THE WOOLMARK COMPANY

WOOL SCIENCE, TECHNOLOGY AND DESIGN EDUCATION PROGRAM

FACILITATOR GUIDE

RAW WOOL SCOURING

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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

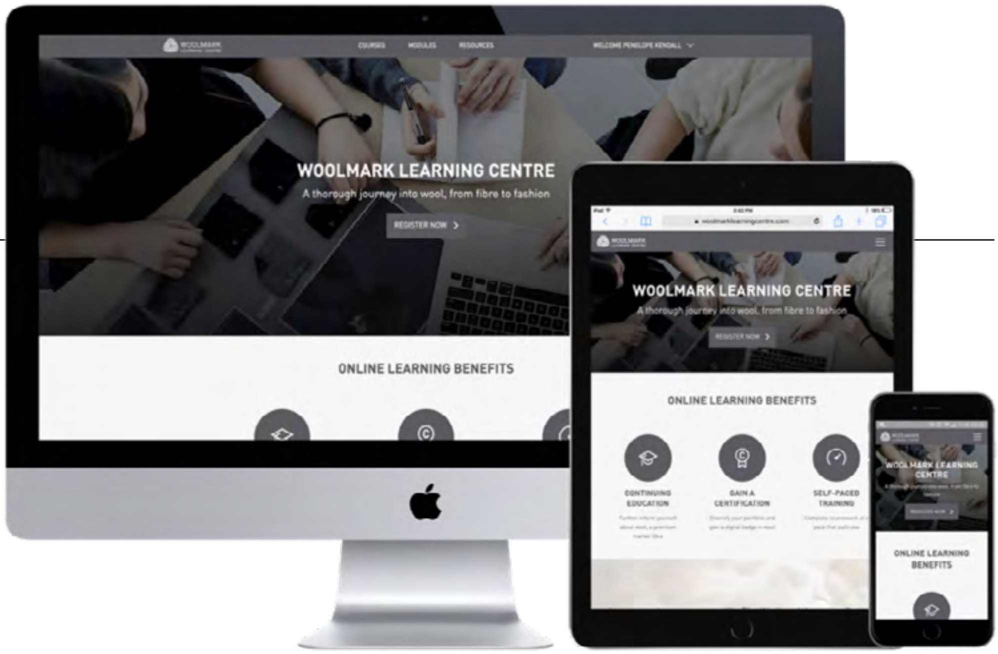
- Wool fibre science
- Introduction to wool processing

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 *Raw wool scouring* course of the *Wool Science, Technology and Design Education Program*.

The 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 *Raw wool scouring* course the pre-requisites for the course
- an overview and learning objectives for *Raw wool scouring*
- a suggested agenda for delivering *Raw wool scouring*
- an overview and the learning objectives for each module within *Raw wool scouring*
- course materials and resources required to deliver *Raw wool scouring*
- administrative requirements and institutional responsibilities when delivering *Raw wool scouring*
- guidelines and processes regarding participant recognition upon completing *Raw wool scouring*
- 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

Raw wool scouring is an advanced-level course, which provides participants with an understanding of:

- the process of wool scouring
- the aims and objectives of scouring
- the machinery used to scour wool
- the issues affecting product quality
- the impact of scouring quality on downstream processing.

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 *Raw wool scouring* 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, *Raw wool scouring* is suitable for participants with sound knowledge of wool or the wool industry, or those 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 *Raw wool scouring* facilitator slides as an optional introductory module.

COURSE LEARNING OBJECTIVES

By the end of the *Raw wool scouring* course, participants are expected to be able to:

- provide a detailed and comprehensive overview of the wool scouring process
- provide a comprehensive overview of the best-practice techniques relating to the wool scouring process that ensure maximum wool cleanliness and minimal entanglement
- provide measures and techniques to resolve issues that might be encountered during the wool scouring process.

COURSE AGENDA

The *Raw wool scouring* course consists of 10 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 account of the introductory Woolmark Company slides as outlined in the following facilitator notes.

MODULE | SLIDE NUMBER	VIDEOS AND PRACTICAL DEMONSTRATIONS
Module 1: Introduction to scouring | 26 slides	Slide 10: Raw and scoured wool (handout) Slide 13: Raw wool scouring (video)
Module 2: Characteristics of wool contaminants | 21 slides	Slide 5: Wool wax (handout) Slide 9: Wool wax (reference)
Module 3: Preparation for scouring | 22 slides	No videos or recommended demonstrations
Module 4: Detergency and entanglement | 28 slides	Slide 6: Wetting (demonstration) Slide 10: Emulsion formation (demonstration)
Module 5: The scouring process: mechanical considerations | 33 slides	No videos or recommended demonstrations
Module 6: The scouring process: process variables | 18 slides	No videos or recommended demonstrations
Module 7: Principles of contaminant recovery | 21 slides	Slide 6: Stoke's Law (demonstration) Slide 16: Gravity separation (demonstration)
Module 8: The practices of contaminant recovery | 17 slides	No videos or recommended demonstrations
Module 9: Wastewater treatment | 23 slides	No videos or recommended demonstrations
Module 10: Process and quality control | 35 slides	No videos or recommended demonstrations

MODULE OVERVIEW AND LEARNING OBJECTIVES

Module 1 — Introduction to scouring starts off this 10-module course by defining scouring and offers an overview of the scouring process. The importance of scouring in wool processing and the factors influencing the scouring process are covered, along with the compromises made during wool scouring.

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

- explain the purpose of the raw wool scouring process
- describe the importance of the scouring process and its effect on subsequent processing
- outline some of the compromises involved in wool processing
- explain what good scouring practice looks like.

*Module 2 — Characteristics of woo*l contaminants identifies the key contaminants found in raw wool, their properties and how these contaminants are classified during scouring. The factors affecting contaminant levels are also outlined in this module.

By the end of this module participants are expected to be able to describe the different types of raw wool contaminants and their characteristics.

Module 3 — Preparation for scouring outlines the steps taken to prepare wool for scouring including:

- preparing wool blends
- bale warming
- blend layouts
- opening raw wool
- best-practice issues during the scouring preparation operation.

At the end of this module participants are expected to be able to describe the steps involved in preparing wool for scouring.

Module 4 — Detergency and entanglement investigates the concept of detergency and the purpose of surfactants in wool processing, including basic detergency, types of surfactants, detergency and wool scouring and removing contaminants from raw wool.

It also investigates the the concept of entanglement during scouring, including causes of entanglement during scouring and the impact of entanglement during scouring on further processing of the wool

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

- explain basic detergency processes
- explain how detergency is applied to wool scouring
- describe the different stages of wool contaminant removal during scouring
- explain the concept of entanglement
- describe how scouring can cause entanglement
- explain the balance between low entanglement and wool cleanliness
- describe the working points during scouring at which entanglement can occur
- describe the methods used to minimise entanglement during scouring.

Module 5 — The scouring process: mechanical considerations investigates the scouring line configuration, wool transport system, liquor handling systems, scouring bowl design and varied scouring line configurations.

At the end of this module, participants are expected to be able to describe the machinery involved in the scouring process and the functions of the key components. Participants should also be able to describe the methods used to minimise entanglement during scouring

Module 6 — The scouring process: process variables investigates the following process variables:

- scour configuration
- water
- surfactants
- builders
- other chemical additions
- temperature ranges

At the end of this module, participants should be able to describe the process variables that need to be considered in the scouring line.

Module 7 — Principles of contaminant recovery explores the topics of contaminant recovery, solid—liquid, liquid—liquid and solid-liquid-liquid separation.

By the end of this module participants will be able to explain the principles of contaminant recovery and the importance of maximising contaminant recovery.

Module 8 — The practices of contaminant recovery explores the use of dirt recovery devices during scouring, the methods of dirt recovery in rinse water and the methods for recovering wool wax during scouring.

At the end of this module, participants should be able to explain the practical process involved in contaminant recovery.

Module 9 — Wastewater treatment investigates:

- the environmental issues associated with scouring
- the pollution propensity of contaminants
- sludge treatment and disposal
- choosing a wastewater treatment
- market pressures
- best practice issues.

At the end of this module, participants should be able to describe the environmental issues associated with scouring and the treatment systems available for scouring wastewater.

Module 10 — Process and quality control, as the final module in the Raw wool scouring course, outlines the importance of process control during scouring in relation to:

- preparation for scouring
- the scouring line
- dirt recovery
- wool wax recovery
- drying
- post-scouring processes
- wastewater treatment.

This module also discusses the location of sensors and process controllers, managing data and potential process control issues and their management.

The module finishes by looking at the principles of quality control during scouring and explores sampling, programs of analysis and methods of analysis.

At the end of this module, participants should be able to:

- describe the types of process control used during scouring
- describe the process controls related to different parts of scouring
- list issues related to process control
- explain the importance of quality control,
- describe the methods used for quality control analysis
- identify troubleshooting methods for different quality control issues.

COURSE MATERIALS AND RESOURCES

To deliver the *Raw wool scouring* 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 on following page)
- 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 RAW WOOL SCOURING 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 *Raw wool scouring* Facilitator Guide.

The following samples and resources for demonstrations are provided in the *Raw wool scouring* Demonstration kit (resources not supplied in the kit will need to be supplied by the facilitator if these activities are to be carried out):

Module 1:
- raw wool samples
- scoured wool samples

Module 2:
- wool wax

Module 4:
- woven wool fabric

ADMINISTRATIVE DETAILS

ORGANISATIONAL RESPONSIBILITIES

Institutions delivering the *Wool Science, Technology and Design Education Program* course *Raw wool scouring* 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 10 *Raw wool scouring* 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 *Raw wool scouring* 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 *Raw wool scouring* course 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 *Raw wool scouring* 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 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 any 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 'Certificate 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 (e.g. speakers).
- ☐ 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 student 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 students 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

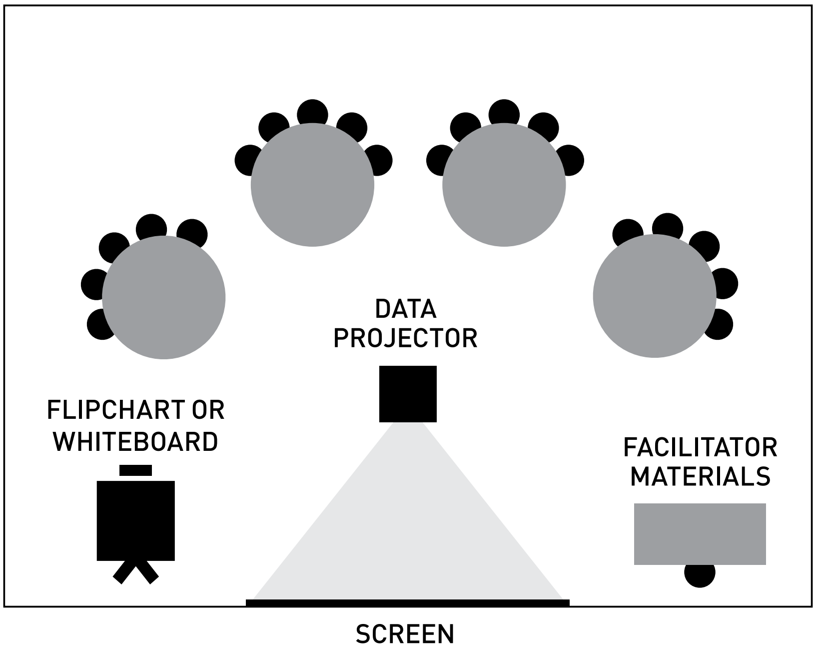
Participant survey:
www.woolmarklearningcentre.com/wstd-surveyparticipant

ROOM LAYOUT

The *Raw wool scouring* 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 student's 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.

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

AWTA	Australian Wool Testing Authority
CMC	Critical Micelle Concentration, the concentration at which surfactants start to aggregate to form micelles
EDTA	ethylenediaminetetraacetic acid — used to reduce hardness of water by sequestering calcium and magnesium cations.
GOTS	General Organic Textile Specification
ISO	International Standards Organisation
IWTO	International Wool Textile Organization
NZWTA	New Zealand Wool Testing Authority
PID	Proportional–integral–derivative controller, used in modern wool scouring operations.
PLC	Programmable Logic Controller, used in automatic process control in wool scouring operations.
WTBSA	Wool Testing Bureau South Africa

GLOSSARY

Term	Definition
adsorption	the process through which a substance, originally present in one phase, is removed from that phase by an accumulation at the interface between that phase and a separate phase.
amphoteric	a substance that can react as both an acid and a base.
anhydrous	containing no water.
bale breaker	device for breaking up the wool, taken from a bale, into smaller pieces.
bellies	short wool found on the stomach region of the sheep, is usually contaminated with vegetable matter and dirt,a lower value component of the wool taken from the sheep and separated from the fleece wool.
blend	wool that is purchased to produce a specific set of products. Also refers to the 'mix' the components of a greasy wool lot.
blending	the physical steps undertaken in a mill to 'mix' the components of the greasy wool that comprise the blend.
brattice feed hopper	a device used at the feed end of machinery that ensures an even flow of raw wool and also breaks up some of the bigger pieces of the wool mass.
builder	a chemical that increases the cleansing action of a surfactant, even though it has no detergency action itself.
centrifuging	the process of spinning liquors at high speeds to facilitate separation by density.
Clearinse (Andar)	a chemical treatment system currently used to treat scouring effluent.
coalescence	the process by which a number of emulsion droplets come together to form a single drop.
commission comber/ top-maker	a processor that converts a customer's raw wool into top, or buys raw wool and converts it to top to sell.
commission scourer	a processor that scours wool on commission for a customer.
conventional scouring	rinsing bowls following the scouring bowls.
cotted wool	heavily-felted or entangled raw wool.
crutchings	wool from around the tail and between the rear legs of a sheep, usually contaminated with urine and faecal matter,a lower value component of the wool taken from the sheep and separated from the fleece wool.

Term	Definition
dags	faecal matter which contaminates fleece.
de-suinting	a process sometimes conducted in the first bowl of a scour which removes suint without removing wool wax.
decanter centrifuge	a device which uses centrifugal force and a long, rotating drum (or bowl) to separate dirt from the scouring liquor.
detergency	the process by which contaminants are removed from the surface of a solid using a liquid.
disc centrifuge	a device commonly used to recover wool wax which combines both increased surface area and centrifugal force for effective separation.
dumped bale	bale heavily compressed for transport.
dunkers	machine components that push the wool under the surface of the scour liquor so it can rapidly and evenly wet out. Dunkers also provide the mechanical action for contaminant removal. Types include: – bell dunkers – fish tail dunkers – rotary dunkers – plate dunkers – box dunkers.
emulsification	the procedure of trapping oil droplets within an envelope of surfactant so they do not re-aggregate (coalesce) in water.
emulsion	a suspension of small globules of one liquid within a second liquid with which the first is immiscible.
entanglement	the very early stages of felting.
EU Ecolabel	a labelling system to encourage fibre processors and product manufacturers to adopt more environmentally-responsible practices.
felting	the process of progressive entanglement of fibres that occurs as a result of agitation by undirected forces, such as mechanical agitation.
fleece wool	the main component of the fleece surrounding the body of the sheep, which contains the wool of highest quality.
hydrocyclone	a device which uses centrifugal force to separate dirt from a scouring liquor and has no moving parts.

Term	Definition
interstage conveyor	the mechanism that transfers the raw wool to the first scouring bowl, between the bowls and finally to the dryer.
IWTO DTM-63 Malcam Microwave method	a test method which uses the difference in the adsorption of microwaves by wool (~0.001) and water (0.5) to measure the moisture content of wool while still in the bale.
IWTO-33 Invoice mass	a test method for determining the 'oven dry mass' of wool from the average moisture content of the core sampling specimens from a bale.
IWTO-41 Invoice mass	a test method which uses a capacitance measuring system to determine the moisture content of the wool in a bale.
lambswool	wool from the first shearing of wool from lambs up to seven months old.
lamella settler	a settling tank that is fitted with additional plates to faciliate the separation process.
lanolin	the refined form of wool wax.
lapping	the covering on the squeeze roller in a scour, also used to describe the process of the loose wool wrapping around the squeeze rollers rather than passing through.
liquid–liquid separation	involves separating wool wax from scouring liquor, using mainly disc centrifuges.
micelles	aggregates of surfactant molecules dispersed in a liquid.
nip	the squeeze point on the roller.
noil	short fibres extracted during the combing operation.
on-off controller	the simplest form of controller where the signal is either 'on' or 'off'.
openers	machinery used to break the mass of wool fibre taken from a bale into small pieces suitable for blending and scouring. The main types are – drum opener – step opener – cyclic opener – hammer mill. These machines differ in the intensity of their opening action.
organic load	the amount of organic material that will consume oxygen during its aerobic degradation.
phytotoxicity test	a test used to determine whether or not composted wastewater treatment sludge is suitable for use as a fertiliser to support plant growth.

Term	Definition
pieces	wool obtained during shearing from the neck, face (wig) and small portions from the lower parts of the legs. Often includes skirtings, a lower value component of the wool taken from the sheep and separated from the fleece wool.
scour line configuration	the sequence of de-suint, scouring and rinsing bowls used in a scouring line. Includes: – convential scouring – two-stage scouring – three-stage scouring
scouring	a stage in wool processing that aims to remove contaminants from wool through agitation in detergent solution (or suitable solvent).
scouring discharges	liquid flows that can come from bowl discharges, primary centrifuge centrate and discharges from any dirt recovery devices.
settling tank	the simplest form of device used to separate dirt from scour liquor (solid–liquid separation) which allows dirt to settle under gravity.
Sirolan CF (CSIRO)	a chemical treatment system currently used to treat scouring effluent.
skirtings	the dirty pieces of wool taken from around the edges of fleece wool, a lower value component of the wool taken from the sheep and separated from the fleece wool.
spray box	part of the liquor handling system, used to distribute the liquor evenly across the width of the scour bowl.
Stoke's law	a formula used to describe the separation of a solid from a liquid, or one liquid from another liquid.
suint	a water -soluble contaminant of wool, also known as sweat.
surfactant	a water-soluble product used to assist in removal of contaminants.
three-stage scouring	two stage scouring preceded by a de-suint bowl.
top-maker	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. Also used to describe an organisation that converts raw wool to top.
transfer mechanisms	the mechanical devices used to move the wool from the scour bowl to the sqeeze rollers. These include : – swing rakes – harrows – triple-crank rakes – suction drums

Term	Definition
transport mechanisms	the mechanical devices used to move the wool along the scour bowl. These include : – harrow – throw fork – triple crank – suction drum – jet scour.
two-stage scouring	a single scouring bowl is placed between the rinsing bowls.
vertical mill	a wool mill that converts greasy wool into a product, such as fabric.
wetting	the procedure whereby water coats the material to be wet out.
working points	the mechanical elements of a scour that exert mechanical action on the wool as it moves though the scour.

COURSE
INTRODUCTION

THE WOOLMARK COMPANY

RAW WOOL SCOURING

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 processing and especially scouring.*

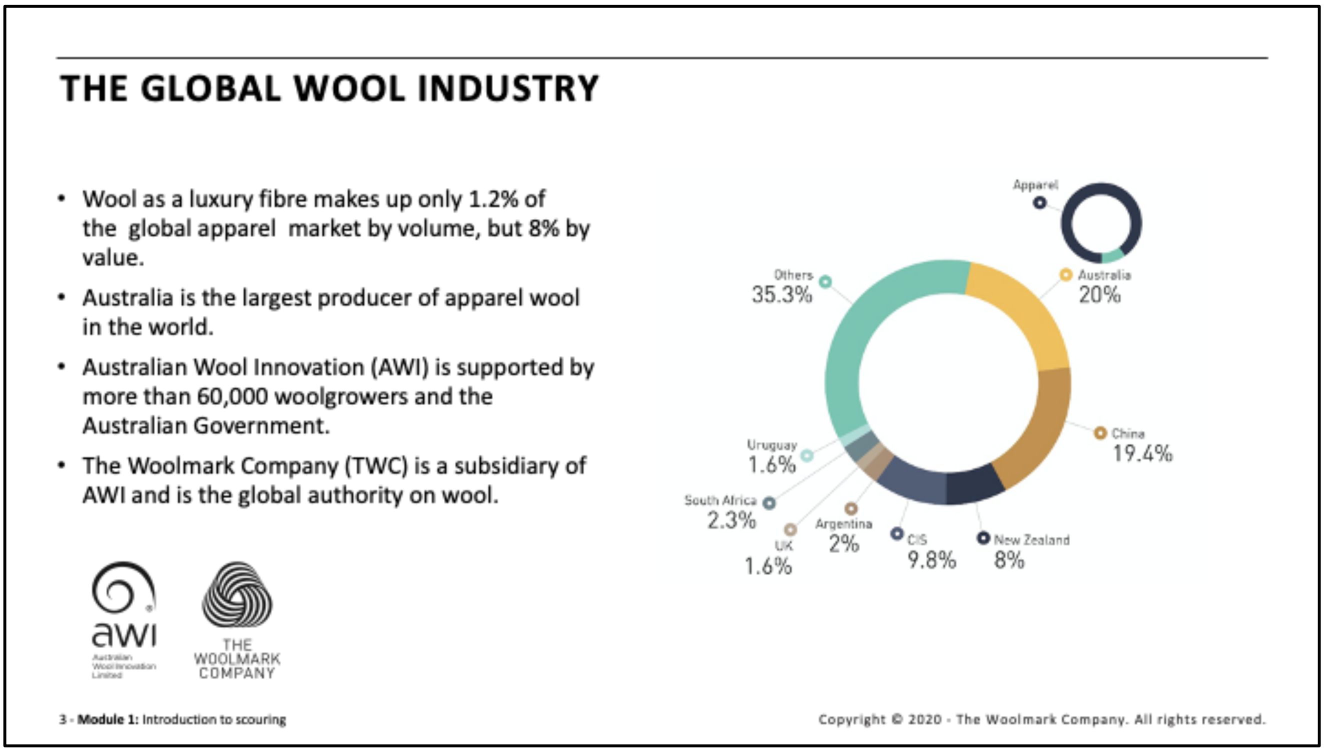
NOTE: *participants should already have some background on wool processing if they have completed the prerequisite* Wool Science Technology and Design Education Program *courses* — Wool fibre Science *and/or* Introduction to wool processing*. Other participants may work in the wool industry.*

Examples of questions you might ask to encourage participation include:

- *Who has studied wool technology and processing before?*
- *Who has visited a wool processing operation?*
- *Why does wool have to be scoured?*
- *Who has visited a wool scouring plant?*

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 — Introduction to scouring*



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*.

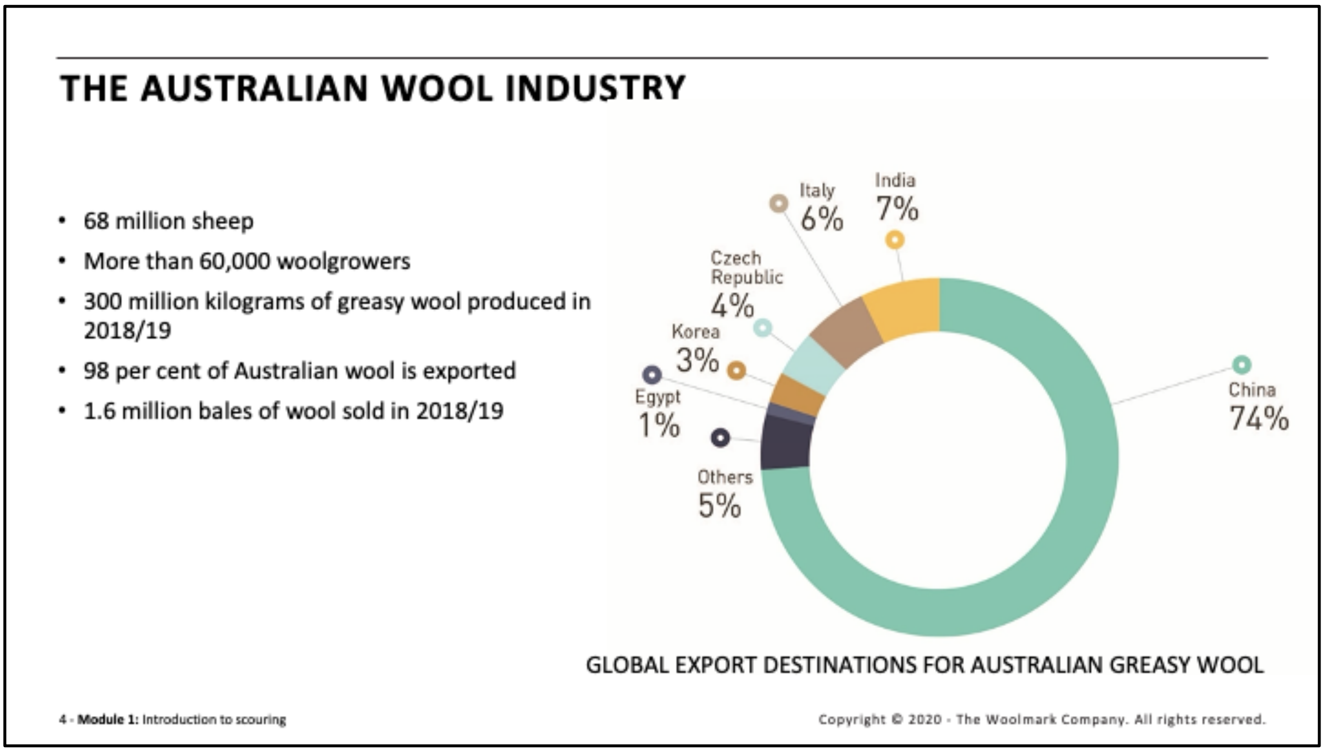
**Source ABARES Agricultural Commodities, March 2020 quarter.*

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.

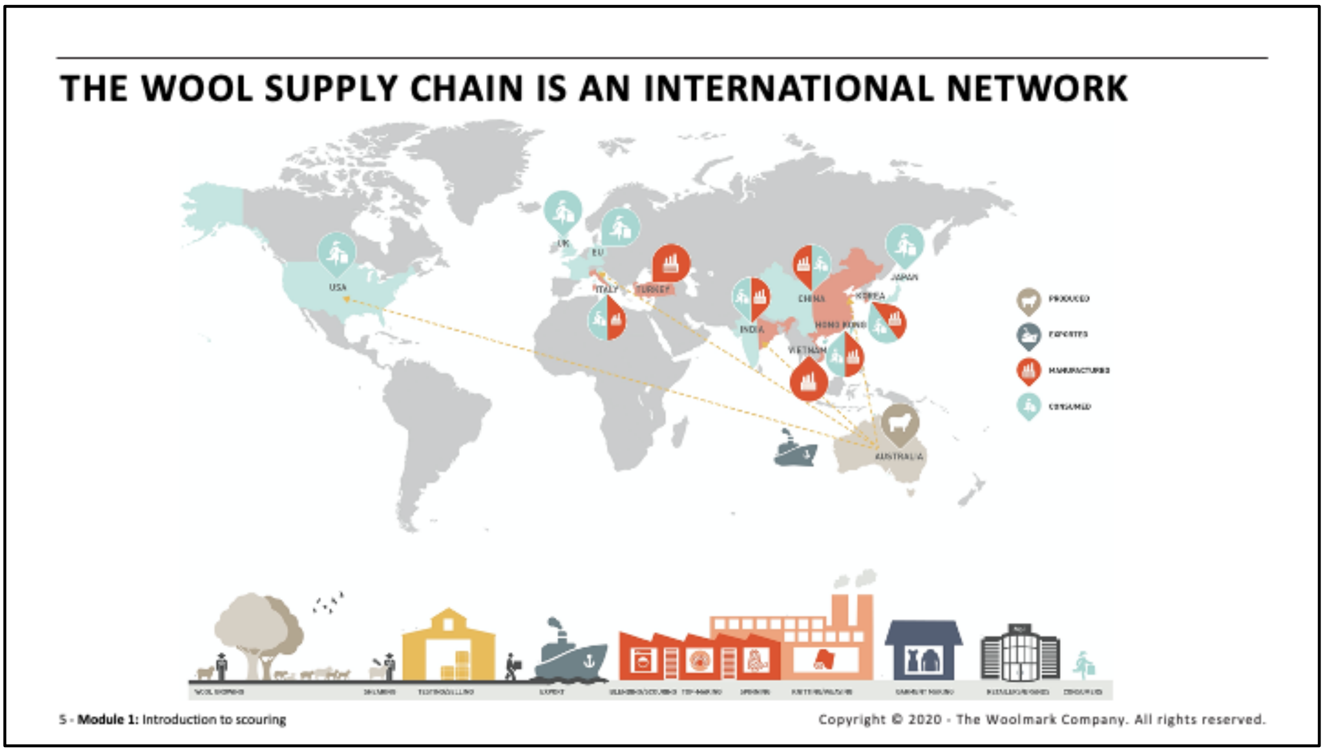
NOTE THAT you will provide a brief overview of the Australian wool industry and global supply chain, and elaborate on the role of The Woolmark Company in the global context before commencing the technical components of the course



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.

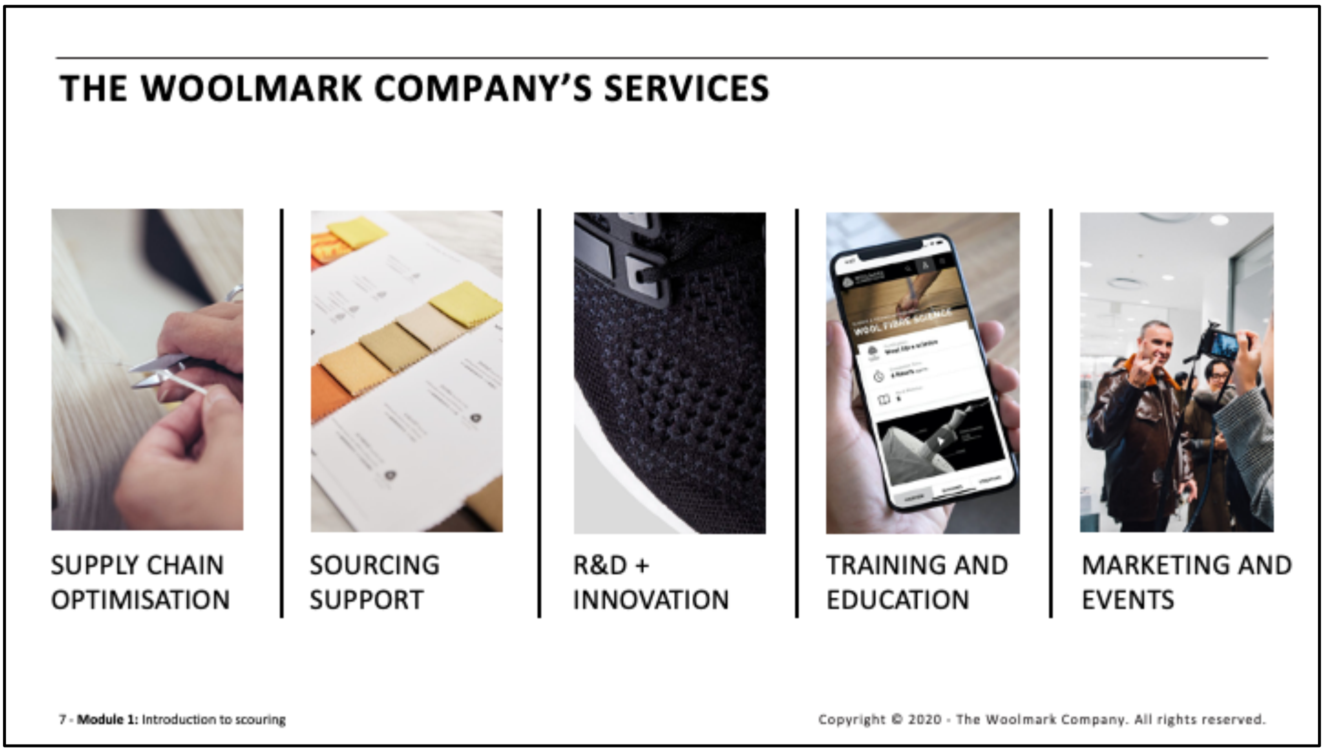
EXPLAIN THAT in line with these global dynamics, The Woolmark Company head office in Sydney, Australia is supported by a growing number of regional offices globally. Through this support The Woolmark Company invests in innovation along the global wool supply chain.

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.

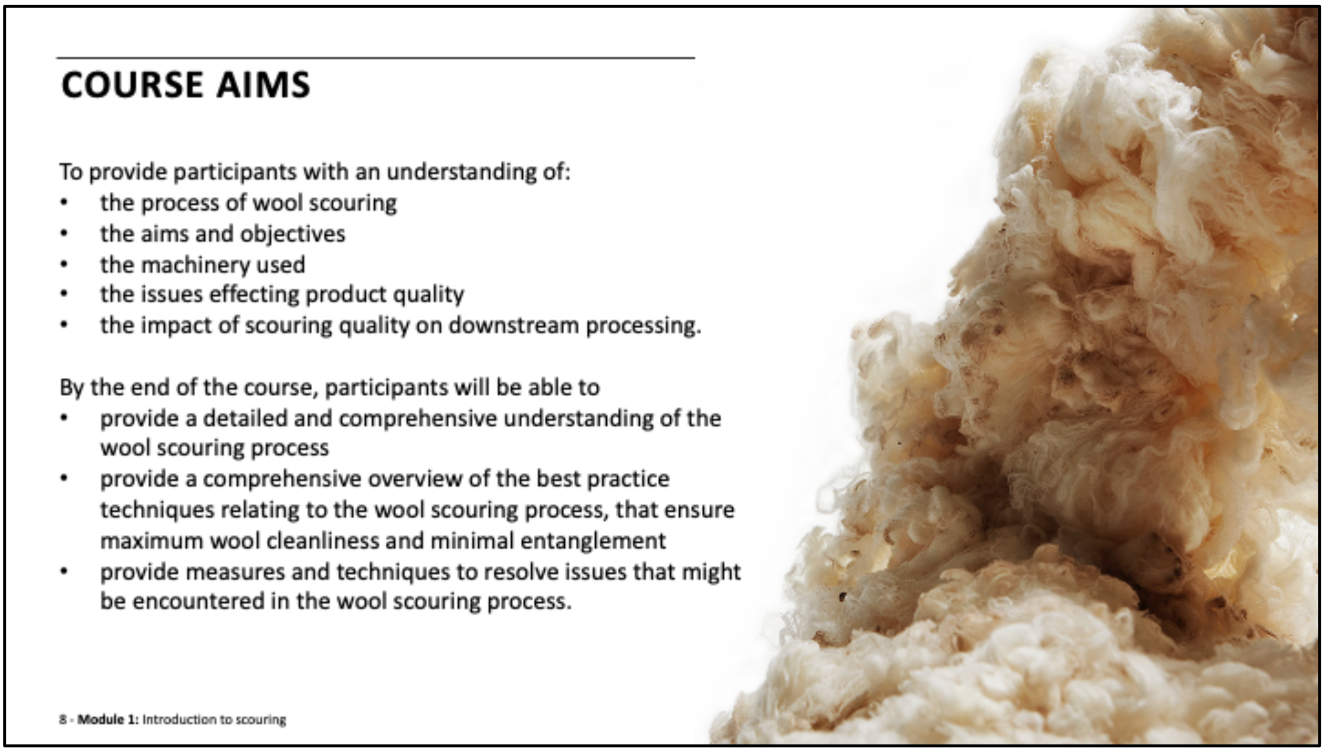
INDICATE THAT The Woolmark Company provides sourcing support through direct access to the global wool manufacturing industry through The Wool Lab. A seasonal guide to the latest innovations in wool, fabrics are sourced from the world's best spinners and weavers in the global supply network.

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.

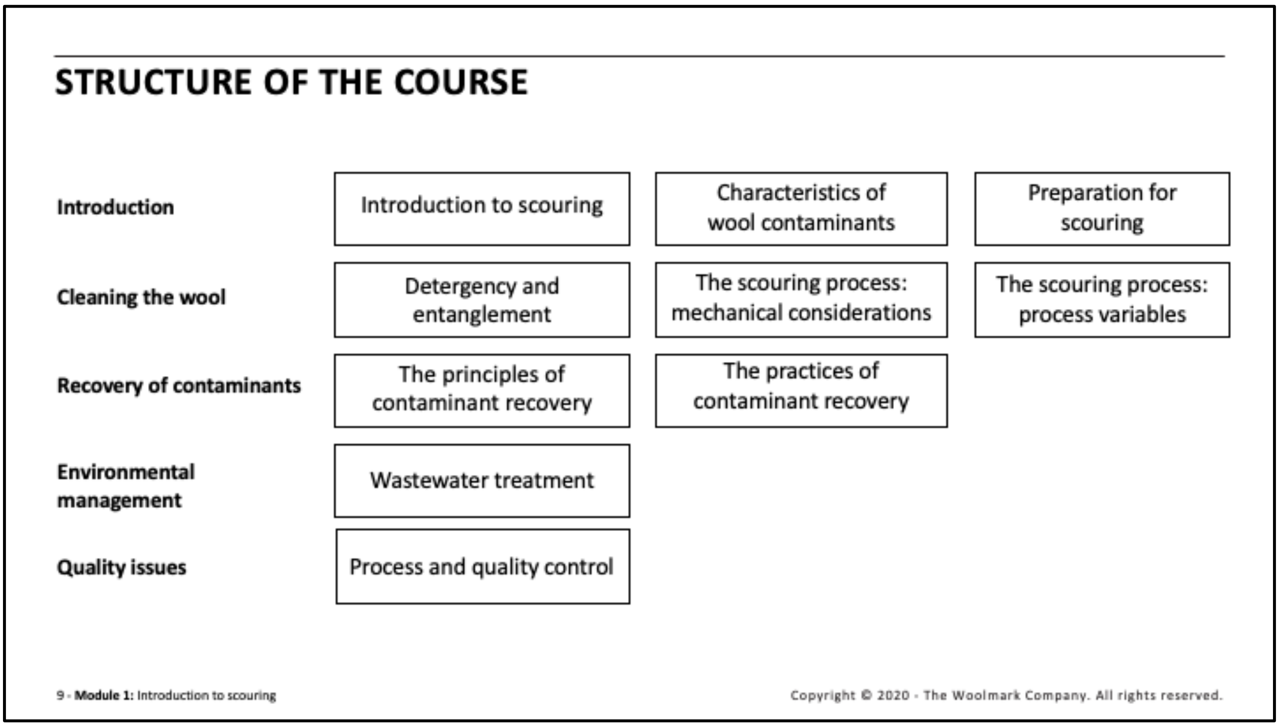


EXPLAIN THAT the aim of this course is to provide participants with an understanding of:

- the process of wool scouring
- the aims and objectives of scouring
- the machinery used to scour wool
- the issues affecting product quality
- the impact of scouring quality on downstream processing.

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

- provide a detailed and comprehensive overview of the wool scouring process
- provide a comprehensive overview of the best-practice techniques relating to the wool scouring process that ensure maximum wool cleanliness and minimal felting
- provide measures and techniques to resolve issues that might be encountered during the wool scouring process.



EXPLAIN THAT the modules covered in this course, as indicated on the slide, are:

Introduction to scouring
- An overview of the process
- The nature of the contaminants on wool
- Preparing for scouring

Cleaning the wool
- The principles of detergency and entanglement
- Mechanical considerations
- Process variables

Recovery of contaminants
- The principles of contaminant recovery
- The practices of contaminant recovery

Environmental management
- Wastewater treatment

Quality control
- Process and quality management

MODULE 1

THE WOOLMARK COMPANY

INTRODUCTION TO SCOURING

RESOURCES — MODULE 1: INTRODUCTION TO SCOURING

Contained in the *Raw wool scouring* Demonstration kit you will find the following resources for use as you deliver **Module 1: Introduction to scouring**:

- raw wool sample
- scoured wool sample

EXPLAIN THAT this introductory module of the Woolmark Wool Science, Technology and Design Education Program *Raw wool scouring — Introduction to scouring* — will cover the following topics:

- What is scouring?
- Overview of the scouring process
- The importance of scouring in wool processing
- Factors influencing the scouring process
- Compromises in wool scouring

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

- explain the purpose of the raw wool scouring process
- describe the importance of the scouring process and its effect on subsequent processing
- describe the compromises involved in wool processing
- explain what good scouring practice looks like.

RESOURCES REQUIRED FOR THIS MODULE:

- samples of raw wool
- samples of scoured wool

HAND OUT *samples of raw and scoured wool among the participants, clearly identifying which sample is which.*

ALLOW *participants to pass the samples around as you continue the lecture.*

ASK *participants what they think scouring achieves for the wool processor.*

COLLECT *responses from two to three participants across the room and record on white board or flipchart.*

ASK *participants why they think scouring is important in wool processing.*

COLLECT *responses from participants across the room and record two or three responses on whiteboard or flipchart before proceeding.*

WHAT IS SCOURING?

- Removes contaminants from wool by agitation in detergent solution.
- Effective scouring balances:
  - product acceptability
  - profitability
  - meeting environmental regulations.

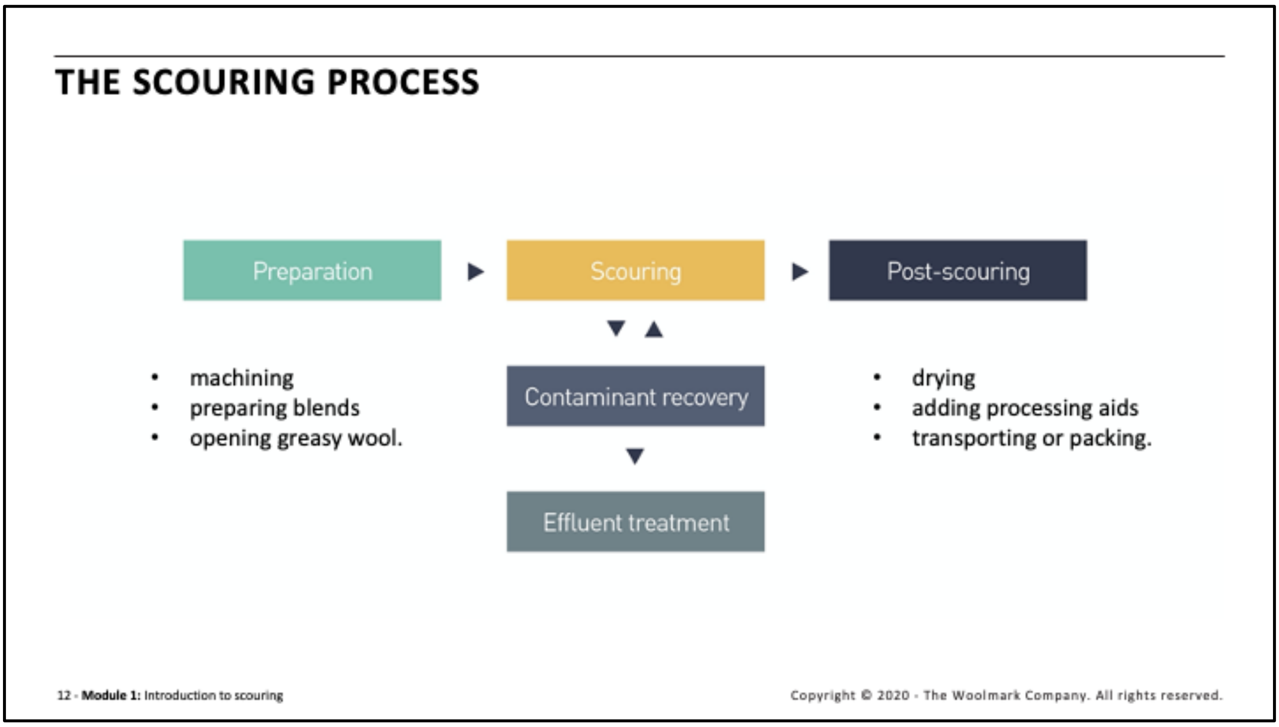
Best-practice wool scouring involves
- making a profit by processing wool
- in an environmentally and economically sustainable way that meets customer standards and requirements.

11 - **Module 1:** Introduction to scouring

EXPLAIN THAT wool must be scoured before it can be used as a textile fibre. Scouring is a stage in wool processing that aims to remove contaminants from wool through agitation in detergent solution (or suitable solvent). Agitation must be performed in a way that minimises entanglement or felting, while adequately removing contaminants.

EXPLAIN THAT an effective scouring process involves balancing:
- product acceptability
- cleanliness
- lack of felting
- limiting fibre damage
- profit versus cost
- meeting environmental discharge regulations.

POINT OUT that this means best-practice wool scouring involves making a profit by processing wool in an environmentally and economically sustainable way, which meets customer standards and requirements.



REFER participants to the diagram on the slide, which shows how the modern scouring process can be divided into a number of elements:

Preparation:
- machining lower-quality wools
- preparing blends
- opening greasy wool.

Scouring line:
- removing contaminants from the greasy wool (the heart of every scouring mill).

Post-scouring processes:
- preparing scoured wool for drying
- drying the wool
- dusting dried wool
- adding chemicals for subsequent processing (processing aids)
- transporting wool to subsequent processing or packing
- packing the scoured wool.

Contaminant recovery:
- using systems to recover wool, wax and dirt
- returning treated scouring liquors to the scouring line.

Effluent treatment:
- treating the scouring liquor for recycling to the scouring line, or for discharge to the environment.

INTRODUCE the video *Raw wool scouring* by explaining the short video will show an overview of a scouring line in action in a wool processing mill.

***ASK** participants to look out for the different stages in the total scouring process previously identified, while viewing the video.*

***PLAY** video (2:45 minutes)*

***NOTE** as the video plays that in the opening part of the video (0:00 to 0:16 seconds)*

- *the wool is removed from the bales and loaded into the opener*
- *the opened wool passes through a scouring bowl*
- *the scoured wool is dried and transported to the next processing stage.*

***INDICATE** that during the next part of the video, each of these stages is viewed more precisely, with each part of the scouring system labelled. Points to note include:*

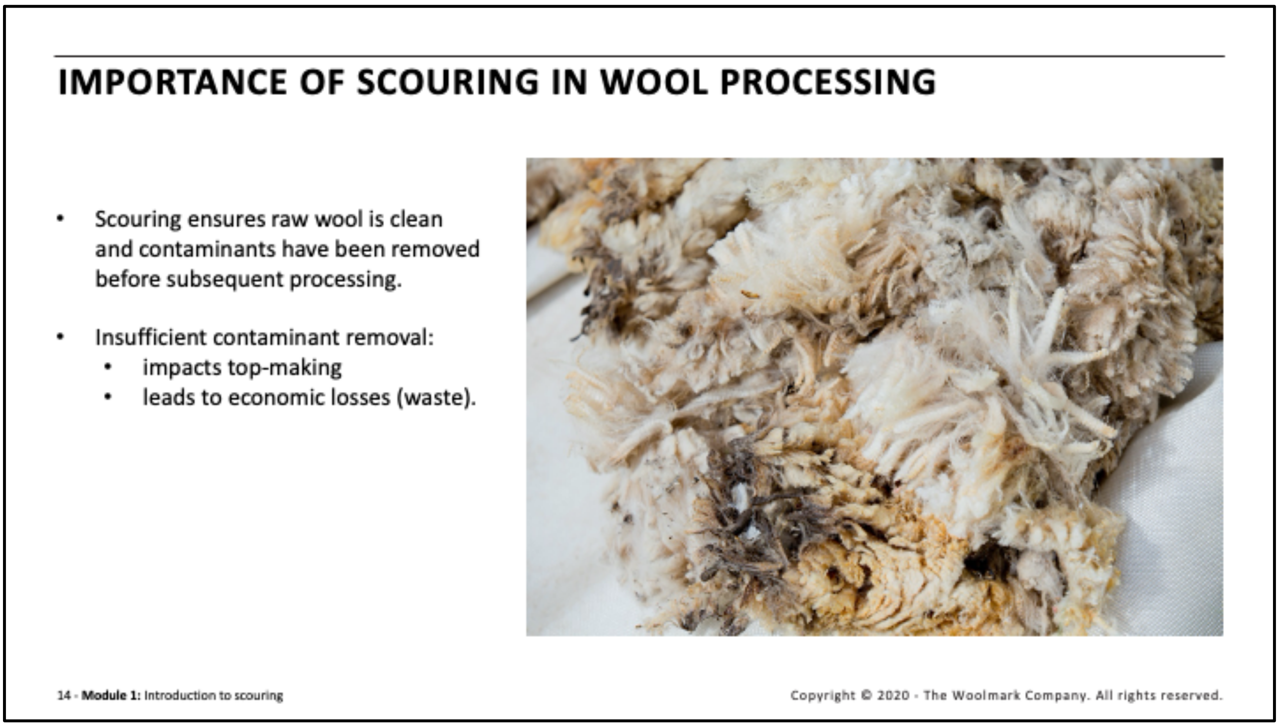
- *the cylindrical dunker is used on the rinse bowl, whereas bell dunkers were used on the scouring bowl (1:55 minutes).*
- *the scour liquor seen in the side tanks of the scour bowls (1:12 minutes) is significantly dirtier than the rinse water (2:07 minutes)*
- *at the completion of scouring the clean wool is put through a step cleaner to remove any remaining dust (2:39 minutes).*

NOTE: These processes will be described more fully throughout this course.

***HAND OUT** samples of raw wool and scoured wool to participants.*

***ASK** for participant feedback on the handle (hand feel) of the samples.*

***ASK** participants to identify the differences between the two samples and encourage them to note the presence of wool wax in the raw wool sample before proceeding*



EXPLAIN THAT scouring is important in wool processing to ensure wool is clean and contaminants have been removed before further processing commences.

REITERATE THAT if contaminants are not removed sufficiently, wool cannot be processed effectively and the top-making process cannot be completed or will involve considerable problems including:

- poor processing yields
- wear and tear on machinery.

EXPLAIN THAT insufficient contaminant removal can also lead to problems in subsequent wool processing, as well as economic losses through breakage of fibres in top-making from entanglement or fibre damage.
For example, a 1% increase in noil (short fibre extracted during the combing operation) can mean a $1 million loss in fabric production per year.

POINT OUT there are five key performance indicators used in scouring:

- wool cleanliness
- entanglement
- fibre damage
- environmental concerns
- economic factors.

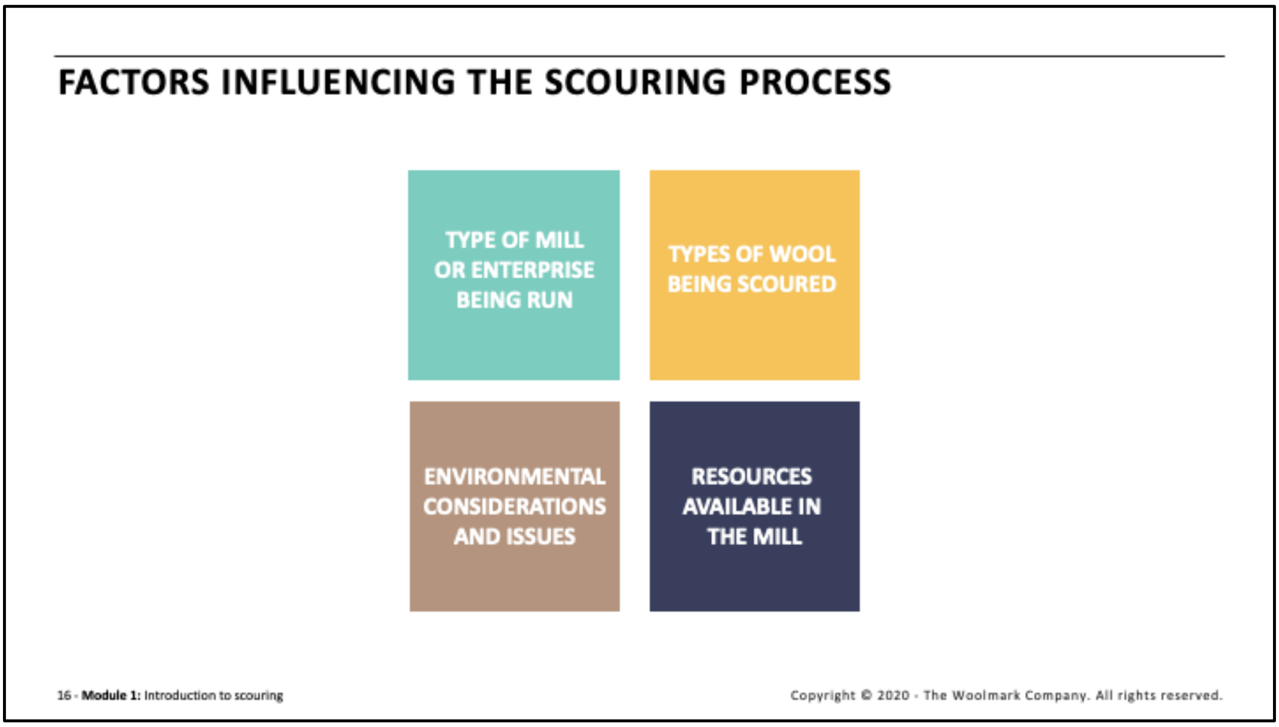
IMPORTANCE OF SCOURING ELEMENTS ON KEY PERFORMANCE INDICATORS

	Cleanliness	Entanglement	Fibre damage	Environment	Economy
Preparation	+	++	+		
Scouring	+++	+++	+++	+	+++
Post-scouring		+	++		
Contaminant recovery	++			++	++
Effluent treatment				+++	++

15 - **Module 1:** Introduction to scouring

REFER participants to the table on the slide as you explain that it indicates the relative importance of scouring process elements on key performance indicators for scouring:

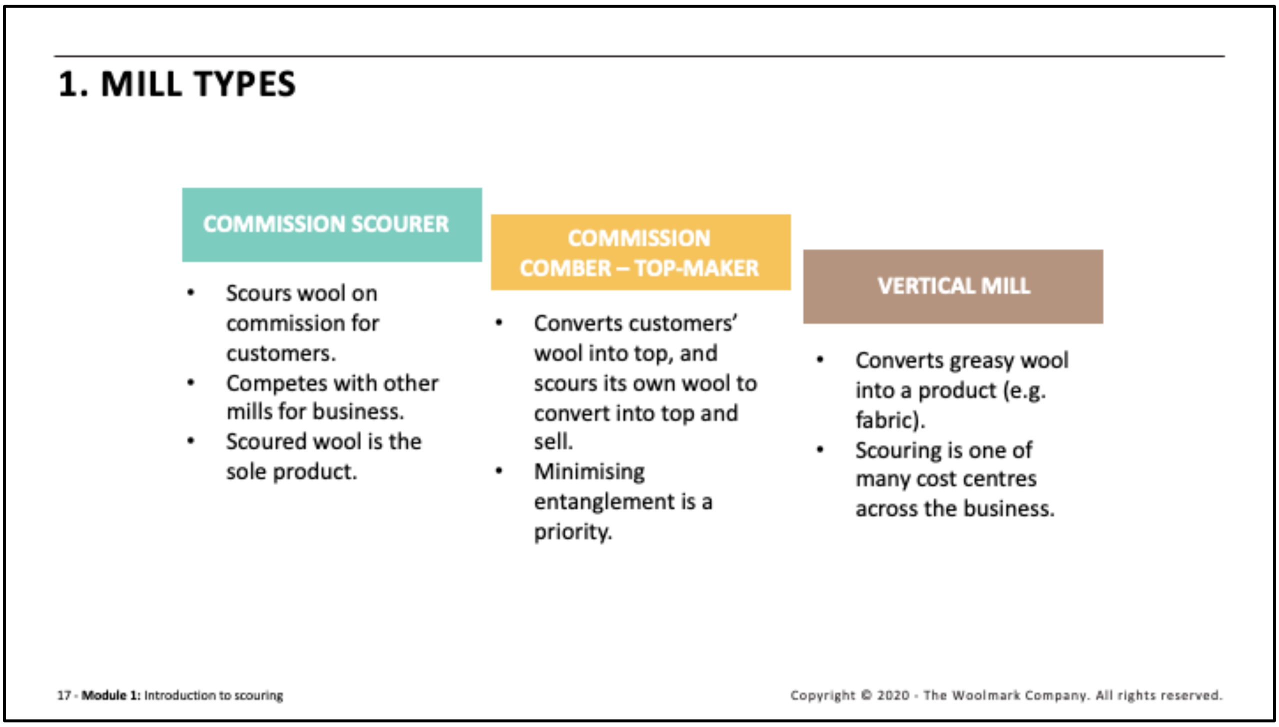
- wool cleanliness
- entanglement
- fibre damage
- environmental concerns
- economic factors.



EXPLAIN THAT there are various factors which influence the scouring process used in a mill, including:

- the type of mill or enterprise being run
- the types of wool being scoured
- environmental considerations and issues
- the resources available in the mill.

INFORM participants that each of these elements will be examined in more detail, beginning with the type of mill or enterprise being run.



INDICATE THAT there are three types of scouring enterprises:

1. commission scourer
2. commission comber–top-maker
3. vertical mill.

1. Commission scourer

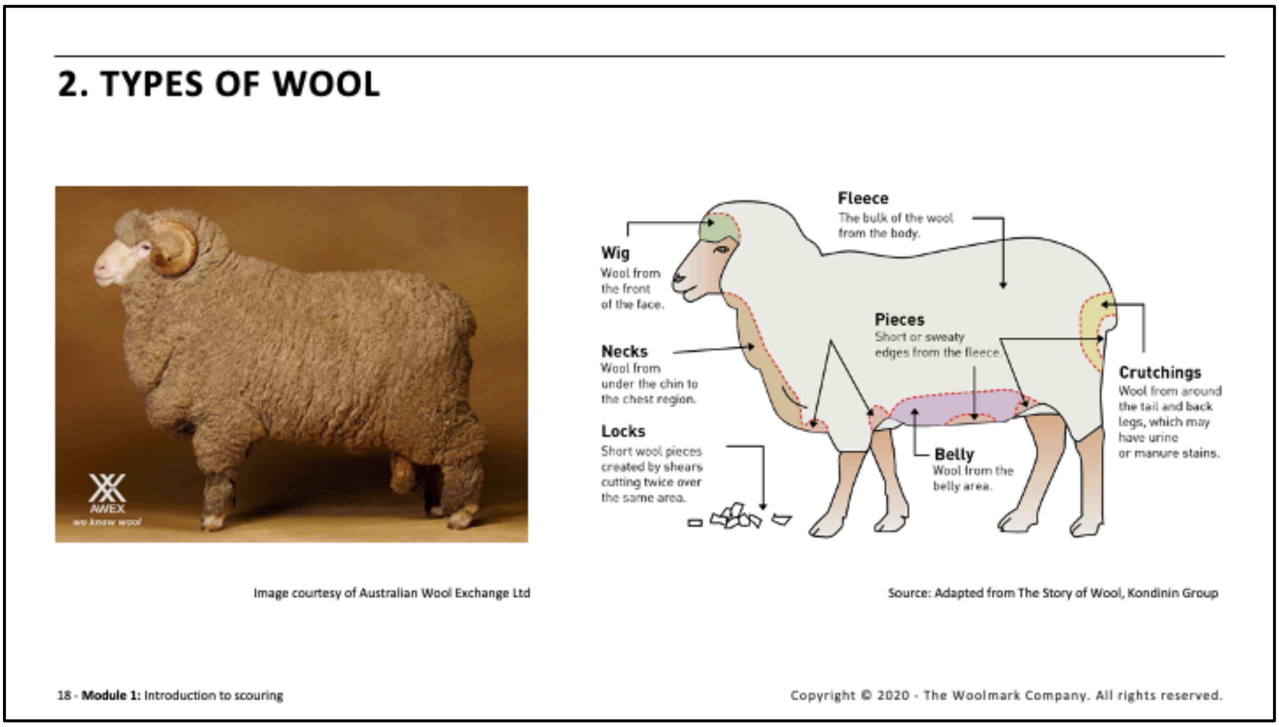
- The commission scourer scours wool on commission for a customer.
- The commission scourer is cost conscious, because this type of mill competes with other mills for business.
- The sole product of a commission scourer is scoured wool.

2. Commission comber–top-maker

- The commission comber–top-maker may convert a customer's wool into top, or scour its own wool and convert it to top to sell.
- Scouring and top-making mills are usually located on the same site.
- Top yield drives the profitability of the mill.
- Minimising entanglement during scouring is a priority.

3. Vertical mill

- The vertical mill converts greasy wool into a product, such as fabric.
- The capacity of the scouring line is usually not a problem, so productivity is of less concern than in other parts of the top-making chain (e.g. combing).
- The cost of scouring in the vertical operation is not as critical as in commission scouring, because scouring is only one of a number of cost centres across the business.



INDICATE THAT wool varies in quality, in terms of:

- the fineness (fibre diameter) of the wool being processed
- the levels of contamination.

EXPLAIN THAT as wool becomes finer, it becomes more difficult to scour because of:

- the greater surface area for cleaning
- higher levels of wool wax
- a greater potential for entanglement.

EMPHASISE THAT as the quality of wool lessens, amounts of contamination increase, making it more difficult to clean the wool.

EXPLAIN THAT wool quality is influenced by many factors including sheep breed, environment and management. The quality of the wool on an individual animal also varies, according to its location on the animal. The illustration on the slide outlines the key types of wool removed from the sheep:

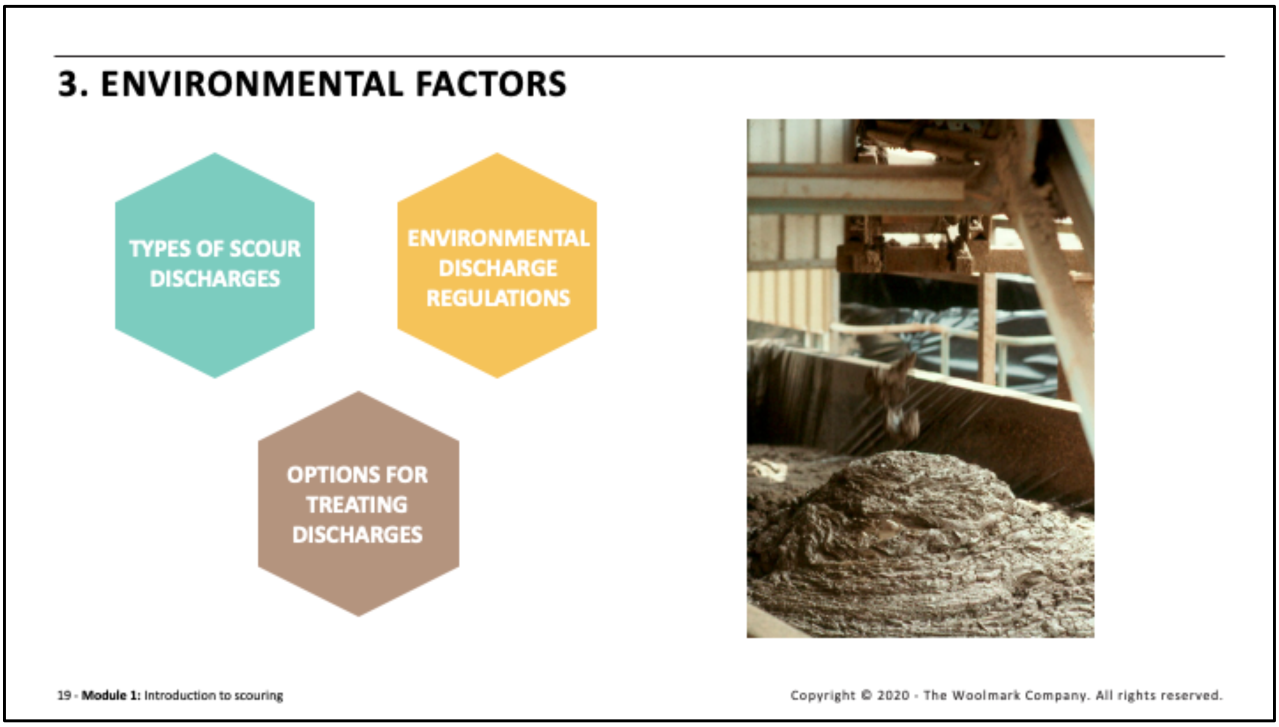
- fleece wool — the main body of the fleece surrounding the body of the sheep, which contains the highest quality wool
- skirtings (not shown on the diagram) — the fleece is skirted to remove any dirty pieces of wool around the edges belly are removed leaving only fleece wool.
- belly — short wool found on the undercarriage of the sheep is usually contaminated with vegetable matter, dirt, etc.
- crutchings — wool from around the tail and between the rear legs of a sheep, usually contaminated with urine and faecal matter
- pieces — wool from the neck, face (wig) and locks (second cuts) small portions from the lower parts of the legs and edges of the fleece, greasy staples, under the forearm, inside the flank and crutch.

NOTE THAT fleece wool has a higher value than the other components mentioned above.

ASK *participants to reflect on the parts of the fleece following the discussion. Ask participants to predict the link between each component of the fleece and its value..*

POINTS *of interest to note include:*

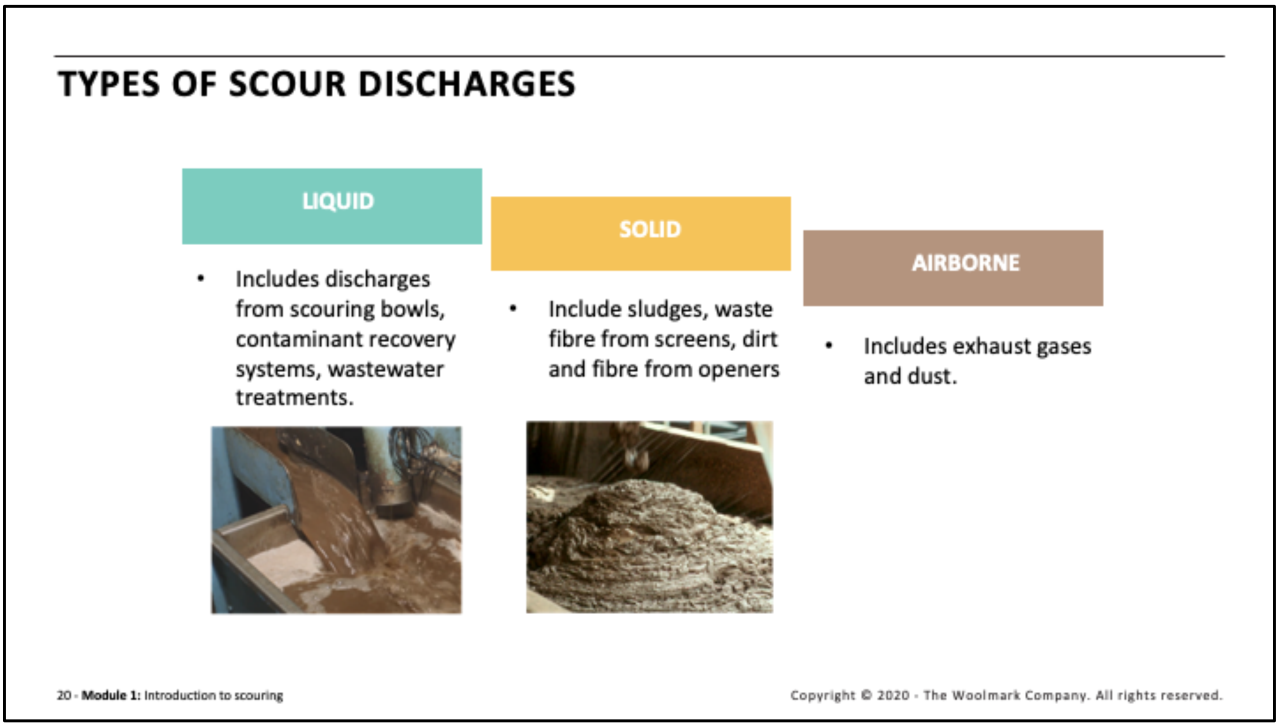
- *Fleece wool is the most valuable part of the fleece.*
- *Skirtings, belly wool, crutchings and pieces are all lower value types of wool.*



EXPLAIN THAT environmental factors associated with the scouring process are important to the viability of the entire scouring operation.

INDICATE the environmental factors that need to be considered include:

- types of scour discharges
- environmental discharge regulations
- options for treating discharges.

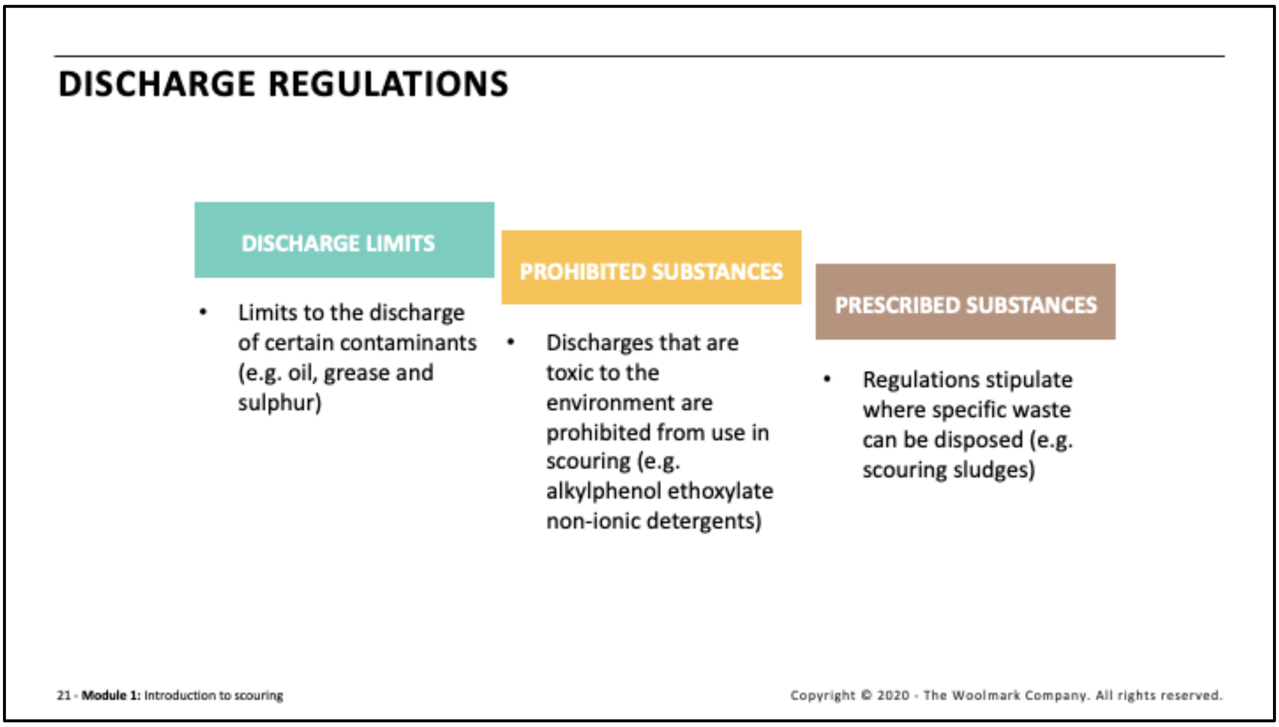


EXPLAIN THAT discharges from a scour can be liquid, solid or airborne, as indicated on the slide.

Liquid discharges — include discharges from scouring bowls, contaminant recovery systems, and wastewater treatments. Uncontrolled liquid discharges suggest a scouring line that is out of control, which might incur higher costs than necessary.

Solid discharges — include sludges discharged from scouring bowls, contaminant recovery systems and wastewater treatments; waste fibre from screens; dirt and fibre from openers, both in preparation and in dusting stages.

Airborne discharges — include exhaust gases from energy generation and dryer operation; and dust generated within the mill, such as carbonaceous dusts from carbonising.



EXPLAIN THAT there are three types of environmental discharge regulation that influence the scouring process:

1. discharge limits
2. prohibited substances
3. prescribed substances.

1. Discharge limits

- There are limits to the amounts of concentrations of contaminants, such as oil, grease and sulphur, that can be discharged from the scouring mill into a sewer or watercourse.

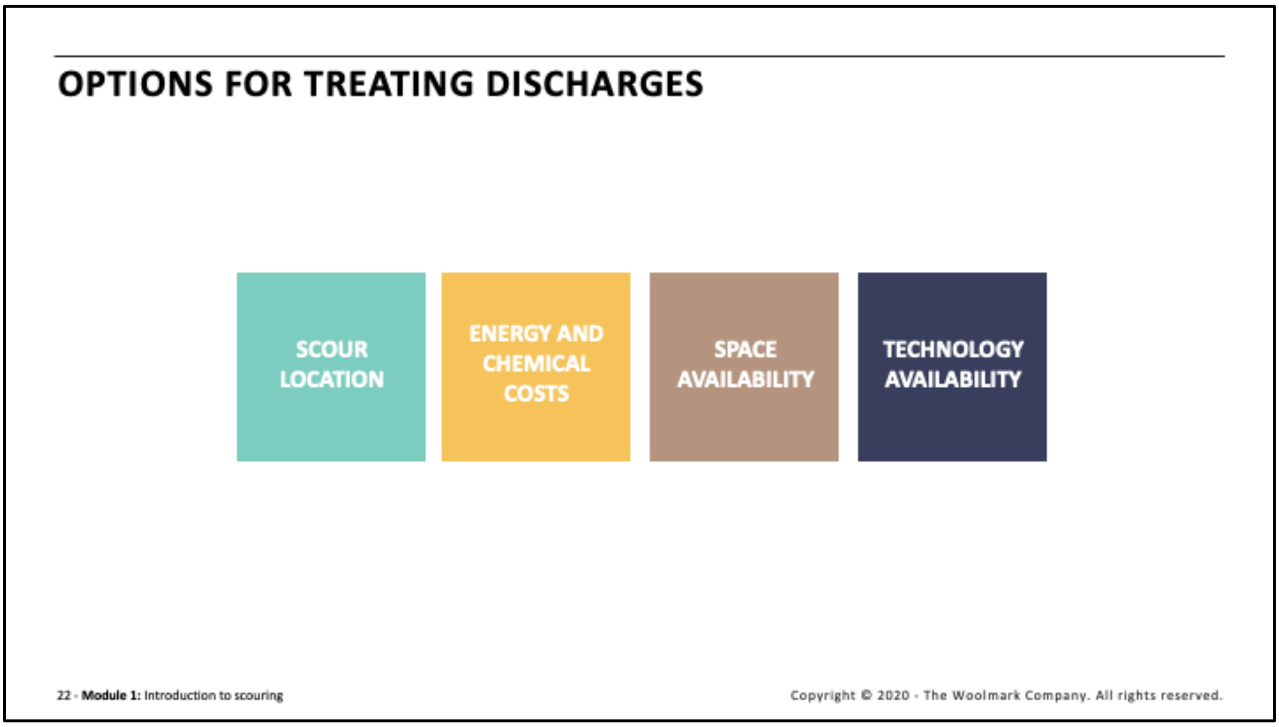
2. Prohibited substances

- Discharges of specific substances that are toxic or potentially harmful to the environment are prohibited from being used in scouring – for example, alkylphenol (poly)ethoxylate non-ionic detergents are prohibited in Europe.

3. Prescribed substances

- Regulations stipulate where a specific waste can be disposed – for example, scouring sludges are classed as a prescribed waste in Melbourne, Australia.
- Prescribed substances must be sent to a prescribed waste processing facility.

INDICATE THAT regulations vary from place to place, and can have a large influence on the economics of operating a wool scour.



EXPLAIN THAT the options available for treating discharges to meet local discharge regulations depend on:

- location
- energy and chemical costs
- space availability
- technology availability.

The location of the scour

- If a scour has access to a sewer in an urban area, then discharge to a sewer is possible.
- Disposal following wastewater treatment is an option in a rural area.

Energy and chemical costs

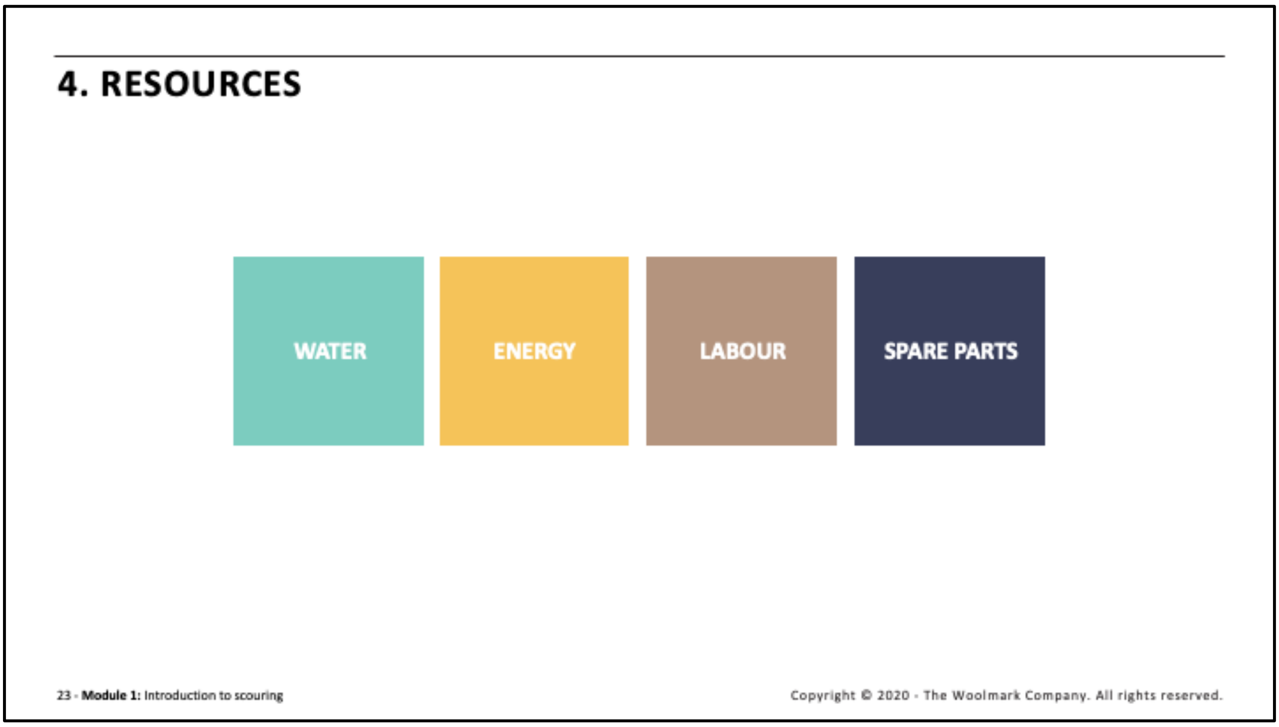
- Total evaporation is one option for treating aqueous effluents, but high energy costs can limit the usefulness of multiple effect evaporators.

Space availability

- If no space is available, options are limited for treating discharges — for example, the technologies for complete treatment of the aqueous effluent are now available, but they require some space.

Availability of appropriate technology

- The specialised equipment for separating and treating wastes (solid and liquid) must be available.



EXPLAIN THAT the types of resources available in the scouring mill also influence the scouring process. These resources include:

- water
- energy
- labour
- spare parts.

Water

- Wool scouring requires high-quality water for optimum performance.
- Compromises may have to be made if water quality is inferior, especially in terms of hardness.

Energy

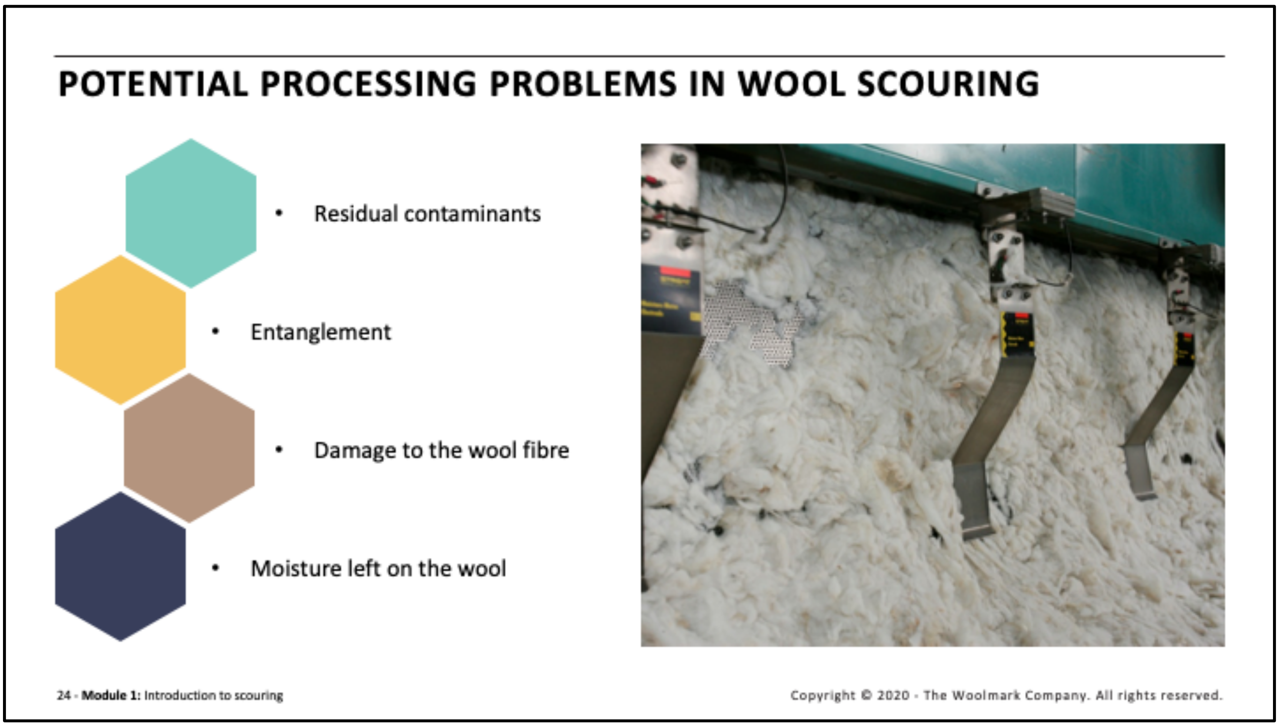
- Type, availability and cost of energy can affect the operation of a scouring line in different ways, including the cost of production and the type of equipment being used. For example, if gas is more cost effective than electricity, it can be more economical to use a brattice dryer instead of a drum dryer.

Labour

- A well-operated scouring mill requires well-trained labour.
- Operators need to understand the nature of the raw materials, the aim of the scouring process, how this will be achieved and how the product will meet desired quality standards in a cost-effective manner.

Spare parts

- The performance of a scouring line can be adversely affected if sub-standard parts are used in scouring machines.



EXPLAIN THAT there are potential challenges for the subsequent stages of wool processing that are associated with the scouring process:

- residual contaminants left on the wool fibre in poorly-scoured wool
- entanglement due to excessive mechanical action
- damage (including yellowing) to the wool fibre, due to inappropriate scouring and drying conditions
- excessive or inadequate moisture left in the wool, due to poor control in the dryer.

INDICATE THAT residual contaminants can have the following effects:

- the effectiveness and cleanliness of the working environment is reduced
- efficiency of subsequent processing is reduced
- wear on working parts in the scouring line, such as carding wire and pins is increased.

POINT OUT that entanglement can have the following effects:

- increased fibre breakage and noil (short fibre extracted during the combing operation)
- lower average (mean) fibre length
- decreased revenue.

EMPHASISE THAT fibre damage can have the following effects:

- higher fibre breakage during top-making
- lower fibre bundle strength
- lower spinning (knitting and weaving) performance
- increased yellowness.

NOTE THAT excessive or inadequate moisture levels can have the following effects:

- processing problems
- nep generation
- problems with vegetable matter (VM) removal during carding and combing.

SUMMARY – MODULE 1

Scouring is a stage in wool processing that removes contaminants from raw wool through agitation in detergent solution or solvent

Steps in the scouring process
- preparation
- scouring line
- post-scouring processes
- contaminant recovery
- effluent treatment

Factors influencing the scouring process
- type of mill or enterprise
- types of wool being scoured
- environmental considerations and issues
- available resources.

Problems associated with wool scouring
- residual contaminants on the wool
- entanglement
- damage to the wool fibre
- moisture levels on the wool left on the wool.

25 - **Module 1:** Introduction to scouring

SUMMARISE this module by reinforcing that scouring is a stage in wool processing that removes contaminants from raw wool through agitation in detergent solution or solvent (note: solvents are not currently used).

REMIND participants that the sections in the scouring process include:
- preparation
- scouring line
- post-scouring processes
- contaminant recovery
- effluent treatment.

REMIND participants that factors influencing the scouring process include:
- type of mill or enterprise
- types of wool being scoured
- environmental considerations and issues
- available resources.

REINFORCE the problems associated with poor wool scouring include:
- residual contaminants on the wool
- entanglement
- damage to the wool fibre
- moisture levels on the wool left on the wool.

REVIEW *any notes made on whiteboard or flipchart.*

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 2 Characteristics of wool contaminants* — 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 fibre samples distributed during the lecture.

THE WOOLMARK COMPANY

CHARACTERISTICS OF WOOL CONTAMINANTS

RESOURCES — MODULE 2: CHARACTERISTICS OF WOOL CONTAMINANTS

Contained in the *Raw wool scouring* Demonstration kit you will find the following resources for use as you deliver **Module 2: Characteristics of wool contaminants**:

– wool wax

WELCOME participants to Module 2 of the Woolmark Wool Science, Technology and Design Education Program — *Raw wool scouring — Characteristics of wool contaminants*.

EXPLAIN THAT this module will cover the:

- contaminants found in raw wool
- classifications of raw wool contaminants
- properties of different contaminants
- factors affecting contaminant levels.

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

- describe the different types of raw wool contaminants
- describe the characteristics of different raw wool contaminants.

RESOURCES REQUIRED FOR THIS MODULE:

- *wool wax*

REVIEW: WHAT IS THE PURPOSE OF SCOURING?

- Scouring aims to remove contaminants from raw wool.
- Contaminant levels vary between 20% and 90% depending on:
  - sheep breed
  - wool quality
  - environmental conditions.

2 - **Module 2:** Characteristics of raw wool contaminants

NOTE TO FACILITATOR: *This slide is animated.*

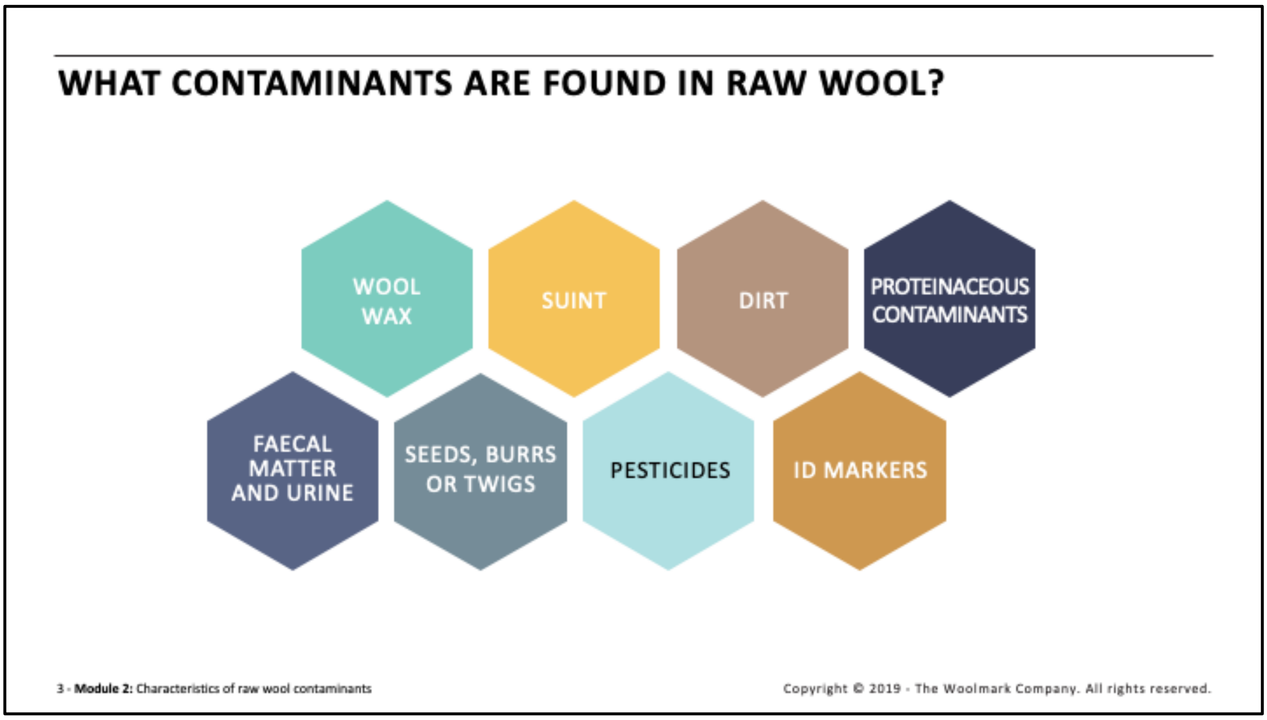
ASK *participants to recall the main purposes of scouring.*

COLLECT *responses from two to three participants across the room and record on the whiteboard or flipchart.*

CLICK *to advance the slide to reveal the purpose of scouring.*

REMIND participants that the purpose of scouring is to remove contaminants from raw wool in preparation for further processing.

EXPLAIN THAT levels of contaminants in raw wool vary between 20% and 90%, depending on sheep breed, wool quality and environmental conditions (e.g. pasture type, location etc).



NOTE TO FACILITATOR: *This slide is animated.*

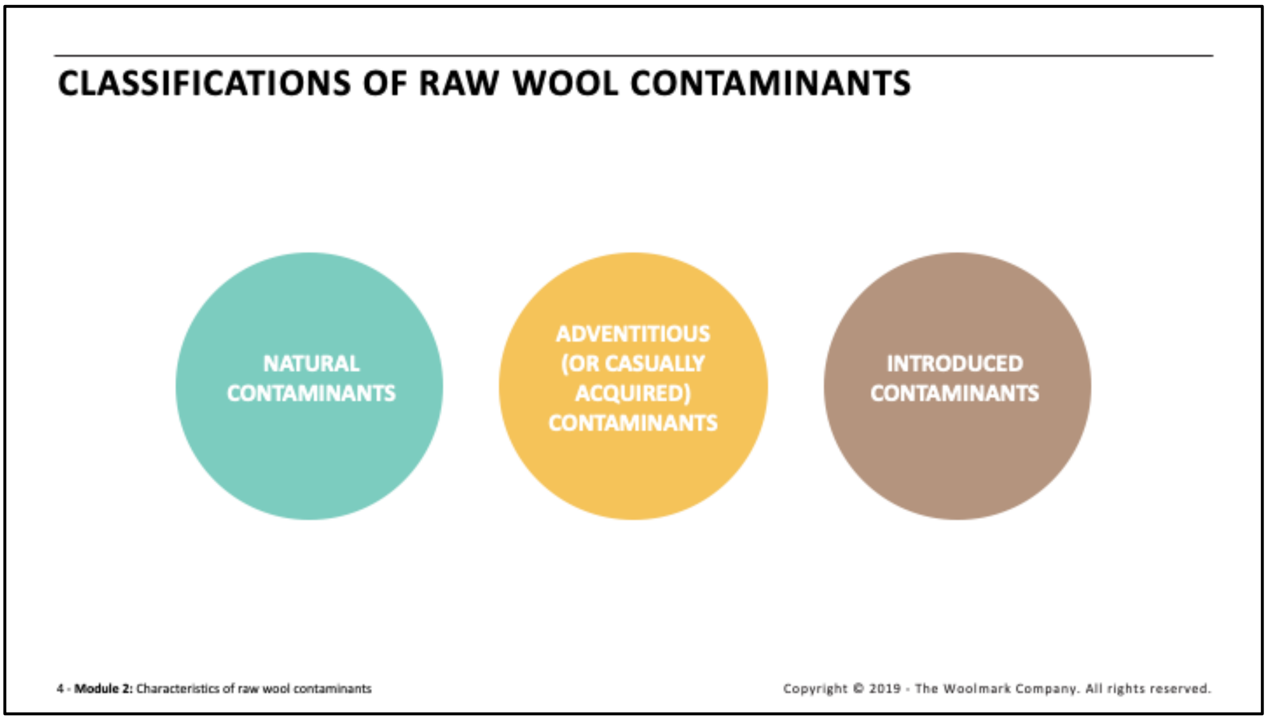
ASK *participants if they can name some of the different contaminants that might be found in raw wool.*

RECORD *participant responses on the whiteboard or flipchart.*

CLICK *to advance the slide. The range of contaminants in raw wool will be revealed. Tick off correct participant responses on the whiteboard or flipchart.*

INDICATE THAT contaminants found in raw wool include:

- wool wax
- suint (sweat)
- dirt
- proteinaceous contaminants (e.g. skin debris and non-wool proteins)
- faecal matter and urine
- seeds, burrs or twigs
- pesticides
- identification markers.



INDICATE THAT there are three classifications for contaminants:

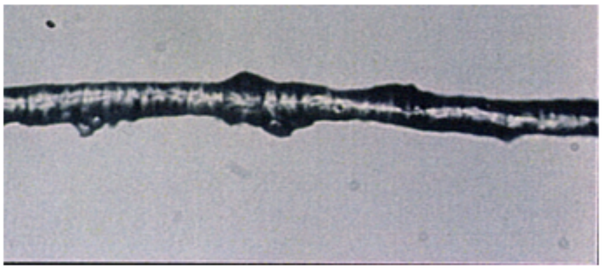
- natural
- adventitious (or casually acquired)
- introduced.

NATURAL CONTAMINANTS

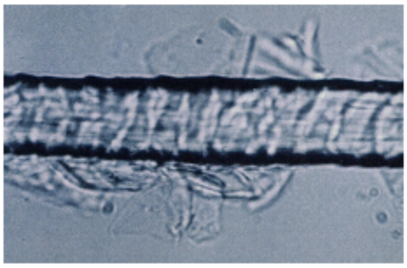
Wool wax
- Water-insoluble material from sheep's sebaceous glands.
- Contains approximately 20,000 esters.
- Not a 'grease'.

Suint
- Water-soluble component of raw wool, mostly consisting of organic potassium salts.

Non-wool proteins
- Skin debris and material (e.g. epithelial tissue).



Optical micrograph of raw wool



Optical micrograph of raw wool in water

Images courtesy of CSIRO

5 - **Module 2:** Characteristics of raw wool contaminants

EXPLAIN THAT natural contaminants of raw wool are secretions from the animal that coat the fibres as they grow and include wool wax, suint (or sweat) and non-wool proteins.

Wool wax
- Wool wax is a solvent-solvent (water-insoluble) material or lipid secreted from a sheep's sebaceous glands.
- It is estimated to contain 20,000 different esters in a complex combination of approximately:
    - 100 organic acids, comprising mainly alkanoic acids (ω-hydroxy acids and ω-hydroxy alkanoic acids)
    - 100 organic alcohols and sterols, such as cholesterol and lanosterol, and alcohols (e.g. aliphatic diols).
- No single ester has been isolated from wool wax.
- Wool wax is sometimes referred to as 'grease'. This is a misnomer: wool wax contains no triglycerides.

HAND OUT *sample of wool wax to the group and ask participants to observe the way it looks, feels and smells.*

ALLOW *participants to pass the sample around as you continue the lecture.*

Suint
- Suint is a water-soluble component of raw wool. Most suint comes from the sudoriferous gland; the remainder comes from protein degradation products and residues, such as peptides.
- Suint predominately consists of water-soluble organic potassium salts.
- The amount extracted depends on the order of extraction used — some components are amphoteric (soluble in water and solvent).
- In some instances, urine may appear in water-soluble extract — this usually only occurs with lower-quality wool, such as locks, bellies and crutchings.

Non-wool proteins
- This includes skin debris and material such as epithelial tissue and other related proteinaceous material remaining after the growth of the fibre.

ADVENTITIOUS CONTAMINANTS

Mineral dirt
- Wind-blown material
- Material picked up when sheep lie on ground

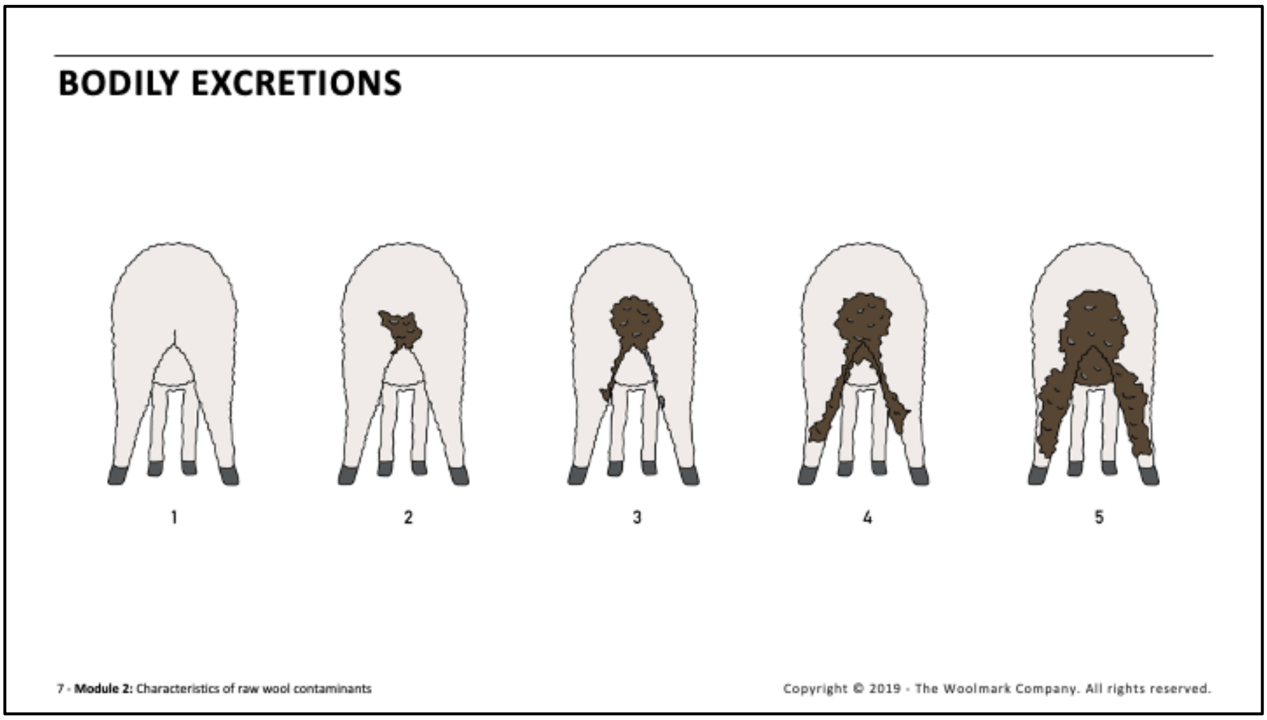
Vegetable matter
- Seeds
- Burrs
- Twigs
- Attach to the fleece while sheep graze or lie down

Faecal matter and urine
- Bodily excretions attached to localised parts of the fleece

Vegetable matter

6 - **Module 2:** Characteristics of raw wool contaminants

EXPLAIN THAT adventitious contaminants are acquired by sheep as the fleece grows. They include:
- mineral dirt — wind-blown material or material picked up when sheep lie on the ground
- vegetable matter — seeds, burs and twigs that attach to the fleece while sheep are grazing or lying down
- faecal matter and urine — bodily excretions that can attach to localised parts of the fleece (as shown on the slide).



POINT OUT the variation on the extent of faecal matter and urine (dags) that can contaminate the fleece is shown on the slide. This variation is affected by factors such as: seasonal variation, pasture type and growth stage and animal health status.

INTRODUCED CONTAMINANTS

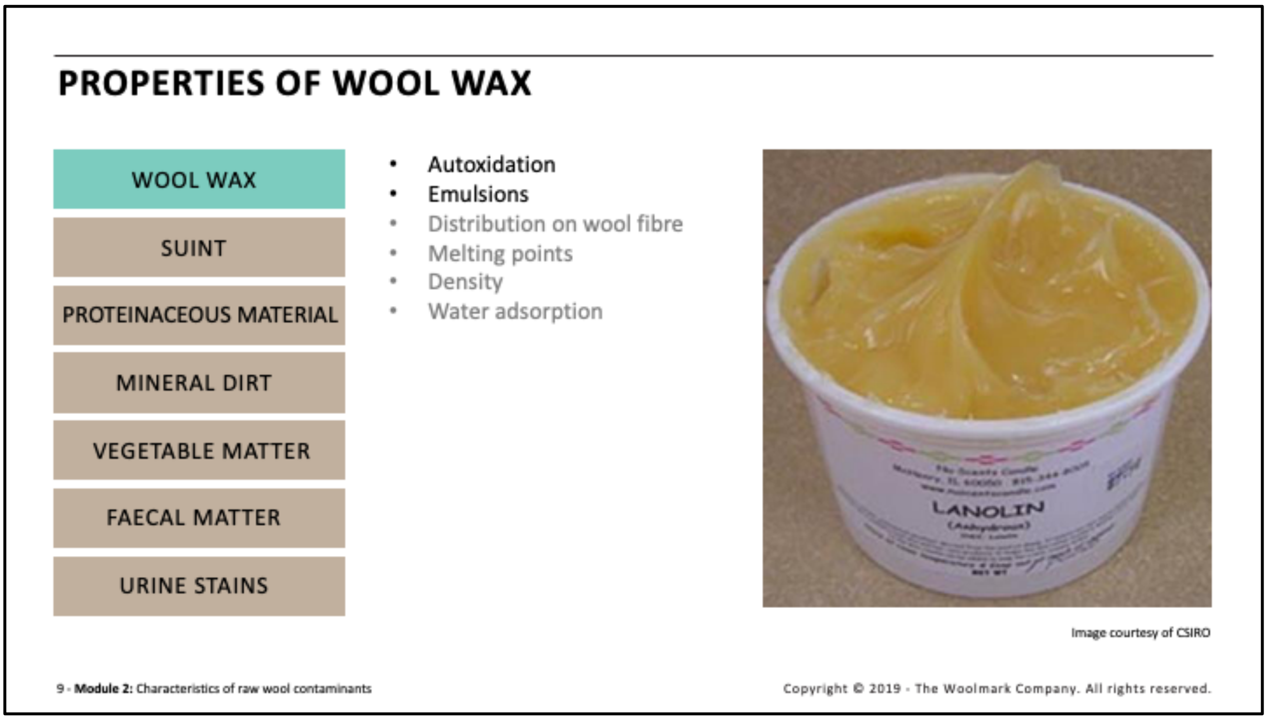
http://www.thefarmstore.com.au/heiniger-home-garden-si-ro-mark-sheep-branding-fluid-4l-blue

https://www.premier1supplies.com/p/si-ro-mark-marking-fluid

8 - **Module 2:** Characteristics of raw wool contaminants

MENTION THAT introduced contaminants can be deliberately added to the fleece by the woolgrower for management purposes, and can include:

- identification markers, such as Siromark, crayons and spray marker
- pesticides to control pests such as lice and flies.



***REFER TO** the sample of wool wax previously distributed to participants.*

EXPLAIN THAT wool wax has a number of properties relevant to wool scouring, which are affected by oxidation processes that occur as part of the weathering process during wool growth on the sheep.

Autoxidation

- Wool wax oxidises in the presence of air. As oxidisation commences, it continues (known as autoxidation).
- Oxidised wool wax contains free acids and alcohols (mainly cholesterol) from split esters and oxidation products, such as 7-oxocholesterol.
- Oxidised wool wax undergoes partial polymerisation.

EXPLAIN THAT compared to unoxidised wool wax, oxidation alters wool wax properties, such as:

- melting point — the melting point of wool wax is about 42°C, whereas highly oxidised wool wax can have a melting point exceeding 80°C
- sensitivity to heat
- emulsion stability
- recovery by centrifuging
- density of emulsion droplets
- composition of droplets.

These changes impact on wax recovery.

Emulsions

- Emulsions are mixtures of two or more liquids that are normally immiscible.
- Oxidised and unoxidised wool wax form characteristically different emulsions. These differences are central in understanding wool wax recovery.
- The amount of wool wax recovered from wools stored for a number of years is low.

PROPERTIES OF WOOL WAX

- WOOL WAX
- SUINT
- PROTEINACEOUS MATERIAL
- MINERAL DIRT
- VEGETABLE MATTER
- FAECAL MATTER
- URINE STAINS

- Autoxidation
- Emulsions
- Distribution on wool fibre
- Melting points
- Density
- Water adsorption

Image courtesy of CSIRO

10 - **Module 2:** Characteristics of raw wool contaminants

EXPLAIN THAT wool wax also has the following properties relevant to wool scouring.

Distribution on wool fibre

- As greasy wool fleece grows outwards, the fibre tips contain more oxidised wool wax, while the base contains completely unoxidised wool wax.
- Oxidised wool wax at the tips comes into contact with adventitious contaminants and forms difficult-to-remove complexes.

Melting points

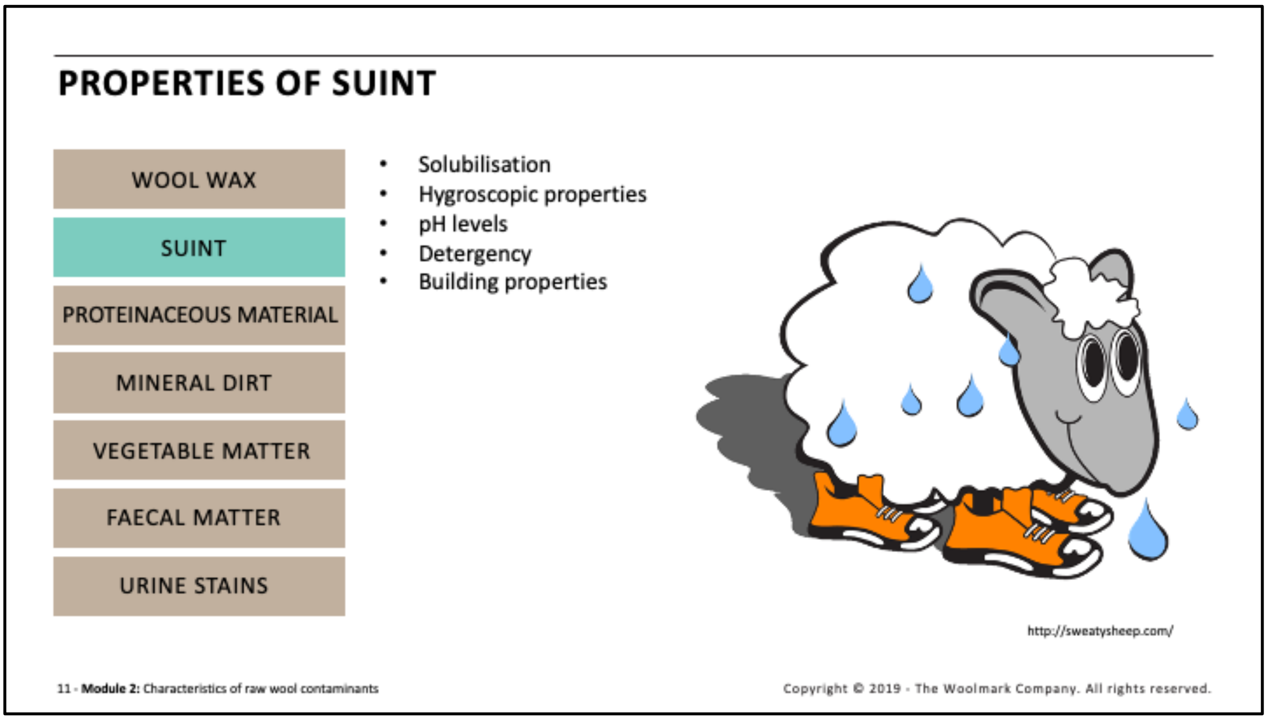
- Wool wax liquefies at around 40°C.
- The individual esters that comprise wool wax have various melting points.
- Solvent-fractioning methods can separate fractions, such as liquid lanolin, that are liquid at room temperature.
- Nuclear magnetic resonance analyses show that approximately 70% of wool wax is liquid at room temperature.
- Oxidised wool wax fractions can have melting points that exceed 80°C.

Density

- Wool wax has a density of about 0.92–0.94 kg/l, and tends to float in water or scouring liquor.

Water adsorption

- Lanolin, the refined form of wool wax, can absorb more than 200% of its weight in water. During scouring, the presence of surfactant restricts this property; the formation of water-in-oil emulsions within the normal oil-in-water emulsion can occur, changing the density of the emulsified wool wax.



INFORM participants that suint contains a number of properties relevant to wool scouring:

Solubilisation

- By definition, suint is water soluble, but the rates of solubilisation of its constituents vary.
- Inorganic and lower molecular weight potassic salts dissolve readily in water, but higher molecular weight potassic salt, peptide and protein residues take longer to hydrate and dissolve.

Hygroscopic properties

- Suint is hygroscopic (absorbs moisture from the air). This can affect subsequent processing if the moisture remains on the scoured wool – for example, if wool is processed in a non-polar solvent.

pH levels

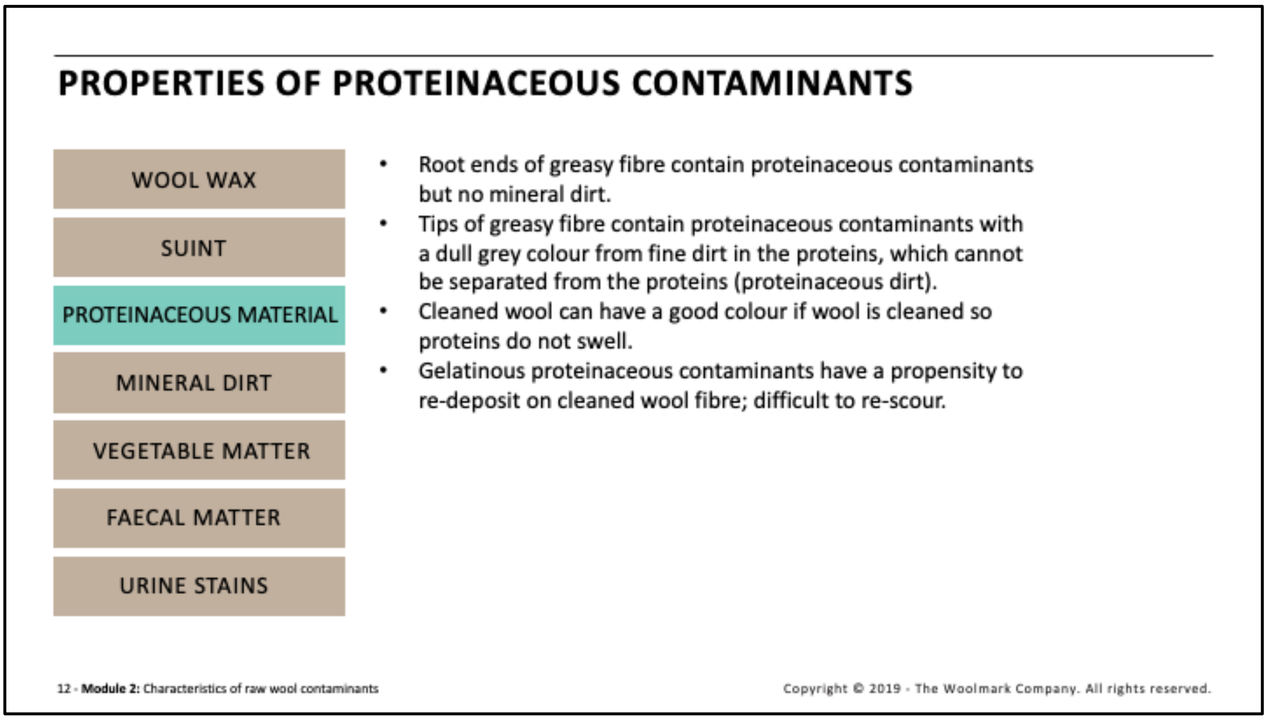
- The pH of a suint extract depends on the types of wool being processed.
- Merino wools have a neutral to slightly acid pH; broad crossbred wools have an alkaline pH.

Detergency

- Under alkaline conditions (high pH), suint develops detergent properties.
- As a result, cold de-suint bowls are not used to scour broad crossbred wools (alkaline suint). If a de-suint bowl is used, detergent consumption increases by approximately 50%.

Building properties

- Suint can act as a builder for scouring detergents because it consists mainly of potassium salts.
- Performance of a scouring line using fresh scouring liquors is not as effective as one where the concentration of dissolved solids is elevated.



EXPLAIN THAT proteinaceous contaminants (e.g. skin debris) have few disulphide bonds so there is little to hinder the water absorption and subsequent swelling of the contaminants.

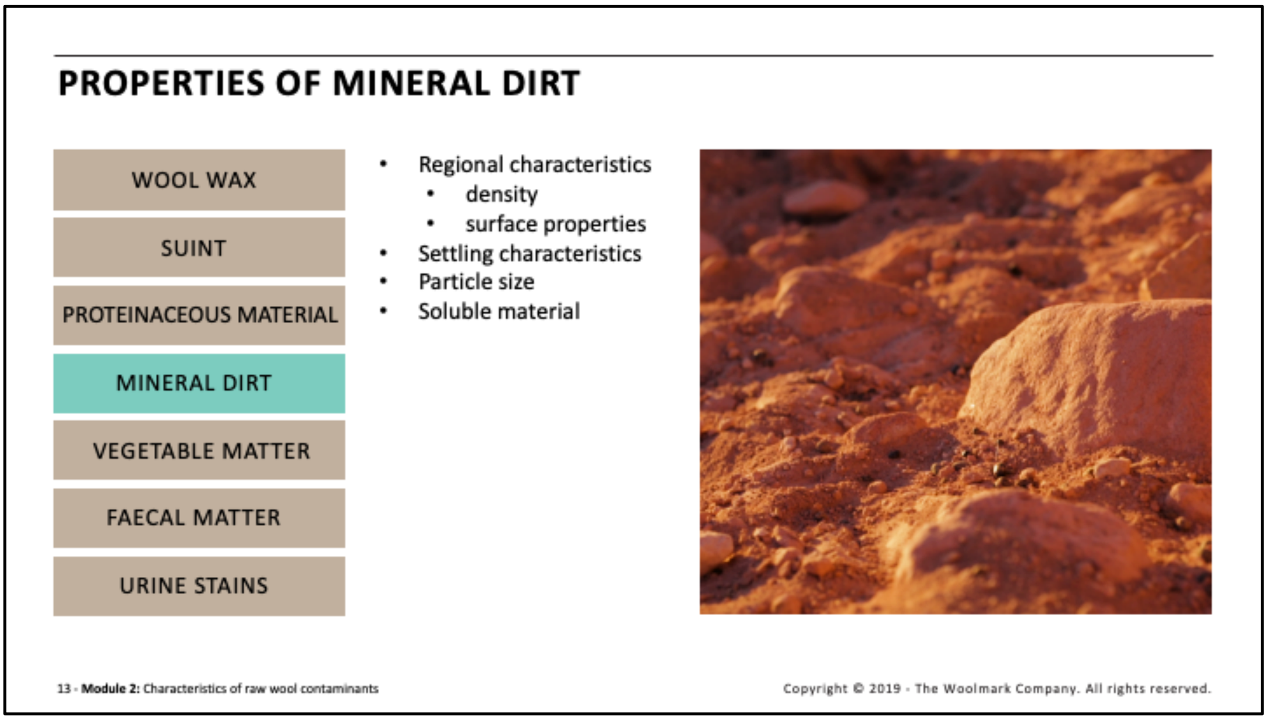
- Gelatine is a protein with similar swelling characteristics.
- The rate of swelling is not rapid, which means the proteins are not ready to be removed until the latter bowls in a scouring line. This material is classified as non-wool proteins present on the greasy wool.

EXPLAIN THAT proteinaceous contaminants contain the following properties relevant to wool scouring:

- **At the root end of greasy fibre —** Proteinaceous contaminants extracted from the root ends of greasy wool fibres, where there is no mineral dirt, have the same colour as the wool fibres.
- **At the tips of greasy fibre —** Proteinaceous contaminants extracted from the tips of wool fibres have a dull grey colour, from the presence of the fine dirt absorbed within the proteins. This dirt cannot be physically separated from the protein and gives poorly-scoured wool its poor colour. The sorption of this dirt occurs during the scouring process, presumably when the proteins become swollen with water.

This material is commonly referred to as 'proteinaceous dirt'.
Cleaned wool (i.e. wool that has been cleaned so the proteins do not swell) can have a good colour despite it having a high ash content.

NOTE THAT gelatinous proteinaceous contaminants swell in water but have a propensity to redeposit on cleaned wool fibres. Experiments have shown that this redeposited material is difficult to re-scour from the wool.



EXPLAIN THAT mineral dirt contains the following properties relevant to wool scouring:

Regional characteristics
Dirt found on greasy wool has distinct regional differences.

Wool from some regions is difficult to scour due to the characteristics of dirt in those regions.

- **Density —** The density of the material depends on the type of dirt and its origin.
- **Surface properties —** The surface properties of the material depend on the type of the dirt and its origin. The surface may be hydrophilic or oleophilic (note: these terms will be explained in a later lecture).

Settling
Mineral dirts have higher densities than water, meaning the dirt should readily settle from a scouring liquor.

EXPLAIN THAT the extent of settlement is determined by the amount of wool wax in the scouring liquor. This is because dirt forms complexes with the wax that can hinder its sedimentation.

Particle size
The particle size of dirt varies significantly and can affect the rate of settling.

NOTE THAT diameters of dirt particles can vary from 100 microns to less than 1 micron.

EXPLAIN THAT sub-micron particles are classified as colloids and are usually absorbed by non-wool proteinaceous contaminants, especially when partially or fully swollen. This material is often responsible for the poor colour of scoured wool.

Soluble material
Mineral dirt is, in most part, not soluble in water, but soluble components can leach into the scouring liquor and affect the scouring practice.

EXPLAIN THAT this is by increasing the hardness of the water, or by increasing the concentrations of metal ions, such as iron that cause re-deposition and adversely affect the colour of the scoured wool.

PROPERTIES AND CONSEQUENCES OF VEGETABLE MATTER

- WOOL WAX
- SUINT
- PROTEINACEOUS MATERIAL
- MINERAL DIRT
- **VEGETABLE MATTER**
- FAECAL MATTER
- URINE STAINS

- Ability to act like a fibre
- Contain natural dyes: staining potential
- Brittleness
- Opening difficulties
- Severe opening

http://www.knitting-and.com/spinning/skirting.htm

14 - **Module 2:** Characteristics of raw wool contaminants

INDICATE THAT vegetable matter (VM) is usually removed from a fleece during skirting.

- Most Australian fleece lines are classed as free or near free of vegetable matter.
- Wools containing high levels of vegetable matter are usually carbonised after scouring.

EXPLAIN THAT vegetable matter has the following properties that are relevant to wool scouring:

Ability to act like a fibre

- Long, thin pieces of vegetable matter can behave like wool fibres during processing and are difficult to separate from the wool fibres.

Contains natural dyes

- These natural dyes have the potential to stain the wool fibres during scouring.

Brittleness

- Brittle pieces of vegetable matter can break up in the fleece, creating further contamination.

Opening difficulties

- Wools that are heavily contaminated by vegetable matter are difficult to open using openers developed for uncontaminated wools.
- These wools need to be carefully machined in preparation for scouring.
- If wool is insufficiently prepared, scour liquor cannot penetrate the wool mass sufficiently to remove the normal wool contaminants.

Severe opening

- The severe opening that might be needed to prepare the wool for scouring may adversely increase the potential for fibre entanglement.

PROPERTIES OF FAECAL MATTER

- WOOL WAX
- SUINT
- PROTEINACEOUS MATERIAL
- MINERAL DIRT
- VEGETABLE MATTER
- **FAECAL MATTER**
- URINE STAINS

- Appears mainly in pieces and crutchings.
- Problems when hydrated and swollen:
  - sticks to squeezing rollers and stains the cleaned wool
  - colour in scour liquor stains scoured wool
  - blocks the mesh of the false bottom
  - colour decreases value of recovered wool wax.

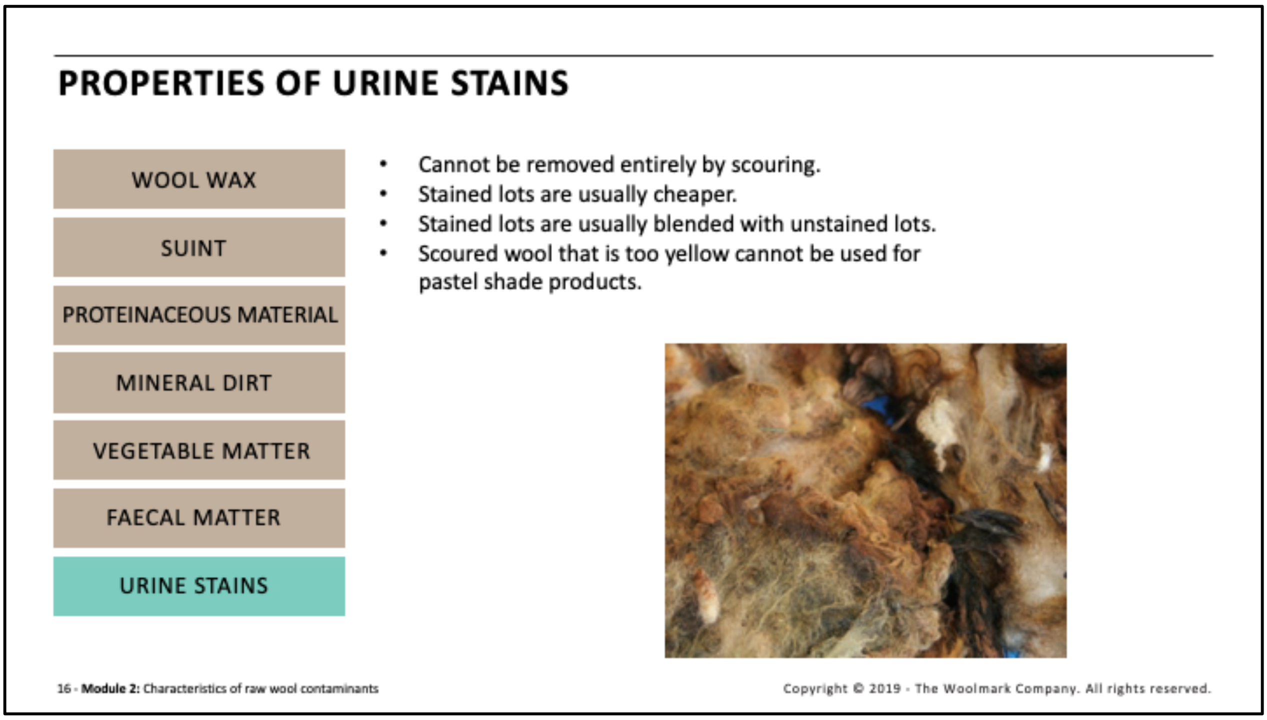
15 - **Module 2:** Characteristics of raw wool contaminants

POINT OUT that **f**aecal matter or 'dags' appear mainly in pieces and crutchings. They are more likely to present problems when processing wools destined for the woollen processing route.

EXPLAIN THAT dags create a number of problems when they become hydrated and swollen:

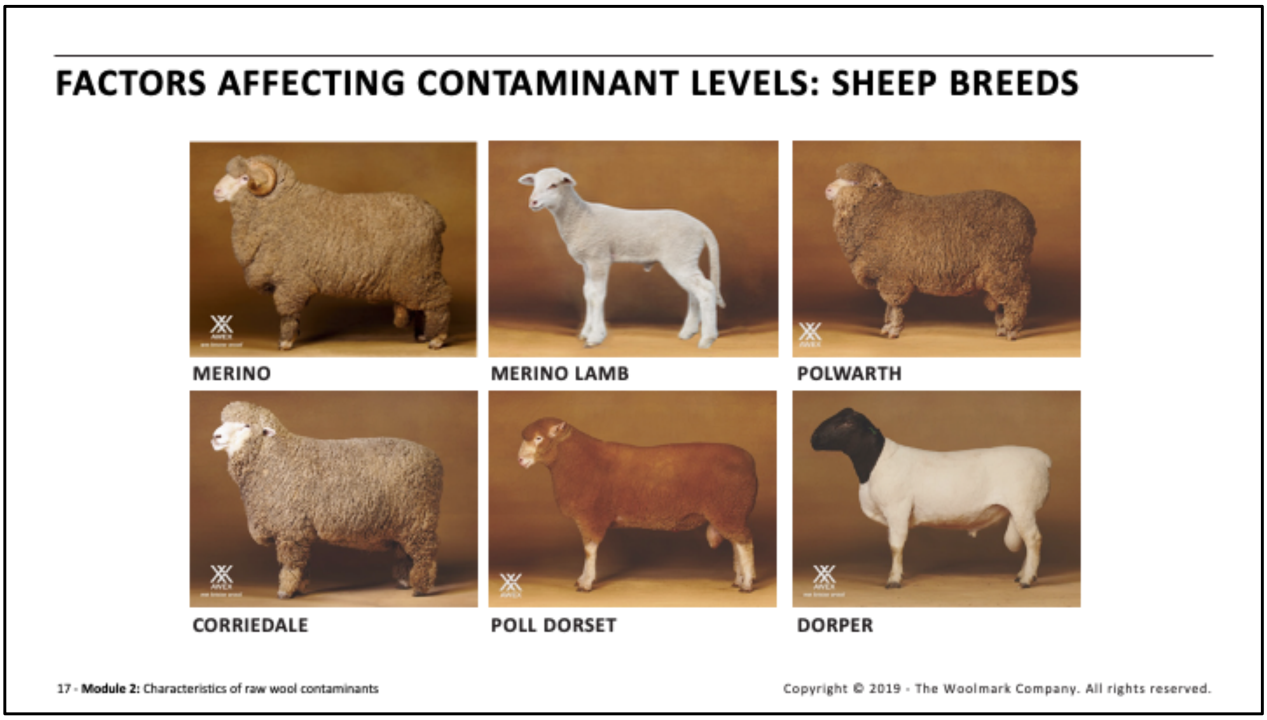
- Swollen dags can stick to the squeezing rollers and stain the cleaned wool.
- Colour in the scour liquor can stain the scoured wool.
- Dags can block the mesh of the false bottom (strategically placing bell dunkers to agitate the bowl contents can prevent the accumulation of dags).
- The distinct green colour of the recovered wool wax decreases its value.

NOTE THAT scourers routinely processing wool containing dags try to remove as many dags as possible as during machining. Dag crushers pulverise the dags for removal by screening. Problems occur when dags are wet or moist.



EXPLAIN THAT urine stains cannot be removed entirely by scouring.

- Stained processing lots are usually cheaper.
- It is common practice to blend stained lots with more expensive, unstained lots.
- When scouring urine-stained wool, its end use should be kept in mind; a scoured wool that is too yellow cannot be used for products in which pastel shades are used to dye the wool.



EXPLAIN THAT there are different factors that affect the contaminant levels in raw wool, including:

Sheep breeds:

- Apart from lambswool, the breed of sheep determines the level of natural contaminants present in greasy wool; the quality of the wool is also affected by the levels of adventitious contaminants present in the wool.
- Around 75–80% of Australian wool is Merino, and the remainder is mainly a cross with Merino sheep.

INDICATE THAT sheep breeds classified by the Australian Wool Exchange include:

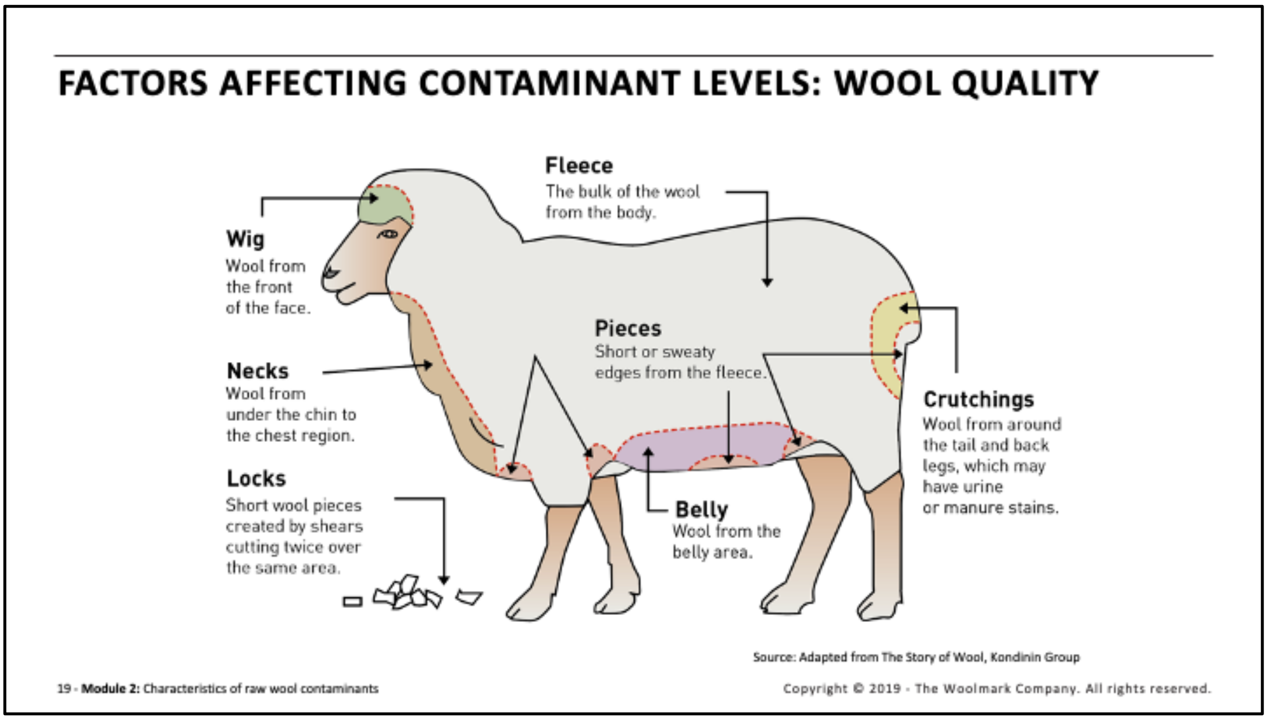
- Merino (e.g. Australian Superfine Merino)
- dual purpose/comeback (e.g. Polwarth)
- crossbreeds (e.g. Corriedale)
- downs wool (e.g. Poll dorset)
- carpet wool (e.g. Tukidale)
- shedding/hair sheep (e.g. Dorper).

LEVELS OF CONTAMINANTS ON DIFFERENT TYPES OF WOOL

TYPE OF WOOL	WAX (%)	SUINT (%)	DIRT (%)
Merino fleece	15	5	15
Merino lambswool	20	5	7
Merino pieces	15	7	20
Coarse crossbred fleece	5	8	4
New Zealand Romney	6	8	8

18 - **Module 2:** Characteristics of raw wool contaminants

EXPLAIN to participants that the table on the slide outlines the average percentage of contaminants in the raw wool of different fleece components, types and breeds.

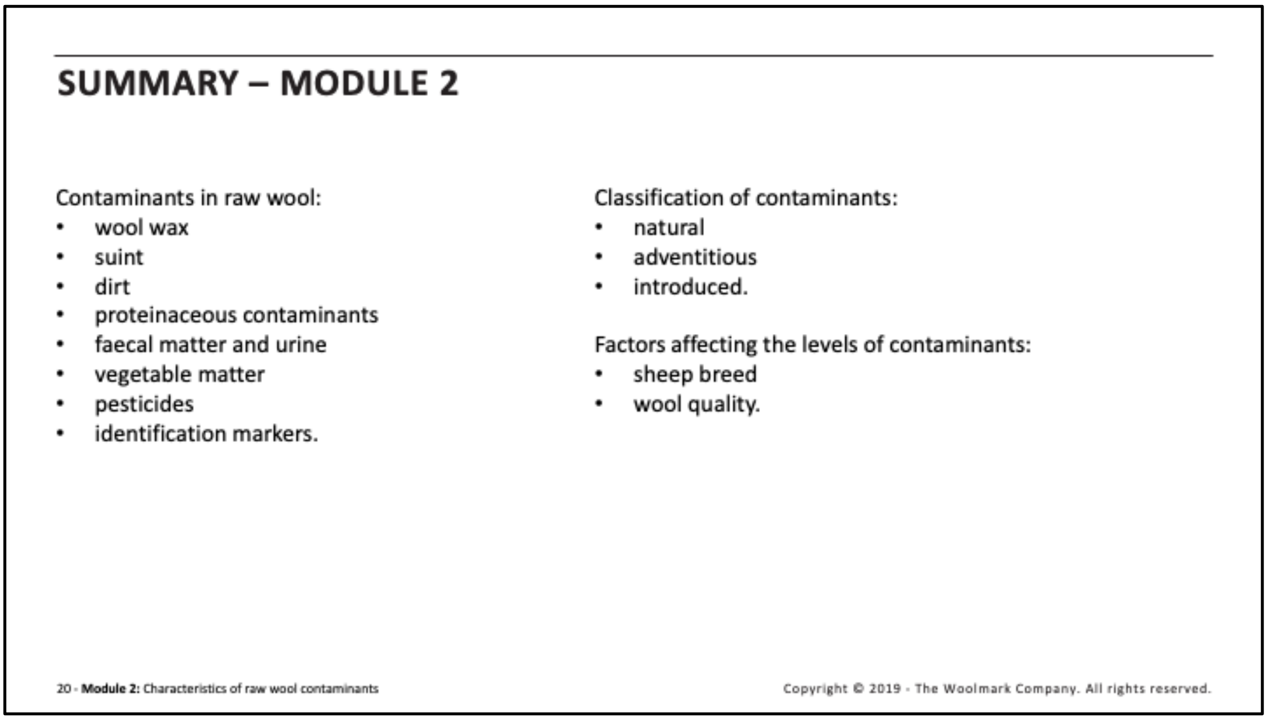


REINFORCE THAT the level of contamination, on an individual animal varies according to where it comes from.

DIRECT participants to the illustration on the slide outlining the key parts of the wool removed from the sheep:

- fleece wool — the main body of the fleece surrounding the body of the sheep, which contains the highest quality wool
- skirtings (not shown on the diagram) — the fleece is skirted to remove any dirty pieces of wool around the edges, leaving only fleece wool.
- belly — short wool found on the undercarriage of the sheep is usually contaminated with vegetable matter, dirt, etc.
- crutchings — wool from around the tail and between the rear legs of a sheep, usually contaminated with urine and faecal matter.
- pieces — wool from the neck, face (wig) and locks (second cuts) small portions from the lower parts of the legs and edges of the fleece, greasy staples, under the forearm, inside the flank and crutch.

NOTE: Lambswool is generally the first shearing of wool from lambs up to seven months old, with shorter staples when compared with the fleece of a mature animal.



SUMMARISE THAT contaminants found in raw wool include:

- wool wax
- suint (sweat)
- dirt
- proteinaceous contaminants (e.g. skin pieces)
- faecal matter and urine
- vegetable matter
- pesticides
- identification markers.

REINFORCE THAT contaminants can be classified as:

- natural
- adventitious
- introduced.

REMIND participants that factors affecting the levels of contaminants in raw wool include:

- sheep breeds
- wool 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 — *Module 3 Preparation for scouring* — 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 samples distributed during the lecture.

MODULE 3

THE WOOLMARK COMPANY

PREPARATION FOR SCOURING

RESOURCES — MODULE 3: PREPARATION FOR SCOURING

No additional resources are required to deliver **Module 3: Preparation for scouring**.

WELCOME participants to Module 3 of the Woolmark Wool Science, Technology and Design Education Program — *Raw wool scouring — Preparation for scouring*.

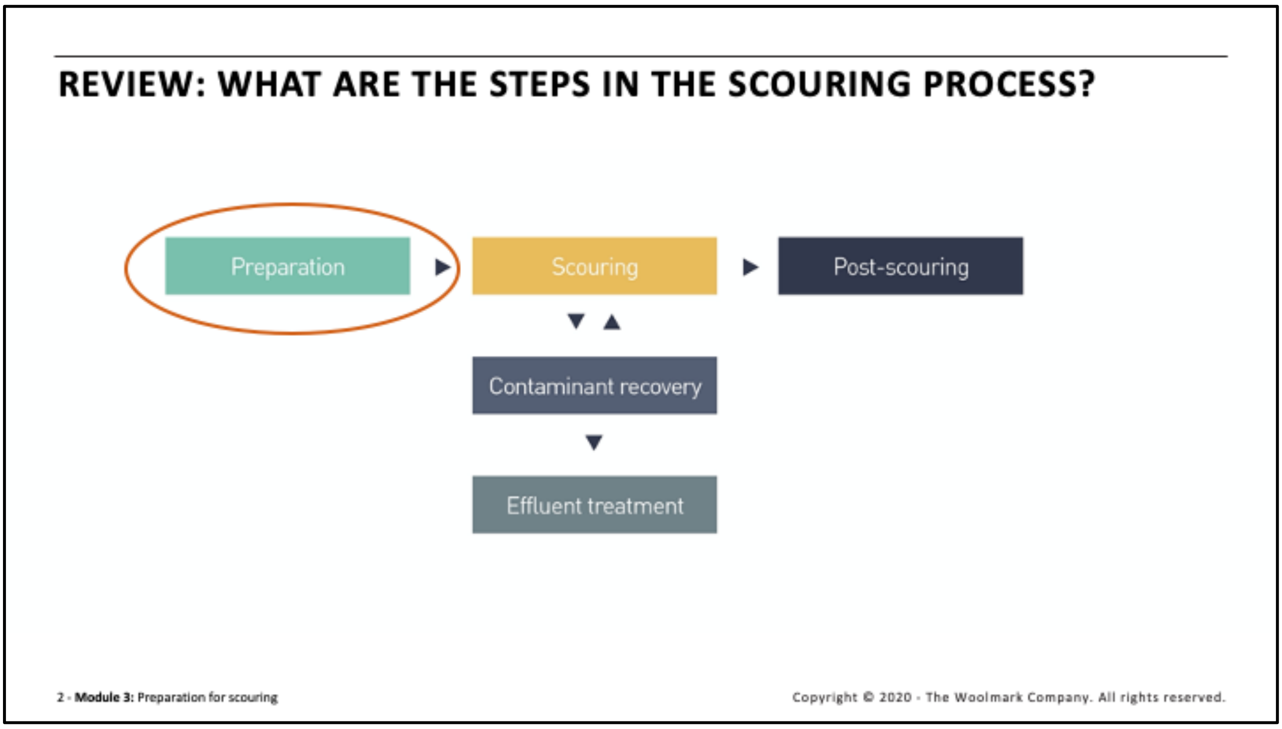
EXPLAIN THAT this module outlines the steps taken to prepare wool for scouring including:

- a review of the steps in the scouring process
- preparing wool blends
- bale warming
- blend layouts
- opening raw wool
- best-practice issues during the scouring preparation operation.

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

- describe the steps involved in preparing wool for scouring.

NO RESOURCES REQUIRED



INDICATE THAT the steps in the scouring process are:

- consignment preparation
- scouring line
    - contaminant recovery
    - effluent treatment
- post-scouring processes.

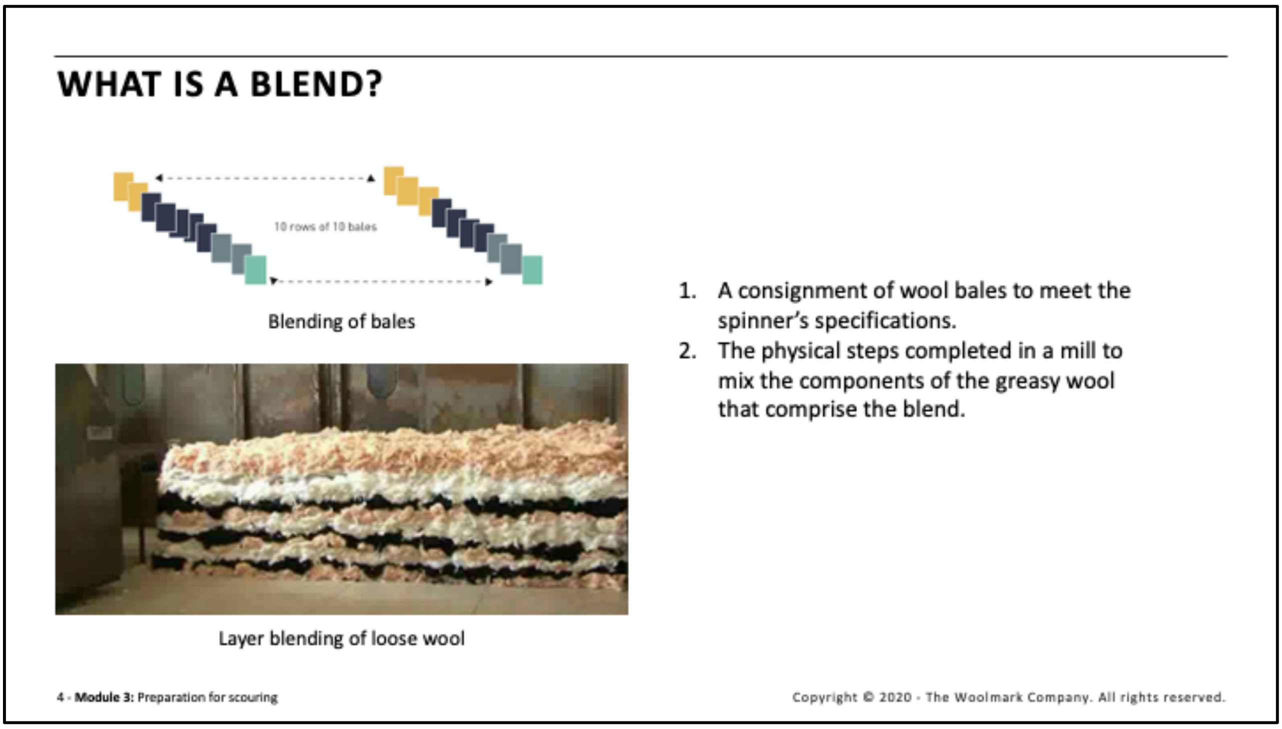
OVERVIEW

- Preparing the wool blend
- Warming the bales
- Laying out the blend
- Machining
- Opening and feeding the scour

3 - **Module 3:** Preparation for scouring

EXPLAIN THAT preparation in a wool scour involves preparing the raw wool for the cleaning process and includes the following processes:

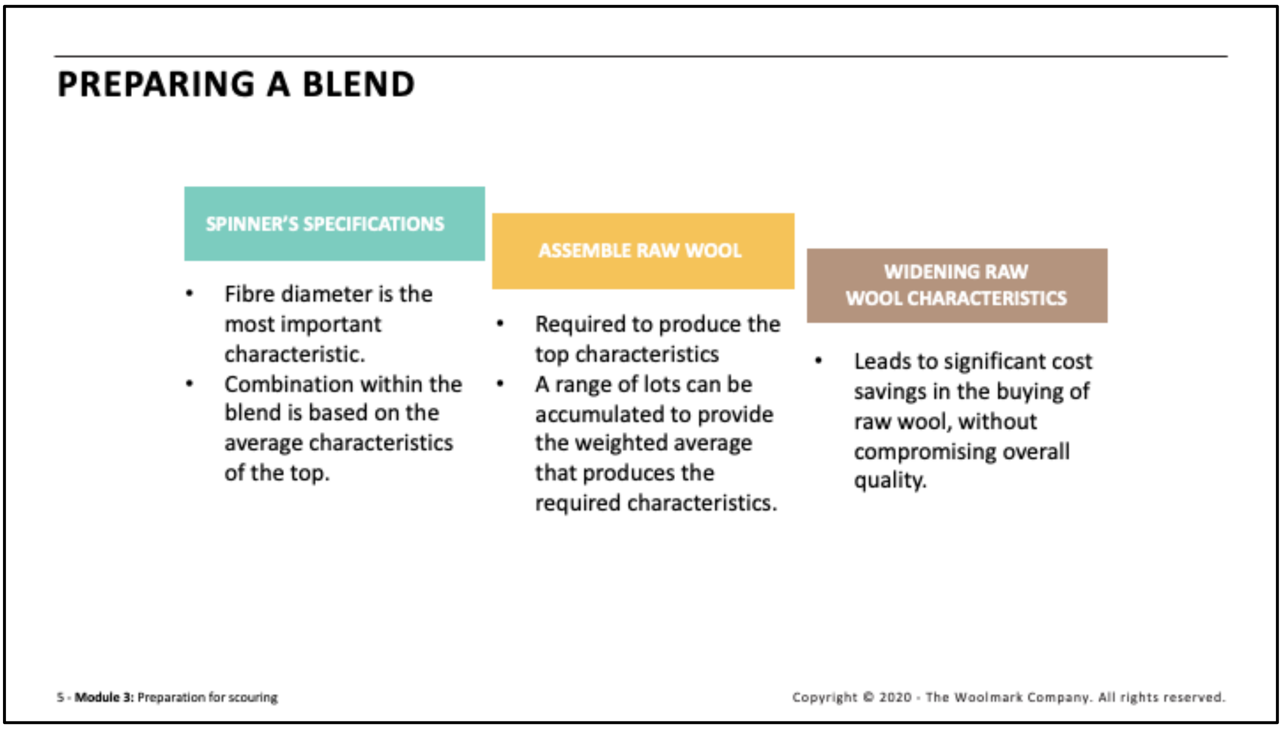
- **Preparing the wool blend** — making decisions on which wool needs to be purchased (NOTE: This is done by wool buyers who have orders to meet: it is not done by the scouring staff).
- **Warming the bales** — to make wool easier to open
- **Laying out the blend** — to arrange batches in proportion to the different types required for blend
- **Machining** — opening some greasy wools requires more mechanical action than in normal in-line opening equipment (e.g. cotted or highly tangled wool)
- **Opening and feeding the scour** — using in-line openers to feed greasy wool to the scouring line.



POINT OUT that the term blending has two meanings in wool scouring:

- Blending can refer to the wool that is purchased to produce a specific set of products.
- Blending can also refer to the physical steps completed in a mill to 'mix' the components of the greasy wool that comprise the blend.

INDICATE THAT blending is fully described in the Wool Science, Technology and Design Education Program course *Worsted top-making*.



EXPLAIN THAT the selection of the different wools that will ultimately comprise a blend can have major financial and technical implications for the scourer and top-maker.

EMPHASISE 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.

INDICATE THAT the choice of wool can be complex due to:

- the large range of wool types available and their origins
- the range of top specifications set forth by a spinner to meet various product specifications.

EXPLAIN THAT the first step a top-maker takes in preparing a suitable blend is to determine the spinner's specification for the top. This process is outlined in detail in the Wool Science, Technology and Design Education Program course *Worsted top-making,* but the key elements of this process are:

- Selecting fibre characteristics that will meet the spinner's specifications — fibre diameter is generally the most important raw wool characteristic. A number of combinations of wool lots can be assembled to produce a single consignment that meets the specifications.
- Selecting a combination of wool lots that delivers the most cost-effective option.
- A range of wool characteristics can be used to provide the weighted average that will produce the required characteristics in the top.
- Widening the raw wool characteristics used to produce the mill consignment can lead to significant savings without compromising the quality of the tops.

***ASK** participants which properties of raw wool are tested before sale.*

***ACKNOWLEDGE** responses before proceeding to the next slides*

AUSTRALIAN WOOL TESTING AUTHORITY (AWTA) TESTS

6 - **Module 3:** Preparation for scouring

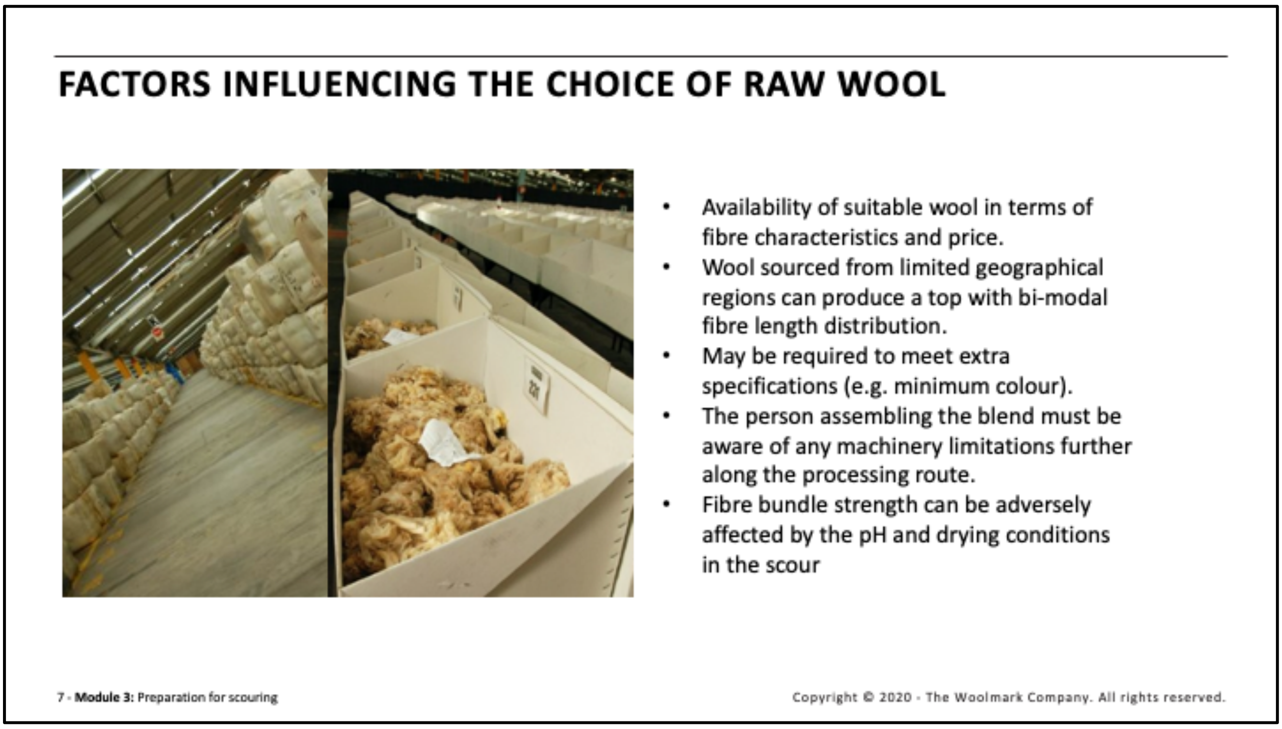
EXPLAIN THAT when assembling a batch of wool lots to meet a client's specifications the key properties in the raw fibre that are of interest to the top-maker include:

- 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.

POINT OUT 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).

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

NOTE THAT the process used by the top-maker to assemble a suitable consignment of raw wool based on these test results is outlined in detail in the Wool Science, Technology and Design Education Program course *Worsted top-making.*



EXPLAIN THAT in addition to the raw wool measurements resulting from AWTA testing, the factors that influence the top-maker's choice of raw wool are:

- availability of suitable wool in terms of price
- regionality of source material — wool sourced from limited geographical regions can produce a top with bi-modal fibre length distribution. This may be disregarded by the spinner due to a greater chance of poor spinning performance.
- additional specifications set out by the spinner (e.g. certain minimum colour or a maximum number of dark fibres).

INDICATE THAT the person assembling the blend must be aware of any machinery limitations that exist along the processing chain (i.e. the mill adjustment factor used in the TEAM-3 formula developed by the CSIRO, The Woolmark Company and the AWTA , which is covered in detail in the Wool Science, Technology and Design Education Program course *Worsted top-making).* The challenge is to improve the scour performance so the mill adjustment can be changed resulting in a reduction in the cost of raw wool, without affecting quality.

The top-maker also must be assured of ability of the scour and top-making plant to handle the wools used in the consignment blend.

POINT OUT that in order to save money, the temptation may be to buy wools that have either a low yield or a high vegetable matter (VM) content. However, if the scourer cannot clean the heavily contaminated wool, or the top-making equipment cannot remove the vegetable matter, money is wasted.

EXPLAIN THAT the scourer can improve fibre length and reduce the amount of short fibre by reducing entanglement. However, the scourer can also impair the fibre strength, which is an important factor in determining spinning performance, by poor control of pH and drying conditions in the scour.

BALE WARMING

Opening bales in cold climates leads to broken fibres, partly-opened fleeces and an uneven feed to the scouring line.

Three methods used to warm bales:
1. warm room
2. dielectric heating
3. steam injection.

8 - **Module 3:** Preparation for scouring

NOTE TO FACILITATOR: *This slide is animated.*

BEFORE *revealing the notes on the slide, ask participants why bales might need to be warmed before opening.*

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

CLICK *to reveal the answers before proceeding.*

EXPLAIN THAT bales are difficult to open in cold climates — especially dumped bales (bales heavily compressed for transport).

INDICATE THAT opening cold or frozen bales can lead to broken fibres, partly-opened fleeces and an uneven feed to the scouring line.

EXPLAIN THERE are three methods are used to warm bales: a warm room, dielectric heating and steam injection.

Warm room

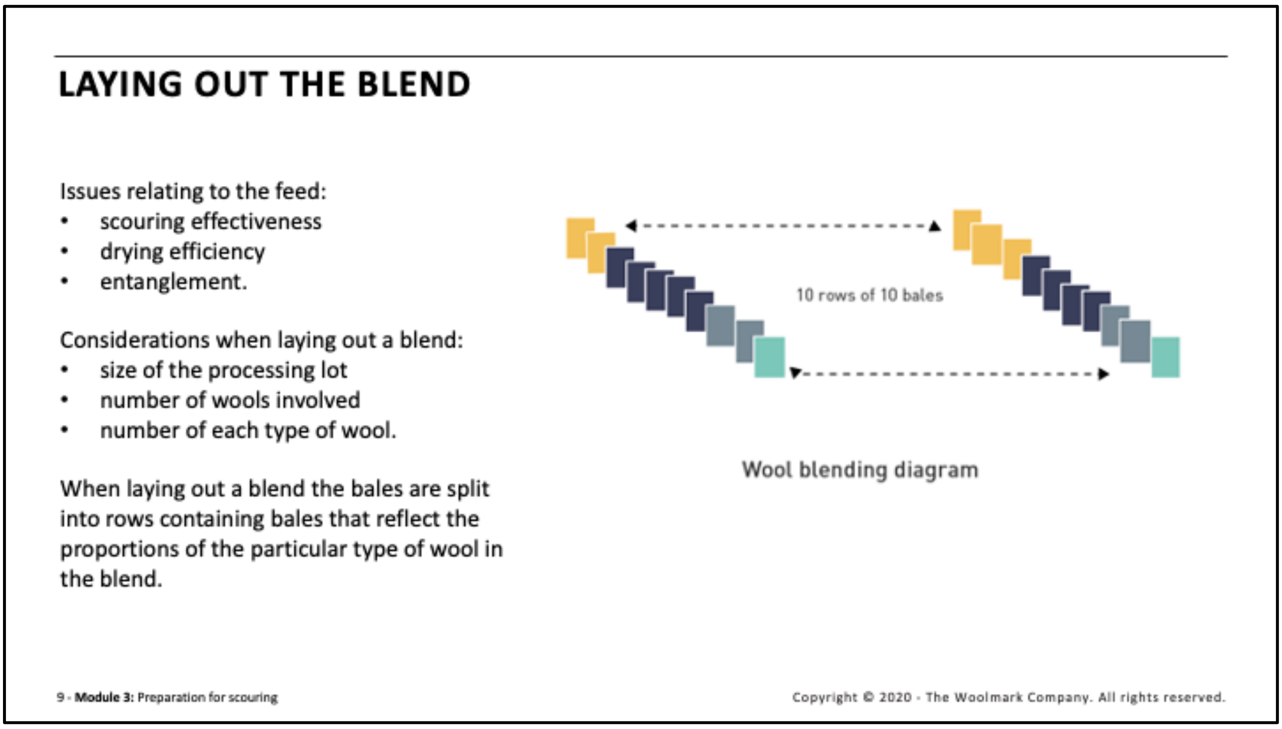
- A warm room relies on the thermal conductivity of wool to transfer energy from the warm air through the fibres. The bales are poor conductors of heat and so the bales need to remain in the warm room for at least two to three days before opening.

Dielectric heating

- The principle behind dielectric heating is that the application of a high-frequency voltage to a non-conducting substance causes cyclic strain and movement of the molecules within the substance, resulting in energy loss that generates heat.
- Radio frequency and microwave heating are both forms of dielectric heating.
  - Advantages are an immediate effect.
  - Disadvantages include high capital costs, high electricity usage and fire risk.

Steam injection

- Steam injection can be applied directly to a bale — internally or externally.
- A steam wand injected into a bale interior is an inexpensive and simple method, but the injecting process can damage and stain the wool.
- Bales can be held in place between two platens and steam can be injected through a number of points in the bale. This helps to push the heat front into the bale and dissipate the high temperatures of the steam, reducing the potential for fibre damage.



EXPLAIN THAT the method used to prepare the blend affects how the wool is fed to the subsequent scouring operation. Potential issues related to the feed to scour line include:

- scouring effectiveness
- drying efficiency
- entanglement.

INDICATE THAT potential issues relating to subsequent processing may include:

- fibre loss in carding and combing
- increased tear.

EXPLAIN THAT the considerations when laying out a blend include the:

- size of the processing lot
- number of wool types involved
- number of each type of wool.

POINT OUT the processes for laying out a blend:

- It is important to split the bales of wool comprising the processing lot into rows containing bales that reflect the proportions of the particular type of wool in the blend.
- Care should be taken to ensure an even (balanced) mix of bales comprising each type if the wool comes from different farm lots.
- After the bales are laid out, they can be inspected and decisions made regarding both the suitability of individual bales and the opening regime needed for particular types.

OPENING RAW WOOL

Wool is 'opened' to:

- remove contaminants
- blend the wool
- break the fleece into smaller clumps
- open up tight portions of fleece
- facilitate scouring.

Machining may be required for more severe opening operations, and is:

- done off-line
- often carried out intermittently
- used on heavily-matted or dirty wools
- more likely to be used on on wools to be processed in the woollen spinning system.

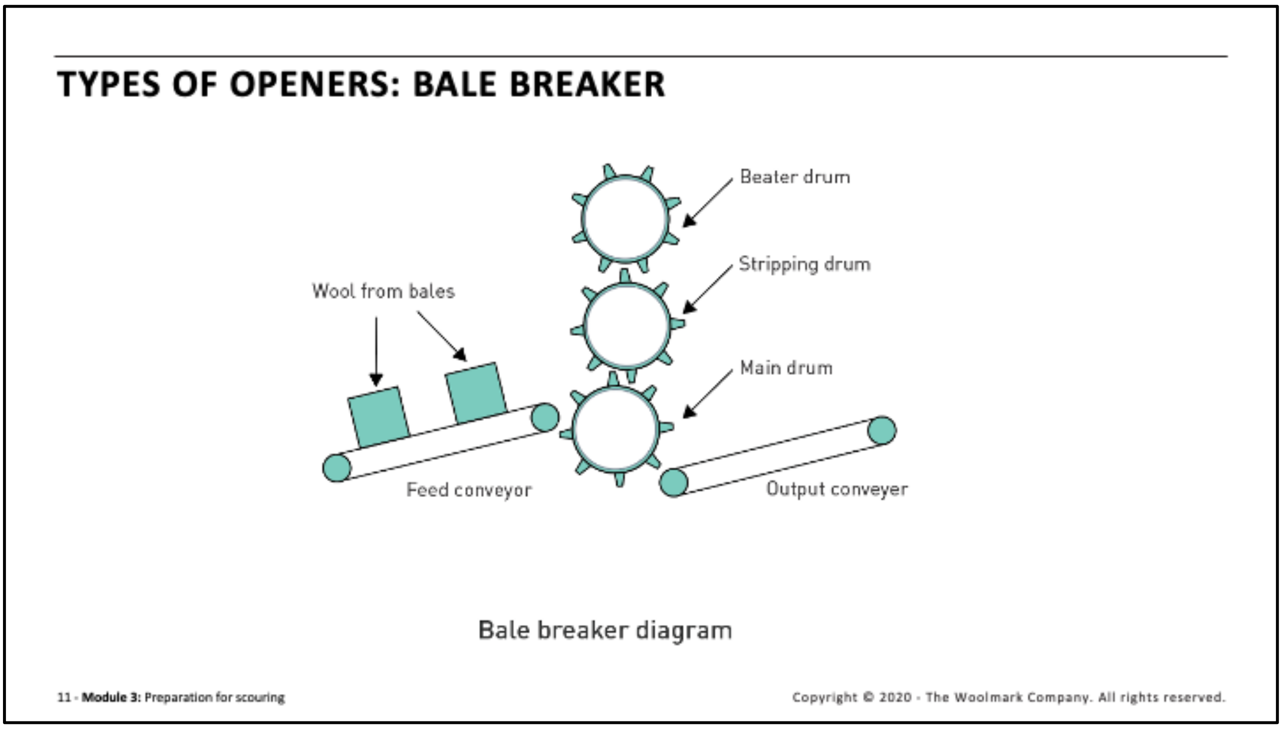
10 - **Module 3:** Preparation for scouring

EXPLAIN THAT the purpose of the 'opening' process is to:

- remove contaminants from the raw wool
- enhance the blending of the wool lots — poorly-blended wool can result in portions of long wool followed by portions of short wool going into carding, causing fibre breakage and losses during the carding process
- break the fleece into smaller clumps — if the wool is not reduced to smaller pieces, the feed to the scouring line can become uneven, leading to poor scouring performance
- open up tight portions of fleece — if a gentle opener cannot open the wool, it may be necessary to machine the wool using special openers.

INDICATE THAT machining for wools that are difficult to open (e.g. broad or cotted wools) or more severe opening operations is:

- done 'off-line' — machined wool is fed to the in-line openers along with raw wool that didn't require machining
- often carried out intermittently — sometimes it is necessary to retain the raw wool within the opener for a pre-determined time to open the wool sufficiently
- used on heavily-matted or particularly dirty wools — more likely to be used on wools to be processed in the woollen spinning system.



POINT OUT that the different types of openers commonly used to prepare wool for scouring include:

- bale breaker
- brattice feed hopper
- drum opener
- step opener (not often used for opening Australian wools)
- cyclic opener
- hammer mill.

NOTE: The methods have been listed in increasing order of the severity of their action.

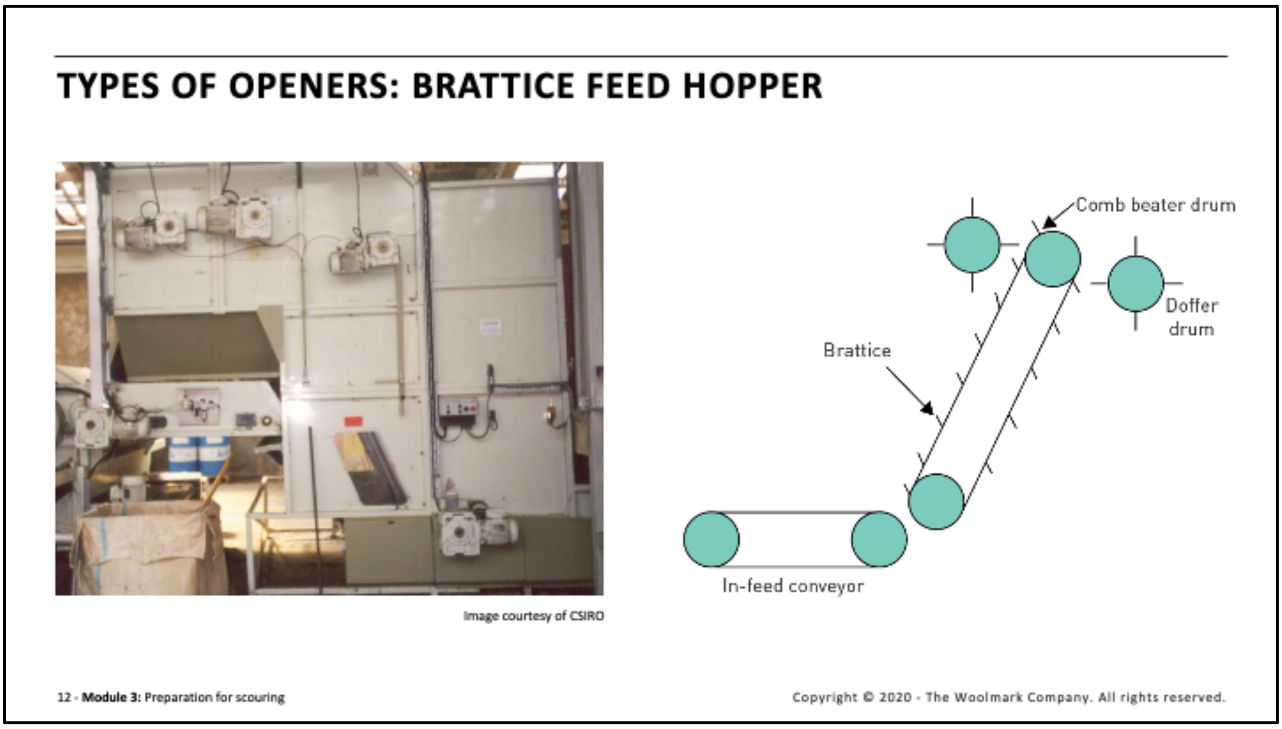
REFER TO the image on the slide as you explain the action of the bale breaker.

Bale breaker
The raw wool is moved by a conveyor towards the main drum that breaks off clumps of wool that are carried around to a second stripping drum, which breaks the clumps into smaller pieces.

Wool is then removed from the stripping drum by the third, top-beater drum, which returns larger clumps to the feed conveyor for further opening.

After the wool is broken into clumps that can be carried past the stripper drum, the wool is transferred from the main drum to the output conveyor.

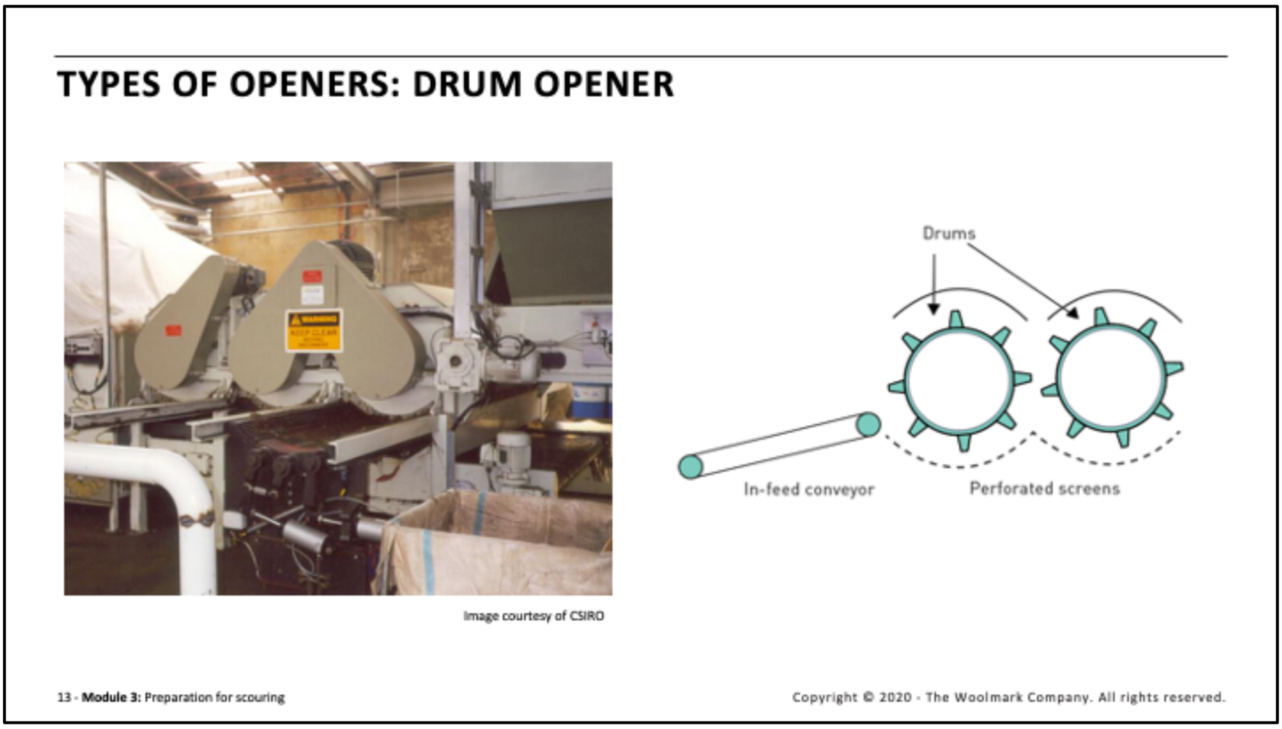
NOTE THAT relative speeds and the extents of interactions of the drums can be varied to facilitate different levels of opening.



REFER TO the image on the slide as you explain the action of the brattice feed hopper.

Brattice feed hopper
Raw wool is placed on, or fed to, a horizontal in-feed conveyor that moves the wool towards a spiked brattice, which is almost vertical.

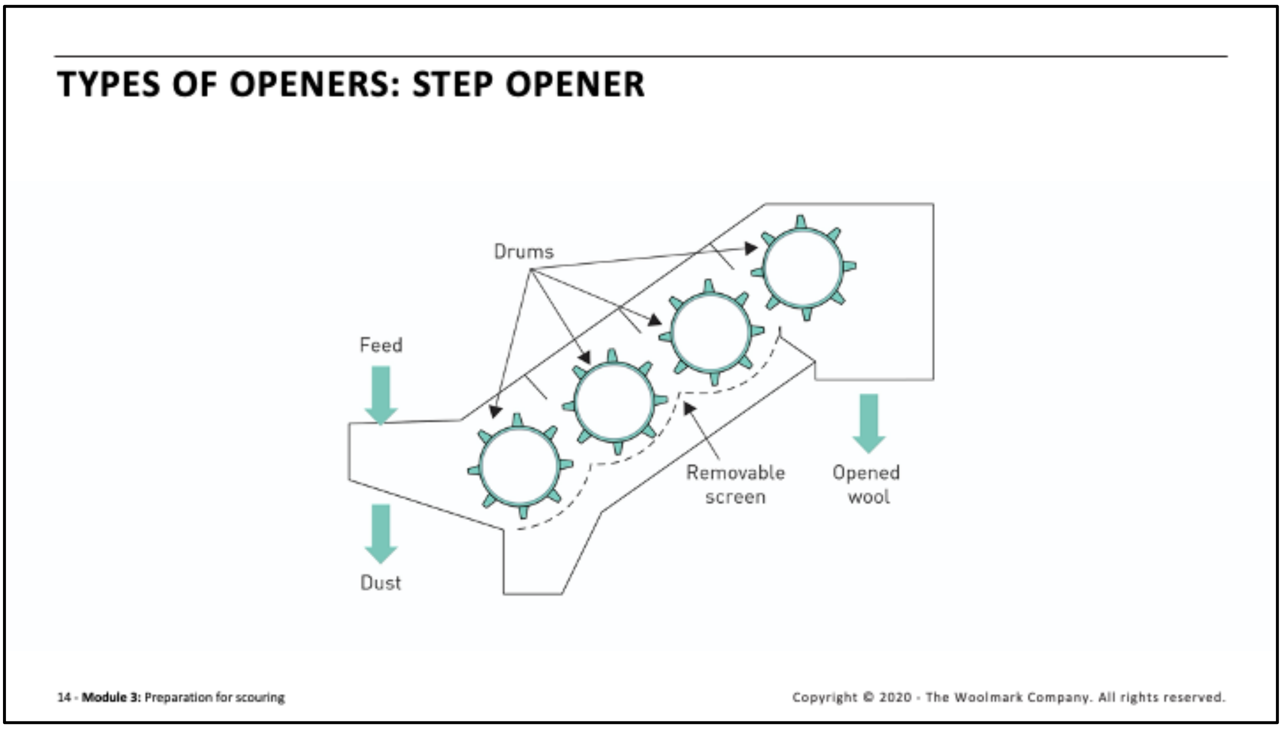
- Wool being carried up this spiked brattice is worked on by a comb beater drum that strips some of the wool from the brattice, knocking it back to the bottom.
- Wool passing through the comb beater is stripped from the spiked brattice by a doffer drum and discharged to the next operation.
- Speeds and interactions with the spiked brattice can be varied.
- Sensors mounted in the hopper can control the amount of wool in the hopper.



REFER TO the image on the slide as you explain the action of the drum opener.

Drum opener
A drum opener consists of a series of 'drums' fitted with triangular steel teeth.

- Raw wool is fed to an in-feed conveyor and conveyed to the drums.
- As wool is fed to the drums, it is held so the first drum pulls the wool into the machine, thereby performing an opening action.
- The wool is further opened by the interactions between the teeth of the drum and the perforated screens placed beneath the drums. Loose dirt and fibre pass through the screens.
- The speeds of the conveyors and drums, as well as the number of drums, determine the extent of opening.

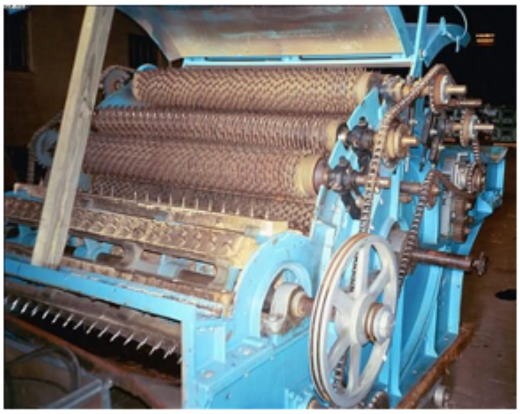


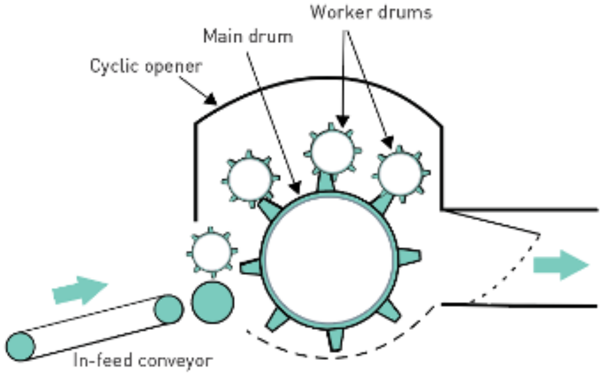
REFER TO the image on the slide as you explain the action of the step opener.

Step opener
The wool is fed into the machine at the bottom of the opener where it is picked up by the lowest spiked drum and beaten against a removable screen before being picked up by the next spiked drum.

- This process continues until the wool is discharged from the top of the opener.
- It is normal practice to increase the speed of the drums as the wool moves up the opener.
- It is not usually used for opening Australian wools as the action is too vigorous for Merino-type wools.
- It is often used for dusting scoured wool.

TYPES OF OPENERS: CYCLIC OPENER AND HAMMER MILL





http://www.wotol.com/1-fearnaught-opener/second-hand-machinery/prod_id/283112

15 - **Module 3:** Preparation for scouring

REFER TO the image on the slide as you explain the action of the cyclic opener.

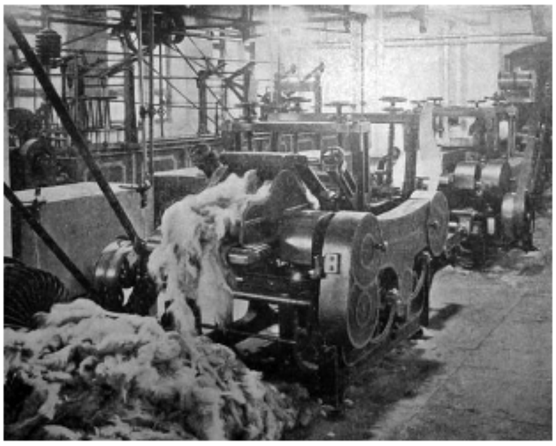
Cyclic opener
In a cyclic opener the wool is placed on the in-feed conveyor and fed intermittently into the cyclic opener.

- This opens the wool by working the triangular teeth of the main drum against the triangular teeth of a number of smaller worker drums.
- The wool is kept within the opener and the cycle repeats automatically.
- The degree of opening is controlled through the time the wool is kept in the opener.

Hammer mill (not shown)
Heavily-contaminated wool with a fibre length less than 100 mm is placed on the conveyor and fed into the opener where a hammer mill crushes the dirt, seed and dags so they can pass through a grate.

- This sort of opener is often used for preparing wools in carbonising mills.
- This process continues for a pre-determined time, after which it is discharged and the cycle is automatically repeated.
- The most aggressive hammer mill opener, the Fearnought, has a carding action that should not be used with wools destined for the worsted spinning system.

POOR OPENING



https://www.bradfordcollege.ac.uk/galleries/lister-building-centenary-looking-back-1911

Under opening can lead to:
- inadequate contaminant removal
- poor wetting-out of the wool
- poor penetration of the wool mat
- attenuation of the liquor flows past fibre surfaces
- uneven feed rate to the scouring line.

Over opening can cause entanglement of the wool during scouring, leading to increased fibre breakage in top-making.

16 - **Module 3:** Preparation for scouring

EXPLAIN THAT poor opening can have a number of unfortunate consequences, both in scouring and in subsequent processing.

NOTE: Under opening — can lead to inadequate contaminant removal due to poor wetting-out of the wool, poor penetration of the wool mat, attenuation of liquor flows past fibre surfaces, and an uneven feed rate to the scouring line.

NOTE: Over opening — can cause entanglement of the wool during scouring, leading to increased fibre breakage during top-making.

CHOOSING AN OPENER

TYPE OF OPENER	COMBING WOOL	CARDING WOOL	CARBONISING WOOL
Bale breaker	✓	✓	✓
Brattice opener	✓	✓	✓
Drum opener	✓	✓	✓
Step opener		✓	
Cyclic opener		✓	✓
Short wool processor		✓	✓
Dag crusher		✓	✓
Decotter		✓	

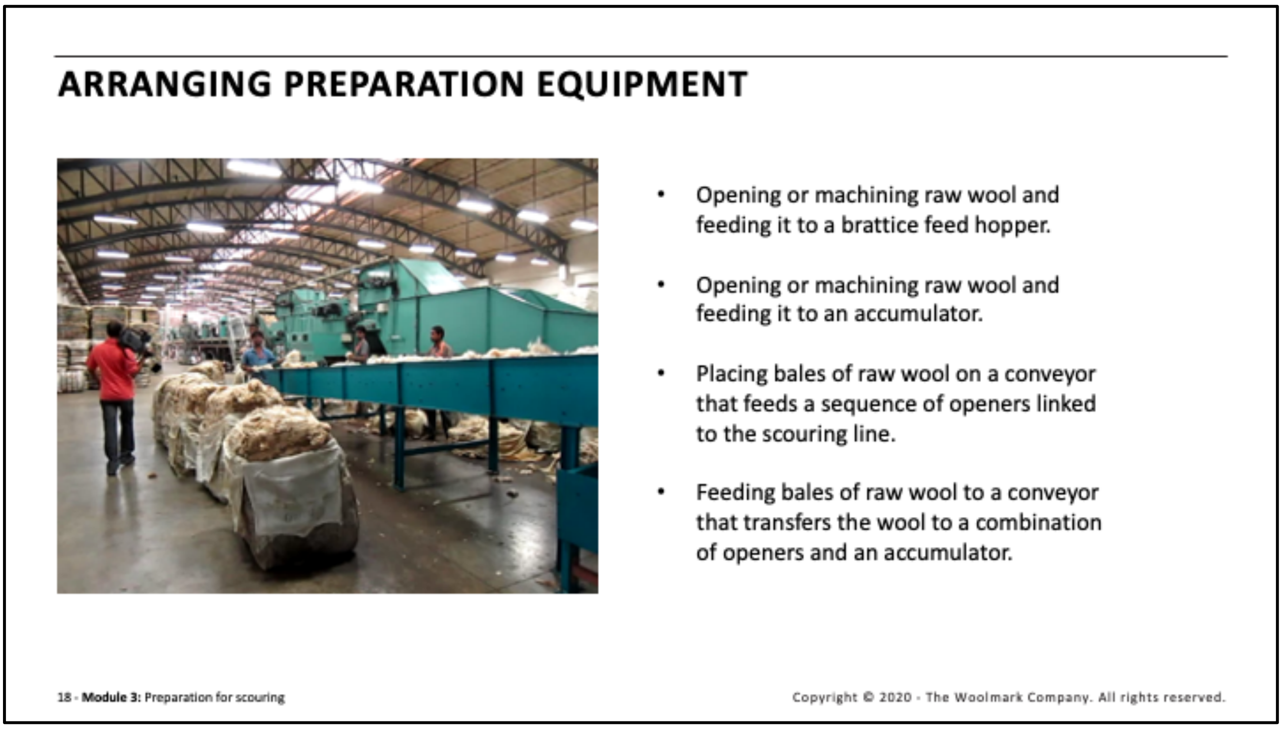
17 - **Module 3:** Preparation for scouring

EXPLAIN THAT the choice of an opener, and whether to machine some or all of the components of a blend, depends on the characteristics of the wool being processed (as outlined on the slide).

- Generally, combing wools do not need extensive opening and carding and carbonising wools are more likely to need some machining.
- Factors that limit the choices of openers include cost and available space.

MENTION THAT other variants on these machines, designed for wools to be processed on the woollen system include:

- short wool processors
- dag crushers
- decotters (for heavily-felted or entangled raw wool).



EXPLAIN THAT many arrangements are used to prepare the wool and feed it to the scouring line, and they all aim to open, blend and provide an even feed of prepared wool to the scour.

POINT OUT that some options are:

- opening or machining raw wool and feeding it to a brattice feed hopper, which is linked directly to the scouring line
- opening or machining raw wool and feeding it to an accumulator (designed to hold wool and even out the feed rate), from which the wool is conveyed to a sequence of openers linked to the scouring line
- placing bales of raw wool on a conveyor that feeds a sequence of openers linked to the scouring line
- feeding bales of raw wool to a conveyor that transfers the wool to a combination of openers and an accumulator.

EXPLAIN THAT blending can be done both before and after scouring.

- The greasy wools that constitute a blend are mixed in the proportions of the blend before the wool is fed to the scour.
- After scouring, the wool is often conveyed into large bins in which it is layered horizontally before being removed in vertical cuts for either baling or top-making.
- Post-scouring blending improves the homogeneous composition of the blend.

NOTE THAT the use of accumulators is one of the best ways of blending the wool.

NOTE TO FACILITATOR: *Before moving to the next slide, ask participants why it is important to get the right degree of opening during the bale opening process..*

COLLECT *responses from two to three participants across the room before proceeding to the next slide.*

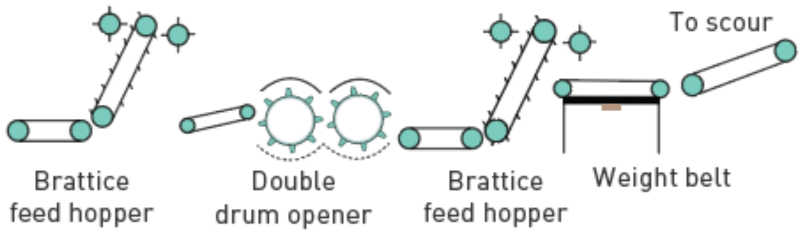
BEST-PRACTICE ISSUES

It is important to get the right degree of opening:

- Too little and the wool will not be washed sufficiently.
- Too much and the wool could become entangled.

The larger the proportion of the processing lot that can be mixed together, the more even the blend.

- The performance of preparation equipment must be kept optimal through maintenance and calibration programs.

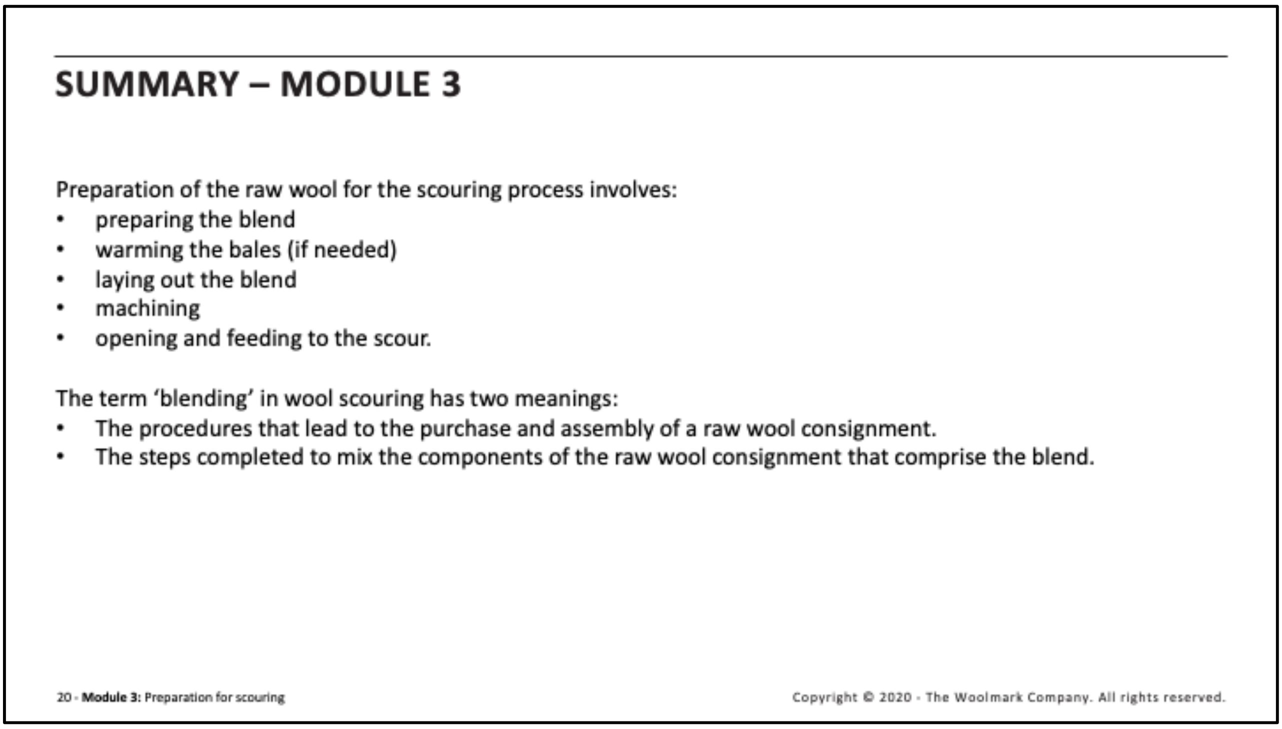


EXPLAIN THAT opening must meet the requirements of the wool to be processed:

- Too little opening — the wool will not be washed sufficiently.
- Too much opening — wool could become entangled.

POINT OUT that the larger the proportion of the processing lot that can be mixed together, the more even the blend.

- This means blending bins, either on-line or off-line, should be used where possible.
- It is important to keep records of rejected bales in order to both facilitate claims against the test certificates and to monitor the source(s) of these bales.
- The performance of preparation equipment must be kept optimal through maintenance and calibration programs.

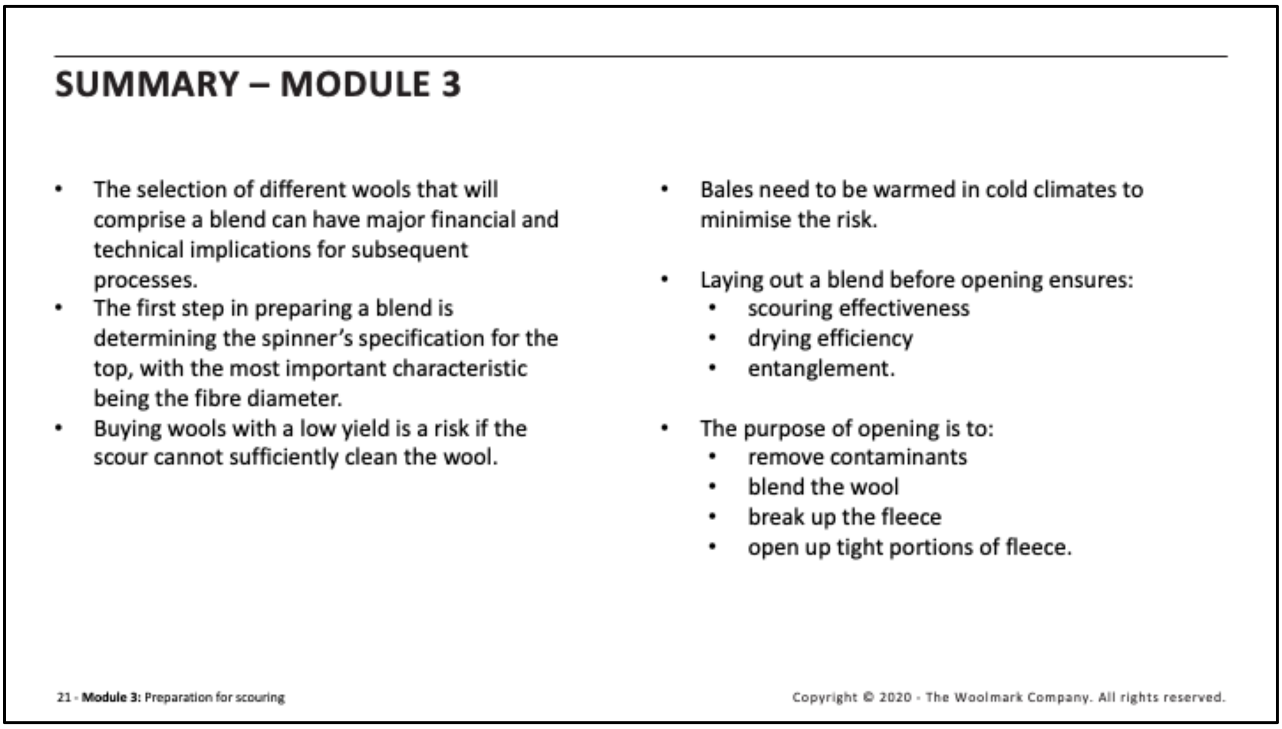


SUMMARISE the module by explaining that preparation of wool for scouring involves the following steps:

- preparing the blend
- warming the bales (if needed)
- laying out the blend
- machining
- opening and feeding to the scour.

REMIND participants that the term blending in wool scouring has two meanings. It refers to:

- the procedures that lead to the purchase and assembly of raw wool sale lots for subsequent processing (e.g. top-making)
- the physical steps completed in a mill to mix the components of the raw wool consignment that comprise the blend.



REINFORCE THAT the selection of different wools that will ultimately comprise a consignment blend can have major financial and technical implications for subsequent processes.

REMIND participants that the first step in preparing a blend is for the top-maker to determine the spinner's specification for the top. The most important characteristic is generally fibre diameter.

- While there is a variety of ways to assemble a blend of raw wool sale lots to meet the average characteristics of the spinner's specifications, buying wools with a low yield is a risk if the scour cannot sufficiently clean the wool.

REITERATE THAT before opening, bales need to be warmed in cold climates to minimise the risk of broken fibres, partly-opened fleeces and an uneven feed to the scouring line.

REMIND participants that the blend is laid out before opening to ensure:

- scouring effectiveness
- drying efficiency
- minimal entanglement.

REVIEW the purpose of opening is to:

- remove contaminants
- blend the wool
- break up the fleece
- open up tight portions of fleece.

NOTE THAT the various machines used to open wool have been described. These vary in the amount of mechanical action involved and some are too severe for Merino wools.

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 Detergency and entanglement*— 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

THE WOOLMARK COMPANY

MODULE 4

DETERGENCY AND ENTANGLEMENT

RESOURCES — MODULE 4: DETERGENCY AND ENTAGLEMENT

Contained in the *Raw wool scouring* Demonstration kit you will find the following resources for use as you deliver **Module 4: Detergency and entanglement**.

- sample of woven wool fabric

Additional resources to be sourced by the facilitator include:

- eyedropper
- bottle of water
- bottle of water with surfactant
- vegetable oil

WELCOME participants to Module 4 of the Woolmark Wool Science, Technology and Design Education Program *Raw Wool Scouring — Detergency and entanglement*

INFORM participants that this module will cover the following topics:

- the purpose of surfactants in wool processing
- basic detergency
- types of surfactants
- detergency and wool scouring
- removing contaminants from raw wool
- the concept of entanglement during scouring
- causes of entanglement during scouring
- impact of entanglement during scouring on further processing of the wool
- methods to reduce entanglement during scouring.

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

- explain basic detergency processes
- explain how detergency is applied to wool scouring
- describe the different stages of wool contaminant removal during scouring
- explain the concept of entanglement
- describe how scouring can cause entanglement
- explain the balance between low entanglement and wool cleanliness
- describe the working points during scouring at which entanglement can occur
- describe the methods used to minimise entanglement during scouring.

***ASK** participants how they think contaminants are removed from wool.*

***COLLECT** responses from two to three participants across the room before proceeding.*

RESOURCES REQUIRED FOR THIS MODULE

- *eyedropper (facilitator to provide)*
- *bottle of water (facilitator to provide)*
- *bottle of water with surfactant (facilitator to provide)*
- *sample of woven wool fabric*
- *vegetable oil (facilitator to provide)*

PURPOSE OF SURFACTANTS IN WOOL PROCESSING

Surfactants are used to:

- remove contaminants from raw wool
- wet-out the surface of wool fibres
- emulsify wool wax
- transfer soil into the scouring solution
- prevent re-deposition of contaminants onto scoured wool.

2 - **Module 4:** Detergency and entanglement

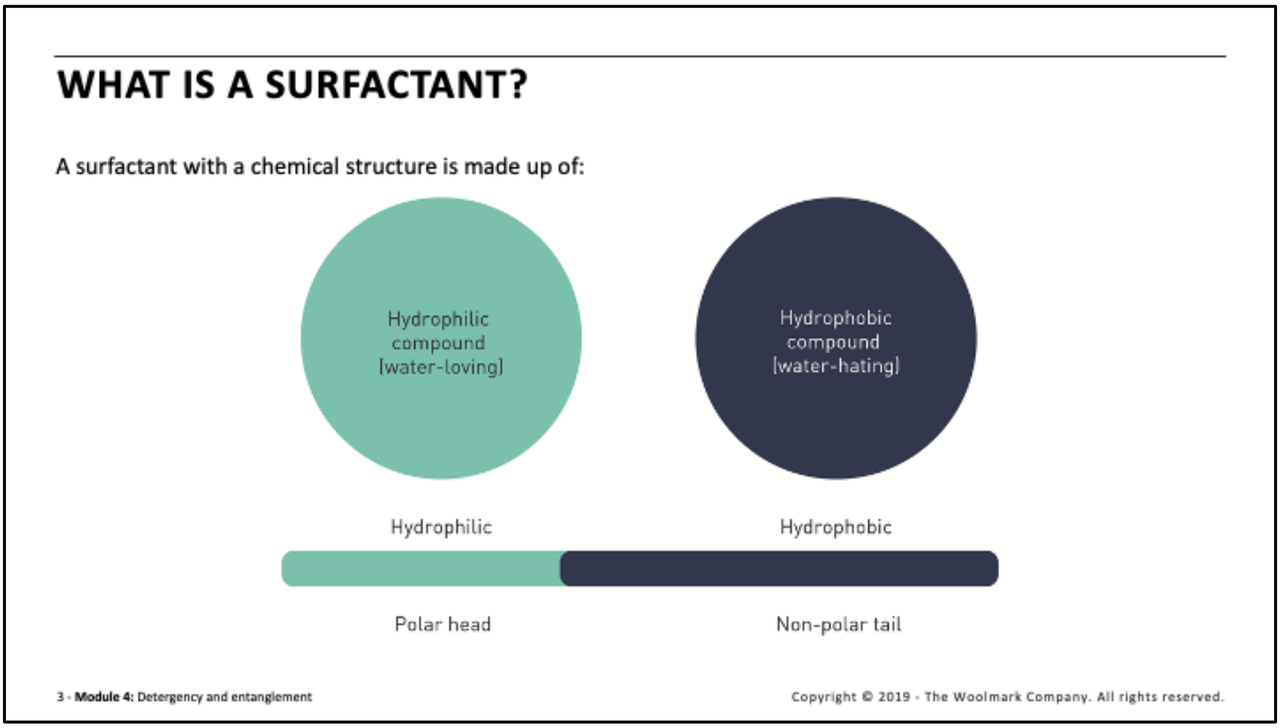
ASK *participants to describe the concept of a surfactant.*

ALLOW *participants two to three minutes thinking time before taking responses and proceeding with the lecture.*

EXPLAIN THAT surfactants are used to remove contaminants from wool and are essential in:

- wetting out the surface of the wool fibres
- emulsifying wool wax
- transferring soil into the scouring solution/liquor
- preventing coalescence and re-deposition of contaminants onto scoured wool.

INDICATE THAT this module will look at the surfactants used in raw wool scouring in detail, and will start by exploring basic detergency.



REITERATE THAT a surfactant is a product used to remove dirt and clean items, for example:

- dishwashing surfactant
- washing surfactant.

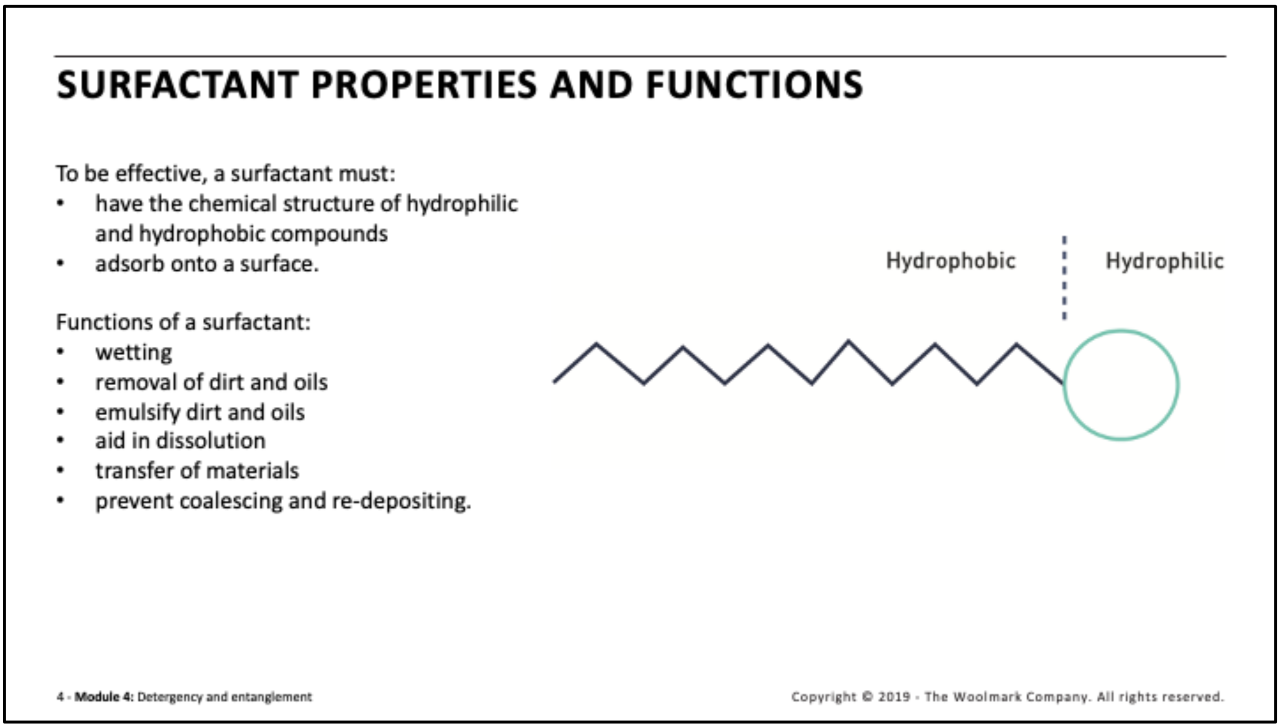
REFER TO the slide and you provide the following definition of a surfactant:

'A surfactant is a colourless water soluble compound with a specific chemical structure made up of:

- *a hydrophilic (or water-loving) compound (or polar 'head')*
- *a hydrophobic (water-hating) compound (or non-polar 'tail').'*

INFORM participants that ethanol is an example of a 'hydrophilic', water-loving compound.

EXPLAIN THAT olive oil is an example of a 'hydrophobic', water-hating compound.



EXPLAIN THAT to be effective, a surfactant must:

- have the chemical structure of hydrophilic and hydrophobic compounds
- adsorb onto a surface.

EXPLAIN THAT depending on the balance of the hydrophobic and hydrophilic parts, surfactants may be used for a variety of purposes:

- to assist the wetting of hydrophobic surfaces, such as the surface of the wool fibre. This type of surfactant is often called a wetting agent
- to assist in removing dirt and oils when materials are cleaned in water (e.g. dirty dishes). This type of surfactant is often called a detergent
- to emulsify oils and dirt particles so they remain trapped in water and do not re-deposit in the material from which they were removed. This type of surfactant is called an emulsifying agent.
- to aid in the dissolution of materials
- to allow transfer of materials on the surface to be cleaned into the water
- to prevent the oils droplets or dirt particles from coalescing and re-depositing on the material.

INDICATE THAT the balance of the hydrophobic and hydrophilic parts of the molecule determine the strength of these roles for a particular surfactant.

EXPLAIN TO participants that 'wetting' is the procedure whereby water coats the material to be wet out. For wool this occurs when the water evenly penetrates the fibre mass.

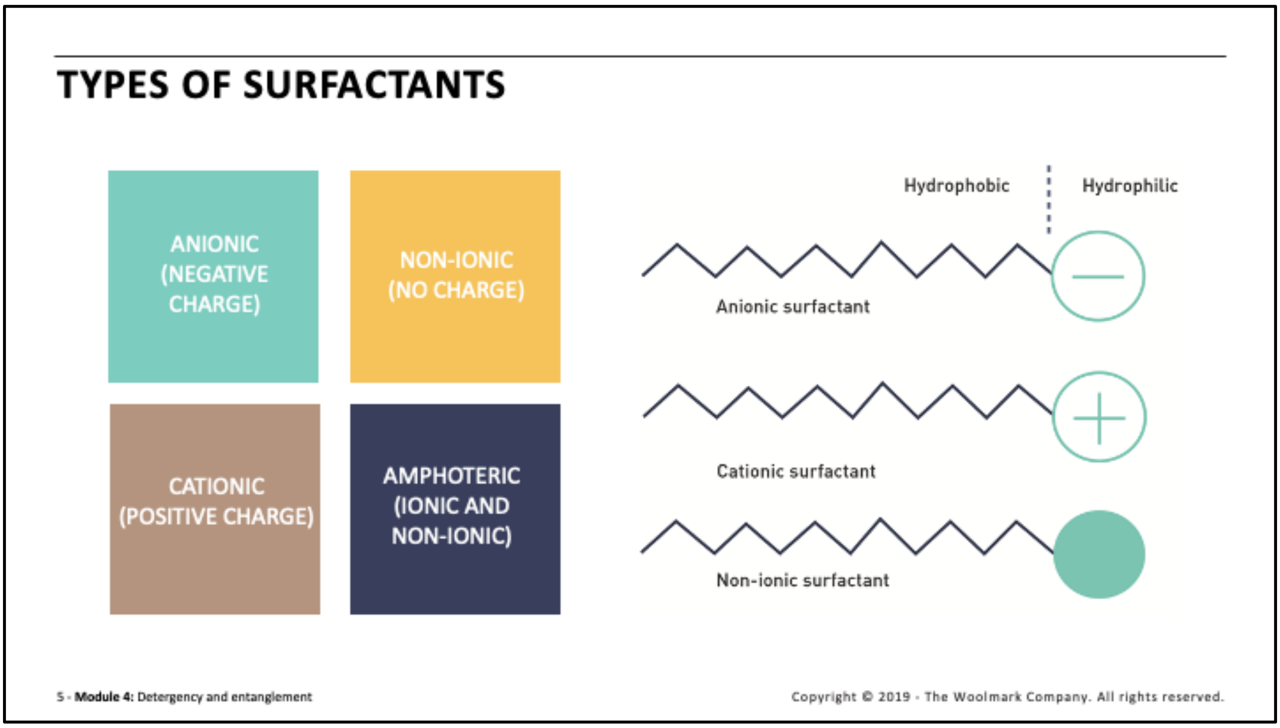
'Detergency' is any procedure that removes soil from the surface of a solid using a liquid.

'Emulsification' is the procedure of trapping oil droplets within a envelope of surfactant so they do not re-aggregate (coalesce) in water.

NOTE: An emulsion is a suspension of small globules of one liquid within a second liquid with which the first will not mix.

EXPLAIN THAT in raw wool scouring, the surfactant used often has to perform each of these roles. However, the major role is as a detergent. For this reason the term 'detergent' is often used to describe the surfactant used in raw wool scouring.

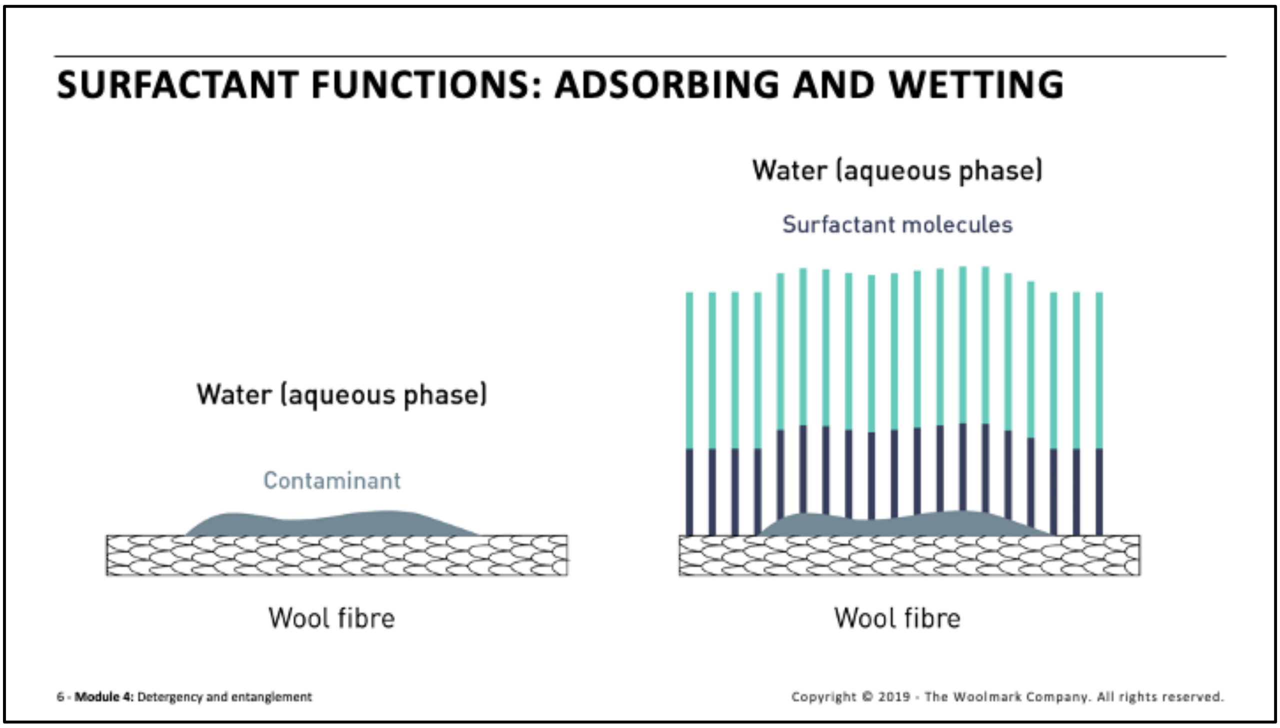
INDICATE THAT suitable surfactant mixtures can be used to ensure the 'detergent formulation' can perform all roles required.



EXPLAIN THAT depending on their electrical charge in water, surfactants are classified as:

- anionic (negative charge)
- non-ionic (no charge)
- cationic (positive charge)
- amphoteric (both ionic, positive and/or negative, and non-ionic functions).

POINT OUT that only anionic and non-ionic surfactants have been used in wool scouring. Modern wool scours mainly use non-ionic surfactants.



Adsorbing
In water, there may be a surface or interface present (e.g. between oil and water, water and air, or dirt and fibre).

EXPLAIN THAT when there is a surface or interface present in water, surfactant molecules preferentially orientate at the surface. This is due to the differing polarities of the head and the tail. This is called 'surface activity' and the surfactant is adsorbed at the interface.

INDICATE THAT adsorption can occur at any interface, and is necessary for wetting out, emulsion formation and soil removal.

EXPLAIN THAT surface or interfacial tension is lowered by the adsorption of surfactant molecules. When interfacial tension is lowered, surfaces become easier to wet. Surfaces must be wet for detergency to occur.

Wetting
Wetting is a liquid's ability to maintain with a solid surface, resulting from intermolecular interactions when the liquid and solid are brought together.

EXPLAIN THAT the degree of wetting (or wettability) is determined by the balance between adhesive and cohesive forces:

- Adhesive forces between a liquid and solid cause a liquid drop to spread across the surface.
- Cohesive forces within the liquid cause the drop to ball up and avoid contact with the surface.

REFER participants to the image on the slide showing when a raw wool fibre is placed in water, cohesive forces dominate, and there is little wetting-out. When sufficient surfactant is added to the water, the adhesive forces dominate and the fibre is wetted-out as illustrated in the right-hand figure on the slide.

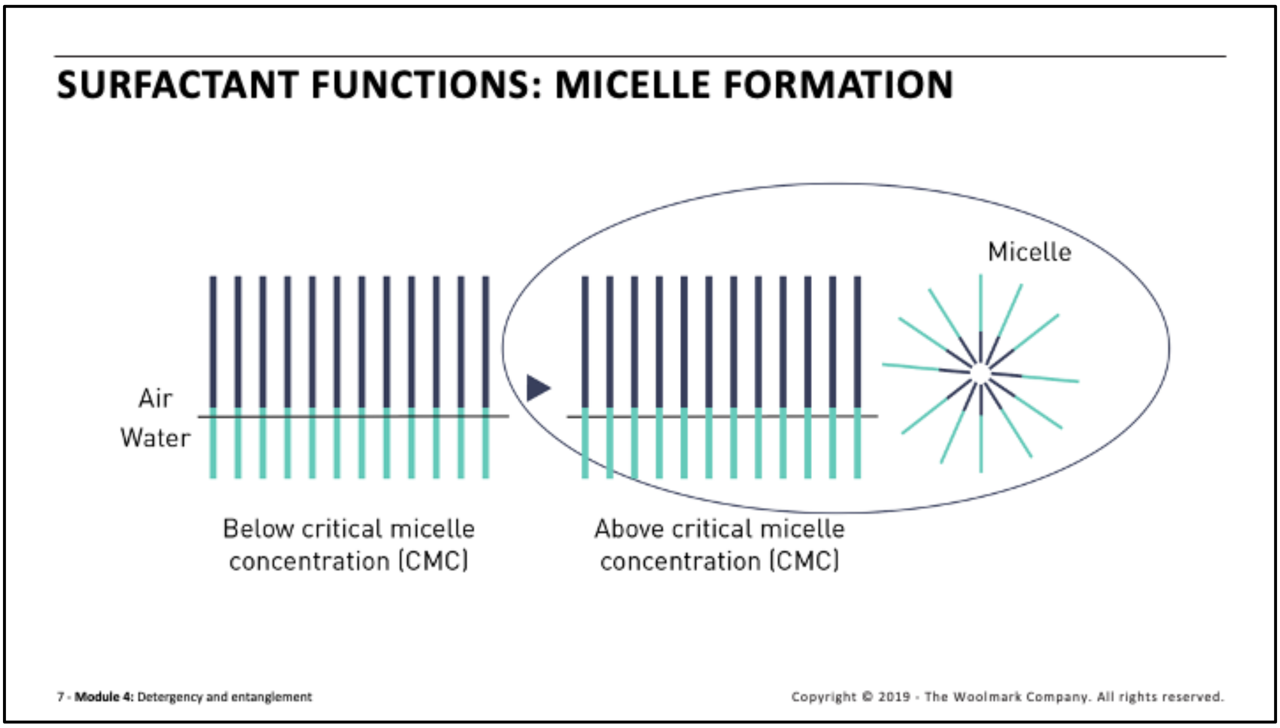
Raw wool floating through a de-suint bowl is an example of poor wetting out.

INFORM participants that a surfactant with excellent wetting properties will not necessarily be an effective wool-scouring agent.

DEMONSTRATION: WETTING

USING *an eye dropper, release droplets of water onto the woven wool fabric and ask participants to observe the fabric does not wet out.*

REPEAT *using a detergent and water solution. Note the fabric wets out.*



EXPLAIN THAT when a surfactant is added to water, the surfactant molecules tend to build up in the air–water interface. When a critical concentration of the surfactant in the solution is reached (CMC), the surface is crammed with surfactant molecules and the surfactant spontaneously forms 'micelles' (aggregates of surfactant molecules dispersed in a liquid colloid).

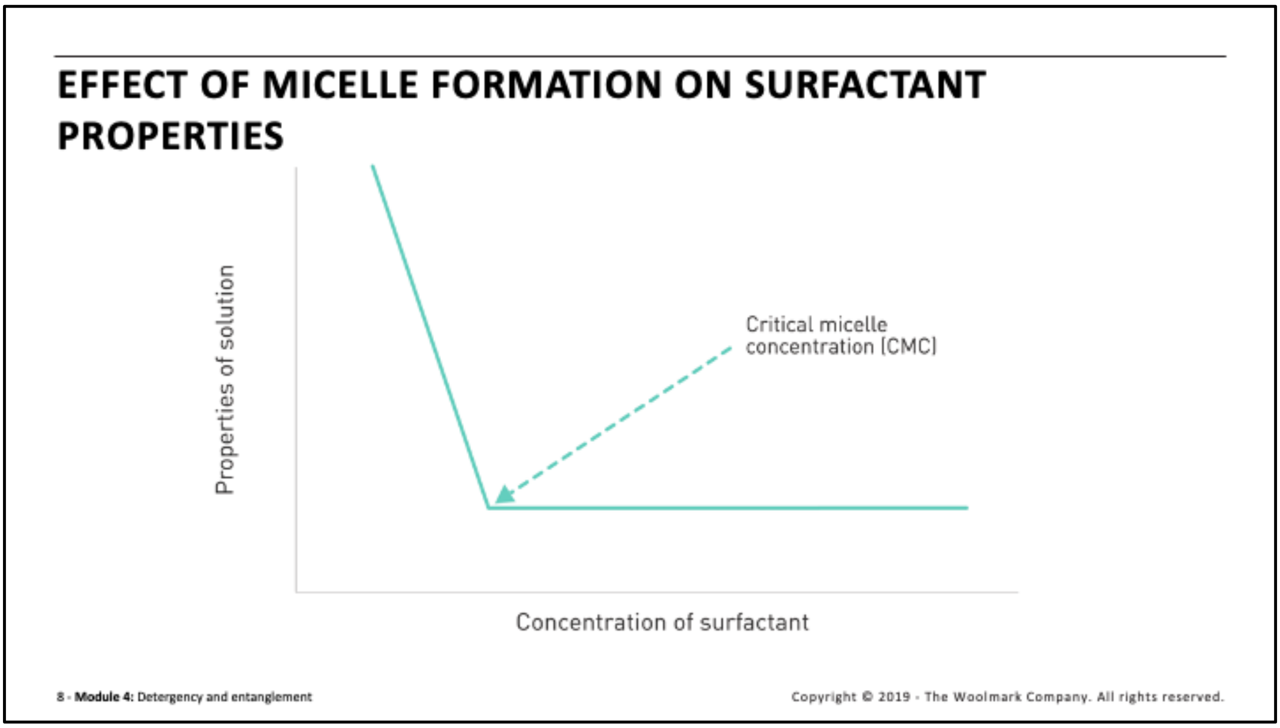
INDICATE THAT in the micelles, the non-polar tails of the molecules (shown in blue) aggregate with the polar heads (shown in green) extending into the water.

EXPLAIN THAT micelle formation is critical for detergency to be effective. The oil and dirt must be emulsified to prevent re-deposition and this is not possible without the formation of micelles. Unless the surfactant emulsifies the oil and dirt the detergency action of the surfactant is less effective.

ASK *participants for suggestions on what influences the hydrophilic–hydrophobic balance.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that the balance depends on the strength of the hydrophobic section compared to that of the hydrophilic section in the surfactant (e.g. the less water soluble the surfactant, the lower the critical micelle concentration and vice versa).*

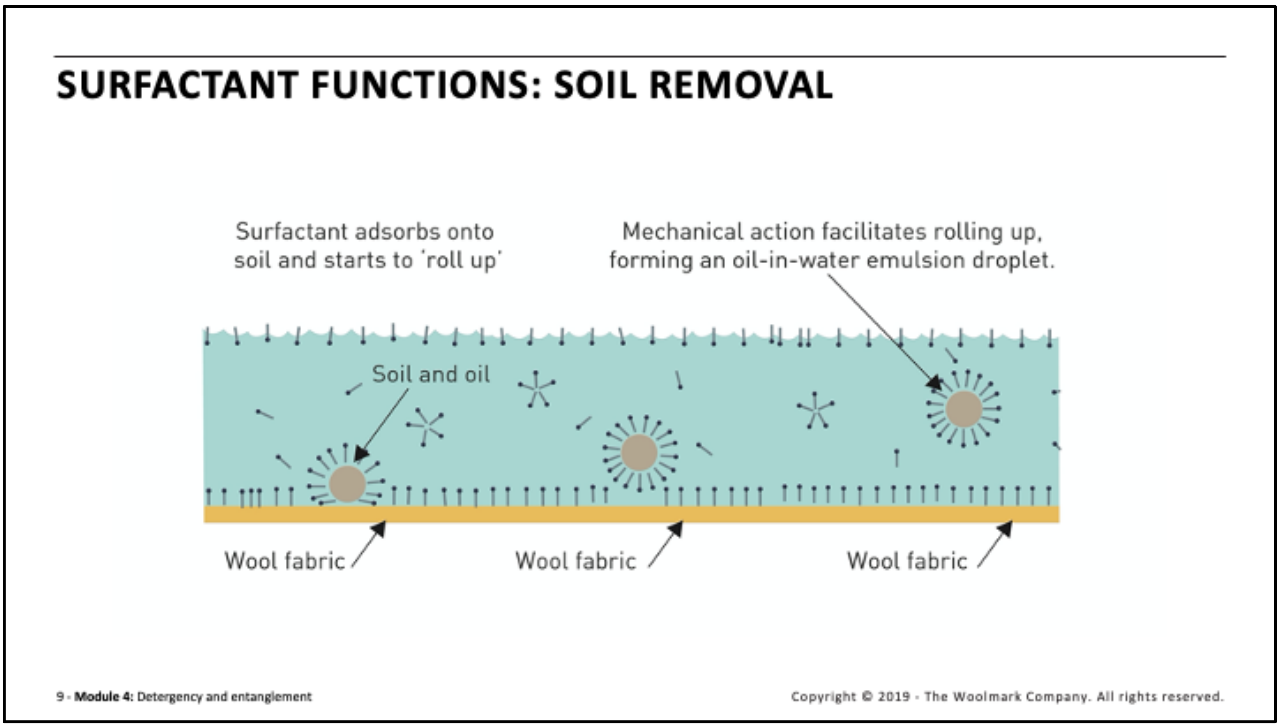


REFER TO the graph on the slide as you explain that as surfactant is added to the solution the properties of the solution change (e.g. surface tension, wetting characteristic).

As previously discussed, the concentration at which surfactants start to aggregate to form micelles is called the 'critical micelle concentration' (CMC).

- At CMC, any further addition of the surfactant causes more micelles to form, but the rate of additional changes to the solution properties slows dramatically as shown on the slide.
- Micelles have different structures depending on the environment and nature of the surfactant molecules. Spherical micelles are most common in textile detergency.
- Micelles do not readily form below the CMC.

POINT OUT that enough surfactant must be used to ensure the concentration exceeds the CMC, or the surfactant will be wasted.



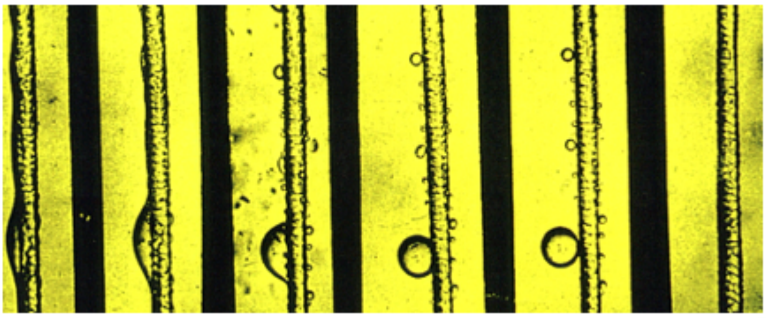
EXPLAIN THAT after the surfaces of the wool and the contaminants are wetted out there are numerous ways to remove the soil, including:

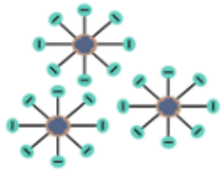
- rolling up oily soil by changing the contact angle
- emulsion formation via a rolling-up mechanism
- emulsion formation through emulsification of the soil
- incorporation of a particulate soil in a micelle
- release of particulate soils after wetting of substrates.

EXPLAIN THAT rolling up is the most common way to remove oily soil:

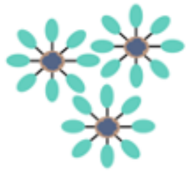
- In a number of rapid stages, the surfactant helps 'unzip' the oily soil to form an emulsion.
- Use of an appropriate surfactant allows adsorption onto the surfaces of the fibre and the oily soil.
- Because the oil wants to form a structure with the lowest surface area, it starts to roll up into a spherical globule, surrounded by surfactant.
- Mechanical action, such as agitation, helps release the globule from the surface of the fibre, forming an oil-in-water emulsion droplet.
- These droplets are relatively unstable and can coalesce into a separate oily phase.

SURFACTANT FUNCTIONS: EMULSION FORMATION





Stabilisation by mutual replusion



Steric stabilisation

10 - **Module 4:** Detergency and entanglement

REITERATE THAT an emulsion is a suspension of small globules of one liquid within a second liquid with which the first will not mix.

- Emulsions are formed from the component liquids either spontaneously or, more often, by mechanical means such as agitation.
- An emulsion is essentially unstable and will eventually separate into two liquid layers.
- An emulsion's stability can be improved through electrical repulsion, physical hindrance and particle size – this is because a surfactant adsorbs at the interface between the two phases.
- Emulsions formed by anionic or cationic surfactants are surrounded by molecules with the same electrical charge. The individual emulsion droplets repel each other, reducing the tendency to separate (coalesce).

EXPLAIN THAT in non-ionic surfactants, emulsions are more likely to be stabilised by a steric hindrance from the long water-solubilising groups, with some electrical repulsion as well.

- Emulsions with a smaller particle size are likely to be more stable (e.g. a high level of agitation can reduce the particle size of the emulsion and increase the amount of wool wax recovered during scouring).

There are two main types of emulsions:

- oil-in-water emulsions, which are oil globules suspended in water
- water-in-oil emulsions, which are water droplets suspended in oil.

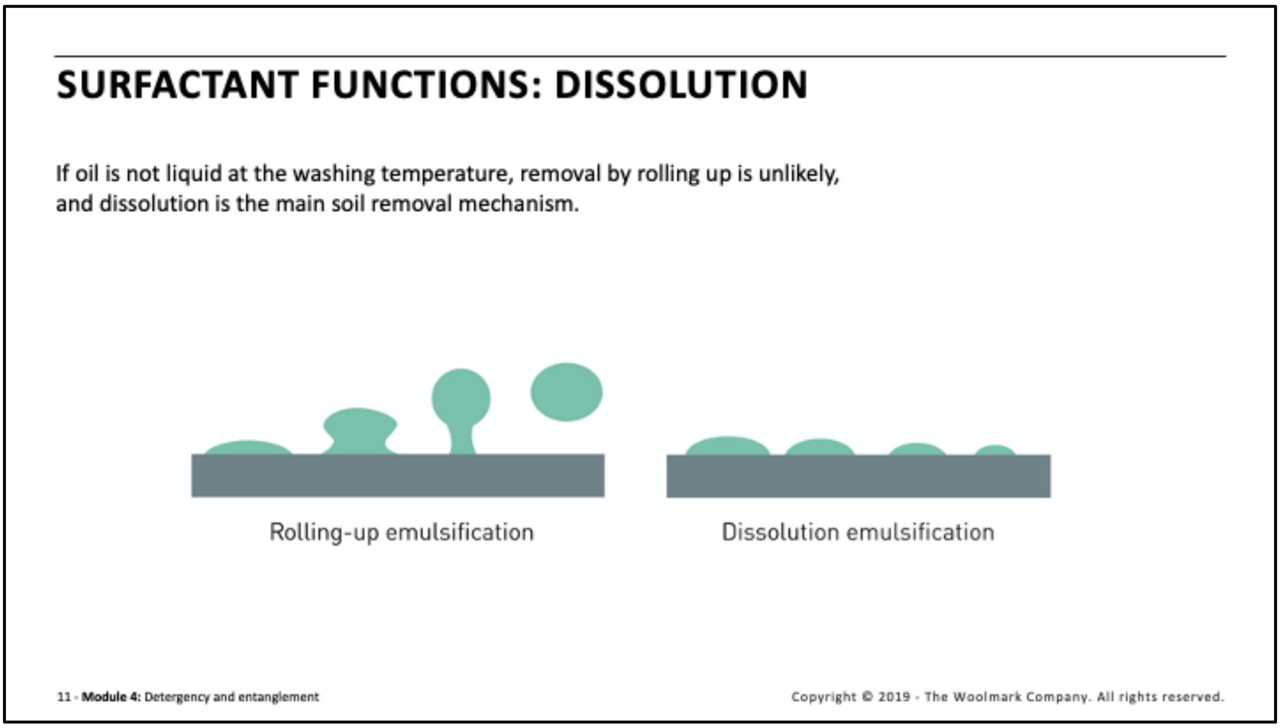
INDICATE THAT during scouring, wool wax becomes a liquid at scouring temperatures. This forms an oil-in-water emulsion. During the last stages of wool wax recovery, the recovered wool wax changes into a water-in-oil emulsion before the wool wax is recovered.

DEMONSTRATION: EMULSION FORMATION
Resources required:

- *one bottle of water (with lid)*
- *vegetable oil*
- *bottle of water and surfactant (with lid)*

***ADD** several droplets of oil to the bottle of water and shake. Allow participants to observe separation of the two components.*

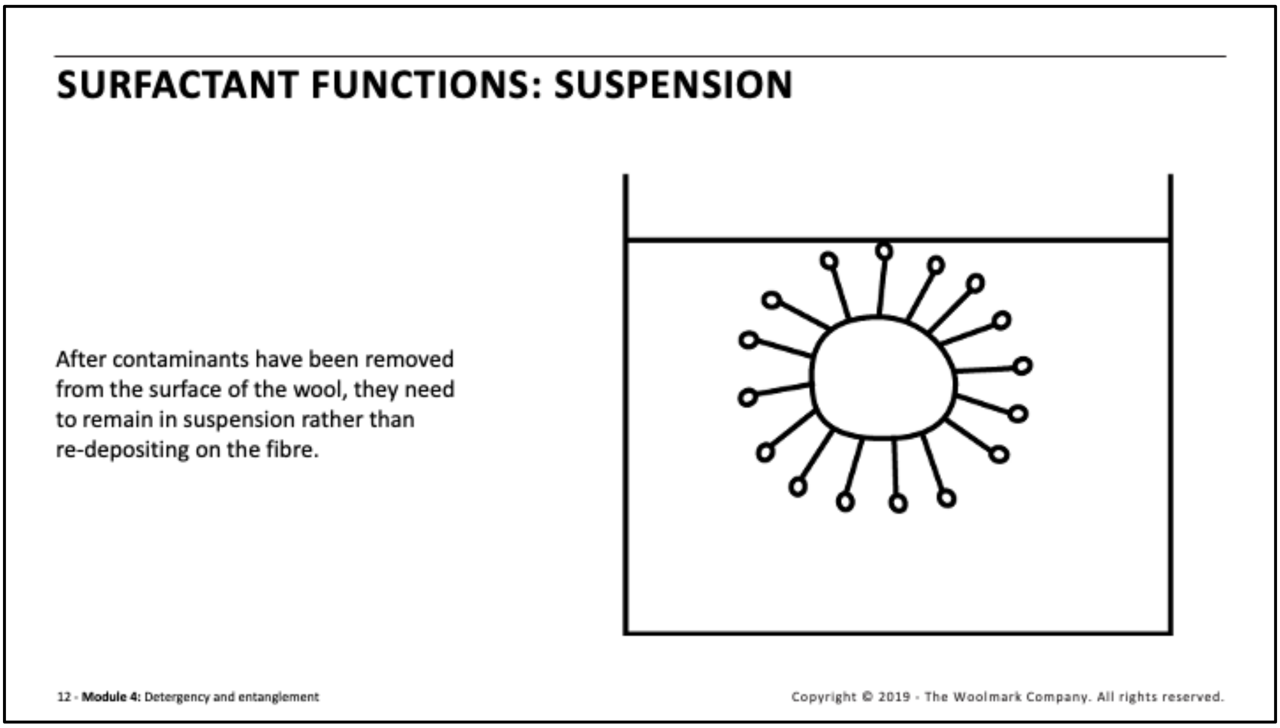
***ADD** several droplets of oil to the allow bottle of water containing the surfactant and shake. Allow participants to observe the white emulsion droplets that form and compare the results.*



EXPLAIN THAT dissolution is another mechanism for removing soil by emulsification.

INDICATE THAT dissolution occurs more gradually than rolling up, due to the characteristics of the soil, which may not be completely liquid at the washing temperature. However, the final result is the same as the rolling-up mechanism.

EXPLAIN THAT if the oil is not liquid at the washing temperature, then removal by the rolling-up mechanism is unlikely, and dissolution is the main mechanism of removal.



EXPLAIN THAT after contaminants have been removed from the surface of the wool, they need to remain in suspension rather than re-depositing on the fibre.

NOTE THAT particulate soils can either be incorporated within surfactant micelles or form suspensions after the soil has been wetted out.

Mechanical action causes the soil to move away from the fibre surfaces.

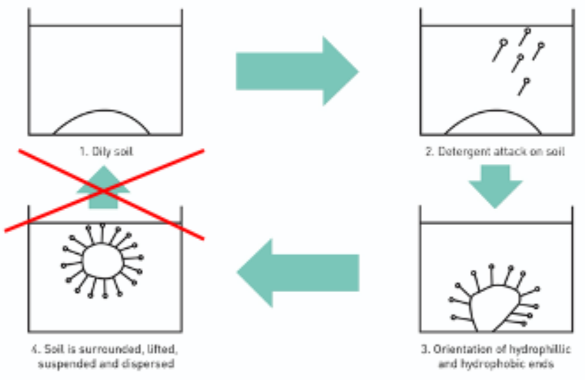
EMPHASISE THAT the size of the particulate matter determines whether it will stay in suspension or settle out quickly.

EXPLAIN THAT at room temperature, wool wax emulsion behaves more like a suspension because the core of the emulsion is no longer behaving as a liquid.

INFORM participants that the next slide will look at another function of surfactants: preventing coalescence and re-deposition.

SURFACTANT FUNCTIONS: PREVENT COALESCENCE AND RE-DEPOSITION

- Coalescence occurs when a number of emulsion droplets come together and 'coalesce' into a single drop.
- The greater size causes the drop to settle more quickly.
- If droplets coalesce, they can clump together and redeposit on the wool fibre.



13 - **Module 4:** Detergency and entanglement

EXPLAIN THAT an important function of surfactants is to prevent coalescence and re-deposition of the soil and wool wax onto the cleaned surface of the wool fibre, which occurs when insufficient surfactant has been used.

INDICATE THAT coalescence occurs when a number of emulsion droplets come together and 'coalesce' into a single drop. Because of its much greater size, this drop settles more quickly. This is not a problem in wool scouring because the surfactants used are stable to the emulsion under scouring conditions.

INFORM participants that when scouring liquors are subsequently centrifuged, coalescence occurs to enable a cream to be separated.

EXPLAIN THAT when the dirt is separated from the scouring liquor (described later) the dirt particles do not necessarily coalesce to form a single drop but they can clump together (coagulate or flocculate). These larger particles can be collected. They can also re-deposit on the wool fibre under adverse conditions — a situation to be avoided.

NOTE the stability of oil in water emulsions previously made in the demonstrations:

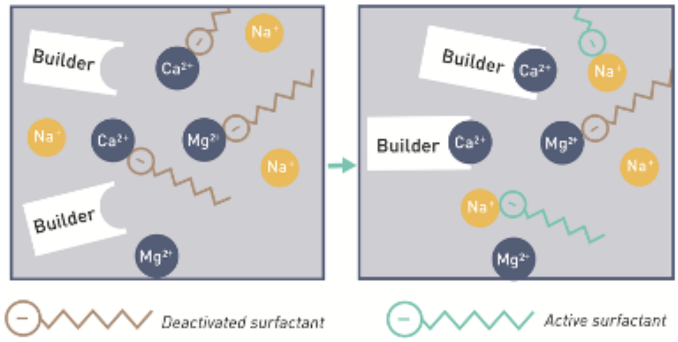
- With detergent , the emulsion is still stable
- Without detergent, the emulsion has separated into its components.

IMPROVING DETERGENCY PERFORMANCE WITH BUILDERS

Builders are chemicals that increase the cleansing action of a surfactant.

Actions:

- pH adjustment
- removing hardness
- aiding soil deflocculation
- increasing surfactant efficiency



Builders binding to calcium and magnesium ions in water

http://surfactantschemistry.blogspot.com.au/2013/07/laundry-detergents-formulation.html

14 - **Module 4:** Detergency and entanglement

POINT OUT that surfactant performance can be improved significantly by the presence of a builder.

EXPLAIN THAT a builder is a chemical that increases the cleansing action of a surfactant, even though it has no detergency action itself.

EXPLAIN THAT builders can have several actions, including:

- pH adjustment
- removal of hardness through sequestering or precipitation of the calcium (Ca^{2+}) and magnesium (Mg^{2+}) cations
- aiding soil deflocculation (flocculation is the term used to describe the formation of large particles from small particles; deflocculation is the prevention or reversal of the process)
- increasing the efficiency of the surfactant.

INDICATE THAT builders commonly used in the textile industry include:

- sodium carbonate — used to reduce hardness by precipitation and to act as a soil deflocculant
- sodium sulphate — improves the efficiency of the surfactant
- sodium hydroxide — used to moderate the pH
- ethylenediaminetetraacetic acid (EDTA) — used to reduce hardness by sequestering calcium and magnesium cations (note: chemicals such as EDTA are banned under ecolabel regulations)
- zeolites — act by capturing calcium and magnesium in the mineral structure.

CHOOSING A SURFACTANT: ENVIRONMENTAL FACTORS

Environmental constraints
- poor biodegradability
- effects of degradation products.

15 - **Module 4:** Detergency and entanglement

INFORM participants that environmental constraints affecting the choice of surfactant include:
- poor biodegradability
- the environmental effects of surfactant degradation products.

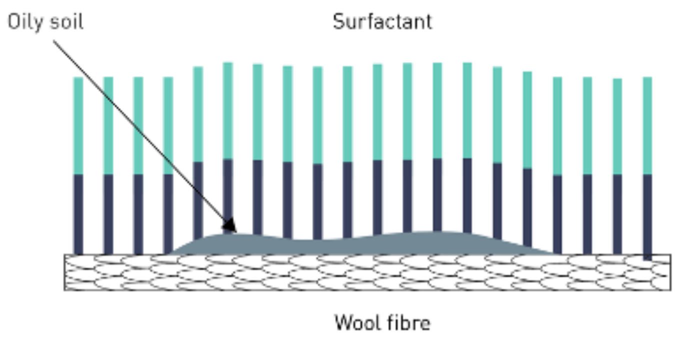
EXPLAIN THAT recently, these concerns have restricted the use of some surfactants otherwise ideal for wool scouring, such as alkylphenolpolyethoxylate non-ionic surfactants.

EXPLAIN THAT a surfactant's adsorbing properties also influence the choice of surfactant used in wool scouring — surfactants adsorb onto wool to varying degrees. Generally, anionic surfactants are adsorbed significantly more than non-ionic surfactants.

REINFORCE THAT adsorbed surfactants:
- deplete the amount of active surfactant in the scouring liquors
- can decrease subsequent processing performance, from top-making to dyeing.

CHOOSING A SURFACTANT: ADSORBING PROPERTIES

Adsorbing properties
- Surfactants adsorb onto wool in varying degrees.
- Anionic surfactants adsorb significantly more than non-ionic surfactants.



16 - **Module 4:** Detergency and entanglement

EXPLAIN THAT a surfactant's adsorbing properties influence the choice of surfactant used in wool scouring — the ideal surfactant will not adsorb onto the wool fibre.

INDICATE THAT adsorbed surfactants:
- deplete the amount of 'active surfactant' in the scouring liquors
- can decrease subsequent processing performance, from top-making to dyeing.

NOTE THAT surfactants adsorb onto wool to varying degrees — generally, anionic surfactants are adsorbed significantly more than non-ionic surfactants.

DETERGENCY AND WOOL SCOURING

In raw wool scouring, a surfactant must perform a number of particular functions:

- wetting
- emulsion formation
- micelle formation
- prevention of re-deposition.

The choice of surfactant is based on four factors:

- It must be able to perform its key functions.
- It must satisfy environmental requirements.
- It not be adsorbed or absorbed on the wool fibres to any great extent.
- It must resist 'falling over'.

17 - **Module 4:** Detergency and entanglement

EXPLAIN THAT a surfactant must perform a number of the particular functions discussed previously and satisfy several constraints during wool scouring, such as wetting, emulsion formation, micelle formation and prevention of re-deposition.

INDICATE THAT during wool scouring, the choice of surfactant is based on four factors:

- It must be able to performs it key functions.
- It must satisfy environmental requirements.
- It should not be adsorbed or absorbed on the wool fibres to any great extent.
- It must resist 'falling over'.

EXPLAIN THAT falling over occurs when the performance of a scouring line has deteriorated and additions of extra surfactant have no effect.

INDICATE THAT the only remedy for falling over is to dump the scouring bowls and recommence scouring with fresh liquors. This causes a loss in productivity and an increase in processing costs to heat the fresh liquors and use more processing chemicals.

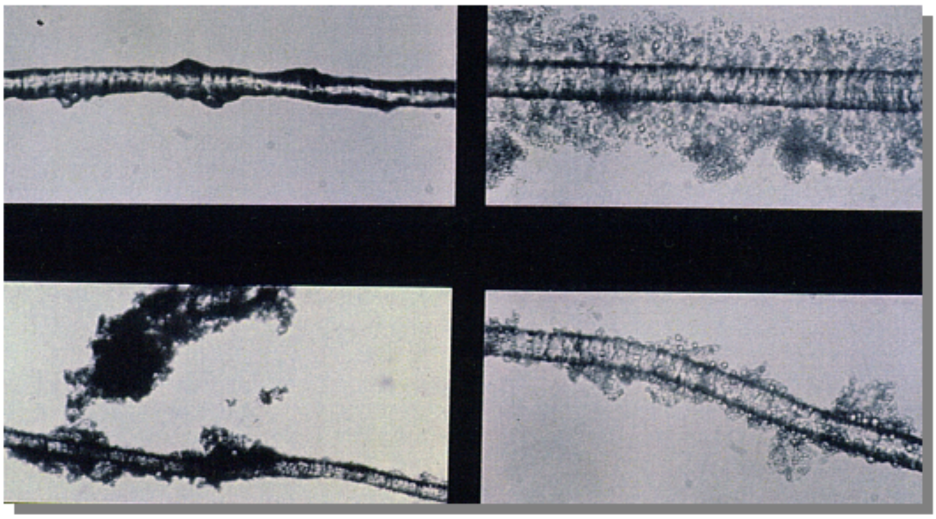
EXPLAIN THAT during the scouring process, greasy wool is passed through a series of scouring bowls, progressively removing contaminants from the wool.

INDICATE THAT the scouring process involves the following steps for contaminant removal:

1. The contaminant mass is penetrated by water and surfactant.
2. Contaminants start to swell as water penetrates the contaminant mass. The rates of penetration and swelling vary considerably for different contaminants and processing conditions.
3. Wool wax globules form within the swollen contaminant mass.
4. Easy-to-remove contaminants are removed from the surface of the wool by mechanical agitation.
5. Hard-to-remove contaminants, which may be only partially swollen or still adhering strongly to the fibre surface, are only partially removed. It takes longer before these are ready to be removed, by which time the wool is being rinsed, and there is insufficient surfactant present to facilitate their removal.

STAGES OF CONTAMINANT REMOVAL

1 3

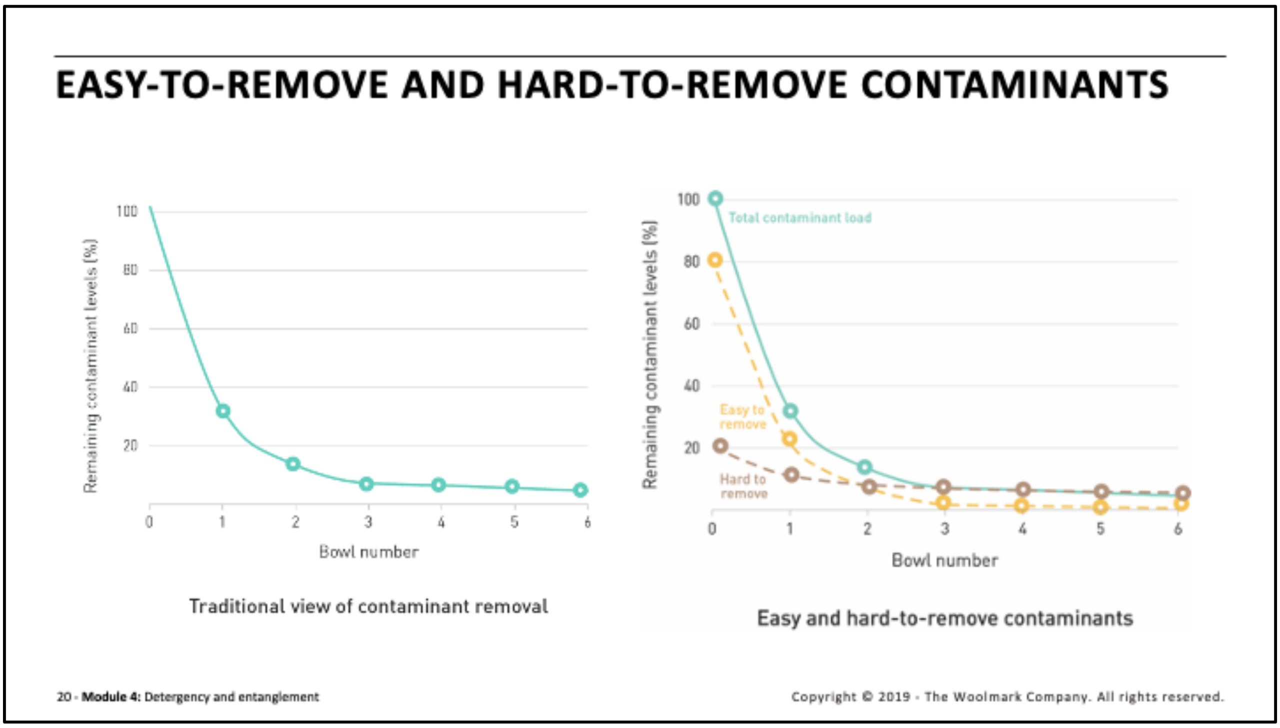


2 4

19 - **Module 4:** Detergency and entanglement

REFER participants to these micrographs showing the stages of oil and dirt removal from the fibre in scouring.

1. Uncleaned fibre.
2. Initial emulsification of contaminants.
3. Removal of contaminants.
4. Late stages of cleaning.



EXPLAIN THAT traditionally contaminants were thought to be homogenous in their behaviour, as illustrated on the left-hand graph on the slide.

INDICATE THAT studies carried out by the CSIRO show contaminants do not behave in a homogenous way and, in fact, fall into two main categories: easy to remove and hard to remove as illustrated on the right-hand graph.

Easy-to-remove contaminants:

- comprise up to 80–90% of total contaminants in raw wool
- are usually totally removed by the third scouring bowl
- contain:
    - unoxidised wool wax
    - some oxidised wool wax
    - readily-soluble components of suint
    - mineral dirt
    - loosely adhering organic dirt.

Hard-to-remove contaminants:

- comprise up to 10% of total contaminants, of which a substantial proportion remain on the wool after scouring
- contain:
    - remaining oxidised wool wax
    - less soluble components of suint
    - fine mineral dirt
    - slowly-swelling proteinaceous dirt that adheres strongly to the wool fibre.

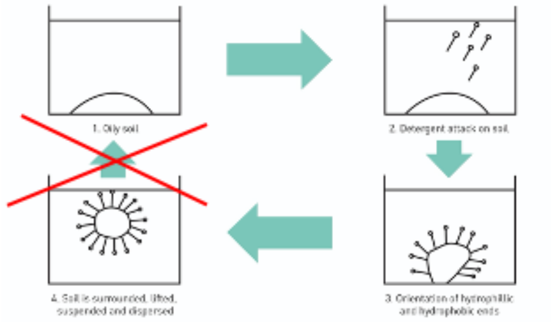
RISK OF RE-DEPOSITION DURING SCOURING

Re-deposition:

- is a major problem in wool scouring
- leads to poor colour of scoured wool.

Causes of re-deposition:

- Complex formation with metal ions originating from hard water or greasy wool contaminants.
- Gelatinous-like non-wool proteins can redeposit on clean wool if insufficient surfactant is used.



21 - **Module 4:** Detergency and entanglement

EXPLAIN THAT re-deposition is a major problem in wool scouring, leading to a poor colour of the scoured wool.

INDICATE THAT re-deposition can be caused by complex formation with metal ions, which originate either from hard water or greasy wool contaminants.

EXPLAIN THAT additionally, gelatinous-like non-wool proteins can re-deposit on clean fibre surfaces if there is insufficient surfactant present. If insufficient water is used or the pattern of water used is incorrect, it may encourage re-deposition.

WHAT IS ENTANGLEMENT?

- When mechanical action is added to a bundle of wet wool fibres, the fibres become entangled with each other.
- If mechanical action continues, the fibre mass starts to felt; an irreversible process.
- Understanding the causes of fibre entanglement can help minimise it during scouring.
- Scouring involves reaching a balance between cleaning the wool and minimising entanglement.

22 - **Module 4:** Detergency and entanglement

EXPLAIN THAT wool fibres have a surface structure of overlapping scales called cuticle cells. The edges of the scales point towards the tip of the fibre. This enables the fibres to slip over one another easily in one direction but not the other.

INDICATE THAT when wool fibres are agitated in water during the scouring process, they can slip over one another and the scales inhibit movement in the opposite direction, entangling the fibres.

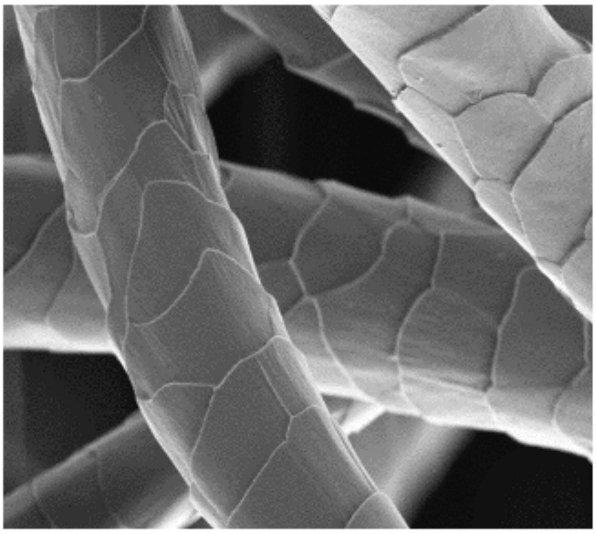
EXPLAIN THAT the more mechanical action that is applied to the wet fibres, the greater the entanglement. This entanglement is the early stages of 'felting': an irreversible process discussed in detail in the Wool Science, Technology and Design Education Program course *Wool fibre science*.

POINT OUT that understanding the causes of fibre entanglement can help to minimise it during the scouring process. Minimising entanglement during scouring reduces losses due to fibre breakage during subsequent processes.

REMIND participants that the purpose of wool scouring is to remove contaminants from the raw wool. Contaminant removal requires some mechanical action and this increases the potential of fibre entanglement.

REINFORCE THAT scouring involves reaching a balance between wool cleanliness and minimising entanglement.

ENTANGLEMENT AND FELTING



Entanglement: the early stages of felting shrinkage.

Felting is:
- the progressive entanglement of fibres that occurs as a result of agitation by undirected forces
- is most prevalent when the wool is sloppy with water but not totally immersed.

Agitation is necessary to achieve movement of the fibres past each other — despite this being a relatively gentle process in scouring, it is still sufficient to cause a degree of entanglement and felting shrinkage.

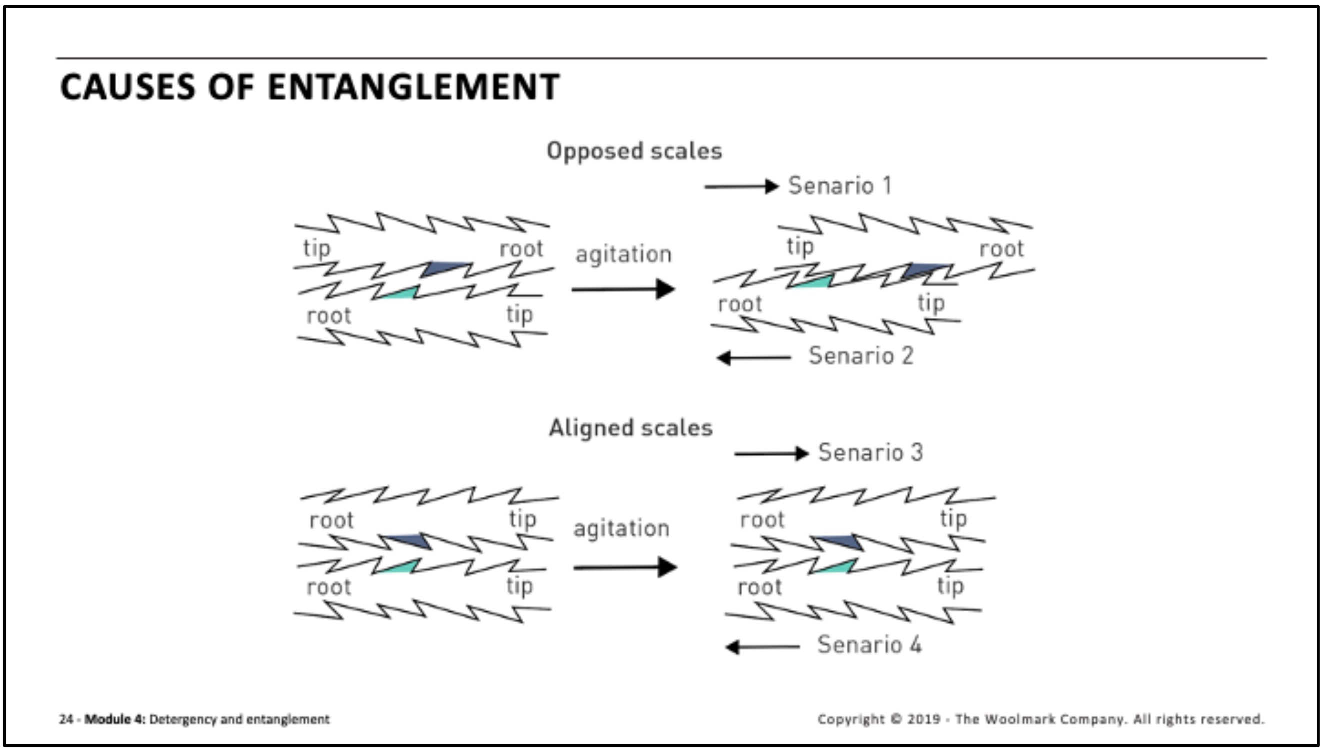
23 - **Module 4:** Detergency and entanglement

POINT OUT that entanglement describes the very early stages of felting shrinkage.

EXPLAIN THAT felting is the process of progressive entanglement of fibres that occurs as a result of agitation by undirected forces, such as mechanical agitation.

INDICATE THAT felting is most prevalent when the material is sloppy with water, but not totally immersed:
- Water acts as a lubricant by allowing the fibres to move past each other.
- Wool also adsorbs water, which tends to raise the scales of the fibre and thus the propensity for felting. Adsorption of water also increases the flexibility of the fibre.

EXPLAIN THAT although the level of mechanical agitation is relatively gentle during scouring, it is sufficient to cause a degree of entanglement and, in the worse case, felting.



POINT OUT that the alignment of adjacent fibres, in terms of the direction of the scales, is relevant when discussing the causes of entanglement.

EXPLAIN THAT friction between the fibres varies according to the fibre alignment. There are four possible scenarios as outlined on the slide:

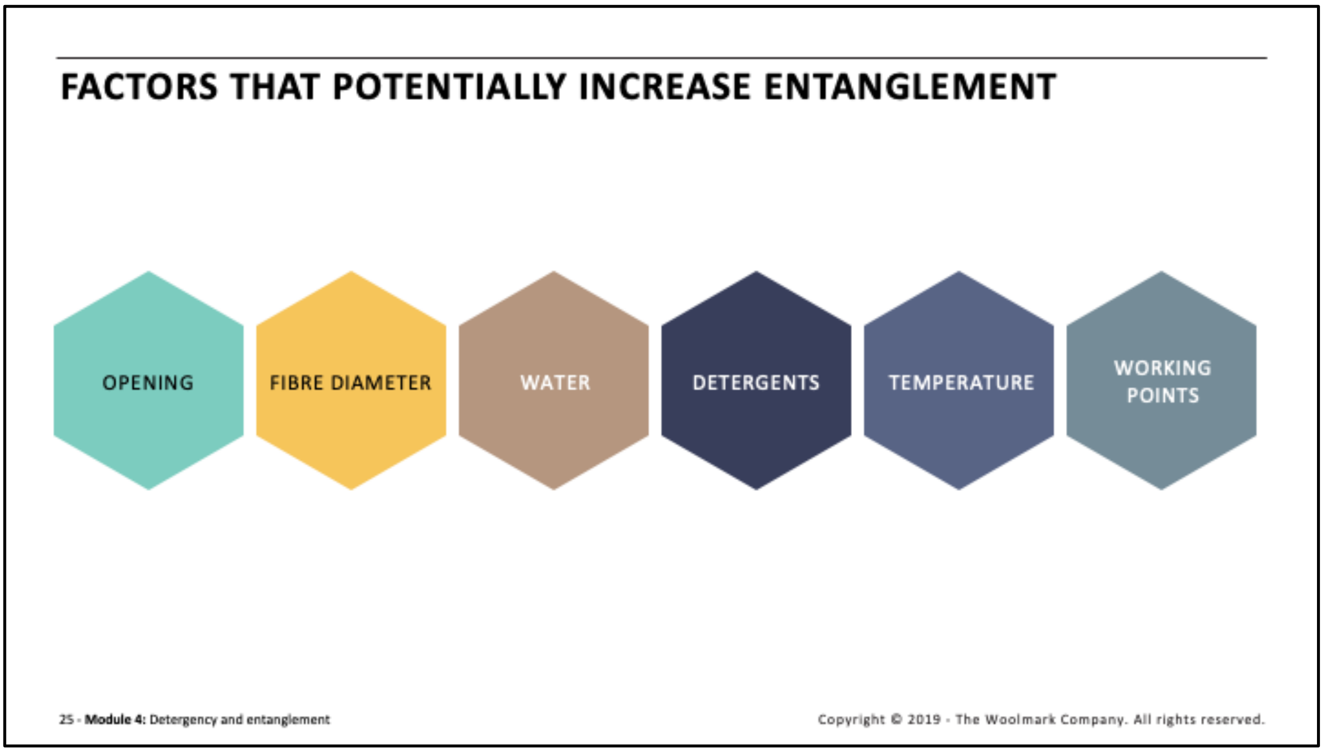
- Scenario 1 — scales opposed and movement in an against-the-scale direction.
- Scenario 2 — scales opposed and movement in a with-the-scale-direction.
- Scenario 3 — scales aligned and movement in an against-the-scale direction.
- Scenario 4 — scales aligned and movement in with-the-scale direction.

EMPHASISE THAT entanglement of wool fibres starts when the wet fibres are subjected to mechanical forces during scouring.

POINT OUT that entanglement is the first stage of felting and extensive entanglement is difficult to distinguish from classical 'felting'.

EXPLAIN THAT processing of entangled fibres will lead to extensive fibre breakage.

REINFORCE THAT the greater the level of entanglement, the more fibre breakage during subsequent stages of processing.



EXPLAIN THAT the potential for entanglement is associated with many aspects of the scouring process and the fibre characteristics.

Opening

- The threat of entanglement starts when the wool is opened prior to scouring and continues until the wool is held in the dryer.
- The potential for entanglement increases with an escalation in the severity of opening because this randomises the positions of the fibres and the direction of the wool fibre.

Fibre diameter

- The differential friction for fine Merino wools is much greater than for broad crossbred wools. This explains why entanglement is less of an issue in the scouring of carpet wools.

Water

- The presence of water promotes differential friction. In water, the height of the scales on Merino wool fibres increases by about 20%.
- Water acts as an internal lubricant, which increases the flexibility of the individual fibres making the entanglement easier with mechanical action.

Detergents

- Detergents (including soaps) can act as external lubricants and facilitate relative fibre movement.
- This is critical when the scouring liquor has partially drained from the wool, and the wool is subjected to mechanical action, especially in the presence of foam.

Temperature

- As the temperature increases the plasticity of the fibre and the flexibility of the fibres also increases. The extent of the effect increases as the fibre diameter decreases.

Working points

- Each of the mechanical elements that 'work on' the wool as it moves though the scour is a working point.
- The number and the severity of the action of working points both impact on the potential for entanglement.

SUMMARY — MODULE 4

In wool processing surfactants are used to:

- wet out the surface of wool fibres
- remove contaminants
- transfer soil to scouring liquor
- prevent re-deposition.

Surfactants are made up of hydrophilic (water-loving) and hydrophobic (water-hating) compounds.

Depending on their electrical charge in water, surfactants are classified as:

- anionic (negative charge)
- non-ionic (no charge)
- cationic (positive charge)
- amphoteric (both ionic and non-ionic).

Functions performed by surfactants

- adsorbing
- wetting
- micelle formation
- soil removal
- emulsion formation
- dissolution
- suspension
- transferring soil into solution
- preventing coalescence and re-deposition.

26 - **Module 4:** Detergency and entanglement

SUMMARISE this module by explaining that during wool processing surfactants are used to:

- wet out the surface of wool fibres
- remove contaminants
- transfer soil to scouring liquor
- prevent re-deposition.

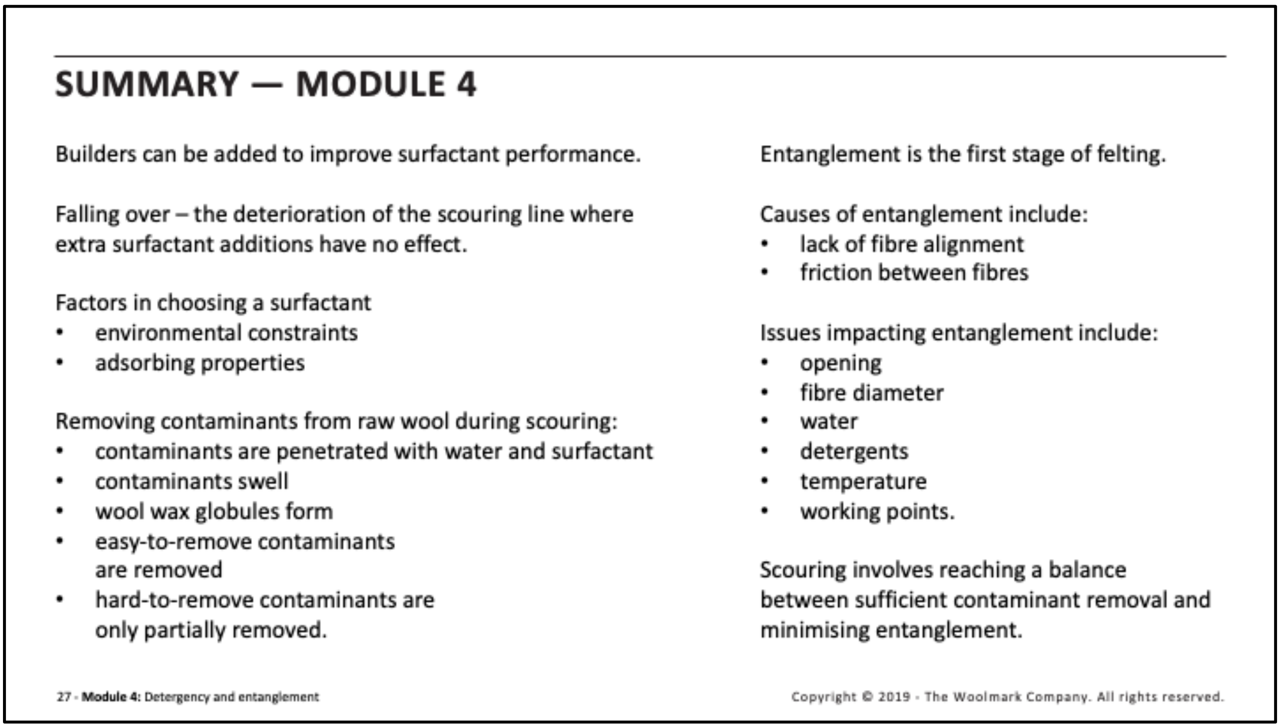
REINFORCE THAT surfactants are made up of hydrophilic (water-loving) and hydrophobic (water-hating) compounds.

REMIND participants that depending on their electrical charge in water, surfactants are classified as:

- anionic (negative charge)
- non-ionic (no charge)
- cationic (positive charge)
- amphoteric (both ionic and non-ionic).

REVIEW the functions performed by surfactants:

- adsorbing
- wetting
- micelle formation
- soil removal
- emulsion formation
- dissolution
- suspension
- transferring soil into solution
- preventing coalescence and re-deposition.



REMIND participants that builders can be added to improve surfactant performance.

REINFORCE THAT falling over can occur in wool scouring — the deterioration of the scouring line where extra surfactant additions have no effect.

REINFORCE THE factors in choosing a surfactant include:

- environmental constraints
- adsorbing properties.

REMIND participants that by removing contaminants from raw wool during scouring:

- contaminants are penetrated with water and surfactant
- contaminants swell
- wool wax globules form
- easy-to-remove contaminants are removed
- hard-to-remove contaminants are only partially removed.

REVIEW THE causes of entanglement including:

- a lack of alignment
- friction between fibres.

REMIND participants that Issues impacting entanglement include:

- opening
- fibre diameter
- water
- detergents
- temperature
- working points.

SUMMARISE this topic by reinforcing that scouring involves reaching a balance between cleaning the wool sufficiently and minimising entanglement in order to reduce losses and fibre breakage during subsequent processes.

ASK *participants if they have any questions about the content overed 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 *Raw wool scouring — Module 5 The scouring process: mechanical considerations*— 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 5

THE WOOLMARK COMPANY

THE SCOURING PROCESS: MECHANICAL CONSIDERATIONS

RESOURCES — MODULE 5: THE SCOURING PROCESS: MECHANICAL CONSIDERATIONS

No additional resources are required to deliver **Module 5: The scouring process: mechanical considerations**.

WELCOME participants to Module 5 of the Woolmark Wool Science, Technology and Design Education Program *Raw Wool Scouring — The scouring process: mechanical considerations.*

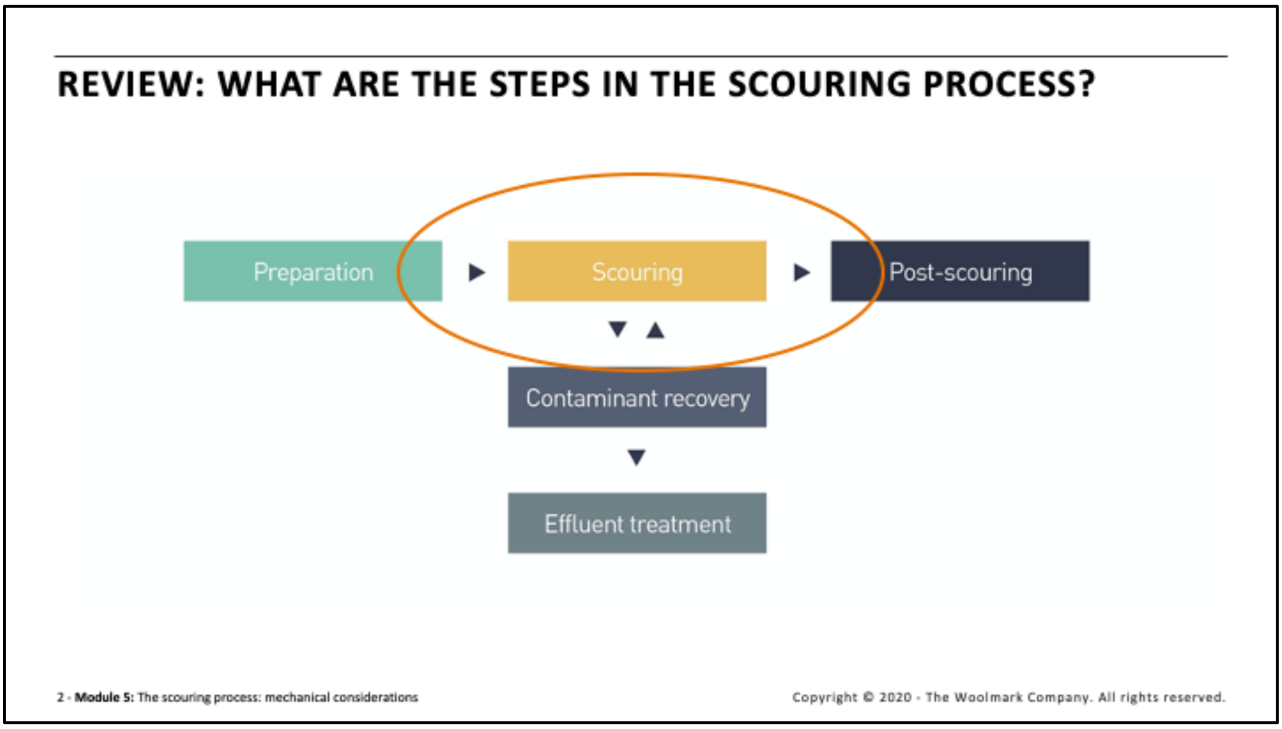
EXPLAIN THAT this module will cover:

- the scouring line configuration
- the wool transport system
- the liquor handling system
- scouring bowl design
- scouring line configurations
- opportunities for entanglement
- drying and dusting opportunities during scouring.

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

- describe the machinery involved in the scouring process and the functions of the key components.
- describe the points along the scouring line at which fibre entanglement can occur and the steps taken to prevent entanglement
- describe the machinery involved in post-scouring drying and dust-removal operations.

NO RESOURCES REQUIRED



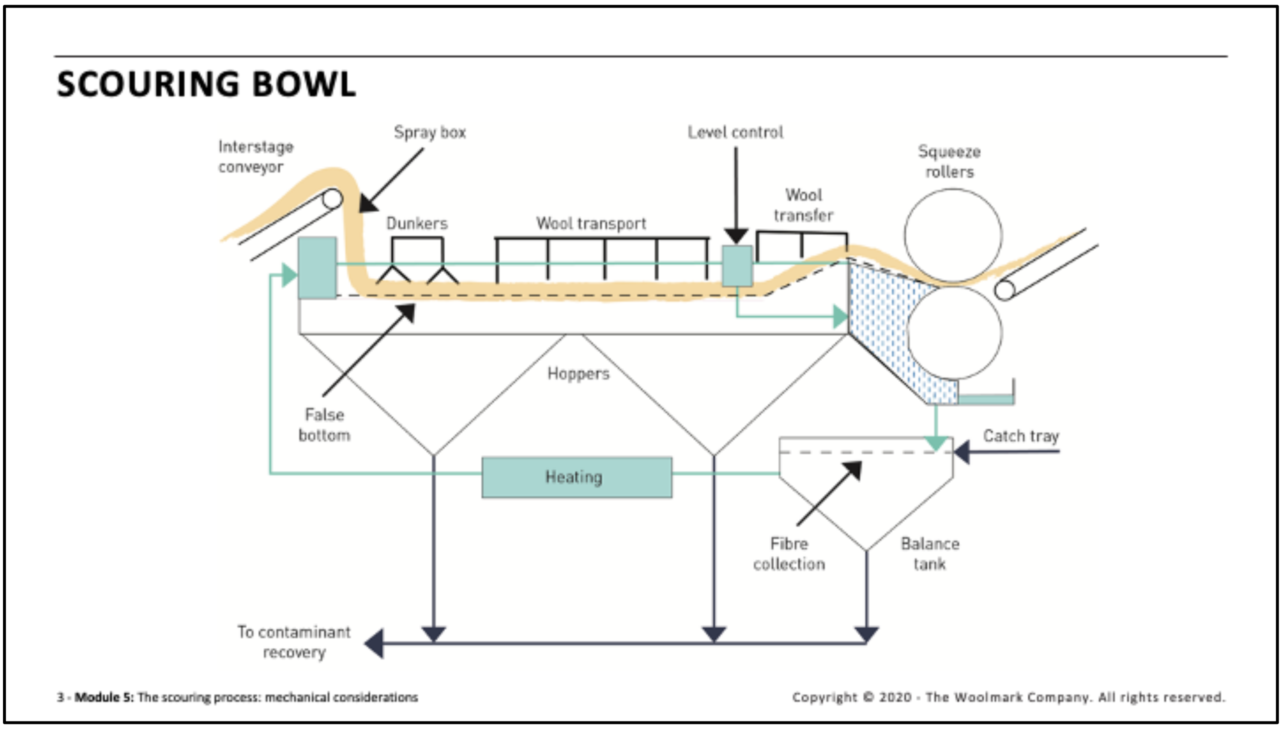
REVIEW THE steps in the scouring process which are:

- consignment preparation
- scouring line
    - contaminant recovery
    - effluent treatment
- post-scouring processes.

EXPLAIN THAT the scouring line consists of the following components:

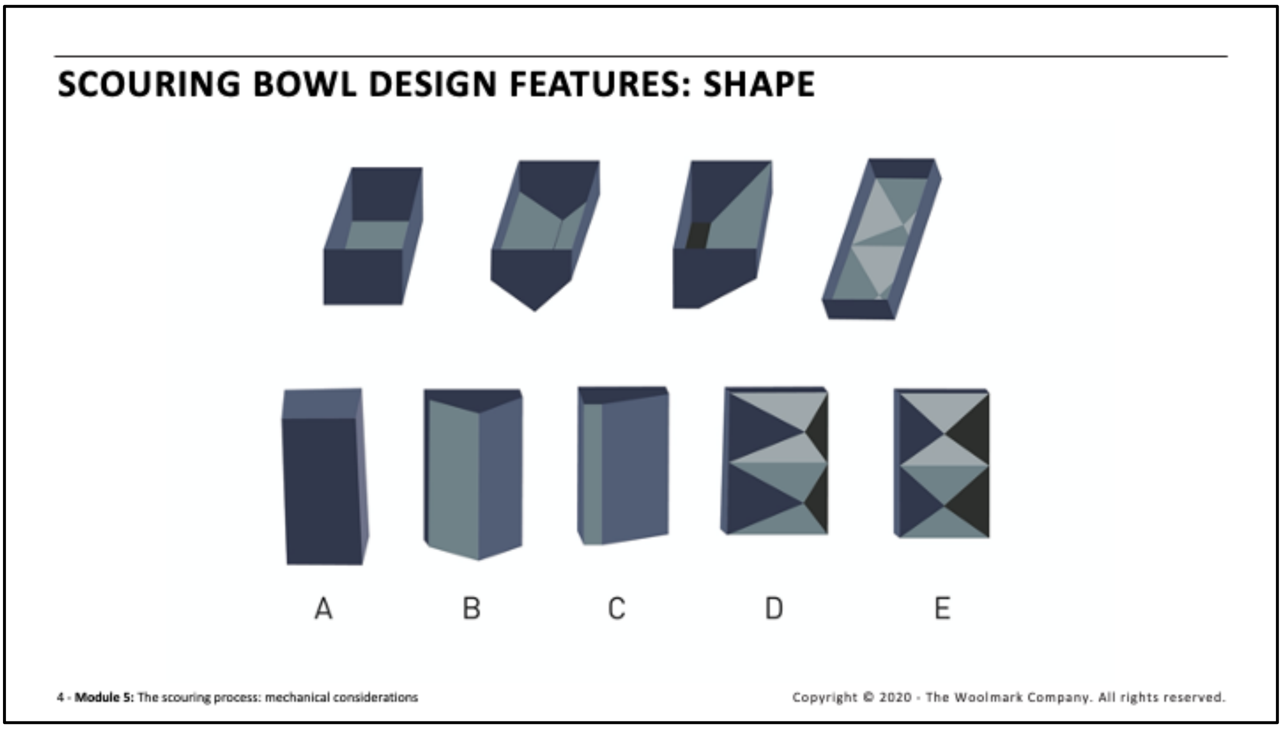
- an in-line opening section (previously discussed)
- a weigh belt, which ensures consistent delivery of the raw wool to the scouring bowls
- scouring bowls
- a dryer.

NOTE THAT the line also may contain post-drying opening and dust removal.



REFER TO the diagram on the slide as you explain that the scouring bowl incorporates the main modular component of the scouring line and is made up of a range of mechanical features to be explored in this module including:

- the wool transport system
- the liquor handling system
- basic scouring bowl design.



EXPLAIN THAT scouring bowls have a number of common features:

- a false bottom, which defines the volume of scouring liquor through which wool passes
- a region underneath the false bottom to collect sludge from the scouring liquor
- a way of emptying the bowl from the bottom.

INDICATE THAT there is a range of different bowl shapes as shown on the slide:

A. Rectangular with rectangular side elevation:

- This is the simplest design — this bowl needs to be dropped periodically to remove sludge.
- This bowl would be used in a carbonising line as an acidising bowl, not a normal scouring line.

B. Rectangular with pentagonal or trapezoid side elevation

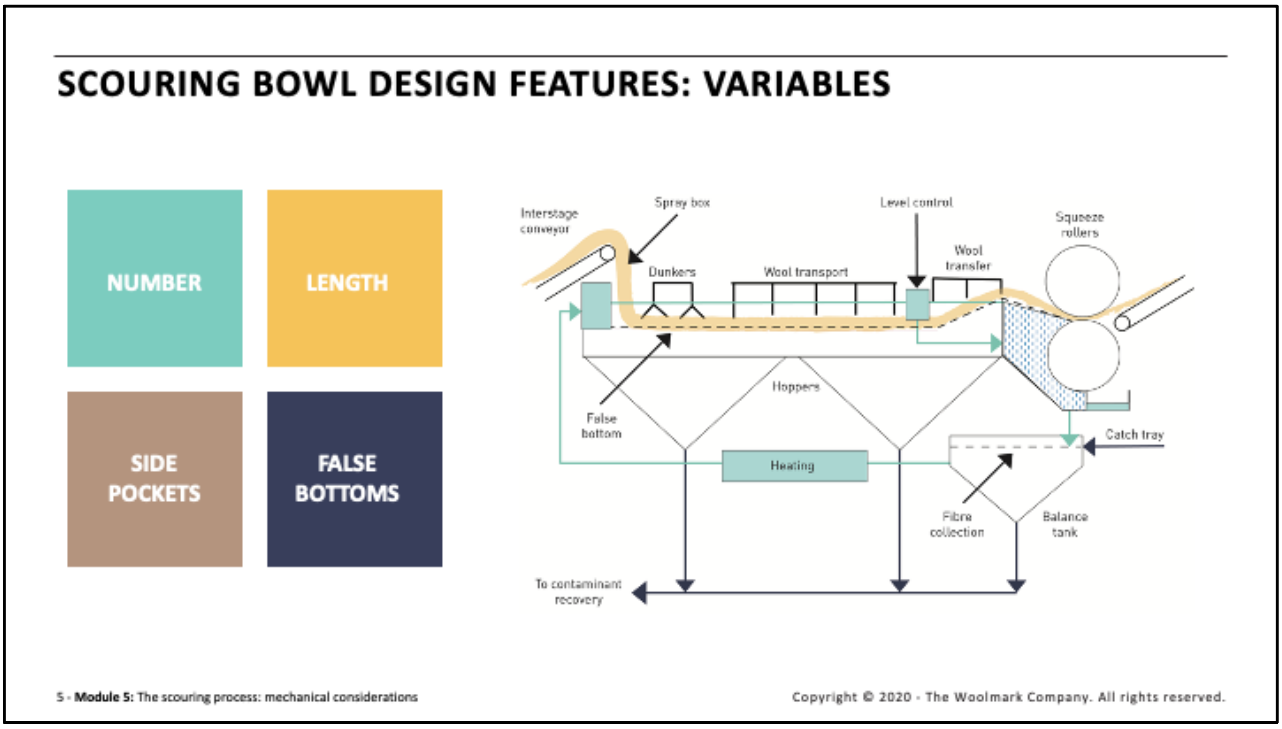
- This scour bowl shape was a common design for cast iron bowls (an older design of bowl).
- Accumulating sludge was supposed to be taken away by screw conveyors located at the bottom of the bowl; however, often the drives became jammed with the sludge.

C. Trapezoid with triangular side elevation

- This scour bowl was designed as a type of hopper bottom, but the shallow angle of the bottom reduced the efficiency of separating the dirt.

D. Pentagonal with triangular side elevation (also shown as E on diagram)

- This is a common modular structure for a hopper bottom bowl constructed of stainless steel.
- It is angled to increase the settling of sludge at the bottom of the bowl.
- This design dramatically changed the layout of a wool scouring line requiring it to be raised well above floor level for easy access to all areas under the bowls.



OUTLINE THE variables in scouring bowl design as per the notes below:

The bowl variables: There are numerous design features that add to the final configuration of the scour.

Number

- When productivity and water consumption were not process issues, typical scouring lines in Australia had four long bowls: two scouring and two rinsing.
- As production rates increased and water consumption decreased, it became necessary to increase the number of bowls to produce a satisfactory product.
- Most modern lines have at least six bowls — their function is described in the next module.

Length

- Modern scouring lines tend to have bowls 2–6 m long and 2–3 m wide.

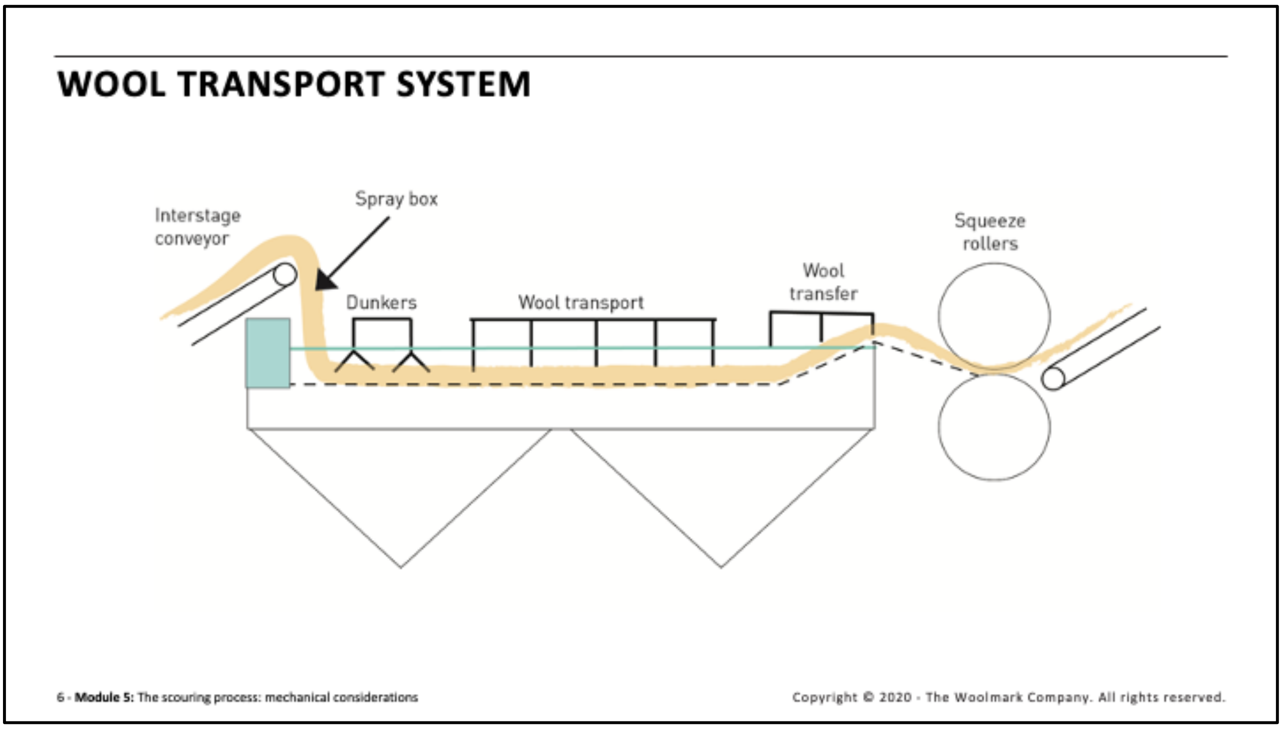
Side pockets

- An important feature not always seen on modern scouring lines is a side pocket on the bowls.
- The side pocket is useful for adjusting liquor level in the bowl and for providing a take-off point for more effective wool wax recovery.
- It also facilitates cleaning the bowls.

False bottoms

- Three variables need to be considered in the design of a false bottom:
  - size of the holes in the screen — large enough to allow the dirt to move through, but small enough to prevent wool fibres from getting through
  - area covered by the holes— with daggy and lower-quality wools the area occupied by the holes needs to much larger to prevent gelatinous solids from accumulating on the screen
  - thickness of the screen — needs to be thick enough to resist flexing during scouring.

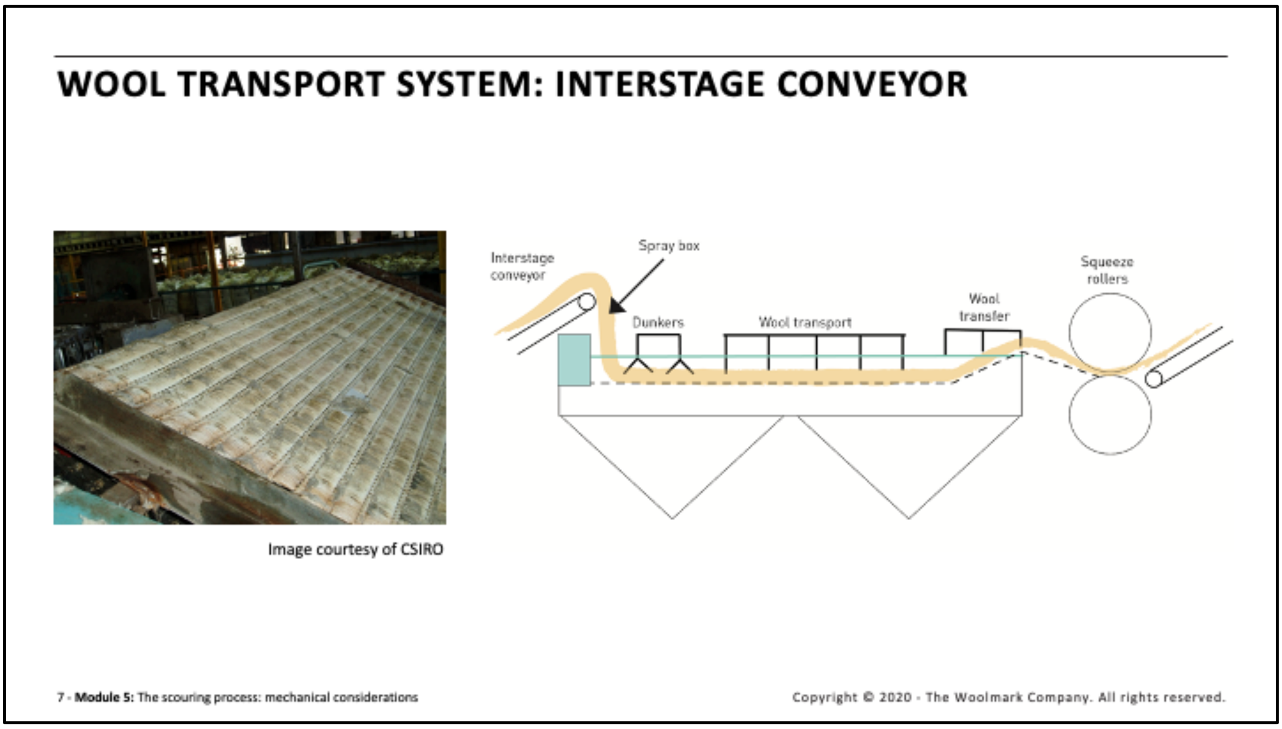
EXPLAIN THAT the most effective design is one that allows dirt to be removed continually and effectively.



EXPLAIN THAT the wool transport system is responsible for moving the wool in and out of the scouring liquor and through the squeeze rollers. It consists of:

- the interstage conveyor
- the spray box
- dunkers
- wool transport through the bowl
- wool transfer to the squeeze rollers
- squeeze rollers.

INDICATE THAT these components will be explored in the following slides, including their effects on entanglement.



REFER participants to the image on the slide where the interstage conveyor transfers the raw wool to the first scouring bowl, between the bowls and finally to the dryer.

EXPLAIN THAT the interstage conveyor can be comprised of:

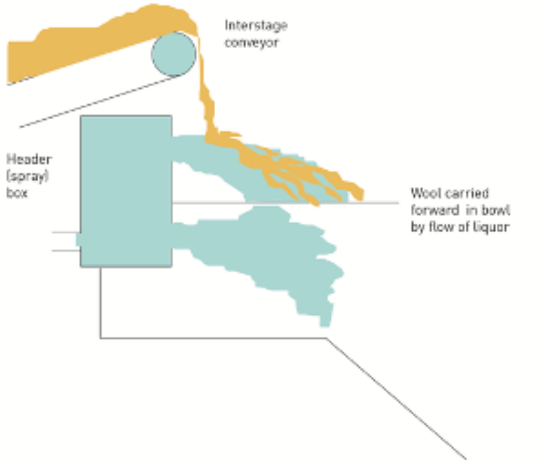
- wooden slats (no longer used in modern scours) as they:
    - are too heavy and place a high load on bearings and gears
    - cause slippage: wool can fall between the slats
- metal chain mesh:
    - fibre and contaminants can accumulate and affect the efficiency of the conveyor
    - tracking of the conveyor can be a major problem
- plastic media:
    - comparatively light and can be driven by several sprockets located across the width of the conveyor reducing tracking problems.

EXPLAIN THAT the linear speed of the conveyor must match the linear speed of the squeeze rollers or the wool will accumulate and the flow become uneven. The speed should be consistent and even.

NOTE THAT wool should not drop from too high when it enters the bowl.

REMIND participants that the surface of the conveyor should be kept clean of accumulated fibres and contaminants.

OPPORTUNITIES FOR ENTANGLEMENT DURING SCOURING: FEED TO A BOWL



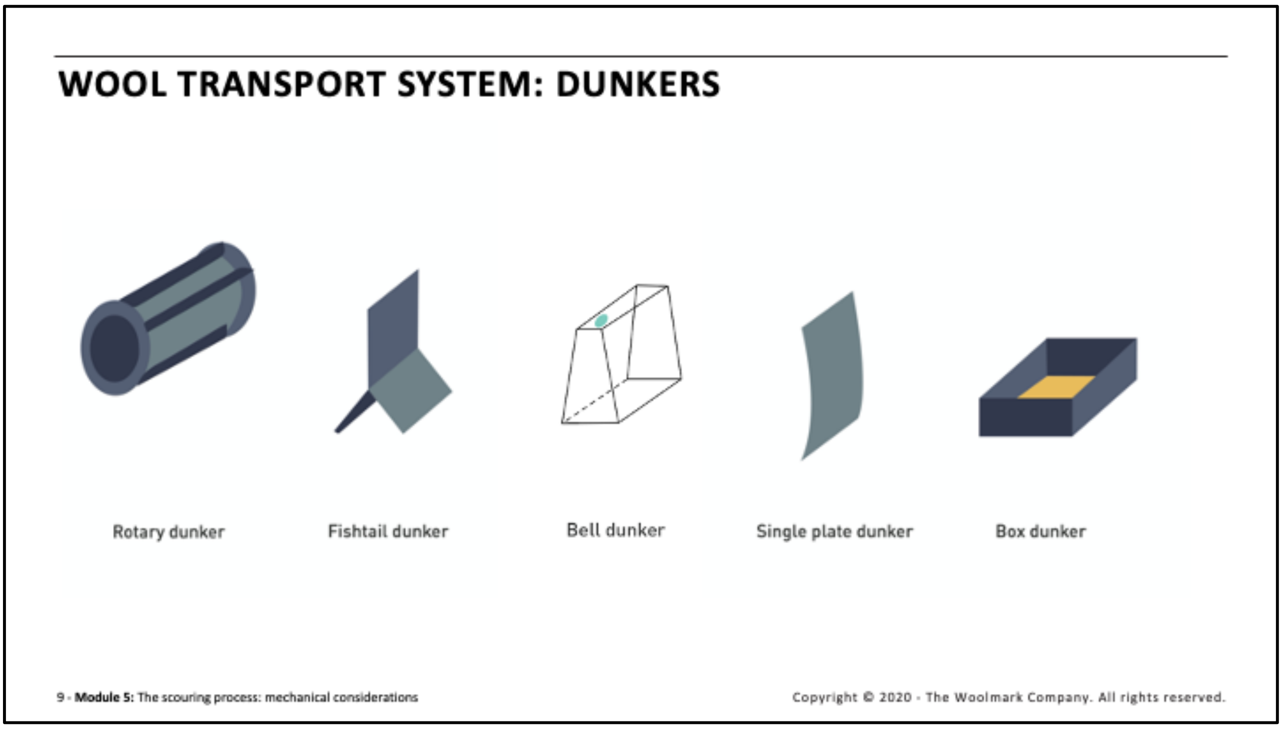
Point of transfer of wool to scouring bowl

8 - **Module 5:** The scouring process: mechanical considerations

NOTE THAT there is an opportunity for entanglement as the wool is fed into the scouring bowl.

EXPLAIN THAT as the wool falls off the interstage conveyor, it is pushed into the bowl by the recirculating scouring liquor as it is pumped into the bowl through the header box (also called a spray box).

NOTE THAT turbulent liquor flow will encourage entanglement.

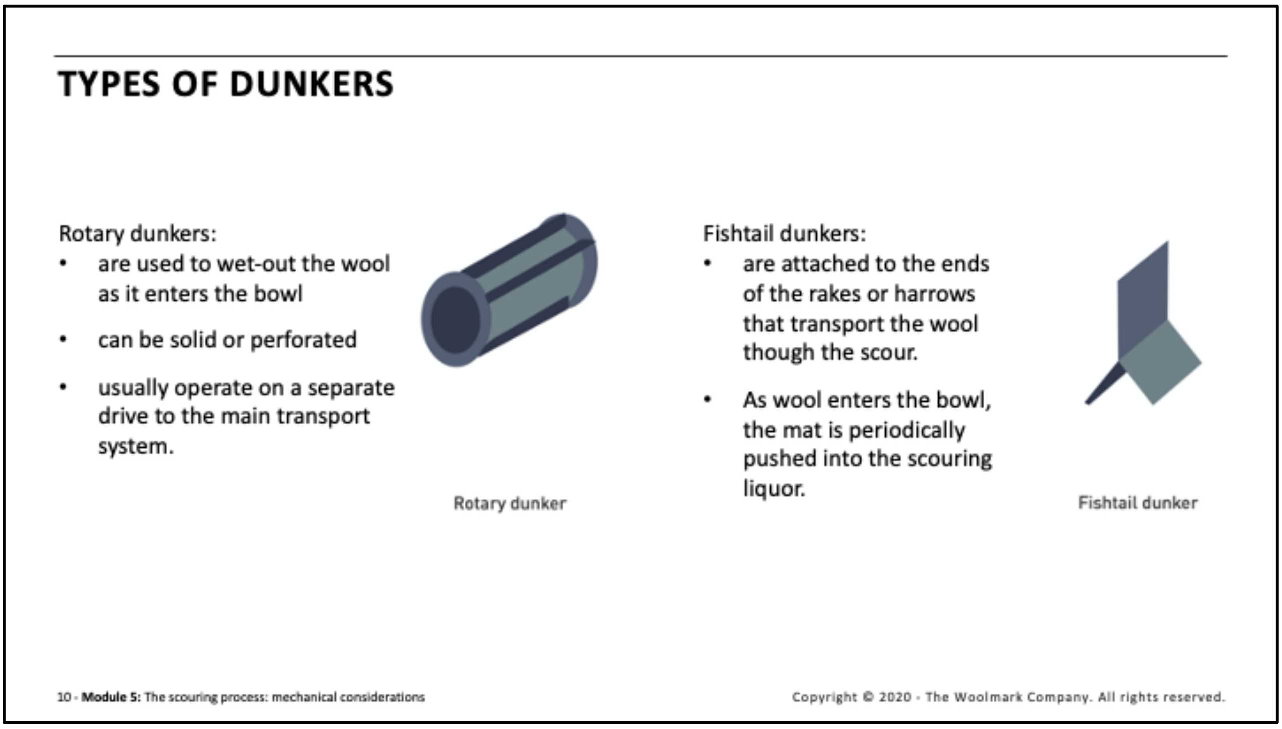


ASK *participants to explain what they think the purpose of dunking is.*

COLLECT *two or three responses from participants before proceeding with the lecture.*

INDICATE THAT the purpose of the dunkers is to:
- wet-out the wool
- provide the mechanical action to remove contaminants
- create a cleaning action on the false bottom (because dunkers create a vacuum when they lift out of a bowl, bell dunkers disturb accumulated material on the false bottom: this is of more importance in processing low-yielding wools in the woollen system)
- move the wool through the scour bowl.

REFER TO the images on the slide as you explain the variety of dunker types used, including:
- rotary dunkers
- fishtail dunkers
- bell dunkers
- plate dunkers
- box dunkers.



EXPLAIN THAT rotary dunkers:

- are used to wet-out the wool as it enters the bowl
- can be solid or perforated
- usually operates on a separate drive to the main wool transport system.

Advantages and disadvantages of rotary dunkers

The advantage of rotary dunkers is that all the wool is forced under the scouring liquor and the wool mat is not disrupted.

EXPLAIN THAT the disadvantages include:

- Wool can accumulate inside the drum, creating pressure on the bearings.
- Contaminants can accumulate underneath the dunker because it doesn't agitate the scouring liquor (this can be a major problem with low-yielding wools).

INDICATE THAT the linear speed of rotary dunkers needs to match the linear speed of the incoming wool mat to avoid breaking up the mat.

Fishtail dunkers:

- are attached to the ends of the rakes or harrows that transport the wool though the scour.

EXPLAIN THAT as wool enters the bowl, the wool mat is periodically pushed into the scouring liquor. Consequently, not all the wool is pushed into the liquor; some portions may not be immersed immediately.

Disadvantages of fishtail dunkers

Fishtail dunkers tend to break up the wool mat and can increase the potential for entanglement.

NOTE THAT some scourers have replaced rotary dunkers with fishtail dunkers in intermediate bowls because they are more effective, but retained a rotary dunker for the final rinse bowl.

***ASK** participants to explain why a rotary dunker is less likely to tangle wool than other forms of dunker.*

***ALLOW** participants sufficient time to respond.*

***IF NECESSARY** explain that compared with other forms of dunkers, a rotary dunker is less likely to tangle wool due to its gentle slow immersion (causing few eddy currents), does not split the matt of wool.*

TYPES OF DUNKERS

Bell dunkers:

- Usually located along the harrows or rakes rather than just at the front.
- In contrast to other dunkers, bell dunkers can provide severe agitation helping to clean the false bottom.

Single plate dunkers

- The simplest form of dunker
- Comprise a flat, or slightly curved, plate attached to the end of a harrow or rake.
- A single line of contact with the incoming wool, reducing the efficiency of wetting.
- Tines can be fitted to help move the wool through the scour.

Bell dunker

Box dunkers

- Consist of a rectangular steel box fitted to the end of a rake or harrow.
- Bottom is stainless steel mesh — either flat or in a sawtooth shape to help move the wool through the scour.
- Design ensures all the incoming wool is wet-out.

Image courtesy of CSIRO

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INDICATE THAT bell dunkers: are usually located along the harrows or rakes, rather than just at the front of the harrows and rakes. In contrast to the other dunker types bell dunkers can be used to provide severe agitation, which helps clean the false bottom.

On its upward motion, the bell dunker lifts some of the scouring liquor from the bowl then releases it through the action of gravity. This degree of agitation can be quite appropriate in suint bowls, in which the wool resists entanglement due to the wool wax on the fibres. Bell dunkers are not appropriate in rinsing bowls (i.e. where there is no wool wax left on fibre) because of their vigorous action.

EXPLAIN THAT the location and spacing of both fishtail and bell dunkers needs to be managed to ensure the wool is wet-out by the scouring liquor as soon as possible: the goal is to maximise the immersion time in a bowl, thereby maximising the washing action of the bowl.

NOTE: the severity of the action of bell dunkers is carefully monitored to avoid entangling finer wools.

- With low-yielding short-wool scours, it is common practice to position bell dunkers along the rakes to ensure solids do not accumulate on the false bottoms.
- For fine long wools, bell dunkers should only be used to wet-out the wool at the entry to the bowls.

EXPLAIN THAT single plate dunkers: are the simplest form of dunker. They consist of a flat, or slightly curved, plate attached to the end of a harrow or rake and only have a single line of contact with the incoming wool. Wetting-out of the wool is less efficient with single plate dunkers than with other dunker types.

Tines can be fitted to single plate dunkers to help move the wool through the scour.

NOTE THAT box dunkers: consist of a rectangular steel box fitted to the end of a rake or harrow.

The bottom of the box is stainless steel mesh, which is either flat or in a sawtooth shape to help move the wool through the scour. The design ensures all the incoming wool is wet-out.

OPPORTUNITIES FOR ENTANGLEMENT: DUNKERS

Bell dunker

Fishtail dunker

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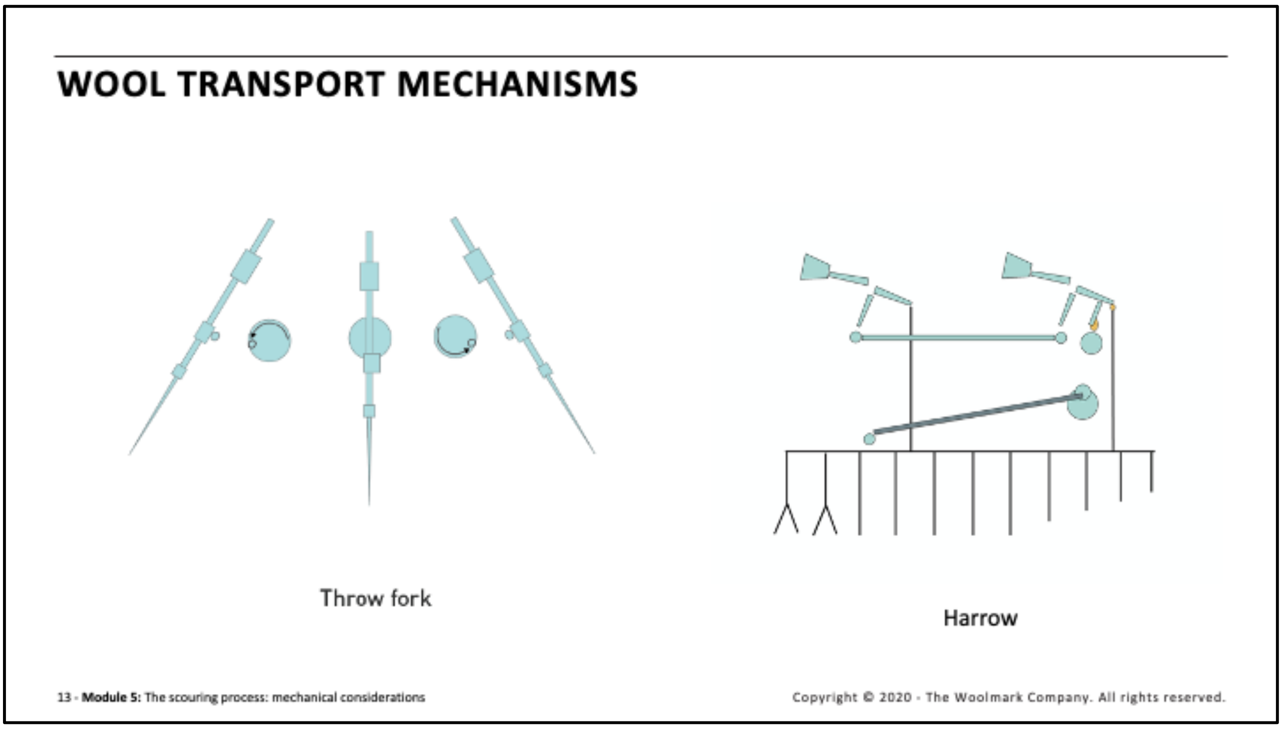
REINFORCE THAT many scours use dunkers to wet-out the wool as it comes into a bowl, and some have dunkers positioned well down the bowl to improve the scouring action. Some scours use bell dunkers to combine the dunking action with a suction action to increase the severity of the dunking effect.

NOTE THAT in pushing the wool down and forwards before releasing it – with or without suction – the wool can receive turbulent treatment, which can in turn promote entanglement.



EXPLAIN THAT after the dunkers wet the wool the wool transport system moves the through wool through the scouring bowl. During this process the transport system continues to provide some degree of mechanical action in order to remove contaminants.

REFER participants to the slide as you explain that over the years five main types of wool transport mechanisms have been used to transport wool through the scour bowl:

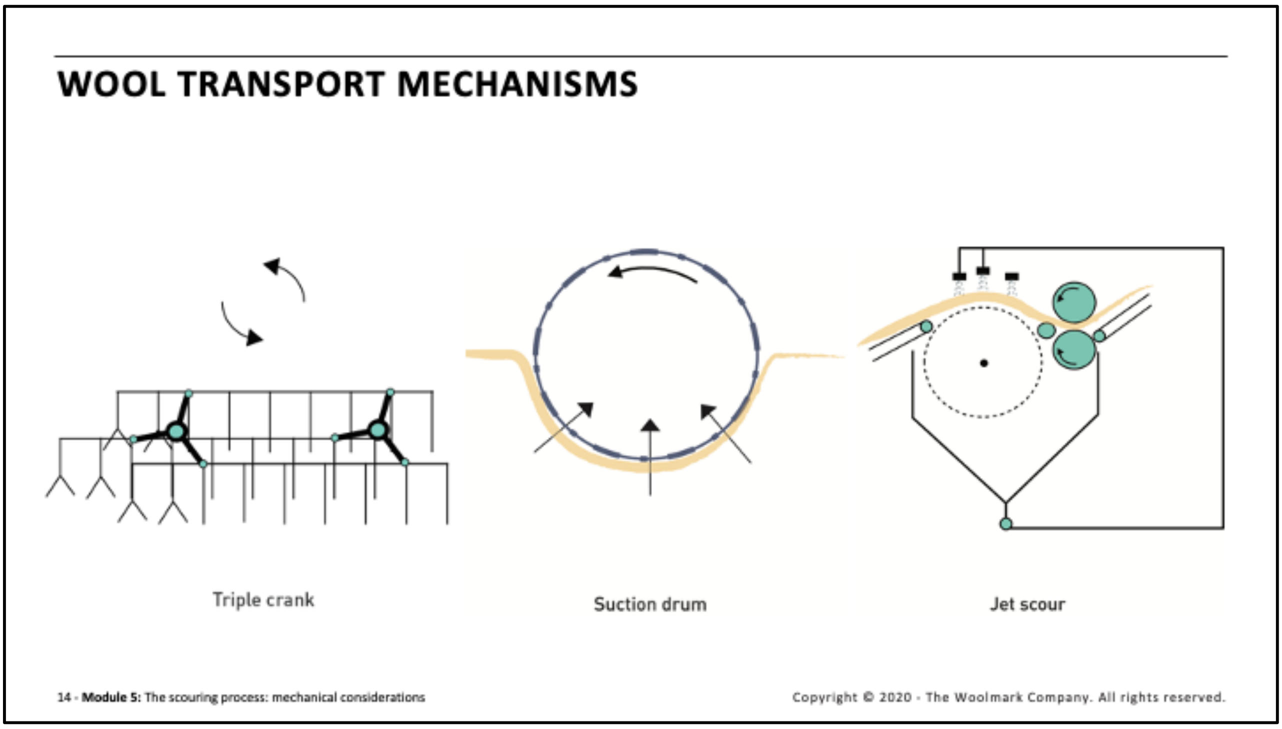
- throw forks and swing rakes
- harrows
- triple cranks
- suction drums
- jet scours.

Throw forks

Although modern scouring systems no longer use a throw fork mechanism, a variation on the throw fork (the swing rake) is still being used on some scouring lines to transfer the wool from the scour bowl to the squeeze roller.
Throw forks simulated the action of a pitchfork and were favoured by scourers who processed low-yielding wools.
To move the wool through the bowl, their action had to be quite severe, creating a high potential for entanglement.
This action also tended to disrupt the evenness of the wool mat.

Harrows

A harrow consists of a rectangle to which rows of tines are attached across the width of the scour bowl. The harrows penetrate the wool as they enter the scouring liquor, moving along the bowl, withdrawing from the scouring liquor and moving back to the start position, in a square action.
Because of the square action and slow rotation rate, the potential for entanglement is quite low, however, over time the driving mechanism can become worn, leading to an uneven action, which can lead to entanglement.
Disadvantages associated with harrows include the need for counterweights, a slightly uneven motion and energy considerations.



EXPLAIN TO participants the following mechanisms, as outlined on the slide.

Triple crank
Most modern scouring lines use triple-crank rakes, which consist of three rakes, arranged 120 degrees out of phase, meaning counterweights are not needed.
Due to the circular action of the triple crank mechanism, the potential for entanglement is relatively high, although less than both the throw fork or the harrow systems, due to the increased ability to control the motion of the mechanism.
Another advantage of the modern-day rake system is that the speed can be reduced for fine wools or substantially increased for low-yielding wools.

Suction drum
A suction drum scouring bowl contains several drums. Scouring liquor is sucked into the drum through the wool mat, which holds the wool on the rotating surface of the drum until the suction ceases when the drum leaves the scouring liquor. The wool is released and carried through the bowl until it is captured by the next suction drum.
This gentle action means the entangling potential is low, but the scoured product tends to be less clean than with other systems.

Jet scour
Jet scour systems spray the wool with hot alkaline detergent while being supported on either porous conveyors or porous drums.
These systems have a low entangling potential, but the wool tends to be less clean than with other systems.

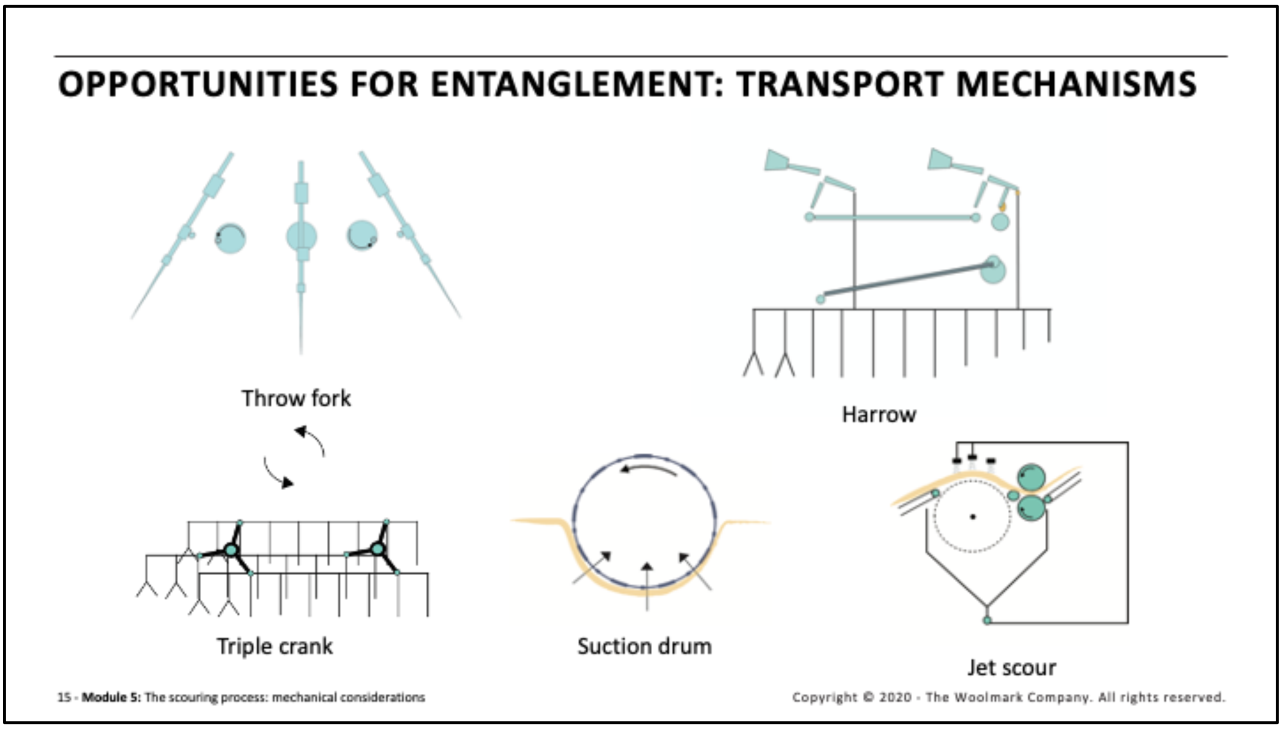
Associated with any rake system is:

- general turbulence from pushing wool through the scour
- a needle felting effect from individual tines as they penetrate the wool (the action is similar to that used in the needle felting of non-woven fabrics)
- irregular or uneven motion of wool if rake action is not smooth.

***ASK** participants to explain the component of the jet scouring process that could contribute to entanglement.*

***ALLOW** participants sufficient time to respond.*

***IF NECESSARY** confirm that the strength of jets will determine the resulting entanglement.*

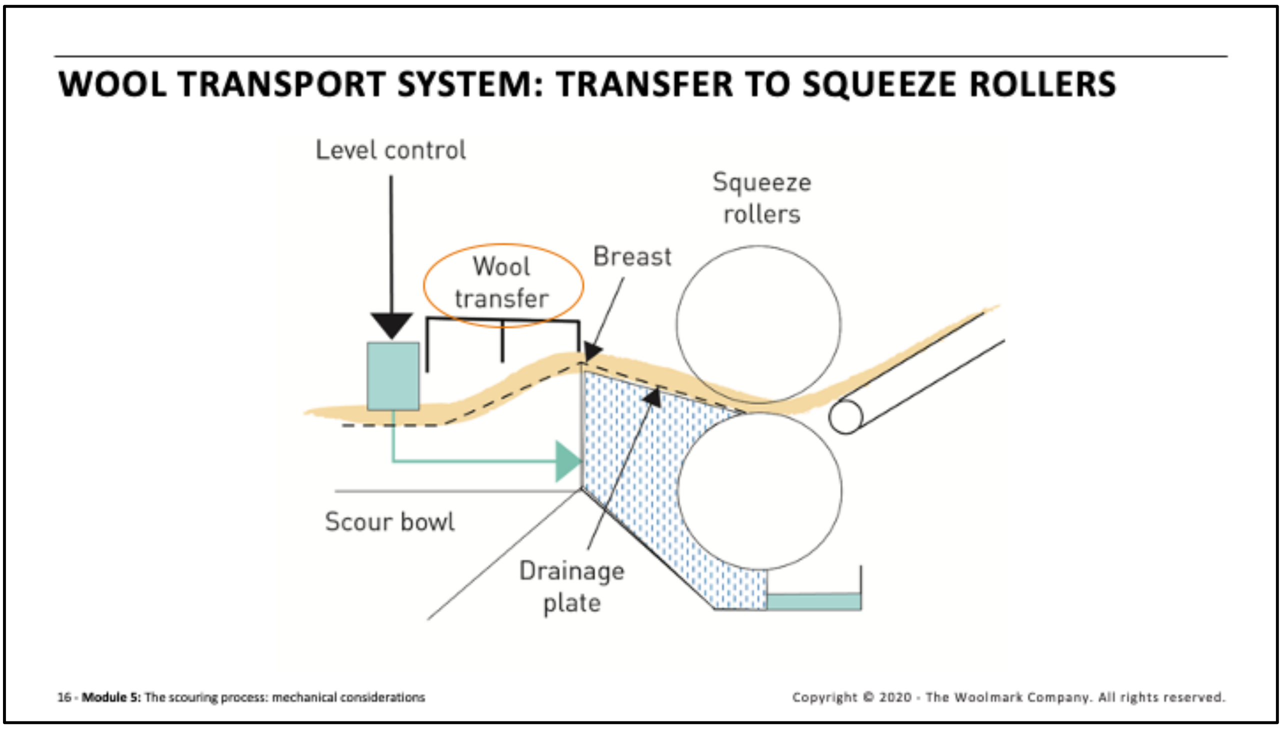


REINFORCE THAT the action of the transport mechanism produces the mechanical action required to move the wool forward, but this action also provides opportunities for the wool to become entangled.

EXPLAIN THAT harrows and triple cranks are often used on scouring bowls to move the wool because they also facilitate cleaning of the fibre, but as mentioned their action also facilitates entanglement.

REINFORCE THAT the suction drum is generally considered to cause the least entanglement, but does not promote cleaning in the same way as the rake systems. For this reason suction drums are often confined to the rinsing bowls, where cleaning is somewhat less critical.

NOTE THAT the jet scour, which used a rotating drum to move the wool was developed in the 1970s and was designed to minimise entanglement, but was not considered to clean the wool as well as the rake systems.



INDICATE THAT most scouring lines have a mechanical system — separate to the main rakes within the scour bowl — to transfer the wool from the scouring bowl to the squeeze rollers.

Like the main rakes, these mechanical transfer systems have differing degrees of severity in terms of their action, and so differ in their propensity to cause entanglement of the fibre mass during transfer.

If wet wool is agitated too much as it is pushed out of the bowl by the transfer mechanism, there is a high likelihood of entanglement.

EXPLAIN THAT a critical factor affecting the performance of the transfer of the wool from the scouring bowl to the squeeze rollers is the level of scouring liquor in the bowl. This level should be high enough to allow the flow of the liquor to carry the wool over the breast of the scour bowl, with the transport system facilitating the transfer.

If the water level is too low, the transport system has to work harder to move the wool out of the bowl and movement can occur in 'spurts'. Sloppy wool under these conditions has a high potential for entanglement, especially with finer wools.

POINT OUT that the nip of the squeeze rollers is usually located below the level of the scouring liquor. When the wool is transferred from the bowl, it is carried along with the scouring liquor, much of which drains away before the wool enters the nip of the rollers.

INDICATE THAT if the porosity of the drainage plate is too high, the scour liquor can drain too quickly and leave the wool stranded before reaching the squeeze rollers. Conversely, if there is insufficient drainage, the squeeze rollers can be flooded with wool and scouring liquor, causing poor and uneven squeezing.

NOTE THAT the systems for transferring the wool out of the scour bowl need to be free of accumulated fibre and debris to avoid the risk of entanglement.

TYPES OF TRANSFER MECHANISMS

Head rake

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NOTE THAT a number of mechanisms have been used to facilitate the movement of wool from the scour bowl to the squeeze rollers in wool scours.

In a modern wool scour one of two methods is normally used — the head rake and the swing rake. Alternatives such as the complex Belgian lift system, or the extended harrow rake are no longer used in modern wool scours.

Head rake
Most modern raw wool scours use head rakes. A head rake is configured with progressively shorter tines as the wool is pushed (or pulled) out of the bowl, but has a more circular action (as opposed the square action of the harrow rake). The forward motion of the head rake is quite short, so the speed of the rake has to be two or three times faster than the main transport system preceding it. This increases the potential for fibre entanglement.

Swing rake
The swing rake is a modern version of a traditional throw fork, which used a pitchfork action to move the wool out of the scouring bowl. This updated design enables the rakes to move at a relatively slow rate, while still moving the wool out of the scouring bowl.
Harrow extension
The harrow used to move wool though the scour bowl can be modified to include an action that allows it to transfer the wool out of the bowl to the squeeze rollers. The tines at the end of the extended harrow are progressively shortened to push the wool up the incline to the breast of the bowl.

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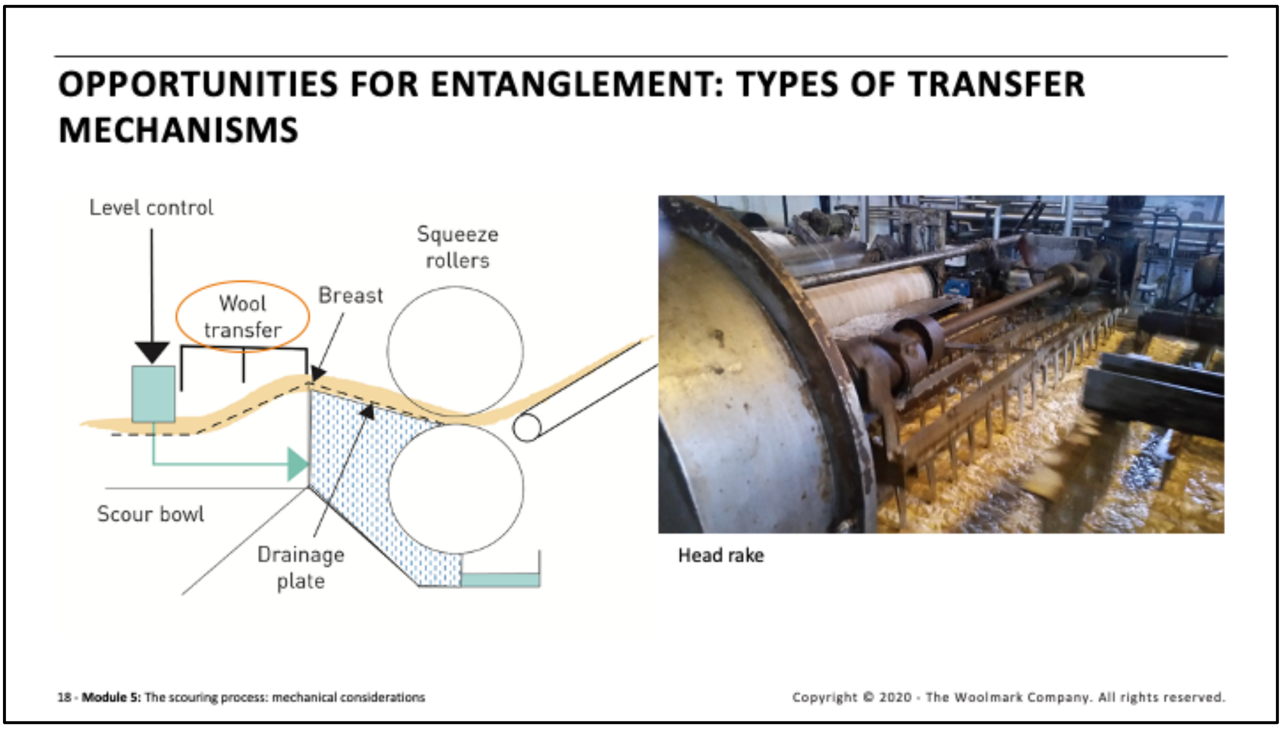

REINFORCE THAT most scouring lines have a mechanical system – separate to the main rakes – to transfer the wool from the bowl to the squeezing rollers.

NOTE THAT if wet wool is agitated too much as it is pushed or pulled out of the bowl, there is a high likelihood of entanglement. Like the main transport mechanism, the transfer mechanisms to the squeeze rollers have differing degrees of severity. Head rakes are considered to cause the least entanglement.

EXPLAIN THAT squeeze rollers play an important role in the best-practice operation of a scouring line. They are responsible for:

- improving contaminant removal by generating high liquor velocities at the nip, which help sweep away contaminants from the fibre surfaces
- reducing the carryover of contaminants into subsequent bowls by squeezing most of the entrained liquor from the wool
- reducing the energy needed to dry the wool by removing most of the water in the final squeeze before drying
- maintaining an even mat of wool through the scouring line by effectively operating squeeze roller sets.

INDICATE THAT the materials used to wrap around the top squeeze rollers include:

- solid rubber
- wool (usually made from broad wool)
- nylon tow
- plaited square ropes made from a synthetic fibre or a wool–synthetic fibre blend.

EXPLAIN THAT the squeezing efficiency of the different materials is similar, but the differences lie in their durability, with plaited ropes being the most durable option.

PROBLEMS WITH SQUEEZE ROLLERS

Problems during squeezing are mostly caused by the type and condition of the lapping (covering on the rollers).

Slippage at the nip:

- too much scouring liquid
- too much foam preventing the rollers from gripping wool fibres
- presence of residual softened wool wax on the wool
- poor maintenance of the lapping
- uneven squeezing.

Rubber rollers are more prone to adhesion of the wet wool than other materials — water sprays on rubber rollers will reduce this problem.

- Uneven squeezing is usually caused by deterioration in the quality of the lapping on the roller.
- If the lapping on the rollers is wool, the scourer must implement a careful maintenance program to avoid contamination.

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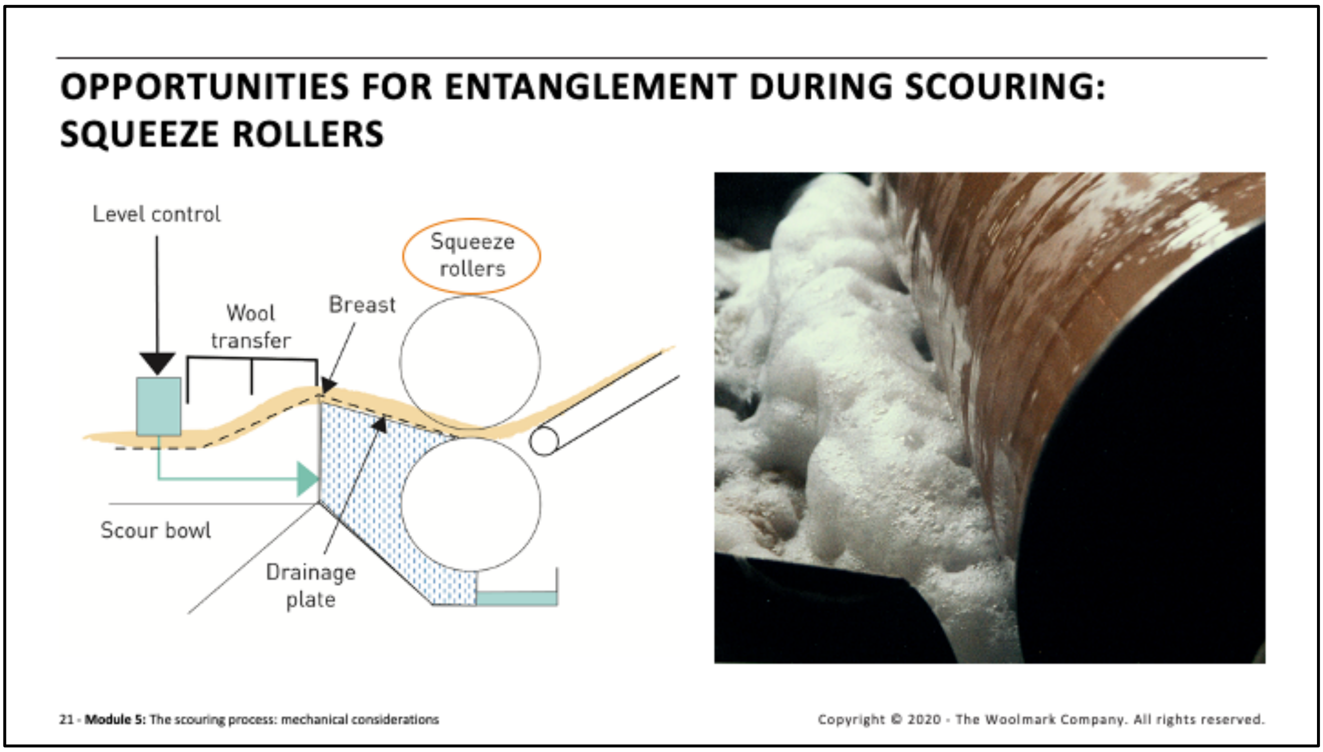
EXPLAIN THAT a number of problems can occur with squeeze rollers; they are mostly caused by the type and condition of the lapping (covering on the squeeze rollers).

INDICATE THAT slippage at the nip is the most common problem and can occur for a number of reasons:

- too much scouring liquid
- too much foam preventing the rollers from gripping wool fibres
- presence of residual softened wool wax on the wool
- poor maintenance of the lapping
- uneven squeezing.

EXPLAIN THAT wool will adhere more easily to rubber rollers than other lapping materials, wrapping around the roller — water sprays on rubber rollers will reduce such adhesion of the wool.

EXPLAIN THAT uneven squeezing is usually caused by deterioration in the quality of the lapping on the roller. If the lapping on the rollers is wool, the scourer must implement a careful maintenance program or pieces of the lapping can slough off the roller and contaminate the wool, especially if broad wools are used to make the lapping.



EXPLAIN THAT entanglement can occur near the nip of the squeeze rollers in two ways:

1. Stuffer box effect

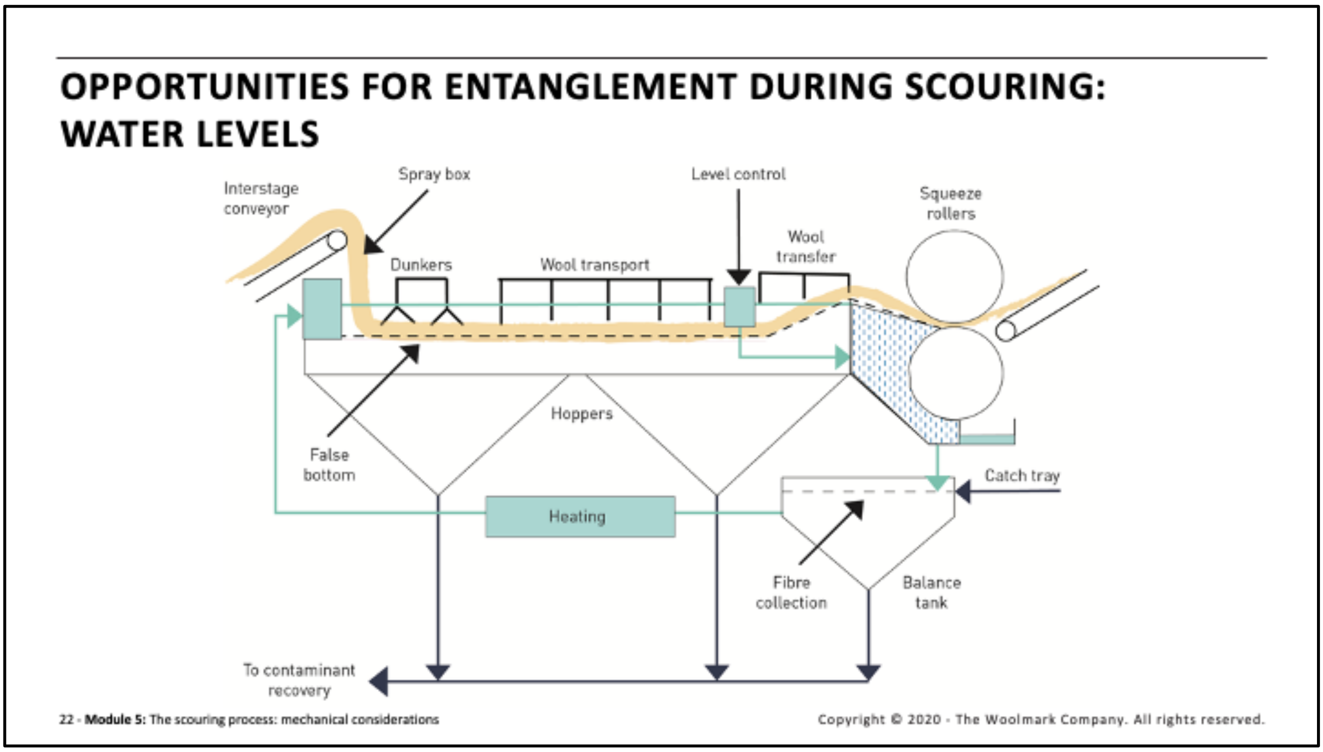
When there is a high production rate in a scouring line, a considerable amount of wool lies on the drainage plate before the squeeze rollers.
Wool is pushed over the breast and down the drainage plate by the action of the rake at the end of the bowl.
Like the stuffer box on a milling machine, the wool is constantly pushed into the nip.
If there is any foam present, the conditions are ideal for entanglement.

2. Turbulence at the roller nip

The conditions that exist near the nip of the squeeze rollers are ideal for entanglement:

- The tip end of a staple is held at the tightest part of the nip.
- The root ends are in a compressed condition but are still free to move.
- The scouring liquor is being pushed out of the wool mass in a highly turbulent flow by the compression of the rollers, causing the root ends to move and become entangled.

In a modern scouring line, this turbulence may well be the major contributor to entanglement.



EXPLAIN THAT at the end of the scour bowl, the wool is pushed up an incline until it reaches the breast, from which it descends to the nip of the squeezing rollers.

INDICATE THAT some scourers adjust the water level in the bowl to allow the flow of the scouring liquor to carry the wool over the breast.

EXPLAIN THAT others believe the water level should be adjusted so the wool flowing down the incline contains as little water as possible; however, this creates a high potential for entanglement.

ENTANGLEMENT AND SCOURING — MECHANICAL PROCESSES

MECHANICAL PROCESSES

- Bowl function
- Length of bowls
- Recirculation system
- Dunker system
- Wool transport mechanisms
- Squeeze rollers

Head rake

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SUMMARISE THE effect of the machine on entanglement by reinforcing that there are numerous opportunities throughout the scouring process in which entanglement is a risk. Some opportunities relate to the mechanical processes and machinery involved and some relate to the conditions under which scouring is carried out.

Bowl function
As the function of the bowls in the scouring line changes, so does the potential for entanglement. The presence of wool wax on fibres helps prevent entanglement — the fibres cannot become entangled when the scales are covered by the wool wax. Consequently, the fibres are not at risk of entanglement in a de-suint bowl, but as soon as the wax is removed the potential for entanglement increases.

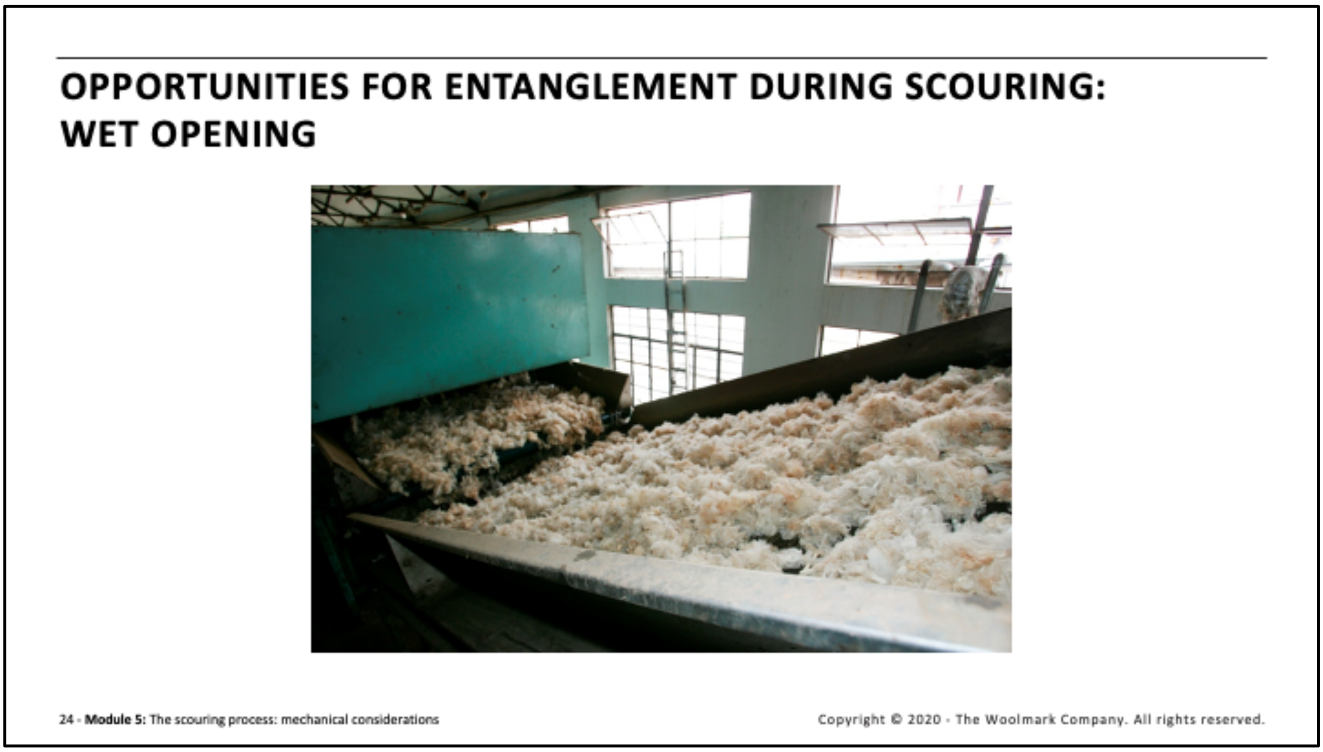
Length of scouring bowls
The longer the wool is in contact with the scour liquor, the greater the potential for entanglement.

Recirculation system: flow rate and turbulence
High rates of recirculating scour liquor can increase entanglement especially at the spray box.

Dunker system:
Dunker type, location of dunkers in individual bowls and along scouring train, and the amount of turbulence caused by the dunking operation all impact on entanglement.

Wool transport mechanisms:
The type of mechanism (e.g. harrow, suction drum), the rate of agitation and evenness of motion all impact entanglement, whether they are transporting wool within or between bowls. Vibration in the transport systems can influence entanglement.

Squeeze rollers
The pressure imparted by the squeeze rollers will impact entanglement.



INDICATE another factor that encourages entanglement is the wet opening process carried out before the scoured wool enters a brattice dryer to ensure an even feed to the dryer.

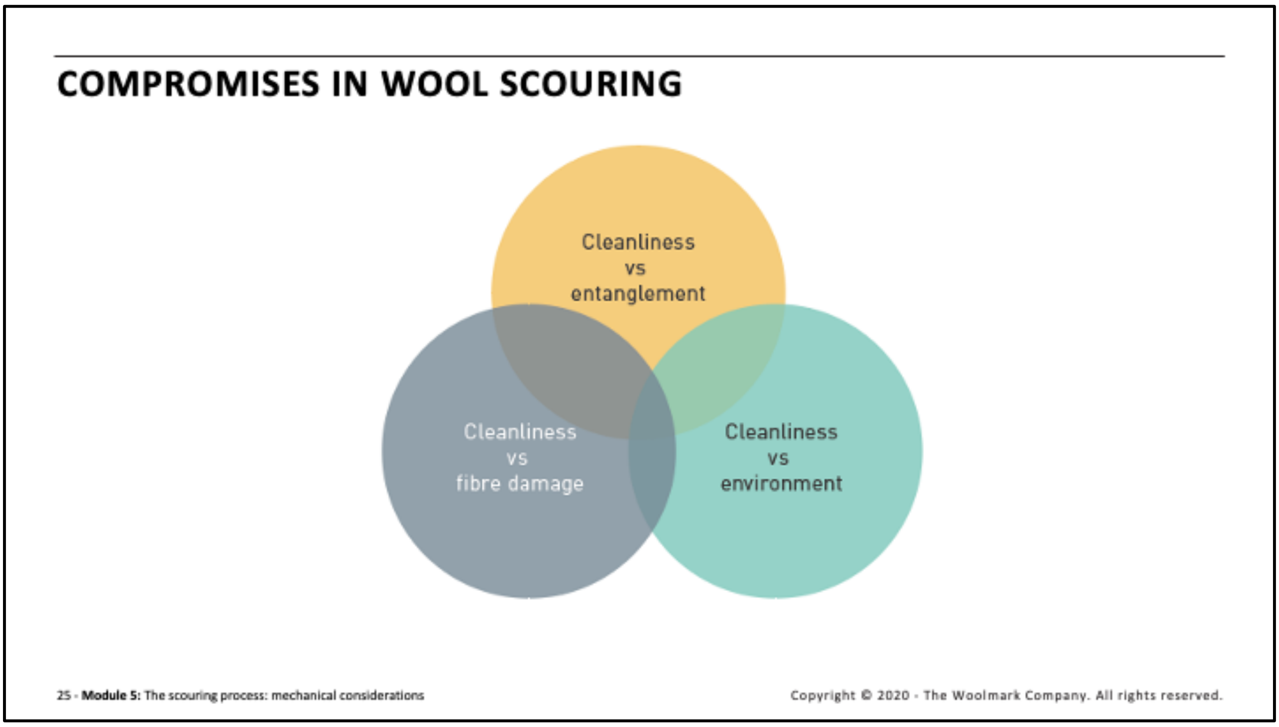
EXPLAIN THAT an accumulation of wool in the feed hopper, and the combination of wet wool and the rolling action of the brattice feed encourages entanglement.

NOTE THAT with modern scouring machines using suction-drum or unidryers, the need to produce an even feed is no longer necessary, because the flow of wool through the scouring line is more controlled.

ASK *participants to explain why wet opening causes entanglement.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *reiterate that wool felts faster when wet and opening provides mechanical action. These two factors combine to promote entanglement in wool as it moves through the scouring line.*



EXPLAIN THAT wool scouring has to contend with three compromises:

1. cleanliness versus entanglement
2. cleanliness versus fibre damage
3. cleanliness versus environment.

Cleanliness versus entanglement

- A balance must be reached between achieving maximum cleanliness and avoiding entanglement.
- The agitation used to remove contaminants also encourages felting.
- A gentle scouring action, such as a suction-drum system, lowers the risk of entanglement, but the wool tends to be dirtier.
- Conversely, more vigorous action in a scour will produce a cleaner product, but a more entangled fibre.

Cleanliness versus fibre damage

- In trying to improve contaminant removal, a scourer might change the scouring conditions by increasing the scouring temperature or pH.
- This will also increase the possibility of damaging the wool.

Cleanliness versus environment

- Meeting environmental regulations can place constraints on the scouring process.

METHODS TO REDUCE ENTANGLEMENT IN SCOURING MACHINERY

- Modification of existing machines
- Radical changes to the scouring machines
- Changing the scouring medium
- Changing the scouring configuration

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REMIND participants that the main purpose of scouring is to remove contaminants to acceptable residual levels. This limits the extent the scouring configuration can be changed, for example, to one involving no agitation or one in which the wool is overly restrained.

EXPLAIN THE following methods used to reduce entanglement in scouring machinery.

Modification of existing machines
The aim is to reduce entanglement by decreasing the amount of mechanical energy imparted to the wool during scouring.
Modification may reduce the number of working points by:

- shortening the bowls
- changing the dunkers (e.g. WIRA Improved Scouring Set, mini bowl scours).

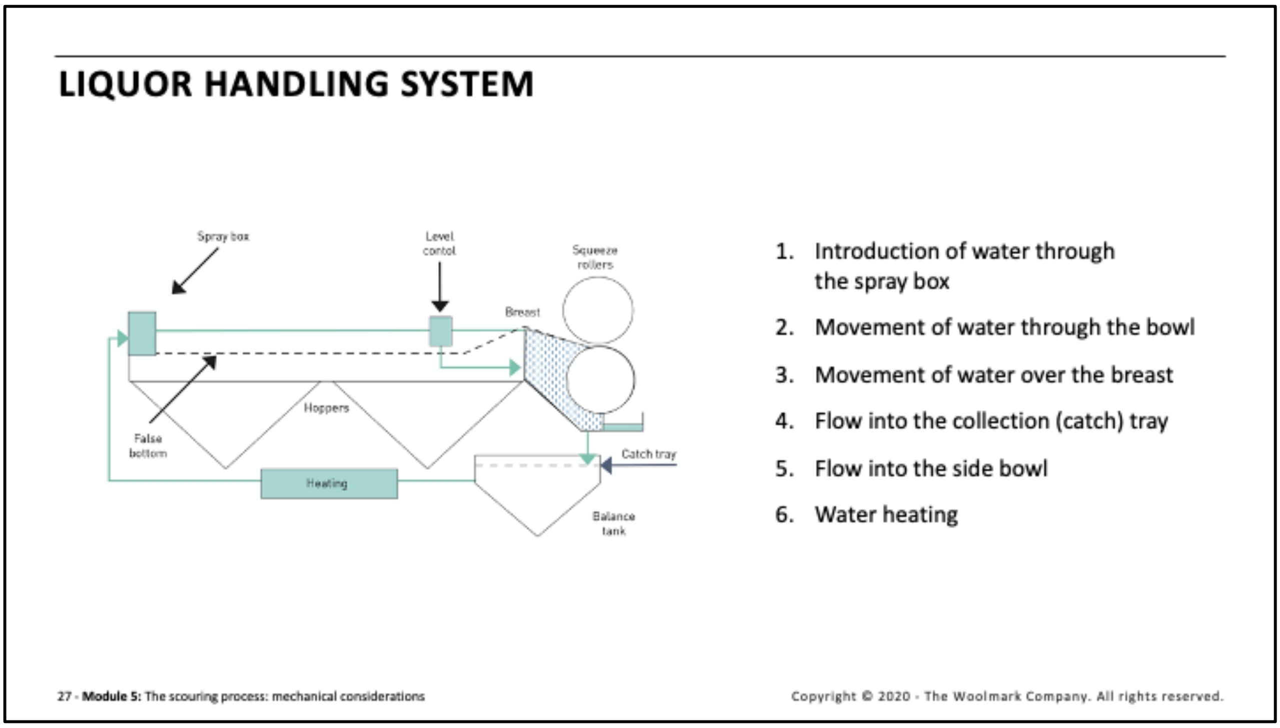
Even so, these modifications offer only limited improvement.

Radical changes to scouring machines
The aim is to reduce entanglement by decreasing the amount of mechanical energy imparted to the wool during scouring.
Radical changes may eliminate working points by conveying wool through washing zones using porous conveyors or drums (e.g. CSIRO jet scouring machine, UNSW jet scouring machine, Fleissner Suction Drum system).
Wool retains higher levels of residual dirt and there is re-deposition of contaminants as a result of filtration of rinse liquors by the wool mat.

Changing the scouring medium
The aim is to reduce entanglement by replacing the aqueous scouring environment with one that does not enhance the differential friction effect or increase the flexibility of the fibres.
Organic solvents, rather than water, are used as the scouring medium.

- There is a higher capital cost due to necessity of solvent recovery systems.
- Organic solvents need to be carefully managed to overcome potential environmental and work health and safety problems.

Changing the scouring configuration
The sequence of the functions carried out in successive bowls (scouring, rinsing) can be changed. This will impact both the cleaning and entanglement of the wool and is described more fully in subsequent modules.



EXPLAIN THAT this slide illustrates the liquor handling system that follows the passage of the scouring liquor through the scouring bowl into a balance or side tank before being heated and returned to the scour.

The flow of the scouring liquor through the bowl should be sufficient to carry the wool through and out of the bowl without severe agitation.

INDICATE THAT the liquor handling system for an individual bowl goes through the following steps:

- introduction of water through the spray box
- movement of water through the bowl
- movement of water over the breast
- flow into the catch or collection tray
- flow into the side bowl (not shown)
- water heating.

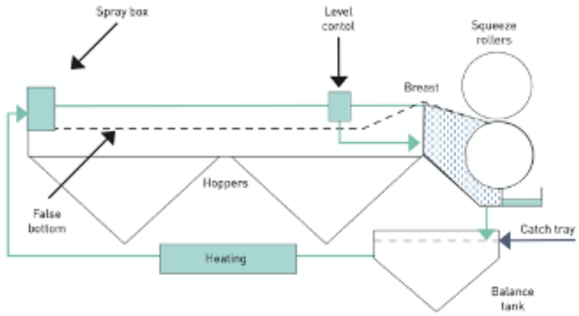
EXPLAIN THAT the equipment used in the liquor handling system includes: the spray box, level controller and collection (catch) tray.

Spray box — used to distribute the liquor evenly across the width of the scour bowl. The flow should be sufficient to push the wool into the bowl but not too vigorous, as this leads to entanglement. Water can be delivered through one or two rows of holes in the spray box.

Level controller fitted to the side of the bowl, the level controller can be adjusted to change the level of the scouring liquid in the bowl. The level should be adjusted to allow a flow of water over the breast, which helps to move the wool out of the bowl.

Collection tray — located under the drainage plate and the squeezing rollers, the collection tray collects scouring liquor from the level controller overflow, the drainage plate and squeeze rollers. Liquor from the collection tray can contain pieces of wool, therefore the liquor is passed through a strainer.

LIQUOR HANDLING SYSTEM



1. Introduction of water through the spray box
2. Movement of water through the bowl
3. Movement of water over the breast
4. Flow into the collection (catch) tray
5. Flow into the side bowl
6. Water heating

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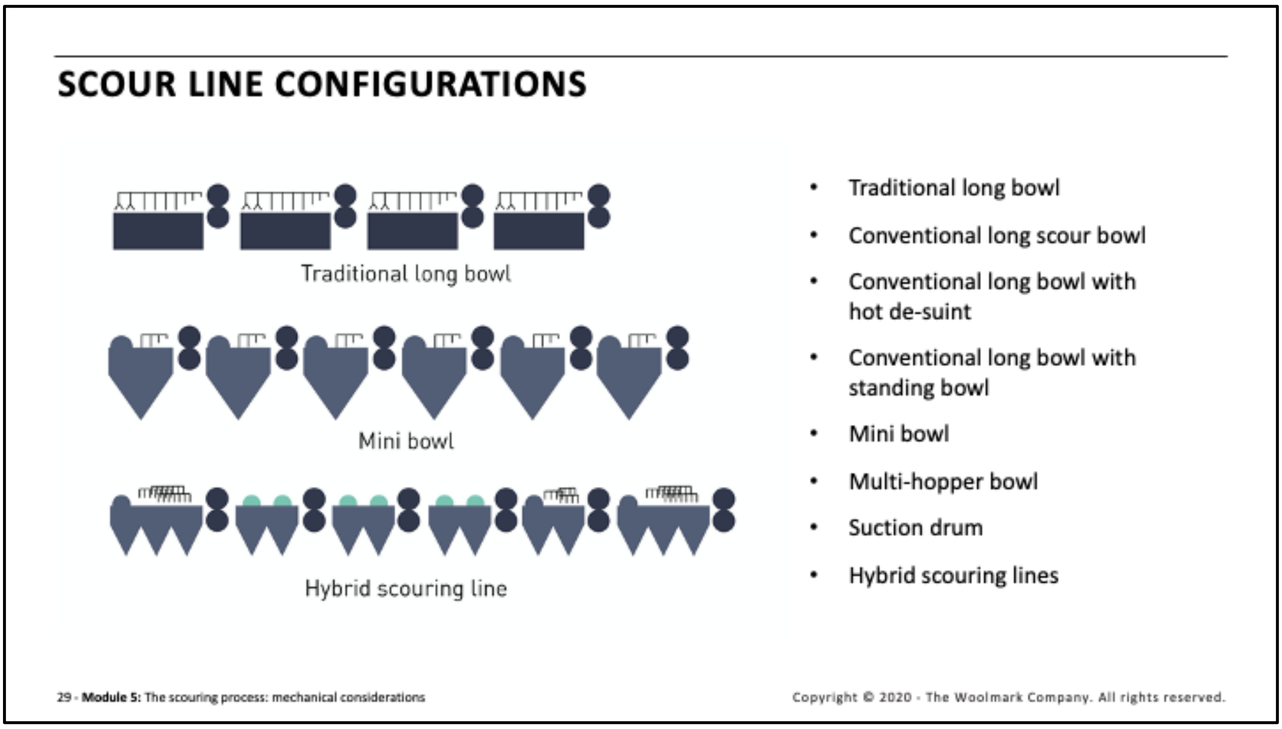
Side bowl — a crucial component of a scouring bowl, the side bowl acts as a:

- buffer system for the scouring liquor (without a buffer system, deterioration in scouring performance will occur as the bowl becomes depleted in liquor)
- tank which flows to the contaminant recovery devices
- receptacle for the addition of scouring chemicals, which allows pre-mixing in the liquor before introduction to the scour bowl
- receiving tank for counter current flow from the subsequent bowl or fresh water.

Heating — the simplest way of heating the water in a scouring bowl is through live stream injection. This is an expensive process, as it consumes large amounts of steam and generates high energy costs.

NOTE THAT modern scours have heat exchangers, which use steam or gas firing to heat the scouring liquor.



EXPLAIN THAT conventional scour configurations include traditional long bowl and variations on this theme, mini bowl, multi-hopper bowls and hybrid systems.

REFER TO the images on the slide as you explain some of the scour line configurations.

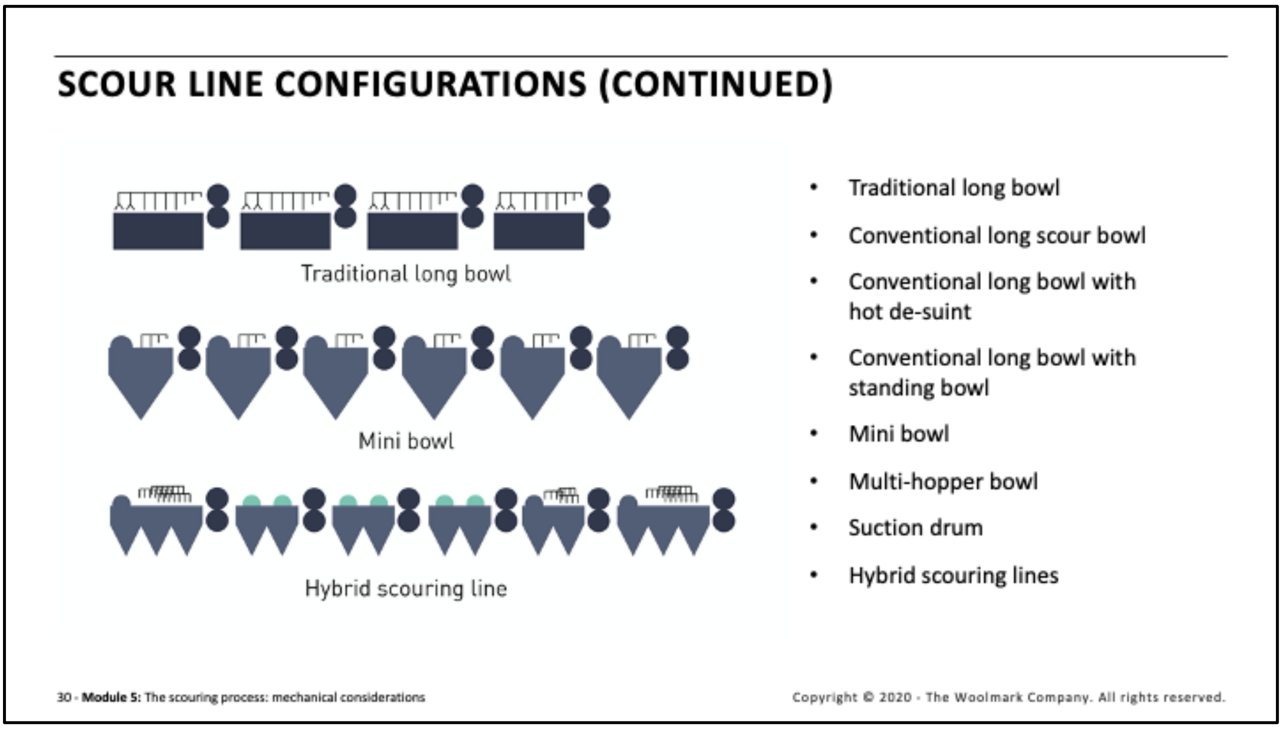
Traditional long bowl (shown on slide)
The traditional long bowl consists of four to five bowls without hopper bottoms.
This conventional long bowl scour was common about 50 years ago and is still used in a number of sites in China.
The advantage of this system is that the long contact time facilitates swelling of contaminants and cleaning of wools, especially for lower-yielding wool types.
However, the potential for entanglement is high due to the number of working points.
Also, the scouring bowls have to be dropped regularly to replace the scour liquor, which increases operating costs and reduces processing efficiency.

Conventional long bowl with hot de-suint
The convention long bowl with a hot de-suint configuration is a variation of the traditional system in which the first bowl is a hot de-suint bowl, followed by two scouring bowls and two rinsing bowls.
It is a typical configuration for many Chinese wool scours.
Several issues can occur with this configuration:

- wool slippage at the nip of the de-suint bowl is common
- reduction in wool wax recovery
- high potential for entanglement, due to removal of wool wax in the de-suint bowl
- increased costs due to bowls needing to be regularly dropped.

Conventional long bowl with standing bowl
Use of a conventional long bowl with standing bowl configuration is limited to only some scouring lines in China.
It involves four or five bowls, consisting of two standing bowls followed by two or three rinsing bowls.
There are a number of disadvantages with this system including:

- frequent dropping of the bowls, impacting cost and efficiencies
- increased carryover of contaminants into rinsing bowls, increasing the possibility of re-deposition and a poor colour in scoured wool.



REFER TO the images on the slide as you further explain scour line configurations.

Mini bowl (shown on slide)
Mini bowls, measuring 2 m long, became popular during the 1970s to scour New Zealand carpet wool.
There are fewer working points in this system given the short length — this is beneficial for high-yielding wools used on the worsted system as it reduces the propensity for entanglement.
The high agitation rate increases the possibility of fibre entanglement.

Multi-hopper bowl
In recent years, configurations have evolved from mini bowls to a multiple hopper (multi-hopper) bowl format in which the numbers of hoppers differ for each bowl.
A typical scour has six multi-hoppers with a total scouring length of 20–30 m.
This system can process lower-yielding wools more effectively; however, the greater length means a greater potential for entanglement.
Care needs to be taken to limit the effects of different working points to produce a clean, quality product.
A typical scouring line for processing Australian wool is a multi-hopper-bottom system consisting of six bowls.

Suction drum
The suction drum scouring configuration produced over the past 30 years has used six or seven double-hopper bowls.
There is low potential for fibre entanglement in this system because of the suction drums, but as the wool mat acts as a filter in the rinsing bowls, this can lead to high levels of re-deposition and poor colour.
Gentle action makes it difficult to effectively scour poorer-quality wools.

Hybrid scouring lines (shown on slide)
The hybrid scouring line combines the gentle action of suction drums for removing wool wax with the more vigorous action of the triple-crank rakes for removing dirt and improving wool colour.
It comprises six multi-hopper bowls with longer bowls at the start and end of the scour line and three scouring bowls with suction drums.
The action of the three suction bowls increases the level of contaminants in the first rinse bowl.

SCOURING LINE CONFIGURATIONS: INFLUENCING FACTORS

- Cost — setting up plumbing, contaminant recovery loops and wastewater discharge.
- Space limitations — arranged in a line from preparation equipment, through the bowls to the dryer.
- Types of wool — length of the bowls needs to be reduced for the finer, longer wools used on the worsted system.
- Production rate — width of the scouring line may need to be altered according to production needs.

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EXPLAIN THAT it is expensive to change a scouring line configuration after installation, therefore, several factors need to be considered when planning a scouring line set-up:

Cost

When a new scour is installed, it is useful to set up the plumbing, contaminant recovery loops and wastewater discharge so the flows of water, liquor and wastewater can be changed.

As this involves extra cost, a compromise needs to be reached between flexibility and cost.

Space limitations

Scouring lines are usually arranged in a line from the preparation equipment, through the bowls to the dryer.

The minimum linear design is: brattice feed hopper, weigh belt feeder, bowls and dryer.

Types of wool being processed

Fine wools are significantly more susceptible to entanglement than broad wools and care needs to be taken to limit entanglement. For such wools shorter bowls are used to reduce entanglement.

Poorer-quality wools require more mechanical action than high-quality wools in terms of preparation and scouring so longer bowls are used.

Production rate

The production rate must match the output from a vertical mill, but can be considerably less than the output from a commission processor.

The width of the scouring line needs to be chosen according to production needs. This cannot be altered after the scour is installed.

DRYING THE SCOURED WOOL

- Pre-drying (mechanical)
- Drying (thermal)

32 - **Module 5:** The scouring process: mechanical considerations

EXPLAIN THAT as the scoured wool leaves the final rinse bowl it is mechanically squeezed to extract excess water before it is delivered to a thermal dryer to further reduce moisture levels. The mechanical pre-drying is usually carried out using a high-pressure squeeze or a double squeeze. Continuous centrifuges have been used during the past, but they require extra components to feed the wet wool to the thermal dryer components. Wet feed hoppers can cause further entanglement.

NOTE THAT after mechanical extraction the scoured wool still may have a moisture content of around 150 per cent. To process this wool into yarn the moisture content needs to be further reduced; ideally to around 15 per cent. If the wool is too dry, the vegetable matter can break up during the carding process, making it more difficult to remove. If the wool is too wet, certain types of vegetable matter can unravel, making it difficult to remove, nep formation will increase and there will be additional fibre breakage in the subsequent sliver or slubbing.

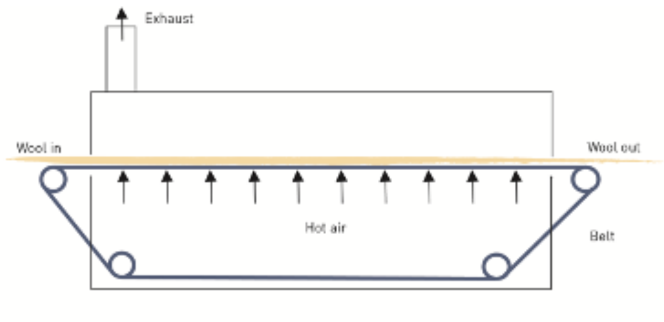
EXPLAIN THAT thermal (hot air) drying is employed to extract the remaining excess moisture. Commonly used dryers include: brattice or tray dryers, drum dryers or a unidryer. These are covered in more detail on the following slides.

EXPLAIN THAT in some types of dryers the wool layer fed to the dryer needs to be of a uniform thickness, without gaps, to ensure even drying. Regardless of the dryer type, the rate of feed to the dryer also must be constant.

As stated earlier, a spiked brattice feed hopper can be used between the final squeeze press (mechanical) and the thermal dryer, which opens the fibres, gives constant feed and a uniform layer of wool. However, this type of feed can also enhance entanglement.

EXPLAIN THAT typically the air used to dry the wet wool is around 120°C. The airflow and the removal of moist air during the drying process are critical control parameters in a modern dryer. The airflow used in dryers is typically 3-4 metres per second and the removal of humidified air is controlled by humidity sensors within the dryer. Temperature and humidity gauges are normally coupled to directly measure the wool moisture as it leaves the dryer (as shown on the slide).

BRATTICE DRYER

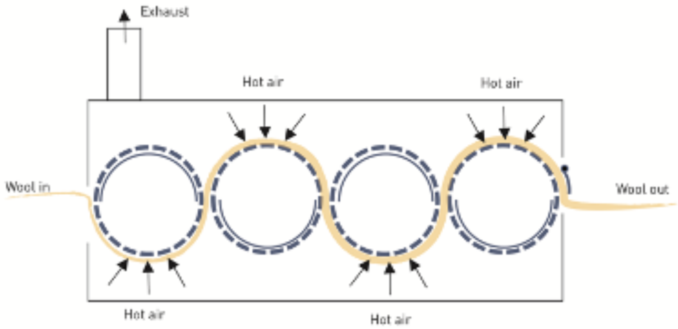


Brattice dryer

33 - **Module 5:** The scouring process: mechanical considerations

REFER TO the slide as you note that an even layer of wool is fed into the brattice dryer and onto a moving belt, through which hot air passes to reduce the moisture within the wool. Moist air leaves the dryer through the exhaust.

DRUM DRYER

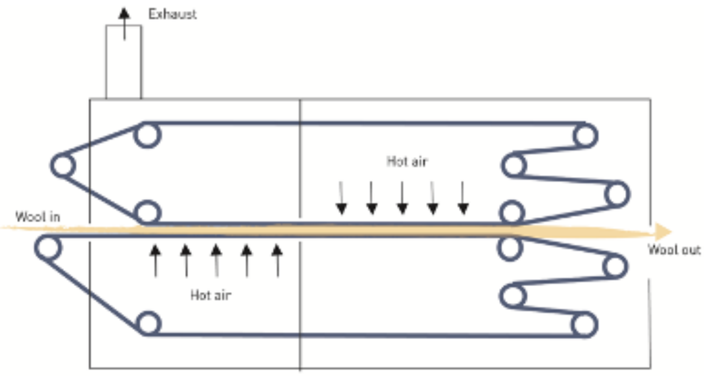


Drum dryer

34 - **Module 5:** The scouring process: mechanical considerations

REFER TO the slide as you note that in a drum dryer the wool layer is sucked onto permeable drums by the hot airflow. This method follows the same principle as that of a suction drum transportation system in the scouring bowls.

UNIDRYER



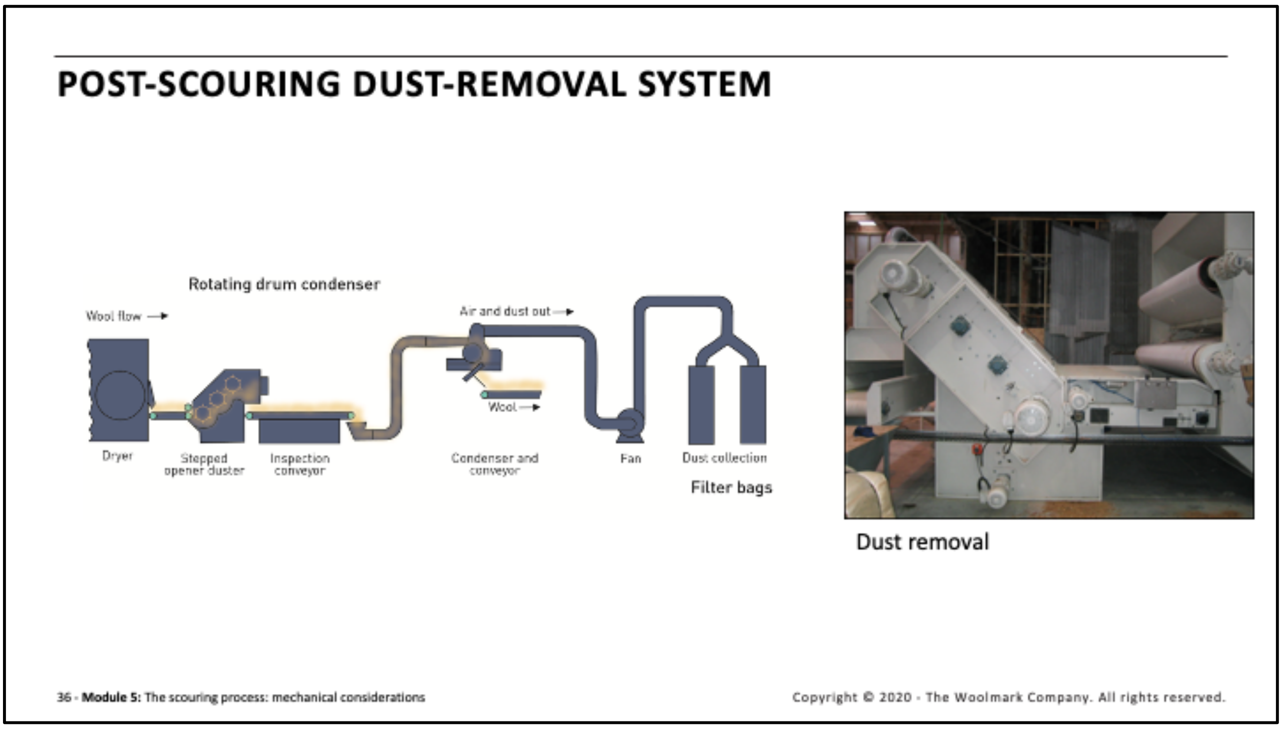
Unidryer

35 - **Module 5:** The scouring process: mechanical considerations

REFER TO the slide as you note that the unidryer is the most modern of the dryer designs and carries the wool through the machine between two permeable belts. The hot air penetrates the wool layer from above and below in the separate sections of the dryer.

POINT OUT that this design effectively traps the wool layer to prevent movement of clumps of wool ensuring a uniform layer of wool is presented to the dryer.

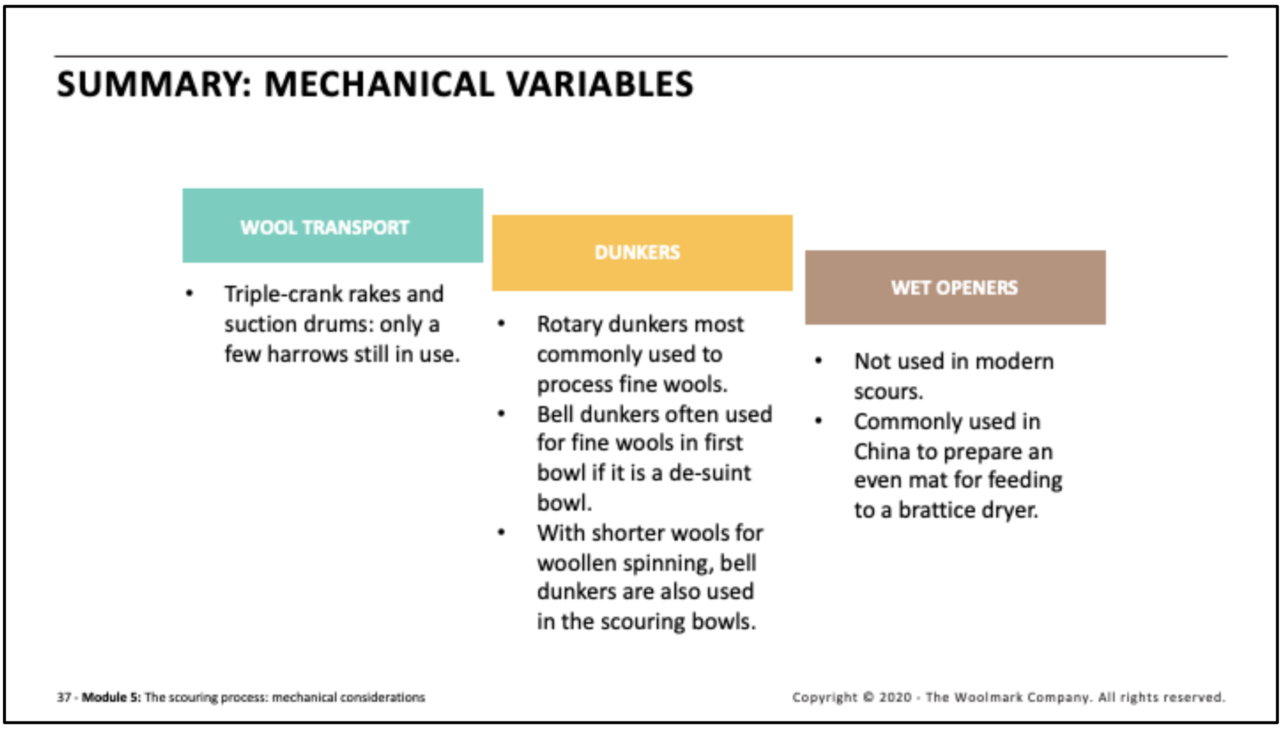
INDICATE THAT the pressure drop over the wool layer is kept to a minimum to ensure even drying.



EXPLAIN THAT after drying, the wool is opened again to break up any clumps of wool, allowing any remaining dust entrapped in the fibre clumps to fall out.

The machines used are similar in action to the opening machines used before scouring and include:

- step blenders
- drum shakers
- single drums
- fearnoughts (for heavily contaminated and entangled wool).



EXPLAIN THAT many different combinations of preparation equipment are used in commercial scouring mills, but the combination of equipment feeding directly into the wool scour is similar.

Wool transport
The systems used for transporting wool are triple-crank rakes and suction drums, with only a few harrows still in use.

Dunkers
Rotary dunkers are most commonly used in modern scours processing fine wools, although fishtail dunkers are used with shorter wools for the woollen system.
With fine wools, bell dunkers are often used in the first bowl if it is a de-suint bowl.
With short wools, bell dunkers are also used in the scouring bowls.

Wet openers
Wet openers are not used in modern scours, although they are commonly used in China to prepare an even mat for feeding to a brattice dryer.

SUMMARY — MODULE 5

A scouring line consists of:
- opening line section
- weigh belt
- scouring bowls
- dryer.

The scouring bowl is the main modular component of the scouring line, and is made up of a range of elements including:
- the wool transport system
- the liquor handling system
- a range of scouring bowl designs and configurations
- a contaminant recovery system.

Factors influencing a scouring line configuration are:
- cost
- space limitations
- types of wool being processed
- production rates.

A typical scouring line for processing is the Australian wool is the multi-hopper-bottom system consisting of six bowls.

38 - **Module 5:** The scouring process: mechanical considerations

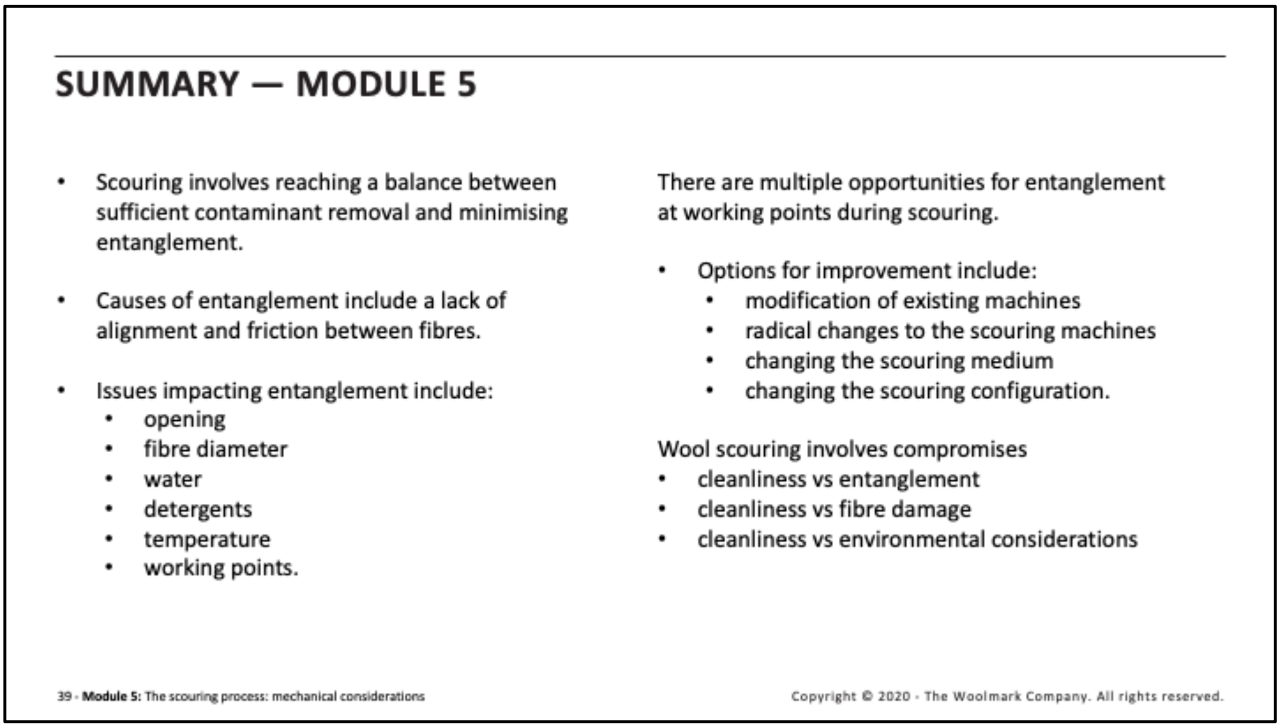
SUMMARISE the module by reinforcing the following points:

A scouring line consists of:
- opening line section
- weigh belt
- scouring bowls
- dryer.

REMIND participants that the scouring bowl is the main modular component of the scouring line, and is made up of a range of elements including:
- the wool transport system — moves wool in and out of the scouring liquor and through the squeezing system and includes: interstage conveyor, dunkers, wool transport, wool transfer to the squeeze rollers
- the liquor handling system — scouring liquor moves through the scouring bowl and into a side tank before being heated and returned to the scour
- a range of scouring bowl designs and configurations
- a contaminant recovery system.

Factors influencing a scouring line configuration are:
- cost
- space limitations
- types of wool being processed
- production rates.

NOTE: A typical scouring line for processing is the Australian wool is the multi-hopper-bottom system consisting of six bowls.



REMIND participants scouring involves reaching a balance between cleaning the wool sufficiently and minimising entanglement in order to reduce losses and fibre breakage during subsequent processes.

Causes of entanglement include: a lack of alignment and differential friction between fibres

REVIEW THE issues impacting entanglement which include:

- intensity of opening
- fibre diameter
- water
- detergents
- temperature
- number and intensity of working points.

REVIEW THE opportunities for entanglement at working points during scouring which include:

- feed to a bowl
- dunkers
- transport mechanisms
- water levels
- transfer from a bowl
- squeezing rollers
- wet opening.

REVISE options for improvement which include:

- modification of existing machines
- radical changes to the scouring machines
- changing the scouring medium
- changing the scouring configuration.

Wool scouring involves compromises between:

- cleanliness vs entanglement
- cleanliness vs fibre damage
- cleanliness vs environmental considerations.

Drying the scoured wool is an important part of the whole process
The wool must be dried evenly to the correct moisture content to facilitate later processes
The three main types of dryer include:

- brattice dryers
- drum dryers
- unidryers.

A dusting operation normally follows drying.

***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.*

39

INFORM participants of the time and location for the next lecture — *Module 6 The Scouring process: process variables* — 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 6

THE SCOURING PROCESS: PROCESS VARIABLES

RESOURCES — MODULE 6: THE SCOURING PROCESS: PROCESS VARIABLES

No additional resources are required to deliver **Module 6: The scouring process: process variables**.

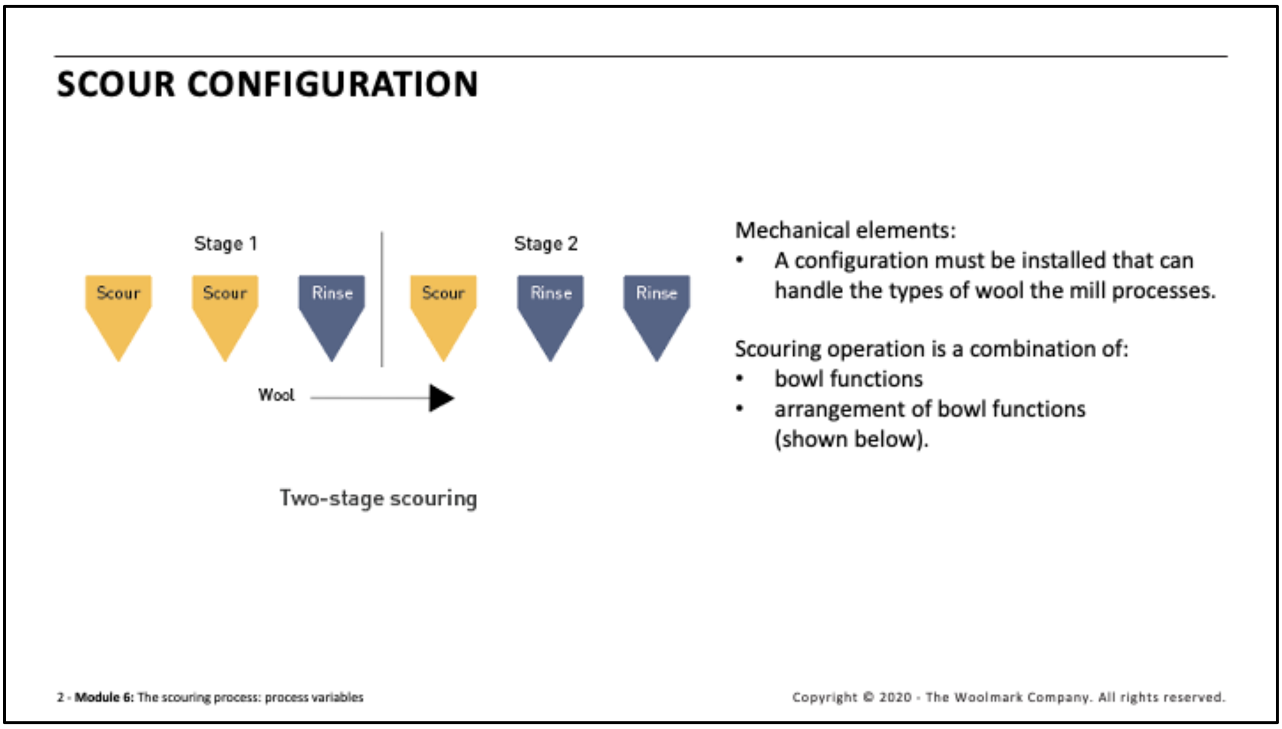
WELCOME participants to Module 6 of the Woolmark Wool Science, Technology and Design Education Program *Raw Wool Scouring — The scouring process: process variables.*

EXPLAIN THAT this module will cover:

- scour configuration
- water
- surfactants
- builders
- other chemical additions
- temperature ranges.

INFORM participants that by the end of this topic they will be able to describe the process variables that need to be considered in the scouring line.

NO RESOURCES REQUIRED



EXPLAIN THAT there are two considerations in the configuration of a scouring line:

- mechanical elements
- the scouring operation.

1. Mechanical elements

The mechanical elements involved in a scour were discussed in *Module 5: The scouring process: mechanical considerations.*
Here the difficulty of changing the physical and mechanical configuration after a scouring line has been assembled is discussed.
As outlined in Module 5 it is important mills install the configuration that can handle the types of wool they will process.

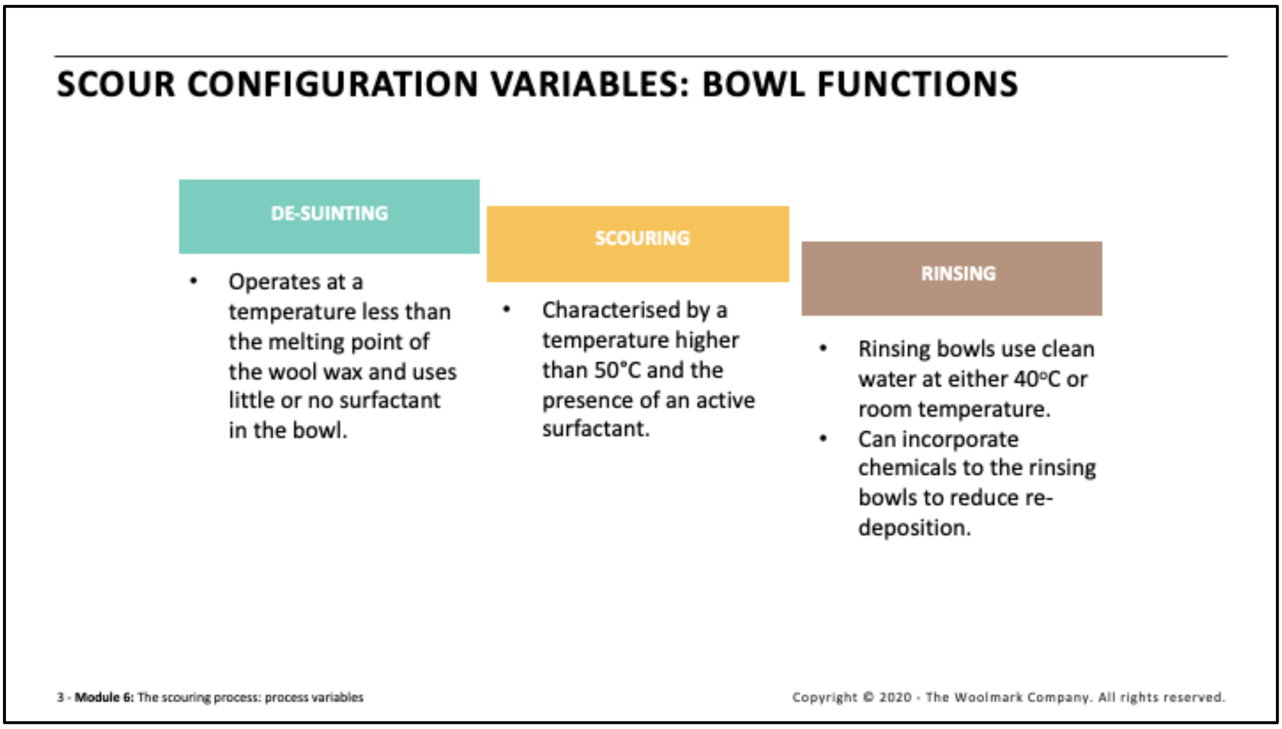
2. Scouring operation

In order to have a flexible system that can handle different types of wool, it is important to consider the piping arrangement for the water distribution between the scouring bowls:

- for contaminant recovery loops
- for wastewater flowdowns.

INDICATE THERE are a number of variables which affect the configuration of a scour including:

- bowl functions
- arrangement of bowl functions (as shown on the slide).



NOTE TO FACILITATOR: *This slide is animated — before revealing the content of the slide:*

EXPLAIN THAT a bowl in the scouring line can perform one of the following three functions:

- de-suinting
- scouring
- rinsing.

ASK *participants to briefly describe the purpose of each of these three functions.*

COLLECT *responses from two or three participants across the room and then reveal the slide contents and expand on each point as outlined in the notes.*

De-suinting

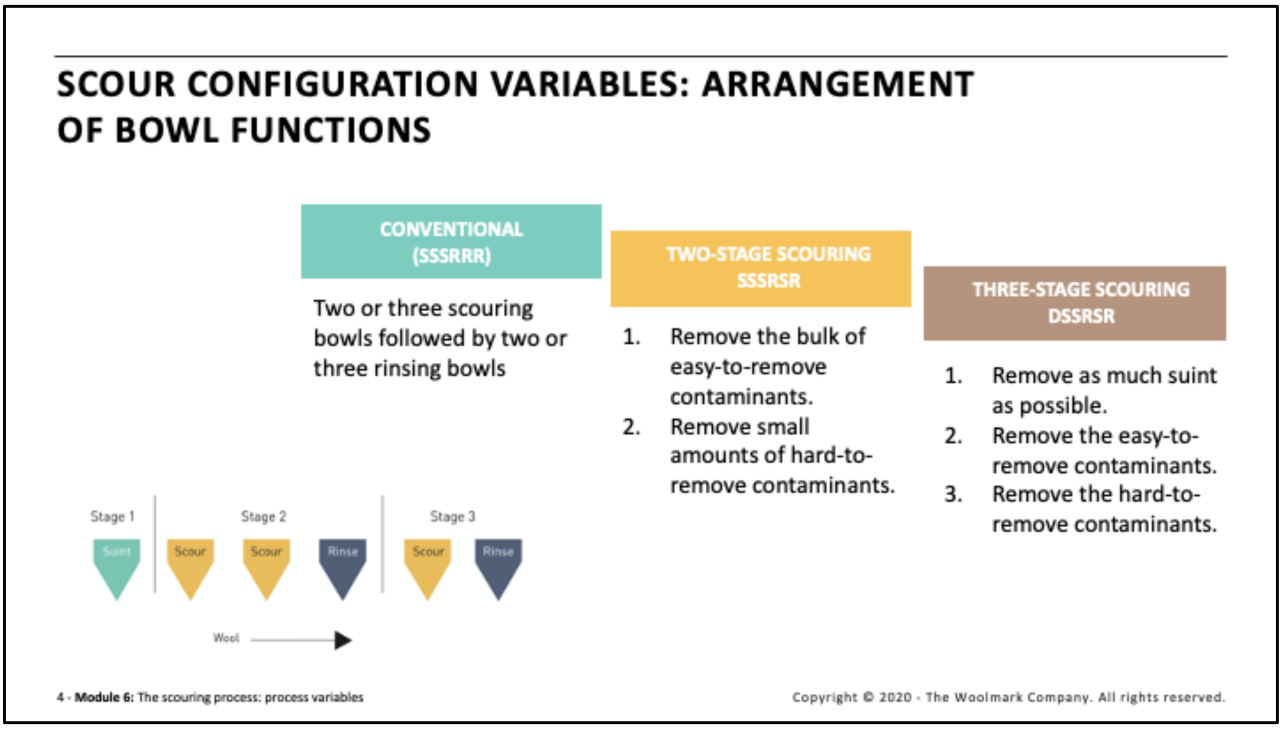
- removes as much dirt and suint as possible without removing wool wax
- operates at a temperature less than the melting point of the wool wax
- involves little or no surfactant in the bowl
- the bowl is often called the ‘suint bowl’.

Scouring

- removes the bulk of the raw wool contaminants, especially the wool wax
- is characterised by a temperature higher than 50°C
- uses an active surfactant.

Rinsing

- removes contaminants entrained in the scouring liquor, carried over in the wool using clean water
- removes loosely-adhering contaminants
- may utilise chemicals in the rinsing bowls to prevent re-deposition of contaminants.



EXPLAIN THAT there are three ways of arranging the bowl functions in a scouring line:

- conventional: scour–scour–scour–rinse–rinse–rinse (SSSRRR)
- two-stage scouring: scour–scour–scour–rinse–scour–rinse (SSSRSR)
- three-stage scouring (shown on the slide): de-suint–scour–scour–rinse–scour–rinse (DSSRSR).

1. Conventional

In this system, two or three scouring bowls are followed by two or three rinsing bowls.

A variation occurs when the first bowl is used as a de-suint bowl.

2. Two-stage scouring

Two-stage scouring can be used with any modern scouring configurations that has at least six bowls.

It doesn't depend on the wool transport system.

The basic principle is to divide the scouring line into two stages:

- remove the bulk of easy-to-remove contaminants
- remove the small amounts of hard-to-remove contaminants.

This approach provides time for hard-to-remove contaminants to hydrate and swell, facilitating their removal.

3. Three-stage scouring

Stage 1

In this modified de-suint bowl (Bowl 1), as much suint as possible is removed without really displacing too much wool wax. This means the dirt will be more readily removed during the dirt recovery system.

By separating the de-suint discharge from the scouring discharge, less chemicals are needed in subsequent wastewater treatment.

Stage 2

The easy-to-remove contaminants are removed. Bowls 2 and 3 are scouring bowls containing hot surfactant solution.

Bowl 4 is a rinse bowl to rinse easy-to-remove contaminants and allow more time for the hard-to-remove contaminants to hydrate and swell.

Stage 3

The hard-to-remove contaminants are removed. Surfactant is added to Bowl 5 to facilitate contaminant removal and to prevent re-deposition.

Bowl 6 provides the final rinsing action.

ARRANGEMENT OF BOWL FUNCTIONS: CONSIDERATIONS

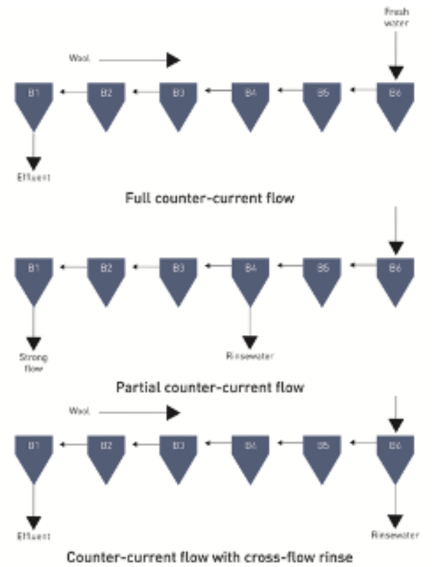
- A bowl is for scouring wool and is not a settling tank.
- Bowls should be erected above the level of the factory floor for access to equipment underneath the bowls.
- A well-configured scouring line can be changed between different modes of operation depending on the quality of the wool being scoured.

5 - **Module 6:** The scouring process: process variables

EXPLAIN THE practical issues or considerations that impact on scouring bowl configurations include:

- A bowl is for scouring wool and isn't a settling tank.
- The bowls should be erected above the level of the factory floor for access to equipment underneath the bowls.
- A well-configured scouring line can be changed between different modes of operation, depending on the quality of the wool being scoured.

WATER VARIABLES



Patterns of water use must change to operate a scour using different configurations.

Options available in a conventional scour configuration:

- full counter-current flow
- partial counter-current flow
- counter-current flow with cross-flow rinse
- partial flow of rinsewater to de-suint bowl.

- Note: Standing bowls with or without cross-flow rinse are now rarely used

6 - **Module 6:** The scouring process: process variables

EXPLAIN THAT wool scours have traditionally been located near sources of high-quality water to avoid issues associated with:

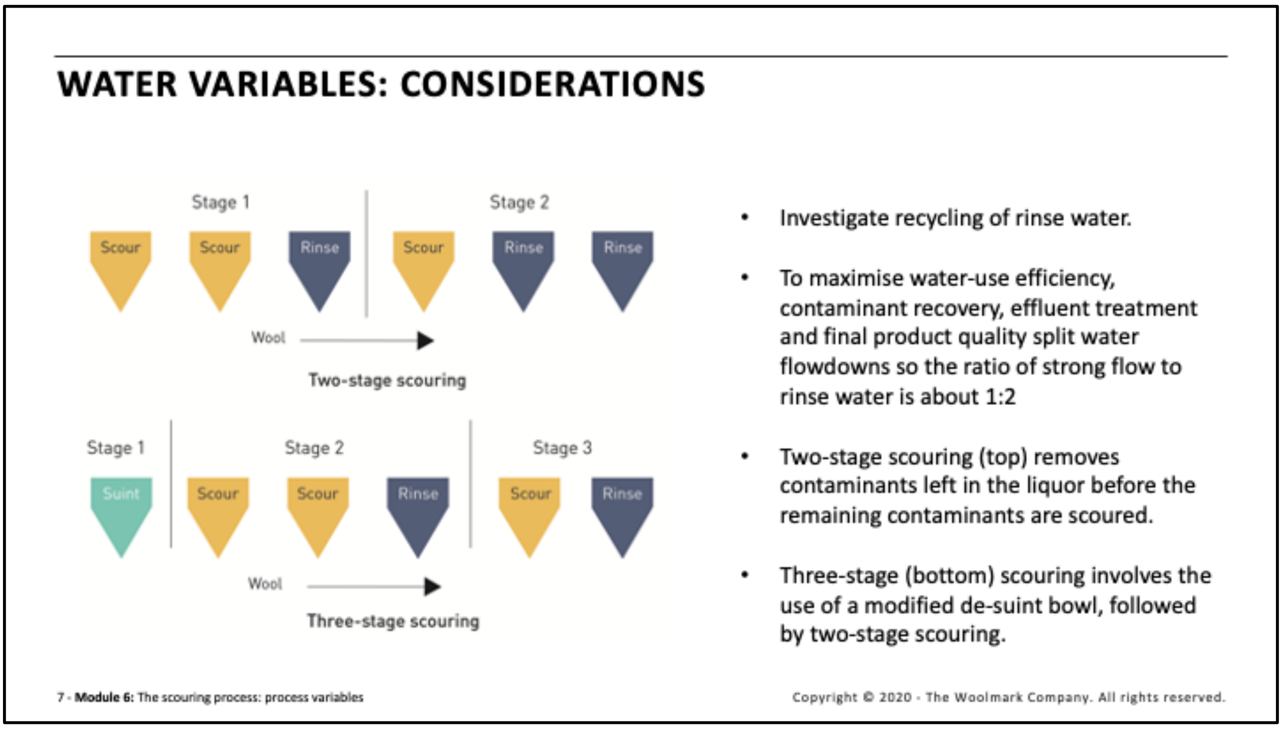
- hardness
- multivalent cations.

NOTE THAT water has become a more expensive and limited resource, so it is important water is used effectively and efficiently during scouring.

Patterns of water use:
To operate a wool scour using different configurations, the pattern of water use must be flexible. Many modern scours are computer controlled, making it possible to change the water usage automatically.

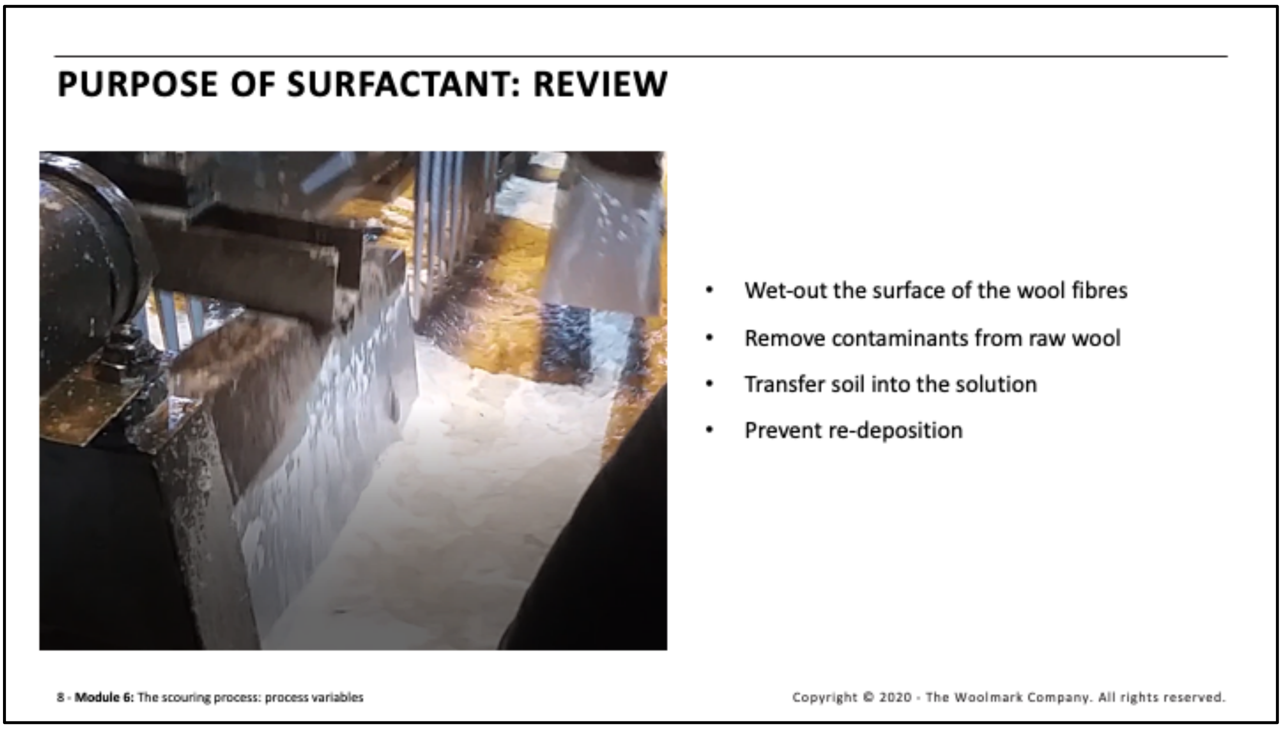
EXPLAIN THAT there are a number of options available in a conventional scour configuration (SSSRRR):

- **Full counter-current flow** (shown on slide) is the most effective use of water in terms of contaminant extraction, however not in terms of contaminant recovery and effluent treatment.
- **Partial counter-current flow** (shown on slide) Standing bowls with partial counter-current flow and cross-flow rinsing are used at some Chinese mills.
- **Counter-current flow with cross-flow rinse** (shown on slide) allows the water to flow back to the first rinsing bowl before it is discharged. This partial counter-current flow is the most common method for using water in modern wool scours.
- **Standing bowls with cross-flow rinse** (not shown). The two scouring stages are separated by a rinsing bowl where contaminants remaining in the liquor are removed before the remaining hard-to-remove contaminants are removed. This system is the best compromise to using water to maximum effect and to producing a more concentrated strong flow of discharge.
- **Partial flow of rinsewater to de-suint bowl** This configuration (not shown) uses rinse water as a feed to the suint bowl resulting in a reduction on water use.



INDICATE THAT the following considerations and practical issues are applicable to water variables in the scouring line:

- Investigate recycling of rinse water to reduce consumption and increase quality of the scoured product by rinsing the wool in clean water.
- In terms of maximising contaminant recovery, effluent treatment and product quality, the water flowdowns should be split so the ratio of strong flow to rinse water is about 1:2.
- Partial counter-current flow with cross-flow or partial counter-current flow in the rinsing bowls compromises the extraction efficacy of full counter-current flow and the need to reduce the volume of the strong flow effluent discharge.
- Two-stage scouring has a rinsing bowl that separates the two scouring stages, which removes contaminants remaining in the liquor before the remaining hard-to-remove contaminants are scoured.
- Three-stage scouring involves the use of a modified de-suint bowl followed by two-stage scouring.



NOTE TO FACILITATOR: *this slide is animated.*

BEFORE *revealing slide contents ask participants to recall the purpose of detergents in wool processing.*

COLLECT *responses from two or three participants and record on whiteboard or flipchart.*

CLICK *to advance the slide to reveal the purpose of detergents in wool processing.*

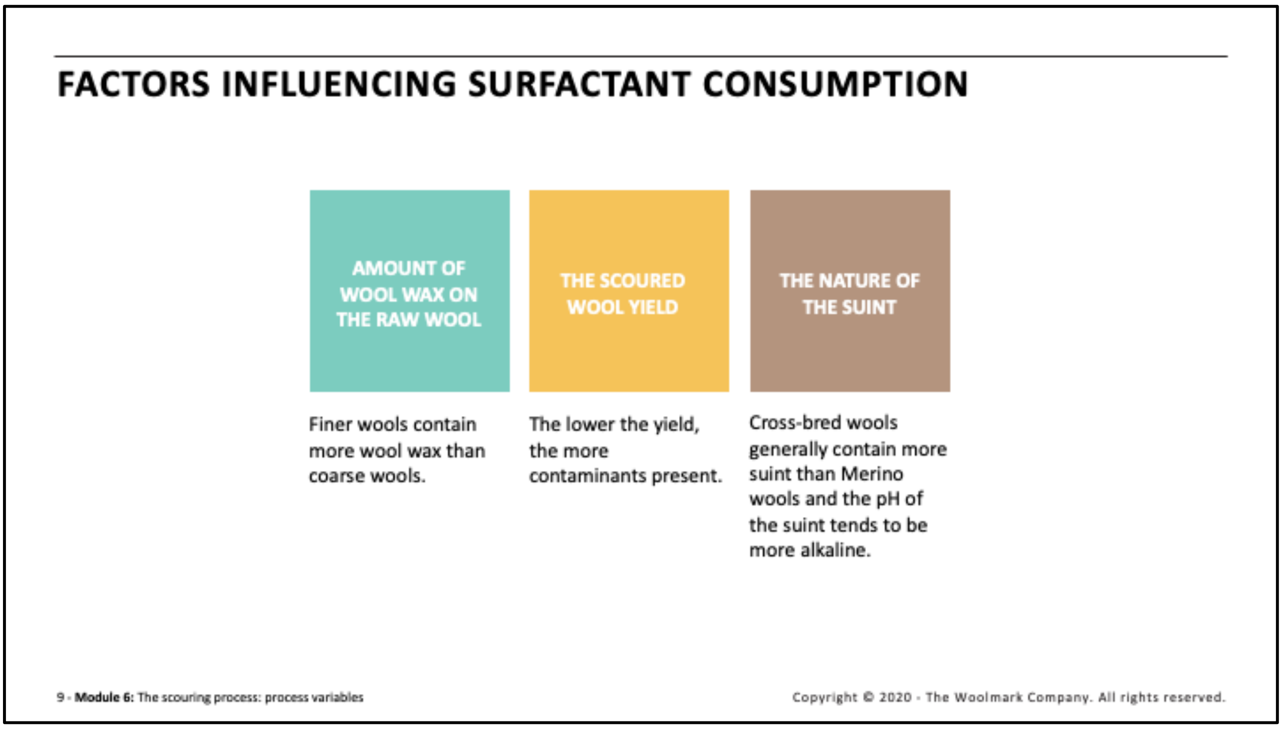
ASK *participants if they can recall the types of detergents normally used during the scouring process.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *confirm that anionic and non-ionic detergents are normally used. They are sometimes mixed.*

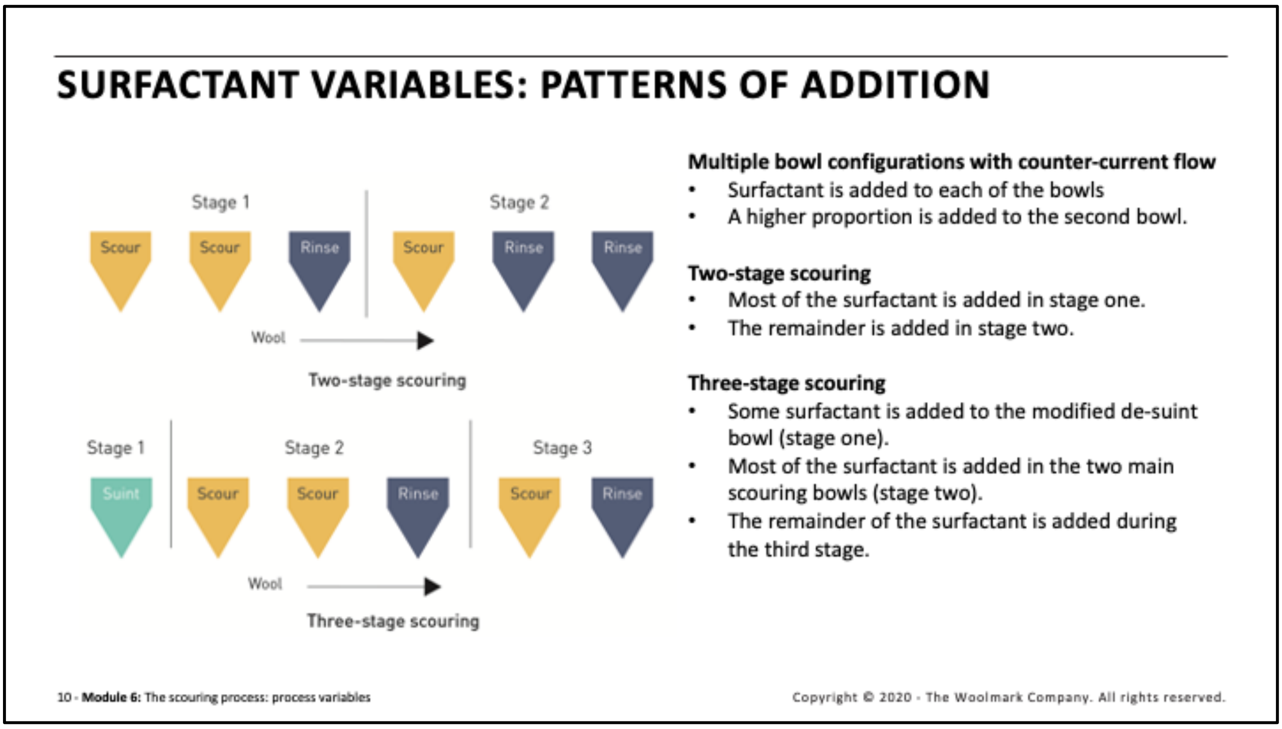
EXPLAIN THAT as discussed in *Module 4: Detergency and entanglement*, the purpose of surfactants in wool processing are to:

- wet-out the surface of the wool fibres
- remove contaminants from raw wool
- transfer soil into the solution
- prevent re-deposition.



EXPLAIN THAT the factors that influence surfactant consumption in wool scouring include:

- the amount of wool wax on the raw wool — finer wools contain more wool wax than broad wools
- the scoured wool yield — the lower the yield, the more contaminants present
- the nature of the suint — cross-bred wools (i.e. broad wools) generally contain more suint than Merino wools (i.e. fine wools) and the pH of the suint from cross-bred wools tends to be more alkaline, which aids the scouring process.



EXPLAIN THAT the patterns of surfactant addition depend on the scour configuration:

Multiple bowl configurations with counter-current flow

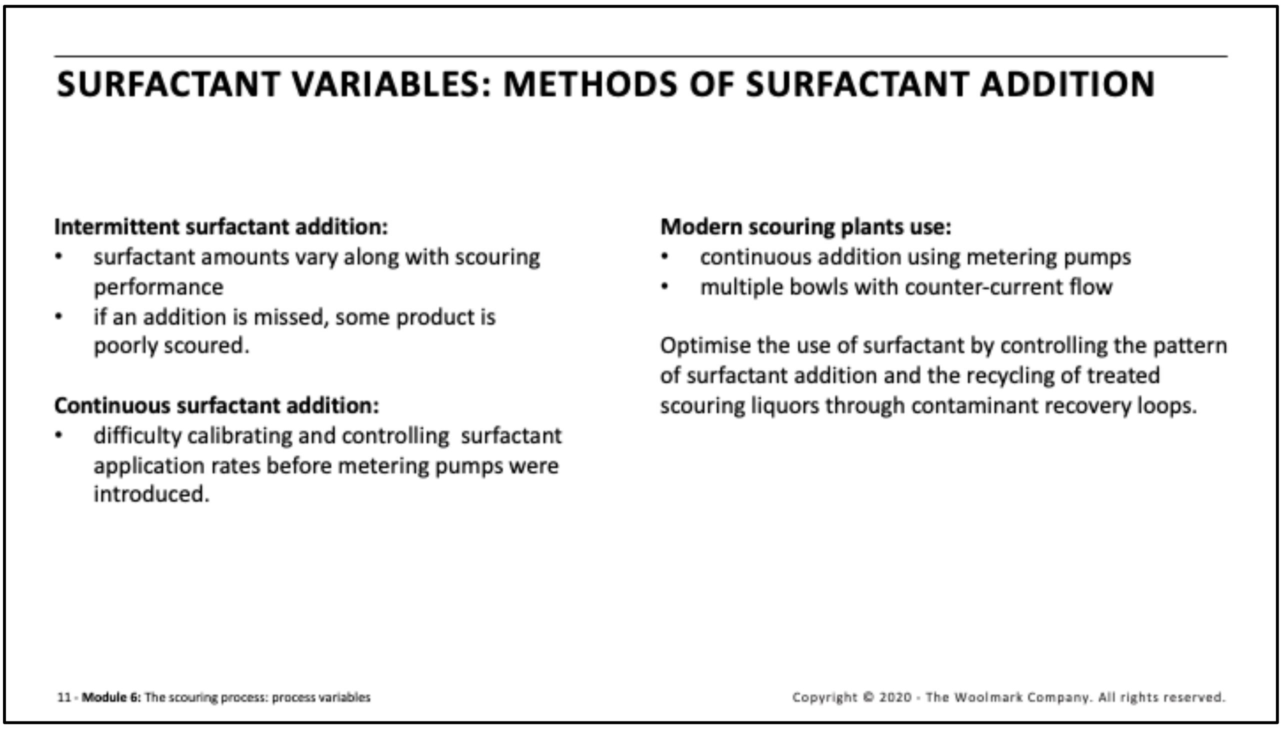
- Surfactant is added to each of the bowls with a higher proportion being added to the second scouring bowl, so surfactant is transferred to the first scouring bowl through counter-current flow.

Two-stage scouring

- Because an intermediate rinse is used at the end of stage one, most of the surfactant is added to the first two 'scour' bowls and the remainder is added to the first bowl of stage two (the final 'scour' bowl) for the second scouring stage.
- Care must be taken not to add too much surfactant to prevent excessive foaming.

Three-stage scouring

- Most of the surfactant is added in the two main scouring bowls in stage two.
- Some surfactant is added initially to the modified de-suint bowl in stage one, but when scouring has started the suint itself, in the presence of soda ash, helps wet out the wool.
- The remainder of the surfactant is added to the scour bowl in the third and final stage.



NOTE THAT surfactant can be added using two methods:

- intermittent addition
- continuous addition.

EXPLAIN THAT before metering pumps became readily available, surfactants were added intermittently— usually every 30 or 60 minutes.

This meant the amounts of available surfactant would vary, as would the scouring performance. If an addition was missed, then some of the product would be poorly scoured.

EXPLAIN THAT this situation was improved by adding surfactant continuously through a drip feed system, but it is difficult to calibrate and control the application rate with continuous addition systems.

INDICATE THAT all modern scours use metering pumps as they are easy to calibrate.

MENTION TO participants the considerations and practical issues with surfactant use:

- Use multiple bowls with counter-current flow.
- Use continuous addition by reliable metering pumps to regulate surfactant flow and quantity.
- Optimise the use of surfactant by controlling the pattern of surfactant addition and the recycling of treated scouring liquors through contaminant recovery loops.

SURFACTANT VARIABLES: BUILDERS

The purpose of a builder can be to:

- improve contaminant removal
- moderate the pH to expedite contaminant removal
- prepare the scoured wool for subsequent processing.

The most common builders are:

- sodium carbonate
- sodium hydroxide
- sodium sulphate
- suint.

12 - **Module 6:** The scouring process: process variables

EXPLAIN THAT a builder is a chemical – usually an inorganic salt – that improves the performance of a surfactant even though it has no surfactant properties itself.

EXPLAIN THAT the purpose of a builder can be to:

- improve contaminant removal
- moderate the pH of the scouring liquor to expedite contaminant removal
- prepare the scoured wool for subsequent processing.

INDICATE THAT the most common builders are:

- sodium carbonate
- sodium hydroxide
- sodium sulphate
- suint.

EXPLAIN THAT sodium carbonate and sodium hydroxide are both alkaline builders, which can have two effects:

- The alkalinity makes it easier to remove dirt from the fibre.
- There is a belief that wool with alkaline pH processes perform better during top-making.

EXPLAIN THAT a disadvantage of alkaline builders is the increased risk of fibre damage leading to increased yellowing and decreased strength of the fibre.

POINT OUT that suint itself is a builder, and under alkaline conditions can have deterging properties apart from acting as a builder. This is clear when cross-bred wools are scoured.

NOTE: If a de-suint bowl is used (as in three-stage scouring), the amount of surfactant required increases significantly.

***ASK** participants if they can explain* why *suint is considered a builder.*

***ALLOW** participants sufficient time to respond.*

***IF NECESSARY** confirm that suint contains significant amounts of dissolved salts and affects the pH of the scouring liquor.*

SURFACTANT VARIABLES: OTHER CHEMICAL ADDITIONS

- Additional chemicals can be required to improve the quality of the scoured wool due to a decrease in water consumption and availability of high-quality water.
- These chemicals perform anti-re-deposition functions to prevent re-deposition of harder-to-remove contaminants and complexing functions to remove metal ions.

13 - **Module 6:** The scouring process: process variables

EXPLAIN THAT the reduction in water consumption in modern scouring processes and availability of high-quality water has meant additional chemicals, mainly in rinsing bowls, are often required to improve the quality of the scoured wool.

INDICATE THAT these chemicals also perform anti-re-deposition functions, to prevent re-deposition of harder-to-remove contaminants, and complexing functions to remove metal ions, such as iron, calcium and magnesium.

SURFACTANT VARIABLES: IMPORTANCE OF TEMPERATURE

- Surfactant effectiveness
  - Non-ionic surfactants have an optimum temperature range.
  - Anionic surfactants improve with increasing temperature.
- Fibre damage
  - The potential for damage increases with increasing temperature.
- Entanglement
  - The potential for entanglement increases due to plasticity of the wool fibre.
- Contaminant removal in suint bowl
  - If the temperature is too high, wool wax can be removed creating slippage and risking entanglement.
- Energy consumption
  - Costs increase as the bowl temperature increases.

14 - **Module 6:** The scouring process: process variables

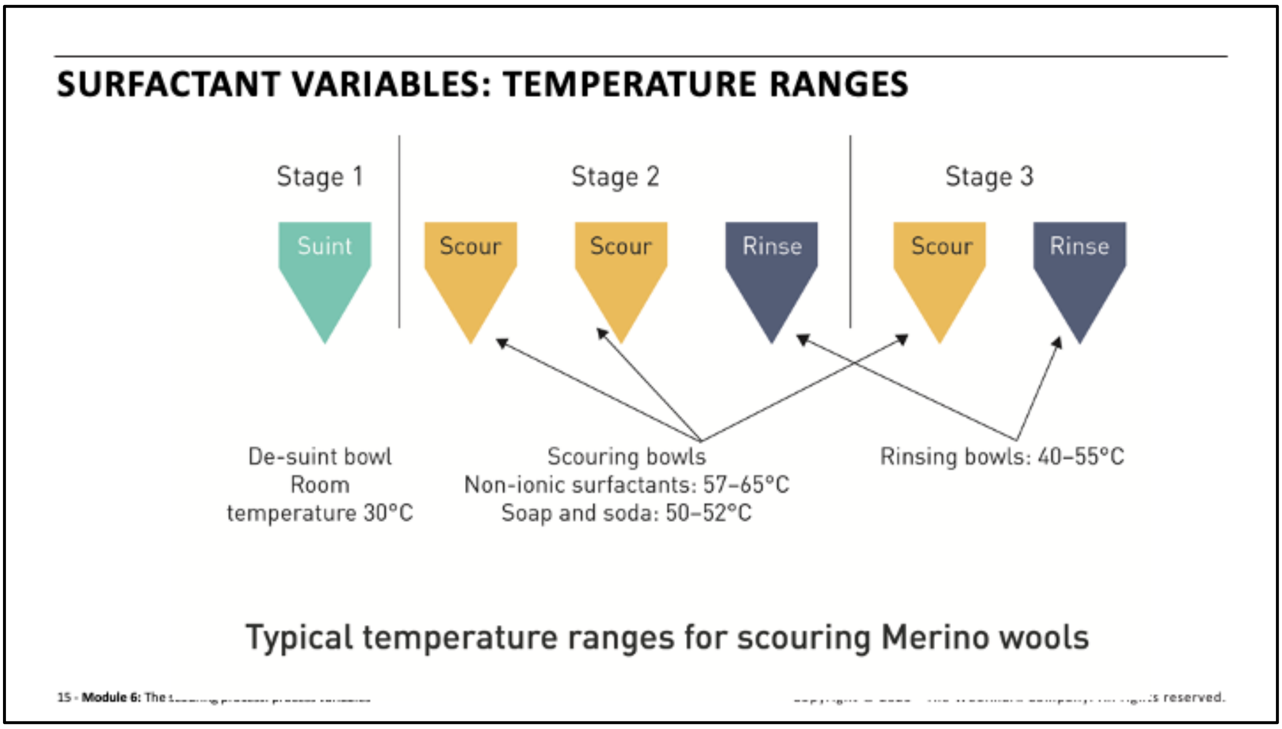
EXPLAIN THAT temperature is a key variable in the operation of a wool scour. Issues that need to be managed in relation to the scour temperature include:

- Surfactant efficacy — non-ionic surfactants have an optimum temperature range, but the efficacy of anionic surfactants increases with increasing temperature.
- Fibre damage — the potential for damage increases with increasing temperature.
- Entanglement — the potential for entanglement increases with increasing temperature, due to plasticity of the wool fibre at high temperatures. The impact of temperature on the wool fibre is discussed further in the Wool Science, Technology and Design Education Program course *Wool fibre science.*
- Contaminant removal in the suint bowl — if the temperature is too high, wool wax can be removed creating slippage and increasing the propensity for fibre entanglement.
- Energy consumption — scouring costs increase as the bowl temperature increases.

***ASK** participants if they can suggest any potential compromises involved in varying the scouring temperature.*

***ALLOW** participants sufficient time to respond.*

***IF NECESSARY** explain that higher temperatures improve the scouring result, but increase entanglement and fibre damage in the wool being scoured.*



EXPLAIN THAT the temperatures used in practice are a compromise between a number of factors. For example, scouring temperatures for carpet wools (i.e. broad wools) can be higher than those for fine Merino wools because they are less susceptible to fibre entanglement.

INDICATE THAT the typical temperature ranges for scouring Merino wools are:

- de-suint bowls:
    - room temperature – 30°C
- scouring bowls:
    - non-ionic surfactants: 57–65°C
    - soap and soda: 50–52°C
- rinsing bowls: 40–55°C.

ENTANGLEMENT AND SCOURING

Scouring machine	Scouring conditions
• Bowl function • Length of bowls • Recirculation system • Dunking system • Rake mechanisms • Squeeze rollers • Transport mechanisms between bowls	• Temperature • pH • Detergent type, concentration, pattern of addition • Production rate

16 - **Module 6:** The scouring process: process variables

EXPLAIN THAT the conditions favouring entanglement in relation to the scouring machine include:

Bowl function, de-suint, scour or rinse:

- Changing bowl function can modify cleaning, but will also affect entanglement.
- The key to preventing entanglement is the presence of wool wax on the wool fibres. The fibres cannot become entangled when the scales are covered by the wool wax. Consequently the fibres are not entangled in a de-suint bowl, but as soon as the wax is removed the potential for entanglement increases

Length of scouring bowls:

- The longer the wool is in contact with the scour liquor, the greater the potential for entanglement.

Recirculation system: flow rate and turbulence

- High rates of recirculation of scour liquors can increase entanglement especially at the spray box.

Dunking system: turbulence, location in individual bowls and along scouring train

- The type of dunking system used also will impact entanglement.

Rake mechanisms: type, rate, evenness of motion

- The type of rake used will impact entanglement.

Squeeze rollers:

- The pressure imparted by the squeeze rollers will impact entanglement.

Transport mechanisms between bowls:

- Vibration in the transportation systems can influence entanglement.

INDICATE THAT the conditions favouring entanglement in relation to the scouring conditions include:

Temperature:

- A compromise between the improved contaminant removal at higher temperatures and increased entanglement must be found.

pH

- Entanglement occurs more rapidly at higher pH levels, but the effect is small compared with other factors.

Detergent type, concentration and pattern of addition:

- Detergents impact the rate of entanglement, but are necessary for contaminant removal. A compromise between these effects of detergent type, concentration and pattern of addition is normally found.

Production rate:

- At low production rates, the opportunity for the wool to move in the scouring bowls is increased along with the potential for entanglement.
- At high production rates there is a greater opportunity for the fibres to become entangled through ‘needle felting’ and ‘stuffer box’ effects.
- A compromise must be found.

SUMMARY – MODULE 6

A number of variables affect the configuration of a scour:
- bowl functions
- arrangement of bowl functions.

A bowl can perform one of three functions:
- de-suinting
- scouring
- rinsing.

Bowl configuration:
- conventional
- two-stage scouring
- three-stage scouring.

Water is a limited resource, therefore it is important it is used effectively and efficiently.

Factors that influence surfactant consumption in wool scouring include:
- amount of wool wax on the raw wool
- the scoured wool yield
- the nature of the suint.

The best method of adding surfactants during scouring is with the use of metering pumps.

A builder is a chemical that improves the performance of a surfactant.

Temperature is a key variable in the operation of a wool scour.

17 - **Module 6:** The scouring process: process variables

SUMMARISE the module by reinforcing the number of variables that affect the configuration of a scour including:
- bowl functions
- arrangement of bowl functions.

Each bowl can perform one of three functions:
- de-suinting
- scouring
- rinsing.

REVIEW the fact that there are three ways to arrange the bowl functions in a scouring line:
- conventional
- two-stage scouring
- three-stage scouring

REMIND participants that water is a limited resource, therefore it is important to use it effectively and efficiently. The following process variables need to be considered when managing the use of water during scouring:
- water consumption
- patterns of water use.

REITERATE the factors that influence surfactant consumption during wool scouring include:
- the amount of wool wax on the raw wool
- the scoured wool yield
- the nature of the suint.

REINFORCE the best method of adding surfactants during scouring is with the use of metering pumps.

REMIND participants that builders are chemicals – usually an inorganic salt – that improve the performance of a detergent.

NOTE THAT temperature is a key variable that requires management during the scouring process.

***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 Principles of contaminant recovery* — 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

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PRINCIPLES OF CONTAMINANT RECOVERY

RESOURCES — MODULE 7: PRINCIPLES OF CONTAMINANT RECOVERY

The facilitator will be required to source the following resources to deliver **Module 7: Principles of contaminant recovery**.

- two glass bottles or jar with lid
- small amount of soil
- tablespoon of tea leaves
- small amount of water
- small amount of oil

WELCOME participants to Module 7 of the Woolmark Wool Science, Technology and Design Education Program — *Raw wool scouring — Principles of contaminant recovery*

NOTE: Within this topic, in GRAVITY SEPARATIONS (see slide 18), you will be required to complete a demonstration. To prepare for this demonstration, ensure you have a glass bottle or jar with lid, oil (e.g. cooking oil) and water.
This topic also requires you to distribute the materials for the class. Make sure these are available in sufficient quantities.

EXPLAIN THAT this module covers the following topics:

- contaminant recovery
- solid–liquid separation
- liquid–liquid separation.

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

- explain the principles of contaminant recovery
- explain the importance of maximising contaminant recovery.

ASK *participants why they think the contaminants removed from wool are recovered.*

COLLECT *responses from two or three participants across the room and indicate that you will expand on these reasons during the lecture.*

RESOURCES REQUIRED FOR THIS MODULE:

- *two glass bottles or jars with lids (facilitator to provide)*
- *small amount of soil (facilitator to provide)*
- *tablespoon of tea leaves (facilitator to provide)*
- *small amount of water (facilitator to provide)*
- *small amount of oil (facilitator to provide).*

WHY ARE CONTAMINANTS RECOVERED?

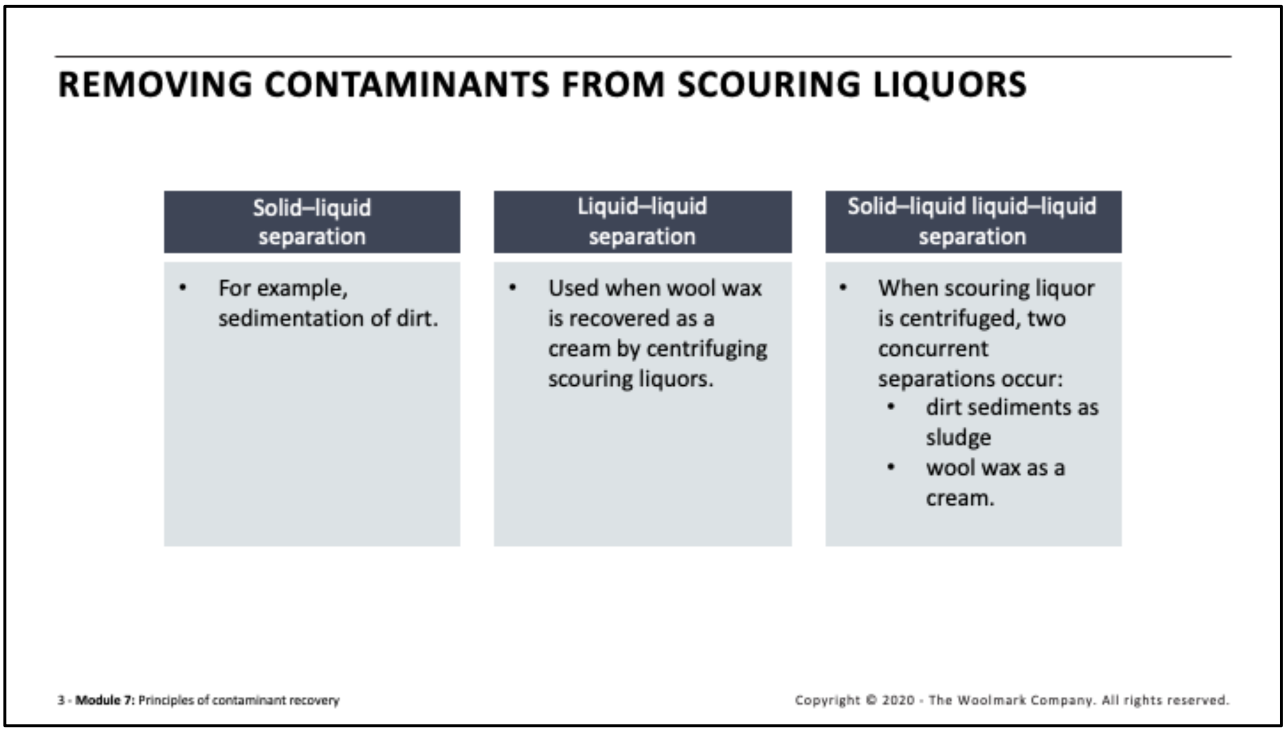
Contaminants are recovered to:

- increase utilisation of the scour (less downtime)
- improve efficiency of resource use
- better use detergents
- increase scouring performance
- lower costs of sewer discharge
- increase cashflow
- increase process control.

2 - **Module 7:** Principles of contaminant recovery

EXPLAIN THAT contaminants are recovered for a number of reasons, including:

- increased utilisation of the scour and less downtime – without effective contaminant recovery, scouring bowls need to be dropped every shift, resulting in decreased productivity and efficiency
- recycling the cleaned scouring liquor results in better use of resources
- better use of detergent by removing dirt, which can adsorb detergent and reduce the concentration of available detergent in the scouring liquor
- lower levels of contaminants in bowls increase scouring performance, this is due to less carryover of contaminants from bowl-to-bowl and less likelihood of re-deposition
- lower costs for sewer discharge and wastewater treatment as a result of reduced pollution load
- sale of recovered wool wax increases cashflow
- increased overall process control.



EXPLAIN THAT two types of separation can occur during wool scouring:

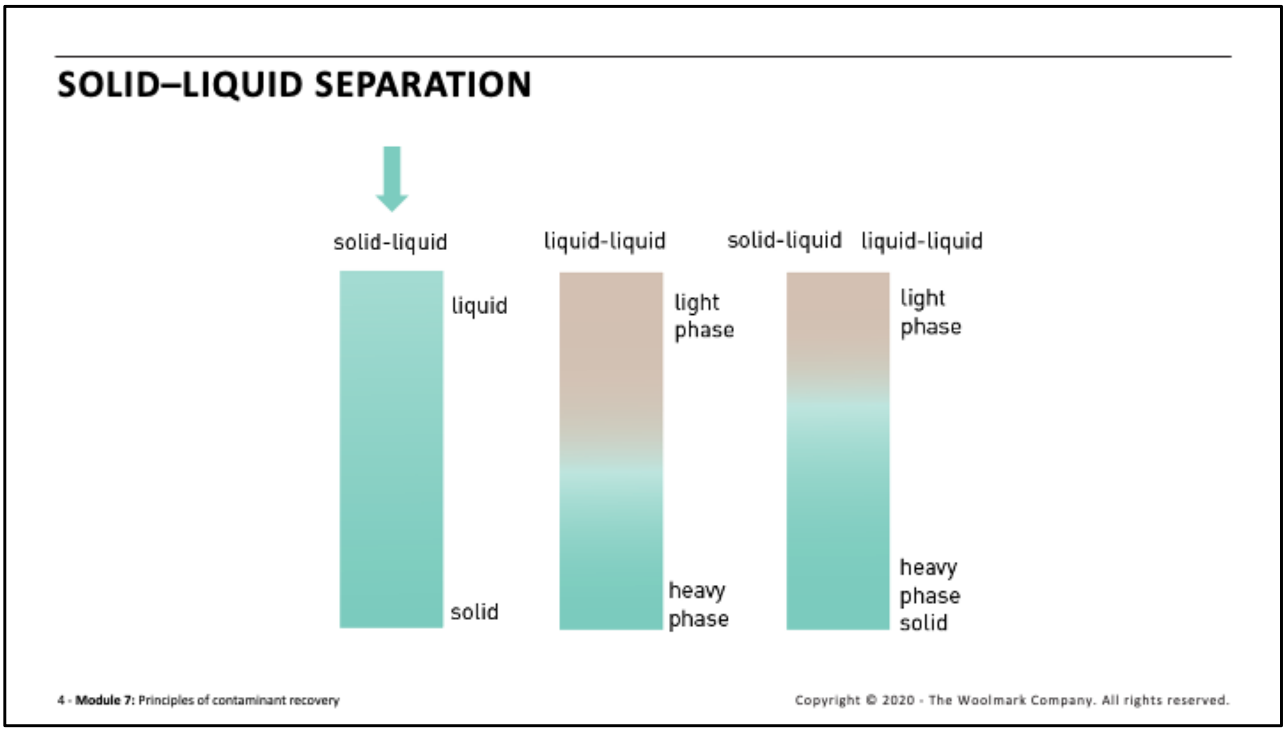
- **solid–liquid** separation — sedimentation of dirt is a typical example of a two-phase solid–liquid separation
- **liquid–liquid** separation — recovery of wool wax as a cream by centrifuging (spinning at high speeds to allow separation by density) scouring liquors is a typical example.

NOTE THAT simultaneous solid-liquid and liquid–liquid separation also occurs when scouring liquor is centrifuged:

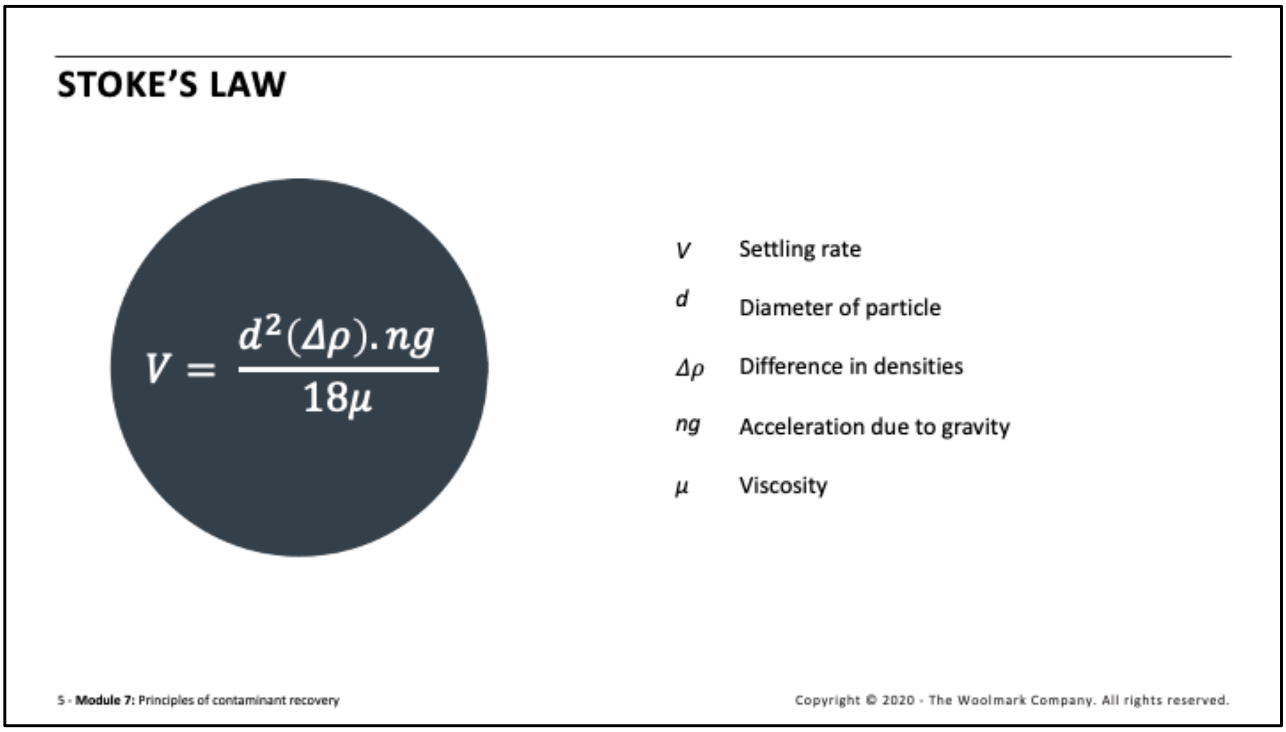
- Dirt sediments — as sludge (a solid–liquid separation)
- Wool wax - as a cream by centrifuging scouring liquors (liquid–liquid separation). The cream has a lower density than water.

EXPLAIN THAT there are three main differences between the two types of separations:

- Dirt removal is a solid–liquid separation, and wool wax is a liquid–liquid separation.
- The density of the dirt is higher than the density of the scouring liquor, while the density of the wool wax is lower than the density of the scouring liquor.
- The density difference between the scouring liquor and dirt is considerably higher than the density between the wool wax and scouring liquor.



REFER TO the image on the slide which shows how solid–liquid separations separate solid contaminants from scouring liquids. The methods used to separate solids from liquids in the wool scouring process will be covered on the following slides.



EXPLAIN THAT the separation of a solid from a liquid, or one liquid from another liquid can be described by Stoke's Law:

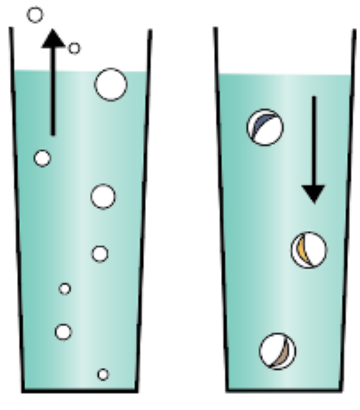
- $V = \frac{d^2(\Delta\rho).ng}{18\mu}$

Each element of the Stoke's Law equation represents:

- V = rate of separation
- d = diameter of the particle being separated (solid or liquid droplet)
- Δρ = difference in density between the solid and liquid, or between the two liquids
- n = multiplier determined by recovery device (n = 1 for gravity separation)
- g = acceleration due to gravity
- μ = viscosity of the main liquid phase (i.e. water for wool scouring).

IMPLICATIONS OF STOKE'S LAW

- The rate of separation is strongly determined by the size of the particles being separated, whether they are solid or emulsion.
- Doubling the size of a particle quadruples the rate of separation.
- Increasing the difference in density between either the solid and liquid, or the two liquids, will increase the rate of separation.
- Reducing the distance the particle or droplet has to travel before it is collected will increase the rate and extent of separation.
- Increasing the centrifugal force on the system will increase the rate of separation.
- Reducing the viscosity of the main liquid phase will increase the rate of separation.



6 - **Module 7:** Principles of contaminant recovery

EXPLAIN THAT Stoke's Law can have various implications, based on different factors:

- The rate of separation (V) is strongly determined by the size of the particles being separated (d), and whether they are solid or emulsion.
- Doubling the size of a particle quadruples the rate of separation.
- Increasing the difference in density (Δρ) between either the solid and liquid, or the two liquids, will increase the rate of separation.
- Reducing the distance the particle or droplet has to travel before it is collected also will increase the rate and extent of separation.
- Increasing the centrifugal force on the system (ng) will increase the rate of separation.
- Reducing the viscosity (μ) of the main liquid phase will increase the rate of separation.

REFER TO the diagram which illustrates that dense items sink, and items with low density float.

DEMONSTRATION: STOKE'S LAW

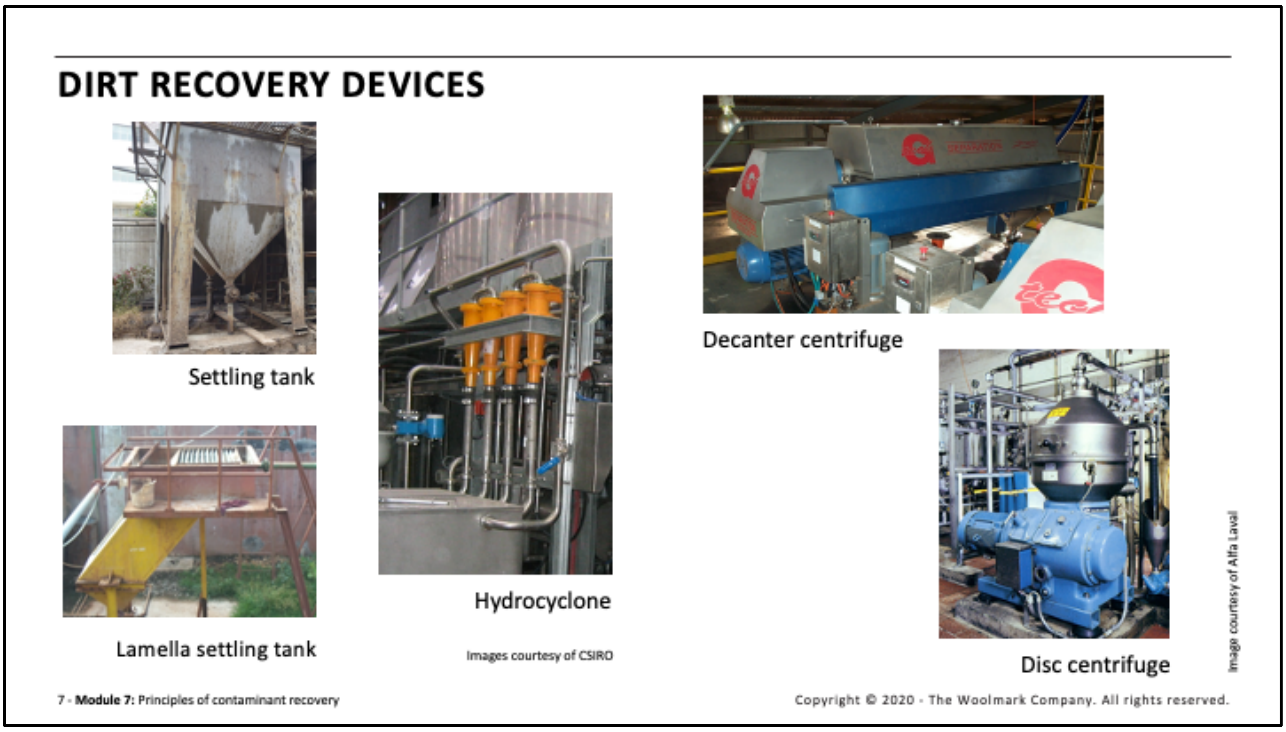
RESOURCES REQUIRED:

- *two glass bottles or jars with lids*
- *small amount of soil*
- *tablespoon of tea leaves*
- *small amount of water in each bottle*

ADD *a small amount of soil to one bottle of water. Add the tea leaves to the other bottle.*

SECURE *the lids, shake contents of both bottles and allow to settle.*

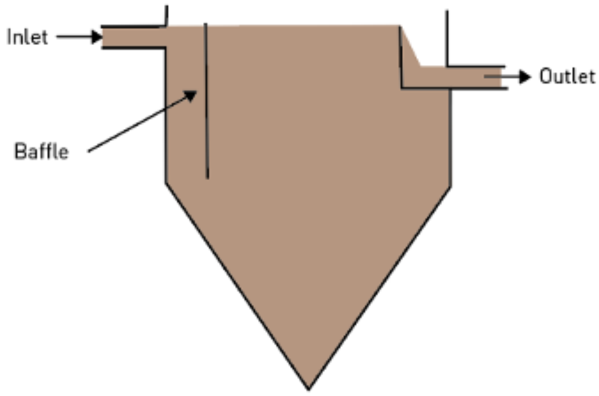
ALLOW *participants to observe the result and relate their observations to the principles outlined on the slide and in the notes.*



REFER participants to the images on the slide showing a number of dirt recovery devices used in solid–liquid separations, including:

- settling tanks
- centrifugal systems:
    - hydrocyclones
    - decanter centrifuges
    - disc centrifuges.

DIRT RECOVERY DEVICES: SETTLING TANKS



8 - **Module 7:** Principles of contaminant recovery

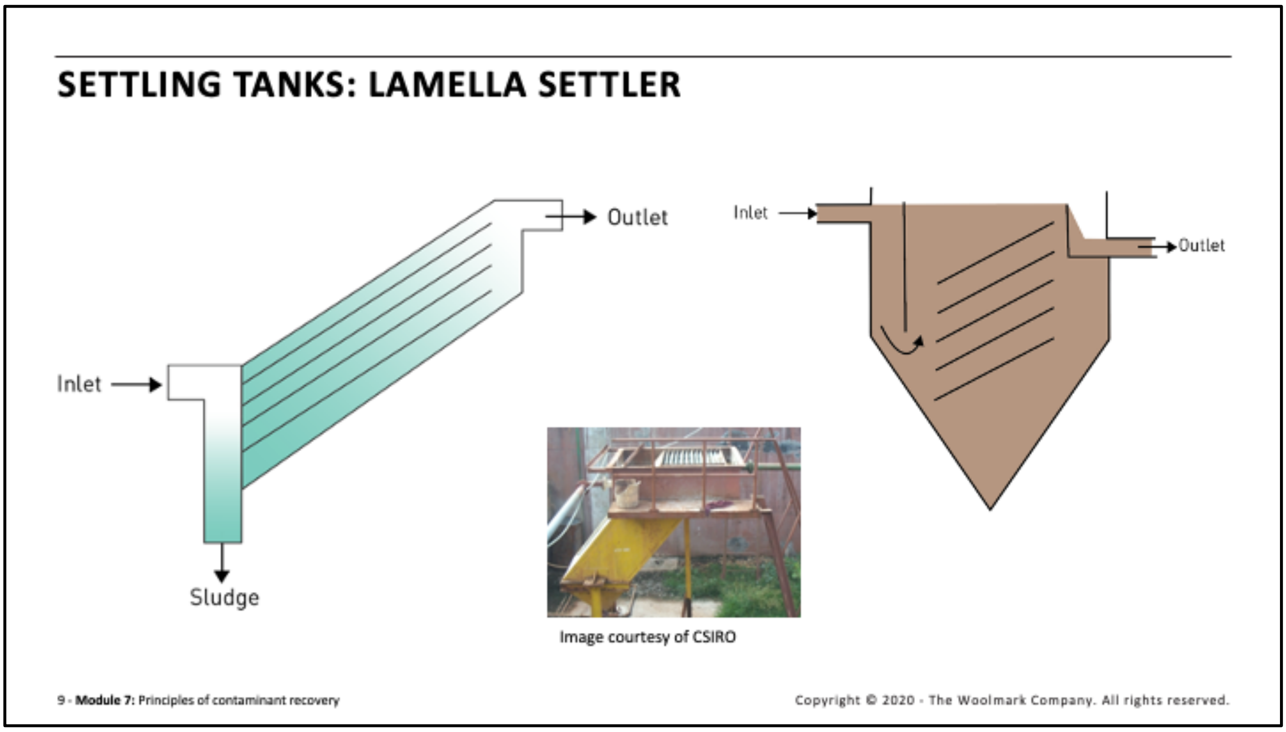
EXPLAIN THAT a settling tank is the simplest form of dirt separator (solid–liquid separation) used to recover dirt, and consists of:

- a tank with a circular or rectangular cross-section
- inlet and outlet pipes on opposite sides
- a baffle plate, which is often placed near the inlet to stop liquid flowing straight across the tank to the outlet.

EXPLAIN THAT settling tanks work according to the following principles:

- Water containing the suspended solids flows into the tank, causing the solids to sediment under gravity.
- The clarified liquor then exits through the outlet.
- Over time, the accumulated dirt will fill the tank and exit from the outlet.
- A hopper may be placed on the bottom of the settling tank, to remove a flow of sedimented dirt from the bottom of the tank, either continually or periodically.

POINT OUT that performance of a settling tank is determined by the volumetric (or hydraulic) residence time (i.e. the average length of time the solid–liquid mixture remains in a constructed bioreactor), the sedimentation rate of the dirt, and the distance the dirt has to settle before it is taken out of the liquor.



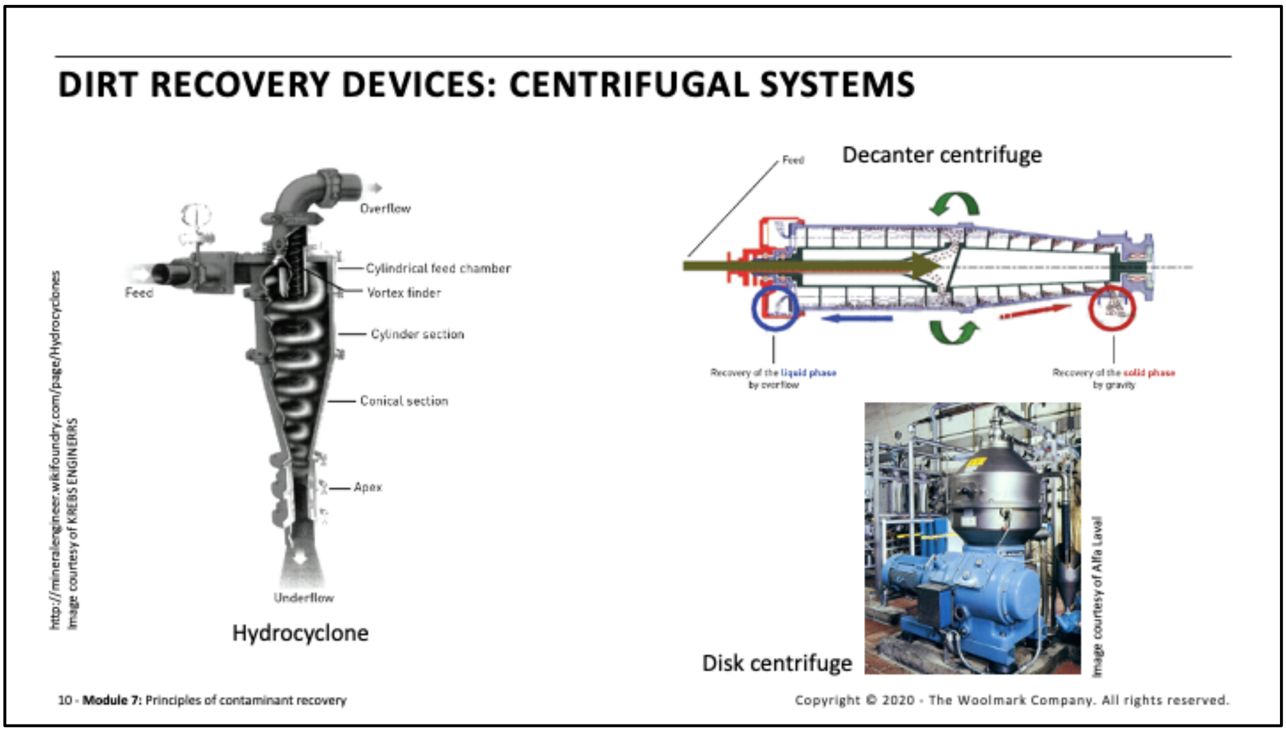
EXPLAIN THAT a lamella settler is a device that can be retrofitted inside existing settling tanks or installed as a stand-alone course.

A lamella settler works in the following ways:
- A series of tilted parallel plates are placed inside the settler.
- Sediment can slide off the plates and collect at the bottom of the settling tank.

EXPLAIN THAT the principles behind a lamella settler are that, for a given volume of liquid, the rate of sedimentation can be increased by changing the shape of the separator to reduce the distance the dirt has to settle.

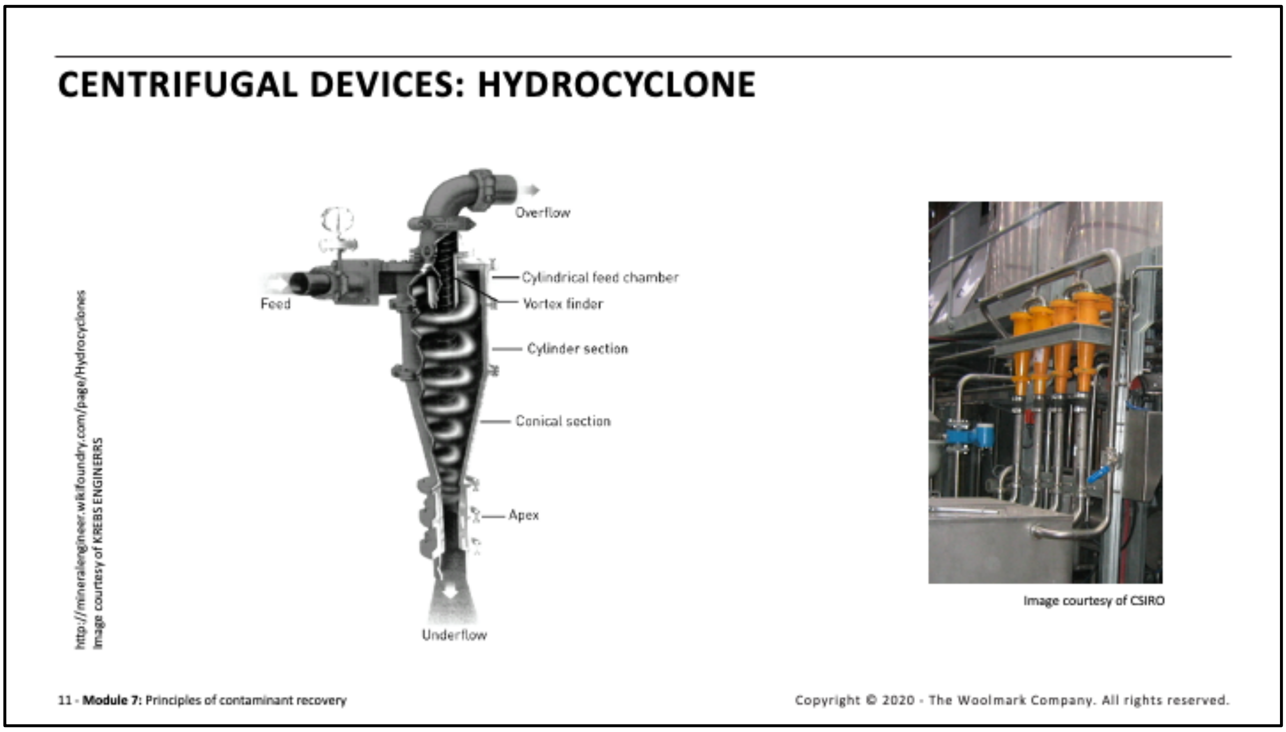
As illustrated in the two diagrams on the slide, there are two types of separator with the same volume, and hence the same 'hydraulic residence' or retention time.

INDICATE THAT the removal of solids is faster in the second diagram than in the first diagram, because the distance the solids have to settle is shorter. The drawback is this design is not cost-effective.



POINT OUT another way to increase the sedimentation of dirt is to increase the centrifugal force using one of three systems:

- hydrocyclone
- decanter centrifuge
- disk centrifuge.



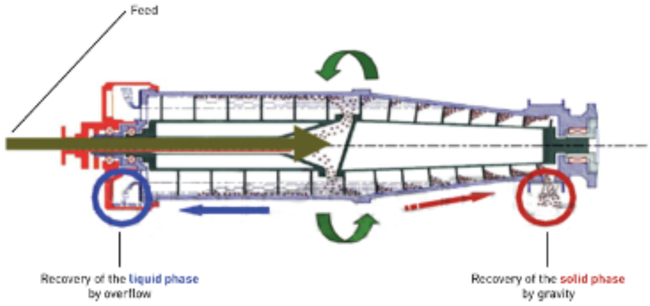
EXPLAIN THAT a hydrocyclone has no moving parts. It relies on the potential energy of the incoming stream being converted to kinetic energy to create the necessary centrifugal force.

NOTE THAT the configuration of the inlet causes the dirty water to start spinning inside the 'cyclone'. The heavier dirt particles move outwards and downwards to be discharged in the 'underflow'; liquor moves to the centre and is discharged as the overflow (or centrate).

POINT OUT that the centrifugal force generated by a hydrocyclone increases as the size of the device decreases. Consequently, the separation efficiency increases with decreasing size, but more hydrocyclones are needed per course flow.

CENTRIFUGAL DEVICES: DECANTER CENTRIFUGE

Image courtesy of CSIRO



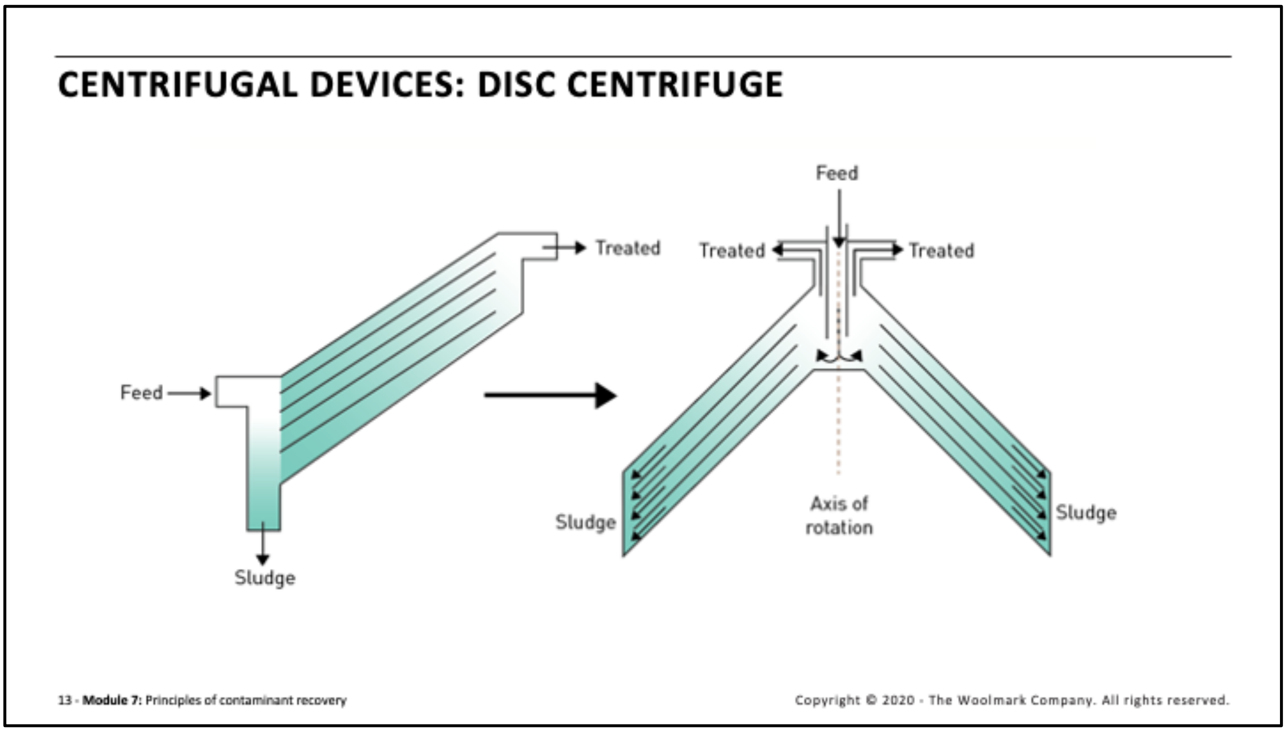
https://dutch.alibaba.com/product-detail/oilfeld-solid-control-centrifugal-decanter-centrifuge-60013414870.html

12 - **Module 7:** Principles of contaminant recovery

EXPLAIN THAT a decanter centrifuge uses a long, rotating drum (or bowl) to separate dirt from the scouring liquor.

- The drum is partly cylindrical and partly conical.
- G-force is generated by the speed of rotation of the drum.
- An axial screw conveyor is located inside the bowl for the continuous removal of solids from the system.
- The rotor moves in the same direction as the bowl, but at a slightly higher or lower speed, which carries the dirt out of the bowl.
- When the dirty water (or slurry) is fed into the decanter, it is distributed inside the decanter near the start of the bowl's conical part.
- The dirt moves to the outside of the bowl and is moved by the axial conveyor to the narrow end of the bowl.
- At some point along the bowl, the separated solids are conveyed out of the liquid phase. This is called the 'beach'.
- From here, the solids are progressively de-watered until being discharged.

NOTE: A decanter centrifuge can be fed in counter-current or co-current feed directions.



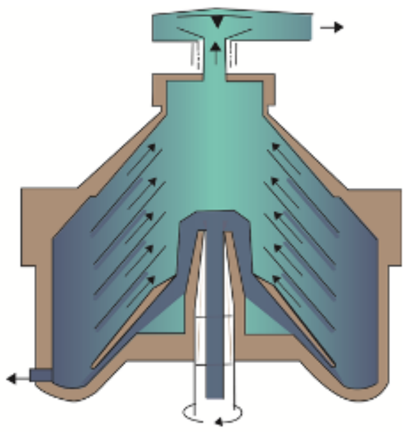
POINT OUT that sedimentation of dirt can be increased by increasing the surface area available for sedimentation, or by applying a centrifugal force.

INDICATE THAT a disc centrifuge is commonly used to recover wool wax, and combines both of these effects (increased surface area and centrifugal force) for effective dirt separation.

EXPLAIN THAT a disc centrifuge operates in the following ways:

- The feed (through the inlet) to the settling tank containing inclined plates is turned so it comes from the top of the device.
- The tank is spun with the axis of rotation along the edges of the tank.
- The inclined plates form a disc stack, which characterise this type of centrifuge. The tank forms the centrifuge bowl. The discs point downwards and outwards from the top of the centrifuge.
- Liquor is fed to the centrifuges through the feed pipe (in the centre of the centrifuge).
- The liquor moves to the outside of the disc stack before moving through it to produce a treated stream.
- Dirt particles collect on the underside of the discs and move downwards and outwards under the centrifugal force until they leave the discs to be collected in a sludge tank.

HANDLING SOLIDS IN DISC CENTRIFUGES



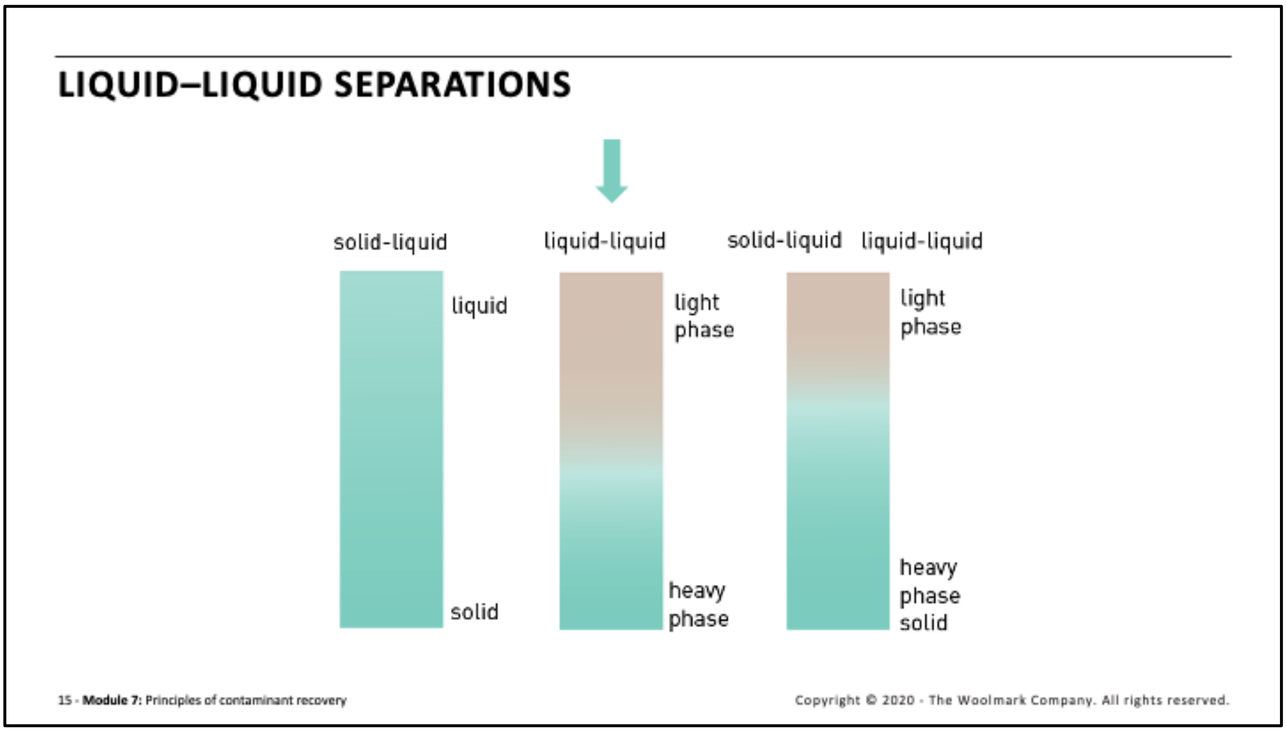
Nozzle centrifuge

http://www.thermopedia.com/content/620/

14 - **Module 7:** Principles of contaminant recovery

EXPLAIN THAT there are three ways of handling solids in disc centrifuges:

- **Solid bowl centrifuge** — solids are retained inside the bowl. The centrifuge has to be stopped and disassembled to remove the sludge, so they are only useful when collecting small amounts of solids.
- **Opening bowl centrifuge** — the bowl is split, with an O-ring forming a seal between the two halves of the bowl. The feed is stopped and the seal is broken to discharge the solids, as required. This process is semi-continuous, as the centrifuge is periodically stopped and disassembled. This type of centrifuge is also useful for feeds containing only a small amount of solids.
- **Nozzle centrifuge** (shown in diagram) — dirt is discharged continuously through the nozzles (shown as small holes at the bottom left of the image) placed on the perimeter of the bowl. The flow rate through the nozzles is determined by their number and internal diameter.

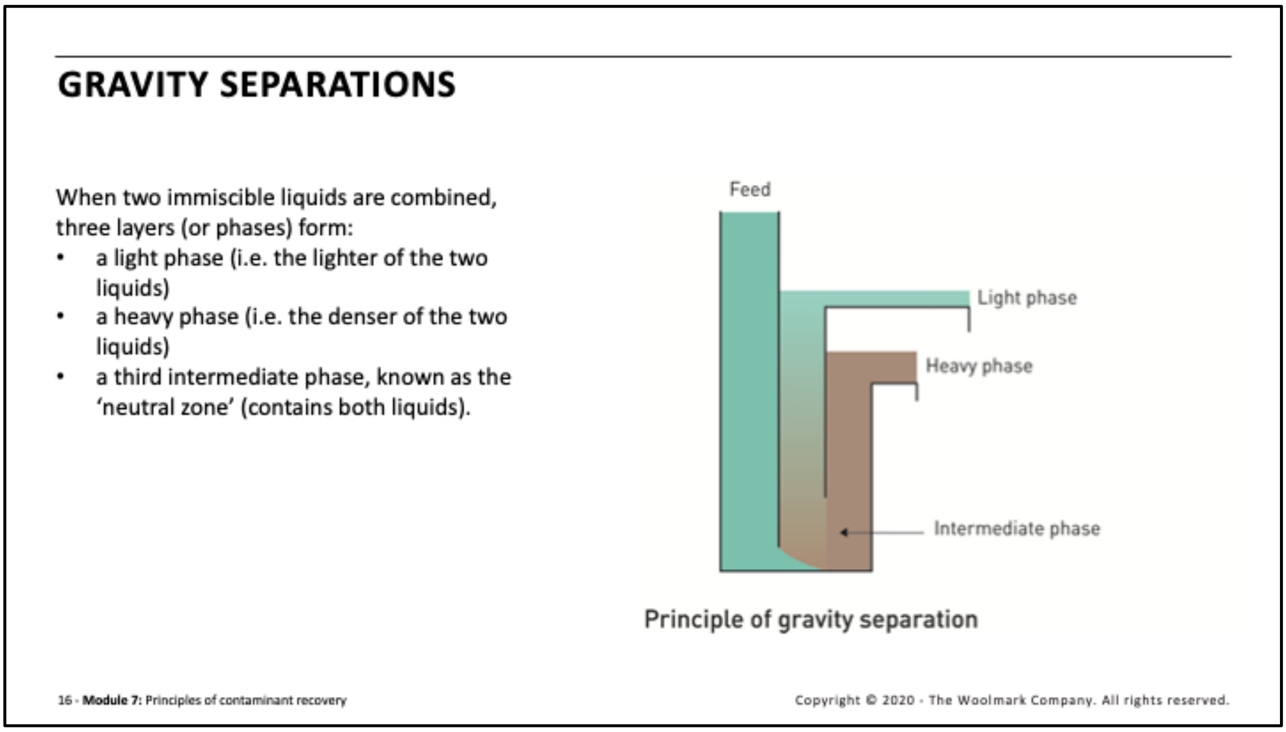


ASK *participants to recap what is meant by liquid–liquid separation.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *confirm that the separation of two immiscible liquids occurs based on their density. An example of a liquid–liquid separation is the separation of wool wax, which is a liquid (and an emulsion) at the temperature of the scour, from the scouring liquor.*

EXPLAIN THAT liquid–liquid separations separate wool wax from the scouring liquid. The methods used to separate wool wax from liquids formed in the wool scouring process will be covered on the following slides.



EXPLAIN THAT when two immiscible liquids (e.g. oil and water) are combined and allowed to settle, three layers (or phases) are formed:

- a light phase (i.e. the lighter of the two liquids)
- a heavy phase (i.e. the denser of the two liquids)
- a third intermediate phase, known as the 'neutral zone', which contains both liquids.

The basic concepts used to describe a liquid–liquid separation are the same as for solid–liquid separations, with one main difference — there have to be two liquid outlets, which means the basic settling tank has to be redesigned, as shown in the diagram above.

When the liquid mixture is fed into the tank it starts to separate immediately, with the lighter liquid discharged from the upper outlet (i.e. the 'light phase'), and the denser fluid discharged from the lower outlet (i.e. the 'heavy phase'). Ideally the 'neutral zone' is located somewhere along the baffle separating the two outlets.

In the case of wool wax recovery, the wool wax concentrates in the light phase, along with a small amount of water, to form a recoverable 'cream'. The heavy phase is mostly water, with a small amount of wool wax.

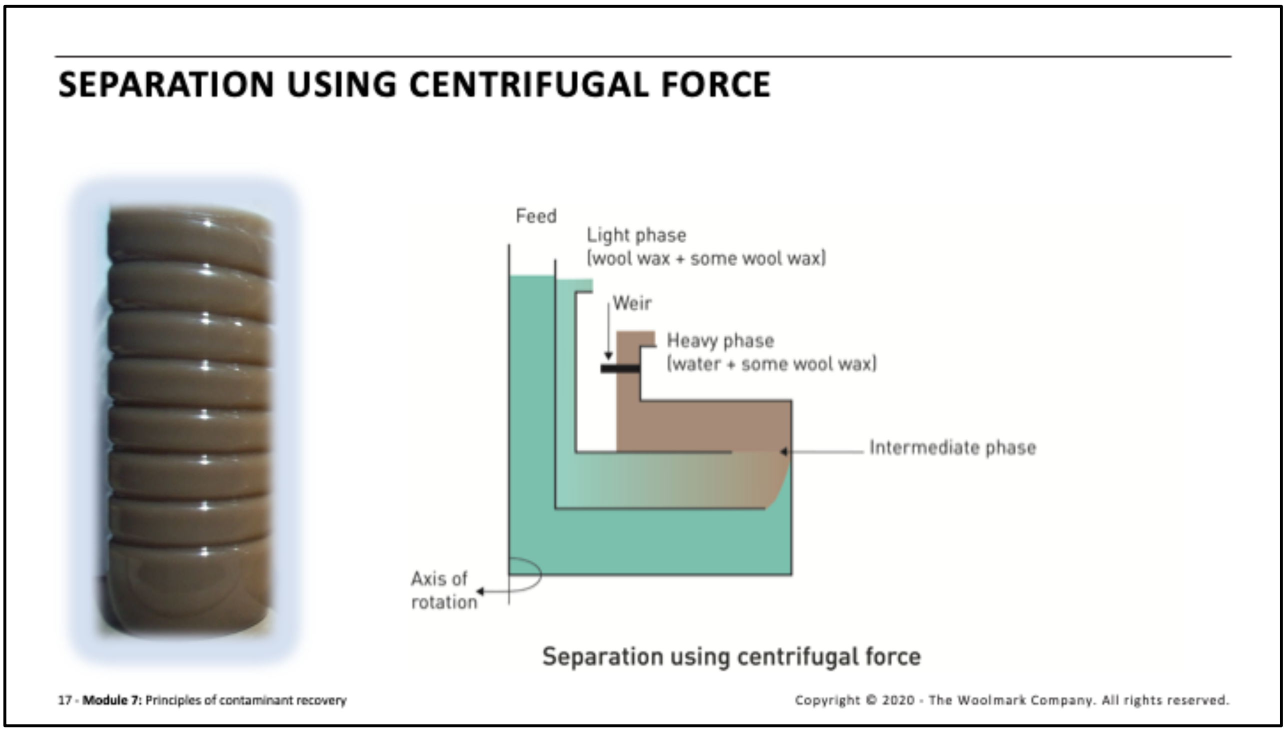
DEMONSTRATION: GRAVITY SEPARATION

RESOURCES REQUIRED:

- *glass bottle or jar with lid*
- *small amount of oil*
- *small amount of water*

***ADD** the water and oil to the glass container and replace lid. Shake vigorously.*

***POINT OUT** the layers formed during the separation process to the participants.*



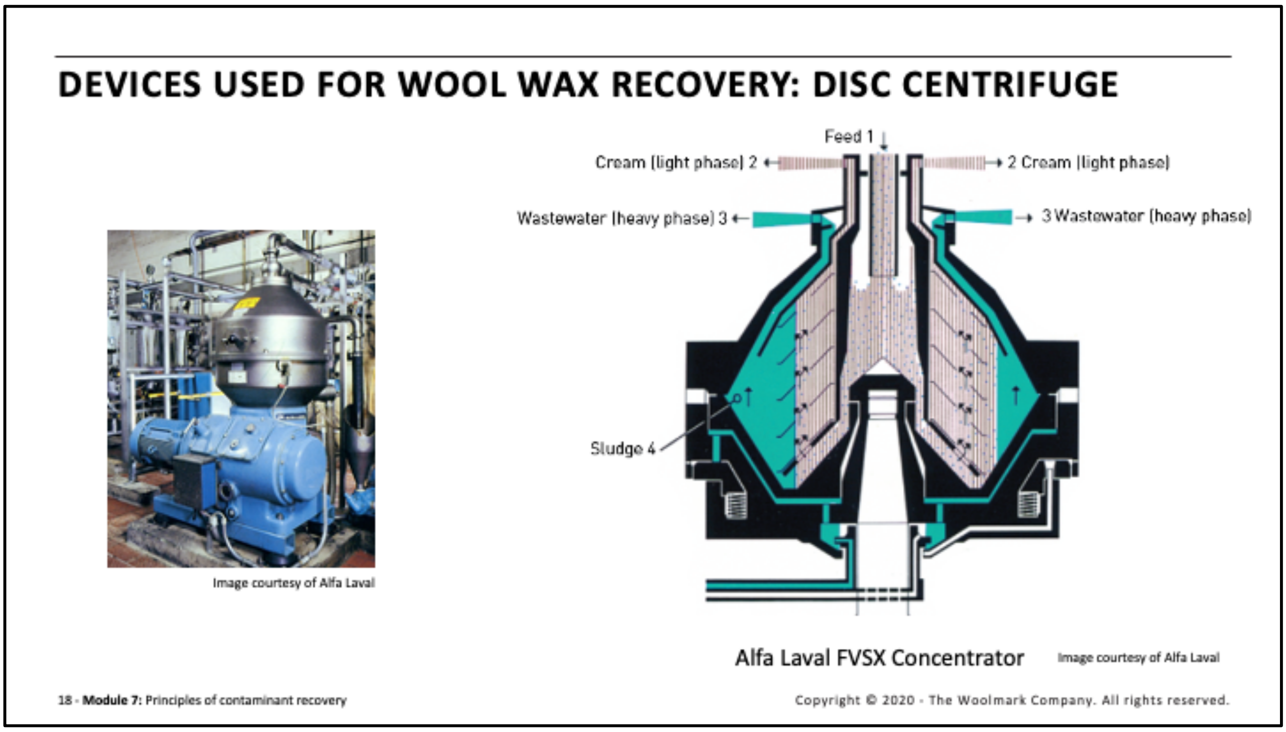
POINT OUT gravity separations can be effective for two immiscible liquids, but for feeds such as stable emulsions (e.g. wool scouring liquors or milk), gravity separation is slow and not very effective. The separation process can be improved markedly by applying a centrifugal force.

EXPLAIN THAT the design of the gravity separation tank is adjusted to support spinning, and to locate the feed, light and heavy phases in the same area (the feed is introduced along the axis of rotation).

INDICATE THAT even when a scouring liquor is centrifuged there is not a clean separation of the light and heavy phases. There is a gradation between a wool-wax-rich phase exiting from the 'light phase' outlet and water containing some wool wax exiting from the 'heavy phase'.

EXPLAIN THAT an adjustable weir (called a 'gravity disc') can be located on the 'heavy phase' (i.e. wastewater) outlet to constrain the flow of the heavy phase and alter the position of the neutral zone.

If the height of the gravity disc is increased, the volume of the 'light phase' increases. In this instance, more wool wax is recovered from the light phase outlet, but the concentration of wool wax in the cream will be lower. Conversely if the weir is lowered there is less of the light phase and less wool wax is discharged from the light phase outlet but the concentration of wax in the cream is higher.



REMIND participants that disc centrifuges were discussed earlier in relation to solid–liquid separations. As mentioned, these devices are more commonly used in liquid–liquid separations for wool wax recovery.

REINFORCE THAT centrifuges use centrifugal force, instead of gravity, to separate the wool wax emulsion from the water taken from the scouring bowls.

INDICATE THAT the efficacy of the separation can be further improved by placing a gravity disc stack inside the centrifuge bowl to shorten the distance of the separation.

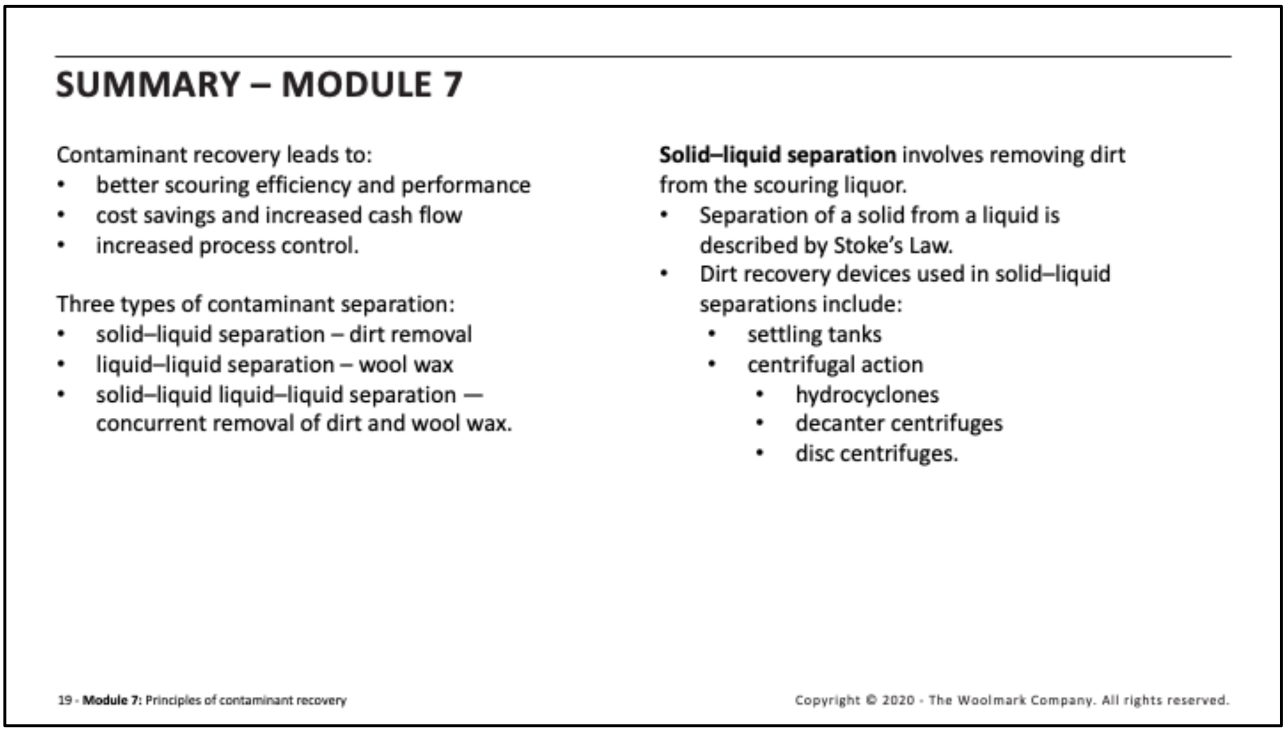
Holes are placed in the disc stack at points corresponding to the neutral zone. The lighter phase moves closer to the axis of rotation and the heavier phase moves away from the axis of rotation. The function of the gravity disc remains the same.

POINT OUT that depending on the wool wax recovery system the concentration of wool wax in the cream can vary from 15–45%.

NOTE THAT the wool wax recovery systems used in raw wool scouring are covered in more detail in *Module 8 The practices of contaminant recovery*.

INDICATE THAT oil-separating hydrocyclones have been trialled for wool wax recovery. These have shown some success, but have not been adopted commercially for this purpose.

Using hydrocyclones to separate oils has one main disadvantage — the shearing forces generated in the hydrocyclone tend to reduce the size of the emulsion droplets, reducing the efficiency of the separation. This can be fixed through designing the inlet manifold to allow acceleration without shearing.



SUMMARISE the module by explaining that contaminant recovery leads to:

- better scouring efficiency and performance
- cost savings and increased cash flow
- increased process control.

REITERATE THAT there are three types of contaminant separation:

- solid–liquid separation: dirt removal
- liquid–liquid separation: wool wax
- solid–liquid liquid–liquid separation: concurrent removal of dirt and wool wax from the scouring liquor.

REINFORCE THAT solid–liquid separation is involved in the removal dirt from the scouring liquor.

- Separation of a solid from a liquid is described by Stoke's Law.
- Dirt recovery devices used in solid–liquid separations include:
    - settling tanks
    - methods using centrifugal action:
        - hydrocyclones
        - decanter centrifuges
        - disc centrifuges.

SUMMARY – MODULE 7

Liquid–liquid separation involves separating wool wax from the scouring liquor.

- Gravity separations occur between two immiscible liquids, forming three layers:
  - top layer — lighter of the two liquids
  - bottom layer — denser of the two liquids
  - intermediate layer — neutral zone containing both liquids.
- Disc centrifuges are the main devices used to recover wool wax.

20 - **Module 7:** Principles of contaminant recovery

REMIND participants that liquid–liquid separation involves separating wool wax from scouring liquor.

REINFORCE that gravity separations occur between two immiscible liquids, forming three layers:

- Top layer — lighter of the two liquids.
- Bottom layer — denser of the two liquids.
- Intermediate layer — neutral zone containing both liquids.

REVIEW the fact that disc centrifuges are the main devices used to recover wool wax.

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 *Raw wool scouring — Module 8 Contaminant recovery*— 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

THE WOOLMARK COMPANY

THE PRACTICES OF CONTAMINANT RECOVERY

RESOURCES — MODULE 8: PRINCIPLES OF CONTAMINANT RECOVERY

No additional resources are required to deliver **Module 8: The practices of contaminant recovery**.

WELCOME participants to Module 8 of the Woolmark Wool Science, Technology and Design Education Program *Raw wool scouring—The practices of contaminant recovery.*

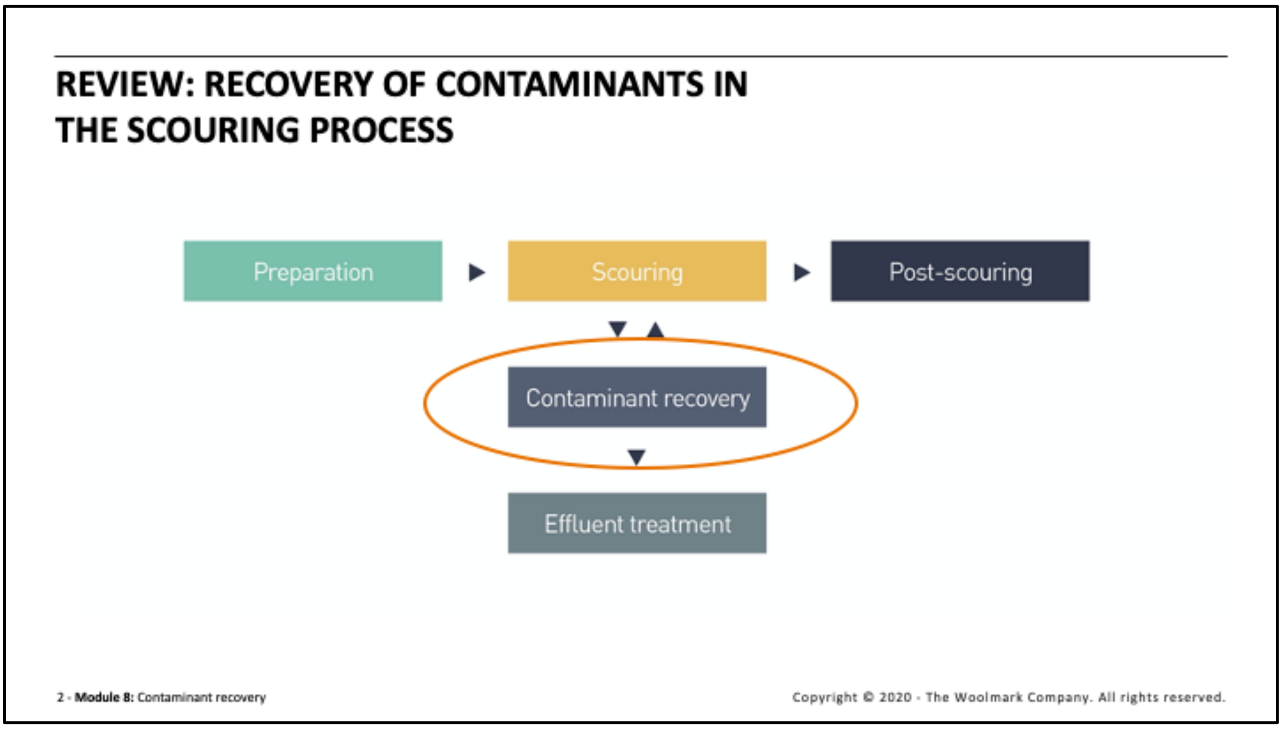
EXPLAIN THAT this module will cover:

- the use of dirt recovery devices in wool scouring
- methods for dirt recovery in rinsewater
- methods for wool wax recovery.

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

- explain the practical process involved in contaminant recovery.

NO RESOURCES REQUIRED



***ASK** participants to recall why contaminants are recovered from wool.*

***COLLECT** responses from two to three participants across the room before proceeding.*

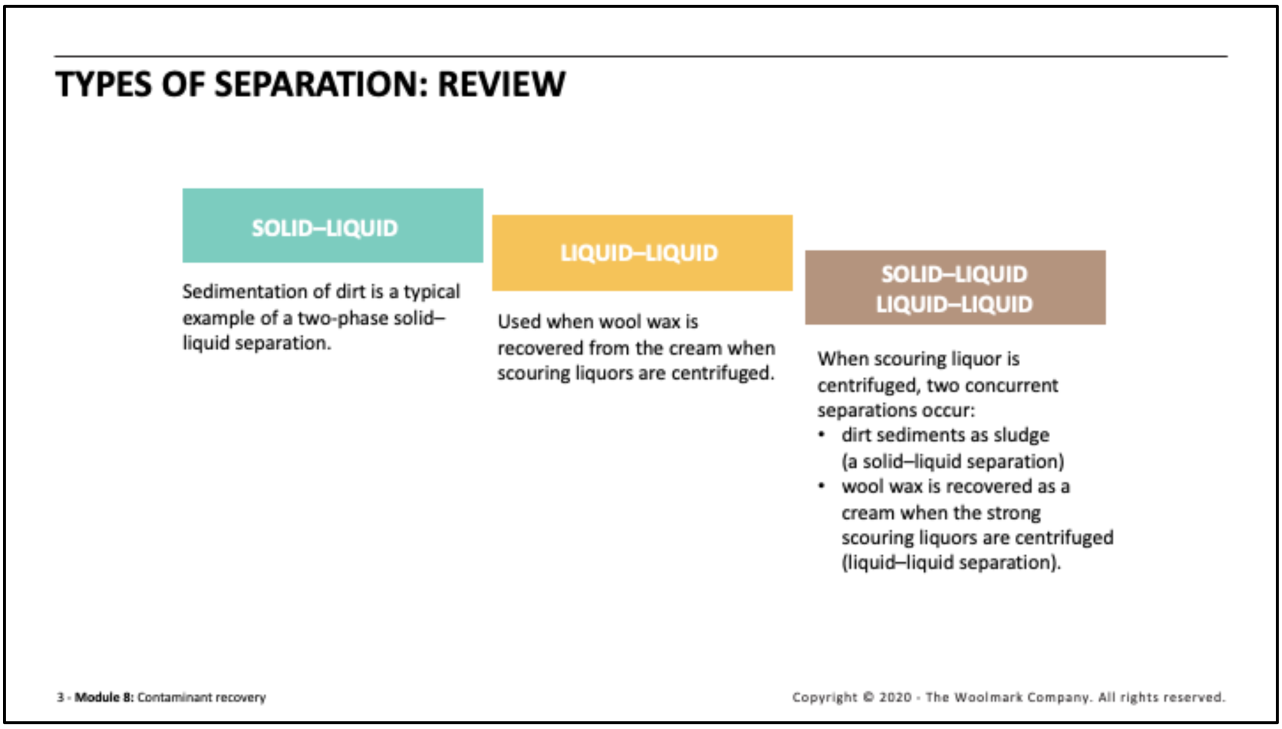
EXPLAIN THAT as introduced in *Module 7 — Principles of contaminant recovery,* contaminant recovery is part of the scouring line. Without contaminant recovery, the scouring bowls, in particular, would need to be dropped frequently due to the accumulation of contaminants (especially wool wax).

EXPLAIN THAT contaminants are recovered from the wool scouring process for a number of reasons, including:

- increased utilisation of the scour and less downtime – without effective contaminant recovery, scouring bowls need to be dropped every shift, resulting in decreased productivity and efficiency
- recycling the cleaned scouring liquor results in better use of resources
- better use of detergent by removing dirt, which can adsorb detergent and reduce the concentration of available detergent in the scouring liquor
- lower levels of contaminants in bowls increase scouring performance – this is due to less carryover of contaminants from bowl to bowl and less likelihood of re-deposition
- better quality product
- lower costs for sewer discharge and wastewater treatment as a result of reduced pollution load
- sale of recovered wool wax increases cash flow
- increased overall process control.

***ASK** participants to recall the types of separation that can occur during wool scouring.*

***COLLECT** responses from two to three participants across the room and if necessary reiterate that the two types of separation are: solid–liquid separation and liquid–liquid separation (wool wax recovery).*



POINT OUT that in removing contaminants from wool scouring liquors, two processes occur simultaneously:

- separation of some of the wool wax as a cream
- sedimentation (settling) typically of the dirt and some vegetable matter

EXPLAIN THAT two types of separation can occur during wool scouring.

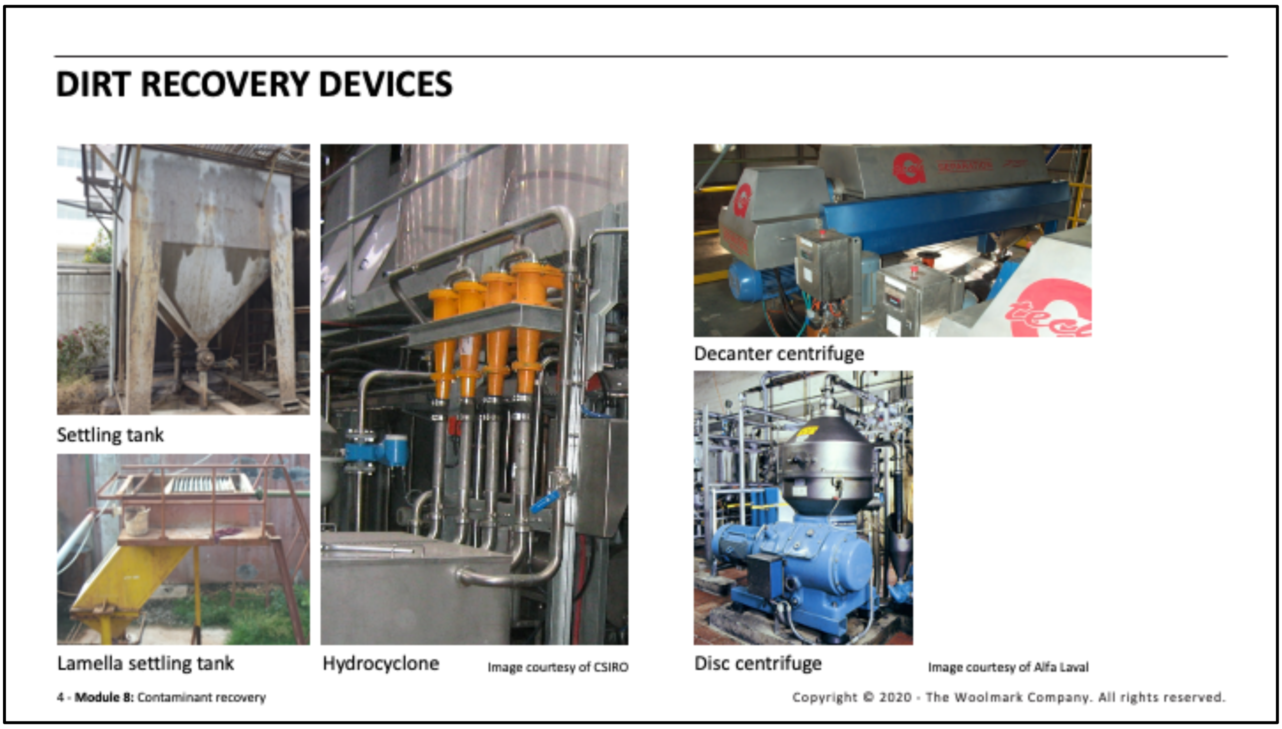
- solid–liquid separation — sedimentation of dirt is a typical example of a two-phase solid–liquid separation
- liquid–liquid separation — recovery of wool wax as a cream by centrifuging (spinning at high speeds to allow separation by density) scouring liquors is a typical example.

INDICATE THAT simultaneous solid-liquid and liquid–liquid separation also occurs when scouring liquor is centrifuged:

- Dirt sediments — as sludge (a solid–liquid separation)
- Wool wax - as a cream by centrifuging scouring liquors (liquid–liquid separation). The cream has a lower density than water.

INDICATE THAT this module will look at dirt recovery devices used in scouring, dirt recovery in rinsewater and wool wax recovery.

NOTE TO FACILITATOR: *The following content was covered during* Module 7 Principles of contaminant recovery *and may be considered as a recap with extra content specific to this module.*



EXPLAIN THAT contaminant recovery is usually associated with a recovery 'loop' in which the scouring liquor is returned to the wool scour after passing through a contaminant recovery device.

With dirt recovery devices, the feed is taken from the bottom of the bowls and the treated liquor is returned to the side bowl. Common dirt recovery devices were covered in Module 4, but are summarised here.

Settling tanks

- Settling tanks are used to remove the dirt from the scouring liquor. It takes a long time to equilibrate the temperatures of the bowls and associated settling tanks due to the volume of scouring liquor being kept in the tank.
- Tanks have to be located away from the scouring line (usually outside) due to the size; therefore, supervision is challenging.
- The discharge port may become blocked if the discharge from the bottom of settling tank is stopped and clearing the blockage can be difficult.

Lamella settlers

- It is possible to install the lamella settling tanks within the scouring mill rather than outside due to the much smaller size.

Hydrocyclones

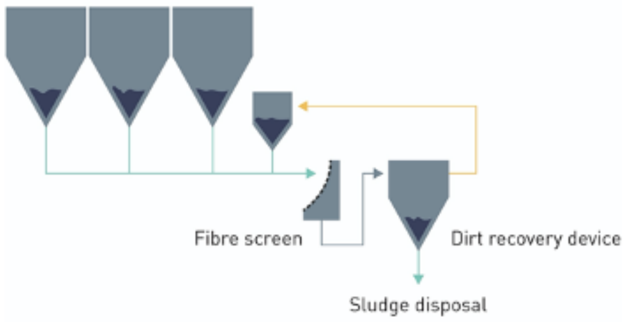
- Wool scours use three sizes of hydrocyclone: the larger is used to remove abrasive solids during wool wax recovery and the smaller for dirt recovery from the bowls.
- It is important to place a fibre strainer before any hydrocyclone to prevent blockages from wool fibres.
- They are placed in close proximity to scouring lines, thereby reducing energy losses and providing better opportunities for supervision.
- There can be considerable losses in potentially-recoverable wool wax due to the proportion of the feed discharged in the underflow (up to 30%).
- More frequent care and maintenance is required as the small size of the orifice controlling the discharge is susceptible to being blocked.
- Some of the dirt particles are also erosive in nature.

Decanter centrifuges

- These have been used on a regular basis in the scouring industry since the late 1970s to dewater discharges from the wool scouring plant before discharge.
- They are not normally used in dirt recovery loops.
- There is a high capital cost.

OPERATING DIRT RECOVERY DEVICES

- Scouring liquor is discharged from the bowl bottoms to the dirt recovery devices via a fibre strainer or wedge-wire screen.
- A high flow of liquor from the bowl hopper bottoms is required to prevent the hoppers blocking with dirt.
- Hydrocyclones are preferred over settling tanks.



Process of dirt recovery

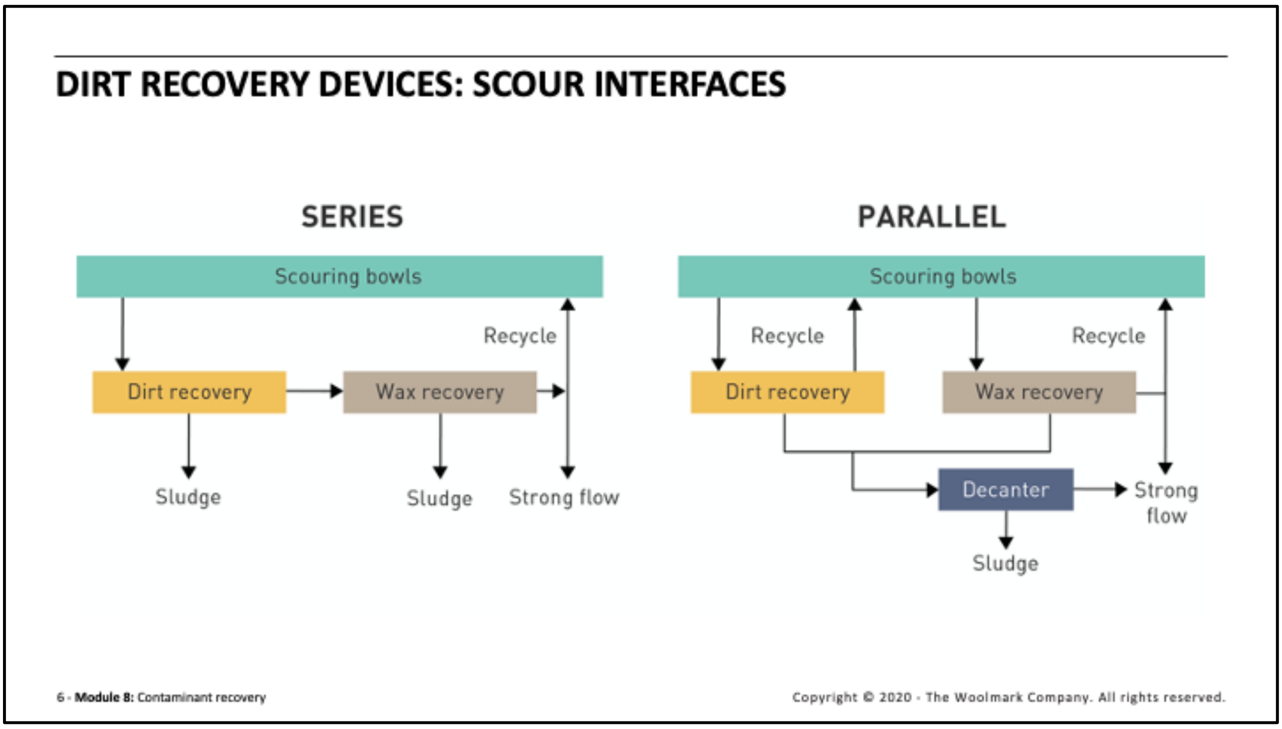
5 - **Module 8:** Contaminant recovery

POINT OUT that scouring liquor is discharged from the bowl bottoms to the dirt recovery devices via a fibre strainer or wedge-wire screen.

INDICATE THAT a high flow of liquor from the bowl hopper bottoms is needed to prevent the hoppers blocking with dirt and anaerobic conditions developing in the scours.

EXPLAIN THAT hydrocyclones are preferred over settling tanks as dirt recovery devices for a number of reasons:

- negligible heat loss
- lower capital costs
- higher dirt separation efficiencies
- shorter times to reach equilibrium in the bowls
- a smaller installation footprint
- location can be next to the scouring bowls.



EXPLAIN THAT a scouring line usually has two dirt recovery loops:

- one services the first bowl, which is being used as a de-suint bowl in a three-stage scour
- the other services the scouring bowls (one, two or three bowls depending on the configuration).

INDICATE THAT when dirt removal is in series with wax removal (left-hand image) the liquid phase from dirt recovery is used to feed the wax recovery system.

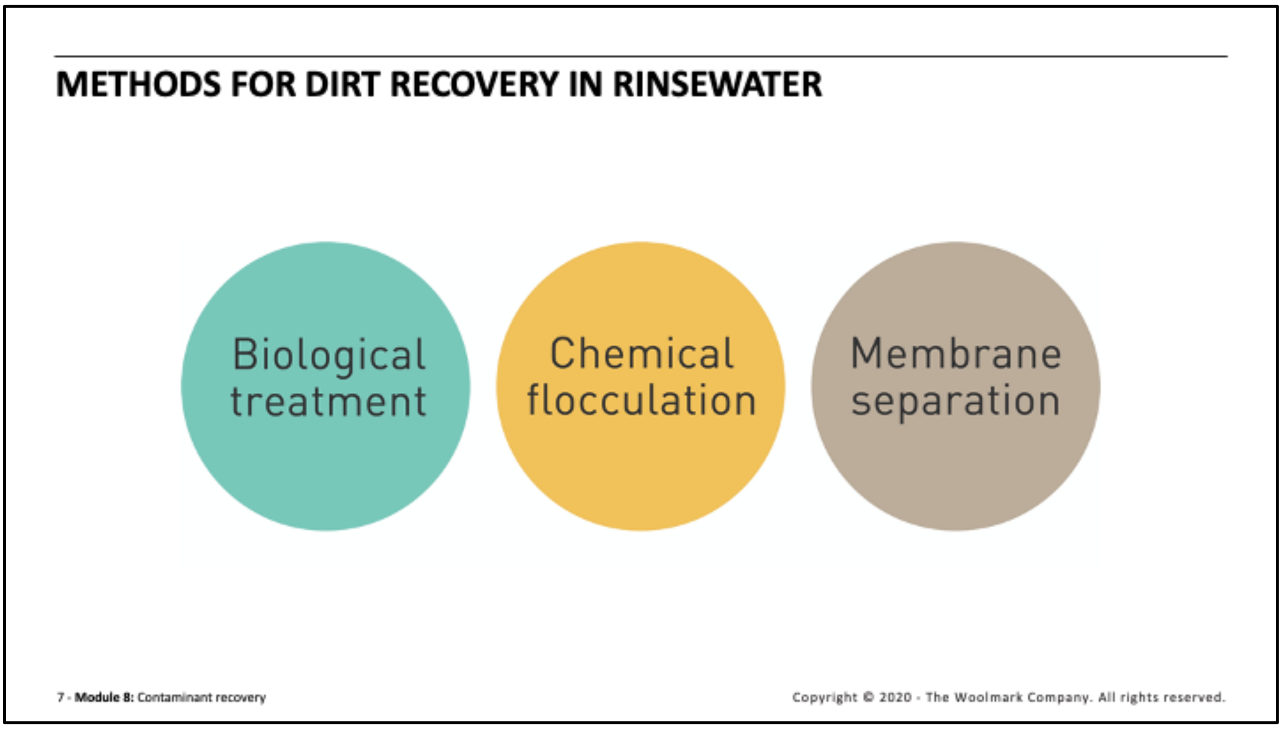
When in parallel (right-hand image), dirt removal is separate from wax removal. By running the removal system in parallel the conditions for dirt removal can be optimised.

POINT OUT that the optimum point to take out the contaminated liquor from the bowl depends on the contaminant. Taking the feed from the bottom of the bowls and side bowls is ideal for dirt recovery, but not for wool wax recovery.

The bowl discharge timers control the proportion of the feed being taken from the individual bowls.

With hydrocyclones, a bank of hydrocyclones services each bowl.

NOTE: In all cases, it is normal practice to return treated liquors to their respective side bowls.



EXPLAIN THAT rinsewater contains relatively low levels of contaminants compared with either de-suint or scouring liquors, so different dirt removal technologies can be used, which enable the treated water to be recycled.

INDICATE THAT three technologies have been used for this purpose in wool scours:

- biological treatment
- chemical flocculation
- membrane separation.

1. Biological treatment

- Rinsewater is discharged to a settling lagoon where it is biologically treated.
- The treated water is then chemically treated before being returned to the scouring line.

2. Chemical flocculation

- In this system, the rinsewater is treated by a combination of inorganic and organic flocculants.
- After settling, the treated water is returned to the scouring line.

3. Membrane separation

- Microfiltration membranes reject particles with a diameter of ~1µm or more, which means the only materials likely to pass through the membrane are dissolved salts, some colloids and detergent molecules.
- Fouling is a problem with any membrane system, but because little wool wax is present in rinsewater the rate of fouling is quite low.

POINT OUT that a major advantage of recycling rinsewater is that rinsing the wool in much cleaner water than normal results in a better colour of the scoured wool.

NOTE THAT another advantage for the chemical and membrane options is savings in heating costs as the treated effluent does not have to be re-heated prior to reuse in the scouring line. In the long biological process the liquor has adequate time to cool down.

DIRT RECOVERY DEVICES: BEST PRACTICE ISSUES

- Make certain a bowl is functioning as a scouring system and not a dirt recovery device.
- Discharge the bowl into a manifold, not an open drain.
- Ensure only the discharge valve to one hopper is open.
- Manage discharges times to avoid accumulation of dirt in the bowl.
- Combine hydrocyclones with a small lamella settler in a two-stage dirt recovery system to limit losses of wool wax.
- Recycle rinsewaters.

8 - **Module 8:** Contaminant recovery

EXPLAIN THAT it is important to make certain a bowl is functioning as a scouring system and not a dirt recovery device by ensuring adequate feed from the bottom of the bowl to a dirt recovery device in a liquor handling loop.

POINT OUT that all discharges from the bowls should flow into a manifold, rather than an open drain.

ENSURE THAT only the discharge valve to one hopper is open at any time to help stop hopper blockages.

EXPLAIN THAT discharge times may need to be changed depending on the accumulation of dirt in the bowls.

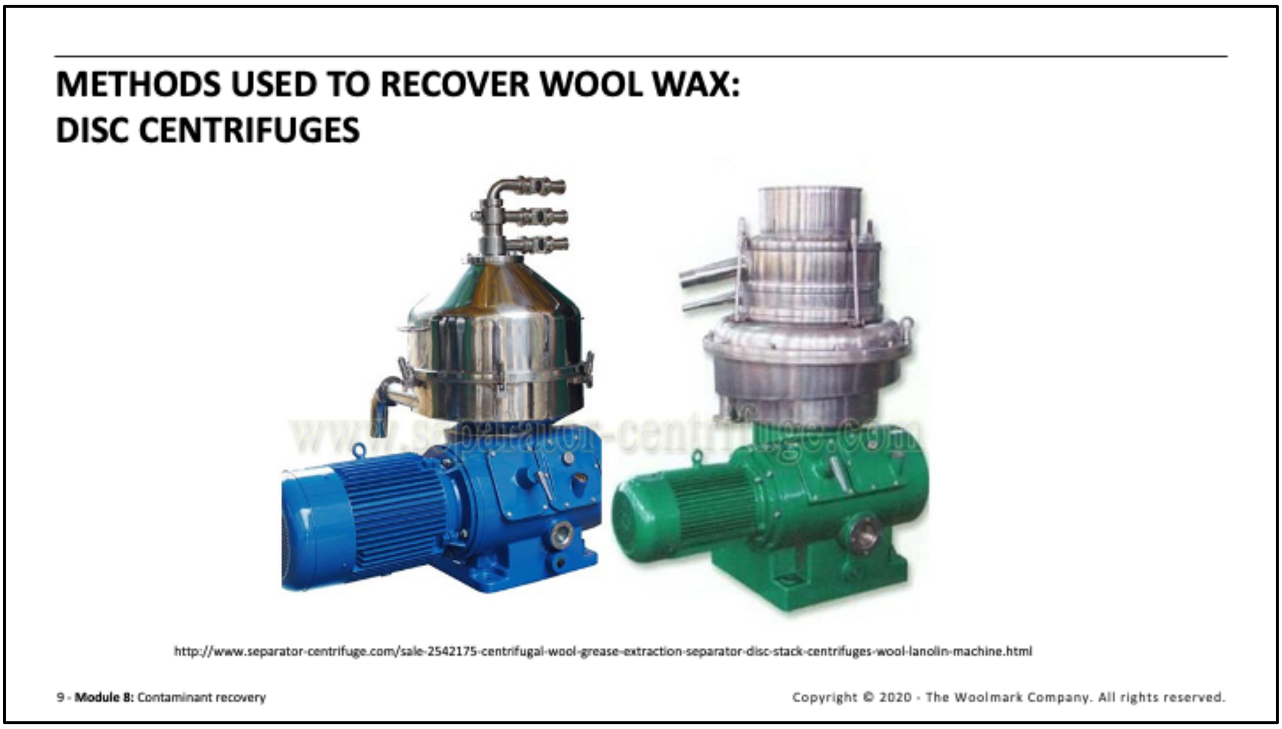
INVESTIGATE combining hydrocyclones with a small lamella settler in a two-stage dirt recovery system to limit losses of wool wax.

NOTE THAT rinsewater should be recycled where possible.

ASK *participants to suggest why the scourer can not simply filter all the dirt from the scour liquor and rinse liquor.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *indicate that if this was to occur, the filters would quickly block up and impede flow.*



As mentioned in *Module 7 — Principles of contaminant recovery*, disc centrifuge devices are commonly used in liquid–liquid separations for wool wax recovery.

EXPLAIN THAT the take-off for the feed from the bowl depends on the bowl design. With some scouring lines, the feed has to be taken from the side tanks or the bottoms of the bowls. When the feed is taken from these positions, the concentration of dirt and wool wax are likely to be highest and lowest respectively. With these systems the dirt and wool wax recovery are on the same recovery loop.

EXPLAIN THAT in modern designs the feed is taken from the scouring bowls near the squeeze rollers. The ideal take-off point is the non-turbulent zone in a side pocket near the squeeze rollers. At this point the level of dirt in the liquor is likely to be lowest and the wool wax concentration the highest.

NOTE THAT disc centrifuges perform two roles:

- Firstly, they are used to recover wool wax (as a cream) from the scouring liquor.
- Secondly, they are used to recover anhydrous wool wax (grease) from the recovered cream.

Wool wax recovery from scouring liquors

Of the three types of disc centrifuge — solid bowl, opening bowl and nozzle — only those with nozzles should be used for wool wax recovery. Solid bowl centrifuges fill too quickly with dirt, while opening bowl centrifuges require the centrifuge to be stopped in order to open the bowl to discharge accumulated dirt.

EXPLAIN THAT disc centrifuges separate the scouring liquor into three phases:

- a cream phase containing the recovered wool wax
- a sludge phase containing dirt
- a centrate that can be recycled to the scouring line.

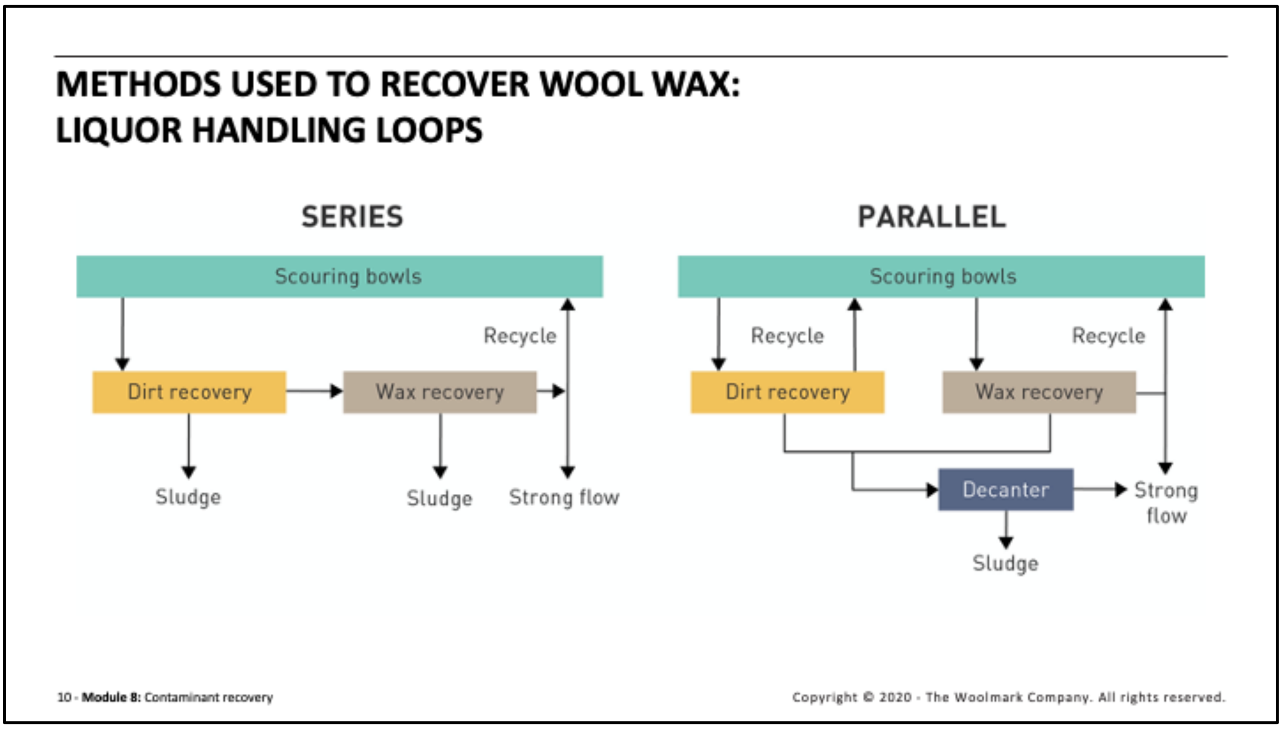
Recovery of anhydrous wool wax

The centrifuges used to recover wool wax from the cream must perform a number of functions:

- remove water-soluble contaminants and fine dirt from the cream by washing with hot water
- concentrate the solids content of the cream
- produce anhydrous wool wax by inverting the emulsion to a water-in-oil emulsion and concentrating the solids content.

***ASK** participants if they can explain why the dirt has to be removed from the centrifuges.*

***IF NECESSARY** indicate that if left in the centrifuge, dirt will damage the device.*



EXPLAIN THAT all wool wax recovery systems need a fibre strainer to remove wool fibres before the liquor reaches the recovery devices.

Wool wax recovery systems also should have a large (100 mm) hydrocyclone to remove erosive solids, such as sand, to protect the centrifuges.

POINT OUT that there is only one loop – a dirt recovery loop – attached to the de-suint bowl. This is not shown on the slide.

INDICATE THAT with a scouring bowl there are two recovery systems:

- one for the dirt
- one for the wool wax.

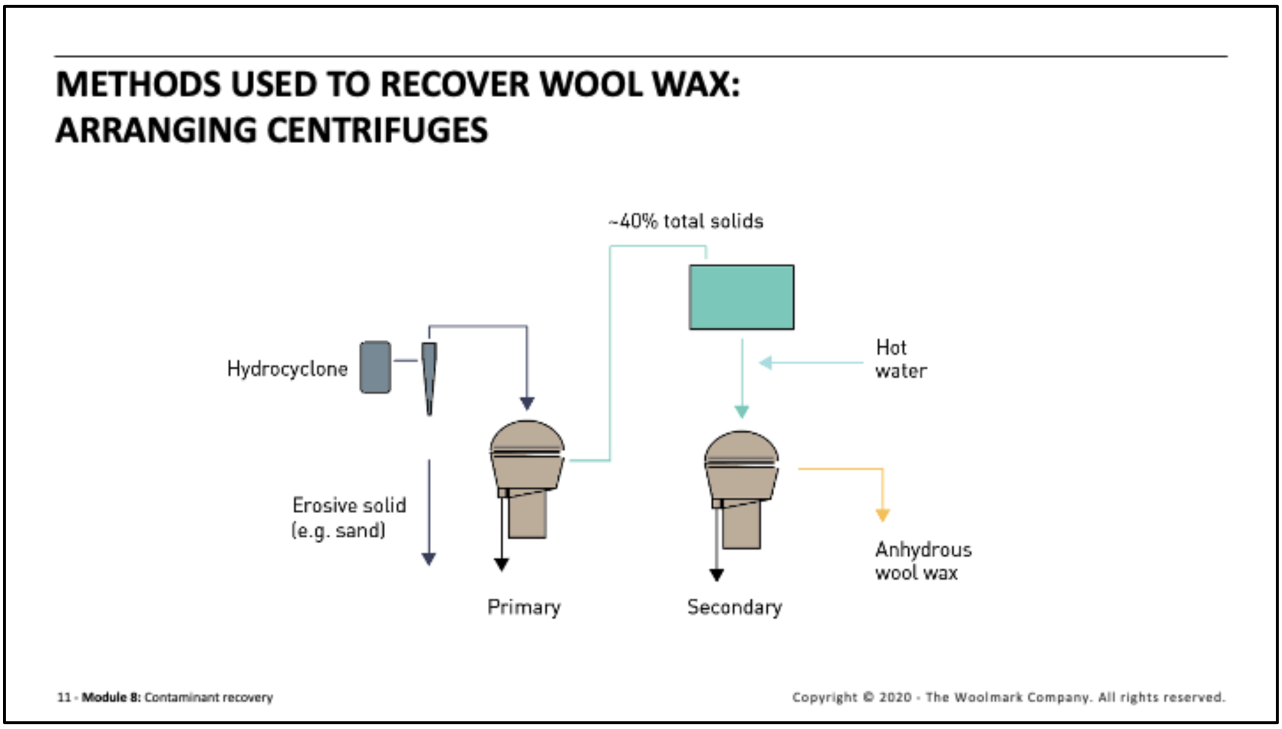
EXPLAIN THAT these may be arranged in series or in parallel as illustrated on the slide.

Series

- The WRONZ system used the dirt and wool wax systems in series, but there are several disadvantages with this arrangement:
    - the feed is taken from the bottoms of the bowls and side bowls (ideal for dirt recovery but not for wool wax recovery)
    - the optimum conditions for the dirt recovery device may not be the optimum conditions for the wool wax recovery.

Parallel

- Modern scouring systems, uses dirt and wool wax systems in parallel.
- In this arrangement, the feeds to the two systems are taken from optimum sites on the scouring bowls and the performance of the two systems can be managed separately for individual optimisation.



POINT OUT there are two ways to arrange centrifuges in a wool wax recovery system:

- two-stage
- three-stage

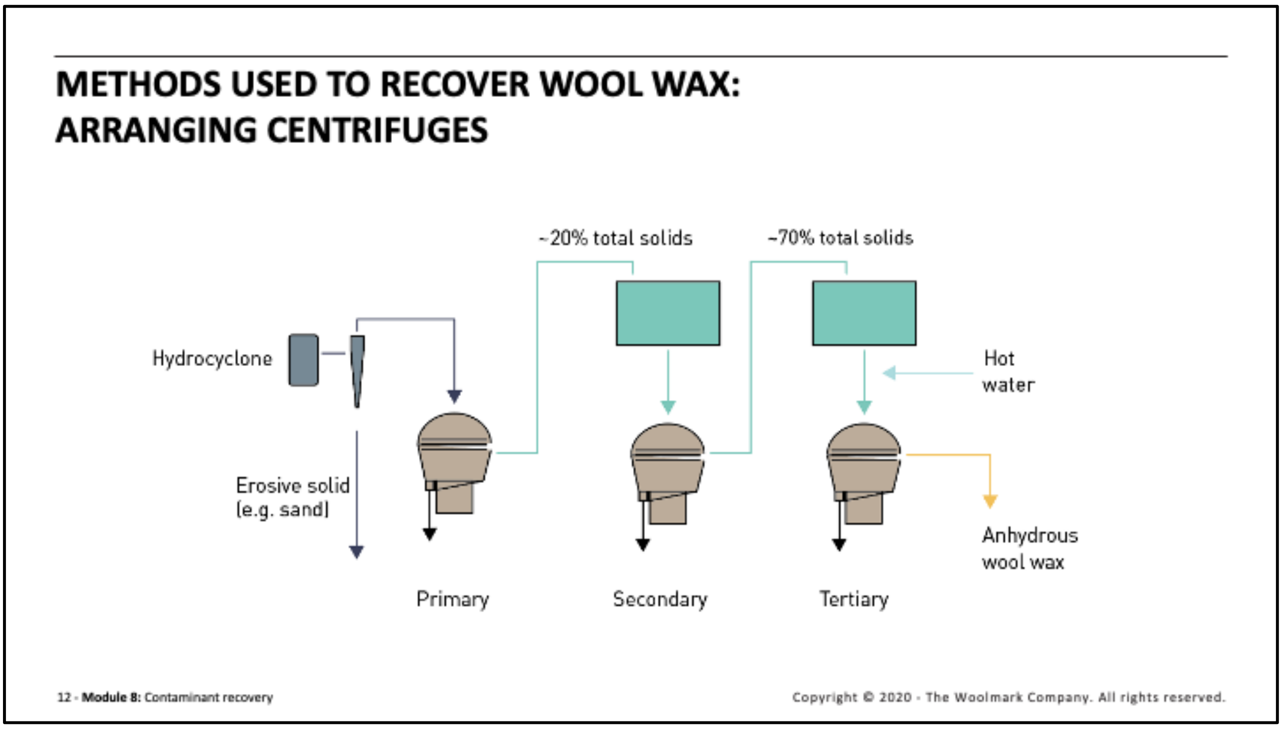
EXPLAIN THAT in a two-stage recovery system (shown on the slide), the cream from the primary centrifuge is about 40–45% total solids.

The cream has to be at least this concentration to allow the purifier centrifuge to produce anhydrous wool grease.

EXPLAIN THAT this arrangement places a heavy strain on the second purifier centrifuge because it has to:

- concentrate the oil-in-water emulsion
- wash dirt and water-soluble material from the cream
- invert the emulsion to form a water-in-oil emulsion so anhydrous wool grease is obtained that contains low levels of water, dirt and water-soluble material.

NOTE THAT all of this is difficult to accomplish.



INDICATE THAT in a three-stage recovery system (shown on the slide), the primary centrifuge recovers a cream with about 15–20% solid content. This is the optimum cream concentration for wool wax recovery.

EXPLAIN THAT during the secondary stage, a concentrator centrifuge reduces the cream to about 70% solids content while washing out water-soluble matter and dirt.

EXPLAIN THAT the third (tertiary) centrifuge acts as a purifier centrifuge as it further concentrates the cream before inverting it to a water-in-oil emulsion on the way to producing anhydrous wool wax.

- The three-stage centrifuge systems recovers more wool wax than the two-stage system, and the wax quality is likely to be higher.

POINT OUT that the characteristics of the cream are governed by the type of centrifuge, the feed rate, the gravity disc size and the back-pressure valve (if available).

METHODS FOR WOOL WAX RECOVERY: BEST-PRACTICE CONSIDERATIONS

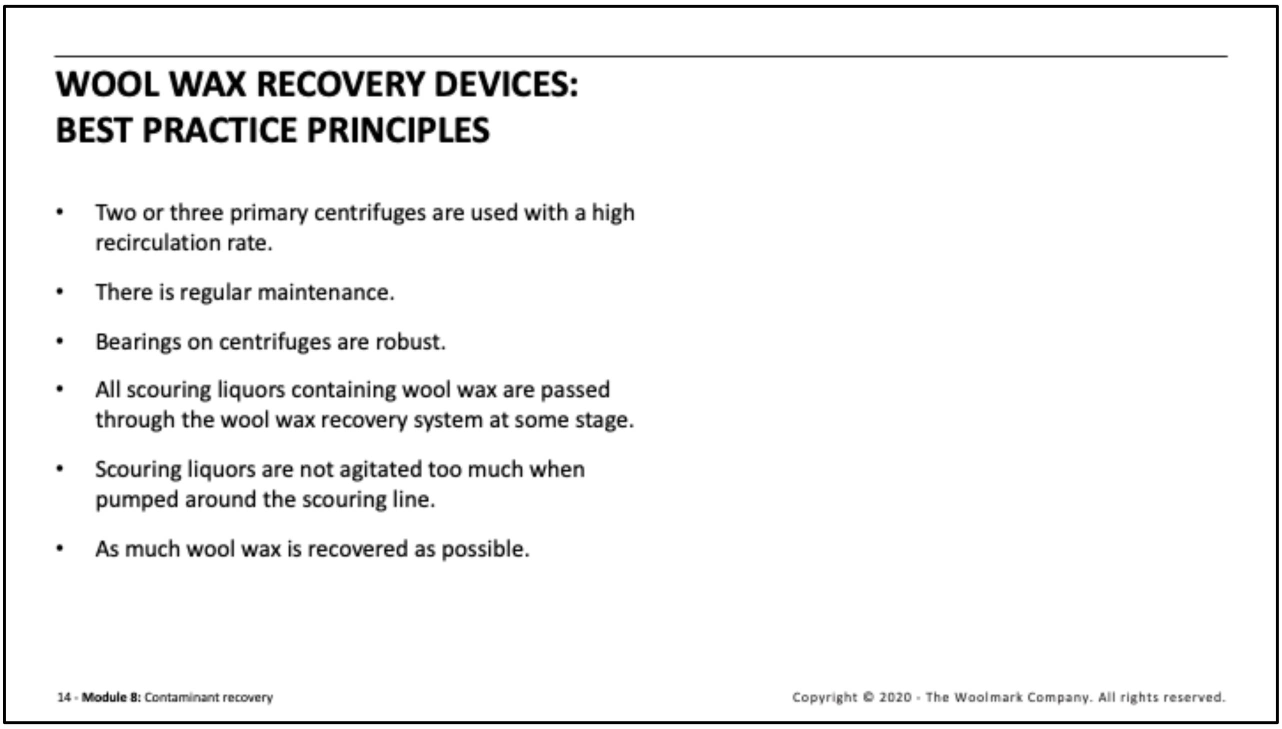
The following issues need to be resolved during wool wax recovery:

- where the feed to the centrifuges should be taken from
- the type of centrifuge to use
- how the liquor handling loops for dirt and wool wax are arranged
- whether two-stage or three-stage wool wax recovery is better for optimum cream composition
- the optimum conditions for wool wax recovery.

13 - **Module 8:** Contaminant recovery

EXPLAIN THAT during wool wax recovery the following issues need to be resolved:

- where the feed to the centrifuges should be taken from: bottoms of the bowls, the side bowl or from the scouring bowl
- the type of centrifuge that should be used
- how the liquor handling loops for dirt and wool wax should be arranged
- whether two-stage or three-stage wool wax recovery is better for optimum wool wax recovery
- the optimum conditions for wool wax recovery.



INDICATE THAT a number of principles needs to be followed to ensure best-practice wool wax recovery:

- Two or three primary centrifuges should be used with a high recirculation rate to ensure the best wax recovery (a rough rule of thumb is a feed of 1 m^3/hour for every 100kg greasy wool).
- Regular maintenance is essential.
- When purchasing centrifuges, take particular care to ensure the bearings are robust.
- All scouring liquors containing wool wax must be passed through the wool wax recovery system at some stage, which means there should be no uncontrolled flowdowns.
- Care must be taken to ensure the scouring liquors are not agitated too much when being pumped around the scouring line — wool wax is reduced by excessive agitation.
- Given the current value of recovered wool wax, care should be taken to recover as much as possible — the amount of wool wax being discharged in the wastewater decreases with increasing wool wax recovery.

SUMMARY – MODULE 8

- Contaminant recovery is usually associated with a contaminant recovery loop.
- With dirt recovery devices, the feed is taken from the bottom of the bowls and the treated liquor is returned to the side bowl.
- Dirt recovery devices used in wool scouring:
  - settling tanks
  - lamella tanks
  - hydrocyclones
  - decanter centrifuges.
- Hydrocyclones are preferred over settling tanks.
- A bowl should function as a scouring system and not a dirt recovery device.
- Three technologies are used for dirt recovery from rinsewater:
  - biological treatment
  - chemical flocculation
  - membrane separation.

15 - **Module 8:** Contaminant recovery

SUMMARISE the module by explaining that contaminant recovery is usually associated with a contaminant recovery loop in which the scouring liquor is returned to the wool scour after passing through a contaminant recovery device.

With dirt recovery devices, the feed is taken from the bottom of the bowls and the treated liquor is returned to the side bowl.

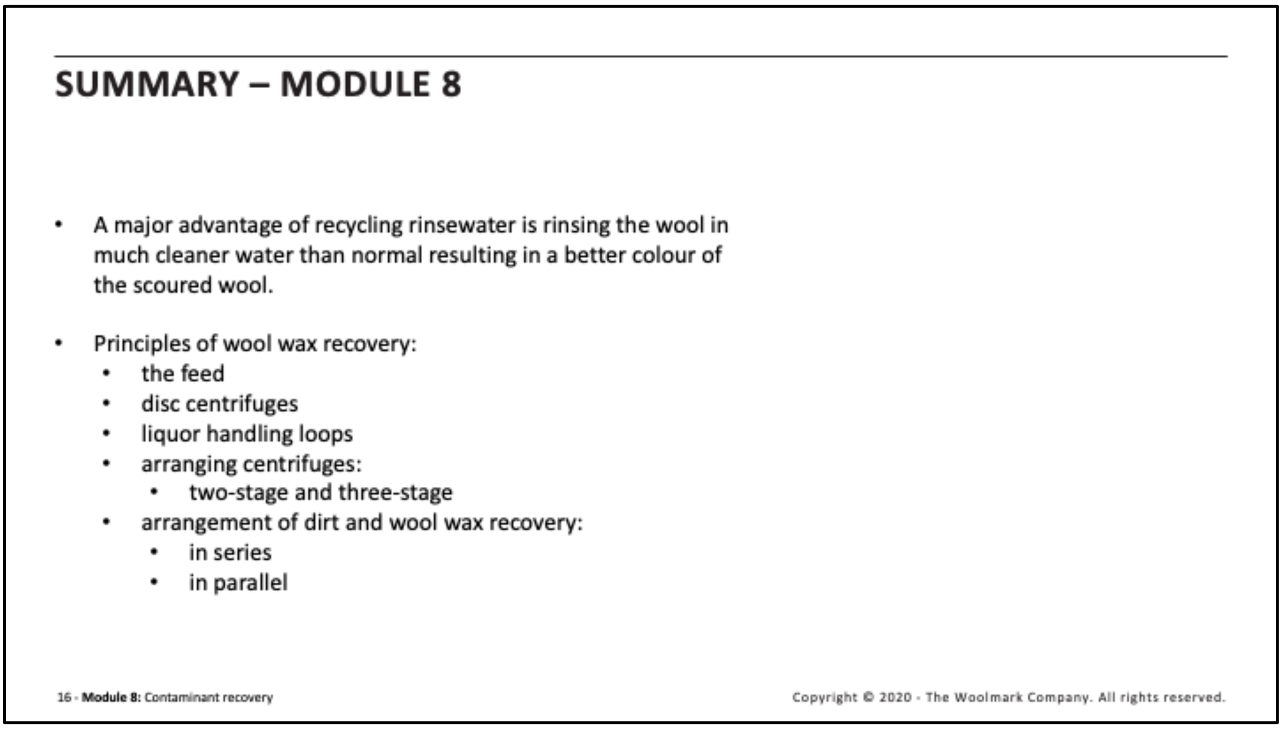
REITERATE that dirt recovery devices used in wool scouring include:
- settling tanks
- lamella tanks
- hydrocyclones
- decanter centrifuges (but not usually in contaminant recovery loops).

NOTE: Hydrocyclones are preferred over settling tanks as dirt recovery devices.

REMIND participants that there are normally two dirt recovery loops:
- one services the first bowl (de-suint bowl)
- the other services the scouring bowls (one, two or three bowls).

REINFORCE THAT it is important to make certain a bowl functions as a scouring system and not a dirt recovery device by ensuring adequate feed from the bottom of the bowl to a dirt recovery device.

REVIEW the fact that three technologies have been used to recover dirt from rinsewater:
- biological treatment
- chemical flocculation
- membrane separations.



REINFORCE the fact that a major advantage of recycling rinsewater is rinsing the wool in much cleaner water than normal, resulting in a better colour of the scoured wool.

REVIEW the principles of wool wax recovery:

- the feed
- disc centrifuges
- liquor handling loops
- arranging centrifuges:
    - two-stage
    - three-stage.

REMIND participants that dirt and wool wax recovery systems can be arranged:

- in series
- in parallel.

NOTE: In a parallel arrangement, the feeds to the two systems are taken from optimum sites on the scouring bowls and the performance of the two systems can be managed separately for individual optimisation.

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 the *Raw wool scouring* course — *Module 9: Wastewater treatment* — 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 9

THE WOOLMARK COMPANY

WASTEWATER TREATMENT

RESOURCES — MODULE 9: WASTEWATER TREATMENT

No additional resources are required to deliver **Module 9: Wastewater treatment**.

WELCOME participants to Module 9 of the Woolmark Wool Science, Technology, Design Education Program *Raw wool scouring — Wastewater treatment.*

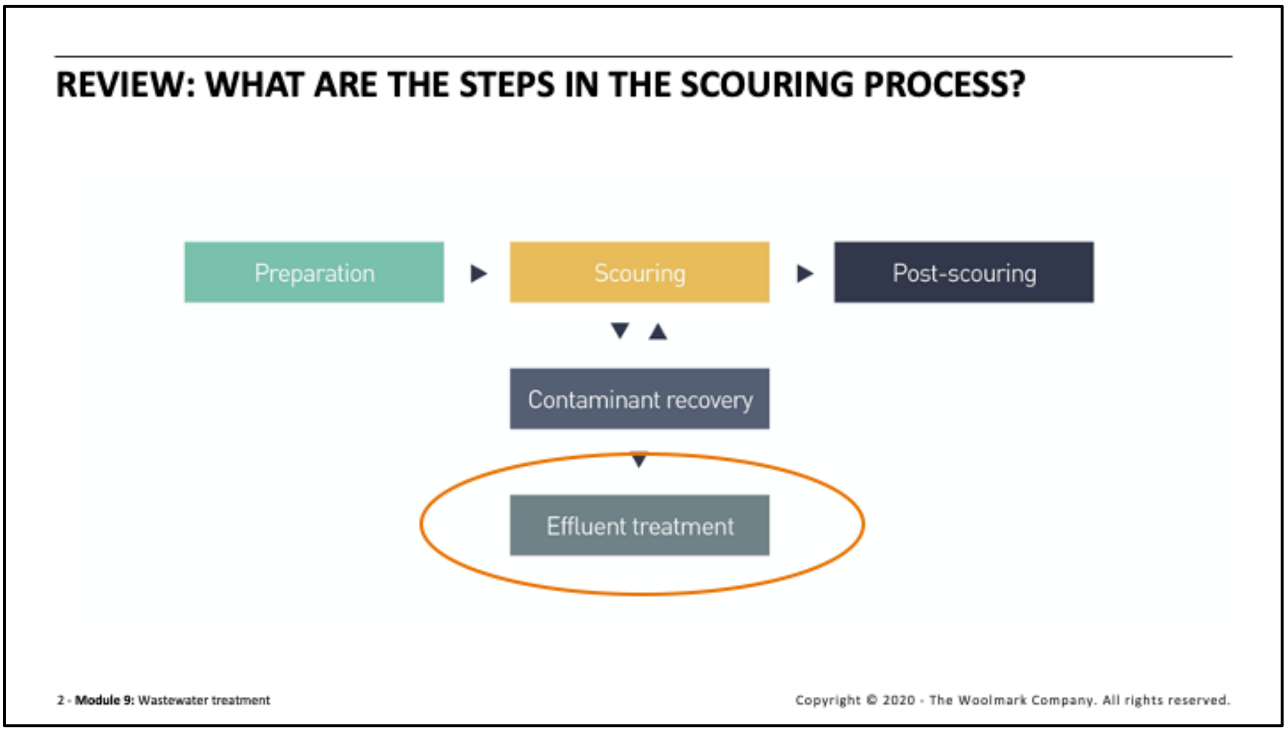
EXPLAIN THAT this module will cover:

- the environmental issues associated with scouring
- the pollution propensity of contaminants
- sludge treatment and disposal
- choosing a wastewater treatment
- market pressures
- best practice issues.

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

- describe the environmental issues associated with scouring
- describe the treatment systems available for scouring wastewater.

NO RESOURCES REQUIRED



REITERATE THAT the steps in the scouring process are:

- consignment preparation
- scouring line
    - contaminant recovery
    - effluent treatment
- post-scouring processes.

EXPLAIN THAT this module will cover the issues associated with effluent treatment following the scouring operation.

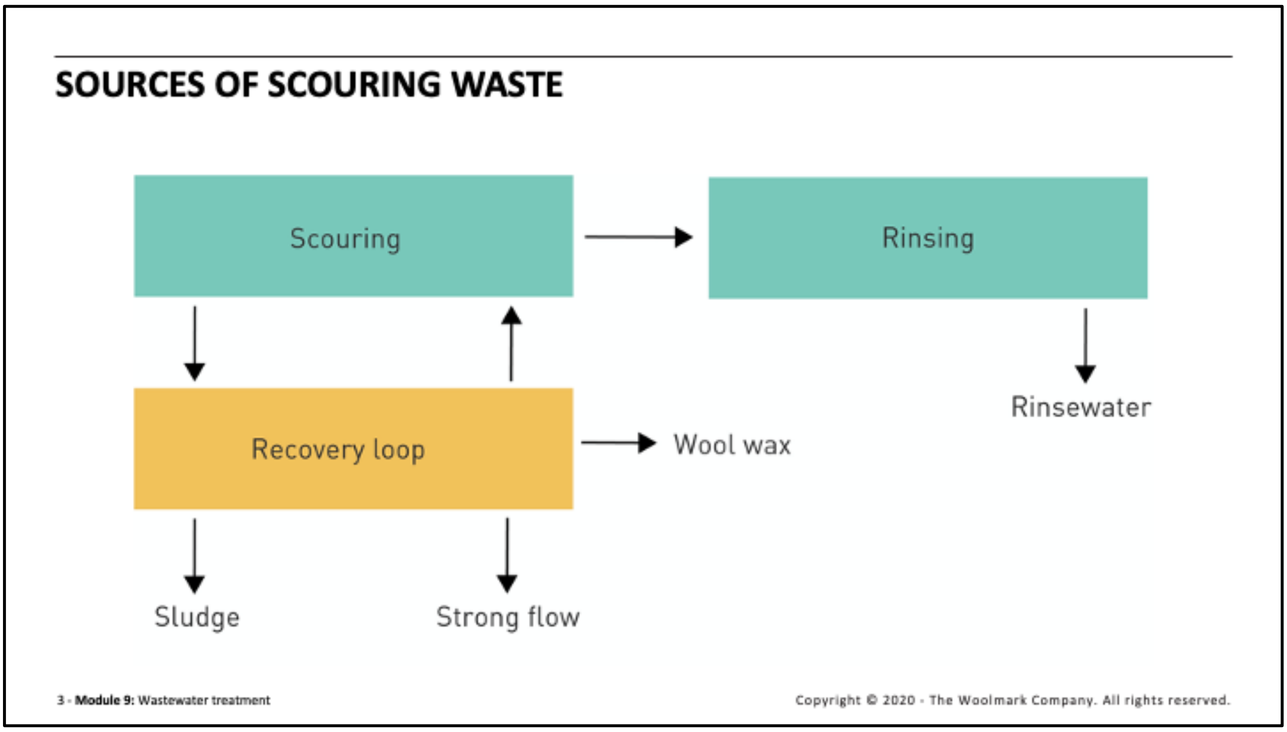
ASK *participants to explain why they think wastewater treatment is important.*

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

POTENTIAL RESPONSES:

- *There are environmental issues associated with scouring effluents.*
- *The expense of water usage and waste disposal are important considerations.*

ADVANCE *to the next slide to explore sources of scouring waste.*



EXPLAIN THAT only a proportion of the wool wax and dirt (about 30–50%) is recovered in the recovery loops that continually treat the scouring liquors before returning them to the scour.

NOTE THAT remaining contaminants are discharged from the scour as wastewater.

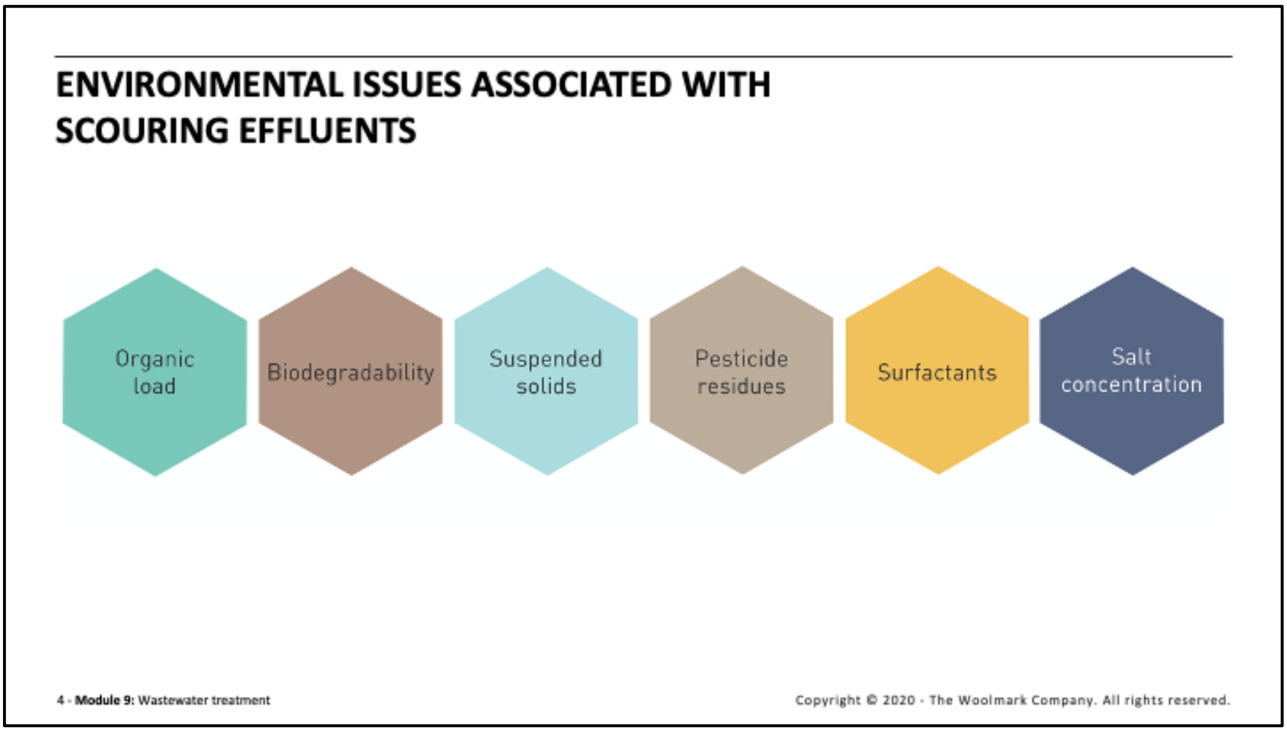
EXPLAIN THAT this wastewater consists of two or three main effluent streams from the wool scour:

- a strong flow
- a rinsewater flow
- flow from a de-suint bowl (if one is being used).

INDICATE THAT the strong flow consists of discharges from the dirt and wax recovery loops and the centrate flowdown from the primary grease centrifuge.

For a typical wool scour processing about 1500 kg raw wool per hour, this means about 140kg wool wax, 140kg dirt and 70kg suint are discharged hourly.

In addition a sludge containing about 45% solids is discharged to landfill (about 7 tonnes per day for the above-mentioned production capacity).



INDICATE THAT a number of environmental challenges are associated with scouring effluents:

Organic load

Organic load is the amount of organic material that will consume oxygen during its aerobic degradation.

The organic load of the effluent from a typical wool scouring line is equivalent to that from a population of 50 000 people.

Although the components are mostly natural (wool wax and suint), the size of the organic load poses challenges for sewage treatment plants, especially in terms of the poor biodegradability of wool wax.

Biodegradability

Wool wax in particular is difficult to degrade by biological microorganisms because of its chemical structure and physical characteristics.

There are also components of the suint, in particular, that resist biodegradation.

Some anionic surfactants formerly used to scour wool in developing countries are poorly biodegradable.

Biodegradation by-products of some non-ionic surfactants are toxic and may have an oestrogen-mimicking ability. Modern mills do not use these surfactants.

Suspended solids

Operation of biological treatment plants can be adversely affected by the suspended solids contained in wool scouring effluent (e.g. biological processes can be hindered in 'lagooning' systems when suspended matter limits the penetration of light into the water).

Suspended matter adds to the amount of sludge processed.

The presence of dirt in a scouring effluent adversely affects the separation of the emulsified wool wax.

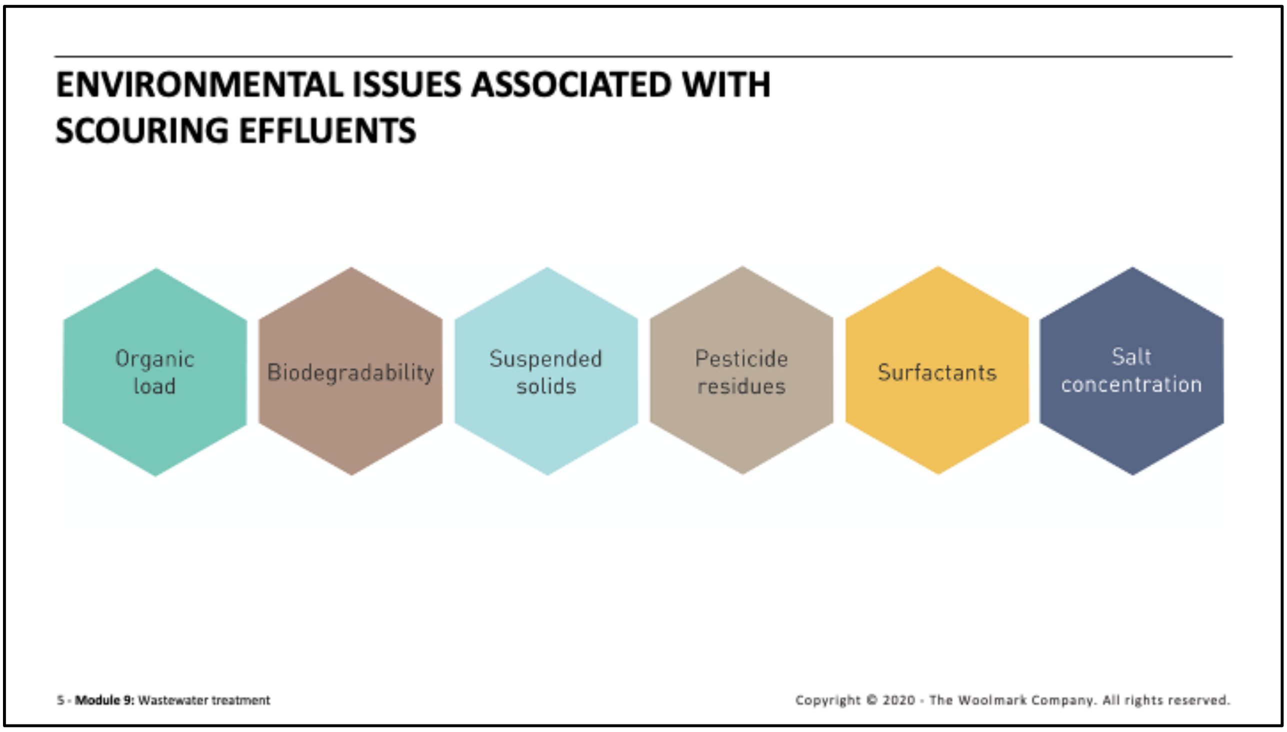
Pesticide residues

Pesticides are applied to wool on the farm to control various sheep parasites.

The type and the amount of pesticides found in the effluent depends on the nature of the parasites and the time of treatment in relation to the time of harvesting of the wool.

The pesticides used by Australian woolgrowers have legal withholding periods, which aim to limit the amount of pesticide in scouring effluent.

Most Australian wools contain low pesticide residues.



Surfactants

Surfactants can cause a number of problems in effluent, including foaming, poor biodegradability and dangerous biodegradation by-products.

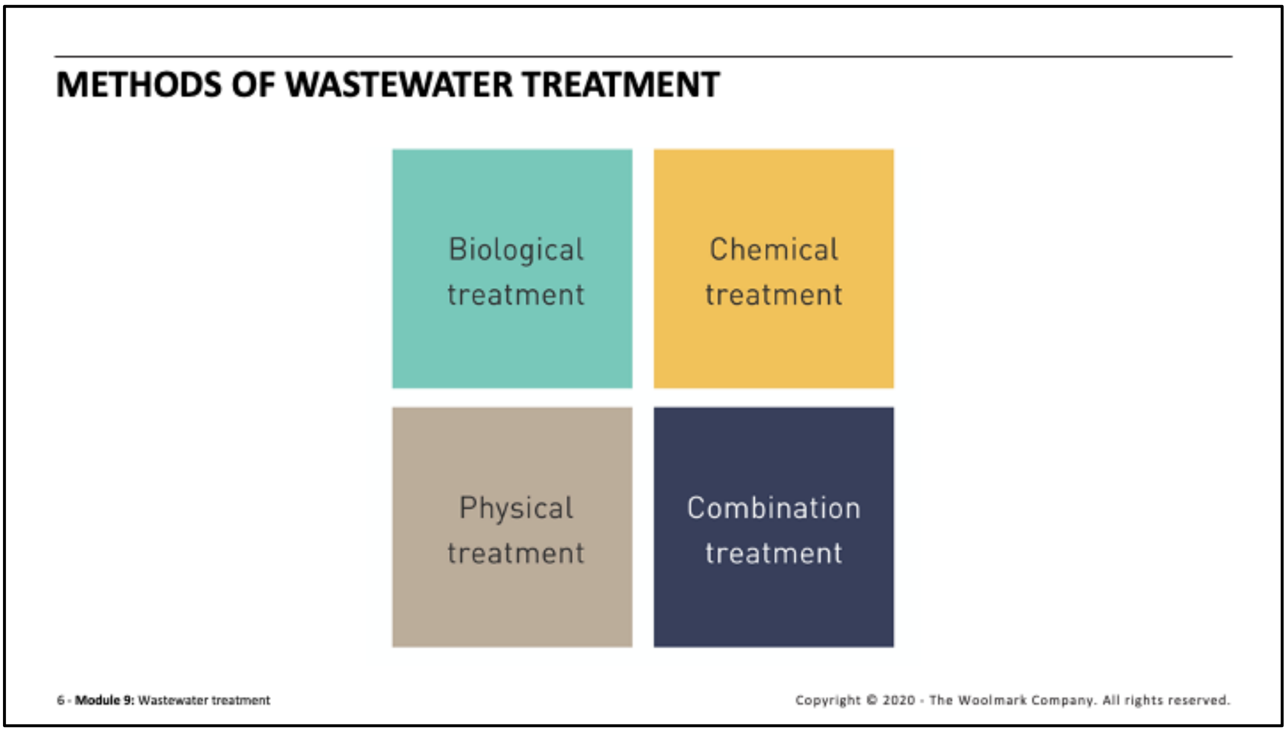
Foaming occurs with excess surfactant, but is not common.

As mentioned, some anionic surfactants used to scour wool in China are poorly biodegradable.

Biodegradation by-products of some non-ionic surfactants are toxic and may have an oestrogen-mimicking ability. Modern mills do not use these surfactants.

Salt concentration

Suint contains about 27% potassium. This means the effluent contains about 1% potassium. If the treated wastewater is applied as irrigation water, over-application of potassium can adversely affect the structure and chemical fertility of soil.



INDICATE THERE are various methods of wastewater treatment, which can be broadly classified as:

- biological
- chemical
- physical
- combinations of methods.

EXPLAIN THAT virtually every method of wastewater treatment has been investigated for wool scouring effluents by research laboratories around the world.

NOTE TO FACILITATOR: *Each of the above treatments will be covered separately on the following slides, starting with biological treatment.*

METHODS OF WASTEWATER TREATMENT: BIOLOGICAL

- The presence of wool wax makes the scouring wastewater difficult to treat.
- In addition the treated effluent produces large amounts of waste biological sludge.
- Much of the wool wax and dirt in the feed remains in the lagoons without being degraded.

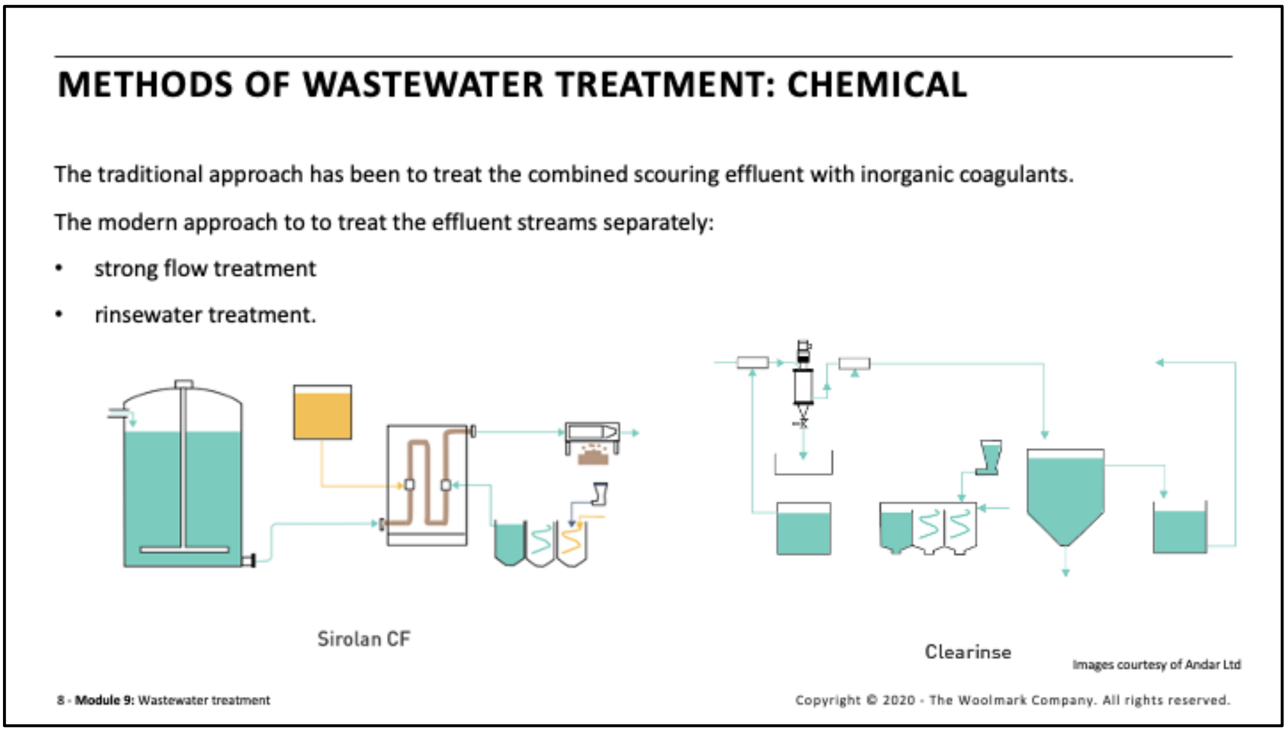
Image courtesy of Dr J Christoe

7 - **Module 9:** Wastewater treatment

EXPLAIN THAT biological treatment involves allowing natural biological processes to degrade the contaminants in effluent as it is stored in ponds or lagoons.

INDICATE THAT the presence of wool wax makes scouring wastewater difficult to treat using biological processes due to its poor biodegradability and physical characteristics.

- In addition, biologically-treated wool scouring effluent produces large amounts of waste biological sludge.
- In Australia during recent years, questions have been raised about the use of lagoons for biological treatment as it is believed much of the wool wax and dirt in the feed remains in the lagoons without being degraded.



EXPLAIN THAT the traditional approach of chemical wastewater treatment has been to treat the combined scouring effluent (strong flow and rinsewater) with inorganic coagulants, such as lime, ferrous, ferric and aluminium sulphates. The sludges produced by these chemicals are quite voluminous.

NOTE THAT the modern approach for chemically treating scouring wastewaters is to treat the different streams separately.

Strong flow treatment:
A new generation of polymeric flocculants can be added to the effluent after pH adjustment using an in-line mixer (i.e. no mixing tanks) and fed immediately into a decanter centrifuge (Sirolan CF and Clearinse by Andar are examples shown on the slide).
The process removes about 85–90% of the organic load.

Rinsewater treatment:
If rinsewater is treated by a small amount of an inorganic coagulant and a polymeric flocculent, the clarified water can be recycled without impacting the quality of the scoured wool.

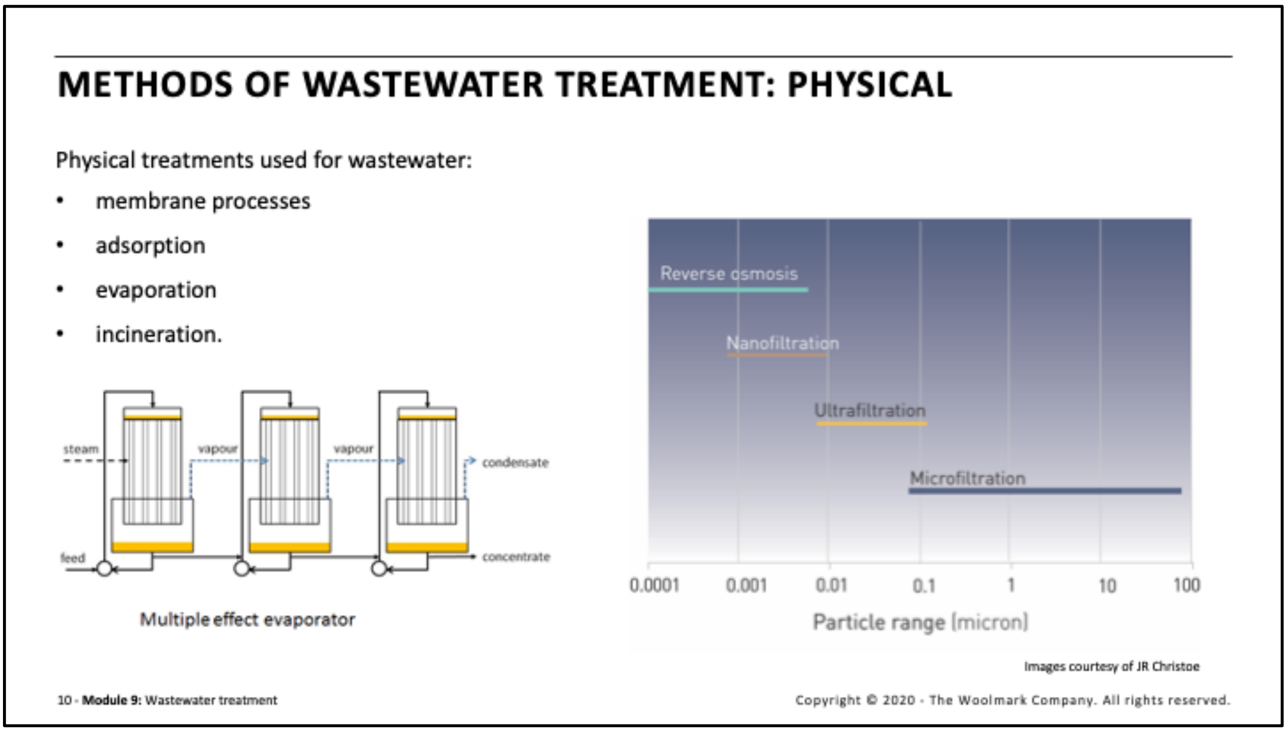
The advantages are: a considerable saving in the amount of water used, a large energy saving (because not all the incoming process water is heated) and cleaner scoured wool.

***EXPLORE** whether participants understand how coagulants work.*

***IF NECESSARY** explain that the positive charge of the coagulant reduces the negative charge on the emulsion particles and suspended material so that the electrical repulsion between the emulsified or suspended particles is reduced and the particles can coagulate (join together) becoming big enough to precipitate.*

REFER participants to the images shown on the slide that illustrate some of the chemical treatment systems currently used to treat scouring effluent:

- Sirolan CF
- Clearinse by Andar.



INDICATE THERE is a variety of physical treatments used for wastewater:

Membrane processes:

- This technology uses a semi-permeable membrane to separate the components of wastewater — suspended and dissolved inorganic and organic solids.
- Most membrane systems use pressure-driven separation in which hydraulic pressure is used to force water molecules, solutes and colloidal matter through the membranes.
- A problem with all membrane processes is disposal of the concentrate.
- The size of the particles captured depends on the type of membrane process (shown in figure on the slide).

Adsorption:

- Adsorption is the process through which a substance, originally present in one phase, is removed from that phase by an accumulation at the interface between that phase and a separate phase.
- In the context of textile wastewater treatment, adsorption can occur at the interface of solid–liquid.
- The wastewater-containing contaminants (adsorbate) is passed through a bed of the adsorbent (the solid) and the molecules of the adsorbate become trapped in the pores of the adsorbent.
- The high levels of contaminants present in wool scouring wastewater means the adsorbent rapidly becomes exhausted or fouled.

Evaporation:

- Evaporators are used to reduce the volume of wastewater.
- Due to the amount of steam required, the process is expensive for larger volumes of scouring wastewater.
- The introduction of multi-stage evaporators utilising vacuum technologies and mechanical vapour recompression has increased their efficiency and reduced operating costs significantly.
- Disposing of the concentrate poses a problem.

Incineration:

- This is a process used in conjunction with other treatment processes (e.g. sludges from chemical and biological treatments can be incinerated).
- An incinerator uses high temperatures to burn the waste solids in the presence of air.
- Disposal of the residues can be a problem because they are mainly water-soluble salts.

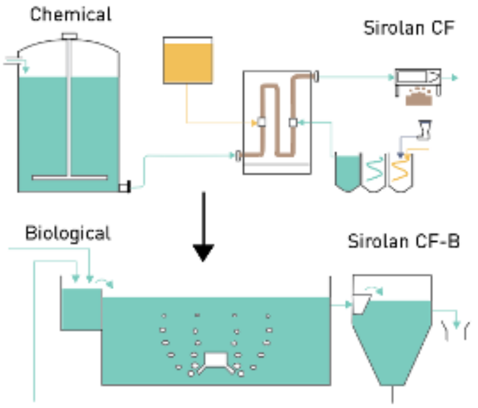
REINFORCE THAT the only processes that wlll remove soluble materials from wastewater are: reverse osmosis, adsorption and evaporation.

METHODS OF WASTEWATER TREATMENT: COMBINED TREATMENTS

A preferred treatment system for wool scouring effluent is a combination of biological and chemical treatments.

As rinsewater contains low levels of dissolved solids, several mills use the combination of biological and chemical treatments to treat rinsewater.

Multi-stage treatments, combining evaporation and incineration treatments reduces the high operating costs of this combination approach.



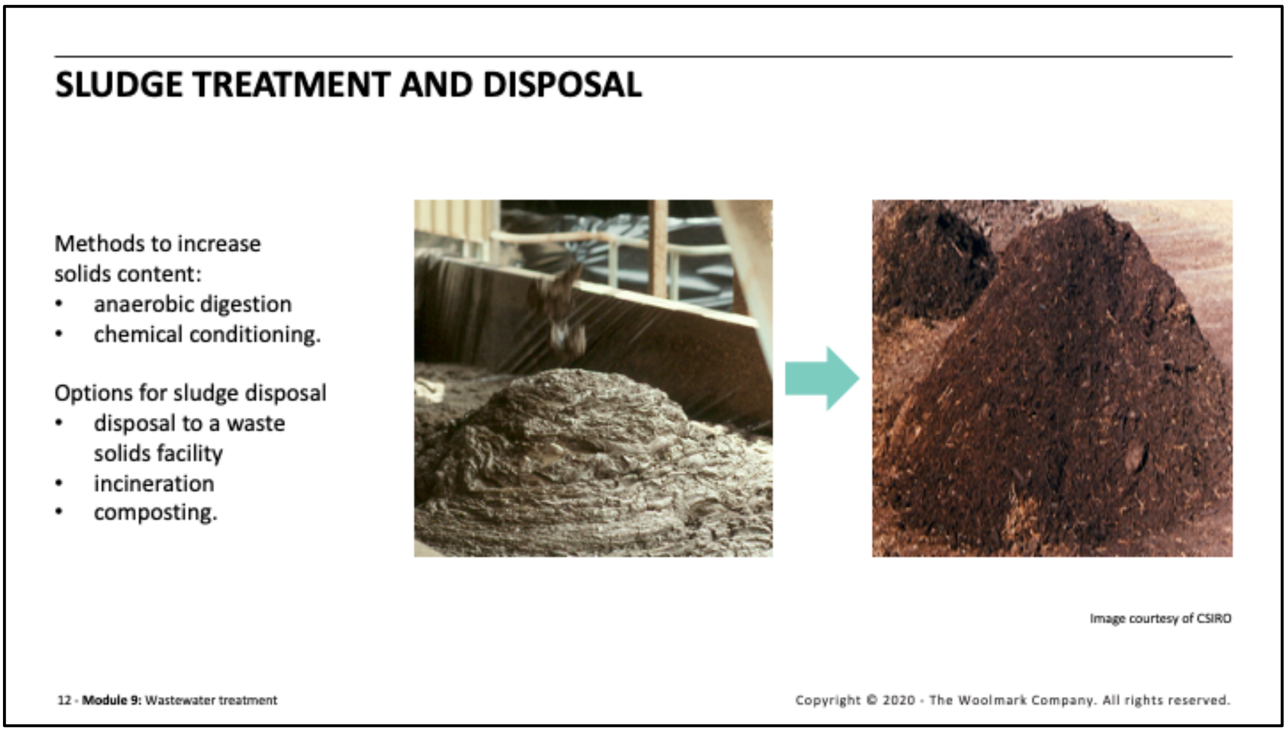
Images courtesy of Andar Ltd

11 - **Module 9:** Wastewater treatment

EXPLAIN THAT combinations of chemical and biological treatments are quite common for treating wool scouring wastewater (see the figure on the slide). However the resulting effluent does not yet meet many of the stringent discharge regulations now in force.

MENTION THAT because rinsewater contains low levels of dissolved solids, several mills use this combination approach to enable recycling of rinsewater. However, treated water is not suitable for re-use in scouring due to presence of dissolved salts

EXPLAIN THAT the introduction of multi-stage treatments, combining evaporation and incineration (using high-efficiency evaporators), reduces the previous high operating costs of this combination for treating both strong flow and rinsewater. The treated wastewater is not suitable for re-use in the scouring line due to the presence of steam-volatile materials, which cause odour problems in the scoured wool. This problem can be alleviated by a biological treatment, allowing re-use of the wastewater in the scouring line.



REMIND participants that all wastewater treatment processes produce some type of sludge.

POINT OUT that biological processes produce sludges with about 2% solids content, whereas typical sludge from inorganic chemical coagulation of a scouring liquor is about 10–20% solids.

EXPLAIN THAT before these sludges can be disposed of, the solids content needs to be increased — the higher the better. There are a couple of ways to do this:

- anaerobic digestion — a common approach to thermal conditioning of biological sludges
- chemical conditioning— a popular approach since the development of high-performance polymeric flocculants.

EXPLAIN THAT the options for sludge disposal include:

- disposal to a waste solids facility, such as a tip, depending on the sludge's classification
- incineration
- composting.

ASK *participants to suggest which methods of sludge disposal create a value-added product.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *indicate that composting sludge can create a value added-product (fertiliser) and incinerated sludge can be used as fuel.*

SUINT AND COMPOSTED SLUDGE AS FERTILISER

Images courtesy of CSIRO

13 - **Module 9:** Wastewater treatment

EXPLAIN THAT when mixed with a variety of other materials, such as sawdust and green waste, composting can be an effective way to dispose of sludge, providing there is sufficient wool wax present to provide the fuel for the composting process.

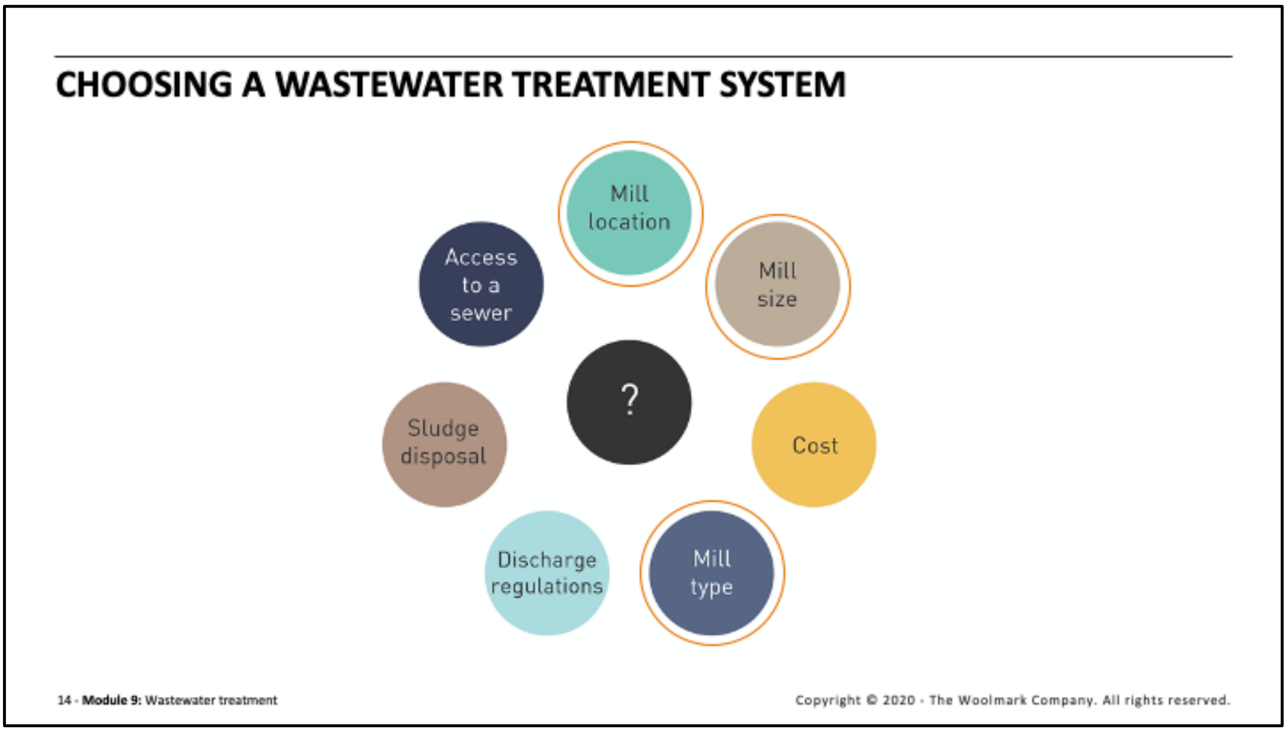
NOTE THAT wool wax has a calorific value similar to fuel oil.

- The temperature required for pasteurisation (greater than 55°C) can be easily achieved ensuring any pathogens and weed seeds in the compost material are destroyed.

EXPLAIN THAT since the introduction the Sirolan CF effluent treatment processor, sludge contains a high proportion of wool wax. It is important the composting process breaks down as much of this waxy residue as possible during the thermophilic stage of the process.

INDICATE THAT after the thermophilic stage of the composting process has finished and the compost has been allowed to mature for a few weeks, a simple phytotoxicity test can be carried out to determine whether or not the material is suitable for use as a fertiliser to support plant growth.

NOTE THAT suint has a high potassium content and can, in the correct application, be used as a fertiliser.



EXPLAIN THAT there are many factors that influence the choice of wastewater treatment:

Mill location

- Rural — Where land is available for the disposal of treated wastewaters, but there is no access to a sewer. Even in rural locations, environmental discharge regulations may prevent land disposal.
- Semi-rural — near an urban centre where there may be access to a sewer, but availability of land is more likely to be restricted.
- Urban — access to a sewer but availability of land is strictly limited.

Mill type

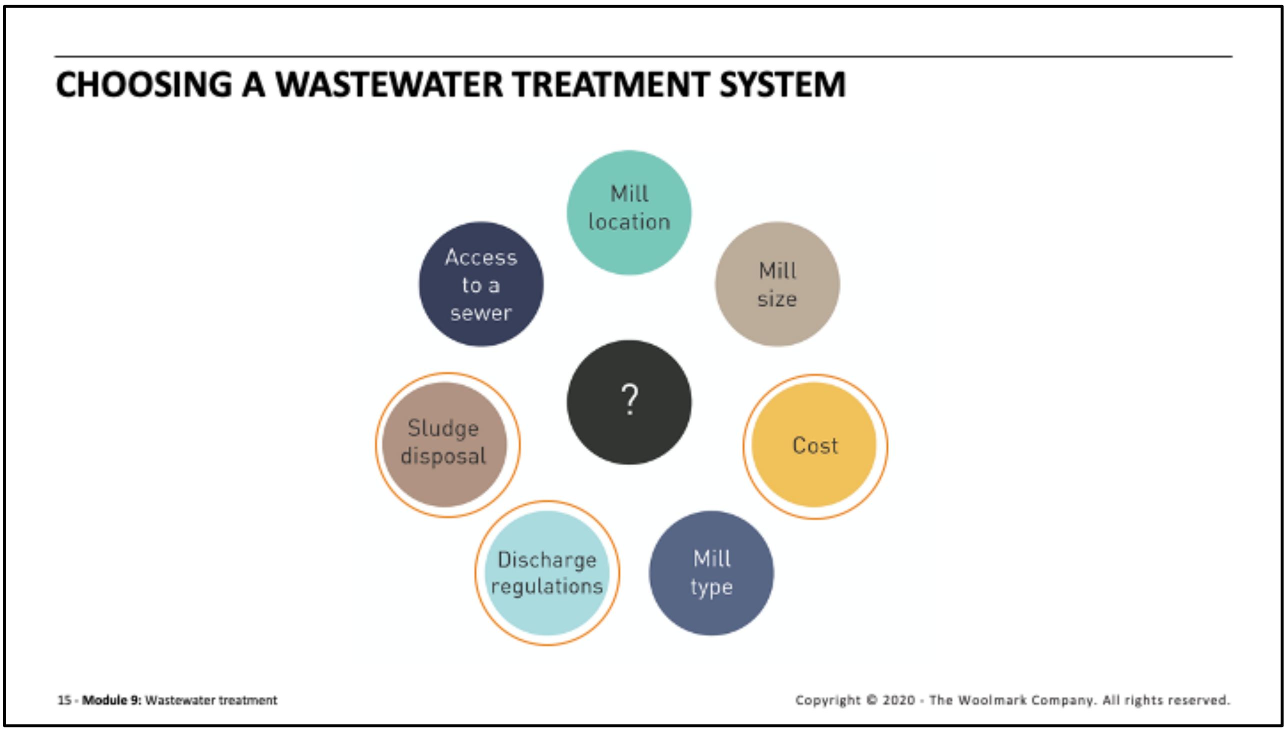
Three types of mill undertake scouring operations:

- scouring only
- scouring plus top-making
- vertical.

With the first two types, the only aqueous effluent comes from the scouring line.
At a vertical mill, dyeing and finishing effluents add to the pollution level load.
Because scouring effluents are quite different to dyeing and finishing effluents, the best-practice approach at a vertical mill is to treat the scouring effluent separately, especially to remove wool wax and dirt, before combining the effluents.

Mill size

The size of a mill will dictate its approach to wastewater treatment because the cost of treating a scouring wastewater decreases with increasing size due to the economies of scale.
At a vertical mill, at which the output of scoured wool is likely to be considerably smaller than a commission processor, the higher cost of wastewater treatment can be carried by a number of cost centres.



Cost
Economics is a major determinant in choosing the method of wastewater treatment. Factors that need to be considered are:

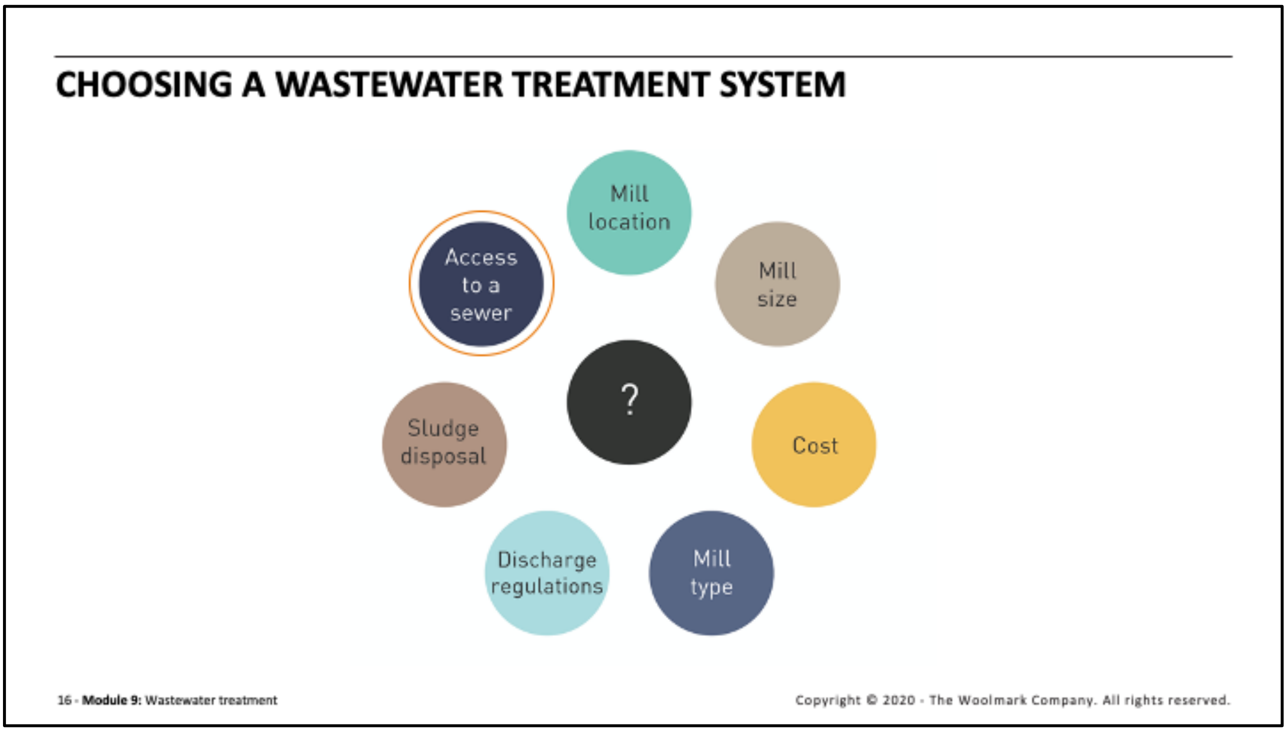
- capital costs of installing a wastewater treatment plant
- operating costs for wastewater treatment, including maintenance
- costs of sludge treatment and disposal
- costs for discharging to a sewer

Market-driven factors and sewer acceptance regulations may dictate installation of some form of wastewater treatment, even if the economics are unfavourable.

Discharge regulations
The conditions for discharge of treated wastewater to the environment depend on the receiving water (e.g. the minimum standards for discharges from sewage treatment plants to coastal waters and many re-use schemes in Victoria are: Biological Oxygen Demand 20 mg/l, suspended solids 30 mg/l).

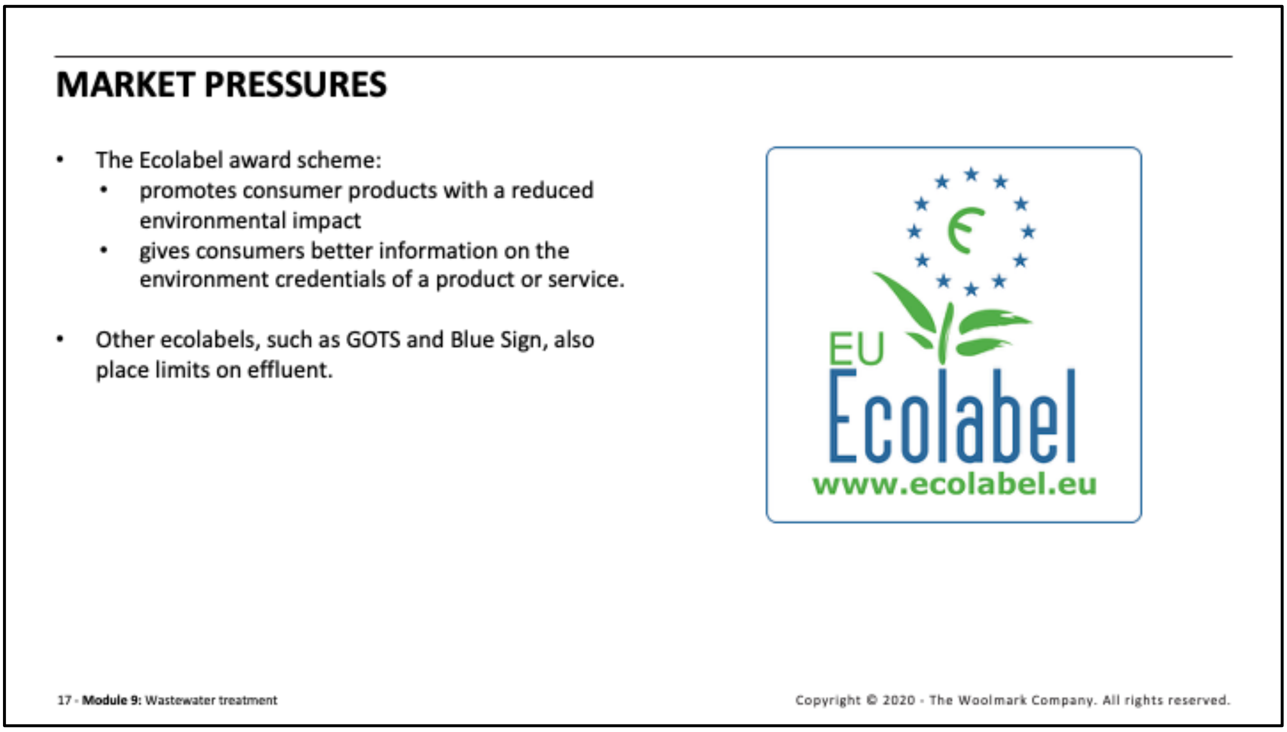
Sludge disposal
With sludge disposal costs making up about 50% of the costs for operating a wastewater treatment plant, it is important to investigate ways to use the sludge. There are, at least, two possibilities:

- Sludge can be composted with green waste and mill wastes (fibre and vegetable matter) to produce a valuable compost.
- Some sludges can be used as a fuel in a furnace if their solids contents are sufficiently high.



EXPLAIN THAT access to a sewer is a critical factor affecting the choice of sludge treatment. At least four factors must be considered when disposing of treated effluent to local sewage systems:

- **Prohibited substances** — can include fibrous substances, which can lead to blockages, and any free or floating oil, fat or grease. This should not be a problem unless there are poor scouring processes at the scour.
- **Acceptance limits** — authorities impose acceptance standards for discharge to sewer that can vary from region to region.
- **Trade waste charges** — are levied by the relevant water authority and should reflect the costs of treating the wastewater to meet the authority's own environmental discharge limits, treating and disposing of the sewage sludge, and maintaining the sewer network.
- **Future trends** — as their own environmental licence conditions tighten and their costs increase, water authorities have tended to tighten their acceptance standards and increase trade waste charges. This trend is likely to continue (e.g. the discharge of dissolved solids is now receiving more attention and tighter regulation).



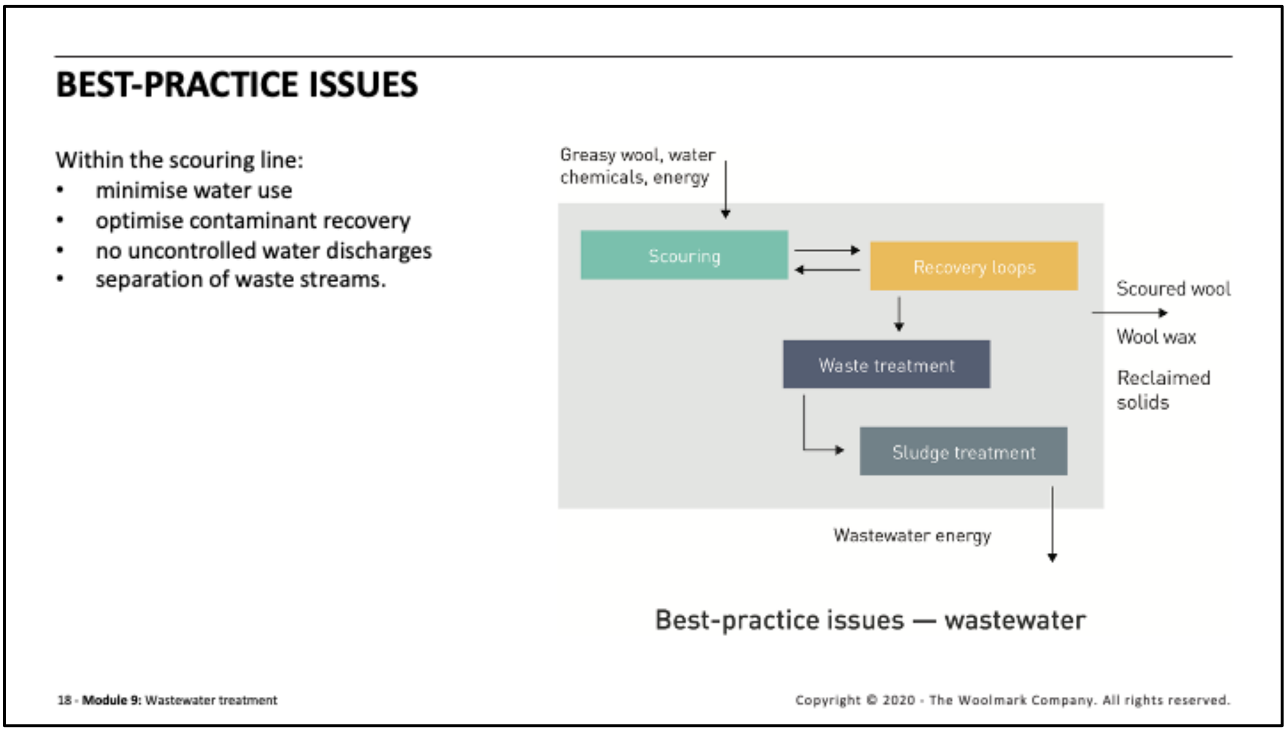
EXPLAIN THAT market pressures are a further factor affecting the choice available to the wool processor.

The EU Ecolabel is an example of a market-driven approach to encourage the processors to adopt more environmentally-responsible practices.

One system that has been developed to reflect this consumer concern is the Ecolabel award scheme. It is a voluntary, market-based scheme with two objectives:

- to promote those consumer products with a reduced environmental impact
- to give consumers better information on the environment credentials of a product or service.

A number of ecolabels also place limits on effluent (e.g. General Organic Textile Specification — GOTS and Blue Sign).



INDICATE THAT best-practice principles should be applied not only within the scouring line, before the wastewaters are discharged, but also to the choice of wastewater treatment processes and their application.

Practice within the scouring line

Minimise water use

- Water is becoming an expensive commodity and wool scours need high-quality water to produce a quality product.
- Minimising consumption without compromising quality can be achieved through the pattern of water use in the scouring line and through recycling of treated process water.

Optimise contaminant recovery

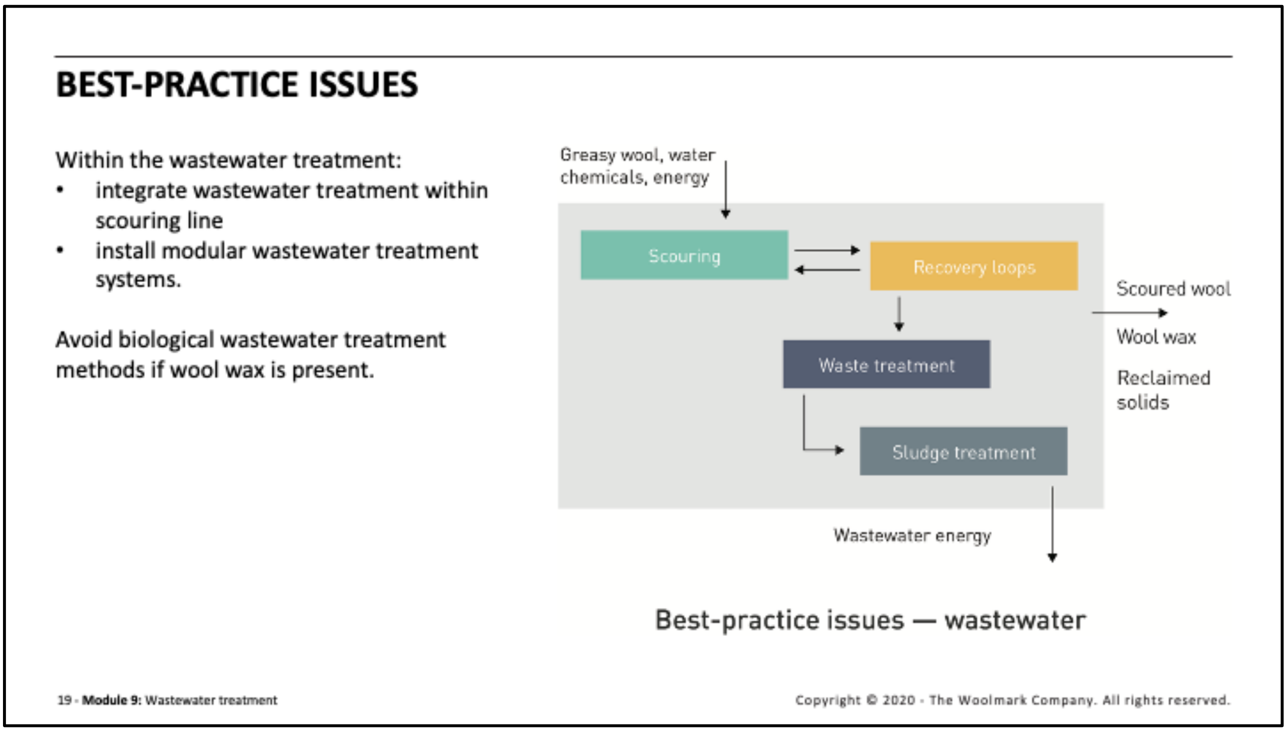
- The performance of the contaminant recovery loops must be optimised to produce concentrates containing as much of the contaminants as possible in the smallest possible volume. This reduces the cost of the effluent treatment.

No uncontrolled water discharges

- Not only do uncontrolled discharges represent a loss in potentially recoverable wool wax, they indicate a scouring line that is out of control.

Separation of waste streams

- The scouring effluent from the different waste streams should be treated separately as they have different characteristics, which require different technologies for optimal treatment.



Within the wastewater treatment process

Integration of wastewater treatment with the scouring line:

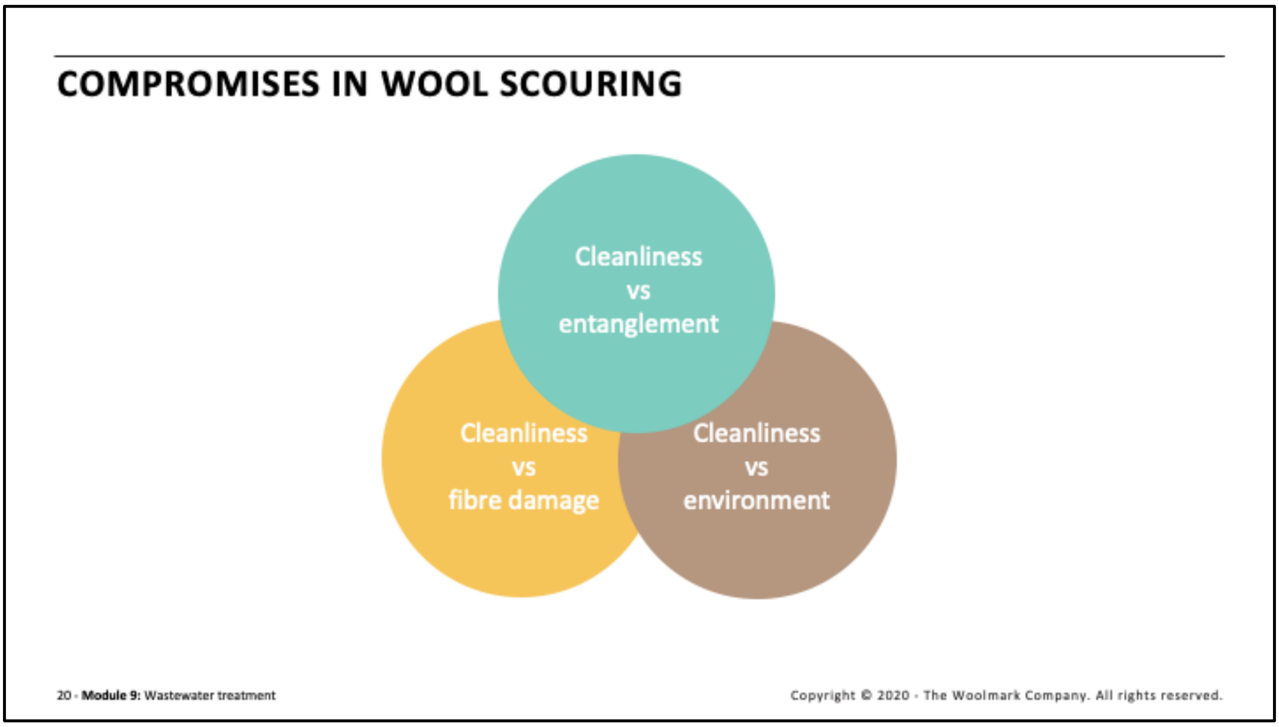
- Recycling treated wastewaters to the scour is an important feature of a best-practice system. This approach facilitates reduced water use and offers a possible improvement in productivity and scoured wool quality.
- This approach also ensures discharges from the scouring line are under control.

Modularity of wastewater treatment systems:

- Wastewater treatment systems are modular, which means the scourer can select technologies appropriate to the local situation.
- If the situation changes (e.g. water costs increase), other modules can be installed to meet the new environmental requirements.

Biological methods:

- Biological methods should be avoided if wool wax is present — the presence of wool wax increases the size of the treatment plant, the operating costs and the costs of sludge treatment and disposal.



POINT OUT that wool scouring has to contend with three compromises:

1. cleanliness versus entanglement
2. cleanliness versus fibre damage
3. cleanliness versus environment.

Cleanliness versus entanglement

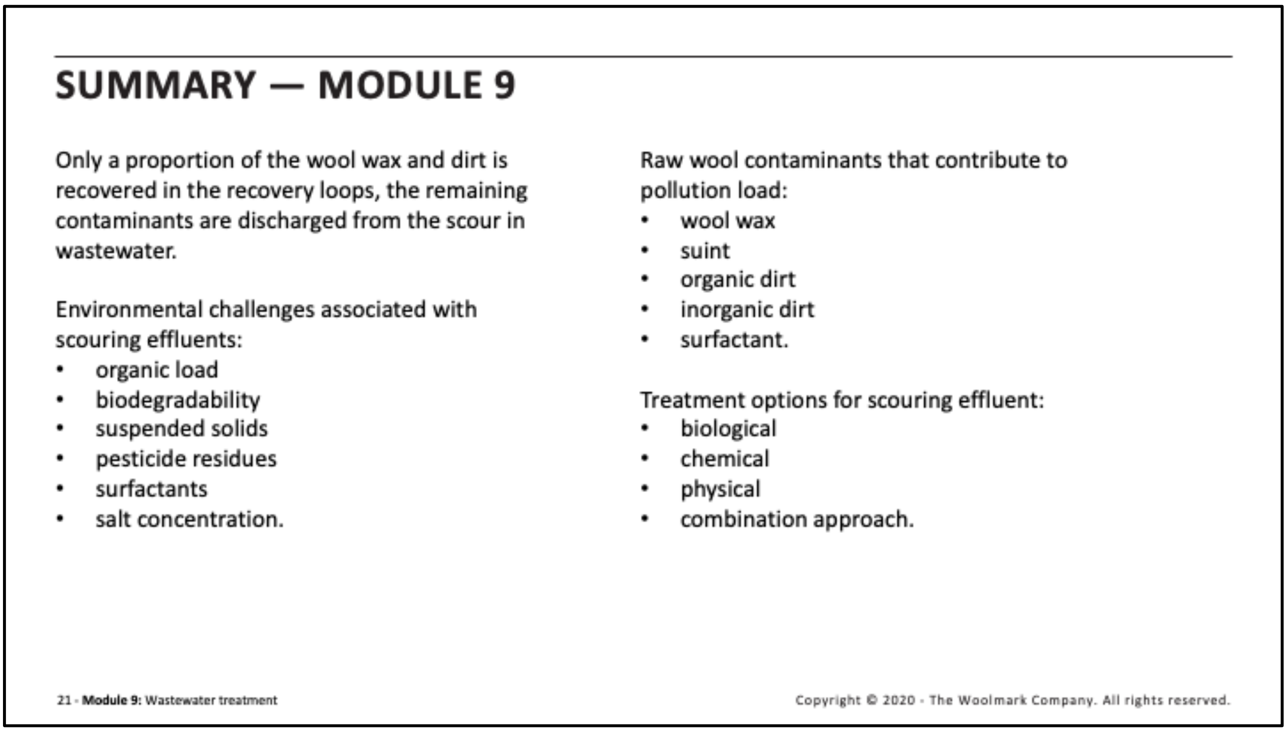
- A balance must be reached between achieving maximum cleanliness and avoiding entanglement.
- The agitation used to remove contaminants also encourages felting.
- A gentle scouring action, such as a suction-drum system, lowers the risk of entanglement, but the wool tends to be dirtier.
- Conversely, more vigorous action in a scour will produce a cleaner product, but a more entangled fibre.

Cleanliness versus fibre damage

- In trying to improve contaminant removal, a scourer might change the scouring conditions by increasing the scouring temperature or pH.
- This will also increase the possibility of damaging the wool.

Cleanliness versus environment

- Meeting environmental regulations can place constraints on the scouring process.



REINFORCE THAT only a proportion of the wool wax and dirt (about 30–50%) is recovered in the recovery loops that continually treat the scouring liquors before returning them to the scour. The remaining contaminants are discharged from the scour as a wastewater.

REMIND participants that a number of environmental problems are associated with scouring effluents:

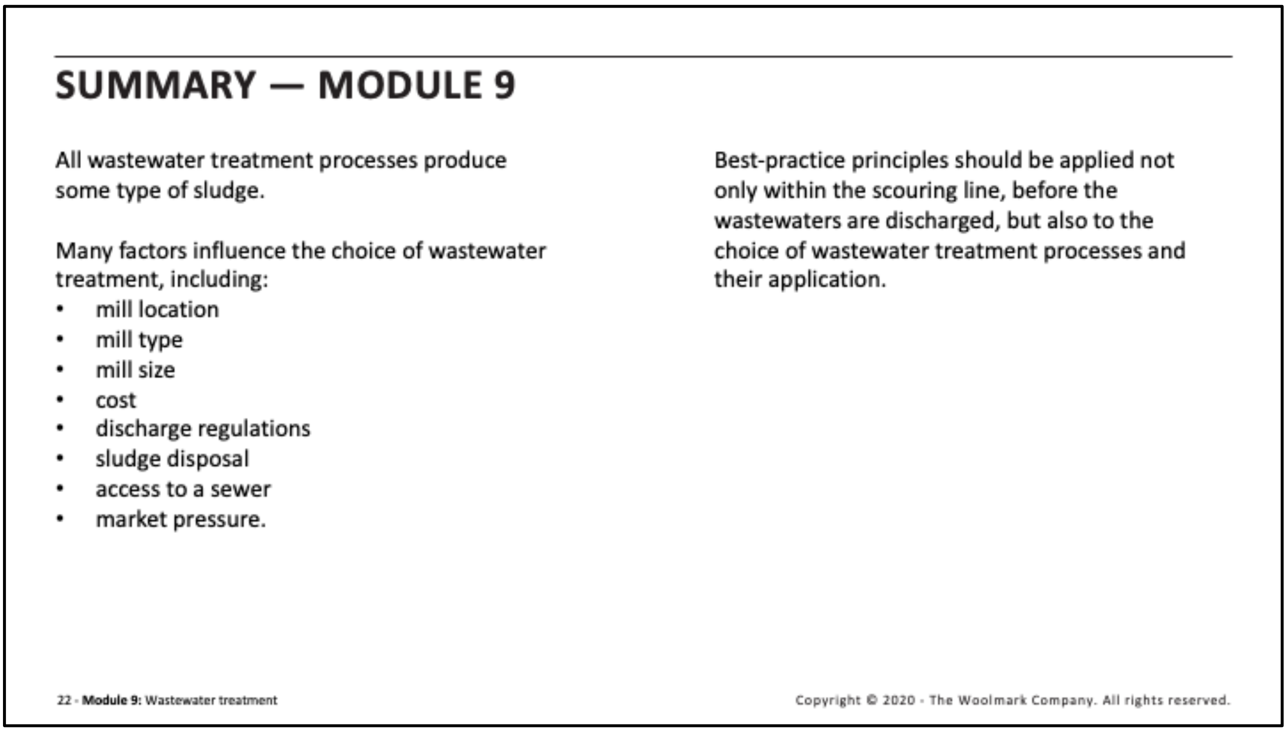
- organic load
- biodegradability
- suspended solids
- pesticide residues
- surfactants
- salt concentration.

REVIEW the type of raw wool contaminants that contribute to the wastewater pollution load, which include:

- wool wax
- suint
- organic dirt
- inorganic dirt
- surfactant added during scouring.

REVIEW the various methods available to treat scouring wastewater:

- biological
- chemical
- physical
- combination.



REMIND participants that all wastewater treatment processes produce some type of sludge.

REITERATE the many factors that influence the choice of wastewater treatment, including:

- mill location
- mill type
- mill size
- cost
- discharge regulations
- sludge disposal
- access to a sewer
- market pressure.

REMIND participants that best-practice principles should be applied not only within the scouring line, before the wastewaters are discharged, but also to the choice of wastewater treatment processes and their application.

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 the *Raw wool scouring* course — *Module 10: Process and quality control* — 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 10

PROCESS AND QUALITY CONTROL

RESOURCES — MODULE 10: PROCESS AND QUALITY CONTROL

No additional resources are required to deliver **Module 10: Process and quality control**.

WELCOME participants to Module 10 of the Woolmark Wool Science, Technology and Design Education Program *Raw wool scouring — Process and quality control.*

EXPLAIN THAT this module will cover:

- the importance of process control
- process controls relating to:
    - preparation for scouring
    - the scouring line
    - dirt recovery
    - wool wax recovery
    - drying
    - post-scouring processes
    - wastewater treatment
- locating sensors and process controllers
- data management
- process control issues
- the principles of quality control
- sampling for quality
- programs of analysis
- methods of analysis.

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

- describe the types of process control used during scouring
- describe the process controls related to different parts of scouring
- list issues related to process control
- explain the importance of quality control
- describe the methods used for quality control analysis
- describe troubleshooting methods for different quality control issues.

NO RESOURCES REQUIRED

THE IMPORTANCE OF PROCESS CONTROLS

- Effective process control improves the economics of the process through better management and more efficient use of resources.
- Effective process control enables better control of product quality in terms of achieving a particular quality level and maintaining a consistent product.
- Automatic process control enables the process to be operated more safely and consistently.
- Automatic process control, operating through a programmable logic controller (PLC) and computer system, enables monitoring of trend profiles for resource use and operator practice.

2 - **Module 10:** Process and quality control

EXPLAIN THAT there are many reasons for effective process control in a wool scouring operation:

- Effective process control improves the economics of the process through better management and more efficient use of resources.
- Effective process control enables better regulation of product quality in terms of achieving a particular quality level and maintaining a consistent product.
- Automatic process control enables the process to be operated more safely and consistently than manual process control.
- Automatic process control, operating through a programmable logic controller (PLC) and computer system, enables monitoring of trend profiles for resource use and operator practice (e.g. a practice of increasing detergent and water use in certain shifts can easily become apparent).

TYPES OF PROCESS CONTROLS

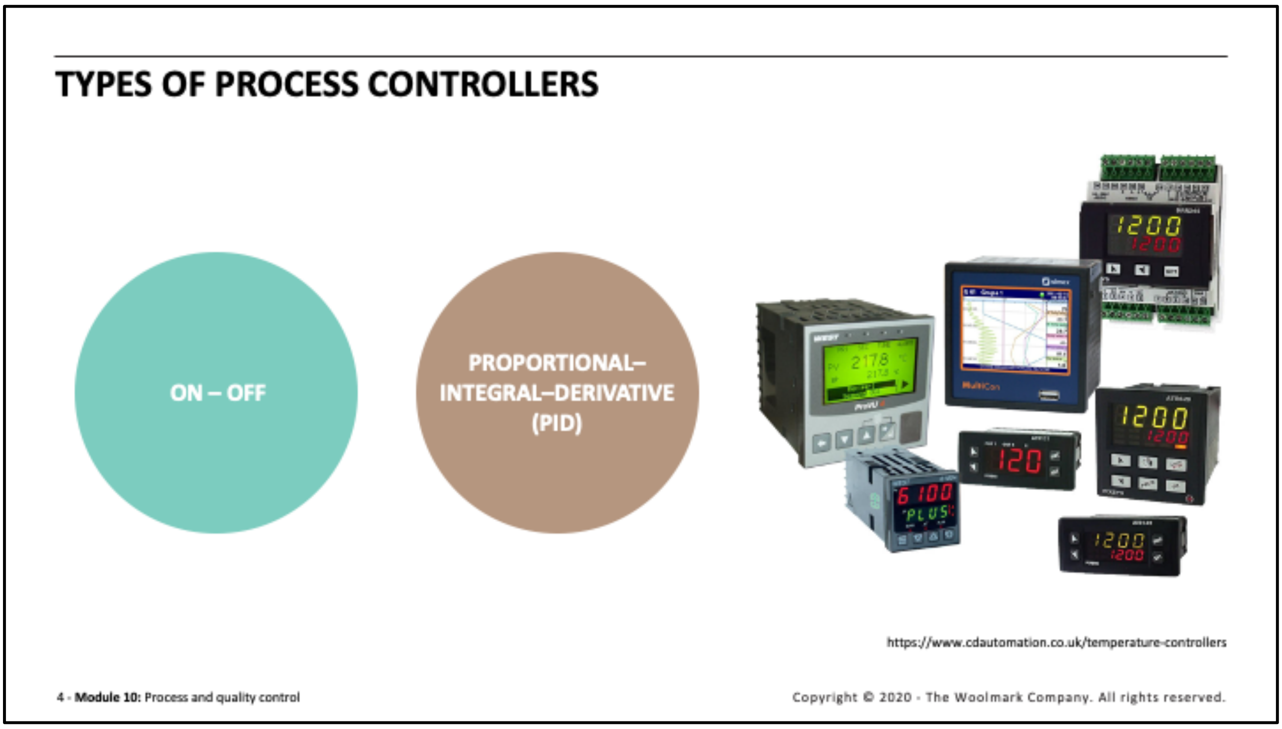
- Manual adjustment of machines.
- Manual control of processes.
- Automatic process control with no feedback.
- Automatic process control with feedback.

pH control is a key to consistent processing

3 - **Module 10:** Process and quality control

INDICATE THAT there are different types of process control in wool scouring:

- manual adjustment of machines, such as the gravity disc in a centrifuge or the settings on an opener
- manual control of processes, such as temperature control in bowls
- automatic process control with no feedback, including control of metering pumps
- automatic process control with feedback, which is the basis of most critical control processes in wool scouring.



EXPLAIN THAT a controller is a device that controls the amount of energy, or flow of material, in a process within specific limits of time, load and process equipment capabilities.

INDICATE THAT there are different types of controllers used in modern wool scouring operations, the most common being 'on–off' and 'proportional–integral–derivative (PID)' controllers.

On–off controller

- This is the simplest form of controller, where the signal is either 'on' or 'off':
- For example, to control the level of wool in a hopper; if the level is too low, the feed is turned 'on' and if the level is too high, the feed is turned 'off'.
- The sensor can be automatic or manual, however, automatic is a far better option due to the potential for human error.
- This type of controller could be used to control the temperature of a bowl, but there could be a problem in controlling the system depending on the difference between the set point and the actual temperature:
- For example, if the bowl temperature is too low at start-up, it would take a long time to reach the desired temperature. This is where a PID controller is useful.

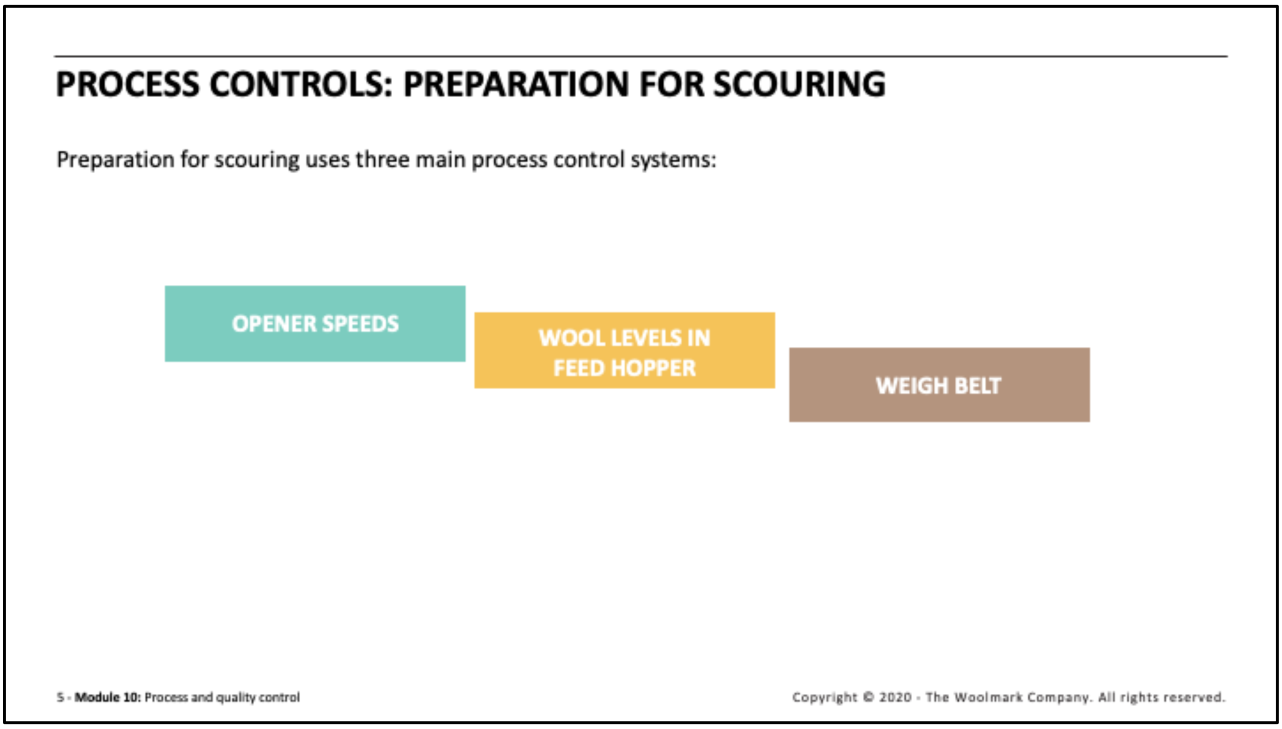
Proportional–integral–derivative (PID) controller

The PID can operate in three ways depending on the system being controlled:

1. Proportional — This occurs where the controller output is proportional to the size of the controller error (e.g. if the difference in temperature between the bowl and the set point were to double, then the controller output would double).

2. Integral — This occurs where the controller output is proportional to both the size of the controller error and the duration of the error. If the difference remains for more than a given time, the controller can act to offset this problem. (e.g. pH drift)

3. Derivative — This opposes change and hence is used to stabilise a process. It is often added to control processes and anticipates and corrects for lag, and avoids overshoot.



EXPLAIN THAT the preparation-for-scouring process uses three main control systems to regulate extent of opening, production rate and evenness of the feed to the scouring line.

1. Opener speeds

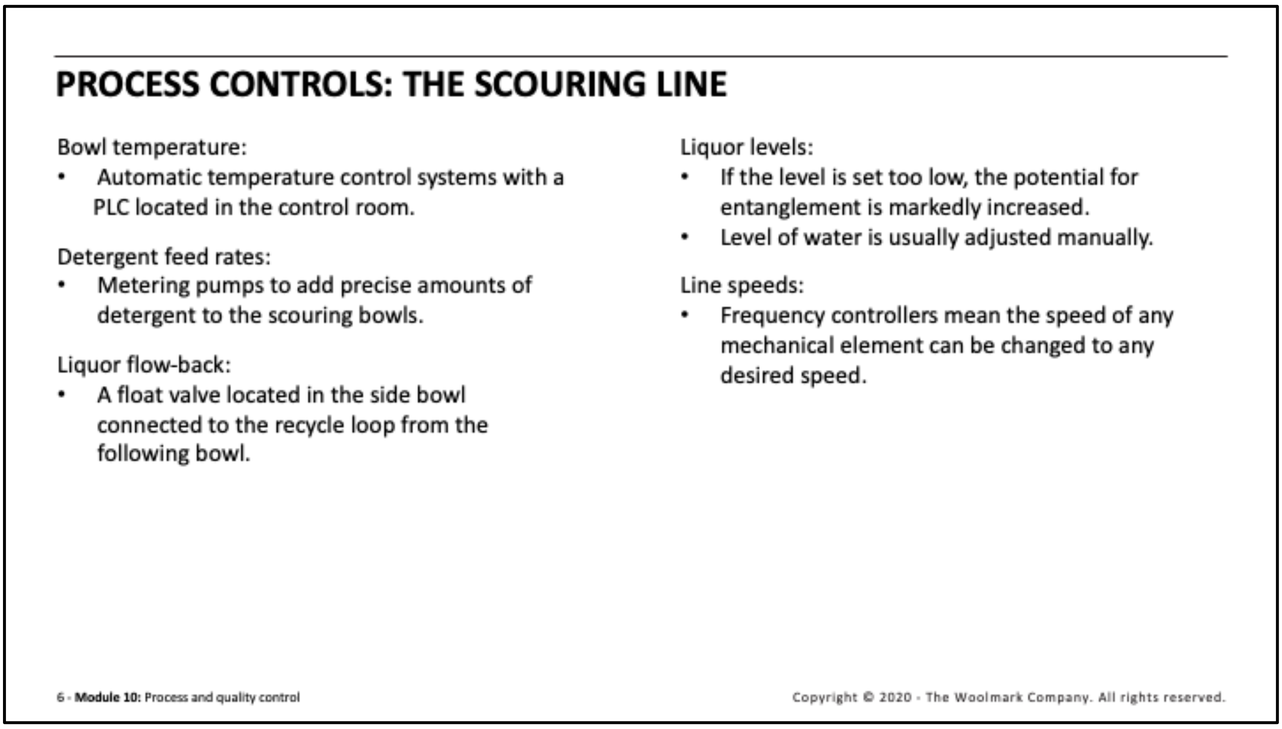
- Control of the individual off-line openers depends on the characteristics of the wool being opened and the extent of opening required.
- Feedback control is required for the amount of opening needed.
- There is also a need to feed wool to the scour, which can affect the settings and speeds of the openers. Feedback control is also required in this situation.

2. Wool levels in feed hopper

- If there is too much wool in the feed hopper preceding the weigh belt, the performance of the hopper is compromised in terms of the feed rate to the scour, the evenness of the feed rate and the evenness of the degree of opening the wool.
- A simple on–off controller on a sensor can be used to detect whether the hopper has too much wool or not.

3. Weigh belt

- The weigh belt monitors the mass of wool passing over it using a load cell. The signal from the weigh belt passes to the controller, which calculates the wool feed rate and compares it to the set point.
- If the feed rate does not match the set point, a signal is sent to the motor controlling the preceding brattice feed hopper, either speeding it up or slowing it down. This is one of the most important factors to be controlled in a wool scouring line.



EXPLAIN THAT the scouring line requires control of the following factors:

- **Bowl temperature** — The modern, best-practice approach to regulating bowl temperature is to use automatic temperature control systems with a PLC located in the control room. The type of controller depends on the mode of heating being used.
- **Detergent feed rates** — The best-practice approach to regulating detergent feed rates is to use metering pumps to add precise amounts of detergent to the scouring bowls. This allows monitoring of detergent consumption, which is important to optimise detergent use and manage input costs.
- **Liquor flowback** — The simplest and most effective method of regulating flowback between bowls is a float valve located in the side bowl, connected to the recycle loop from the following bowl.
- **Liquor levels** — It is important to be able to adjust the level of water in a bowl because if the level is set too low, the potential for entanglement is markedly increased. The level of water is usually adjusted manually.
- **Line speeds** — Frequency controllers mean the speed of any mechanical element along the scouring line can be changed to any desired speed. Advantages of this include:
  - tuning the scouring line to achieve an even flow of wool through the scour
  - minimising the extent of agitation and the amount of entanglement.

PROCESS CONTROLS: DIRT RECOVERY

- Bowl discharge.
- Settling tank.
- Hydrocyclone.

7 - **Module 10:** Process and quality control

INDICATE THAT during the dirt recovery process, the process control systems depend on the device being used:

Bowl discharge

In modern scours, knife-gate valves control the discharges from the bottoms of bowl hoppers. Best practice is to discharge to a manifold rather than directly to a drain.

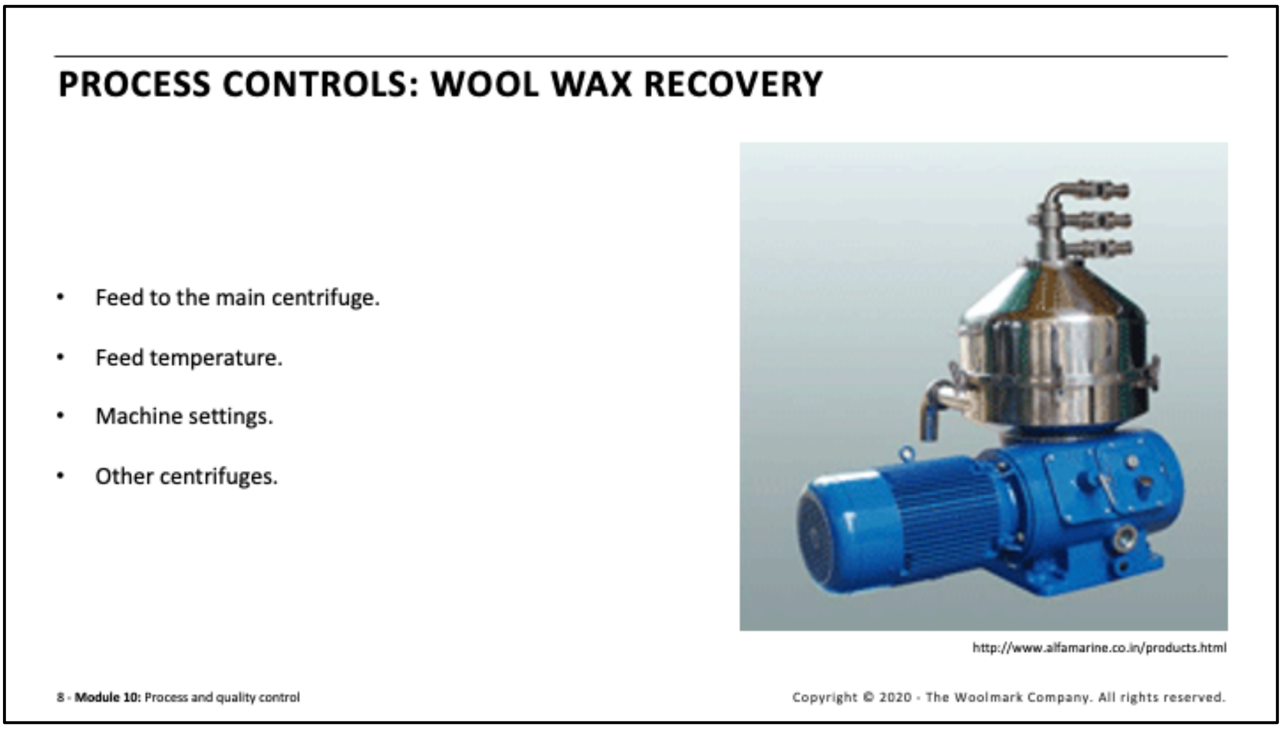
- Longer and more frequent discharge times are allocated to the first hopper in a multi-bowl hopper.
- This promotes a positive flow of liquor from the hopper and reduces the possibility of a blockage occurring.
- It is important to have only one valve open at any one time on a multi-hopper bowl.
- There are timers on discharge valves on hopper bottoms
- Flow rates on bowl discharges to recovery device are closely monitored.

Settling tank

- The discharge of sludge from the settling tank can be periodic using a timer, or episodic using a device that detects the accumulation of sludge and operates the discharge valve.

Hydrocyclone

- With some 100 mm hydrocyclones, used to protect the primary centrifuge, the discharge of the underflow is periodic to reduce the volume discharged, which needs to be controlled by a timer.
- Other than this, hydrocyclones do not need any control systems.
- It is important to monitor the volume of the underflow to prevent unnecessary loss of the process liquor due to erosion of the orifice controlling the rate of discharge from the hydrocyclone.



EXPLAIN THAT the control of the wool wax recovery plant is a combination of automatic process control and manual changes to the machine settings, including:

Feed to the main centrifuge

- For any configuration the total feed can be controlled from a PID controller.
- For multiple bowl take-offs, timers activate the valves from the individual bowls to enable flows from the bowls.
- To ensure centrifuged liquors are returned to the bowl from which they came, an offset time must be used to compensate for the volume of scour liquor in the piping to open the return valve when required.

Feed temperature

- In some mills, the temperature of the feed liquor needs to be raised to improve the efficiency of wax removal. This is done by passing the feed through a two-stage heat exchanger.
    - First stage: The feed is heated by a hot centrate from the primary centrifuge.
    - Second stage: The feed is further heated by hot water or steam. The energy requirement for the second stage should be low.

Machine settings

- Different controls are needed to separate the cream and sludge phases in the primary centrifuge.
- The concentration of cream can be controlled in three ways:
    - changing the feed rate to increase solids content
    - changing the gravity disc (a manual task to partially dismantle the centrifuge)
    - manually adjusting the back pressure valve on the centrate stream, if it is possible.
- The sludge phase — The nozzle discharge is controlled by the diameter of the nozzles. Gradual erosion increases the diameter of the nozzle and hence the flow of the heavy phase (strong flow). Modern machines have sensors to warn when a nozzle needs replacing.

Other centrifuges

- There are no major issues associated with the control of the secondary and tertiary centrifuges as the machine settings do not need to be changed often.
- Factors to consider are:
    - temperature of water used to wash the creams and cream storage tanks (controlled by simple temperature controllers)
    - the volume of wash water used to wash the creams (manually controlled due to the small volume).

PROCESS CONTROLS: DRYING

- Used to control the performance of the dryer to produce wool with the desired moisture content at the maximum possible effectiveness.
- DRYCOM moisture meter, measurement and control system is most commonly used in scours processing Australian wools.

Image courtesy of CSIRO

9 - **Module 10:** Process and quality control

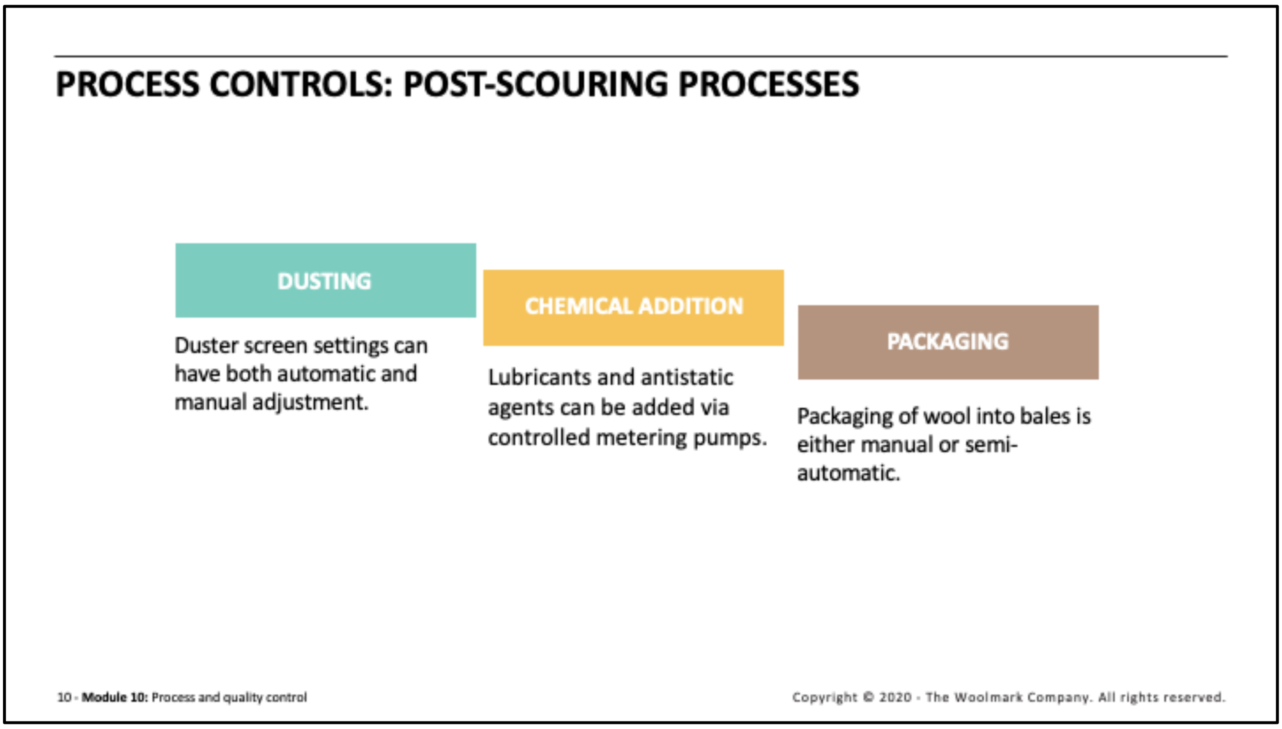
EXPLAIN THAT modern scouring lines are fitted with a regain (i.e. moisture content) measuring system on the outlet of the dryer. This is used to control the performance of the dryer to produce wool with the desired moisture content at the maximum possible efficacy.

MENTION THAT the DRYCOM moisture meter, measurement and control system is most commonly used in scours processing Australian wools. This controller receives information on the wet bulb and dry bulb temperatures in the dryer and the moisture content of the dried wool. The micro-processor then adjusts the exhaust damper setting, the energy supply and the distribution of heat between the zones in the dryer.

ASK *participants to explain why it is important to control the moisture content of wool after drying.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *emphasise that moisture affects the subsequent processing. Problems can result if the wool is too wet or too dry.*



EXPLAIN THAT controls used in post-scouring processes include:

Dusting

- The dusters can have both automatic process control (speed adjustment) and manual adjustment of the screen settings.
- Duster control is not usually critical, but if a scour processing broad wools changes to fine wool, there may be unacceptable amounts of fibre damage.

Chemical addition

- Chemicals added during the post-scouring stage (e.g. lubricants and anti-static agents) can be added via controlled metering pumps.

Packaging

- The packaging of wool into bales post-scouring is either manual or semi-automatic.
    - In a manual system, the wool is put into bales and compacted until the desired bale weight is reached.
    - In semi-automatic systems, a fixed weight of wool is packed automatically into bales, the material for which is manually placed on the baling equipment.

PROCESS CONTROLS: WASTEWATER TREATMENT

- Discharges of wastewater are the only parts of the effluent system that need to be controlled in wool scouring.
- Sensors can continuously record temperature, flow rate and pH of the final discharge, which can be monitored continuously and displayed graphically.

Image courtesy of Dr J Christoe

11 - **Module 10:** Process and quality control

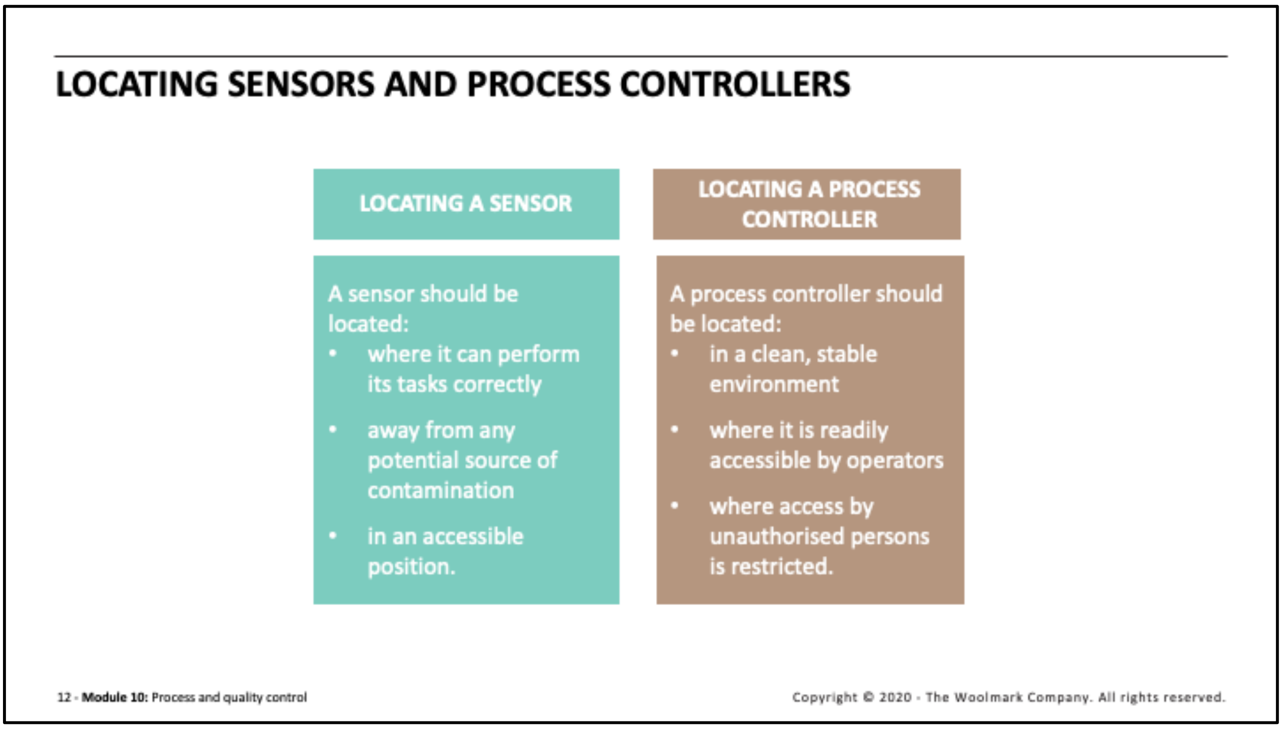
INDICATE THAT the discharges of wastewater, either to sewer or to a wastewater treatment plant, are the only parts of the wool scouring effluent system that need to be controlled.

EXPLAIN THAT the actual discharges can be manual or automatic. The best-practice approach is to adopt automatic discharge because uncontrolled discharges in some scours have exceeded 50% of total discharges.

MENTION THAT in some cases, the temperature of the discharge may need to be reduced. This is best achieved by using heat exchange with the incoming process water to the scouring line.

- A process controller should be sufficient to control the flow of cold water into the heat exchange.
- Sensors can continuously record temperature, flow rate and pH of the final discharge

EXPLAIN THAT with modern scours, the discharges from the scouring line, along with their characteristics, can be monitored continuously and displayed graphically.



NOTE THAT the correct location of a sensor is a key to its effective use.

Locating a sensor

There are three main factors to consider when locating a sensor:

1. It should be located where it can perform its tasks correctly.
2. It should not be in a position where it can become contaminated and lose its functionality.
3. It should be in an accessible position to allow for maintenance or repair.

Locating a process controller

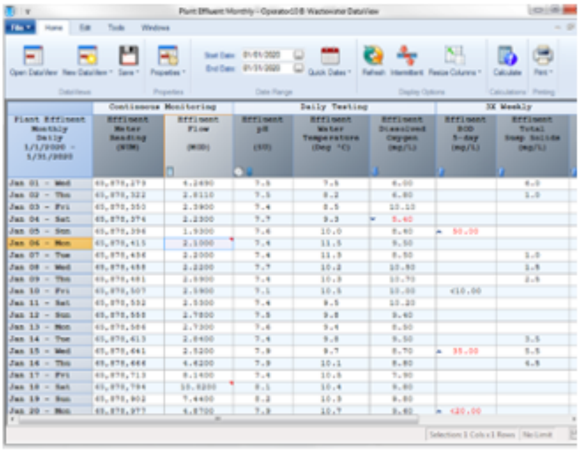
There are three factors to consider when locating a process controller:

1. It needs to be located in a clean, stable environment such as an air-conditioned control room.
2. It must be readily accessible by operators.
3. Its access may need to be restricted from unauthorised persons.

EXPLAIN THERE may be conflict between the first two factors because some aspects of control may need to be closer to the process and a compromise may have to be reached. For example, the operator needs to be able to start or stop the mechanical elements in the bowls, after stoppages and during tuning. It is far easier to do this at the scour than from the control room.

DATA MANAGEMENT

- Modern scouring lines use computer control.
- Store and activate recipes for the scouring of different types of wool.
- Warn the operator when an element in the system becomes non-functional or is operating outside the control system.
- Review the performance of the scouring line to determine causes for any poor quality scoured wool.



13 - **Module 10:** Process and quality control

EXPLAIN THAT for many years, some of the better wool scours were using chart recorders to measure specific pieces of data, such as production rates, bowl temperatures and water flows. This data was used to monitor the performance of the scouring line.

INFORM participants that during the 1970s, mimic panels were introduced to show a basic flow diagram of the scour, indicating the status of the individual electrical elements.

EXPLAIN THAT controls such as weigh belt, feed rate, dryer settings, bowl temperatures and timer controls were incorporated on the panel giving some process control through simple controllers.

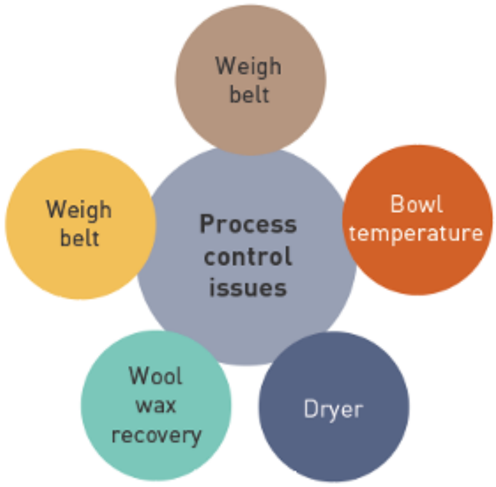
Modern scouring lines are built using computer control where computer graphics have replaced the mimic panel.

EXPLAIN THAT computers can store and activate recipes for the scouring of different types of wool that specify:

- production rates
- opener speeds
- bowl temperatures
- rake speeds
- detergent additions
- patterns of water usage.

INDICATE THAT a computer system can warn the operator when an element in the system becomes non-functional or starts operating outside the control system. This can be used to review the performance of the scouring line to determine causes for any poor quality scoured wool.

PROCESS CONTROL ISSUES



14 - **Module 10:** Process and quality control

INDICATE THE common issues encountered that relate to process controls:

Weigh belt

- The weigh belt is central to the best-practice operation of the wool scouring line, therefore it needs to be cleaned and recalibrated at least once a week.

Bowl temperatures

- The temperature sensors in the bowls can become contaminated with material, which can affect the response of the sensors.

Dryer

- If the dryer and its controls are not maintained and calibrated, several problems can occur:
    - Wool may not be dried to the desired level, leading to problems during subsequent processing. For example, if the carder believes the regain is a certain value and the actual value is different.
    - The wool may not be adequately dried due to the exhaust system being blocked.
    - The wool may be over-dried leading to a waste of energy.

Wool wax recovery

- The primary centrifuge has to handle a difficult process fluid.
- If regular maintenance is not carried out, the performance of the centrifuge will deteriorate and expensive repairs will have to be carried out.

Dirt recovery

- Hydrocyclones are susceptible to blockage from the wool fibres and larger dirt particles.
- A regular maintenance and cleaning program can help alleviate this.

WHY IS QUALITY CONTROL IMPORTANT?

Quality control is important to:

- obtain useful and timely information on scouring effectiveness
- provide a better and more consistent product
- troubleshoot problems occurring with scoured wool
- meet certain quality criteria
- avoid productivity losses
- avoid financial losses.

Image courtesy of CSIRO

15 - **Module 10:** Process and quality control

NOTE TO FACILITATOR: *This slide is animated. Before revealing the content of the slide ask participants why they think quality control is important.*

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

CLICK *to advance the slide to reveal the following points.*

EXPLAIN THAT quality control is important to:

- obtain useful and timely information on scouring efficacy
- provide a better and more consistent product
- troubleshoot problems occurring with scoured wool
- meet certain quality criteria
- avoid productivity losses
- avoid financial losses through disputes with customers over product quality.

PRINCIPLES OF QUALITY CONTROL

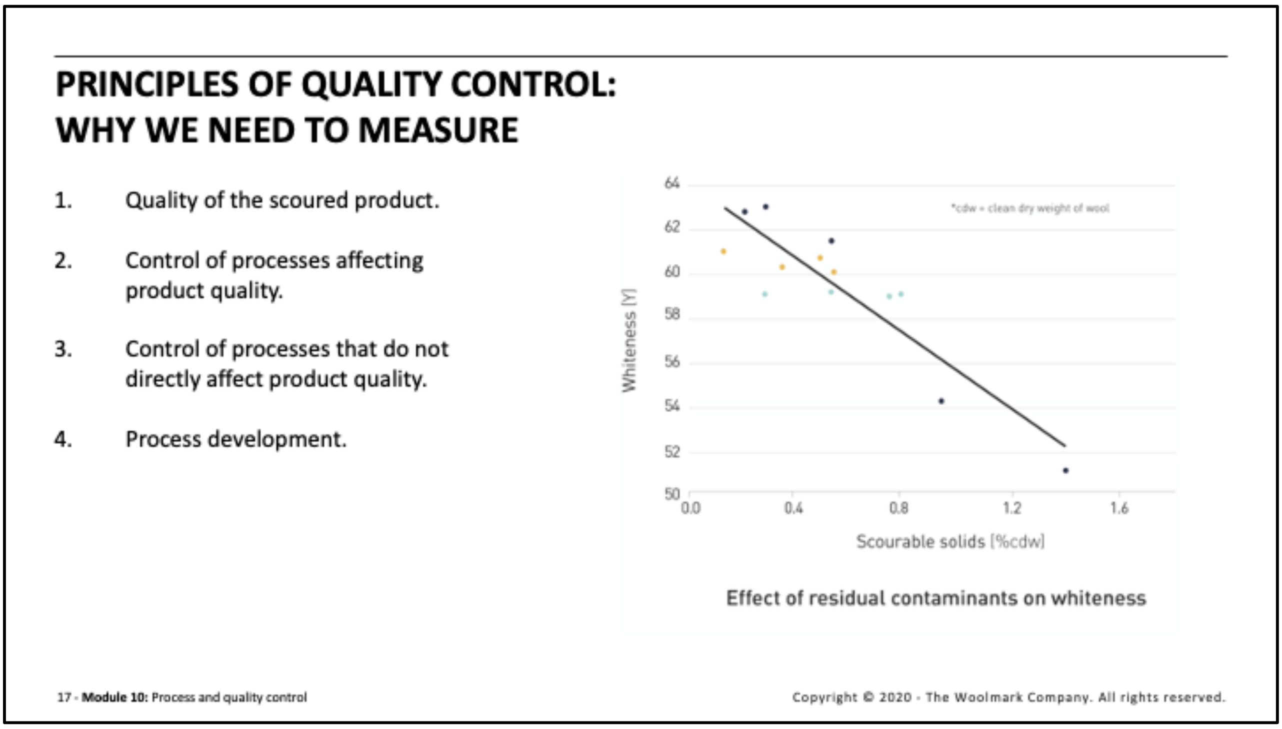
- Why do we need to measure?
- What do we need to measure?
- How do we measure?
- When and how frequently should we measure?
- What should we do with the data?

Image courtesy of CSIRO

16 - **Module 10:** Process and quality control

EXPLAIN THAT in order to implement a quality control program, a number of questions need to be answered, which will direct the required actions. These questions include:

- Why do we need to measure?
- What do we need to measure?
- How do we measure?
- When and how frequently should we measure?
- What should we do with the data?



INFORM participants that the answer to "Why do we need to measure?" is "To ensure we produce a product of a quality that meets the customer's specifications".

EXPLAIN THAT measuring a range of properties for the purposes of quality control is important, as illustrated by the graph on the slide, which shows that as the level of residual contaminants increases, the whiteness of the scoured wool is reduced.

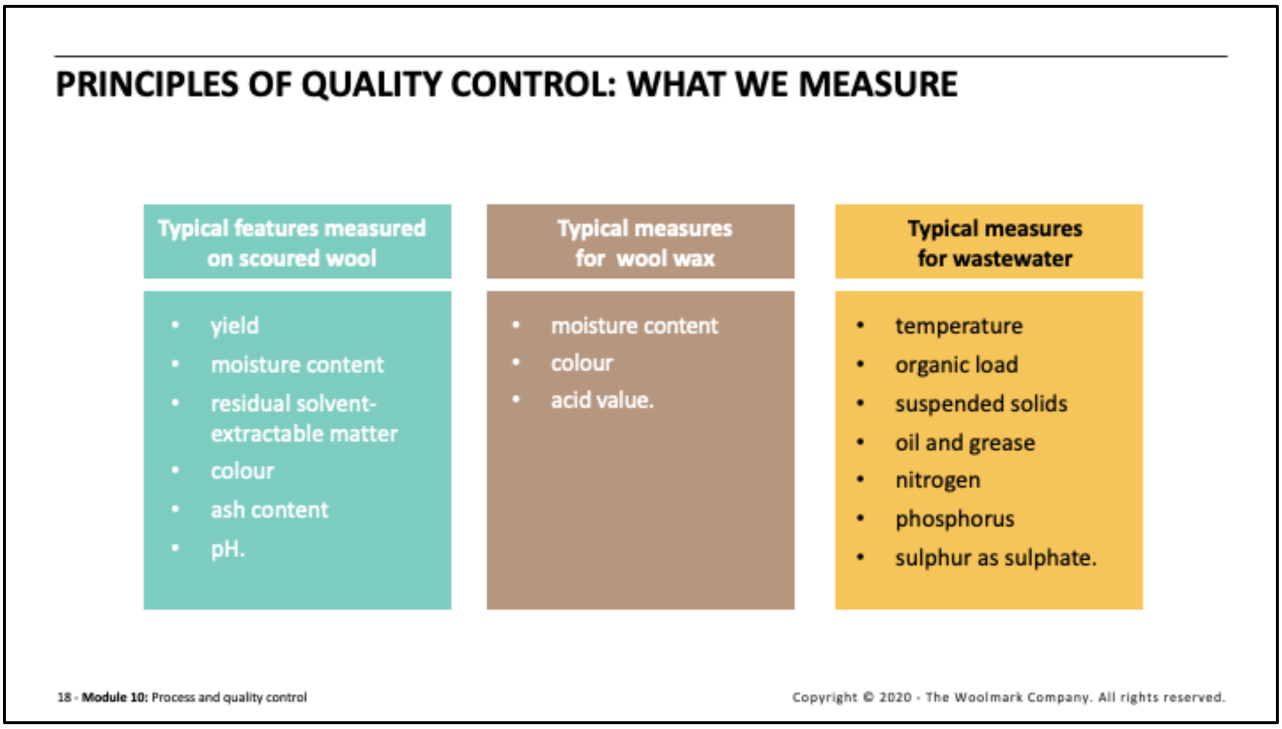
INDICATE THERE are four types of quality control a scourer needs to consider:

- **Quality of the scoured product** — Without quality control a scourer cannot be sure the product being produced will be acceptable to customer.

- **Control of processes affecting product quality** — Most modern scours are controlled through computers, but if something is incorrectly set up or out of calibration, the process may be in control but operating to produce a sub-standard product. For example a scour may be operating consistently but not cleaning the wool to the customer's satisfaction.

- **Control of processes that do not directly affect product quality —** Some processes, such as the operation of a wastewater treatment plant, do not affect product quality but will affect profitability.

- **Process development** — At times the scourer may change detergent or install new equipment, and the quality control program can be used to determine how the changes will affect product quality.



INDICATE THAT the step towards developing a meaningful quality control program is to identify the quality characteristics required by the customer.

EXPLAIN THAT the typical features measured on scoured wool include:

- yield
- moisture content
- residual solvent-extractable matter
- colour
- ash content
- pH.

MENTION THAT for the recovered wool wax (grease) typical measures include:

- moisture content
- acid value
- colour.

EXPLAIN THAT for wastewater processes the typical measures are:

- temperature
- organic load
- suspended solids
- oil and grease
- nitrogen
- phosphorus
- sulphur as sulphate.

PRINCIPLES OF QUALITY CONTROL: SAMPLING

A poor sampling regime will provide results with little meaning.

The sampling method used will depend on:
- the nature of material being sampled
- the size of material being sampled
- the test being performed
- the data to be provided by the test
- the level of accuracy needed.

Samples are typically taken of:
- raw wool
- scoured wool
- liquor
- recovered wool wax (grease).

http://www.environet.com.au/services.asp?id=75&cid=15

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REMIND participants that raw wool is a diverse (heterogeneous) material — even on a single fleece there are large variations in the physical characteristics, such as fibre diameter, staple length and the levels of contamination.

EXPLAIN THAT this variation becomes greater after we incorporate the variations between the fleeces in a wool consignment containing multiple wool sale lots, with variations between bales of the same wool type and variations between different types.

NOTE THAT a crucial aspect of quality control in the scouring operation is obtaining small, random samples that are truly representative of the population and free from bias.

A poor sampling regime will provide results with little meaning.

INDICATE THAT the sampling method used will depend on:
- the nature of the material being sampled
- the size of material being sampled
- the test being performed
- the data to be provided by the test
- the level of accuracy needed.

EXPLAIN THAT as part of a standard quality control program in a scouring operation, samples are typically taken of: raw wool, scoured wool, scouring liquor and recovered wool wax.

Raw wool

Sometimes it is necessary to sample raw wool for in-plant processing trials.
- A sample size of about 0.5 kg is required, which is then divided into 16 zones.
- A small sub-sample of fibres is taken from each zone in turn until the weight of the wool is 50 g, and this combined sample is tested.

Scoured wool

Two types of sample are taken either from the individual bowls along the scouring line or from the exit of the dryer.
- Scoured wool ex-bowls:
  - A sample of at least 200 g is taken from the interstage conveyor, making sure the wool is not taken from the immediate edge of the conveyor.
  - The dried sample is then sub-sampled using the raw wool procedure.
- Scoured wool ex-dryer:
  - If access is possible, the wool should be sampled across the width of the dryer.
  - A sample of at least 200 g is taken and the combined sample is dried before sub-sampling using the raw wool procedure.

PRINCIPLES OF QUALITY CONTROL: SAMPLING (CONTINUED)

A poor sampling regime will provide results with little meaning.

The sampling method used will depend on:

- the nature of material being sampled
- the size of material being sampled
- the test being performed
- the data to be provided by the test
- the level of accuracy needed.

Samples are typically taken of:

- raw wool
- scoured wool
- liquor
- recovered wool wax (grease).

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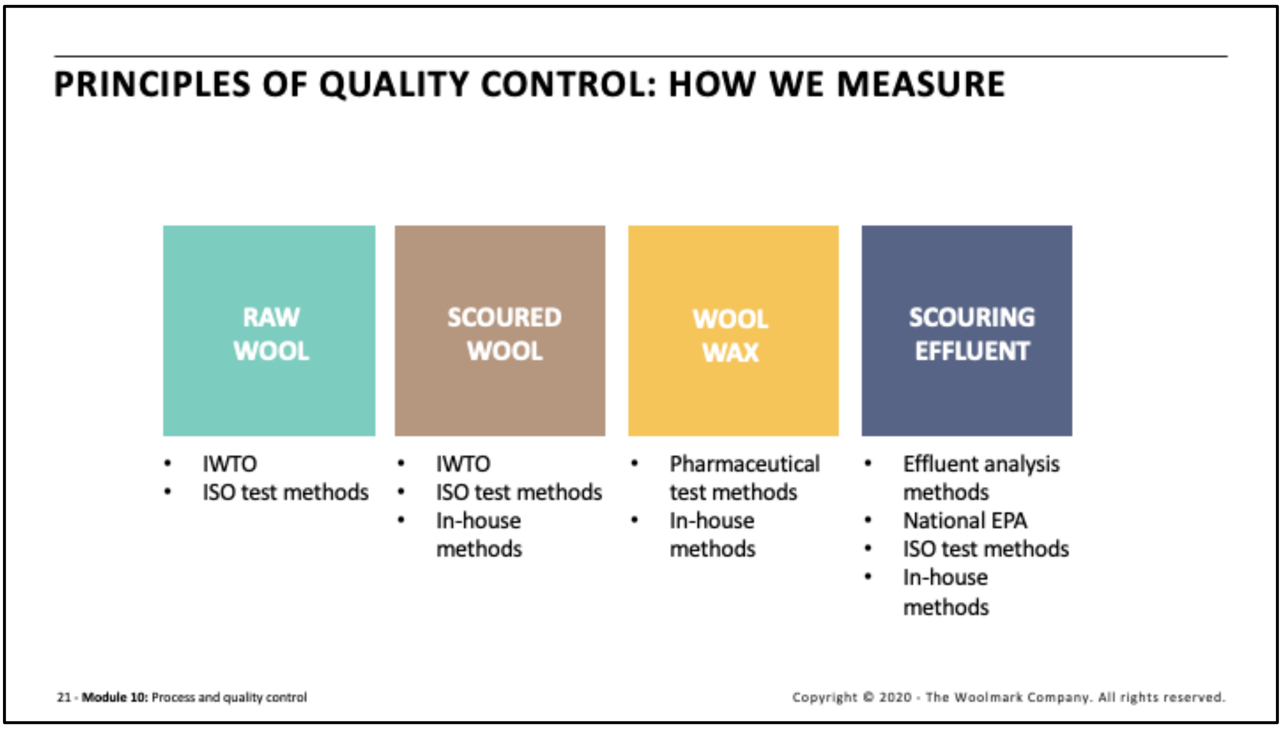
Liquor

All liquor samples should be sampled using a 50–100 ml stainless steel beaker fitted with a long handle.

- **Scouring liquor** — If the scouring bowl has a side pocket, the sample should be taken from here, otherwise it should be taken from the overflow weir of the water-level controller of the bowl.
- **Scouring discharges** — These consist of liquid flows that can come from bowl discharges, primary centrifuge centrate and discharges from any dirt recovery devices.
- **Wastewater treatment** — The streams encountered in a wastewater plant will depend upon the methods of treatment being used. The samples will either be liquid (inputs or outputs) or semi-solid (sludges).

Recovered wool wax (grease)

It is normal practice to sample the contents of each drum of recovered wool wax for moisture content, acid value and colour.



MENTION THAT the first step in determining how to measure the parameters for analysis is to decide which analytical methods will be used.

EXPLAIN THAT the standard methods published by the International Wool Textile Organisation (IWTO) provide a useful starting point, although a mill may adopt its own internal methods. For example, when measuring the scourable solids, a mill could use the International Standards Organisation (ISO) test method or an in-house method, such as the colour of the residue collected on a filter paper as an indicator of the amount of material left on the wool as opposed to the method in IWTO-10.

INDICATE THAT the next step is to determine whether to use simple statistical analyses or quality control charts.

- Statistical analyses are readily performed using spreadsheets or software packages.
- Alternatively, monitoring the moisture content and pH of dried wool is an example where a quality control chart would be useful.

EXPLAIN THAT the final step involves deciding which sorts of analyses to perform. The choice is determined by a number of factors including:

- time available for the analysis
- the required level of precision
- the customer's acceptance of the method. For example, with residual solvent-extractables, there are two methods, each taking different times:
    - soxhlet extraction takes three hours to complete and provides an accurate measure (this method will be covered in later courses of the Woolmark Wool Education Course).
    - a method based on the WIRA Rapid test is less precise, but only requires 30 minutes and can provide real-time data if this is the higher priority.

INDICATE THAT test methods are available for all types of sample from standards organisations (IWTO) or other sources. The choice depends on the customer.

Some examples are shown on the following slides.

***ASK** participants to suggest which part of the scouring line cannot be monitored on-line.*

***IF NECESSARY** explain that although most aspects of liquor can be monitored, wool properties such as solvent extractables (total fatty matter) etc., cannot be monitored on-line.*

IWTO TEST METHODS

Tests published by IWTO:

- Oven dry mass (IWTO-33, 41, DTM-63)
- Residual fatty matter (IWTO-10, DTM-43, DTM-61)
- Diameter distribution characteristics (IWTO-08, 12, 28, 47)
- Colour (IWTO-56)

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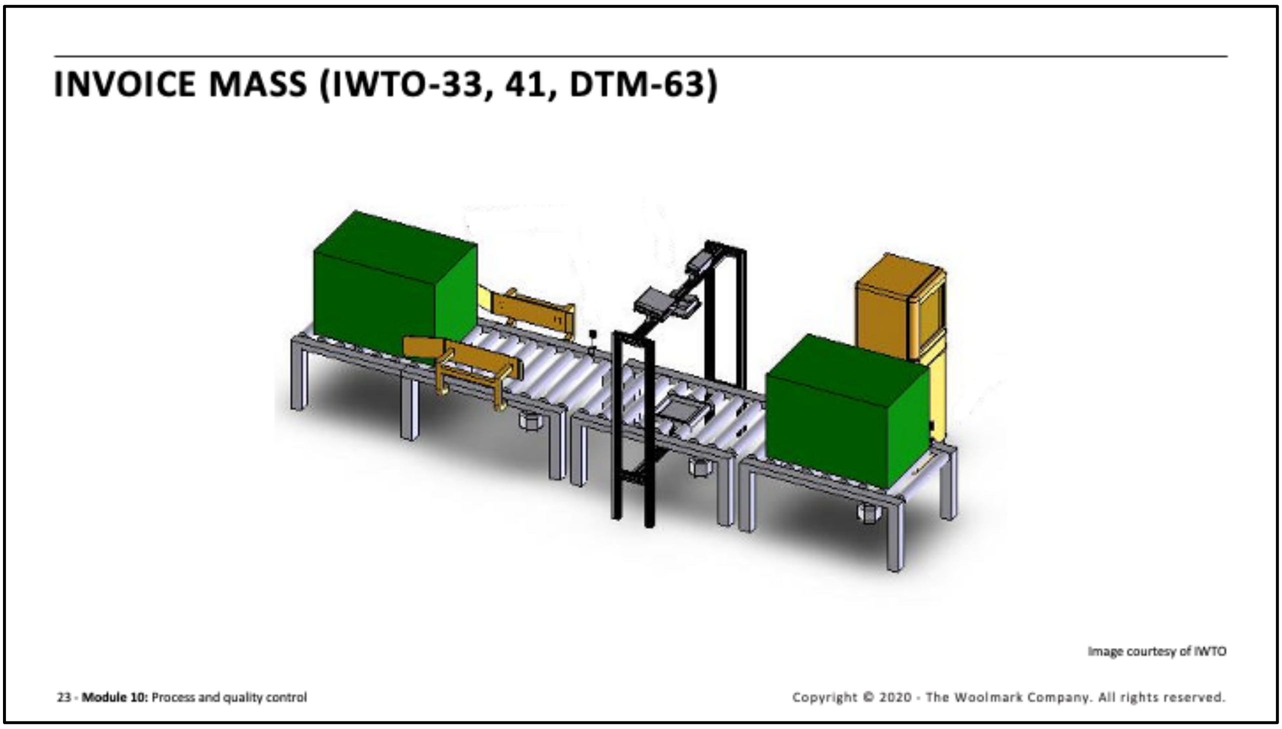
EXPLAIN THAT objective tests are carried out on scoured and carbonised wool for a number of reasons:

- To determine the regain (moisture content) of the wool in the consignment because after scouring and carbonising, most of the impurities have been removed.
- To determine the amount of non-wool residuals on the fibres.
- To determine the fibre diameter characteristics.
- To determine the colour as a measure of cleaning and yellowing of the fibre in scouring and/or carbonising.
- To determine scouring performance using the solvent extractables and/or colour as a measure.

EXPLAIN THAT fibre diameter is measured using the same methods as for greasy wool except no pre-scouring of the sample is required, except where the base colour of the fibre is to be measured.

MENTION THAT IWTO regulations for testing scoured and carbonised wool apply to:

- weighing the lot
- sampling
- oven dry mass (IWTO-33). This is also called the 'invoice mass'.



Invoice mass (IWTO-33)
Also referred to as 'oven dry mass' this relatively simple test method involves:

- determining the mass of the consignment of wool
- core sampling the consignment (>500 g)
- determining the mass of the sample
- weighing and then drying a specimen at 105°C 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 between-laboratory variance is 0.152%.

Malcam Microwave method (DTM-63)
This test (shown on slide) uses the difference in the adsorption of microwaves by wool (~0.001) and water (0.5) to measure the moisture content of wool while still in the bale.

- Malcam's MMA-2020 system is used.
- The method is 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 on-line.

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

IWTO-10
- scoured
- carbonised
- combed top
- using extraction with dichlormethane.

DTM-61
- wool yarns
- some blends
- using petroleum ether.

DTM-43
- scoured wool
- Sliver (top)
- using NIR.

NIR meter

Image courtesy of B and W Tek (USA)

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Residual fatty matter
After scouring and/or carbonising, wool can contain residual or trace amounts of materials, such as:
- wool wax
- suint
- dirt
- non-wool proteins
- faecal matter and urine
- detergent (used in scouring)
- salts used as builders or water conditioners during scouring.

NOTE THAT these materials can affect the subsequent processing of the wool.

EXPLAIN THAT several test methods are available to measure the levels of these residues upon the completion of the scouring process.

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

MENTION THAT 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 105°C) wool specimen is conducted for at least 10 siphonings over 90 minutes. The extracted matter is weighed after evaporating the solvent at 106°C.

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

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

LENGTH AFTER CARDING

Scoured wool

Carding

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EXPLAIN THAT while the length of greasy wool can be measured as staple length and the length of fibre can also be measured in top, the length of fibres in scoured wool is much more difficult to measure.

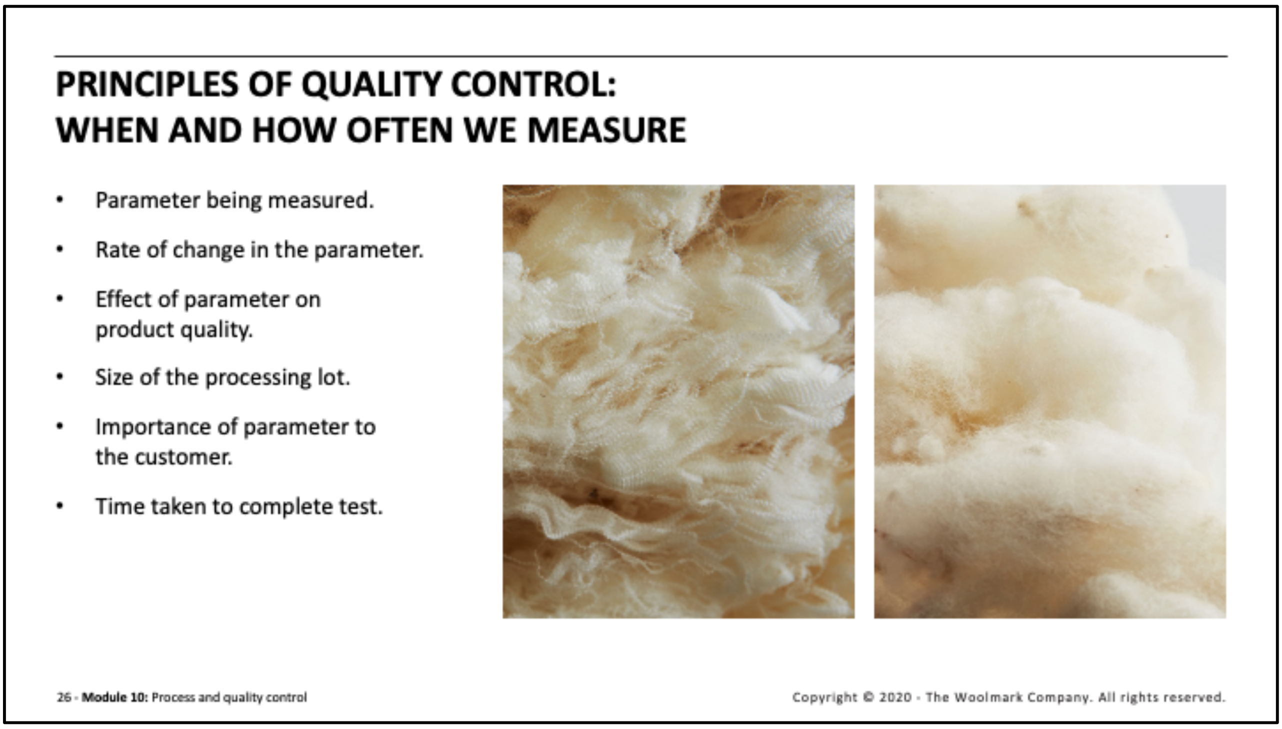
MENTION THAT a single fibre length measurement is available (IWTO- DTM05) but it is labour intensive and unreliable and is not recommended for use on scoured wool.

EXPLAIN THAT a 'length after carding' test has been developed in New Zealand to measure the length of fibres in scoured wool after being disentangled and aligned.

- A standardised carding lubricant is added to a sample of the scoured and dried wool.
- After conditioning, the sample is treated in a standardised sample card and the resultant sliver is gilled three times.
- The fibre length in the sliver is measured on an Almeter, which is described in the Wool Science, Technology and Design Education Program course *An introduction to wool processing*.

NOTE THIS is not an IWTO test method and is used only in New Zealand. The test has value in assessing fibre entanglement during scouring, which will tend to reduce length after carding.

MENTION THAT regulations covering sampling testing and re-testing have been published in NZ.



EXPLAIN THAT a number of factors affect the timing and frequency of measurement:

Parameter being measured
For example, the yield of the scoured wool is usually determined when a lot is finished and is being shipped out; however, it may be important to carry out regain measurements once per shift to ensure the product has the correct regain.

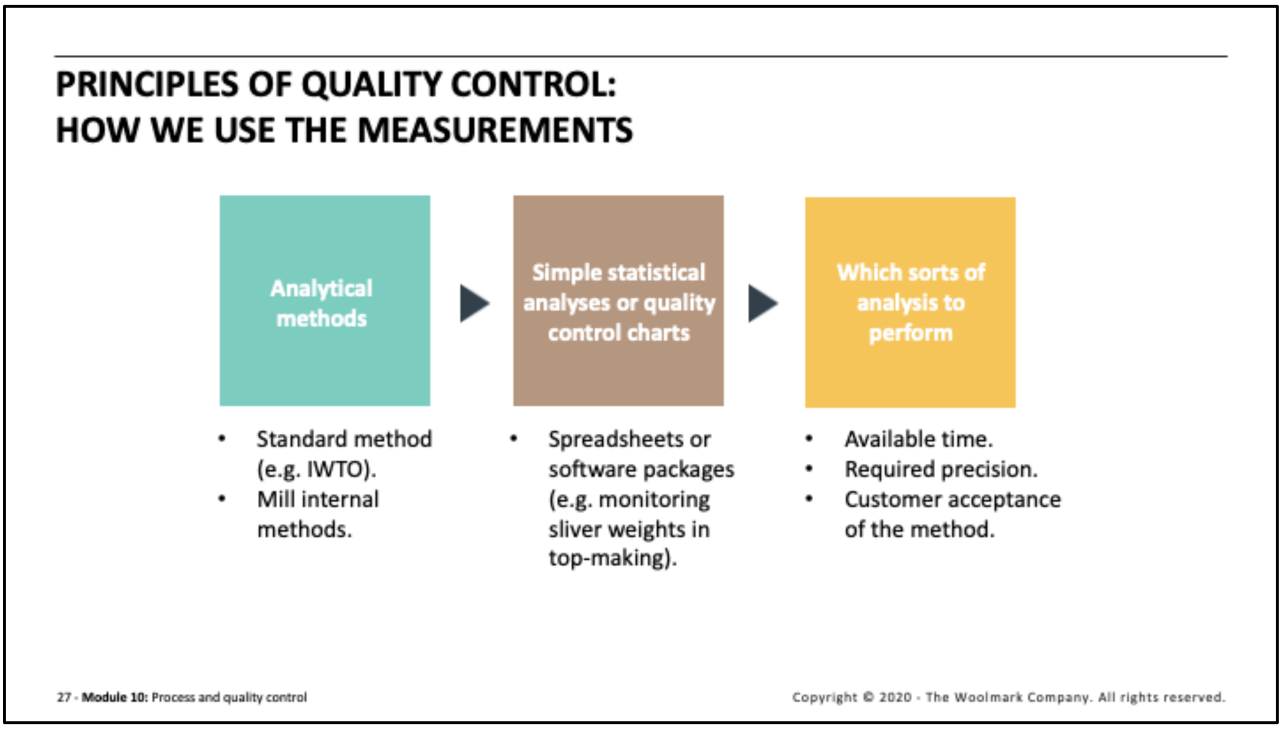
Rate of change in the parameter
During normal operation the rate of change is low; however, if a fault develops the effects can manifest themselves quickly.

Effect of parameter on product quality
For example, if the calibration of the feed belt is faulty, either due to poor calibration or to drifting set points, then the quality of the scoured wool could gradually worsen.

Size of the processing lot
When processing a small lot, there is relatively little time to correct a problem.
With a large lot, although there is the time to correct a problem, there could be difficulties ensuring that the quality of the wool at the end of the lot is the same as that processed earlier.

Importance of parameter to the customer
For example, if colour is of concern, samples of scoured wool should be tested frequently.

Time taken to complete test
Some tests take many hours or longer to complete, whereas others sacrifice accuracy for rapidity.



REITERATE THAT data needs to be gathered with a clear purpose for it to be useful. The information gathered must be used to improve the scour performance and not just for the sake of collecting data.

INDICATE THAT two types of response to data collection can be considered:

- A rapid response can improve the operation of the scour in real time. This requires rapid methods of analysis.
- A longer-term response based on data collected on the general operation of the scour under particular conditions (e.g. information on the patterns of contaminant removal when using a new detergent or when scouring a different type of wool).

EXPLAIN THAT the next step is to decide how to best use the data:

- In a modern scour, data can be automatically collected and software used to generate control charts showing patterns of parameters such as temperature and detergent additions over time. These can then be compared with product quality results.
- Another advantage of computer control is that the operating parameters can be changed automatically to suit a certain type of wool. In this case, statistics can be used to determine whether the scoured wool was similar to products produced previously.

PRINCIPLES OF QUALITY CONTROL: DATA ANALYSIS

A single sample can only provide a spot check.

Using a number of samples allows the information to be used in a number of ways.

Two statistical concepts are key in quality control for wool scouring:

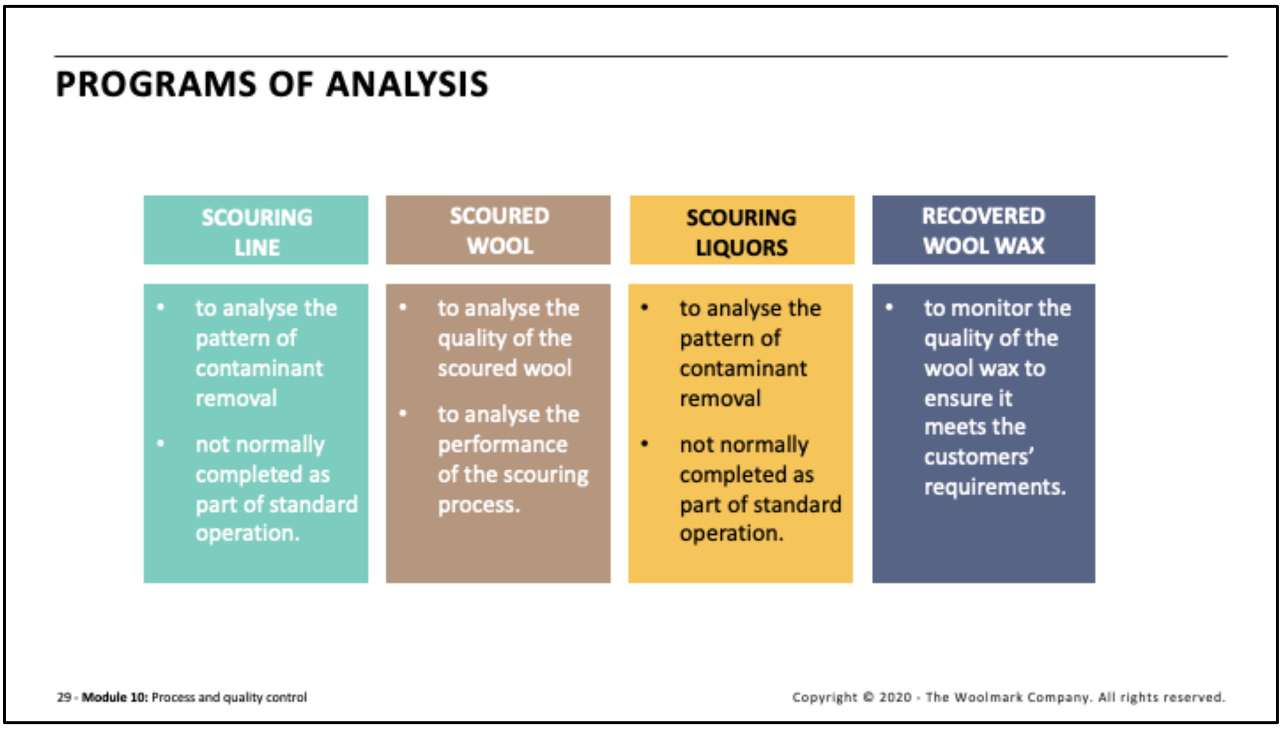
1. average (mean)
2. variation
    - standard deviation
    - coefficient of variation
    - error bars
    - critical differences.

EXPLAIN THAT the basic principles of data analysis indicate that a single sample can only provide a spot check. For example, an ash analysis tells us the ash content of that sample, but it does not tell us anything else about the product quality.

However, if we have a number of samples, the information can be used in a variety of ways, depending on the nature of the samples.

INDICATE THAT in quality control for wool scouring, we are concerned mainly with two statistical concepts:

- average (mean)
- variation:
    - standard deviation
    - co-efficient of variation
    - error bars
    - critical differences.



EXPLAIN THAT the common programs of analysis undertaken for quality control in a scouring operation are:

The scouring line
The purpose of analysing the scouring line is to analyse the pattern of contaminant removal (not normally completed as part of standard scouring operation).

- During a research trial, if different wools are being scoured, if a changed pattern of water use or new detergent is being investigated, then a mill might want to investigate the levels of contaminants on the wool after each bowl.

Scoured wool
The purpose of analysing scoured wool is to analyse the quality of the scoured wool and the performance of the scouring process.

- The measurement of parameters would depend on the customer's requirements.
- If a quality problem occurs with the scoured wool, the performance of the scour may need to be monitored.
- Samples should be taken from the end of the dryer.

Scouring liquors
The purpose here is to analyse the pattern of removal of contaminants and gain insight into the scouring performance by measuring the characteristics of liquors in the scouring bowls.

Recovered wool wax
The purpose of analysing the recovered wool wax is to monitor the quality of the wool wax to ensure that it meets the customers' requirements

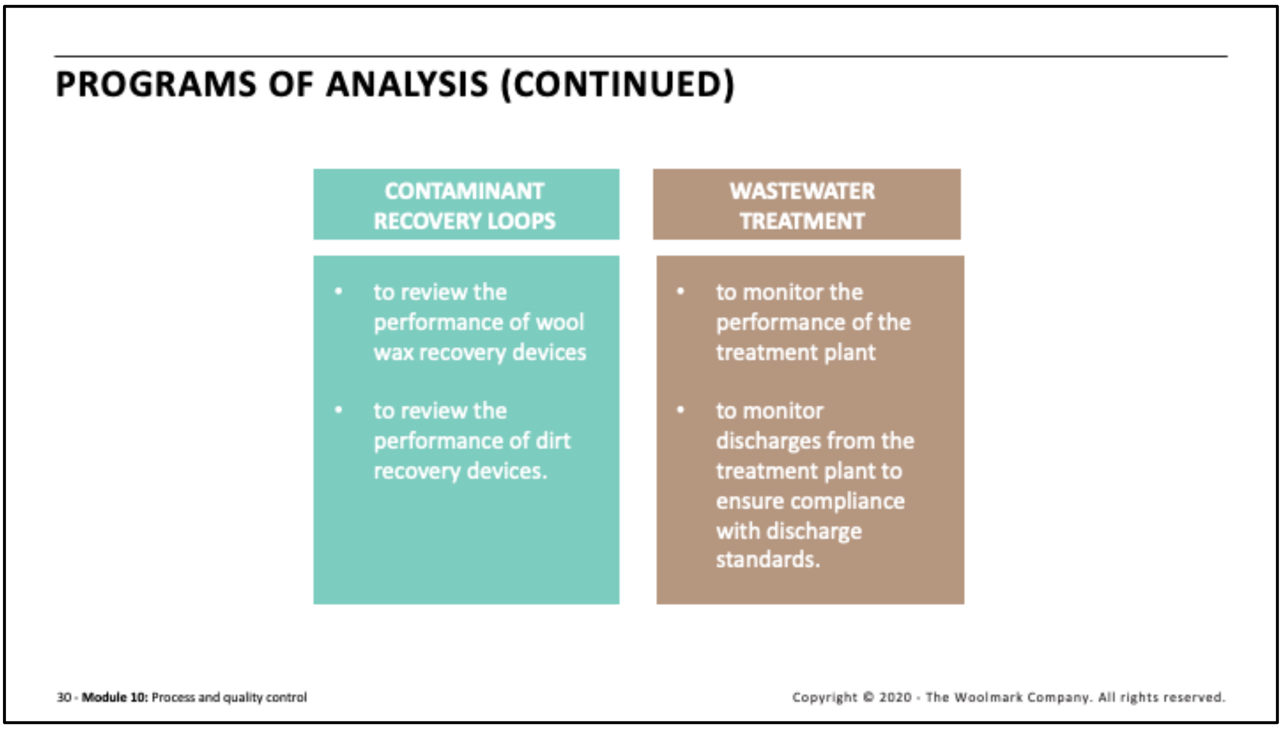
MENTION THAT customers often place limits on some characteristics of the wax such as:

- moisture
- ash content
- acid value and colour.

ASK *participants to suggest reasons why the colour of wool might gradually deteriorate during the scouring lot.*

IF NECESSARY *indicate the reasons include:*

- *a lack of detergent*
- *poor function of dirt removal*
- *poor temperature control.*



EXPLAIN THAT appropriate sampling of contaminant recovery loops and wastewater treatment plant is necessary to assess and manage performance. Appropriate sampling procedures are required to provide meaningful test results and support best management practices.

Contaminant recovery loops
The purpose of analysing the contaminant recovery loops is to review the performance of wool wax recovery devices by investigating three factors:

1. the composition of the cream
2. the spot efficiency of the centrifuge for wax recovery
3. the composition of the nozzle discharge.

INDICATE THAT another purpose is to review the performance of the dirt recovery by investigating two factors:

1. the efficiency of dirt removal
2. the split between underflow and overflow phases.

Wastewater treatment
The wastewater is analysed to monitor the performance of the waste water treatment plant. If the wastewater plant is not running correctly the final discharges may not meet compliance standards and there could be a waste of resources.

NOTE THAT monitoring discharges from the wastewater treatment plant ensures compliance with discharge standards.

PROGRAMS OF ANALYSIS: SAFETY CONSIDERATIONS

- Many chemicals used in the scouring laboratory are dangerous.
- Proper handling techniques should be used at all times.
- Specific information should be sourced from chemical suppliers or other literature.
- In general, all organic solvents should be used inside fume hoods and protective clothing should always be used when handling organic solvents and corrosive agents.

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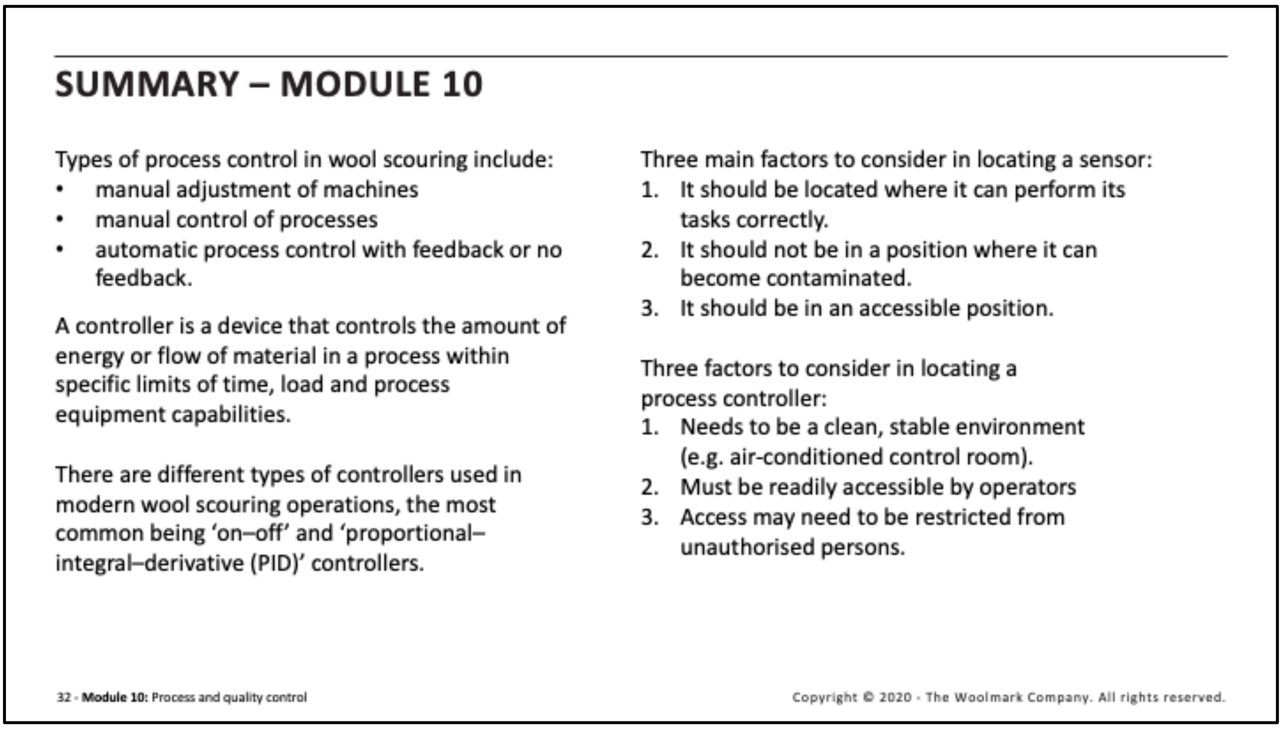
EXPLAIN THAT a number of the chemicals used in the scouring laboratory for testing as part of a quality control program are dangerous, and proper handling techniques should be used at all times.

REMIND participants that specific information should be sourced from chemical suppliers or other literature — in general, all organic solvents should be used inside fume hoods, and protective clothing (e.g. goggles, gloves, laboratory coat) should always be used when handling organic solvents and corrosive agents.



REINFORCE THAT process control improves the economics of the scouring process through better control and more efficient use of resources. It also enables better control of product quality.

REVIEW THE different types of process control in wool scouring include:

- manual adjustment of machines
- manual control of processes
- automatic process control with feedback or no feedback.

REITERATE THAT a controller is a device that controls the amount of energy or flow of material in a process within specific limits of time, load and process equipment capabilities.

There are different types of controllers used in modern wool scouring operations, the most common being 'on–off' and 'proportional–integral–derivative (PID)' controllers.

REMIND participants that there are three main factors to consider in locating a sensor:

1. It should be located where it can perform its tasks correctly.
2. It should not be in a position where it can become contaminated and lose its functionality.
3. It should be in an accessible position.

REINFORCE THAT there are three factors to consider in locating a process controller:

1. It needs to be a clean, stable environment such as an air-conditioned control room.
2. It must be readily accessible by operators.
3. Its access may need to be restricted from unauthorised persons.

SUMMARY – MODULE 10

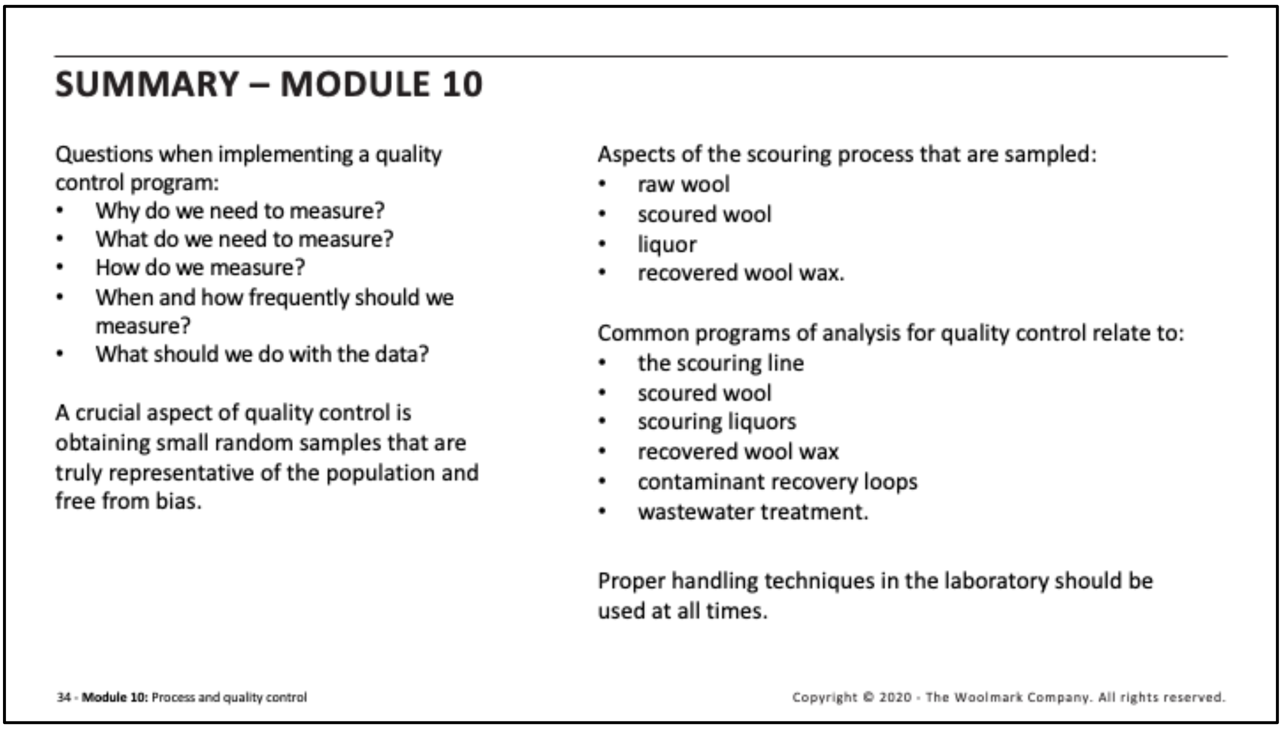
- Modern scouring lines are built using computer control where the computer can store and activate recipes for the scouring of different types of wool.
- Process control issues include:
  - weigh belt
  - bowl temperatures
  - dryer
  - wool wax recovery
  - dirt recovery.

33 - **Module 10:** Process and quality control

REMIND participants that modern scouring lines are built using computer control where the computer can store and activate recipes for the scouring of different types of wool.

REVIEW the fact that process control issues can occur with :

- the weigh belt
- bowl temperatures
- the dryer
- wool wax recovery
- dirt recovery.



REMIND participants that in order to implement a quality control program, we need to answer a number of questions:

- Why do we need to measure?
- What do we need to measure?
- How do we measure?
- When and how frequently should we measure?
- What should we do with the data?

REINFORCE a crucial aspect of quality control is obtaining small random samples that are truly representative of the population and free from bias.

Aspects of the scouring process that are sampled include:

- raw wool
- scoured wool
- scouring liquor
- recovered wool wax.

REMIND participants that common programs of analysis for quality control relate to:

- the scouring line
- scoured wool
- scouring liquors
- recovered wool wax
- contaminant recovery loops
- wastewater treatment.

NOTE: A number of the chemicals used in the scouring laboratory are dangerous, and proper handling techniques should be used at all times.

***ASK** participants if they have any questions about the content covered in this final 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 *Raw wool scouring* course.

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

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