure dispersions of the selected lubricant do not separate, become viscous or darken in colour during storage.

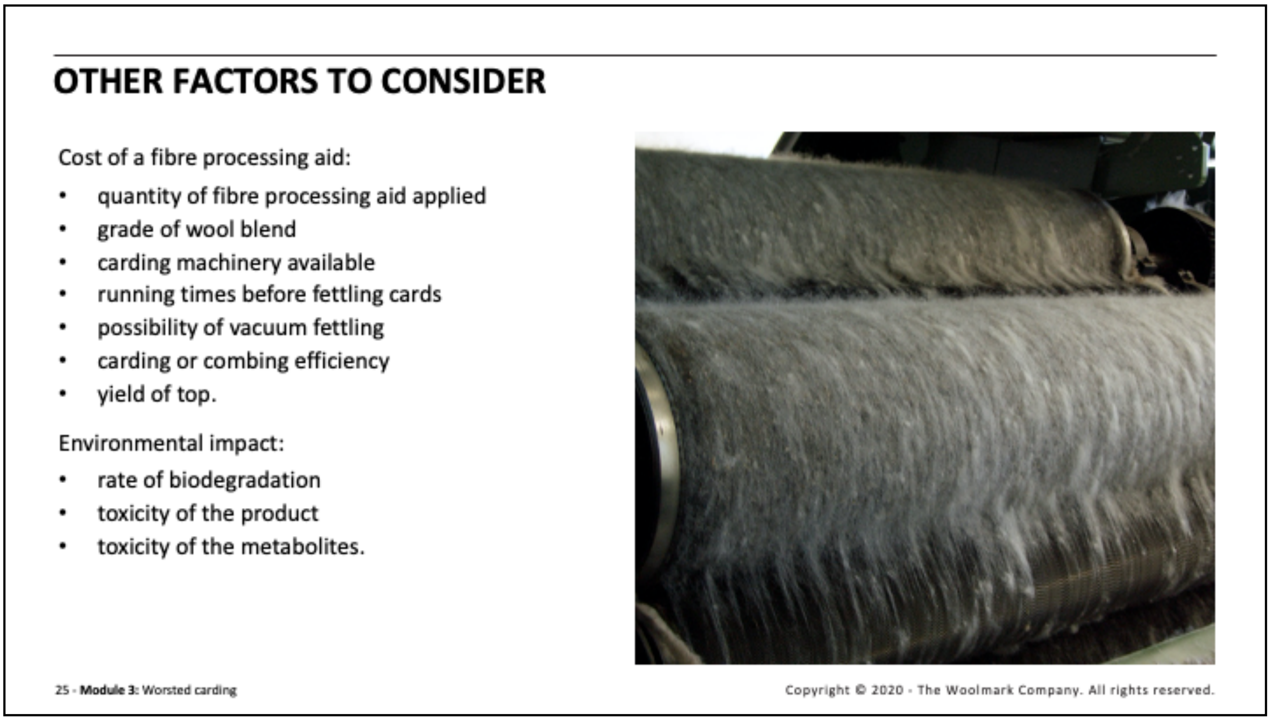
Avoid fibre processing aids that easily oxidise when dispersed over the wool, or are highly susceptible to microbiological attack.

Storage: Select a fibre processing aid that will be stable to the transport and storage conditions likely to be encountered (e.g. frost or high temperatures).
The product's flash point (the lowest temperature at which it can vaporise to form an ignitable mixture in air) is also important.

Toxicity: Some fibre processing aids can irritate the skin or eyes if used carelessly. The general toxicity of fibre processing aids is low, with median lethal dose (LD50) values in the 'not harmful' range.

Effect on materials: Fibre processing aids should not have detrimental effects on metals, paints, plastics, rubber or leather and do not adversely affect the card clothing, combing leathers, covered rollers, drafting aprons, etc., used in carding, combing, gilling and spinning.

Compatibility with dyeing auxiliaries: Where fibre processing aids are soluble in water, treated tops can be directly introduced to the dyebath. Because of the wide variety of dyebath auxiliaries available, assess any possible interactions between the fibre processing aid and the dye formulations being used.



EXPLAIN THAT in addition to technical performance, the other factors that affect the choice of a suitable lubricant are as follows:

Cost and savings associated with a fibre processing aid

The price of the fibre processing aid is just one aspect of the overall cost of top-making. Each processing plant manager must consider the situation along with the following factors, some of which may interact:

- quantity of fibre processing aid applied
- grade of wool blend to be processed (including grease content)
- carding machinery available
- running times before maintenance of cards, and possibility of vacuum cleaning
- carding or combing efficiency
- yield of top.

Environmental impact

Environmental factors to consider in an industrial effluent plant include:

- rate of biodegradation
- toxicity of the product
- toxicity of the metabolites from the biodegradation process.

POINT OUT that all reputable lubricant manufacturers supply the relevant technical information to the user. Avoid sourcing lubricants from manufacturers who do not supply sufficient supporting information about their products.

APPLICATION OF PROCESSING AID

Application technology:

- in-line mist applicator
- table applicator
- storage bin applicator
- tower applicator.

In-line mist application

26 - **Module 3:** Worsted carding

EXPLAIN THAT fibre processing aids are dissolved or dispersed in water using purpose-designed mixing equipment. The resultant liquid is metered onto the wool, usually as the fibre is being transported to the storage bins in the carding room where the fibre awaits the carding process.

NOTE THAT the objective is to apply the exact quantities of fibre processing aid and water as uniformly as possible across the fibre mass.

POINT OUT that sophisticated equipment is available for controlling the quantities applied, and application to opened wool helps uniformity of application.

INDICATE THAT four main types of applicator are available: in-line mist applicator, table applicator, storage bin applicator and tower applicator.

In-line mist applicator
With the in-line mist applicator, the processing aid and water are atomised and sprayed onto the wool in an air vortex before a fan, or as it passes along the trunk of a pneumatic conveyor system.

Table applicator
With a table applicator, wool is sprayed with processing aid and water (typically four jets are used) as it passes along a conveyor.

Storage bin applicator
Wool can sprayed as it falls into the storage bin using a storage bin applicator.

Tower applicator
The tower application system feeds the fibre into a tower via a bucket-wheel condenser and it is sprayed as it falls down the tower. A pair of deeply fluted rollers at the base of the tower take the wool into a pneumatic conveying system.

EXPLAIN THAT in the case of top-making, after the fibre processing aid is applied to the scoured wool before carding, it is also common to use a spray mechanism to apply a small quantity of fibre processing aid and water at the preparing stage of the gill box, to assist gilling and combing.

EFFECTS OF CARD SPEED

Experimental condition	Card production rate (kg/m/h)	Card speed (swift) (m/min)	Fresh fibre density (g/m^2)
I	17	450	0.6
II	30	450	1.1
III	30	800	0.6
IV	53	800	1.1

27 - **Module 3:** Worsted carding

NOTE THAT as discussed previously, card production can be increased using a number of methods. An alternative to increasing the width of the card (as previously discussed) is to increase the speed of carding (i.e. the speed of the rollers).

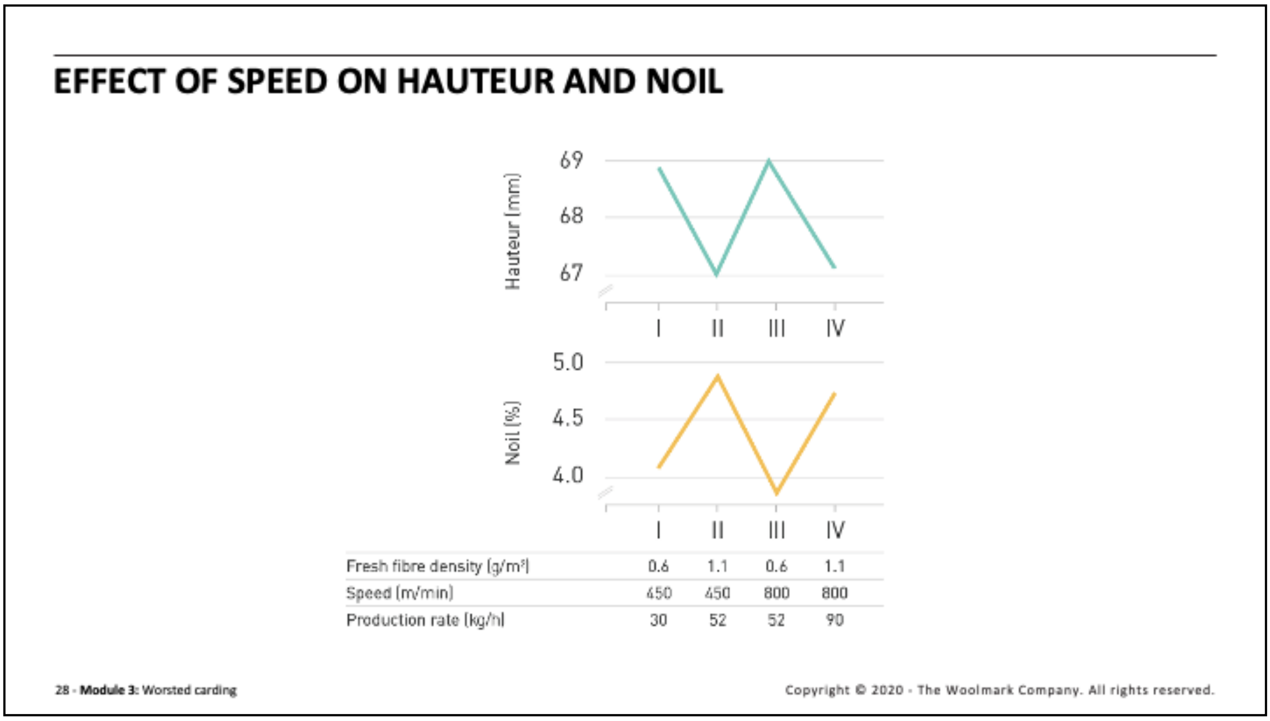
NOTE: When speed is altered, the speed of all rollers in the machine increases.

EXPLAIN THAT as wool was always considered a relatively fragile fibre, which had to be processed with care, the concept of a speed increase was traditionally considered unsuitable for wool. CSIRO studied the role of card speed in 1985.

POINT OUT that the impact of speed was studied by observing four carding conditions as outlined in the table on the slide:

- **Condition II** was considered a 'standard' condition for carding 21µm wool at that time with a swift roller speed of 450 m/min and a fresh fibre density (FFD) of 1.1 g/m^2.
- **Condition III** increased card speed to 800 m/min and the standard production rate of 30 kg/h/m was achieved with a lower fresh fibre density (FFD) of 0.6 g/m^2.
- **Condition IV** elevated the speed to 800 m/min, but maintained the standard FFD of 1.1 g/m^2 to give much higher production rates.
- **Condition I** completed the comparison.

NOTE THAT with each condition there was an associated impact on fibre length (hauteur) and noil (waste) as we will now explore.



EXPLAIN THAT as we have discovered, the settings with a carding machine are varied and complex and have a lesser or greater impact on the carding objectives depending on the nature of the setting.

REFER participants to the diagram on the slide showing the effect of varying the carding conditions on hauteur and noil in the resultant top.

Increasing fresh fibre density only

Compare:

- condition I (450m/min, FFD=0.6) to condition II (450m/min, FFD=1.1)
- condition III (800 m/min FFD=0.6) to condition IV (800m/min, FFD=1.1)

In both cases, noil increases and hauteur reduces with increasing fresh fibre density.

Increasing speed only

Compare

- condition I (450m/min, FFD=0.6) to condition III (800 m/min FFD=0.6)
- condition II (450m/min, FFD=1.1) to condition IV (800m/min, FFD=1.1)

There is no additional penalty of noil or hauteur for an increase in speed, although the production rate has increased in each case.

Increasing speed and reducing fresh fibre density

Compare

- condition II (450m/min, FFD=1.1) to condition III (800 m/min FFD=0.6)

A higher speed and lower FFD has no impact on production rate, but gives improved performance (low noil and high hauteur).

Conclusions:

- No significant effect of card speed on fibre breakage (and hauteur) even though traditional speeds have been nearly doubled.
- Noil and hauteur are determined by fresh fibre density.

POINT OUT that it is interesting to note that this study was repeated with five different types of wool, which might be expected to yield a range of problems in high-speed carding. The wools included one with fine diameter, another sound wool, a tender wool, and a high VM content wool. Results consistent with the first set of data (shown on the slide) were found.

HIGH SPEED CARDING ON THIBEAU CA7 — fine wool

Wool diameter (µm)	Swift speed (m/min)	FFD (g/m²)	Card production rate (kg/h/m)	Hauteur (mm)	Comb noil (%)
19.2	454	0.87	23.2	61.8	7.5
19.2	1036	0.87	53.3	61.0	7.3
19.2	1036	0.39	23.2	61.5	6.5
17.2	454	0.80	22.0	61.4	12.0
17.2	817	0.45	22.0	63.2	9.7

29 - **Module 3:** Worsted carding

NOTE THAT the outcome of the fundamental studies described here resulted in a collaboration between CSIRO, Australia, and the card machine manufacturer Thibeau, France.

POINT OUT that from this collaboration, the manufacture of a radically new wool carding machine, the CA7 high speed card was completed. This card incorporated:

- main swift speeds of up to 1200 m/min
- twin burr beaters
- a double doffer system.

The machine was released at the 1995 ITMA in Paris.

Using the superfine wools used in the CSIRO trials, positive results were obtained with the CA7 machine as outlined in the table on the slide.

EXPLAIN THAT high-speed carding has little or no detrimental effect on fibre length in the top or combing noil.

NOTE THAT there are significant gains for superfine wools. A reduction of more than 2% in noil for the 17.2µm diameter wool, as shown in the table, would be extremely valuable to the top-maker.

CARD CLOTHING

Image courtesy of Holland Card Clothing

Traditional card clothing

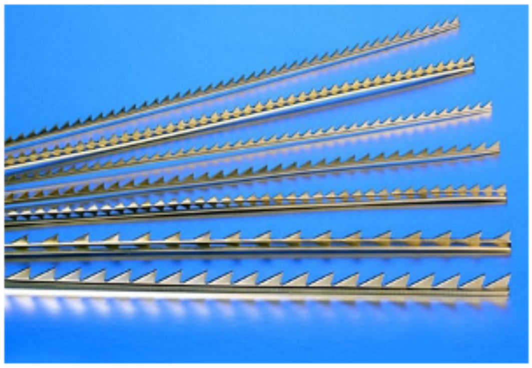


Image courtesy of WEL industry

Metallic card clothing

INDICATE THAT there are two types of card clothing — traditional fillet and metallic card clothing.

SHOW *participants the two types of card clothing.*

ASK *them to identify the key differences.*

ACKNOWLEDGE *participant responses before proceeding.*

Traditional fillet

The fillet is embedded with closely-spaced wire pins. The shape, length, diameter and spacing of these wire pins is dictated by :

- the card designer
- the particular requirements of the application

Metallic card clothing

Metallic card clothing uses a single strand of serrated wire wrapped around a roller. It was developed during the latter half of the nineteenth century and is found only on commercial carding machines.

EXPLAIN THAT the choice of card clothing for the carding cylinder surfaces (swift, workers and strippers) is a trade-off between machine efficiency (time taken to clean the card) and fibre breakage .

In general, metallic card clothing has a life span approximately twice that of traditional fillet, sometimes remaining serviceable for up to 10 years.

EXPLAIN THAT although metallic card clothing is not highly fibre retentive, it does retain excess wool grease, dirt, burrs and twigs, which will reduce the efficiency of the card clothing.

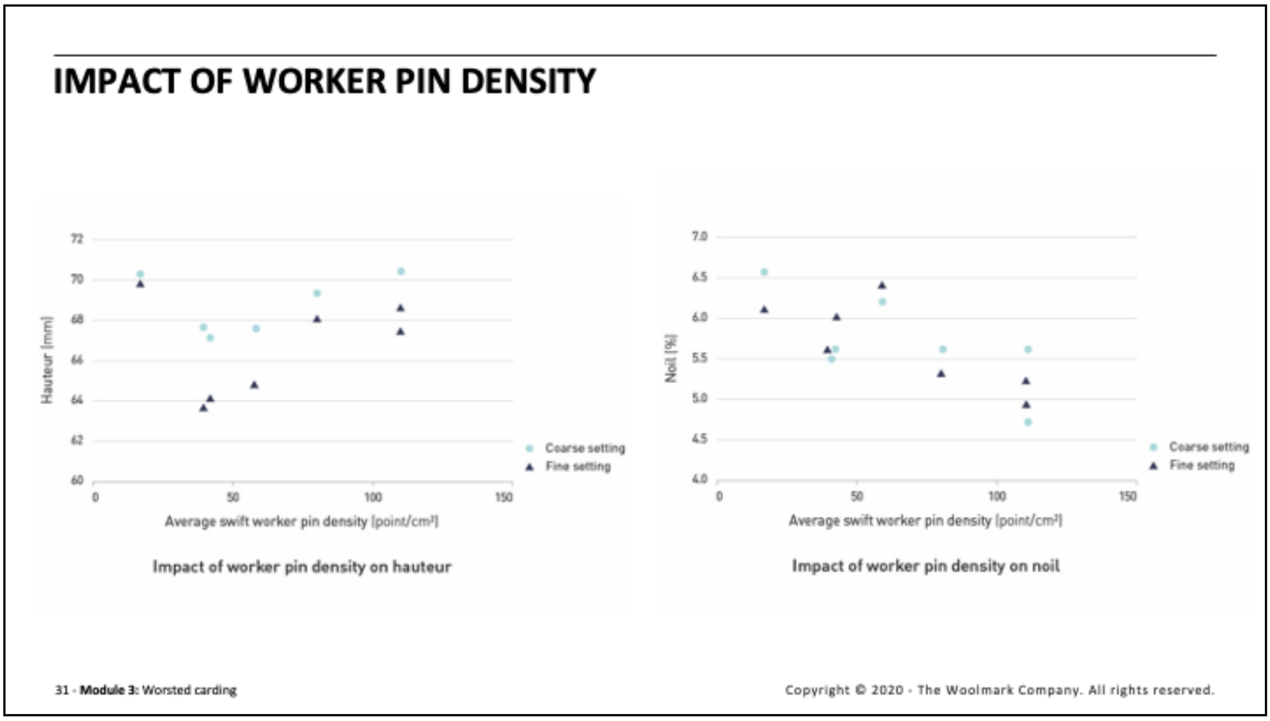
NOTE THAT today, most carding machines use metallic card clothing rather than traditional fillet. The trade-off is fibre length and nep generation versus ease of maintenance and card clothing wear.

POINT OUT that card clothing choice will depend upon wool types and quality levels required, and should be discussed with the card manufacturer and card clothing supplier.

EXPLAIN THAT high-efficiency doffer card clothing can improve the doffer stripping efficiency. This reduces the amount of recycled fibre on the swift, or main cylinder, and reduces fibre breakage. In turn this means longer fibre length in the top and less waste during combing

NOTE THAT the card typically breaks 30% or more of the wool fibres.

MENTION THAT a study using tracer fibres confirmed significant breakage of the fibres on the forepart of modern wool worsted carding machines.



INDICATE THAT worker pin density affects the efficiency of the card.

POINT OUT that using a 19.2µm fleece wool, trials in Australia on the role of average wire density on the workers showed that :

- as the worker pin density increased (became finer), the noil reduced
- nep counts in the card sliver followed a similar trend indicating finer pinning reduced the number of neps in the card sliver
- the results also showed that reducing the setting of the clearance between the workers and the swift generally resulted less noil, or produced little difference
- hauteur of the top decreases with closer setting, by about 2–3mm.

CARD CLOTHING — MAINTENANCE

Card clothing must be cleaned to remove
- wool wax and lubricants
- vegetable matter
- short fibre
- dirt and dust

Cleaning can be done using:
- a burnishing roller
- a vacuum fettling course

Rollers from a narrow-width card removed for cleaning

32 - **Module 3:** Worsted carding

EXPLAIN THAT some form of periodic cleaning of the card clothing is required to remove accumulated wool wax, lubricant, short fibre as well as dirt, or dust. Cleaning of cards is called 'fettling'… an old English word.

INDICATE THAT card clothing may be cleaned in one or a combination of the following ways:
- A burnishing roller can be used to polish the teeth of the card clothing, although some hard twigs and burrs may require removal by hand.
- Vacuum fettling courses can be used to maintain card clothing at peak cleanliness. The best system is to fit with a device that removes vegetable matter.

EXPLAIN THAT grinding of metallic card clothing is not generally recommended as this can be detrimental to the point profile.

NOTE THAT the best practice is to replace worn or blunt metallic card clothing.

COMPROMISES IN CARDING

	Positive	Negative
High fibre moisture content	Better static control	Poorer burr (VM) removal Increased neps
Efficient burr (VM) removal	Cleaner top	Greater fibre loss
Higher worker pin density	More open fibres	Increased fibre breakage
Faster roller speed	Higher production rate	Increased noil

33 - **Module 3:** Worsted carding

EXPLAIN THAT as in all processing operations involving wool, there are compromises to be made during the carding process.

INDICATE THAT the higher the moisture content of the wool fibre:

- the better the static control
- the worse the burr removal efficiency (burr removal efficiency comes with an increased fibre loss)
- the greater the chance of producing neps.

The more working points on the card, the greater the chance of breaking fibres.

NOTE THAT the faster the rotation of the main cylinder of the carding machine, the greater the production rate but the more chance of increased waste through fibres being thrown into the atmosphere.

SUMMARY — MODULE 3

The objectives of carding are to:

- disentangle the fibres
- remove vegetable matter
- initiate the alignment of fibres
- produce a rope-like sliver.

The key attributes of the raw material that impact the worsted carding process include:

- moisture content
- level of residual contamination.

The commercial carding machine achieves its various tasks through:

- Working — separating the fibre clumps and the fibres within these clumps.
- Stripping — moving wool from one roller to another.
- Raising —lifting the fibres on a cylinder to improve transfer.

34 - **Module 3:** Worsted carding

SUMMARISE the module by reinforcing the following points:

The objectives of carding are to:

- disentangle the fibres,
- remove vegetable matter
- initiate the alignment of fibres
- produce a rope-like sliver.

REITERATE THAT the processing conditions during carding are designed to :

- minimise the inevitable fibre breakage, which occurs as the scoured wool is disentangled
- minimise the frequency of fibre faults and nep (a small entanglement of fibre)
- maximise carding efficiency and profitability, while meeting product quality parameters.

REMIND participants that the key quality attributes of the input material that impact the worsted carding process include the moisture content of the scoured material and the level of residual contaminants.

Moisture content affects:

- fibre tenacity
- fibre-to-fibre and fibre-to-metal friction.

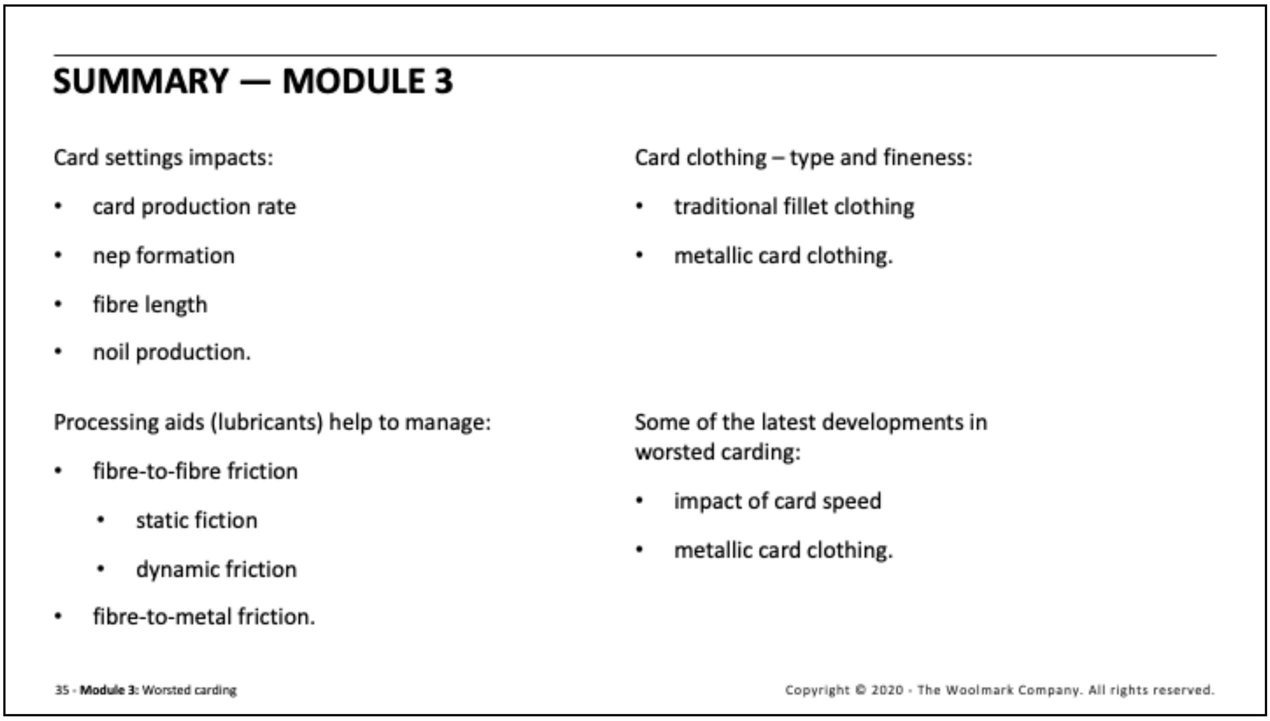
Moisture content is important for controlling fibre static (15-17% optimum).

The commercial carding machine achieves its various tasks through working, stripping and raising actions.

- Working — describes the separation of the fibre clumps and the fibres within these clumps.
- Stripping — describes the movement of the wool from one roller to another.
- Raising — describes the lifting of the fibres on a cylinder to improve transfer.

REMIND participants that the components of a card and their function are as follows:

- Feed rollers present the wool in a well opened, uniform wedge.
- The licker-in starts the separation of the fibre tufts.
- The first morel course removes vegetable matter especially burrs.
- The breast continues opening of tufts.
- A second morel course removes vegetable matter, especially burrs.
- The swift carries the wool to the working points.
- Workers open the micro-tufts of wool (in combination with the swift) to individual fibres.
- Strippers move the wool from the worker back to the swift.
- The doffer removes the wool web from the swift.
- The doffer comb removes the web from the doffer.



REVIEW the fact that settings within a carding machine are varied and complex, and have a lesser or greater impact on the result depending upon the nature of the setting.
Card settings impact:

- card production rate
- nep formation
- fibre length
- noil production.

REMIND participants that fibre processing aids (lubricants) are generally added to scoured wool during the blending process to reduce fibre-to fibre and fibre-to-metal friction and static. Adding lubricants during carding increases the length (hauteur) of the wool after combing and reduces noil (waste). A range of factors needs to be considered when selecting an appropriate lubricants.

REVIEW card clothing – type and fineness

- traditional fillet clothing
- metallic card clothing.

REVIEW some of the latest developments in worsted carding:

- impact of card speed on card production and top quality
- metallic card clothing.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 4: Drafting and gilling*— and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

MODULE 4

DRAFTING AND GILLING

RESOURCES — MODULE 4: DRAFTING AND GILLING

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 4: Drafting and gilling**:

- several lengths (1m) of card sliver
- sample of gilled sliver
- sample of worsted top

Additional resources to be sourced by the facilitator include:

- faller bar

WELCOME participants to Module 4 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making — Drafting and gilling*.

EXPLAIN THAT this module covers:

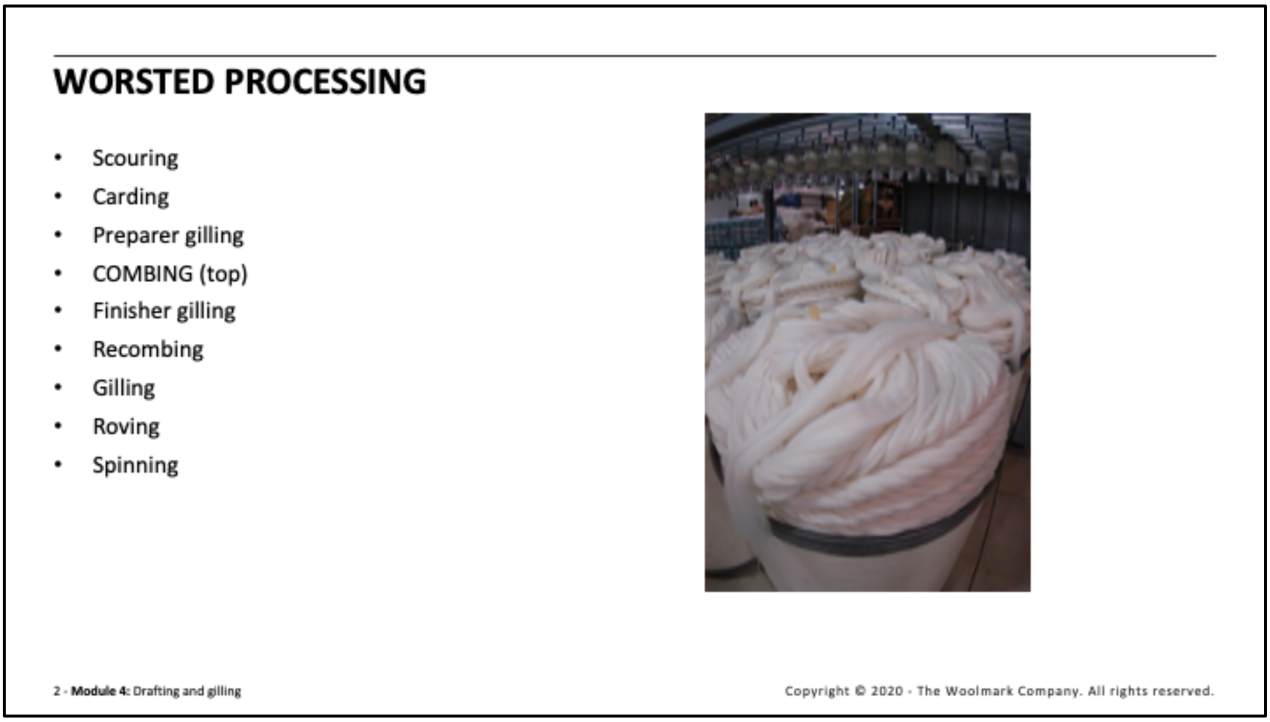
- the aims and practice of gilling operations
- the theory and mechanics of drafting wool in sliver form
- the types of gilling operations
- the mechanics of gilling using rollers and faller bars
- the issues associate with gilling
    - before combing and re-combing (preparer gilling)
    - after combing (finisher gilling).

INFORM participants that by the end of this module they will be able to:

- describe the aims of gilling
- describe the theory and mechanics of the drafting operation
- list the different types of gilling operations
- describe the mechanics of gilling using rollers and faller bars
- list the range of issues associated with gilling.

RESOURCES REQUIRED FOR THIS MODULE:

- *several one-metre lengths of card sliver*
- *sample of gilled sliver*
- *sample of worsted top*
- *faller bar (to be supplied by facilitator)*



EXPLAIN THAT this slide reviews the various stages in the worsted processing chain at which a sliver or top may be gilled or drawn.

NOTE the terminology used:

Preparer gilling before combing:

- aligns the fibres through the gilling head by drafting the sliver
- blends fibres through the doubling process (a number of slivers are fed into the gillbox and only one sliver emerges — a blend of all the input slivers).
- ensures an even weight per course length of sliver to facilitate setting of the combing machine
- ensures that hooks produced during carding are aligned the correct way (i.e. trailing position) to minimise breakage in the combing machine.

Finisher gilling after combing:

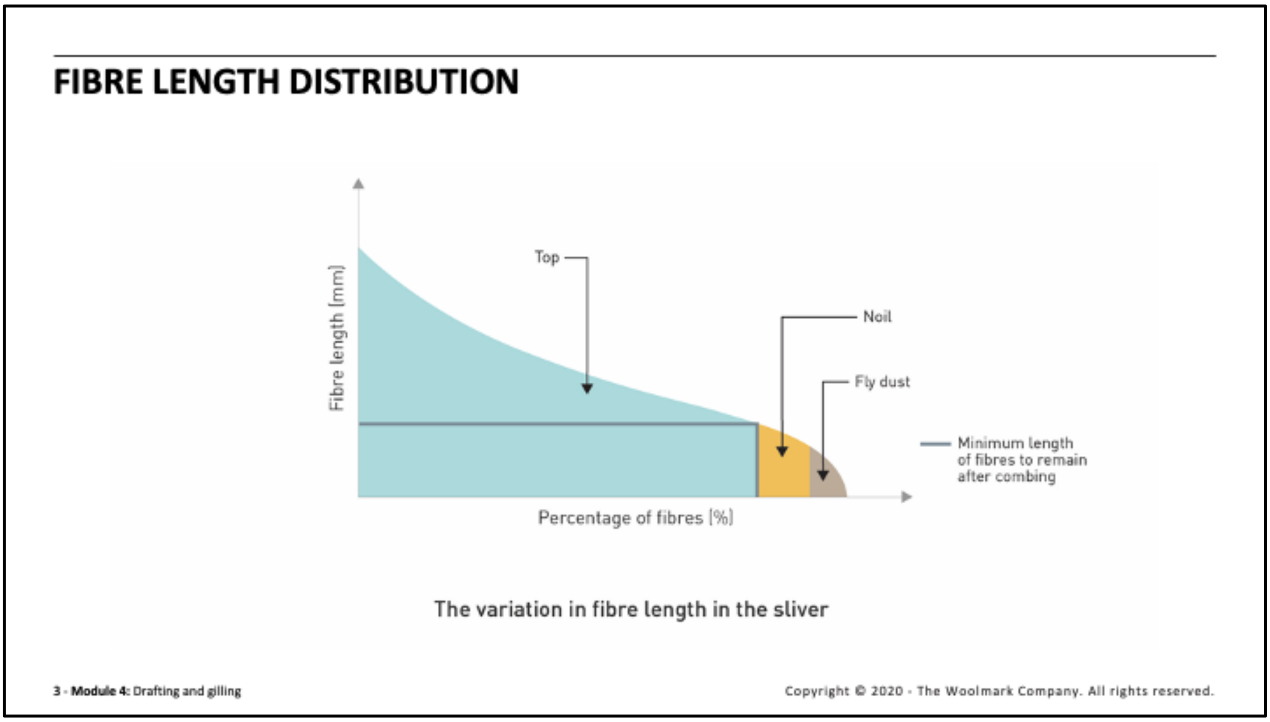
- realigns the fibres
- evens out the density of the combed top. The doubling helps to reduce any irregularity present in the input material or introduced by the comb or in the drafting process.

Gilling before roving:

- progressively thins the combed and re-combed top
- develops the correct sliver and roving linear density for optimum spinning
- drafts the strand by a larger amount than the number of input slivers

INDICATE THAT when the sliver is thick, the control of fibres is achieved using pins. As the sliver thins, better control is provided by balloon rollers and/or aprons.

EXPLAIN THAT a minimum of three and up to seven gilling stages are used in worsted processing. With careful selection of fibre loading, draft and pinning, neps and combing noil can be minimised.



NOTE THAT a card sliver contains fibres which vary greatly in length.

INDICATE THAT fibres in the card sliver now ready for gilling, can vary depending on fibre type and diameter from as short as 5mm to as long as 200mm.

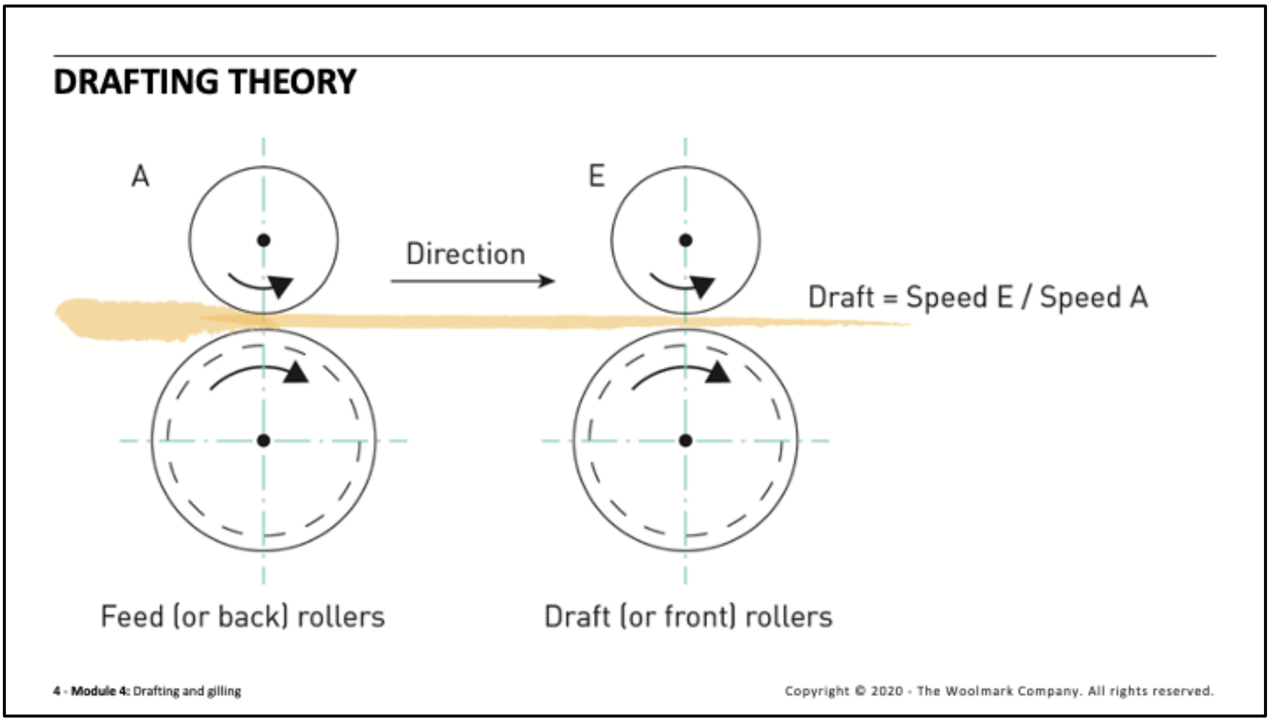
EXPLAIN THAT this variation makes the setting of the drafting components of the gill box challenging.

REFER participants to the hauteur diagram on the slide showing the amount of fibre of given length. The diagram illustrates the form of a fringe in which the fibres are all held at one end and laid side by side, evenly spaced and ranked from left to right from longest to shortest.

This shows the variation in fibre length in the sliver.

NOTE THAT after combing the:

- long fibres will remain in the top
- short fibres will be removed as noil
- very short fibres will be removed as ’fly dust’.



EXPLAIN THAT drafting is the term used for stretching the top, so that without doubling, the weight of the top would be reduced.

DEMONSTRATION: DRAFTING THEORY

Resources required:

- *One length of card sliver*

***STRETCH** the card sliver as you explain that this represents the 'drafting' process.*

NOTE THAT the basic system for drafting sliver consists of two pairs of rollers with different surface speeds.
The material passes from the slower-moving feed rollers to the quicker-moving delivery (or draft) rollers:

- The first pair (A) called feed or back rollers, has a speed 'SA'.
- The second pair (E) called draft, delivery or front rollers has a speed 'SE', which is faster than 'SA'.
- The speed ratio SE/SA = the amount of 'draft' applied by the system.

POINT OUT that the bottom rollers are positively driven, while the top rollers are friction driven against the wool sliver.

EXPLAIN THAT the pressure on the top roller is applied against the wool sliver, either by their own weight, or by mechanical means (springs, weights, pneumatic or hydraulic pressure). The role of this pressure is to ensure a nip strong enough to make the fibres move either at the speed of the back rollers or at that of the front rollers without unwanted slipping within the fibre strand. The pressure applied to the top rollers must be adjustable according to material type, sliver weight, draft and speed of the rollers.

The bottom rollers are generally fluted in various manners, generally helically for the draft roller, to assure proper grip.

The top rollers are covered with soft synthetic rubber.

The grip of the front rollers must be adjusted in such a way that the fibres are pulled at the same speed of these front rollers as soon as they are gripped by them.

NOTE THAT the distance between the two gripping points must be bigger than the length of the longest fibres in order to avoid fibre breakage.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the gilling process. Following the video we will look at the gilling process step by step.

PLAY *video (~46 seconds)*

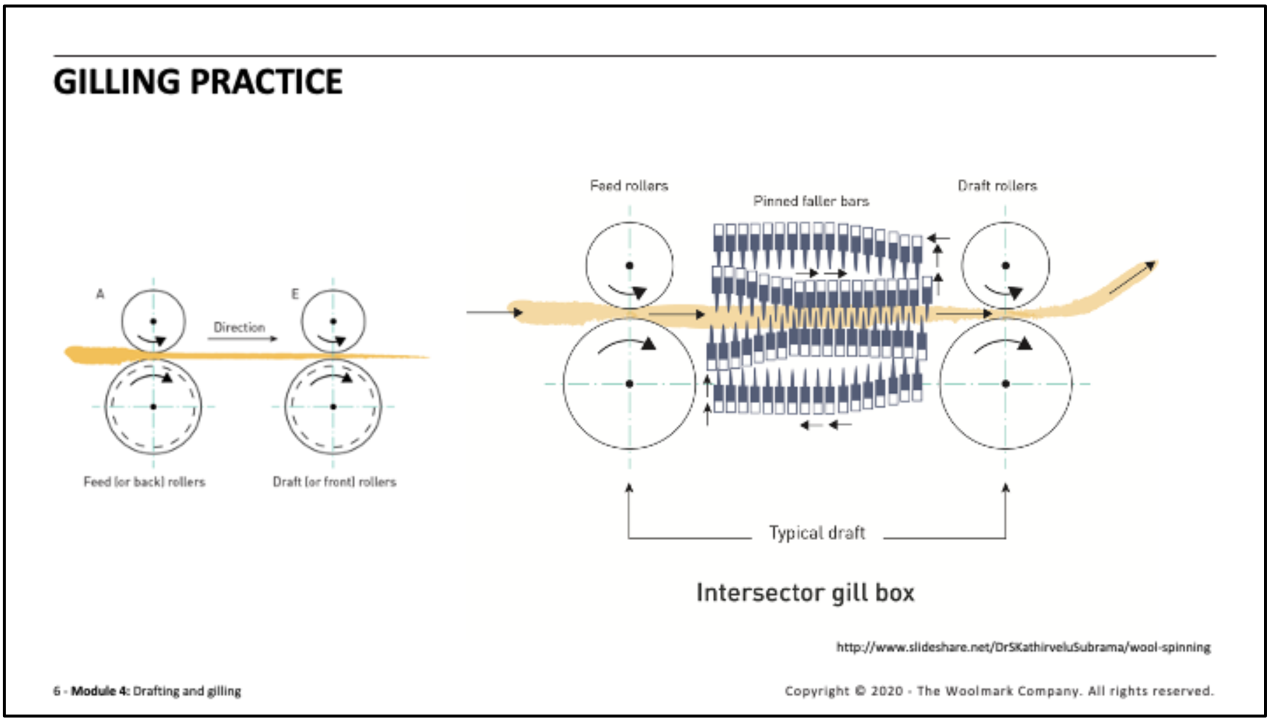
AS THE *video plays note that:*

- *the sliver from the card is gilled a number of times.*
- *the sliver is normally fed from a can (8:30 seconds)*
- *a number of slivers are fed into the machine (16:00 seconds)*
- *the fibres being controlled by pinned bars, called faller bars. Note that the faller bars move at the same speed as the input roller (21.00 seconds).*
- *the gilling machine straightens the fibres by drafting and blends by doubling (22:30 seconds)*
- *one sliver emerges from the gill box (33:00 seconds).*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

HAND OUT *samples of gilled sliver and worsted top as you explain that the sliver is the result of the gilling process and the top is the final result from top-making.*



POINT OUT that in practice, a simple drafting system, as discussed previously, would only be suitable for rather short fibres with a consistent length.

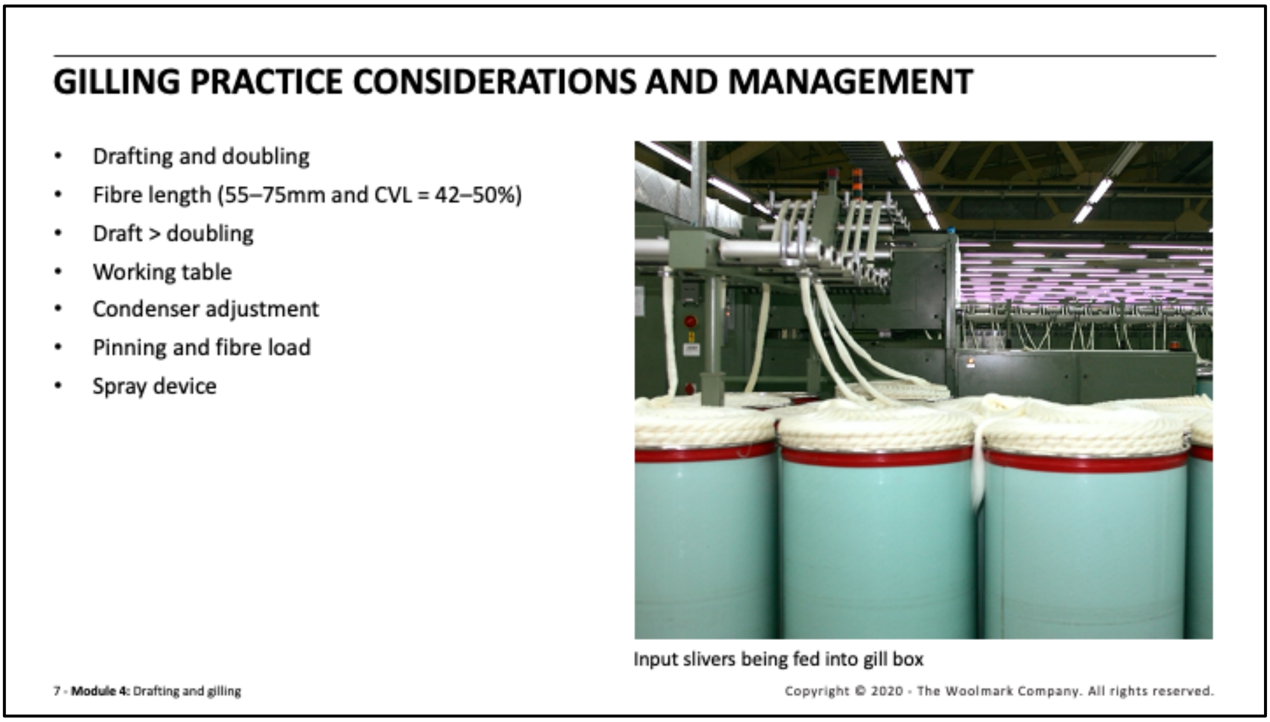
EXPLAIN THAT to avoid breaking fibres, the distance between the two pairs of rollers must be at least equal to the longest fibres. Most of the fibres, and especially the short fibres, are left in the draft zone located between the two pairs of rollers.

POINT OUT that these fibres are called 'floating fibres' and can be dragged away by longer fibres before they reach the front roller (i.e before it is their turn) before their heads have been gripped by the draft rollers' nipping point. This is chiefly because the floating fibres are in contact with fibres already moving at front-roller speed, and are influenced to move by these faster-moving fibres.

INDICATE THAT in this situation, the uncontrolled fibres move away in batches, which results in an uneven sliver. To remedy this, it is necessary to control the floating fibres, keeping them at the feed roller speed and prevent them from moving at the draft roller speed before they are gripped by the front roller.

EXPLAIN THAT this is achieved by means of supporting and controlling elements such as:

- faller bars (pinned bars) used in gill boxes and finishers.
- porcupine combs or pinned disks, used in gill boxes and rubbing frames
- intermediate supporting rollers
- a simple apron underneath the fibre strand, fitted with floating rollers above the fibre strand:
    - These rollers can be self weighting or have a light pressure applied.
    - This is used in roving and spinning frames
- double aprons:
    - The fibre strand passes between the apron pair.
    - These systems of fibre control in drafting are commonly found high-draft rubbing frames and spinning frames.



EXPLAIN THAT the other major function of the gilling operations is to increase the evenness of the sliver (regularity of the fibre mass per course length). This is achieved by feeding the gill box with a large number of slivers, which are simultaneously drafted to form a single output sliver.

It is best practise for the draft in the gill box to exceed the number of 'doublings', so there is a net reduction in sliver weight. The reductions in sliver weight are small in pre-comb gilling, but increase in operations after combing.

DEMONSTRATION: DRAFTING AND DOUBLING

Resources required:

- *Several lengths of card sliver*

TAKE *several slivers and stretch them together as you explain that this is represents the drafting and doubling process.*

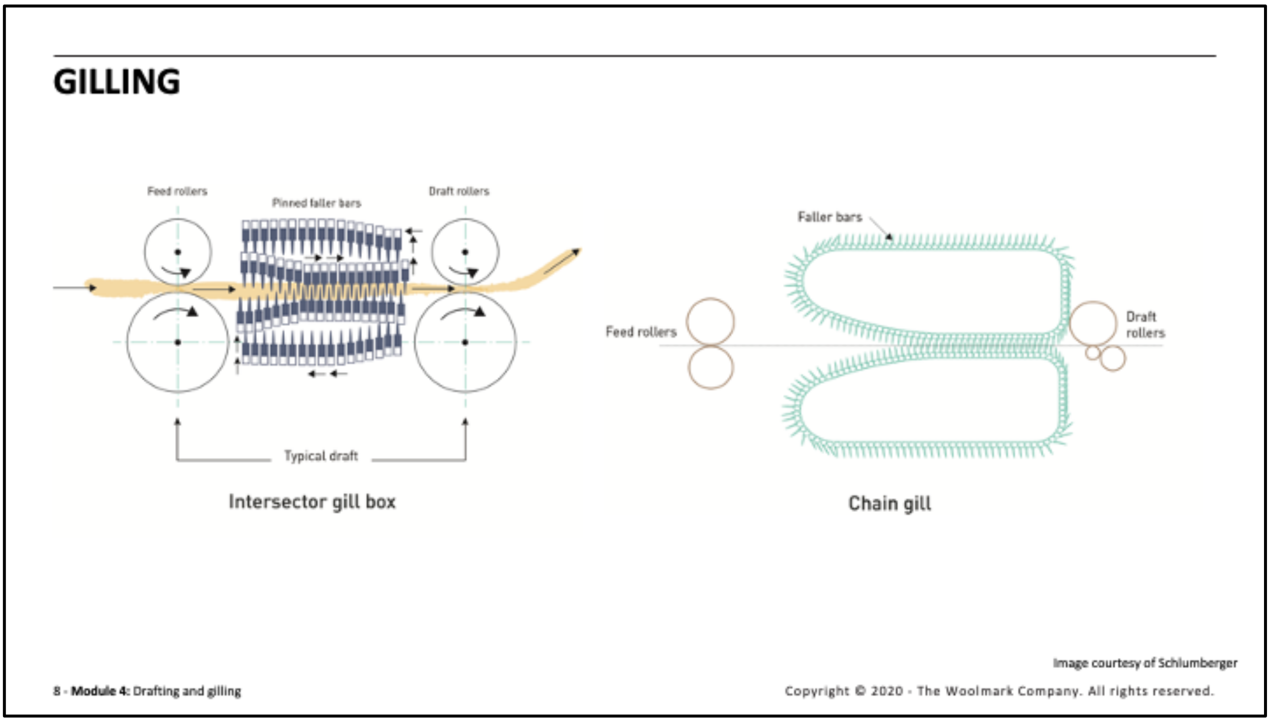
NOTE THAT fibre length properties among wool types (fine and broad) vary considerably and so the settings of the gill box are altered to optimise drafting outcomes.

EXPLAIN THAT to manage and control the process, optimum settings are recorded to provide a reference for when the same wool type is processed in the future.

MENTION THAT condensers are carefully adjusted to minimise fault formation at the edges of the feed and delivery material.

INDICATE THAT the load of fibres on the pins must be considered, as 'overload' can lead to faults being generated, while insufficient load reduces productivity.

EXPLAIN THAT the position and operation of the spray device for lubricant or moisture application also needs to be carefully considered so that it facilitates rather than interferes with the drafting/doubling actions.



EXPLAIN THAT prior to the 1980s, most pre-combing gilling operations used the intersecting faller type gill box. In this machine, the fibre drafting zone is controlled by two sets of intersecting pinned faller bars (rows of pins), driven by either screw, chain or rotary slot devices.

***PASS** around a faller bar to participants in the group.*

***ALLOW** participants time to observe the faller bar closely.*

***EXPLAIN THAT** the faller bar controls the fibres in the gill.*

NOTE THAT conventional screw-driven intersector gills operate at about 2000 faller drops per minute with feed speeds of 20–25 m/min.

EXPLAIN THAT in more recently-developed chain and rotary gills, the faller bars are driven in a continuous fashion using tracking mechanisms to orientate the pins at insertion into, and withdrawal from, the fibre mass. Input speeds are up to three times faster than those of the traditional screw gill.

NOTE THAT for chain gills, 50% of the fibres must be longer than 50mm, which includes about 70% of worsted slivers.

EXPLAIN THAT most gilling machines – screw, chain or rotary – have a similar layout:

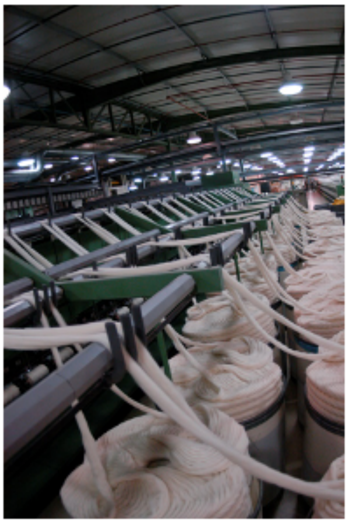
- a creel for assembling the slivers to be processed
- a pair of feed rollers
- an intersecting head to control fibres drafted
- a pair of draft (or delivery) rollers
- a can coiler or sliver balling device for packaging the processed sliver.

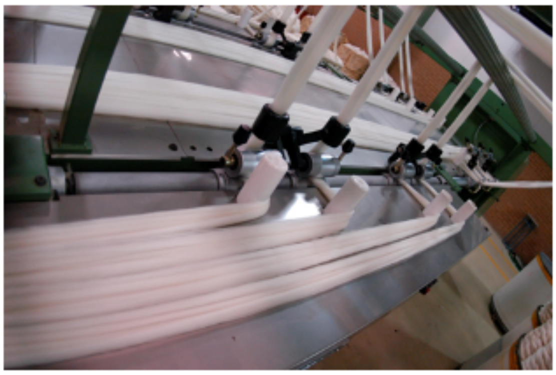
REFER TO the image on the slide, which shows the top of a chain gill.

NOTE THE pinned bars, which are connected to a chain drive on each side of the box.

EXPLAIN THAT the visible bars move left to right.

GILLING – TRADITIONAL INTERSECTOR TYPE





The creel (at left) showing the creel rollers (at right)

10 - **Module 4:** Drafting and gilling

EXPLAIN THAT the creel consists of a table down each side of the gill box, on which a number of creel rollers are driven from a common point. Each roller incorporates a detector that stops the machine when a running end (input sliver) finishes. These rollers feed the input slivers (normally six or eight) to the rear or feed rollers.

Feed rollers

The feed rollers rotate slightly faster than the creel rollers, to apply tension on the input slivers.

Faller bars

As the fibre mass (slivers) emerge from the feed rollers, the faller bar pins of the intersecting gill head push into the sliver mass. When the pins are first thrust into the sliver, the feed (rear) rollers are still gripping the fibres. The bars move forward at an even speed with the fibres, which controls the acceleration of the fibres between the feed (rear) and delivery (front) sets of rollers.

Delivery rollers

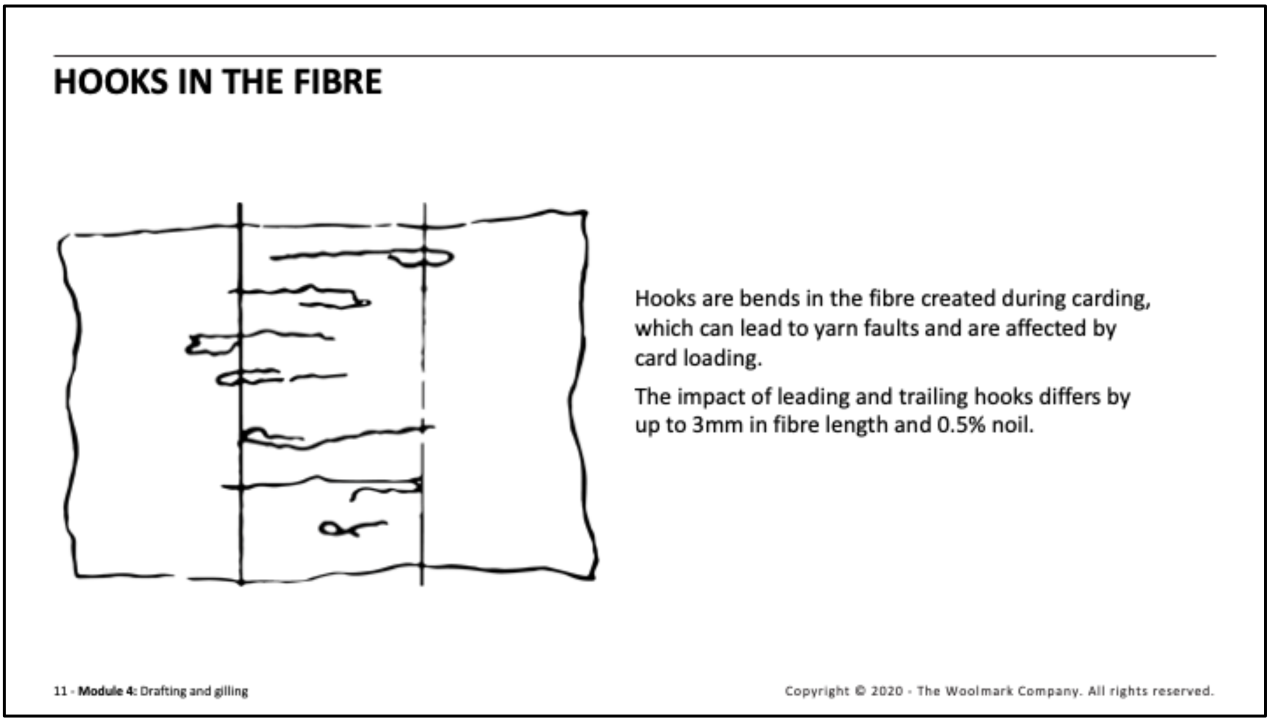
The delivery (front) rollers pull the fibres faster than the pins are moving, effectively pulling the fibres through the pins to create a combing and straightening effect.

NOTE THAT a speed differential of six or eight to one between the feed (rear) and delivery (front) rollers imparts the required attenuation, or drafting.

EXPLAIN THAT the ratio of the front roller speed to the back or feed roller speed is termed the draft. The maximum feed roller speed on modern gill boxes is 90 metres per minute and delivery speeds can be as high as 450 metres per minute.

From the front rollers, a single sliver comes out of the gill box and is packaged for the next operation.

POINT OUT that it is normal for a variety of wool types to have three gill passages between the wool worsted carding machine and the wool combing machine.

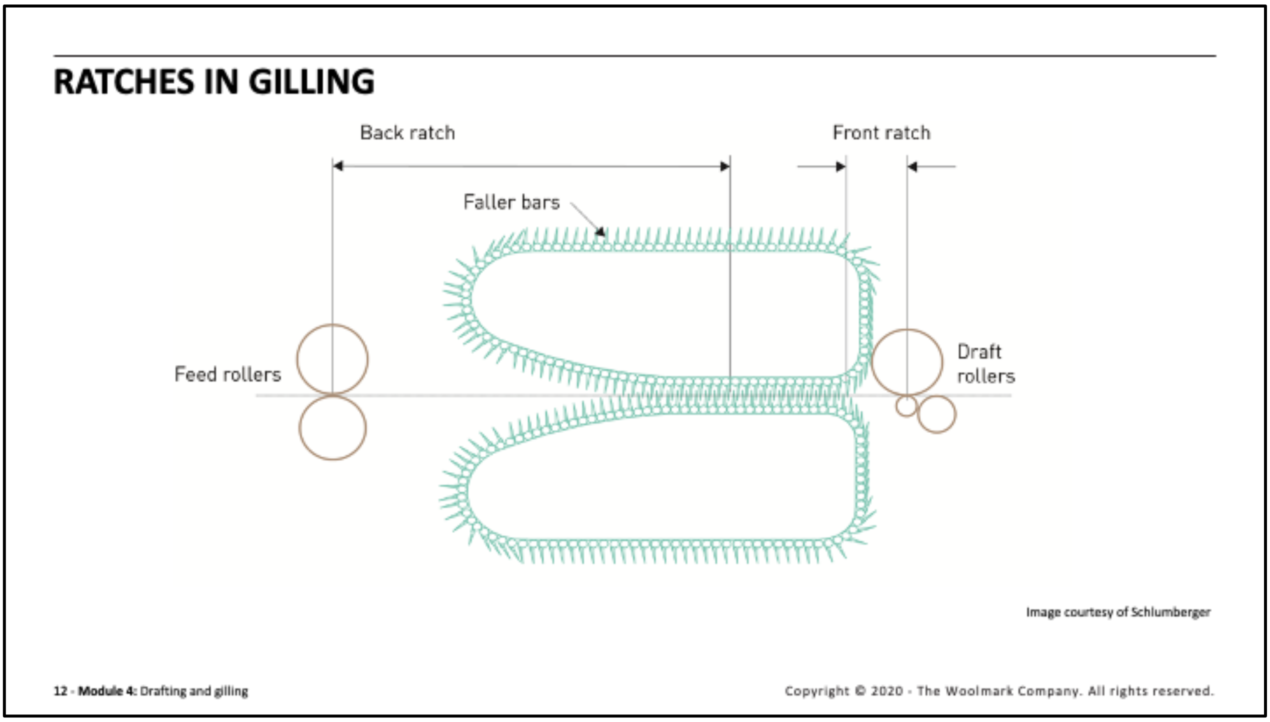


EXPLAIN THAT a ‘hook’ is a bend in the fibre, which is created during carding by the action of the card clothing wire on the wool fibre mass. The friction of the fibre being pulled past the wire creates the bend (hook) at one end of the fibre.

INDICATE THAT if this fibre is presented to the combing machine with its hook in the leading position, the fibre is likely to break. If the fibre is presented in the trailing position, it is likely to be straightened. The difference could be up to 3mm in average fibre length and 0.5% noil.

EXPLAIN THAT because the sliver is reversed in direction at each gilling operation, an odd number of gilling operations will ensure the ‘hooks’ trail into the combing machine.

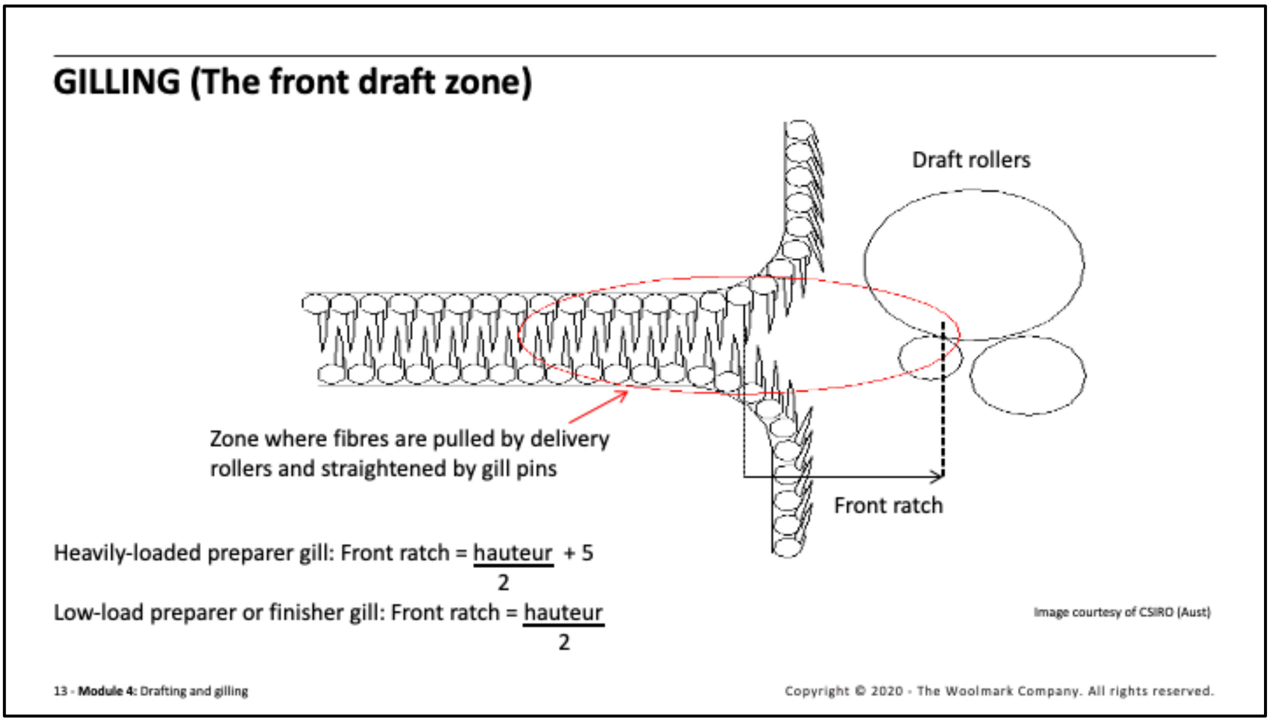
POINT OUT that although there is a great deal of science in the measurement of ‘hooks’ and their effect on top length and waste, some processors do not consider it important.



NOTE THAT the distance from the nip of the feed rollers to the point of control by the faller bars is known as the 'back ratch'.

The distance from the nip of the front draft roller to the exit or delivery point of the draft control mechanism is known as the 'front ratch'.

EXPLAIN THAT this distance is adjustable, within a limited range, depending on the average fibre length, variation in fibre length (CVH) and the cohesion between fibres in the sliver being processed.



EXPLAIN THAT wools of different quality and types will not run identically on the same machine settings. It is not simple to determine the exact setting of the front rollers to achieve optimum gilling performance.

POINT OUT that the gauge on a gill box measures the distance between the draft rollers and the faller bar or pin bed at its closest approach. The distance of influence of the fibres exiting the pins varies depending upon

- the fibre properties
- the draft
- the pinning geometry
- the fibre loading.

INDICATE THAT these factors have to be taken into account when selecting the draft levels and associated settings for the machine.

EXPLAIN THAT fibre length plays an important role in drafting — longer, coarser wools can be run at a higher draft than short, fine Merino fibre. The fibre length is also critical in deciding the front ratch.

NOTE THAT it is usual practice to adjust the front ratch on most gills to half the average fibre length (hauteur), which should be regarded as the maximum for effective fibre control. For example, a 65mm hauteur = 32.5mm front ratch.

____

***ASK** participants if they know why the front ratch is less than the hauteur.*

***IF NECESSARY** explain that the front ratch is less than the hauteur to control the short fibres.*

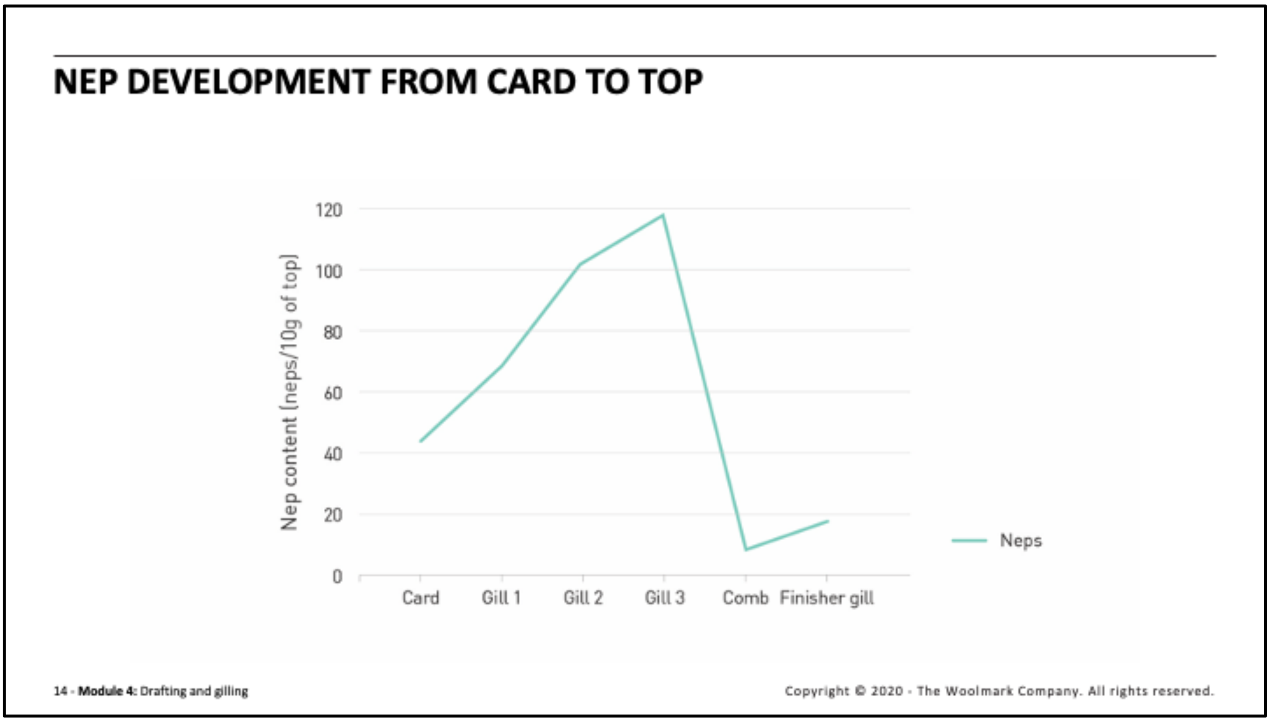
____.

If the loading is high on pre-comb gilling (preparer) then 5mm can be added (37.5mm).

EXPLAIN THAT however, as drafting proceeds it is best practice to tighten the setting on the later gills to better control fibre movement.

POINT OUT that for finisher gills, or preparer gills with a lower loading, the setting used is half the hauteur. This can be further tightened in the later finisher gillings.

NOTE: When producing short blends (i.e. <50 mm long), or conventional wool with a high variation of fibre length, this distance becomes critical.



POINT OUT the general picture for nep development during carding, gilling and combing is outlined on the slide.

NOTE THAT as seen in the graph, the various gilling processes significantly increase the nep content, while combing removes neps. However, nep removal at the comb is achieved at the expense of a cost penalty to the business through the production of noil (waste).

EXPLAIN THAT while the comb sliver is often nep free, neps usually increase again during post-comb (finisher) gilling. The finer the wool, the larger this effect.

INDICATE THAT an important question is whether the nep generated during gilling is caused by the gills themselves, or is it the structures in the card web that lead to neps as the web is drawn out in the gilling machine?

EXPLAIN THAT experiments with carding and combing top (untangled fibre) reveal it is the fibre arrangement in the card web that is the major culprit in neps being generated during gilling operations.

EFFECT OF THE NUMBER OF PREPARER GILLINGS ON COMBING NOIL AND NEPS

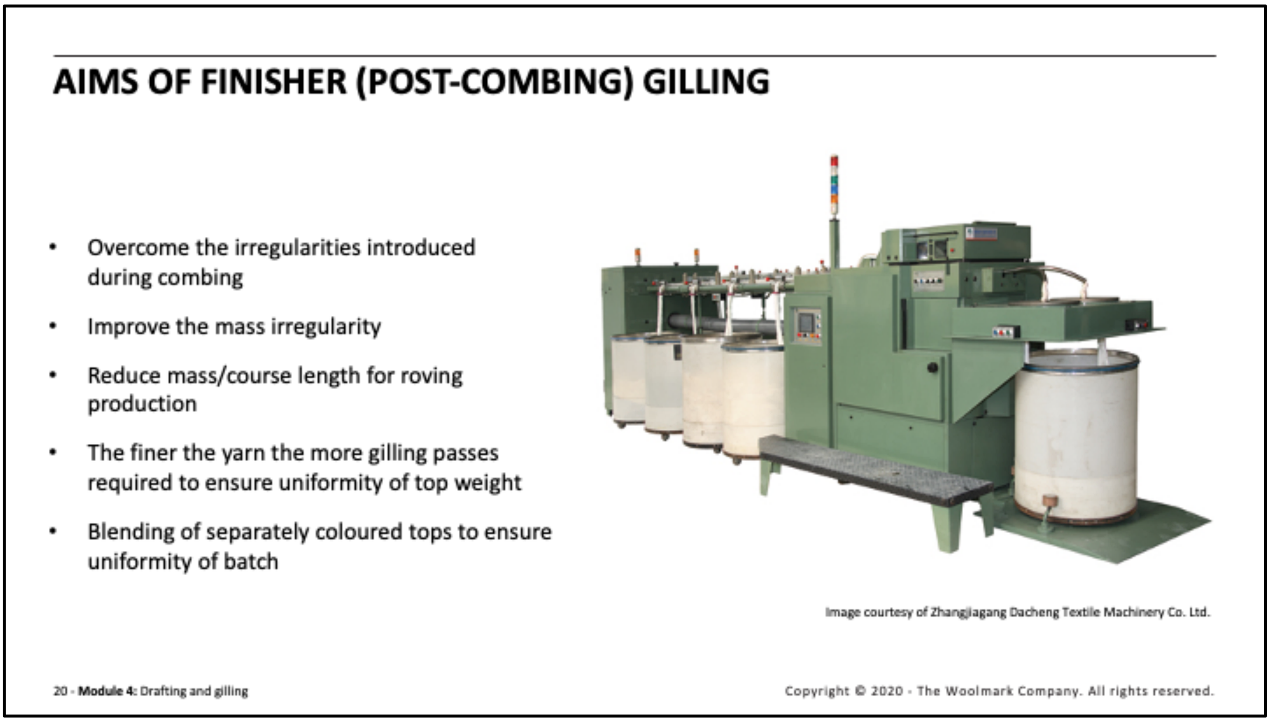
Number of gillings	0	1	2	3	4	5	6	7
Combing noil (%)	14.6	12.1	10.8	10.1	9.6	9.3	9.0	8.8
Total neps in top/100g	12	19	21	20	18	22	27	29

15 - **Module 4:** Drafting and gilling

POINT OUT that it is well established that combing noil (waste) is reduced as the number of gilling stages before combing increases (see the table on the slide).

EXPLAIN THAT for optimum economics the industry has judged three gillings to be sufficient, even though one extra gilling typically reduces noil by approximately 0.5%.

NOTE THAT unless a cost-effective way is found to improve the alignment of fibres before combing, current industry practice is unlikely to change.



POINT OUT that after combing, the delivered sliver needs to be gilled again (called finisher gilling) and doubled several times avoid unacceptable high mass irregularity imposed by the action of the comb. The fibre ends aligned during the combing action must be randomised.

EXPLAIN THAT several passages of finisher (post-combing) gilling are required to improve the regularity in the combed top for the production of an acceptable yarn.

NOTE THAT the additional drafting process also allows accurate control over the mass per course length of the top to meet the specification required by the yarn manufacturer. This may involve reducing the weight of the top to meet the requirements of roving — often the first stage of yarn production.

MENTION THAT production of finer yarn may require more finisher gilling passes to ensure adequate uniformity of top weight.

EXPLAIN THAT finisher gilling also offers an opportunity to blend differently-coloured tops (for multi-coloured yarns) to ensure even colour uniformity in the final yarn.

GILL BOX PINNING RECOMMENDATIONS

Fibre diameter (µm)	17	18	19.5	21	22	23	25
Preparer gill 1	3.5 R	3.5 R	3.5 R	3.5 R	3.0 R	3.0 R	2.5 R
Preparer gill 2	4.0 F	4.0 F	4.0 F	4.0 F	3.5 R	3.5 R	3.0 R
Preparer gill 3	5.0 F	5.0 F	5.0 F	5.0 F	5.0 F	5.0 F	5.0 F
Following the combing operation							
Finisher gill 1	5.0 F	5.0 F	5.0 F	4.5 F	4.5 F	4.0 F	4.0 F
Finisher gill 2	6.0 F	6.0 F	6.0 F	5.0 F	5.0 F	5.0 F	5.0 F

R- Round pins F- Flat pins

17 - **Module 4:** Drafting and gilling

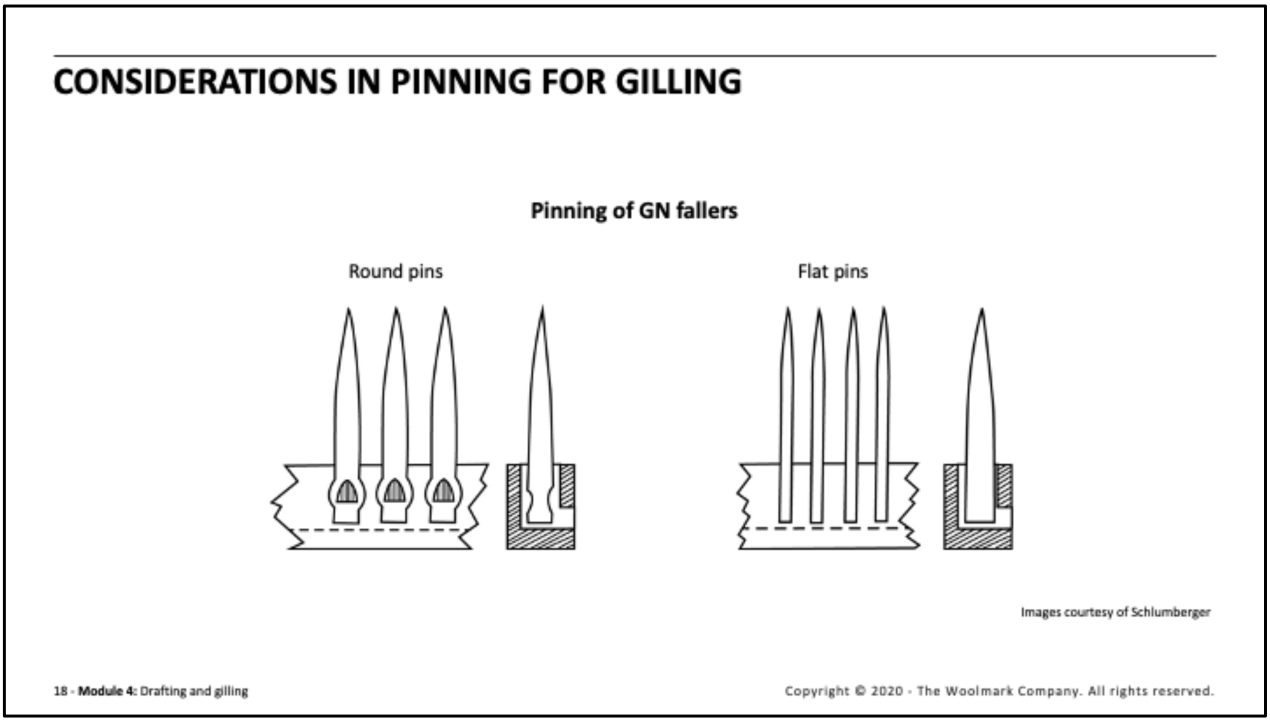
INDICATE THAT the pinning arrangement used during preparer gilling is determined by:

- the fibre properties
- the draft control mechanism
- the productivity balance required.

REFER participants to the table on the slide showing the recommended pinning for preparatory and finisher gilling.

EXPLAIN THAT in preparer gills, pinning used is reasonably stable, with a set of recommendations for wools with an average fibre diameter of 17–21µm and another set of recommendations for wool with an average fibre diameter of 22–25µm.

NOTE THAT in finisher gilling (post combing), which is more critical, the pinning arrangement varies more to suit the particular needs of the different wool characteristics.



POINT OUT that as outlined on the previous slides, to maintain fibre control, pinning density should increase with the fineness of wool and lighter machine loading.

INDICATE THAT additional factors to consider when selecting the pinning arrangement on any particular machine include:

- number of pins/course length
- pin number = gauge
- pin length = total length of pin
- projection = the extent to which the pin extends from the bar
- pitch = distance between pin tips
- free space (FS) between pins
- total free space (TFS) per centimeter – sum of free space between pins over 1cm.

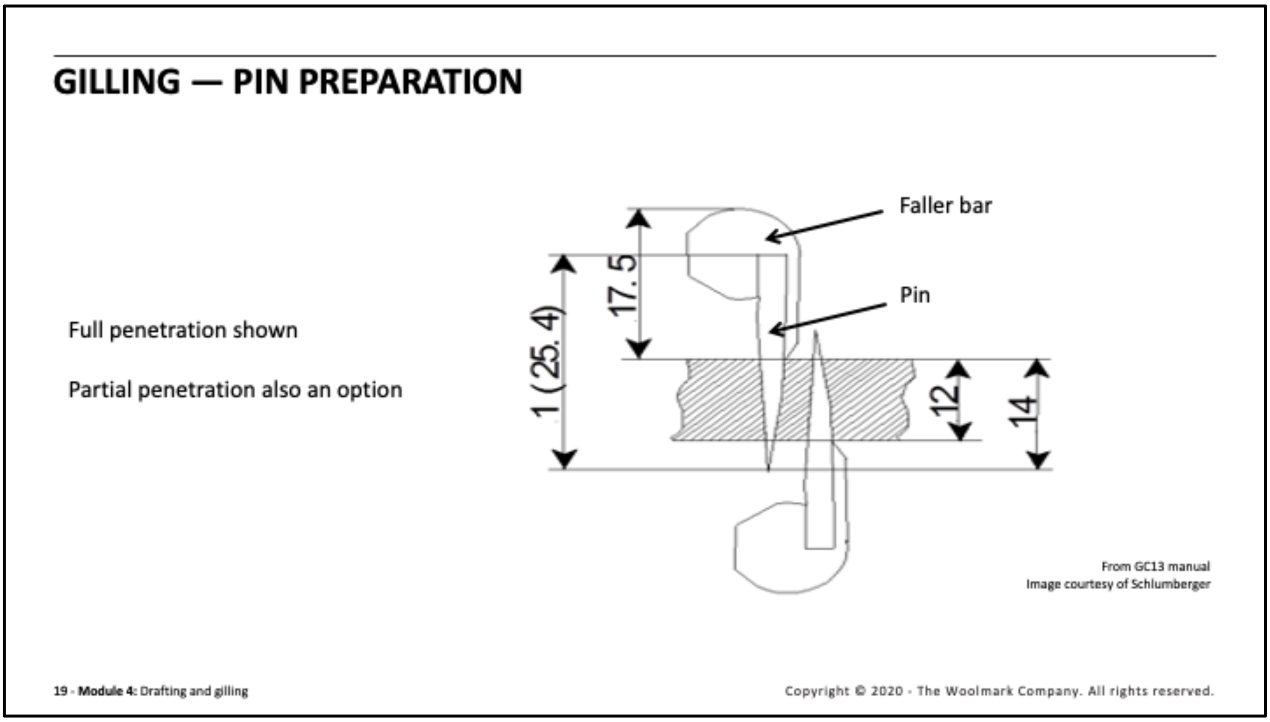
Free space and total free space

For any material, total free space (TFS) should remain a constant throughout the successive gilling operations. Free space (FS) should decrease as the fibres become more parallel (i.e. the pins will be finer and closer together).

EXPLAIN THAT as illustrated on the slide, pins are available in two forms — round and flat. This can cause problems in defining the pin geometry in a gilling set. For example, most operators are unaware of the fact that a round pin of size 16 has a diameter of 1.63mm while a flat pin of size 16 has a thickness relevant to a spacing calculation corresponding to a size 22 pin.

In other words, a width of only 0.79mm.
The most frequent mistake is to replace a faller bar with round pins with a bar having flat pins both having the same pinning density, namely pins/cm.

NOTE THAT there also needs to be communication between equipment suppliers and users so this issue is managed appropriately.



EXPLAIN THAT depending on the stage of manufacture, the types of material, and associated needs, gilling pins may have :

Full penetration: For 1/1 (i.e. full) penetration of the fibre during the gilling process, the pitch of the faller bars (distance between the pins on successive faller bars) is reduced to 12mm, and flat pins (with four to eight flat pins/cm) can be used.

Partial penetration: Partial penetration of the sliver usually indicates penetration of only 1/3 of the fibre, to minimise fibre damage when the fibres are less well aligned. For 1/3 penetration, round pins at three or four pins/cm are used, which results in a distance between fallers of 20mm.

AIMS OF FINISHER (POST-COMBING) GILLING

- Overcome the irregularities introduced during combing
- Improve the mass irregularity
- Reduce mass/course length for roving production
- The finer the yarn the more gilling passes required to ensure uniformity of top weight
- Blending of separately coloured tops to ensure uniformity of batch

Image courtesy of Zhangjiagang Dacheng Textile Machinery Co. Ltd.

20 - **Module 4:** Drafting and gilling

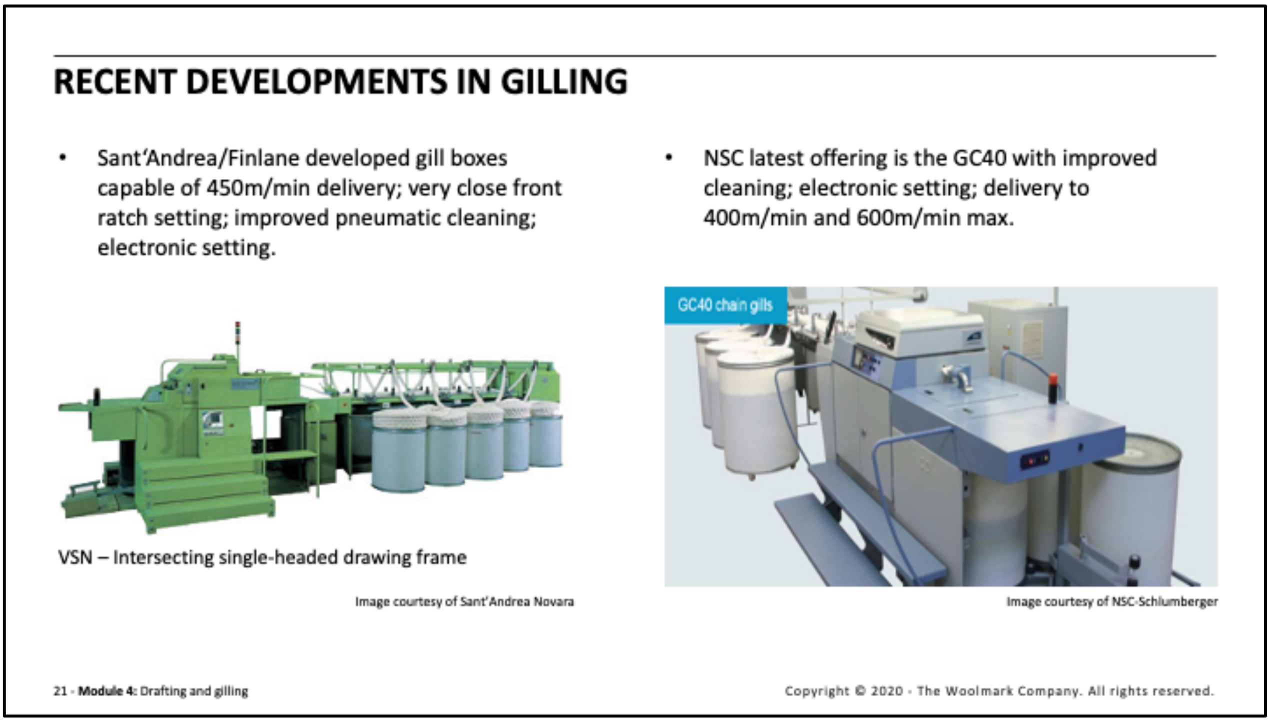
POINT OUT that after combing, the delivered sliver needs to be gilled again (called finisher gilling) and doubled several times avoid unacceptable high mass irregularity imposed by the action of the comb. The fibre ends aligned during the combing action must be randomised.

EXPLAIN THAT several passages of finisher (post-combing) gilling are required to improve the regularity in the combed top for the production of an acceptable yarn.

NOTE THAT the additional drafting process also allows accurate control over the mass per course length of the top to meet the specification required by the yarn manufacturer. This may involve reducing the weight of the top to meet the requirements of roving — often the first stage of yarn production.

MENTION THAT production of finer yarn may require more finisher gilling passes to ensure adequate uniformity of top weight.

EXPLAIN THAT finisher gilling also offers an opportunity to blend differently-coloured tops (for multi-coloured yarns) to ensure even colour uniformity in the final yarn.

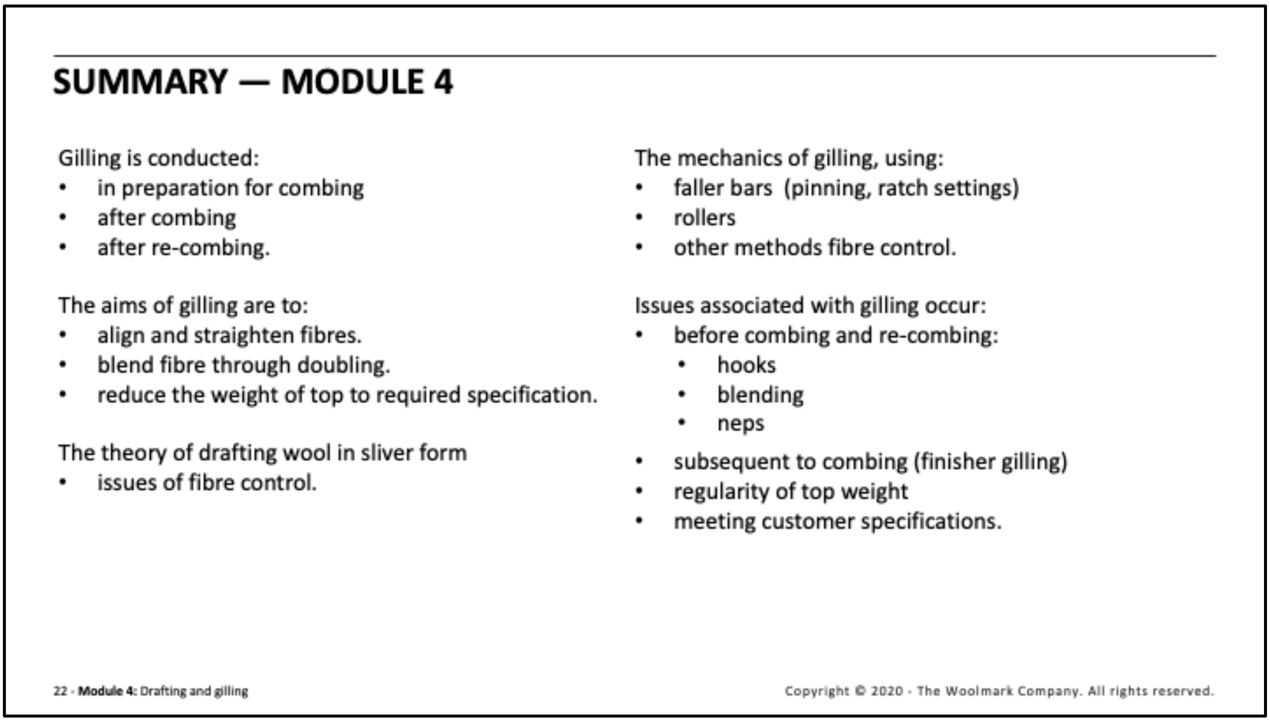


INDICATE THAT the general aim in the development of improved gilling machines has been to:

- increase productivity through increased speed
- simplify design allowing less downtime during batch changes
- reduced maintenance.

EXPLAIN THAT as outlined with the examples of recent gilling machine developments on the slide, newer machines feature:

- 450–600m/min delivery;
- very close front ratch settings
- improved pneumatic cleanings
- electronic settings.



SUMMARISE the module by reinforcing the following points:

Gilling is carried out:

- in preparation for combing (preparer gilling)
- after combing (finisher gilling)
- after re-combing and before roving (again called finisher gilling).

REVIEW the aims of gilling and drafting are to:

- ensure fibres are parallel and straightened
- enhance blending of the wool by doubling
- control the weight of top to meet the required specification

REMIND participants that successful drafting of wool in sliver form involves controlling the fibre between the input and output rollers.

REITERATE THAT fibre control during gilling is achieved using:

- faller bars (pinning, ratch settings)
- rollers
- other methods (e.g. aprons) not included in this talk can be found in some machines.

REMIND participants that the key issues associated with gilling occur:

- before combing and re-combing (preparer gilling) and include:
    - management of hooks formed during carding (odd numbers of gillings are often used to reduce the impact of hooks formed during carding)
    - ensuring adequate blending.
    - mininising nep formation
- subsequent to combing (finisher gilling) to:
    - ensure regularity of top weight
    - adjust top weight to meet the customer specifications.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 5 Combing* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

MODULE 5

THE WOOLMARK COMPANY

COMBING

RESOURCES — MODULE 5: COMBING

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 5: Combing**:

- sample of combed sliver
- sample of worsted top
- coarse comb
- fine comb
- bag of combed noil

WELCOME participants to Module 5 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making — Combing*.

EXPLAIN THAT this module covers:

- the aims of combing
- the factors that affect the combing operation
- the important settings and maintenance issues to ensure high-quality combing including:
    - pinning of the combs
    - fibre loading
    - combing speed
- the aims of finisher gilling.

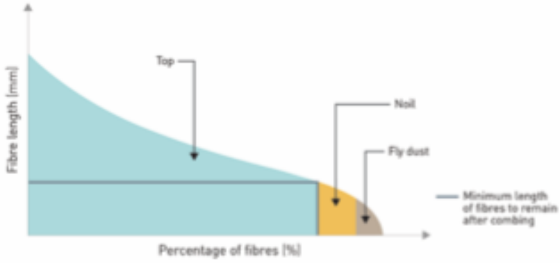
INFORM participants that by the end of this module they will be able to:

- describe the aims of combing and operation of the comb
- outline the key factors affecting the operation of the comb
- describe the impact of the combing conditions on top quality
- outline the role of finisher gilling.

RESOURCES REQUIRED FOR THIS MODULE:

- *sample of combed sliver*
- *sample of worsted top*
- *coarse comb*
- *fine comb*
- *bag of combing noil*

COMBING



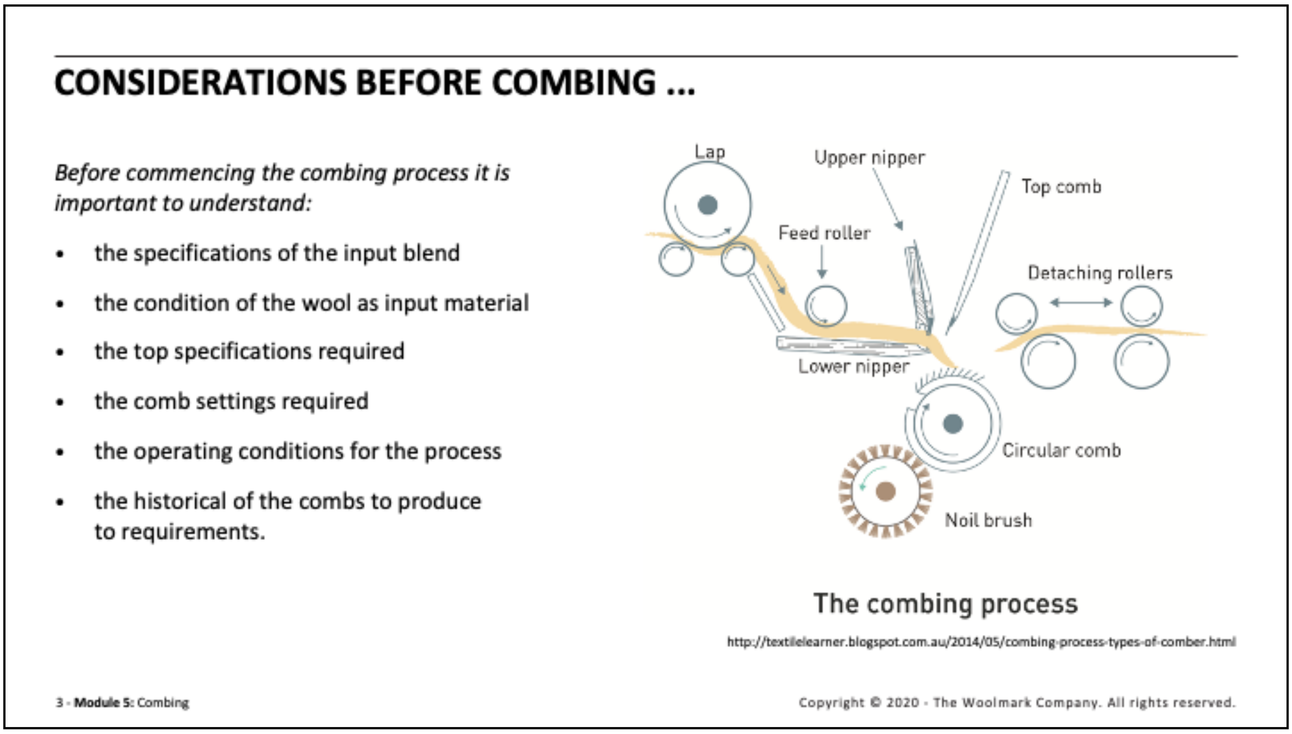
The variation in fibre length in the sliver

2 - **Module 5:** Combing

EXPLAIN THAT combing is at the centre of the worsted processing route, for it is during combing that:

- the fibres receive their final alignment
- remaining vegetable matter is removed
- neps (small entanglements) produced during carding or developed during gilling, through the tightening of structures in the slivers, are removed
- fibres shorter than a nominated length, which cannot be adequately controlled during spinning, are removed as noil (waste)
- the fibres are formed into top suitable for further drafting and spinning.

NOTE THAT combing has a critical role to play in downstream processing efficiency and in the quality of the subsequent yarn and final wool product.



EXPLAIN THAT before commencing the combing process it is important to understand.

- the specifications of the input blend
- the condition of the wool as input material
- the top specifications required
- the comb settings required
- the operating conditions for the process
- the historical ability of the combs to produce to requirements.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the combing process. Following the video we will look at the combing process step by step.

PLAY *video (38:00 seconds)*

AS THE *video plays, note that the combing machine removes short fibre and vegetable matter.*

INDICATE THAT *it is difficult to film inside the combing machine.*

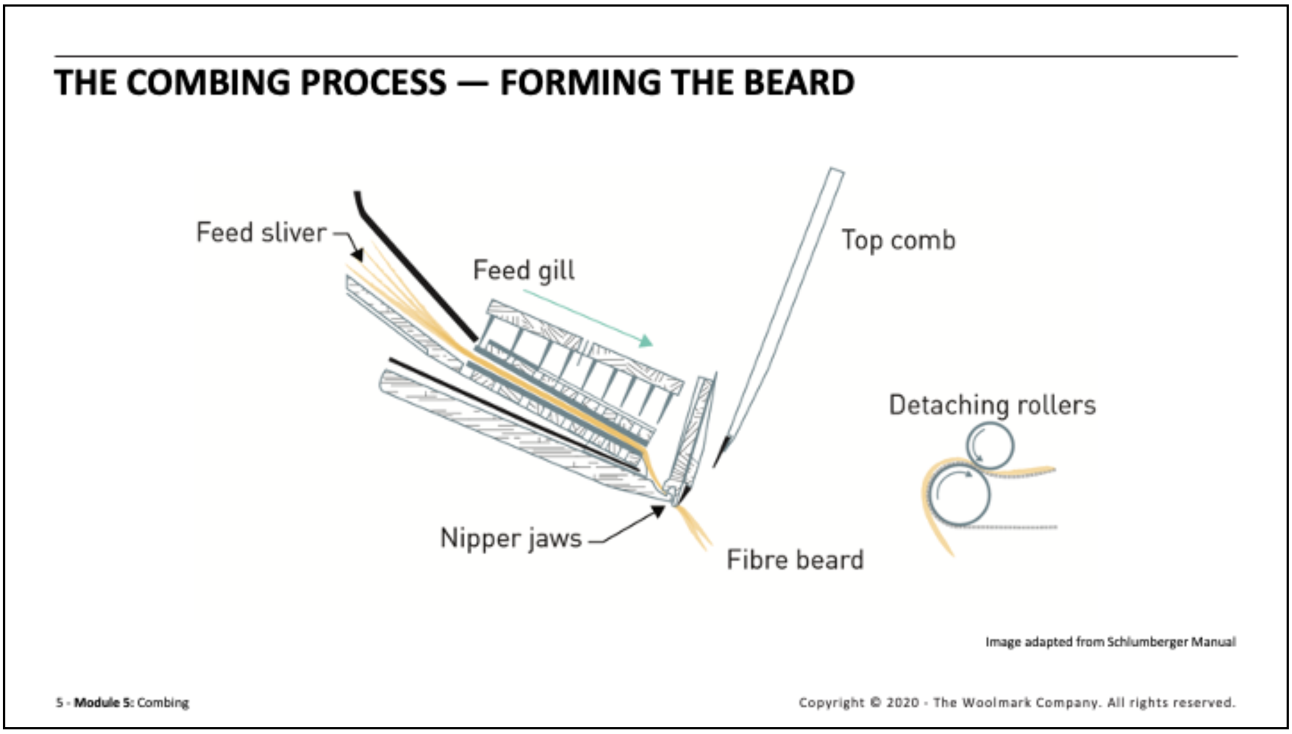
POINT OUT *that the animation in the next slide shows the combing action.*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

HAND OUT *samples of combed sliver and worsted top as you explain that the sliver is the result of the combing process and the top is the final result from top-making.*

NOTE *that because the combed sliver is nearing the final stages of top-making there will be little difference between the two samples.*



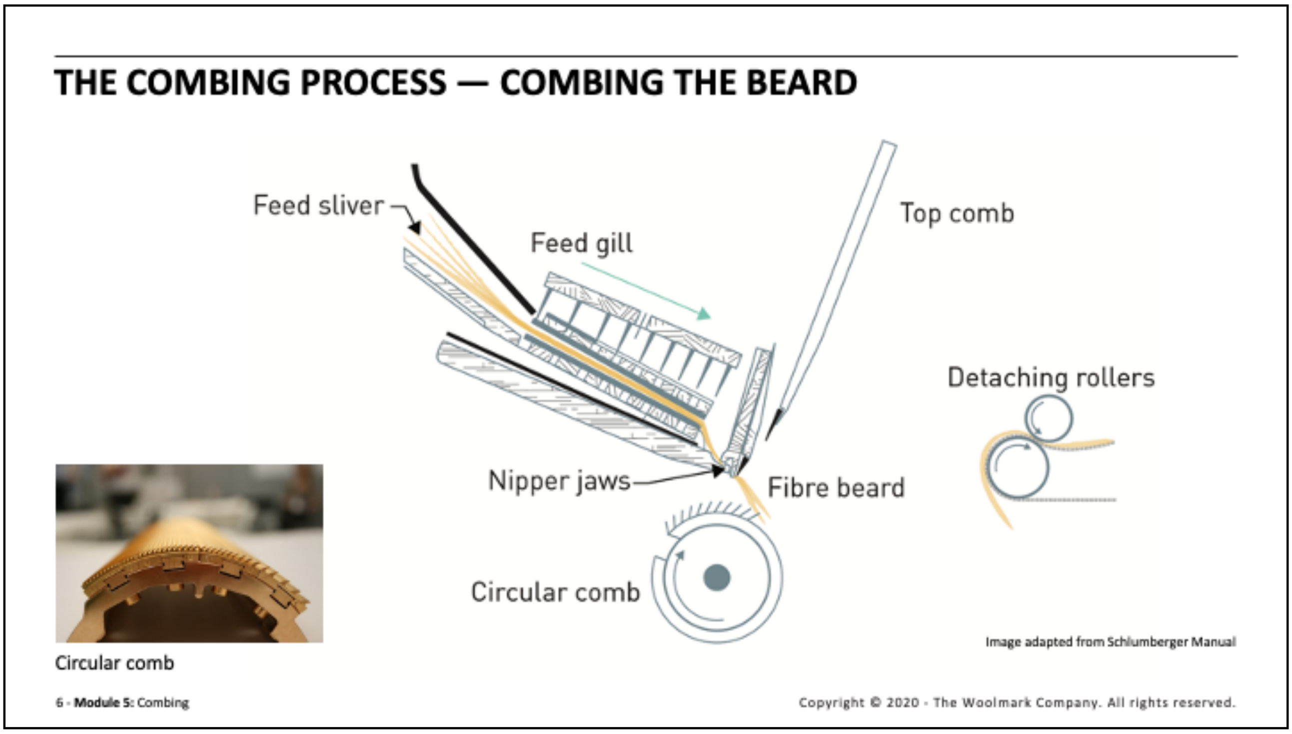
INDICATE THAT the combing machines used almost exclusively in worsted processing are called a 'rectilinear comb'. This type of comb was previously called a French comb.

NOTE THAT earlier forms of combing were used (e.g. the Noble comb), but these comb types are no longer used because they were much less effective and efficient than the 'French comb'.

INDICATE THAT the concept of the combing process is simple:

1. A beard or fringe of wool is formed at the front of the uncombed feed sliver and held by the nipper jaws.
2. The beard or fringe is combed by the circular (bottom) comb (not shown).
3. The detaching rollers move back to grab the front of the combed beard. The beard is pulled through the 'top comb' to detach it from the uncombed sliver.
4. The detaching rollers join the combed beard to previously combed beards.

NOTE: The mechanics of combing are more complex and will be discussed in the next series of slides.



REFER participants to the diagram on the slide and point out the slivers to be combed are assembled by the creel and presented to the feed gill via the back (feed) rollers (not shown).

The front of the sliver is moved forwards by the feed gill to form a fibre beard shown on the illustration on the slide.

EXPLAIN THAT the beard of fibres is held by the nipper jaws for combing. The beard is then combed by the pins of the rotating circular comb, (also known as the segment or half lap).

The beard, gripped by the nipper jaws, is pressed into the rows of pins of the rotating circular comb by a nipper brush (not shown).

The rows of teeth on the comb become progressively more finely pinned as the circular comb rotates.

EXPLAIN THAT fibres that are too short to be held by the nipper jaws are combed from the beard and subsequently removed from the circular comb as noil by the noil brush (shown in a later slide).

NOTE the difference in the fine and coarse teeth on the circular comb in the image on the slide.

POINT OUT that the movement of the feed gill, combined with the length of the fibres, determine how much fibre is removed by the circular comb.

- A long beard – more fibre is removed
- A short beard – less fibre is removed

DEMONSTRATION: COMBING THE BEARD

Resources required:

- *sample of combed sliver*
- *coarse comb*
- *fine comb*

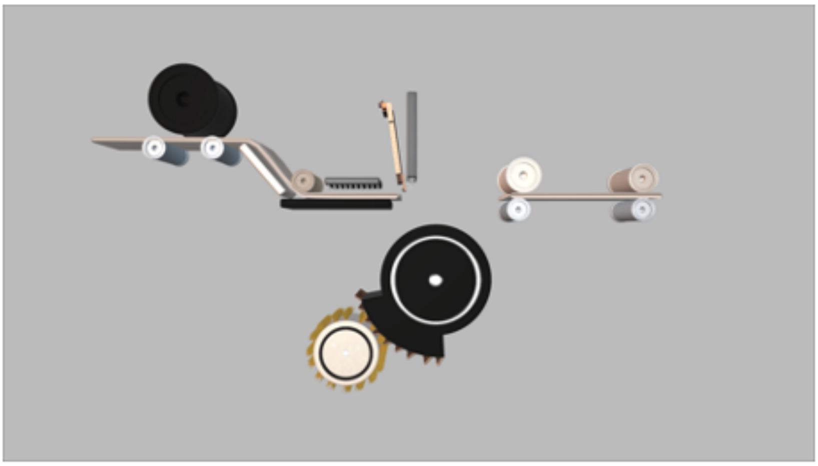
COMB *a fringe of the sliver using both combs, noting the difference in the use of fine and coarse combs.*

CREATE *a long beard, demonstrating the removal of large amounts of fibre during the process.*

CREATE *a short beard, demonstrating that much less fibre is removed.*

THE COMBING PROCESS — COMBING THE BEARD

A view of the comb from above



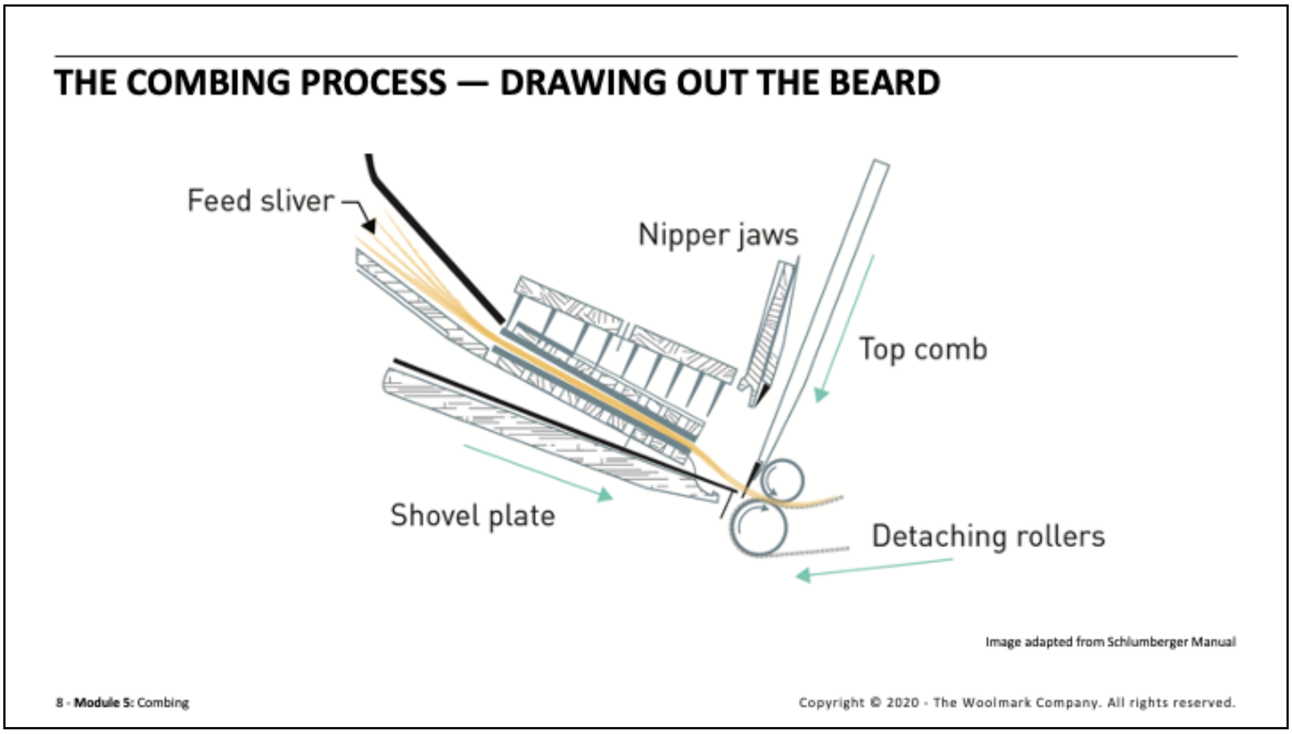
7 - **Module 5:** Combing

REFER TO the image on the left, which shows the view of the comb from above. Note the lid of the machine is closed during operation.

PLAY *the animation (55:00 seconds)*

AS THE *animation plays, note the actions of a comb, including:*

- *the extension of the beard*
- *the combing of the beard by the circular comb*
- *the movement of the withdrawal rollers*
- *the lowering of the top comb*
- *the transfer of the beard, the back of which is combed by the top comb*
- *the collection of short fibres and vegetable matter combed out of the beard by the circular comb brush.*



REFER participants to the diagram on the slide as you explain the nipper jaws then open and the combed beard is presented to the detaching rollers, which move towards the combed beard.

The top comb penetrates the beard of fibres, which is partly supported by the shovel plate and the beard is raised from the circular comb (no longer shown in the diagram).

INDICATE THAT the nipper jaws open, the shovel plate extends to support the beard, and the finely-pinned top comb is inserted down through the fibres of the beard.

The detaching rollers, the lower one of which carries a leather or a synthetic apron, advance through the motion of their carriage towards the fringe or beard, grasp the fibre ends and draw them through the top comb onto the apron.

EXPLAIN THAT fibres, neps and vegetable matter behind the top comb are trapped and will be submitted to the circular comb in the next cycle.

NOTE THAT during the withdrawal stage, the feed gill is inserted into the feed slivers to ensure the fibres not gripped by the rollers do not advance.

EXPLAIN THAT when all gripped fibres have been withdrawn, the detaching roller carriage retracts and the rollers then reverse so the tail of the withdrawn fibres is held in place by the suction channel.
At this point the uncombed sliver is fed forward through the open nipper jaws by a forward motion of the feed gill.

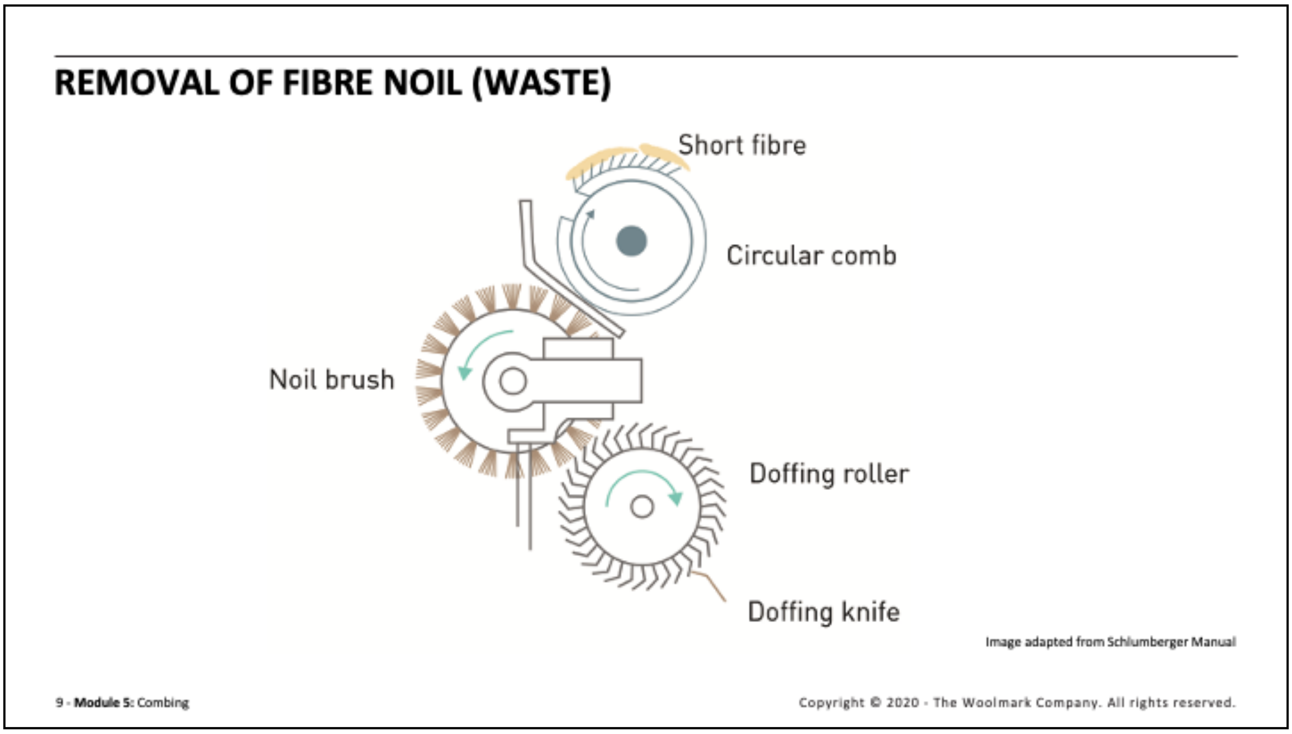
The nipper jaws close and the cycle is repeated.

DEMONSTRATION: DRAWING OUT THE BEARD

Resources required:

- *sample of sliver*
- *coarse comb*

***PULL** the previously combed fibres through a second comb to demonstrate drawing out the beard.*



INDICATE THAT the first noil is removed from the segment or half lap of the circular comb by a rotating noil brush, which is cleaned by a doffing roller and finally by the doffing knife.

POINT OUT that the second noil, taken at the detaching stage, which includes a high percentage of vegetable matter, dust and fly, is sucked away and kept separate from the first noil.

EXPLAIN THAT the term 'romaine' is often used to describe the amount of noil. It is the amount of noil produced during combing expressed as a percentage of the total top and noil produced.

SHOW *participants a bag of combing noil.*

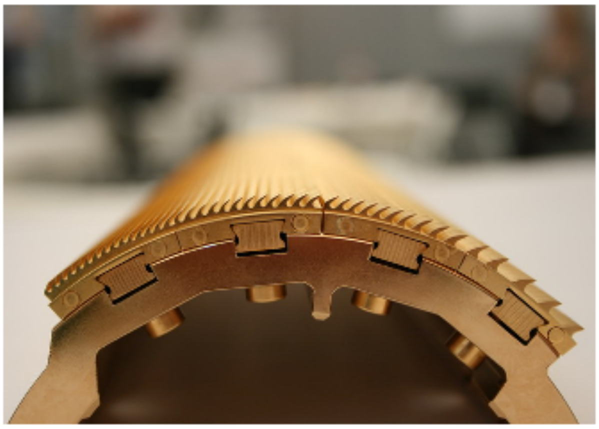
ASK *participants to share their observations of the noil.*

NOTE *the short fibre length of the noil.*

SETTING OF THE COMB

Key comb settings include:

- the pinning density of the circular comb (segment or half lap)
- the pinning density of the top comb
- the combing machine loading
- the feed length
- the draw-off length.



Pins on circular comb (finer pins on the left segment)

EXPLAIN THAT to achieve the desirable combing outcomes for different qualities of wool it is necessary to manage:

- the pinning density of the circular comb (segment or half lap)
- the pinning density of the top comb
- the combing machine loading
- the feed length
- the draw-off length.

These adjustments can be determined when tuning the comb.

NOTE THAT the top comb always consists of pinned strips, and the typical pinning density is 24 pins/cm for Merino wool.

POINT OUT that the life of the top combs is approximately 21 days (under constant use), depending on the particular installation and the material being processed.

EXPLAIN THAT the circular combing segment, or half lap, has two parts:

- the coarse segment
- the fine segment.

These segments come in a variety of designs, with the most common being the Staedtler pinned strips with 20 pinned strips per circular comb (i.e. 10 pinned strips on the coarse segment and 10 on the fine segment).

NOTE: Other designs include Unicomb, Vario and Hicomb.

COMB SETTINGS

All comb settings are CRITICAL as these settings, either independently, or acting together, will affect…..

- production rate
- top quality
- romaine
- machine wear

11 - **Module 5:** Combing

NOTE THAT all comb settings are CRITICAL as these settings, either independently, or acting together, will affect:

- production rate
- quality of the combed top
- hauteur and romaine (noil)
- machine wear.

***HAND OUT** samples of combed sliver and worsted top to participants.*

***ASK** participants to compare the top and the sliver and note the differences in:*

- *alignment of the fibres*
- *straightness of fibres*
- *vegetable matter content of the samples.*

EXPLAIN THAT there are two main types of feed used to deliver the sliver to the comb — can or ball feed (as shown on the slide above).

NOTE THAT most wools (especially coarser wool types) are delivered using can feed.

When combing fine wools, which generally contain high levels of fibre crimp or curvature, advantages in combing quality can be gained by using ball feed.

INDICATE THAT the savings achieved by using ball feed over can feed for these fine wool types can be in the order of 0.5–1.0% in romaine.

EXPLAIN THAT when combing high vegetable matter wools, it is common to reduce the combing machine load for the given fibre quality. This enables:

- finer pinning densities to be used on the top comb and circular comb while the machine speed is reduced
- the use of a burr knife
- a wider nip distance
- a reduced feed length.

COMBING FAULTS

Poorly-combed heads caused by:

- damaged or dirty circular pins
- poorly-adjusted nipper brush
- nip distance too short
- nipper too high.

Poorly combed tails caused by:

- damaged or dirty pins in both top or circular combs
- feed comb adjustment to detaching rollers
- top comb too fine
- flocks – circular brush/ pinning on doffer/doffer blade.

Poor web clarity caused by:

- dirty circular comb
- nip setting too short
  - top comb to drawing off rollers distance too great
  - top comb too coarse and/or dirty or damaged teeth.

Pin wear considerations:

- normal life six months (24/7)
- impact of wear.

13 - **Module 5:** Combing

INDICATE THAT neps or fibre faults in the combed top can be the result of a number of factors.

EXPLAIN THAT to identify any faults it is important to inspect the combed web on the apron immediately after the detaching rollers.

Poorly combed heads (leading edge of fibre) can be caused by:

- worn, damaged or dirty circular pins
- poorly adjusted nipper brush
- too short a nip distance
- nipper jaw being too high.

Poorly combed tails (trailing edge of fibres) can be caused by:

- worn pins or dirty pins in both the top and circular combs
- incorrect feed comb adjustment, especially in relation to the drawing-off rollers
- top comb for the feed load is too fine

Flocks, or small fibre faults present in the combed sliver may be caused by:

- poorly-adjusted circular brush
- dirty or damaged pinning of the doffer
- poorly-adjusted doffer blade.

Poor web clarity can be caused by:

- dirty circular comb

EXPLAIN THAT recommended actions are as follows:

For poorly combed heads and tails:

- increase the nip setting
- consider moving the feed comb closer, along with the shovel plate setting
- timing of the movement of the various components (top comb, drawing-off rollers) may be important.

For insufficiently combed heads:

- clean the circular comb
- clean the top comb
- consider higher pinning of the top comb.

For poorly combed tails:

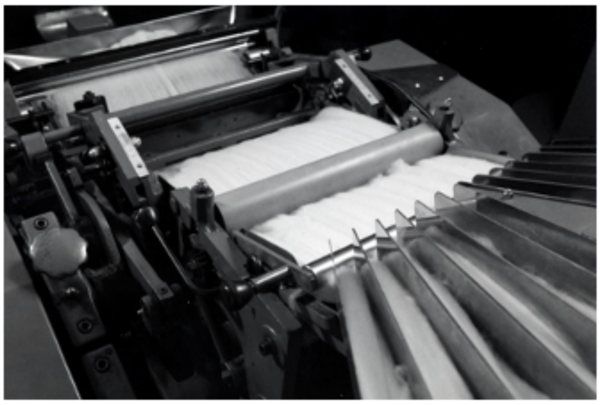
- consider a finer top comb
- check for dirty/damaged teeth particularly on top comb and the circular comb.

Pin wear

INFORM participants that wool is a relatively abrasive fibre and working elements must be checked regularly to ensure they retain their geometry and can undertake the work for which they are designed. This is particularly true of pins in combing, in particular those fine pins used in the combing segment. The expected life of combing pins is on the order of six months under constant use.

IMPROVING TOP QUALITY AT COMB

- Check nep and VM levels on the apron.
- Reduce input load.
- Increase feed length.
- Consider a finer top comb.
- Maintain a constant production rate.



Feed of combing machine

14 - **Module 5:** Combing

EXPLAIN THAT managing the quality of the top during the combing process starts with combing technicians assessing the combed fibres on the apron of the comb, and is supported by objective testing of the sliver in the laboratory for neps.

INDICATE THAT if levels of neps and/or vegetable matter do not meet accepted top specifications, the following options may improve the situation, without reducing production rate:

- reducing the input load
- increasing the feed length
- use of a finer-pinned top comb.

NOTE THAT if the above fail, increasing the noil setting, with a concomitant loss of production, is the only alternative.

MODERN COMBING MACHINERY

FIBRE DIAMETER (µm)	COMB PRODUCTION (kg/h/m)	
	1985	2005
17 – 18	22 – 24 →	40
19 – 22	26 – 33 →	46
21 – 25	30 – 37 →	52
26 – 30	39 – 45 →	60

15 - **Module 5:** Combing

EXPLAIN THAT combing production rates improved slowly from 1965 to 1985, due to the impact of refined engineering, but subsequently increased dramatically during the 1990s. Increases of more than 50% occurred by 2005, compared with figures from 1985 as highlighted in the table on the slide.

INDICATE THAT the new features of note on the new era machines were as follows:

- significant advances in clearing, particularly of nep, in superfine wools
- increased width and feed length, giving an equivalent production increase of 25%
- smaller 360 degree-pinned circular comb, which turns at a constant speed
- further refinement of change points and thereby simpler maintenance and fewer moving parts
- electronic setting of nip distance and feed length, leading to the development and recording of recipes for combing different wools
- pneumatic threading of crimper box.
- speed remains at 260 cycles per minute
- progressive combing
- nipper brushes were replaced with specially-contoured brushes
- power consumption 7.28kW
- movement by the detaching roller assembly reduced to 49mm.

RECENT DEVELOPMENTS

San Andrea/Finlane

- released the P100 in 1999
- running at 260cpm
- detacher setting altered by turning a knob
- reduced apron motion to 90mm (from ~140mm) setting new standards.

NSC — PB 33

- released in 1999
- speed increase to 260cpm
- simple replacement of circular brush
- continuous adjustment of nipper brush pressure
- visual readouts.

NSC — the new Era comb

- released in 2003
- claims for improved nep removal
- increased width/feed length giving +25% production
- easier maintenance with lower power consumption

Finlane — the Millennium comb

- released a new machine in 2003
- based on, and very similar to, the P100 machine.

16 - **Module 5:** Combing

EXPLAIN THAT in 2003, Finlane released a new machine, the Millennium comb, based on the popular P100 machine and the highlight points of this machine are as follows :

- The machine operates to 280 cycles per minute.
- The large diameter circular comb allows improved cleanliness and handling for every type of fibre due to its greater contact surface.
- The increased angle of the pinned arch ensures gradual and gentler fibre processing.
- Changes made in terms of the position and profile of the top comb allow a more effective cleaning action.
- Production claims 2.3 –2.5 times that of the fibre fineness in microns.
- The throw of the head is still much larger than the NSC comb.
- The epicyclical drive to undertake the main drives has now been increased to four epicyclical gears.
- The nip setting undertaken electronically does not require adjustment of all the other associated settings as in the past.
- There is automatic adjustment of the nipper brush.

TOP FINISHING

The objectives of finishing (finisher gilling) are to.....

- produce a sliver with an even and uniform weight per course length
- ensure adequate blending of fibres
- final correction for moisture and oil content
- the final product for the customer.

17 - **Module 5:** Combing

EXPLAIN THAT following combing, the top undergoes one or more finisher gills to:

- produce a sliver with an even and uniform weight per course length
- final correction for moisture and oil content
- prepare final product for the customer.

The first finisher gill usually has:

- a moisture application for final adjustments to 'conditioning' of the fibres
- a can delivery for economics and ease of sliver reversal

The second finisher gill usually:

- has an auto-leveller (mechanical or electronic)
- can deliver the top as bobbin or bump
- has automatic delivery.

INDICATE THAT the final gilling operation may be delivered onto one of several package types, depending on the requirements of the combed top recipient or customer.

The package would most likely be a

- 10kg or 22kg bump top
- 10kg wound top or ball.

NOTE THAT where no preference is specified, the top-maker would supply as a 22kg bump: greater efficiencies are achieved as the machine stops less frequently.

INDICATE THAT with the advent of high-speed gilling technology, machine manufacturers have developed 50kg bump tops that further increase machine efficiencies.

EXPLAIN THAT tops may be re-combed as part of preparation of the wool for spinning. This is discussed in the Wool Science, Technology and Design Education Program course *Worsted and woollen spinning.*

FINANCIAL IMPLICATIONS OF BEST-PRACTICE TOP-MAKING

PLANT	REDUCTION OF 1% ROMAINE	PLANT EFFICIENCY (%)	PRODUCT VALUE (USD)	POTENTIAL GAIN (USD/YEAR)
Greasy to top (1000kg/hr)	+10kg/hr	80	8.00 (10.00 – 2.00)	0.67M
Vertical – greasy to fabric (350kg/hr)	+3.5kg/hr	70	15/linear metre (3m/kg)	1.32M

18 - **Module 5:** Combing

A reminder of the cost of waste in top-making

REFER participants to this slide, which featured earlier in this course and shows the impact of reducing waste, through efficient processing.

SUMMARY — MODULE 5

The aims of combing are to:

- impart the final straightening and aligning of the fibres and remove any remaining vegetable material
- remove any small entanglements or neps produced during carding or developed in gilling
- remove any fibres shorter than a nominated length
- form fibres into top suitable for further drafting and spinning.

The mechanism of combing operation:

- The rectilinear comb has a reciprocating action so that beards of fibre are combed and recombined.

The important settings and maintenance issues to control for high-quality combing include

- pinning of the combs
- fibre loading
- combing speed.

Finisher gilling is designed to:

- randomise the fibre length groups
- produce a sliver with an even and uniform weight per course length
- ensure adequate blending of fibres
- correct moisture oil content for spinning
- deliver a final product for the customer.

19 - **Module 5:** Combing

SUMMARISE this module by reminding participants that the aims of combing are to:

- impart the final straightening and aligning of the fibres and remove any remaining vegetable material
- remove any small entanglements or neps produced during carding or developed in gilling
- remove any fibres shorter than a nominated length
- form fibres into top suitable for further drafting and spinning.

NOTE THAT the combing operation of a rectilinear comb has a reciprocating action so beards of fibre are combed at each end of the fibre (head and tail) and recombined to form a coherent top.

REVIEW the important settings and maintenance issues to ensure high-quality combing include:

- pinning of the combs
- fibre loading
- combing speed.

REMIND participants that the aims of finisher gilling are to:

- randomise the fibre length groups
- produce a sliver with an even and uniform weight per course length
- ensure adequate blending of fibres
- final correction for moisture and oil content
- the final product for the customer.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture in *Worsted top-making— Module 6 Predicting top from raw wool properties (TEAM)—* and ensure they read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

MODULE 6

PREDICTING WOOL TOP FROM RAW WOOL PROPERTIES (TEAM)

RESOURCES — MODULE 6: PREDICTING WOOL TOP FROM RAW WOOL PROPERTIES (TEAM)

No additional resources are required to deliver **Module 6: Predicting wool top from raw wool properties (TEAM)**.

WELCOME participants to Module 6 of the Woolmark Wool Science, Technology and Design Education Program — *Worsted top-making — Predicting top from raw wool properties (TEAM)*.

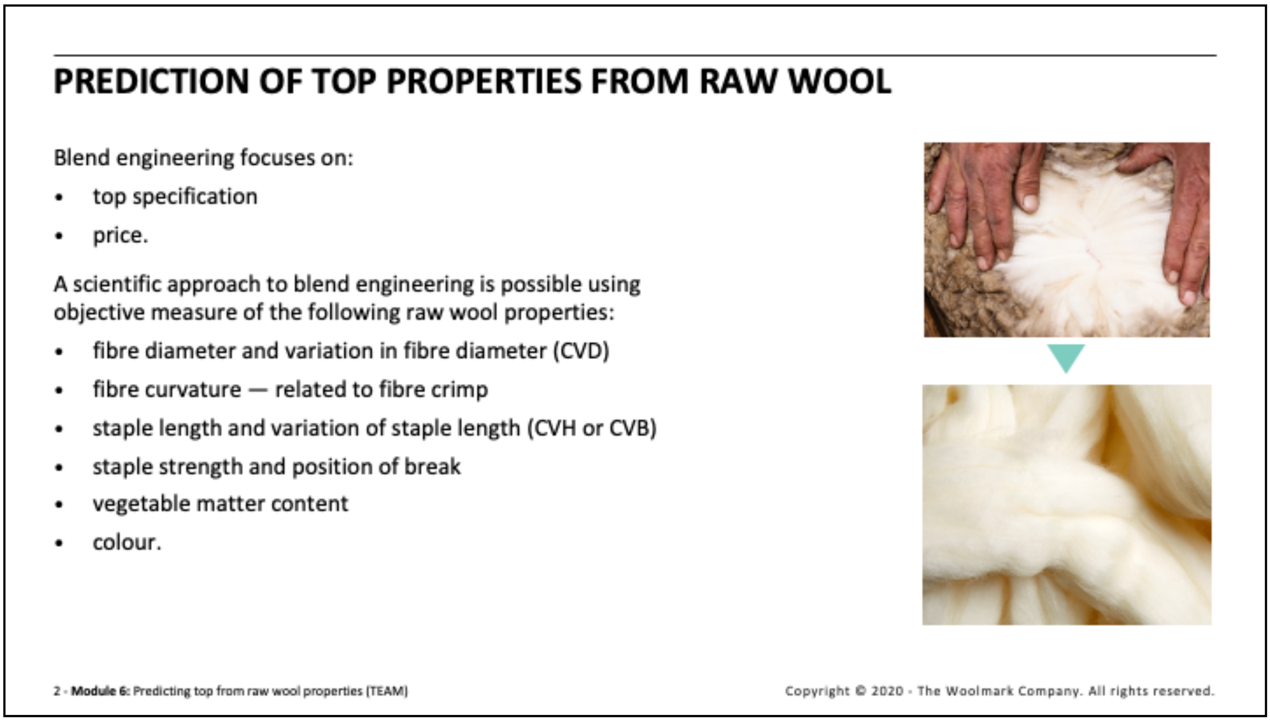
EXPLAIN THAT this module will cover:

- the principles of predicting top properties from raw wool measurements,
- the TEAM equations and their application
- boundaries and understandings required when applying the formulae
- influence of some fibre properties on hauteur and romaine predictions.

INFORM participants that by the end of this module they will be able to:

- describe the TEAM equations and their function
- describe the use of the equations in wool purchasing and processing
- explain the role of the mill factor
- describe the use of the TEAM equations in quality assurance (QA) programs.

NO RESOURCES REQUIRED



EXPLAIN THAT the aim of top-making is to convert an assembly of raw (greasy) wool sale lots in bales into combed wool or top to meet required specifications at the right price.

INDICATE THAT the specifications required in the top will ultimately be determined by the yarn into which the top, often blended with other fibres, is to be spun.

EXPLAIN THAT blend engineering, with these two factors — specification and price — in mind, is a complex and difficult process. Since the development of objective measurement for raw wool it has been possible to use a scientific approach to blend engineering.

POINT OUT that testing instruments and methods are available to test all of the important physical characteristics of wool, including:

- fibre diameter and variation in fibre diameter (CVD)
- fibre curvature – related to crimp
- staple length and variation of staple length
- staple strength and position of break
- vegetable matter content
- colour.

NOTE THAT the important benchmark processing performance parameters and top properties can be calculated from the objective measurement of the key raw fibre components of a consignment of wool lots.

TEAM-3 EQUATIONS

- Hauteur (mm)
  $$H = 0.43SL + 0.35SS + 1.38D - 0.15MBC - 0.45VM - 0.59CVD - 0.32CVL + 21.8$$
- Coefficient of variation of hauteur (%)
  $$CVH = 0.30SL - 0.37SS - 0.88D + 0.17MBC + 0.38CVL + 35.6$$
- Romaine (%)
  $$R = -0.13SL - 0.18SS - 0.63D + 0.78VM + 38.6$$

- D = mean fibre diameter
- CVD = coefficient of variation of fibre diameter
- SL = staple length
- CVL = coefficient of variation of staple length
- SS = staple strength
- MBC = corrected mid breaks (if <45%, MBC = 45%; if >45%, MBC = actual value)
- VM = vegetable matter content

3 - **Module 6:** Predicting top from raw wool properties (TEAM)

EXPLAIN THAT from a series of international trials carried out in the 1980s known as the 'trials to evaluate additional measurement', the TEAM formulae were developed, within the context of the International Wool Textile Organisation (IWTO) to predict the properties of a top from measured properties of the raw wool.

EXPLAIN THAT the TEAM formulae predict, from the weighted objective measurements of a consignment of wool lots:

- hauteur
- coefficient of variation of hauteur (CVH)
- romaine

At the commencement of the TEAM trials during the 1980s the formulae were designed to evaluate which raw wool attributes were important in predicting top-making performance. The first set of equations were subsequently put through validation trials and in 1988, the TEAM general formulae, which provide predictions of hauteur, CVH and romaine were created.

POINT OUT that top-makers, whether associated with exporters or combing plants, could now buy and assemble consignments using these formulae. By trading off the price of the raw wool against the objective measurements on sale lots, top-makers could optimise their purchase, based on objective measurements.

EXPLAIN THAT additional work resulted in TEAM-2 and then TEAM-3 equations being developed. The TEAM 3 equations are listed on the slide above.

Knowing the weighted objective measurements of a consignment of wool lots allows top-makers to calculate all the important benchmark processing performance parameters and top properties. Individual mills make allowances in the use of similar equations to describe their own performance.

NOTE THAT while some top-makers still blend with untested wool in order to cheapen the blend, the more rational approach is to manage the economics through specification and prediction.

POINT OUT buying specified wool based on objective measurement offers top-makers a number of advantages, these include:

- the potential for detecting abnormal situations in deliveries and minimising these deliveries
- the ability to improve processing predictions and productivity
- the ability to monitor the mill's capital investment
- the ability to monitor and evaluate combing results and link back to purchasing decisions.

AN EXAMPLE OF PREDICTION (TEAM-2)

If:	Staple length (SL)	= 87
	Staple strength (SS)	= 36
	Mean fibre diameter (D)	= 21
	Vegetable matter (VM)	= 1.0
	Position of mid-breaks (MBC)	= 45

Then hauteur (mm) =

0.52SL + 0.47SS + 0.95D + 0.45VM - 0.19MBC – 3.5

0.52x87 + 0.47x36 + 0.95x21 - 0.45x1.0 - 0.19x45 - 3.5
= 70mm

4 - **Module 6:** Predicting top from raw wool properties (TEAM)

NOTE THAT an example calculation for hauteur, using the TEAM-2 formula, is presented on the slide.

EXPLAIN THAT the TEAM formulae average all of the mills' performances into one general formula. Thus the coefficients of the parameters can be quite different for different mills.

POINT OUT that TEAM is adaptable — there are individual mill adjustment techniques, as well as within-mill adjustments for different blends or processing lines and all of these adjustments are only a start for developing mill-specific formulae.

NOTE THAT TEAM predictions were always seen to be a starting point before mills developed their own specific formulae.

AN EXAMPLE OF PREDICTION (TEAM-3)

If: Staple length (SL) = 75
Staple strength (SS) = 38
Mean fibre diameter (D) = 16
Position of mid-breaks (MBC) = 45
Vegetable matter (VM) = 1
CV diameter (CVD) = 18
CV staple length (CVL) = 10

Then hauteur (mm) =

$0.43SL + 0.35SS + 1.38D - 0.15MBC - 0.45VM - 0.59CVD - 0.32CVL + 21.8$

68.41mm

And coefficient of variation of hauteur (%)=

$0.30SL - 0.37SS - 0.88D + 0.17MBC + 0.38CVL + 35.6$

41.41%

And romaine (%) =

$-0.13SL - 0.18SS - 0.63D + 0.78VM + 38.6$

12.71%

5 - **Module 6:** Predicting top from raw wool properties (TEAM)

INDICATE THAT an example calculation for hauteur, using the TEAM-3 formula, is presented on the slide.

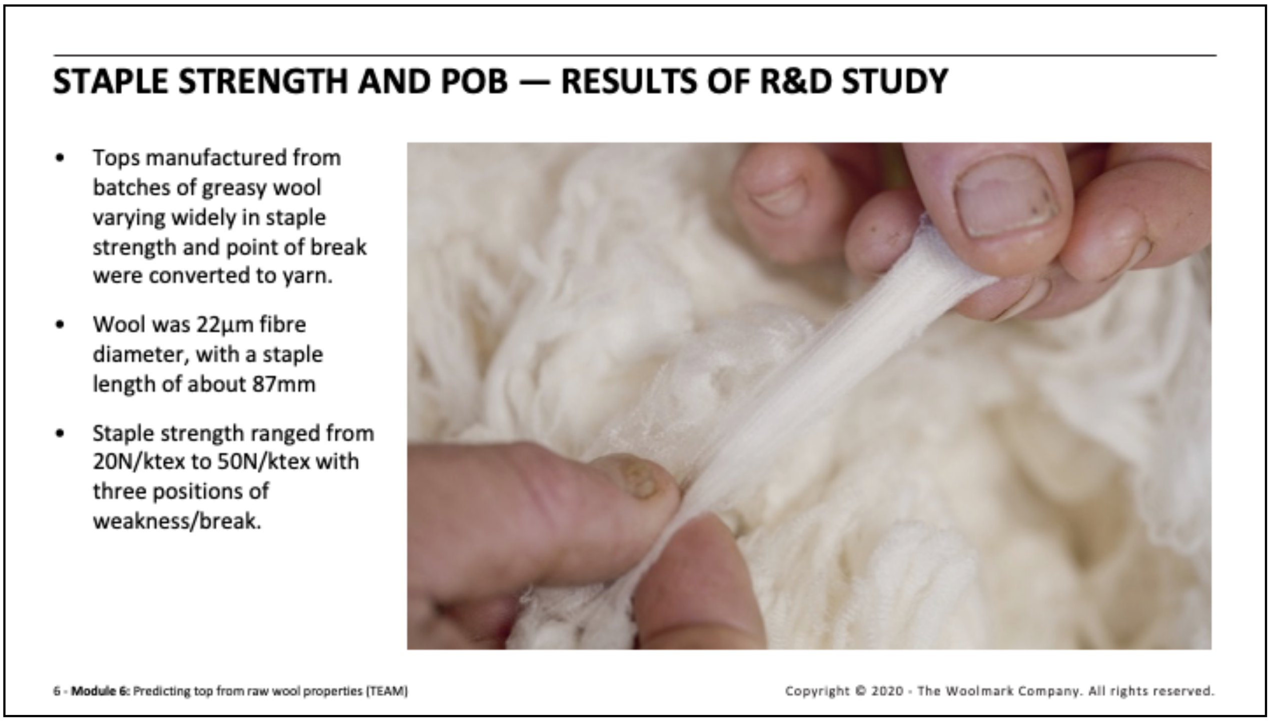
NOTE THE TEAM-3 equations use additional measurements to TEAM-2:

- coefficient of variation of diameter (CVD) and
- coefficient of variation of staple length (CVL).

EXPLAIN THAT providing the mill is using wool from within the data sets, the prediction is a valid exercise. However, mills using lots that fall outside of the TEAM parameters, such as lots of pieces or with wider micron spreads, should treat the general formulae with some caution. Excessive use of general formulae without specific reference to internal data sets can lead to incorrect conclusions.

NOTE THAT one of the critical differences between the prediction and actual mill performance can lie in the impact of mid breaks and the load at which breaking occurs. For one mill the critical values may lie at 32 N/ktex while in another mill the critical values lies at 38N/ktex. This difference has a significant impact on these mills' performance.

EXPLAIN THAT likewise, some mills are more sensitive to vegetable matter input conditions types and quantities than other mills.



INDICATE THAT an investigation has been reported in which tops were manufactured from batches of 22µm greasy wool, varying widely in staple strength and location of the point of break (POB) or zone of weakness.

EXPLAIN THAT the batches of greasy wool consisted of four levels of staple strength — 20, 30, 40, and 50 newtons per kilotex (N/ktex) and three POB.

Close control of staple length was maintained at about 87mm across the batches.

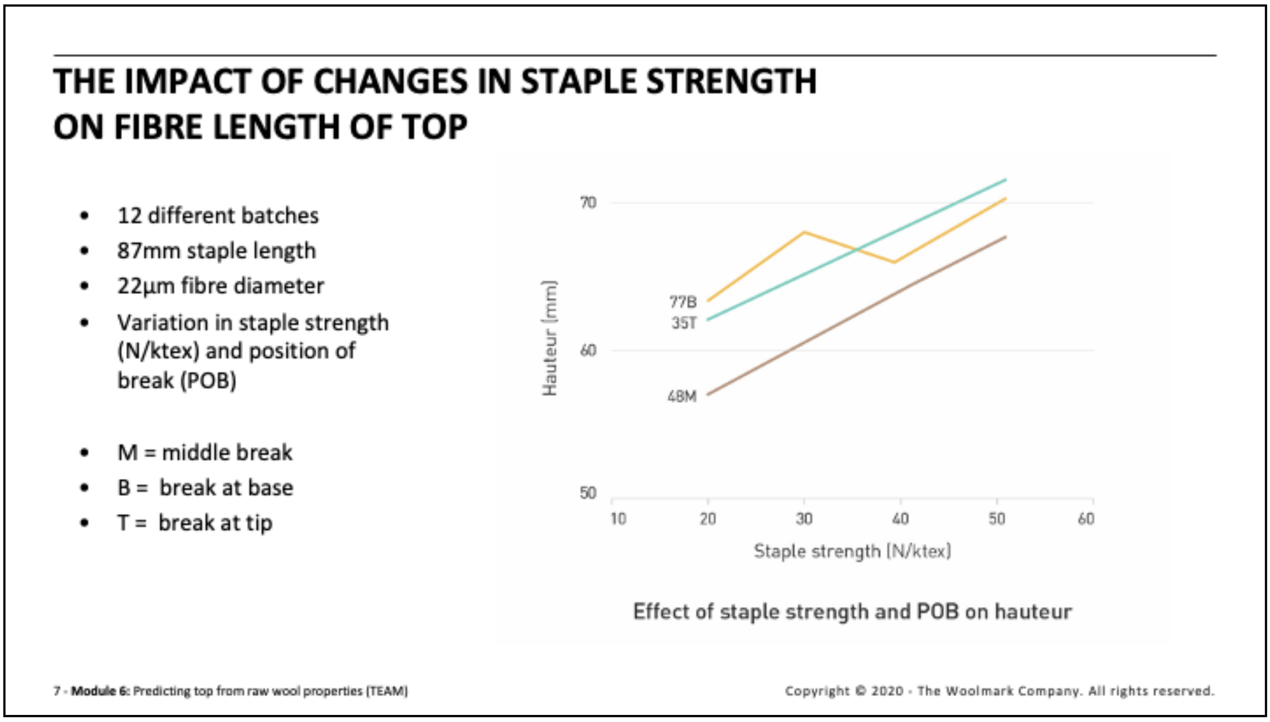
In the investigation 12 batches of wool were processed to top. Fibre diameter and staple length were, within tolerance, held constant.

These same tops were then converted to yarn at two levels of tension by varying the spindle speed. The results are shown on the next graphs.

ASK *participants what they would expect the relationship between staple strength and point of break on hauteur of the top to be.*

COLLECT *two or three responses from across the room.*

ADVANCE *to the next slide for the correct answer.*



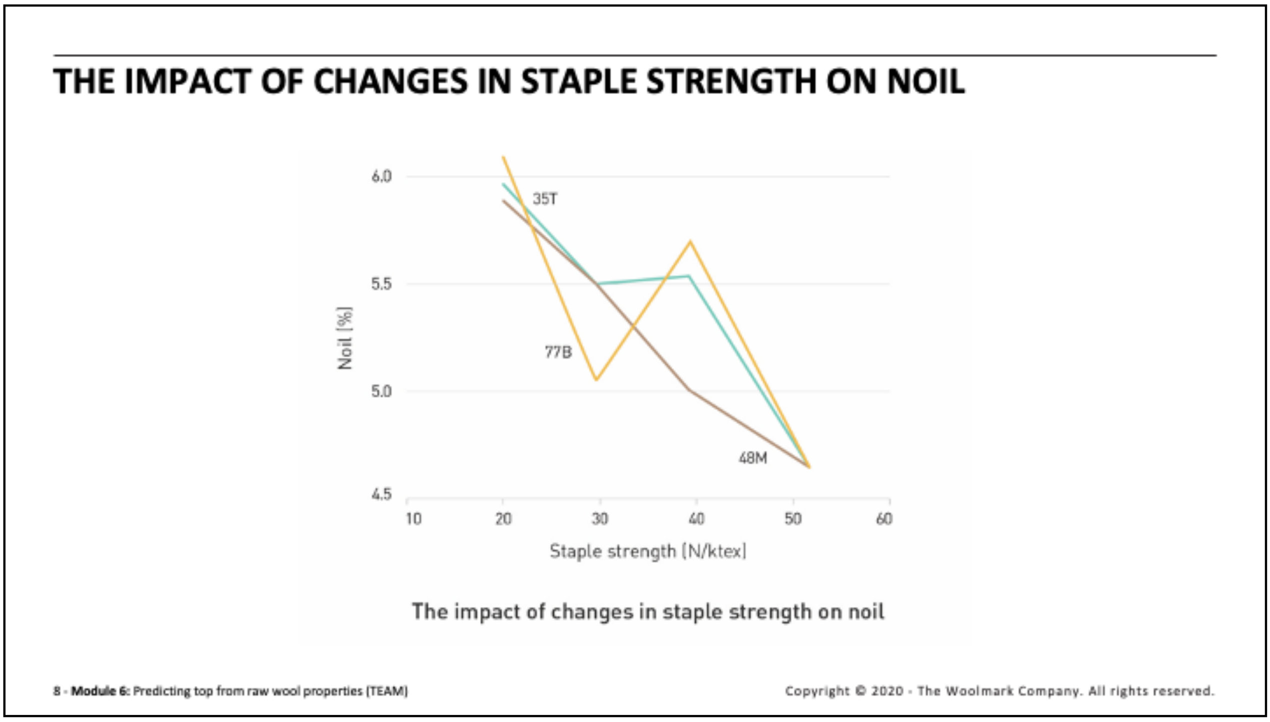
REFER participants to this slide indicating the effect of staple strength and point of break (POB) on hauteur of the top.

NOTE THAT it would be expected that the staple strength, and the position of the weakest point in the staple will modify the expected processing behaviour and the ultimate hauteur.

EXPLAIN THAT the results of the trial investigation into the influence of changes to the staple strength and the POB on hauteur in the top and combing, noil as outlined in the last slide are shown above.

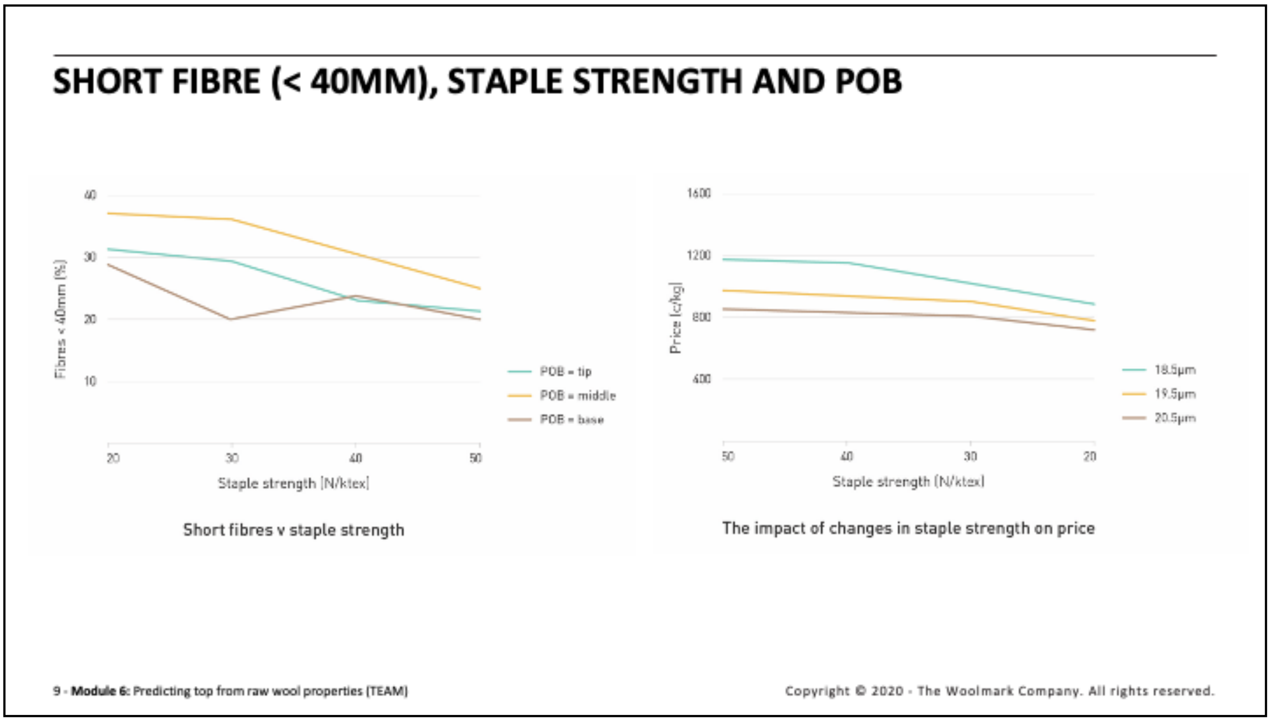
INDICATE THAT it can be seen from the graph on the slide that:

- increasing staple strength results in increasing hauteur (length)
- when the position of break is largely in the middle of the staple (48M), these wools give shorter hauteur than either tip (35T) or base break wools (77B).



POINT OUT that from the same investigation, the impact of a variation in staple strength on combing waste (noil) shows that increasing staple strength reduces waste.

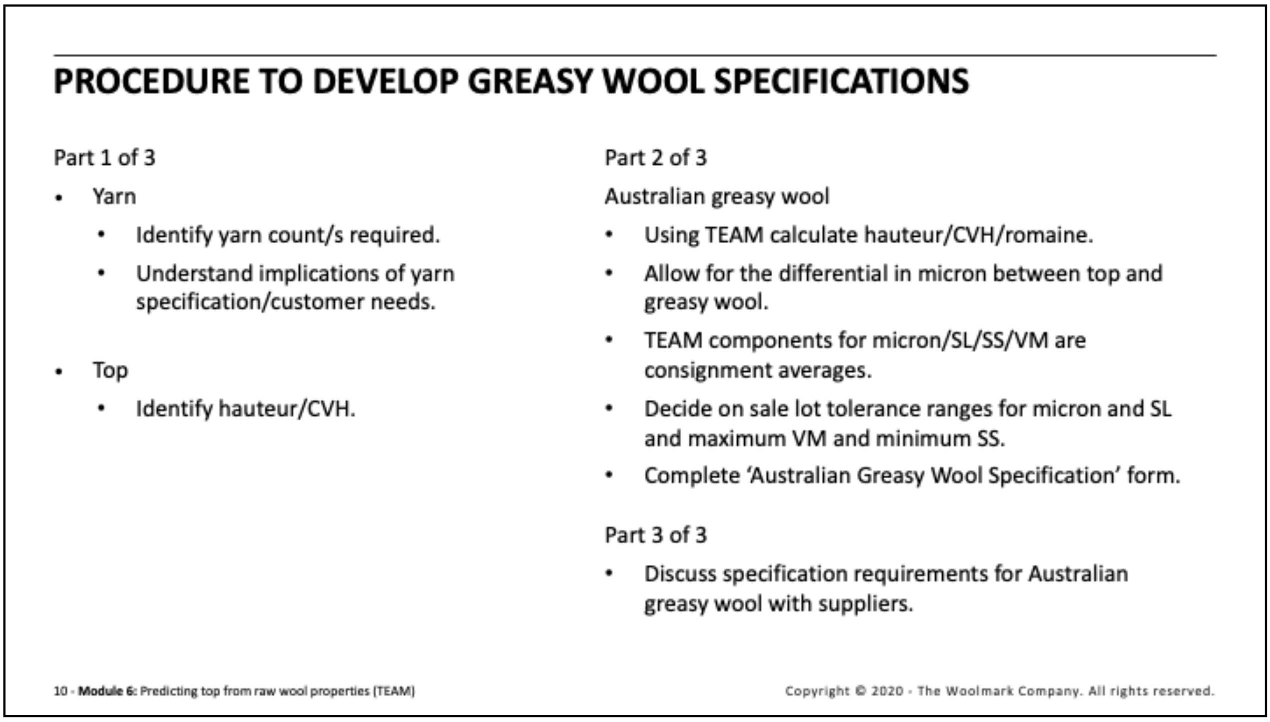
EXPLAIN THAT in this trial there is no clear-cut effect on waste with a variation in the point of break. However industry reports indicate wools with predominantly tip or base position of break generate more waste than wools with predominately mid-breaks.



POINT OUT that as indicated by the graph on the left-hand side of the slide, short fibre levels are reduced as staple strength increases, and wool with a position of break (POB) in the middle generates more short fibres than when the POB is at the tip or base.

NOTE THAT this is true of all levels of staple strength.

EXPLAIN THAT it also can be seen from the graph on the right-hand side of the slide that price discounts in fine wool follow a similar trend for decreasing staple strength.



INDICATE THAT when armed with the TEAM-3 formulae, and information based on objective predictions, the top-maker can then enter into negotiations with the spinner about the type of yarn required.

EXPLAIN THAT firstly, with a knowledge of the required:

- yarn count
- yarn twist
- product type
- yarn tensile properties

the specifications of the top can be developed by the spinners and agreed with the top-maker.

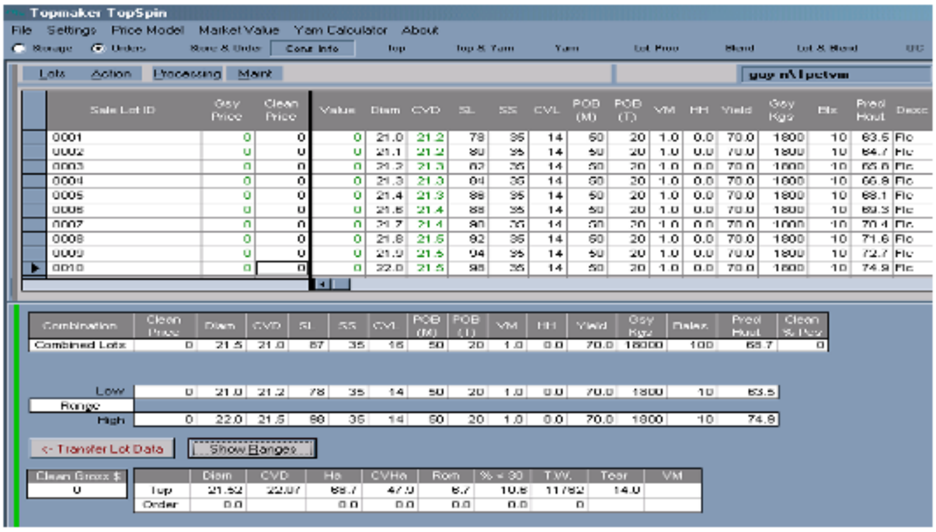
EXPLAIN THAT the next phase of developing the specifications for the greasy wool is to make up the consignment blend.

The top-maker can:

- expand the use of TEAM to include CVH and romaine
- allow for changes in the fibre diameter between greasy wool and top caused by machine influences
- assign consignment averages as indicated by the TEAM predictors
- assign tolerances allowed for ensuring the specifications and tolerances in the top are going to be satisfactorily met
- complete an Australian Greasy Wool Specification form.

NOTE THAT in the third and final step, the top-maker can discuss the greasy wool specification with Australian suppliers.

DECISION TOOLS



11 - **Module 6:** Predicting top from raw wool properties (TEAM)

POINT OUT the steps outlined in the previous discussion are more easily generated, and optimum technical and cost parameters decided, by computer software.

Most advanced top-makers and processors use some form of software program to support their purchasing decisions.

NOTE THAT an example is given on the slide of the 'Topmaker' output showing:

- the ID of the sale lots
- cost figures, along with the objective measurements made on each lot
- proportions by weight of each lot in the total batch.

EXPLAIN THAT coupled with these technical factors are supply issues of reliability and continuity of supply. The top-maker must also be aware of these issues to ensure a plentiful and continuous volume of supply from a price-sensitive supply source.

INDICATE THAT such a situation allows the plant manager to reliably predict outcomes before processing and to ensure the customer is satisfied with the final input quality.

EXPLAIN THAT there is also scope for the manager of the top-making business to trim costs by negotiating to purchase slightly different wools at a lower cost, and still meet the spinner's expectations, while improving the bottom line.

EXAMPLE OF A COMBING CONSIGNMENT

Contract reference	Date
Mean fibre diameter	21.0 µm
Maximum range for any component lot	± 1.0µm
Average greasy length (mm)	87mm
Maximum range for any component lot	± 15mm
Average strength	36N/ktex
Minimum for any component lot	26N/ktex
Mean vegetable matter content	1%
Maximum content for any component lot	3%
Vegetable matter type exclusion	Seed/shive
Predicted top length as per TEAM-3	62mm hauteur

All component lots must be measured for length and strength

Seller………………………………………………. Buyer ……………………………………………….

12 - **Module 6:** Predicting top from raw wool properties (TEAM)

REFER participants to the example on the slide showing how a greasy wool specification might be developed to ensure the required fibre length (hauteur) in the top is as predicted from the properties of the greasy wool and calculated by the TEAM-3 formula.

NOTE THAT under this scenario, variations in the properties of the greasy wool can be applied and their influence on the hauteur and on the cost of the greasy wool can be managed

EXPLAIN THAT as outlined on the slide, tolerances are set for each property. It is advisable to discuss with the spinner if upper and lower tolerances are required, for example, while the purchaser does not want the fibre to be coarser than the specification, they will not be concerned if it is finer than required.

MILL FACTOR: ACTUAL vs PREDICTED RESULTS

Combing results of the wool top

	Length(mm)	CVH(%)	Romaine(%)
Mill	68.0	47	12.0
TEAM formula	70.0	47	7.0
Difference	2.0	0	5.0

13 - **Module 6:** Predicting top from raw wool properties (TEAM)

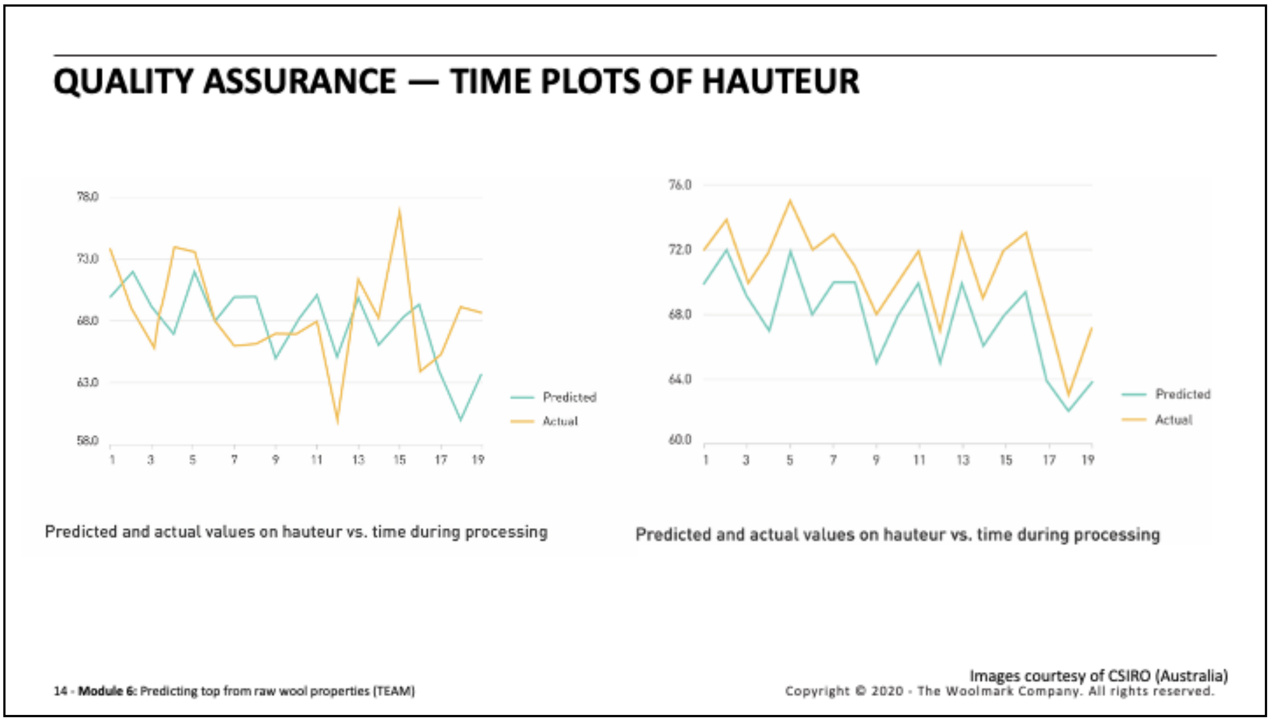
EXPLAIN THAT the TEAM formulae were developed using the average results obtained from a number of mills using a limited range of wool types. Individual mills may get slightly different results from this prediction depending on:

- the type of wool being processed
- the machinery available
- the processing conditions.

NOTE: An example of the difference between predicted and actual data a single batch is shown in the slide.

POINT OUT the correction a mill must make to the predictive equation can be determined from the **average** difference between the predicted and actual results for a specific mill over a number of batches.

NOTE: This difference is called the **'mill factor'** or **'mill correction'**.



EXPLAIN THAT it becomes the role of the top-maker, in combination with their technical advisors, to track the predicted values against the real values obtained during processing to ensure accurate results are obtained.

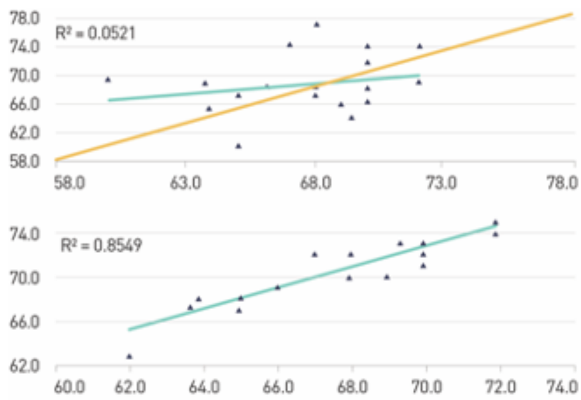
The predicted and actual values can be determined and plotted on a time chart as shown on the slide. This gives the mill additional information on its performance.

NOTE THAT the results on the left of the slide for this particular plant vary with the difference between predicted and actual, P-A (sometimes positive, other times negative) and more importantly the magnitude of the variation fluctuates.

These results reflect a manufacturing plant running with little control of their purchasing and processing operations.

EXPLAIN THAT in contrast, the results shown on the right of the slide indicate the actual result is consistently superior to the predicted value across a large number of different batches and the difference is reasonably consistent in magnitude.

NOTE THAT these results indicate a plant operating under effective purchasing and processing control.



Processing relativities — predicted and actual hauteur

Adapted from images courtesy of CSIRO (Australia)

EXPLAIN THAT the diagrams on this slide plot the predicted and actual data in a different way, and the correlation coefficient has been determined.

INDICATE THAT for the first plant (top) the association is poor, (correlation coefficient ~0.22), indicating no assertion between predicted and actual results. This would be a disastrous business to manage and make profitable. However it has to be realised that this situation exists in many plants who do not sensibly apply the tools that have been discussed.

EXPLAIN THAT the bottom graph shows results from a second plant in which there is a strong association between the predicted and actual results (correlation coefficient ~0.92). This indicates a plant under effective management.

REPEATING the statement made earlier,
TEAM is adaptable:

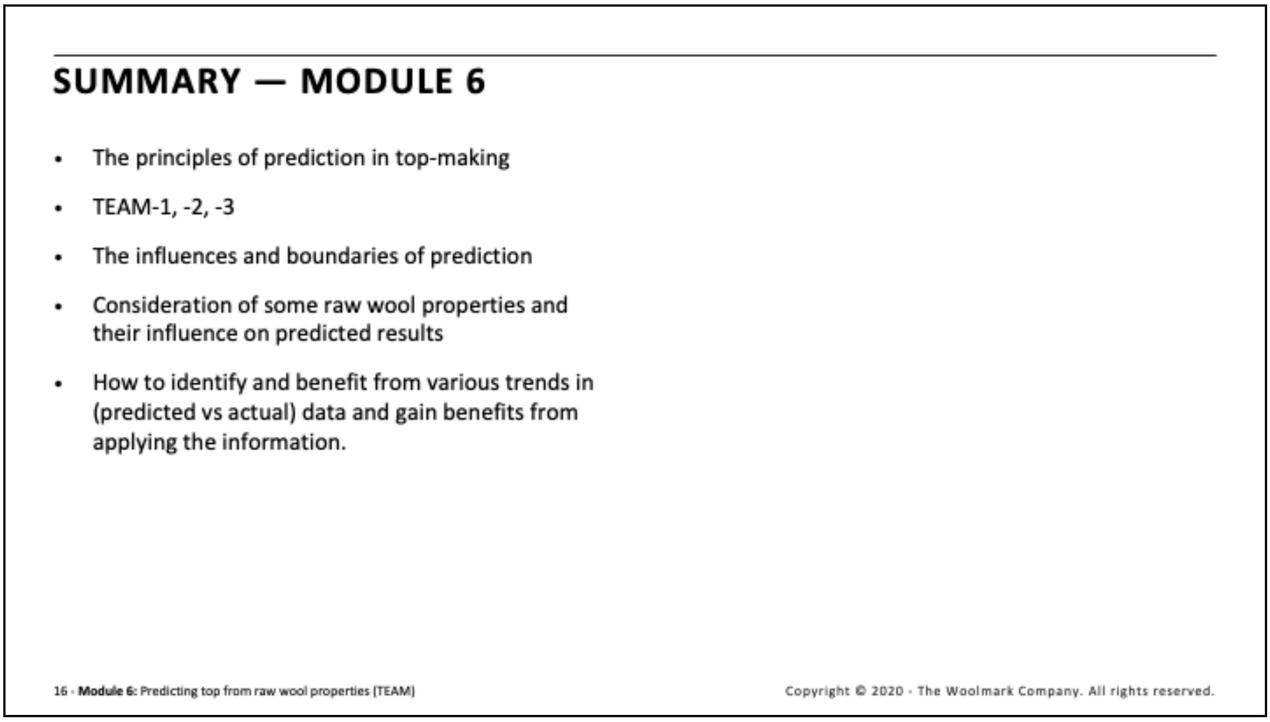
- There are individual mill adjustment techniques, as well as within-mill adjustments, for different blends or processing lines and all of these are only a start for development of mill-specific formulae.
- TEAM predictions were always seen to be a starting point before mills developed their own specific formulae.
- To the current time, few mills have felt the need, or have found the time, to take the next step of developing their own mill-specific formulae.

The TEAM equations offer improved understanding of the technical variables that top-makers can control to increase profit of the business.

NOTE THAT the aim of the business is of course to make money. Consequently it is vital to have a sound understanding of the consequences of sub-optimal processing practises.

The financial implications of a one-unit change in romaine were discussed earlier.

Add to this any financial consequences with hauteur and the final consequences of impacts of poor raw material selection and/or poor manufacturing practises and the implications are enormous.



REMIND participants this module has covered:
- the principles of prediction of top properties from raw wool measurements,
- the TEAM equations and their application
- boundaries and understandings required when applying the formulae
- influence of some fibre properties on hauteur and romaine predictions.

REITERATE THAT an example was given for:
- specifying a consignment
- evaluating the difference between predicted and actual from production statistics in quality assurance programs.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 7 Quality assurance of wool top* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

MODULE 7

THE WOOLMARK COMPANY

QUALITY ASSURANCE OF WOOL TOP

RESOURCES — MODULE 7: QUALITY ASSURANCE OF WOOL TOP

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 7: Quality assurance of wool top**.

– sample of worsted top

WELCOME participants to Module 7 of the Woolmark Wool Science, Technology and Design Education program course — *Worsted top-making — Quality assurance of wool top.*

EXPLAIN THAT this module covers the key features that define top quality, and how these features can be monitored, measured and managed.

INFORM participants that by the end of this module they will be able to:

- describe the key features of wool top that define its quality
- indicate the measurements and instruments used to evaluate the key quality attributes
- outline the rationale for sampling and testing
- outline the key features of a quality assurance program for top.

RESOURCES REQUIRED FOR THIS MODULE:

- *sample of worsted top*

ASK *participants to nominate and describe the quality attributes of top.*

COLLECT *two or three responses from across the room.*

ACKNOWLEDGE *responses before proceeding.*

QUALITY ATTRIBUTES OF TOP

- Mean fibre diameter
- Variation of diameter (CVD)
- Fibre length — hauteur and barbe
- Variation in fibre length — (CVH and CVB)
- Short fibre content (i.e. maximum and minimum tolerances)
- Vegetable matter (frequency and size per 100g)
- Solvent extractable material
- Top weight (grams per metre)
- Variation in top weight per metre – Uster CV (%)
- Moisture content (%)
- Neps (frequency and size per 100g)
- Colour (Y–Z)
- Fibre modification criteria (e.g. felt-resist treatment)

2 - **Module 7:** Quality assurance of wool top

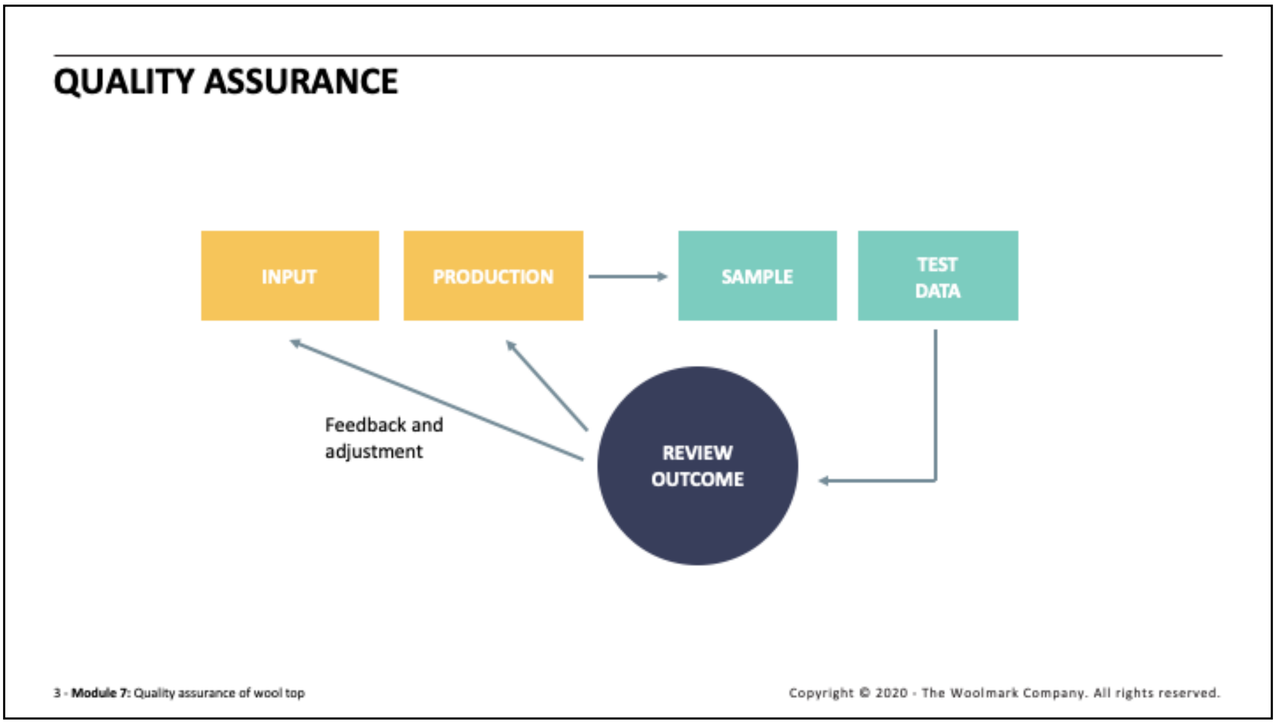
EXPLAIN THAT as previously outlined in Module 1 *The role of the top-maker,* the key quality attributes of top include:

- Mean fibre diameter
- Variation of diameter (CVD)
- Fibre length — hauteur and barbe
- Variation in fibre length — (CVH and CVB)
- Short fibre content
- Vegetable matter (frequency and size per 100g)
- Solvent extractable material
- Top weight (grams per metre)
- Variation in top weight per metre – Uster CV (%)
- Moisture content (%)
- Neps (frequency and size per 100g)
- Colour (Y–Z)
- Fibre modification criteria (e.g. felt-resist treatment)

ASK *participants to describe what is meant by the terms:*

- *quality control*
- *quality assurance.*

RECORD *responses on the white board or flipchart before proceeding with the lecture.*

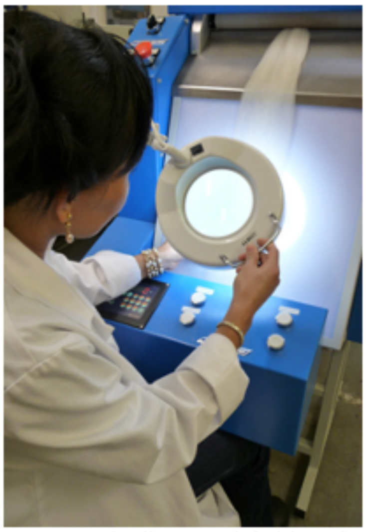


REFER participants to the image on the slide showing how quality assurance involves a feedback loop in which results of testing are reviewed and adjustments are made on that basis.

SAMPLING AND TESTING

Two of the most important aspects of quality control are:
- sampling
- testing.

When sample, each sample must be a true reflection of the bulk:
- with minimum error introduced by the sampling technique
- on a basis that allows to the statistical evaluation of variation.



http://www.sgs.com/en/trade/commodity-trading/agricultural-goods/fibers/wool-chemical-residue

4 - **Module 7:** Quality assurance of wool top

POINT OUT that two of the most important aspects of any top-making quality control (QC) and quality assurance (QA) programs are :
- sampling
- testing.

Sampling

A well-organised and comprehensive sampling and testing regime is an essential part of any program and must reflect the volume of top being produced.

EXPLAIN THAT it is important each sample is taken:
- with minimum error introduced by the sampling technique
- on a basis that allows to the statistical evaluation of variation.

Sampling of top and sliver

Top is more even than card sliver and is easier to handle. The problems of measuring the weight of sliver and top for QC purposes are similar:
- how to measure an accurate metre
- cutting and weighing the conditioned material.

INDICATE THAT moisture content (regain) may vary within the batch and can influence the sliver weight. Proper adjustment of a gilling machine will ideally maintain the sliver weight within a range of ±0.4 gm/m.

Sampling rate

At 80m/min input speed and with 6–8 cans feeding a finisher gill, checking each new can could mean a 'weigh and adjust' every 12.5 minutes — patently impossible.

NOTE THAT machines are generally set up at the start of a new batch and checked once or twice a shift.

EXPLAIN THAT construction of a control chart is an effective way of determining when a machine needs adjusting.

MEASUREMENT OF TOP

Fibre characteristics	IWTO method	
Mean fibre diameter	8	Projection microscope
	12	Laserscan
	28	Airflow
	47	OFDA
Fibre diameter distribution	8	Projection microscope
	12	Laserscan
	47	OFDA
Colour	35	
Mean fibre length	18	Almeter
	DTM1	Comb sorter
	DTM16	WIRA fibre diagram
Fibre length distribution	18	Almeter
	DTM1	Comb sorter
	DTM16	WIRA fibre diagram
Residual fatty matter	10	

5 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT top is one of the key points at which wool is sold and objective measurements are widely used to value the wool in top form.

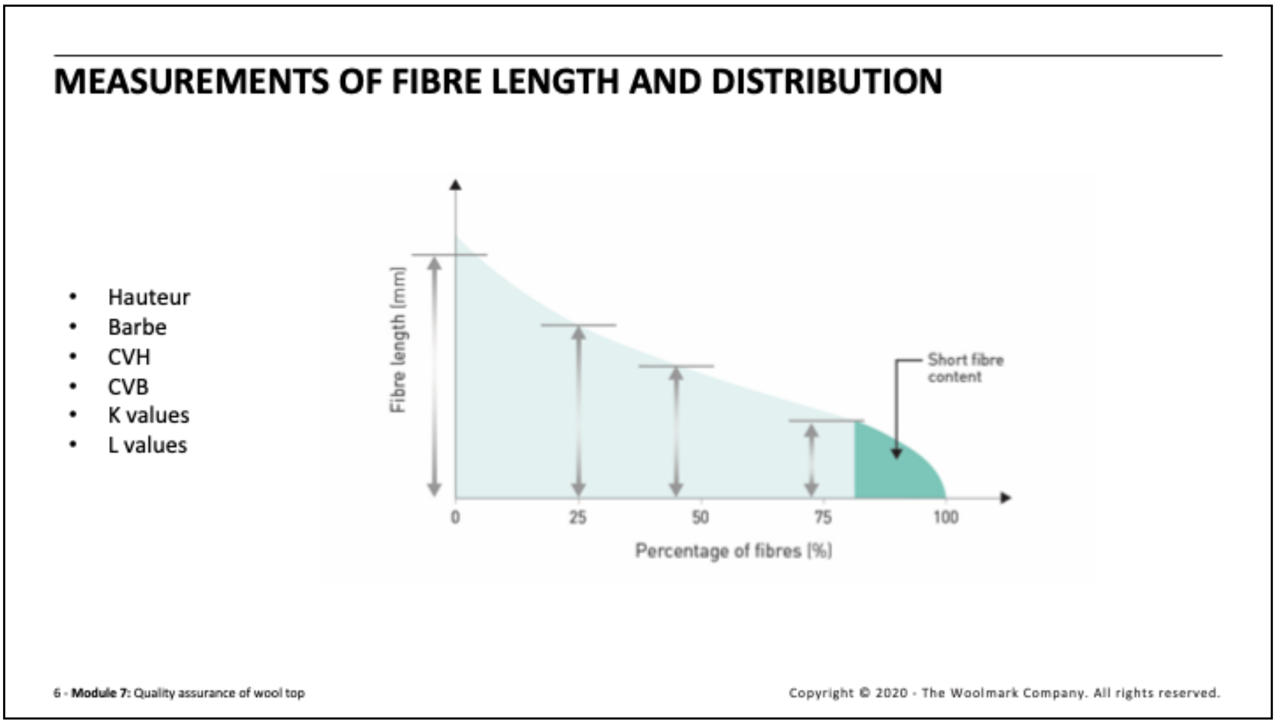
The parameters normally measured, and the IWTO test methods used to measure these parameters, are shown on the slide.

INDICATE THAT sampling of top is controlled by the IWTO Regulation 6: Sliver test regulations as quoted below:

Samples shall be taken from bales (of top) distributed equally throughout processing of the consignment.

- *Only one (1) sample shall be taken from a bale.*
- *A minimum of five (5) samples must be taken per consignment.*
- *When sampling is carried out during processing, samples should be taken at equal intervals throughout processing.*

EXPLAIN THAT the key difference in the measurement of raw wool and top is the measurement of the fibre length characteristics of the wool in the top.



EXPLAIN THAT a number of parameters are used to describe the length and length distribution characteristics of wool fibres in top and sliver. As discussed in an earlier module, the definitions used by IWTO are as follows:

Hauteur (H) measured in millimetres (mm): Mean length biased by cross-section (or linear density) of the fibres.

Barbe (B) measured in millimetres (mm): Mean length biased by fibre weight.

CVH (%): Coefficient of variation of fibre length based on hauteur

$$CVH\ \% = 100 * SQR\left[\frac{(barbe-hauteur)}{(hauteur)}\right]$$

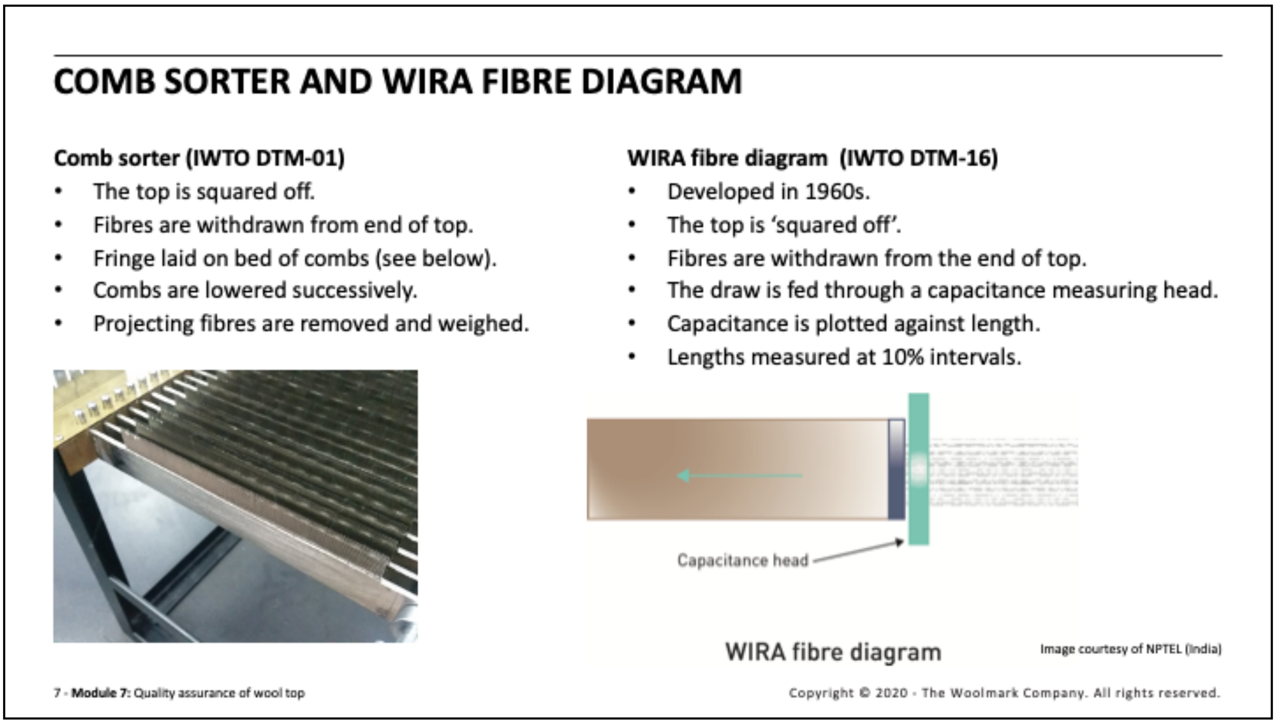
CVB (%): Coefficient of variation of fibre length based on barbe

L values (length @ x% of fibres)

- For example, L10H is the length reached by the longest 10% of the fibres

K values (% fibres <x mm)

- For example, K20H is the percentage of fibres less than 20mm — a measure of short fibre content of the top (indicated by the shaded area on the diagram on the slide).



EXPLAIN THAT this slide outlines two methods of measuring the fibre length distribution of sliver and top.

Comb sorter (IWTO DTM-01)
This is the oldest method of measuring fibre length distribution in sliver and top.
The method is as follows:

- The top is squared off.
- Fibres are withdrawn from the end of the top.
- The fringe is laid on a bed of combs lining up the gripped ends with the first comb.
- Combs are lowered successively.
- Projecting fibres are removed and weighed.
- The length distribution characteristics are calculated from the weights of each length group.

An interlaboratory trial demonstrated that the error in hauteur measurement using this method was 0.86.

WIRA Fibre Diagram (IWTO DTM-16)
This instrument was developed in 1960s.
The method is as follows:

- The top is 'squared off'.
- The exposed ends of the fibre are clamped to a plastic strip and withdrawn from the top.
- The fringe is drawn through a capacitance head.
- Capacitance is plotted against length.
- The length at 5% (and every succeeding 10%) of the capacitance maximum is measured.

NOTE THAT these methods are rarely used commercially to any significant extent.

The image provided by NPTEL is from

- Course : Textile Engineering
- Module: Wool Fibre Length

ALMETER (IWTO-17)

Fibroliner

Images courtesy of SAV Srl (Italy)

8 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT the Almeter is the most widely used instrument for measuring the fibre length characteristics of wool in sliver or top form.

The Almeter has two components:

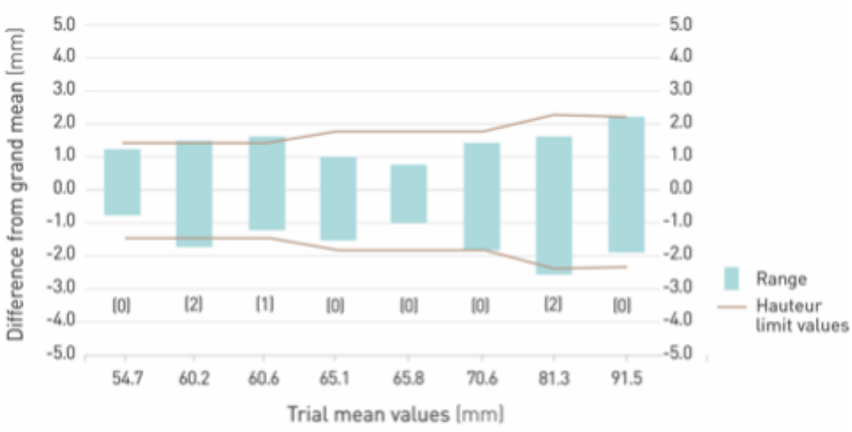
- the fibre aligner —creates a test specimen in the form of a fringe of fibres in which one end of the fibre is placed on a single line perpendicular to the direction of the fibres and the rest of the fibre is laid in a single direction to form a fringe.
- the measurement head — on which the fringe is placed between mylar sheets is held by a carriage.

NOTE THAT the carriage moves under a capacitive measurement head and the mass of fibre is determined continuously.

NOTE THAT in later models of the Almeter (AL2000), the measuring head moves over the sample rather than the sample moving under the measuring head.

EXPLAIN THAT the change in the amount of fibre at various distances from the aligned fibre ends is used to calculate the length distribution parameters.

INTERWOOLLAB TRIALS OF THE ALMETER (2013)



Interwoollabs trials of the Almeter (2013)

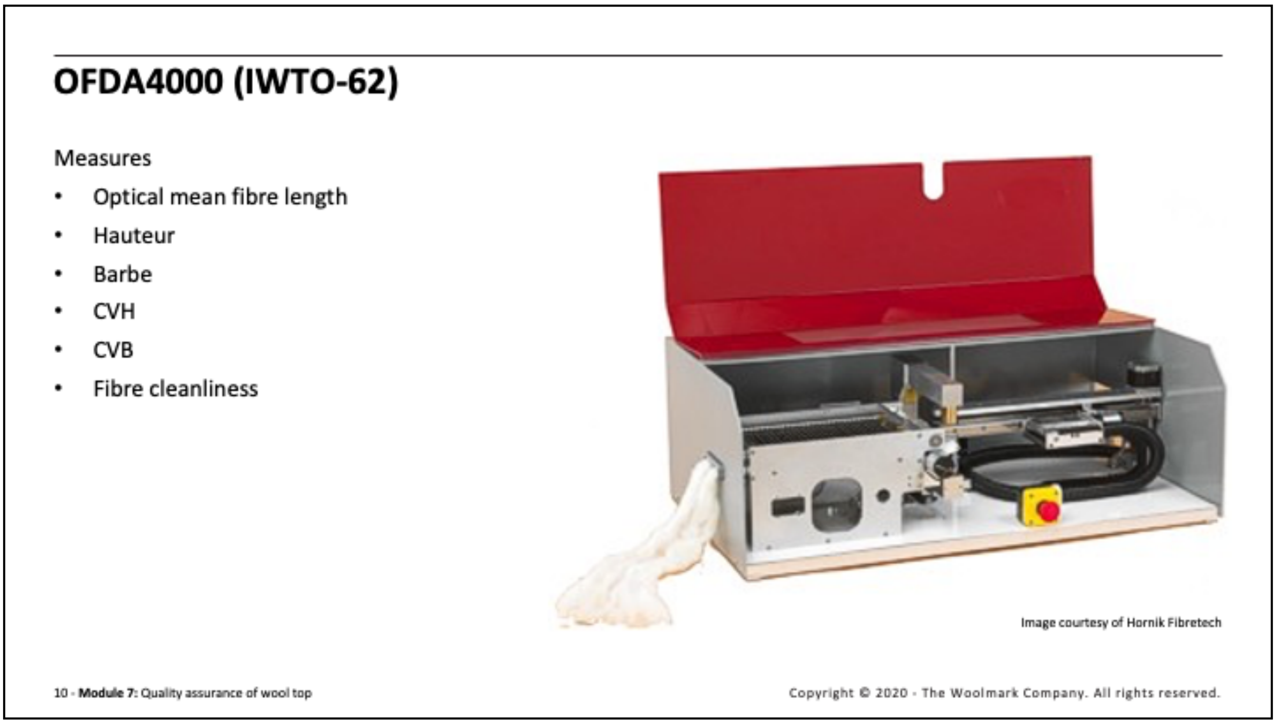
Source: IWTO

9 - **Module 7:** Quality assurance of wool top

INDICATE THAT as it does for the users of instruments for measuring fibre diameter characteristics, INTERWOOLLABS also runs accreditation trials for the users of the Almeter, using the same series of standard tops.

EXPLAIN THAT the results of a trial of users from one of these trials conducted twice a year is shown on the slide. Any laboratory whose results fall outside the agreed limits shown must repeat the trial.

INTERWOOLLABS reports to IWTO on these trials annually.



EXPLAIN THAT the OFDA4000 is a more recently-developed instrument for measuring the fibre length distribution of sliver and tops.

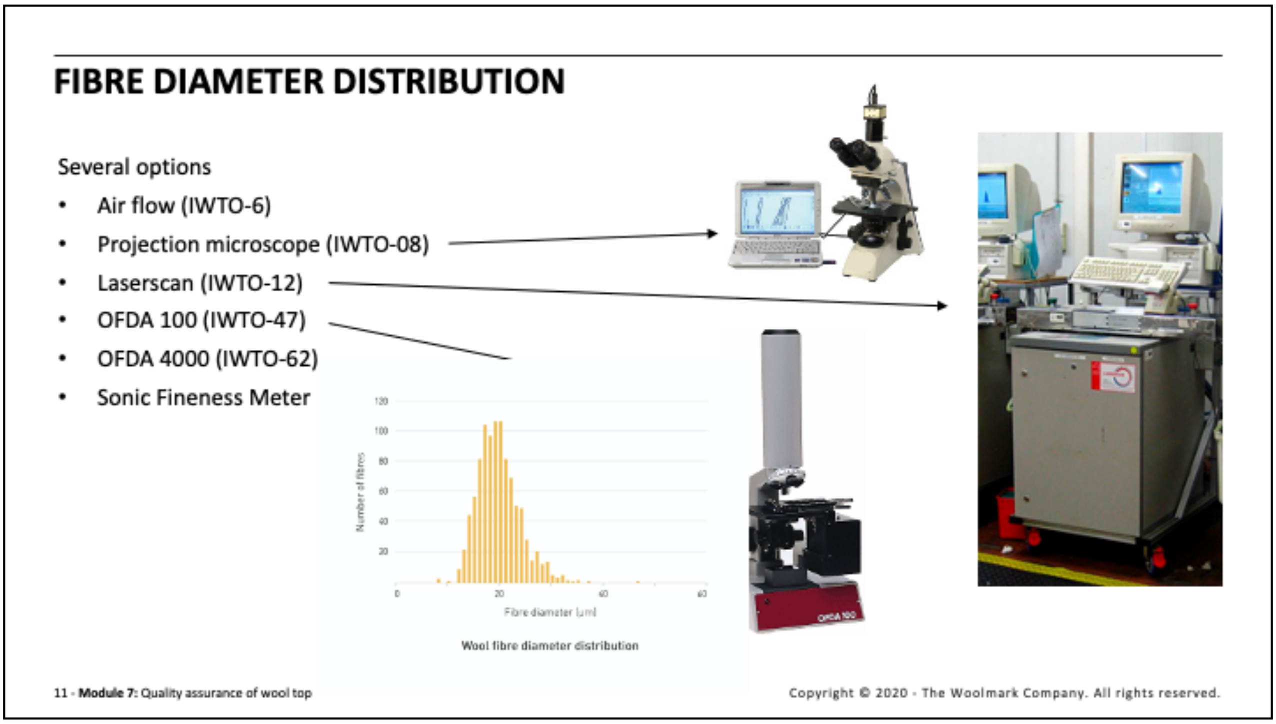
INDICATE THAT the instrument uses a gripper to draw end-aligned fibres from the top. A moving needle bed aligns and holds the fibres. A traversing video microscope is used to count the number of fibres remaining in the fringe at 5mm intervals as the fringe is drawn past the measurement point.

An option to measure at 5mm intervals to 60mm and thereafter at 10mm intervals is available.

EXPLAIN THAT image analysis is used:
- to count the number of fibres along the length of the fringe
- to determine the fibre diameter characteristics of the fibre at each point in the draw.

POINT OUT the instrument can be used to measure the normal characteristics of the top:
- Hauteur and Barbe
- CVH and CVB
- L and K values

NOTE THAT in addition the instrument measures:
- optical mean fibre length — mean fibre length determined by count
- mean fibre diameter
- diameter distribution statistics
- along-the-fibre diameter profile (similar to OFDA2000)
- comfort factor
- fibre end-comfort factor
- fibre end-fineness index
- fibre curvature
- a measure of fibre cleanliness.



EXPLAIN THAT all the technologies used to measure the fibre diameter characteristics of raw wool can be used to determine these characteristics of wool in top.

INDICATE THAT the differences between regulations for testing core samples of raw wool and those for sampling and testing of top naturally apply.

EXPLAIN THAT the IWTO test method for determining fibre diameter characteristics of top using air flow (IWTO-6) differs only slightly from that for the measurement of raw wool (IWTO-28).

- It is only applicable to non-medullated fibres.
- The top must have less than 1% DCM-extractable matter.
- Oil spun top must be cleaned before measurement
- The fibres in the specimen must be randomised, cut into 20mm lengths and randomised using a Shirley Analyser or using hand cards.

In IWTO-28 the raw wool is scoured and a subsample is randomised using the Shirley analyser.

NOTE THAT similar restrictions also apply to the use of the Sonic Fineness Meter, which can also be applied to the measurement of mean fibre diameter in tops

RESIDUAL FATTY MATTER (IWTO-10)

- Residuals on top include antistatic materials and other processing aides used in the top-making process.
- The test method IWTO-10 is used subjection to the IWTO regulations for top
- Near Infrared instrumentation may also be used
  - calibrated against solvent extraction

12 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT unlike the residual fatty matter on scoured wool, which is primarily in the form of wool wax, the residuals on top include antistatic materials and other processing aides used in the top-making process.

INDICATE THAT many of these processing aids are also water soluble and if required can be removed by scouring prior to dyeing or in a backwash.

The test method IWTO-10 is used subject to the IWTO regulations for top.

NOTE THAT Near Infrared instrumentation may also be used, provided it is calibrated against solvent extraction.

TOP EVENNESS

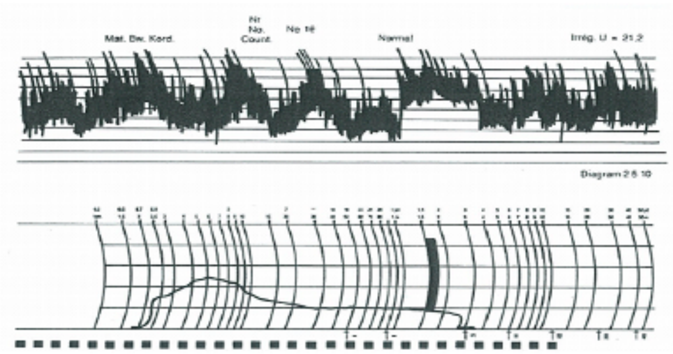


Image courtesy of Uster Technologies AG (Switzerland)

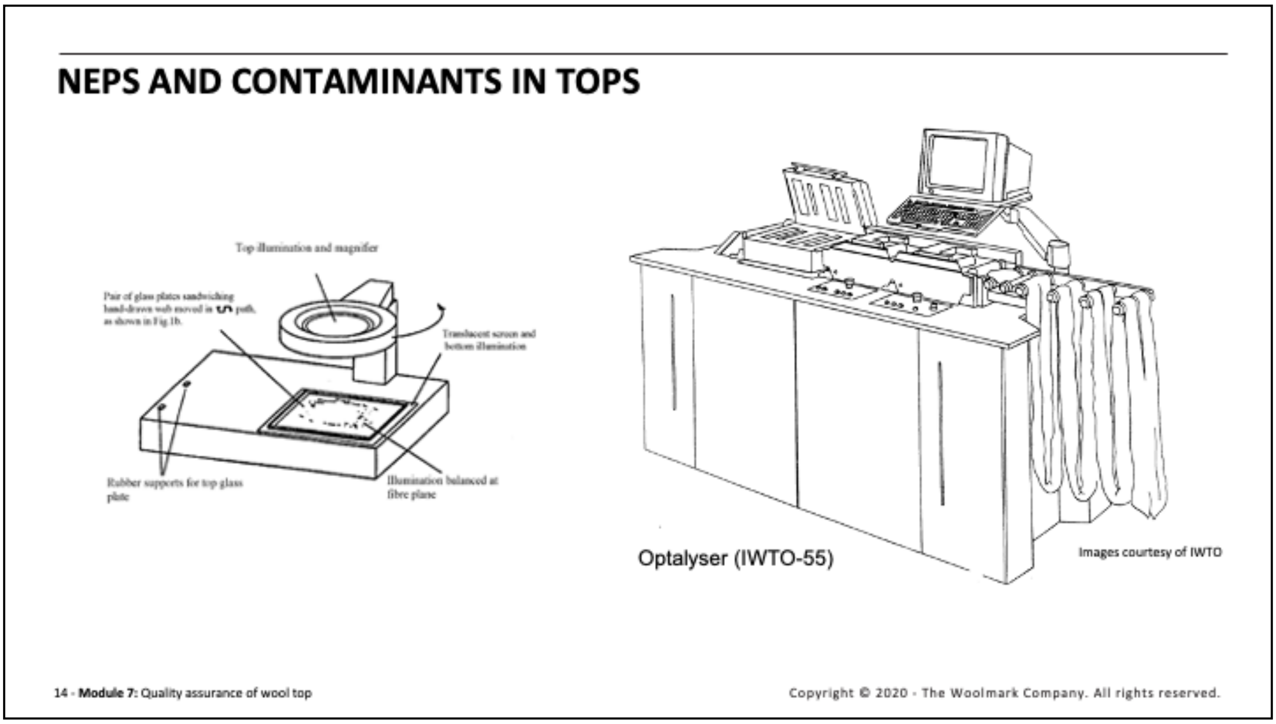
13 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT the evenness of sliver and top is important for ensuring the evenness of yarns. A number of methods are available to measure evenness of sliver and top.

IWTO-18
This method requires the top to be passed through a capacitance detector. The evenness is determined from the signal.

The instrument most commonly used for this assessment is the Uster evenness tester.

NOTE THAT the alternative approach of cutting the top into accurate lengths and weighing each is time consuming and tedious and rarely used.



EXPLAIN THAT quantitative assessment of contaminants in tops is difficult because of the different types of contaminants, such as:

- vegetable matter
- coloured fibre
- neps (small entanglements).

INDICATE THAT the simplest method is **visual inspection** (IWTO DTM-13). The method is as follows:

- the top is drafted and spread over a suitably-lit area.
- the operator observes, classifies and counts the various contaminants.

NOTE THAT coloured fibres are often classified by the depth of colour or origin of the fibre.

Optalyser

IWTO-55 describes an automated method for detecting contaminants using the Optalyser. The instrument drafts the top, which is then inspected electronically. Between-laboratory variance for neps is 0.0182, for vegetable matter 0.0123 and for coloured fibre 0.0369, expressed in defects per kilogram.

FibreGEN

FibreGEN is a new development from Australia in which the specimen of top is placed in a plastic bag and wool fibres are optically dissolved by adding benzyl alcohol. Benzyl alcohol has the same optical density as wool.

EXPLAIN THAT the contaminants are more readily seen and can be classified and counted using image analysis of the output of an optical scanner.

The method has been shown at IWTO meetings but not yet adopted as an IWTO test method.

STRENGTH OF WOOL FIBRES

The tensile strength of fibres is an important determinant of
- spinning efficiency
- yarn strength

Fibre strength in tops is often measured as the breaking load of a fibre bundle strength in N/ktex.

Several instruments can be used
- Sirolan Tensor
- ASTM D1294-05(2013)

The measured strength depends on the gauge length

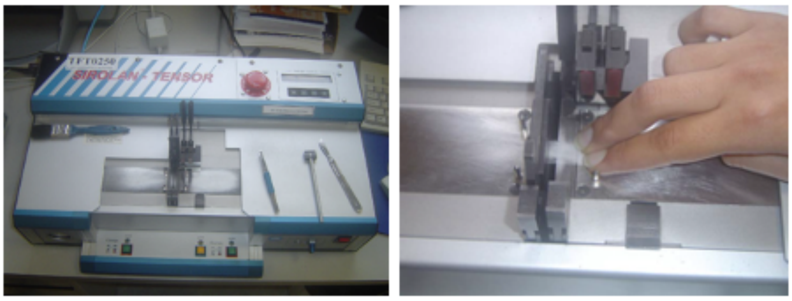


Image courtesy of CSIRO (Australia) and The Cotton CRC

15 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT the tensile strength of fibres is an important determinant of spinning efficiency and yarn strength.

INDICATE THAT the strength of fibres in sliver and top form are normally measured as a bundle. The method is as follows:
- A bundle of fibres is combed to make all fibres parallel.
- The bundle is secured between two clamps.
- The clamps are separate to apply tensile load.
- The force increases until the fibre bundle breaks.

NOTE THAT the tensile strength of the fibres is determined from the maximum load (breaking load) and the mass of fibres in the bundle.

The concept is similar to staple strength measurements.

EXPLAIN THAT several instruments can be used to measure fibre strength:
- Sirolan Tensor
- ASTM D1294-05(2013).

Fibre strength is reported as the breaking load per course mass (N/ktex).

DEMONSTRATION: STRENGTH OF WOOL FIBRES

Resources required:
- *sample of worsted top*

ASK *a volunteer to take a sample of fibres from the top and break them by hand.*

REPEAT *the process with a larger sample of fibres asking the volunteer to describe the increased difficulty in breaking the sample.*

EMPHASISE *the need to normalise the breaking load to allow for varying sample size (N/Ktex).*

STAPLE VS BUNDLE STRENGTH

RAW WOOL	STAPLE STRENGTH (N/ktex)	43	32	24
Top	Bundle strength (N/ktex)	10.4	10.8	10.0
	Hauteur (mm)	71.1	64.6	61.9
	Combing noil (%)	10.2	12.4	12.9
Re-combed top	Bundle strength (N/ktex)	10.3	10.3	9.9
	Hauteur (mm)	70.5	65.3	62.7
Yarn (82Nm)	Tenacity (N/ktex)	77.0	73.5	70.5
Yarn (40Nm)	Tenacity (N/ktex)	88.9	85.3	81.6

16 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT the tests to measure the staple strength of raw wool and the fibre strength of wool in top using a bundle test (as in Sirolan Tensor) are similar in concept. Both lead to a measurement in N/ktex.

INDICATE THAT CSIRO has done work to compare the results obtained on raw wool with the fibre strength of the same wool after processing to top. The results are shown on the slide.

It is notable that staple strength has only a small affect on the bundle strength of the wool in top form. The authors concluded that the staple strength of raw wool only affected top-making and spinning and had little impact on the properties of the final product.

However, stronger wools make tops with longer hauteur and less waste during combing — presumably because fewer fibres break during processing.

INDICATE THAT the resultant yarn is also stronger, but this may reflect the longer fibre length rather than the stronger fibres.

MENTION THAT presumably all the weaker fibres, which contributed to low staple strength, have broken leaving only the longer stronger fibres.

ISO STANDARDS

ISO137: 2015 Wool — Determination of fibre diameter — projection microscope method

ISO190: 1976 Wool — Determination of fibre length (barbe and hauteur) using a comb sorter

ISO1136: 2015 Wool — Determination of mean fibre diameter — air permeability method

ISO 2646:1974 Wool — Measurement of the length of fibres processed on the worsted system, using a fibre diagram machine

ISO 2648:1974 Wool — Determination of fibre length distribution parameters — electronic method

ISO 3074:2014 Wool — Determination of dichloromethane-soluble matter in combed sliver

17 - **Module 7:** Quality assurance of wool top

INDICATE THAT listed on the slide are some of the ISO standards pertaining to wool sliver and top.

- ISO137: 2015 Wool — Determination of fibre diameter — projection microscope method
- ISO190: 1976 Wool — Determination of fibre length (barbe and hauteur) using a comb sorter
- ISO1136: 2015 Wool — Determination of mean fibre diameter - air permeability method
- ISO 2646:1974 Wool — Measurement of the length of fibres processed on the worsted system, using a fibre diagram machine
- ISO 2647: 1974 Wool — Determination of fibre length distribution parameters — electronic method
- ISO 3074:2014 Wool — Determination of dichloromethane-soluble matter in combed sliver

NOTE THAT many of these are similar to those described by IWTO, but are not subject to IWTO Regulations.

QUALITY CONTROL TABLE (SAMPLING AND TESTING)

[illegible]

[illegible]	[illegible]	[illegible]	TOLLERANCE	[illegible]
[illegible]	[illegible]	Every 4 hours	+/-	Scour leader
	RG [illegible]	Every 4 hours	+/-	Lab staff
[illegible]	[illegible]	Every 8 hours	+/-	Card Leader
	TFM	Every 8 hours	+/-	Lab staff
[illegible]	[illegible]	Every 4 hours	+/-	Card leader
	[illegible] ([illegible])	Every 4 hours	+/-	Card Leader
	[illegible] ([illegible])	Every 4 hours	+/-	Card Leader
	[illegible]	Every 4 hours	+/-	Card Operators
[illegible]	[illegible]	Every 4 hours	+/-	Preparer Operators
	[illegible]	Every 4 hours	+/-	Preparer Operators
[illegible]	[illegible] / [illegible] [illegible]	xx combs / shift	+/- +/-	Comb Operators
	[illegible] ([illegible])	xx combs / shift	+/-	Lab staff
	[illegible] ([illegible])	xx combs / shift	+/-	Lab staff
[illegible]	[illegible]	Every 2500 kg	+/-	Lab staff
	[illegible]	Every 2500 kg	+/-	Lab staff
	[illegible] ([illegible])	Every 2500 kg	+/-	Lab staff
	[illegible] ([illegible])	Every 2500 kg	+/-	Lab staff
	[illegible]	Every 2500 kg	+/-	Lab staff
	[illegible]	Every 2500 kg	+/-	Finisher Operators
	[illegible]	Every 2 hours	+/-	Finisher Operators
	[illegible]	Every 2 hours	+/-	Finisher Operators

Note *The above plan represents an example only of how such a system may be designed and operated.*
The tollerances have not been filled in as the client mill must decide on their own

18 - **Module 7:** Quality assurance of wool top

REFER participants to the table on the slide as an example of a sampling regime.

EXPLAIN THAT the data must be organised to ensure that:

- adequate analysis can be completed
- information is reported in a timely fashion to all parties who require the outcomes.

NOTE THAT sharing and discussion of these results with all relevant staff is the responsibility of senior management.

MINIMUM MILL TESTING LABORATORY EQUIPMENT

PROPERTY TO BE MEASURED AND EQUIPMENT	MEASURING
Sliver linear density • Weighing equipment correct to 0.1g • Length measuring equipment	Sliver weight (g/m)
Fibre length testing ** • Almeter • Comb sorter • OFDA 4000	Hauteur (mm) Barbe (mm) Coefficient of variation of hauteur Coefficient of variation of barbe (%)
Fibre diameter ** • Airflow meter • Laserscan • OFDA (100, 2000 or 4000) • Projection microscope	Mean fibre diameter (µm) Coefficient of variation of diameter (%) • CVD not measured by airflow

** Instruments are options available

19 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT a first-class wool top-making plant will contain a well-equipped and well-controlled air-conditioned testing laboratory.

INDICATE THAT the laboratory has a dual purpose:

- to provide a control testing facility for the manufacturing plant to ensure the material specifications defined by the quality assurance program are met
- to providing a QA service to all customers.

Sliver weight testing requires a device for cutting a known length of top and a balance.

Sliver weight regularity is measured electronically on a running top.

Mean fibre diameter and distribution (CVD)
Three instruments can be used to measure MFD and distribution

- Laserscan,
- OFDA
- Projection microscope

Airflow only measures mean fibre diameter.

POINT OUT the instruments listed in each group on the slide are options for testing. A detailed description of these instruments is provided in the Woolmark Wool Science, Technology and Design Education Program course *Introduction to wool processing*.

Mean fibre length and distribution (CVH)
These measurements are traditionally made using an Almeter. A newer instrument called the OFDA4000 can also be used.

MINIMUM MILL TESTING LABORATORY EQUIPMENT

MEASURING EQUIPMENT	MEASURING
Extractable matter testing equipment ** • Soxhlet • WIRA rapid • Other rapid tests	Solvent extractable matter Total fatty matter (TFM)
Moisture testing equipment ** • Oven method • Rapid regain tester	Regain (%) Moisture content (%)
Imperfection counting equipment • Drafting device (Tonneison) • Manual	Neps and vegetable matter

** Instruments are options available

REFER participants to the list of other necessary equipment and the tests they undertake shown on the slide.

Soxhlet extraction and balance for measuring solvent extractables (also called total fatty matter).

An oven and weighing device for measuring moisture content.

A device that drafts and opens the top so it is more open and imperfections can be counted manually.

PROCEDURES MANUAL

- Standard operating procedures (SOP) manual – includes activities, responsibility, accountability, documents
- Example:

STAGE	ACTIVITIES	RESPONSIBILITY	ACCOUNTABILITY	DOCUMENTATION
Raw material	Wool top quality report is received from wool combing department and linked to raw wool tests.	QAD technician	Head of QAD	Raw wool register
	Wool combing reports shown to head of production for approval	Head QAD/Head of prod.	Head of QAD	Wool combing report

21 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT a quality assurance program should include a manual detailing all standard operating procedures, including those for quality control sampling and testing.

NOTE THAT all operatives must be fully aware of their duties and responsibilities and to some extent the roles of other personnel in the department.

Additionally, the reporting functions and responsibilities also need to be fully understood by all employees.

INDICATE THAT the written documents for all staff to access the necessary information are:

- the standard operating procedures (SOP)
- job specification sheets.

Verbal communication is also vital.

NOTE THAT workplace health and safety (WHS) and associated notes are also mandatory for all staff.

MATRIX FOR CONTINUOUS PROCESS IMPROVEMENT TOOLS

TOOL	PLANNING	ANALYSIS	INTERPRETATION	TEAM	INDIVIDUAL
Brainstorming	X	X		X	
Affinity diagram	X	X		X	
Matrix diagram	X			X	X
Force field diagram		X		X	
Cause and effect		X		X	
Check sheet		X	X		X
Tree diagram	X			X	
Pareto chart			X		X
Criteria rating	X		X	X	

22 - **Module 7:** Quality assurance of wool top

EXPLAIN THAT a wide range of statistical and quality control textbooks provide the theory of applying a range of analysis tools to support the vital role of data analysis.

INDICATE THAT the matrix provided above is meant to assist the manager in selecting and applying the wide and diverse range of tools to choose from and when and where to apply these tools.

EXPLAIN THAT too often data is collected without sufficient or appropriate analysis, leading to a waste of resources and, more importantly, a lost opportunity for the business to improve profit.

As a business continues to grow and change, it is important to maintain the manual carefully.

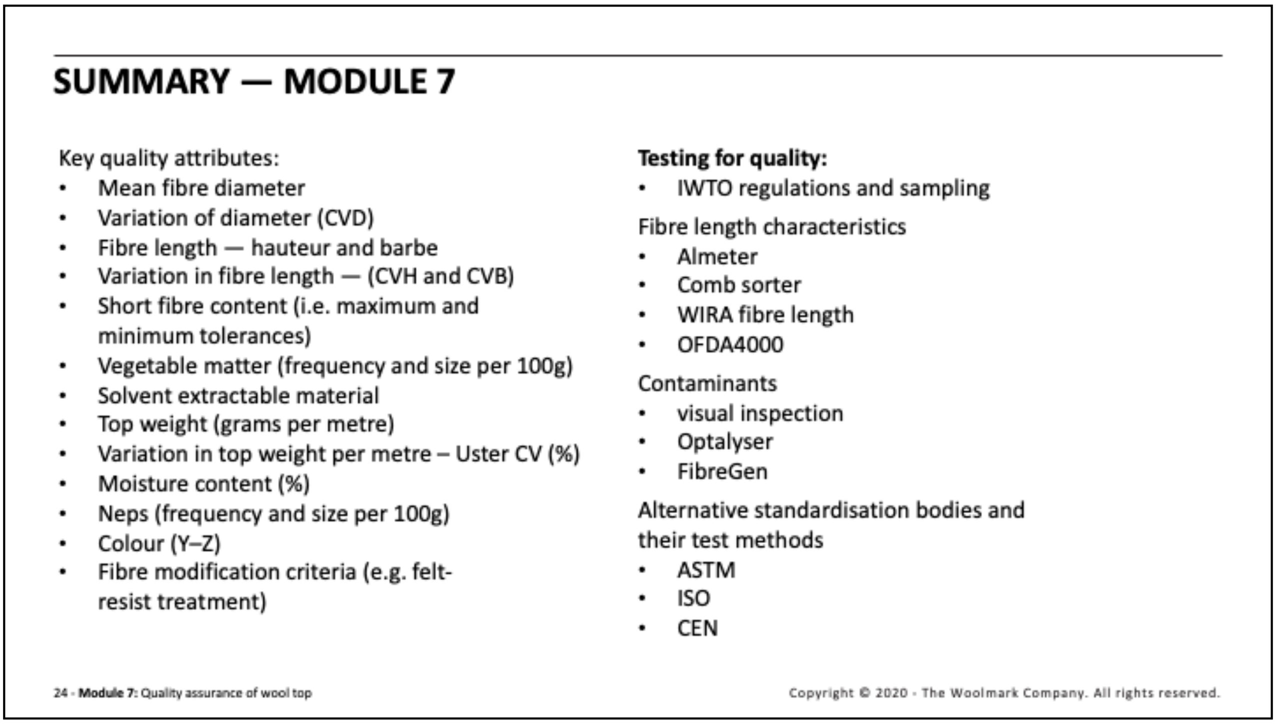
INDICATE THAT it is highly likely some of the work practises that worked well one or more years ago may not be the most effective or productive processes to use if the business is to meet current and future quality demands.

NOTE THAT a business must continue to improve to remain competitive.

MATRIX FOR CONTINUOUS PROCESS IMPROVEMENT TOOLS

TOOL	PLANNING	ANALYSIS	INTERPRETATION	TEAM	INDIVIDUAL
Sequence flow chart	X	X		X	X
Process flow chart	X	X		X	X
Scatter diagram			X		X
Run chart		X	X		X
Control chart		X	X		X
Histogram		X	X	X	X

EXPLAIN THAT the above diagram also lists potential statistical tools that can be used to analyse QC data.



SUMMARISE THAT the key attributes important for top quality include:

- Mean fibre diameter
- Variation of diameter (CVD)
- Fibre length — hauteur and barbe
- Variation in fibre length — (CVH and CVB)
- Short fibre content
- Vegetable matter (frequency and size per 100g)
- Solvent extractable material
- Top weight (grams per metre)
- Variation in top weight per metre – Uster CV (%)
- Moisture content (%)
- Neps (frequency and size per 100g)
- Colour (Y–Z)
- Fibre modification criteria (e.g. felt-resist treatment)

REMIND participants that the tests used to measure the key properties of top are similar to those used for raw wool. The major differences in the test regimes are in the tests used to determine fibre length distribution characteristics.

REVIEW the tests for fibre length distribution described include:

- Almeter for sliver and top
- Comb sorter
- WIRA fibre length diagram
- OFDA400

REITERATE THAT the other key tests are for contaminants in top. The methods for testing include:

- visual inspection (IWTO DTM-13)
- the Optalyser (IWTO-55)
- FibreGen inspection.

REMIND participants that while the regulations and test methods of IWTO are the most widely used, other national and international bodies also have regulations and methods for testing wool (e.g. ASTM, ISO, CEN).

REITERATE THAT the sampling protocols, instrumental measurements and data analysis are key parts of any quality assurance program involving problem solving and the continuous improvement of top quality.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture in *Worsted top-making— Module 8: Treatment of top—* and ensure they read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

MODULE 8

TREATMENT OF TOP

RESOURCES — MODULE 8: TREATMENT OF TOP

Contained in the *Worsted top-making* Demonstration kit you will find the following resources for use as you deliver **Module 8: Treatment of top**.

- sample of ecru (untreated and undyed) top
- sample of dyed top
- sample of re-combed dyed top
- sample of mélange top
- sample of felt-resist treated top
- sample of mercerised top
- sample of stretched top

WELCOME participants to Module 8 of the Woolmark Wool Science, Technology and Design Education Program course *Worsted top-making — Treatment of top.*

INFORM participants that by the end of this module they will be able to describe:

- the common treatments used on top to :
    - improve processing
    - impart colour
    - impart functional properties
- the methods used to impart these properties
- the impact on the subsequent processing of wool
- the procedures adopted to maximise subsequent spinning efficiency.

RESOURCES REQUIRED FOR THIS MODULE:

- *sample of ecru (untreated and undyed) top*
- *sample of dyed top*
- *sample of re-combed dyed top*
- *sample of mélange top*
- *sample of felt-resist treated top*
- *sample of mercerised top*
- *sample of stretched top*

EXPLAIN THAT the combed top is the feedstock for spinning. At this stage the material can be processed:

- without modification (i.e. untreated)
- or it can be modified in a number of different ways and for various reasons to achieve specific effects.

Dyeing/printing

- Processed to colour the fibre.

Backwashing

- Used on top that has been dyed as top or as ultimate cleaning of the unmodified fibre.

Colour blending of tops

Felt-resist processing

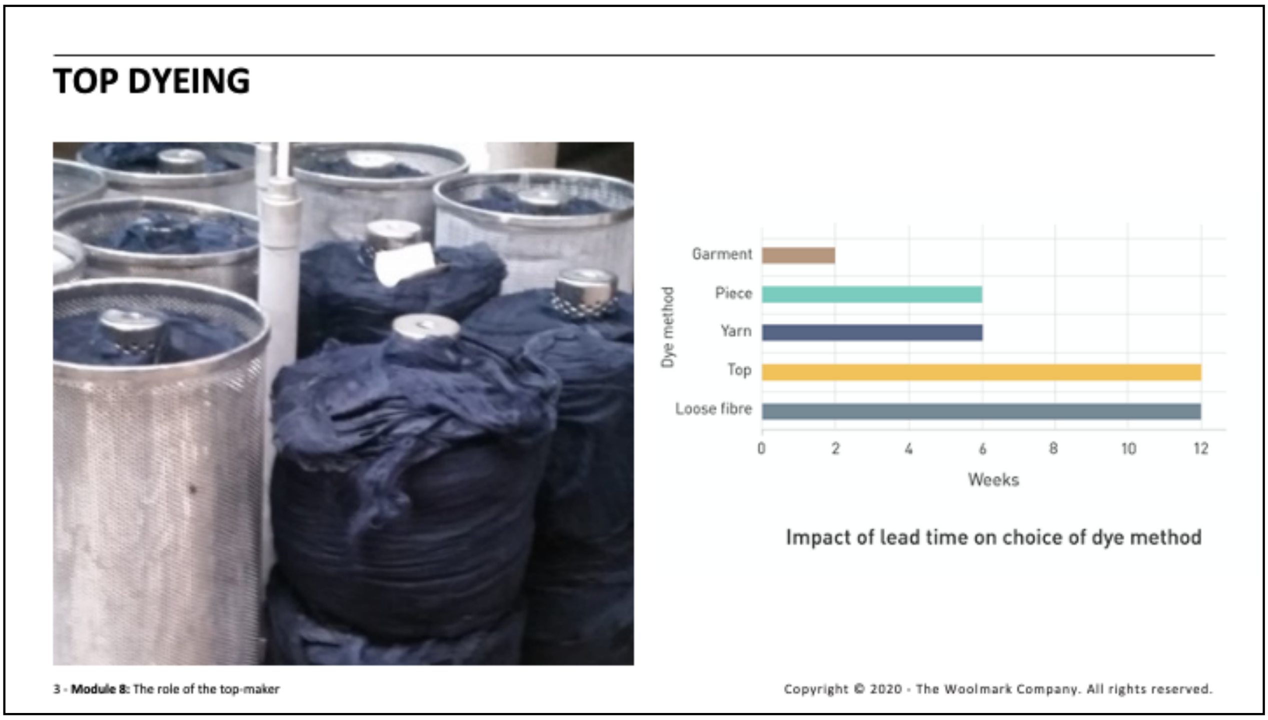
- A number of methods can be used to make the wool fibre felt-resistant.

Soft lustre/mercerisation

- A process can be used to improve the lustre and handle of the fibre.

Modification by stretching

- A process can be used to reduce the mean fibre diameter of the wool by extending the wool fibres and setting them in the extended form.



EXPLAIN THAT dyeing at the top stage is the most popular mode of dyeing for worsted products. It allows:

- continuity of colour, by blending multiple dye batches to form large lot size
- the formation of mélange, multicolour, or 'heather' yarns (yarns formed from fibres of different shade or depth of colour).

INDICATE THAT there are some disadvantages to dyeing at top stage:

- Top must be recombed and gilled after dyeing to restore their performance in spinning.
- The spinning efficiency of dyed top is lower than that of the equivalent untreated top — a reflection of the damage to the fibre caused by the dyeing conditions.

NOTE THAT methods to reduce damage to the fibre during top dyeing are described in the Wool Science, Technology and Design Education Program course *Wool dyeing*.

EXPLAIN THAT top can also be printed with one or more colours to create multicolour or multitone effects in the spun yarns. Printing avoids multiple dyeings and blending of the tops.

NOTE THAT the most common form of top printing is called 'Vigoreux' printing. A black–white melange is created by printing sections of the top black, avoiding the need to blend black and white top. The printed top is steamed to allow penetration of the dyestuff into the fibre. Auxiliaries that promote migration are used in the print paste in addition to those used to control paste viscosity.

***HAND OUT** samples of ecru (untreated and undyed) top, dyed top and re-combed dyed top to participants.*

***ALLOW** participants sufficient time to explore the samples.*

***ASK** participants to share their observations with the group and if necessary emphasise the impact of dyeing (i.e. disturbs the fibre alignment within the top, which is corrected by re-combing).*

TOP DYEING — POST-DYEING PROCESSES

Top dye
- backwash or equivalent
- de-felting gill
- first pass gill
- second pass gill
- third pass gill
- re-comb
- first finisher
- second finisher.

Top print
- steam
- backwash or equivalent
- de-felting gill
- first pass gill
- second pass gill
- third pass gill
- re-comb
- first finisher gill
- second finisher gill.

4 - **Module 8:** The role of the top-maker

Processes following top dyeing
EXPLAIN THAT after top dyeing a number of processes are used to restore the top to a condition suitable for preparation for spinning.

INDICATE THAT the procedure for finer yarn counts (above 20Nm) is as follows:
- Top dye – backwash or equivalent – de-felting gill – first pass gill – second pass gill – third pass gill – re-comb – first finisher – second finisher.

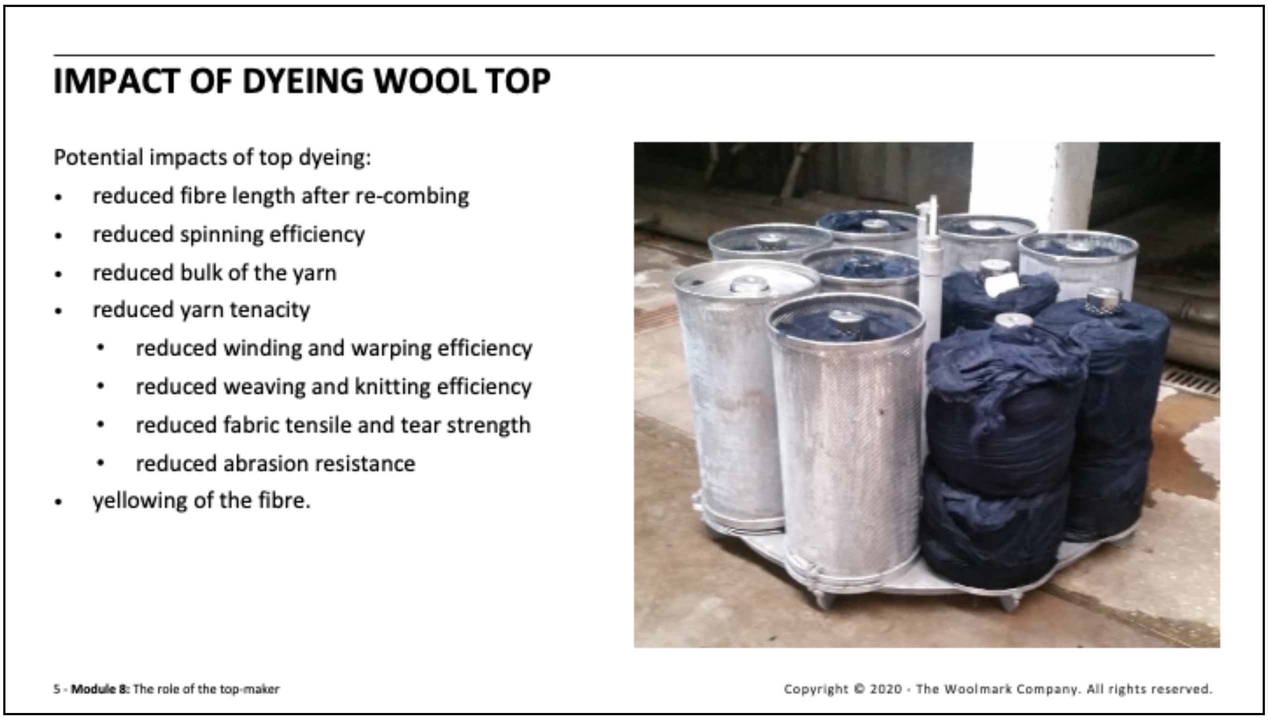
NOTE THAT there is compaction of the fibres in the top during the dyeing process and in some cases, light gluing of the fibres together. Proceeding direct to yarn manufacture after dyeing would result in a yarn comprising an unsatisfactory number of fibre faults, such as slubs and neps. Dyed top is almost always re-combed to separate and re-align the fibres before being processed into yarn.

EXPLAIN THAT sometimes dyeing and yarn production is done without re-combing, but this is only recommended for counts coarser than about 15 to 20Nm.

NOTE THAT when fine wools, which are more prone to developing fibre faults after dyeing, are used in these coarser counts, this upper count limit may need to be re-examined.

Processes following top printing
EXPLAIN THAT the procedures adopted to restore the top to a condition ready for spinning after printing are similar to those following dyeing, except the top must be steamed to allow the dye to penetrate the fibre:
- Top print – steam – backwash or equivalent – de-felting gill – first pass gill – second pass gill – third pass gill – re-comb – first finisher – second finisher.

The need for a third pass gill depends on the wool fineness and the capability at the de-felter gill box.



INDICATE THAT some damage occurs during top dyeing. This often impacts the production of a high-quality yarn.

EXPLAIN THAT damage during dyeing is most readily seen as:

- a loss of fibre strength
- increased fibre breakage
- increased noil during re-combing
- reduction in fibre length during gilling and roving
- reduced spinning efficiency.

NOTE THAT damage in dyeing of wool in top can impact on:

- the spinning process
- performance in yarn winding, knitting and weaving
- the overall quality of yarn
- the properties of the final product.

MENTION THAT damage can be quantified by assessing:

- reduced yarn strength and extensibility
- reduced weaving or knitting efficiency
- reduced fabric abrasion resistance
- reduced fabric tensile or tear strength
- fibre yellowing.

CONSEQUENCES OF DYEING WOOL

DYES	YARN	STRENGTH (g)		EXTENSION (%)	
		2/48 Nm	2/56Nm	2/48 Nm	2/56Nm
Undyed		290	306	14.8	26.4
Acid levelling	Control	266	263	15.1	22.4
Milling	Control	250	242	12.5	16.9
1:2 Metal-complex	Control	248	232	11.3	12.9
Afterchrome	Control	260	261	12.4	19.3

Techniques to reduce damage during dyeing:
1. Low temperature dyeing
2. Use of wool protecting agent
3. Use of anti-setting agents

6 - **Module 8:** The role of the top-maker

INDICATE THAT the impact of dyeing on the tensile properties (strength and extension) of the yarn is highlighted in the table on the slide. The extent of that damage, as measured by the change in tensile properties, varies with the type of dyestuff used.

EXPLAIN THAT the reduction in strength is greater for fine yarns. As shown on the slide, the percentage loss in strength of the 2/56Nm yarn is greater than that of the 2/48Nm yarn. Dyeing also can reduce the extensibility of the yarn.

NOTE THAT a number of techniques can be used to reduce damage to wool during dyeing.

Low-temperature dyeing methods
When wool is dyed at low temperature or for a short time of boiling using a suitable auxiliary there is:
- a reduction in damage
- no effect on the dye fastness or in the final colour.

Wool protecting agents
A number of wool protecting agents can be used during dyeing to protect the fibre:
- Soluble proteins, which degrade (hydrolyse) faster than wool in the dyeing conditions slow hydrolysis of the wool proteins.
- Crosslinking agents (e.g. formaldehyde) chemically crosslink the labile proteins in the fibre preventing their solution

Anti-setting dyeing technology
This technology is used to restrict the permanent setting of wool while it is being dyed. The following advantages have been found in trials of the technology under industrial conditions.
- improved processing performance during spinning
- increased yarn elongation
- increased knitting and weaving efficiency
- increased tensile strength of woven fabric
- improved handle of knitted goods.

BACKWASHING

- Improves the cleanliness of the fibre.
- Removes loose or unfixed dyes from the fibre.

PROCESS	BACKWASHED	
	NO	YES
Roving		
Laps	10	0
Fly (%)	0.3	0.1
Spinning (EDMSH)	238	64
Yarn faults per 10^5 m	168	129

7 - **Module 8:** The role of the top-maker

EXPLAIN THAT backwashing is used for two major reasons:

- to improve the cleanliness of the fibre — removing any residual contaminants can enhance the spinning efficiency (as shown in the table on the slide)
- to remove loose or unfixed dyes from the fibre — if left unwashed, this poorly-fixed dye would be rubbed from the fibre during the spinning operations, becoming a nuisance and causing faults in the final yarn and fabric.

INDICATE THAT backwashing is a traditional technology, which brings rewards to manufacturing efficiency and therefore reduced costs of manufacture. It ensures a higher-quality product (normally yarn), but it is quite expensive.

MENTION THAT backwashing has largely disappeared from wool manufacturing plants that produce undyed (untreated) tops.

NOTE THAT the advantages accrued from backwashing, especially with superfine wools, are substantial and worth considering in specialist fine-wool manufacturing plants.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the backwashing process. Following the video we will look at the backwashing process step by step.

PLAY *video (53:00 seconds)*

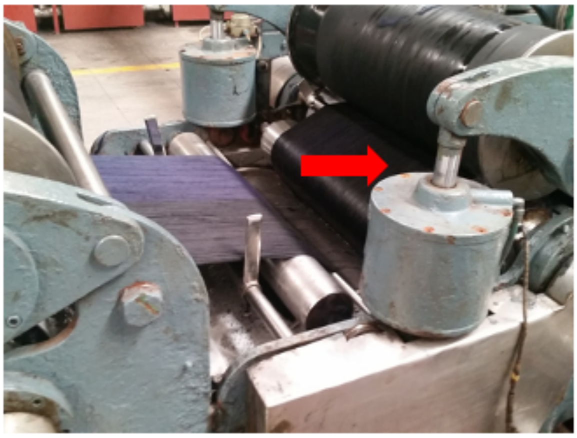
AS THE *video plays note that:*

- *the backwasher is used to wash tops to remove processing aids and loose dyes*
- *many tops are fed into the machine (5:00 seconds)*
- *the tops pass through a water-filled bowl — in this instance with a suction drum (29:00 seconds)*
- *the tops are then squeezed and dried using hot air (31:00 seconds)*
- *the tops are finally wound onto balls (36:00 seconds).*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

MACHINERY FOR TOP DRYING FOLLOWING BACKWASHING



De-watering (squeeze)

Thermal drying

9 - **Module 8:** The role of the top-maker

INDICATE THAT mechanical de-watering systems for dyed fibre include centrifugal hydroextraction and squeezing through rollers. This is used to minimise the residual water content of dyed fibre as this will, in turn, reduce the time and temperature of thermal drying.

NOTE THAT residual moisture levels of 40–45% should be the target.

The thermal dryer should be sufficiently large to dry the fibre to 17% moisture at no more than 100°C. Higher temperatures can lead to fibre damage and reduced processing efficiency.

Radio frequency (RF) drying is increasingly used for all shades — conveyor belt types are the most common RF types.

EXPLAIN THAT some RF dryers can generate high temperatures in the centre of tops or in the middle of a deep layer of loose fibre. Careful control is necessary when drying pale or bright shades, or bleached white wool to minimise yellowing at the package centre.

COLOUR BLENDING

Two operations conducted in gill boxes

- post dye opening
- combs and gills to mix.

The intimacy of a blend is determined by:

- the number of colours in the material
- fibre diameter
- the machine settings
- the number of doublings
- the sliver weight(s) fed to the machine.

Image courtesy of Divinity Fibres

10 - **Module 8:** The role of the top-maker

EXPLAIN THAT the blending of fibres or colours, or both at the same time, is performed after the initial combing and gilling operations. The input is most commonly top dyed in bumps or balls.

NOTE THAT colour blending can also include top that has been Vigoureux printed.

EXPLAIN THAT the intimacy of a blend is determined by a number of factors including:

- the number of colors in the material
- fibre diameter
- machine settings, including:
    - the action of pins
    - the amount of draft
- the number of doublings
- sliver weight normally fed to the machine.

EXPLAIN THAT to ensure a satisfactory blend is produced, remembering the level of color intimacy is decided by the designer, some technical considerations are vital and the following needs to be known:

- the weight of the different slivers composing the blend (g/m)
- the number of slivers that can be fed to the machine under consideration (the higher this number the better)
- options for altering draft, pinning, and any other relevant parameter.

***HAND OUT** the mélange top to participants.*

***ASK** participants to extract a white and a black fibre from the sample they are given.*

***EMPHASISE** that mélange is a specific colour blending technique.*

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the colour blending process. Following the video we will look at the colour blending process step by step.

***PLAY** video (21:00 seconds)*

***AS THE** video is playing indicate that coloured tops are often blended during gilling.*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond before proceeding.*

COLOUR BLENDING — AN EXAMPLE

Consider :

- a lot with 1000kg of top
- sliver weight is 20g/m
- a feed creel with 10 ends

The color blend required: 15% yellow | 60% brown | 25% black.

For 1000kg of top: 150kg yellow | 600kg brown | 250kg black.

For a 20g/m sliver, with a doubling potential of 10 slivers:

- yellow 7500/5000 = 1.5 slivers
- brown 30,000m/5000 = 6 slivers
- black 12,500/5000 = 2.5 slivers needed.

Image courtesy of Divinity Fibres

12 - **Module 8:** The role of the top-maker

EXPLAIN THAT the following example illustrates the practical working issues that require consideration when colour blending top.

Consider an intersector gill box:

- a lot with 1000kg of top
- sliver weight is 20g/m
- a feed creel with 10 ends

The colour blend required is: 15% yellow | 60% brown | 25% black.

From 1000kg we will need: 150kg yellow | 600kg brown | 250kg black top.

For a sliver weight of 20g/m, we will have 7500m of yellow | 30000m of brown | 12500m of black — total of 50,000m.

With a doubling potential of 10 slivers, we will have:

- 50,000/10 = 5000m of feed length/can.

Per colour:

- Yellow 7500/5000 = 1.5 slivers needed
- Brown 30,000m/5000 = 6 slivers needed
- Black 12,500/5000 = 2.5 slivers needed.

INDICATE THAT unfortunately, we need to pre-draw the yellow and black slivers to a suitable sliver weight to arrive at whole numbers of feed slivers. In this example we would make the black 20% heavier so two slivers of black are fed and at the same time, reduce the weight of the yellow by 25% so two slivers can be used.

EXPLAIN THAT to overcome this expensive additional pre-drawing exercise, options are available from machinery manufacturers for having special creels with individual pre-draft adjustment available in the feed to bring the feed onto a more exact linear density for the blend feed required.

FELT-RESIST TREATMENT

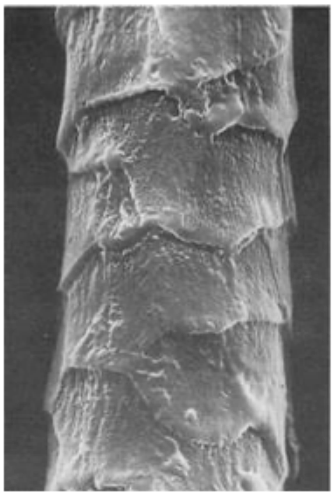
The most common method to felt-resist treat wool is the treatment of top.

The process involves:

- treating the fibres with chlorine or an alternative oxidising agent
- removing the solubilised protein
- applying a polymeric substance to mask the scales
- drying and curing the applied polymer.

The process causes adjacent fibres to be joined by polymeric interfibre bonds.

- This will inhibit drawing and spinning.
- The top is re-gilled and re-combed to re-align and re-separate the fibres.



13 - **Module 8:** The role of the top-maker

EXPLAIN THAT the most common method to felt-resist treat wool to allow for machine-wash performance is the treatment of top.

INDICATE THAT the felt-resist process involves:

- treating the fibres with chlorine, or an alternative oxidising agent
- removing the solubilised protein
- applying a polymeric substance to mask the scales
- drying and curing the applied polymer.

EXPLAIN THAT the felt-resist process causes adjacent fibres to be joined by polymeric interfibre bonds. These bonds will inhibit subsequent drawing and spinning operations. The top must be re-gilled and re-combed to break the interfibre bonds and re-align and re-separate the fibres.

NOTE: Terms such as shrink-resist treatment are commonly used, but the more correct term is felt-resist treatment as is used in this module.

***HAND OUT** samples of felt-resist treated top and untreated top to participants.*

***ALLOW** them time to identify the differences between the two samples.*

***ASK** participants for comments on differences in handle (hand feel) of the two samples.*

FELT-RESIST TREATMENT

14 - **Module 8:** The role of the top-maker

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the felt-resist process.

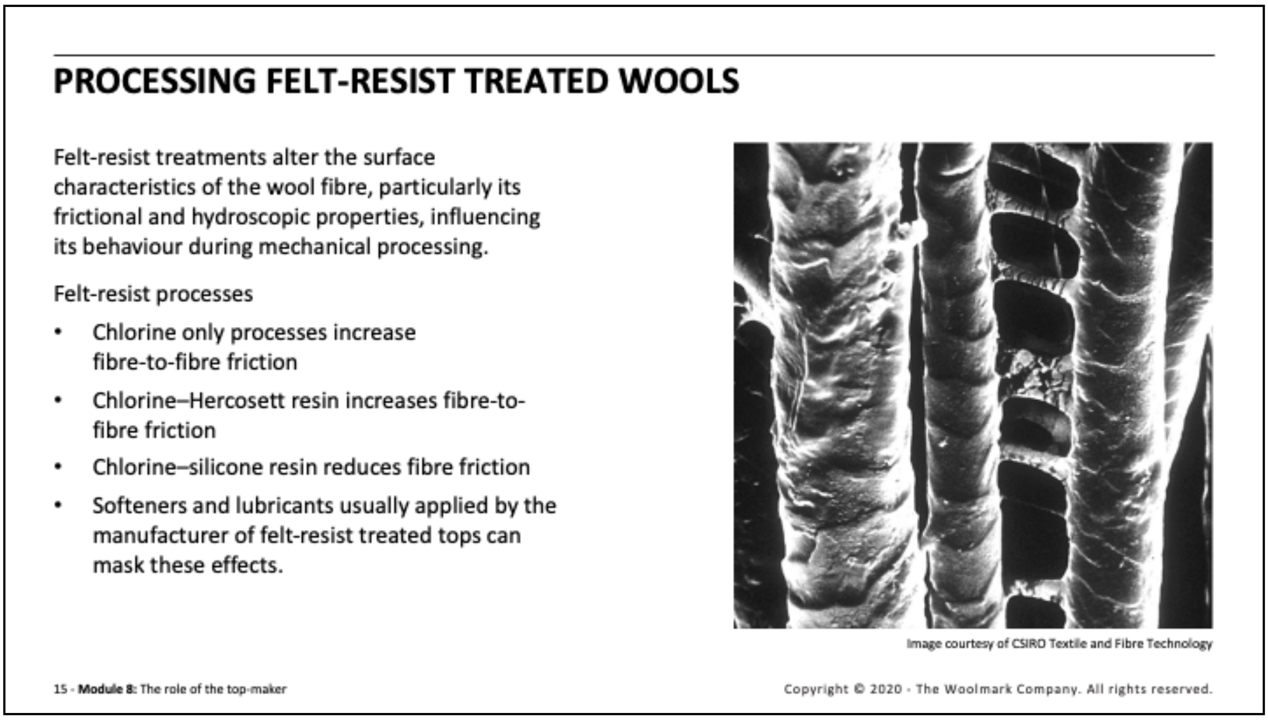
PLAY *video (2:00 minutes)*

AS THE *video plays explain that:*

- *the video shows the felt-resist treatment of top using the chlorine-Hercosett process*
- *the tops are placed on the creel. Many tops are treated at the same time (11.00 seconds)*
- *the machine used is a modified back-washing machine (30.00 seconds)*
- *the first bowl is a suction drum, which pulls the chlorine solution through the top. Fume extraction is required to remove any chlorine (poisonous) escaping from the machine. The second bowl neutralises the remaining chlorine and removes it from the wool (45.00 seconds)*
- *the last bowl is a rinse bowl (1:06 minutes)*
- *the tops are dried using a suction drum dryer by recirculating hot air (1:18 minutes)*
- *the dried tops are wound onto balls (1:30 minutes).*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*



NOTE THAT the way in which the frictional properties of the fibre are changed depends upon the actual type of felt-resist treatment applied.

EXPLAIN THAT chlorine-only and some chlorine-Hercosett treatments increase fibre-to-fibre friction. These effects can be masked by the type of softener and/or fibre processing lubricant applied during the final stage of the felt-resist treatment.

Chlorine–resin-based treatments that use silicones tend to reduce the fibre frictional characteristics.

INDICATE THAT in practice, an increase in fibre friction tends to:

- assist the actual spinning operation, due to an increase in fibre cohesion
- cause problems during preparatory gilling and drawing stages, due to a higher fibre-to-metal friction.

EXPLAIN THAT the fibre processing lubricant needs to be applied during early gilling operations to reduce friction. The product chosen, and amount applied, should offer a compromise between the differing frictional requirements during gill blending, drawing and spinning.

EXPLAIN THAT in practice a reduction in friction tends to:

- reduce cohesion of the top, making handling more sensitive
- assist in knitting and weaving by reducing fibre-to-metal friction
- reduce the need for lubricants.

In the case of felt-resist fibre, which tends to have high frictional properties, there is a wide scope for selecting a suitable fibre processing lubricant to reduce the fibre frictional characteristics.

NOTE THAT most fibre processing lubricants available are designed to ‘lubricate’ the fibres.

The application of a softener to treated wool has a similar effect.

PROCESSING FELT-RESIST TREATED WOOLS (continued)

Felt-resist treatments alter the surface characteristics of the wool fibre, particularly its frictional and hydroscopic properties, influencing its behaviour during mechanical processing.

Felt-resist processes

- Chlorine only processes increase fibre-to-fibre friction
- Chlorine–Hercosett resin increases fibre-to-fibre friction
- Chlorine–silicone resin reduces fibre friction
- Softeners and lubricants usually applied by the manufacturer of felt-resist treated tops can mask these effects.

Image courtesy of CSIRO Textile and Fibre Technology

16 - **Module 8:** The role of the top-maker

EXPLAIN THAT in the case of chlorine–silicone treated wool top (which has low friction), without the application of a suitable fibre processing lubricant, excessive end breakages can occur during the spinning operation.

INDICATE THAT a number of fibre processing lubricants designed to increase interfibre cohesion are available. Some of these contain colloidal silica.

NOTE THAT when applying such products, take care to control the application to a minimum level. These types of product can adversely affect the handle of the treated wool.

POINT OUT that contact with such products can also lead to premature wear of machine parts that come into contact with the fibre or yarn.

EXPLAIN THAT for these reasons it is advisable to only use colloidal silica-containing products as a last resort.

MERCERISATION – SOFT LUSTRE

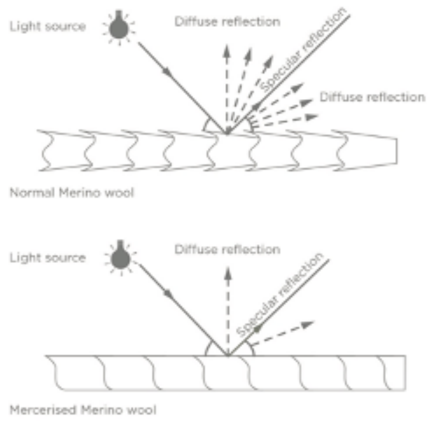
Mercerisation and soft lustre is a single process that improves the lustre and handle of treated top.

The process involves:

- treating the top with high levels of chlorine (~4%)
- removing the solubilised protein
- treatment with a silicone micro-emulsion.

Mercerised top must be re-gilled and re-combed to re-separate and re-align the fibres for further processing and spinning.

Mercerised Merino



17 - **Module 8:** The role of the top-maker

EXPLAIN THAT mercerisation and soft lustre are names for a single process that improves the lustre and handle of treated top.

INDICATE THAT the process involves degrading the scale structure from the surface of the wool fibre to create a smoother fibre surface. The effect is to increase the reflectance, or sheen, of the fibre.

POINT OUT the second part of the process involves applying a fine layer of silicone polymer, which is grafted permanently onto the fibre surface. The application of the silicone polymer brings about significant improvement in the handle of the wool and subsequent products.

EXPLAIN THAT while the actual diameter (micron) of the fibre does not change significantly as a result of the treatment, the perceived improvement in hand feel is the equivalent of using wool 2–3µm finer.

INDICATE THAT the process involves:

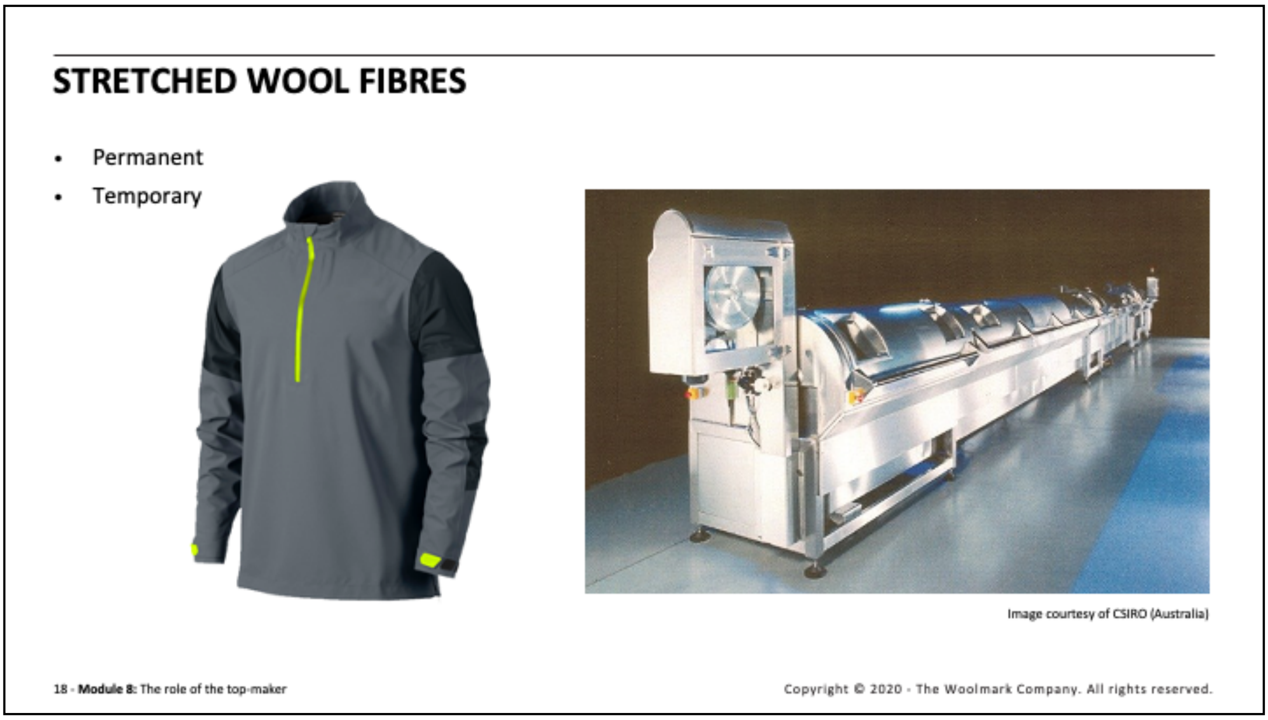
- treating the top with high levels of chlorine (~4.5%)
- removing the solubilised protein
- treating the fibre with a silicone micro-emulsion.

NOTE THAT as with the felt-resist treatment, the mercerised top must be re-gilled and re-combed to separate and re-align the fibres for further processing and spinning.

HAND OUT *samples of mercerised top and untreated top to participants.*

ALLOW *them time to identify the differences between the two samples.*

ASK *participants for comments on differences in handle of the two samples.*



EXPLAIN THAT wool fibres in top form can be stretched. The stretching process reduces the fibre diameter and changes the cross-sectional shape of the fibre, in turn improving the handle and lustre of the fibre.

NOTE THAT the stretch can be:

- temporary, so the resultant yarn will shrink when exposed to hot water – to create a high bulk yarn.
- permanent, so the fibres will not shrink when fabricated in the final product.

INDICATE THAT again, the treated top is re-gilled and re-combed to separate and re-align the fibres to ensure improved spinning performance. The cohesion of the top is reduced by the treatment so combing aids and machine settings must be altered to allow for this feature.

HAND OUT *samples of stretched top and untreated top to participants.*

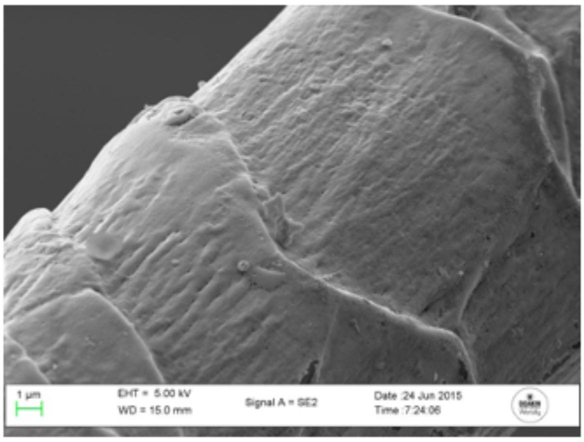
ALLOW *participants time to identify the differences between the two samples.*

NOTE *specifically the lack of crimp in the stretched top.*

ASK *participants for comments on differences in handle of the two samples (the stretched top will have a more 'slippery handle').*

POTENTIAL PROBLEMS WITH FIBRE MODIFICATION

- Fibre moisture content changed
- Fibre strength is reduced
- Fibre friction and cohesion is altered
- Spinning performance is altered
- Fibre handle is altered, which is
  - desired in some cases
  - avoided in other cases.



Surface of felt-resist treated fibre showing modification

19 - **Module 8:** The role of the top-maker

EXPLAIN THAT various problems can occur or need to be considered when processing modified wool in addition to those already mentioned.

Fibre moisture content is changed so that:

- static generation may be affected
- it can be difficult to re-add moisture with silicone on surface.

Fibre strength is normally reduced when top is treated before further processing.

Fibre friction is altered.

Fibre cohesion is modified:

- Reduced cohesion increases dust and fly and difficulties handling the top.
- Increased cohesion can cause additional fibre breakage.

Spinning performance is changed, which means:

- there is a need to re-apply spinning assistants
- special combing auxiliaries will be required in subsequent processing.

Handle is changed which is:

- desired in some cases
- avoided in other cases.

NOTE THAT the solutions to any of the these problems are broad and outside the context of this course and for more information speciality literature must be sought out.

RISK OF CONTAMINATION

There is a risk of contamination:

- after the wool top has been removed from the bale:
- during gill blending, re-combing and drawing
- gill blending after top dyeing
- during drawing and roving and spinning due to fly
- during twisting (i.e. singles yarn of untreated folded with a treated yarn)
- during knitting (i.e. mixed cones of yarn used to produce garments).

The keys to avoiding contamination include:

- Carefully cleaning all machinery
- Clearly identifying treated wool
- Using differently coloured cans
- Possibility of fugitive tints
- Packing in differently coloured bags/packs
- Staff training
- Customer advice

Image courtesy of CSIRO (Australia)

20 - **Module 8:** The role of the top-maker

MENTION THAT housekeeping issues in the mills are important when handling modified wool top to avoid the risk of contamination. For example, the effectiveness of the felt-resist treatment is seriously impaired even if small amounts of untreated wool are inadvertently or otherwise mixed with the treated material. Amounts as small as 0.1% untreated wool can cause noticeable 'spot felting' to occur during washing.

EXPLAIN THAT the greatest potential for contamination, or mixing of untreated and treated materials, occurs at the following stages of production:

- after the wool tops have been removed from the bale
- during gill blending, re-combing and drawing
- during backwashing, after top dyeing
- gill blending after top dyeing
- during drawing, roving and spinning due to fly
- during twisting (i.e. singles yarn of untreated folded with a treated yarn)
- during knitting (i.e. mixed cones of yarn used to produce garments)

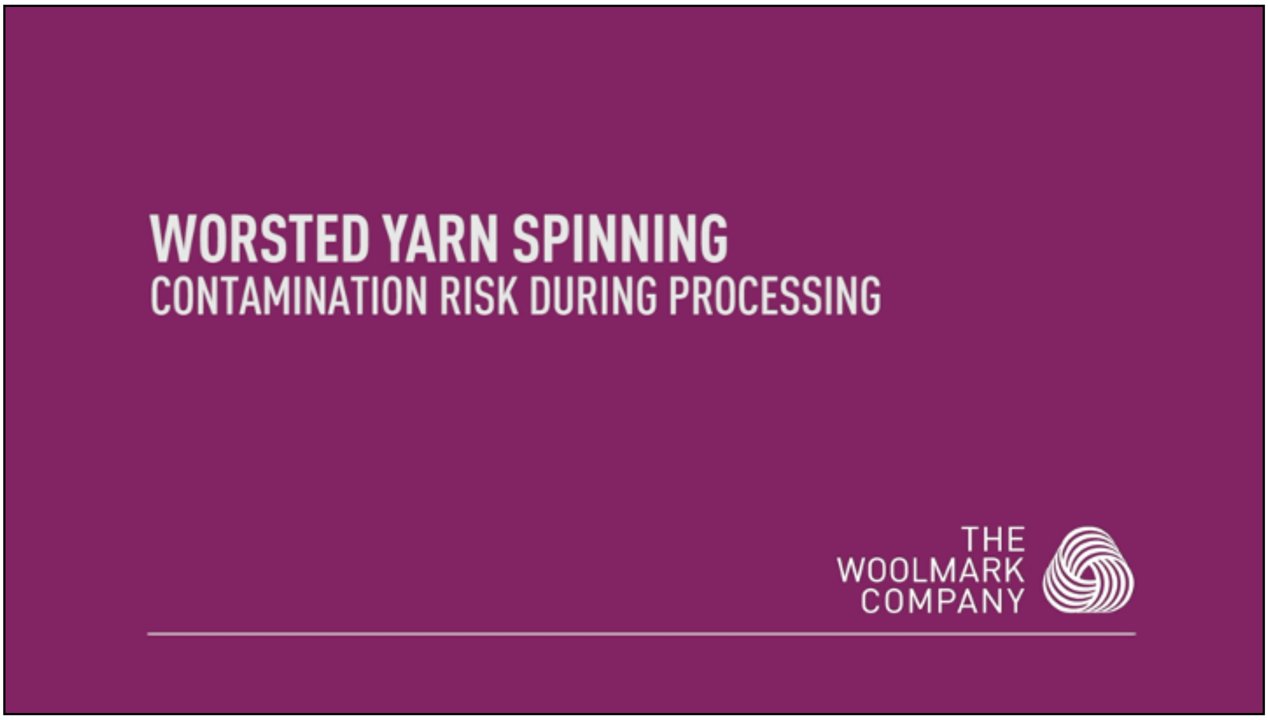
NOTE THAT treated wool must be kept completely separate to untreated wool at all times.

EXPLAIN THAT it is essential to ensure all machines are thoroughly cleaned before processing treated wool. If possible, specific machines should be allocated for processing treated wool.

POINT OUT it is essential to clearly identify treated wool. The following methods are useful:

- Use cans that clearly indicate they contain treated material.
- For undyed material it is possible to use fugitive tints – a small amount of colourant that is easily washed out and does not affect final colour
- Pack treated wool in polythene bags of a different colour.
- Print labels carrying a warning.
- Train staff to manage wool top to avoid contamination.

NOTE: Advise all customers by including warnings on, for example, tariff sheets, delivery notes, invoices etc.



EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers a brief overview of the risk of contamination during processing.

PLAY *video (~25 seconds)*

AS THE *video plays note that:*

- *ensuring there is no cross-contamination of coloured or felt-resist treated tops is important to maintain quality*
- *plastic curtains are often used (9:00 seconds)*
- *covers also help maintain quality and minimise cross-contamination (10.00 seconds).*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

SUMMARY — MODULE 8

Processes for modifying wool top include:
- dyeing/printing
- backwashing
- colour blending
- felt-resist treatment
- soft lustre (mercerisation)
- stretching.

There are advantages and disadvantages of these processes:
- altered fibre strength
- altered moisture content
- altered fibre friction
- altered fibre cohesion
- reduced spinning performance
- altered handle.

Management of top following various modifications depends on the impacts of the treatment process, but often include the need for:
- additional gilling and re-combing
- the use of specific treatment methods (e.g. low-temperature dyeing)
- protection agents or lubricants.

Effective management strategies are required to avoid contaminating treated top with untreated fibres, such as:
- ensuring all processing machinery is clean
- packaging and identifying treated top separately and clearly.

22 - **Module 8:** The role of the top-maker

SUMMARISE the module by reminding participants a number of different processes are used to modify wool top including:
- dyeing/printing
- backwashing
- colour blending
- felt-resist treatment
- soft lustre (mercerisation)
- modification by stretching.

REITERATE THAT there are advantages and disadvantages of these processes:
- altered fibre strength
- altered moisture content
- altered fibre friction
- altered fibre cohesion
- reduced spinning performance
- altered handle.

REMIND participants that management of top following various modifications depends on the impacts of the treatment process, but often includes the need for:
- additional gilling and re-combing
- the use of specific treatment methods (e.g. low-temperature dyeing)
- protection agents or lubricants.

REVIEW the fact that felt-resist treatments have the greatest effect as they can:
- increase or reduce fibre-to-fibre friction
- affect top cohesion and draft in spinning
- modify moisture content, which in turn affects static generation.

NOTE THAT on felt-resist treated wool, alternative lubricants or cohesion aids may be required.

REMIND participants that effective management strategies are required to avoid contaminating treated top with untreated fibres. Even miniscule amounts of contamination will impact on further processing and final product performance.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

REMIND participants that this module completes the Woolmark Wool Science, Technology and Design Education Program course *Worsted top-making.*

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

THE
WOOLMARK
COMPANY

woolmark.com