PLANNING A NEW DAIRY

Planning a new dairy takes time to get right. However, taking time to plan has many benefits in terms of efficiency, productivity and profitability. These include:

- Reduced cost – getting things right the first time.
- Correct number of clusters – a good fit with herd and milking labour to increase efficiency.
- Pleasant working environment – making milking easier, safer and more productive.

This chapter contains ideas to consider in the following key areas:

Information in this chapter will assist in choosing the type of dairy to meet milk harvesting targets. It will also assist in determining dairy size – the number of clusters required.

Key principles to keep in mind ...

Planning a new dairy is a complex process that can be difficult and time consuming to work through. The dairy must be designed so that all elements of the system – the cows, people and facilities – work together to harvest milk efficiently.

Although the final choice often depends on the budget, there are some general principles that need to be kept in mind throughout the decision-making process.

Milk harvesting targets

It is important to have a clear, specific view about what the new dairy will help to achieve, now and in the future. Answering these questions may help clarify milk harvesting targets.

- How many people will normally milk? Who is the principal milker? Will a number of different people milk during the week?
- How long should the milking take? Is it important for the milking to be restricted to less than 2 hours? Could the dairy operate for much longer at each milking shift?
- How much time should be spent on each cow to manage herd health issues? Is it important to have the option of spending a bit more time with some cows if they need it?

Clear targets and priorities are the road map to the final destination – an efficient milk harvesting system.

Check implications

There are many choices to make when building a new dairy and decisions are not always clear cut. Efficiency gains in one area often mean trade offs in another – that is why it is critical to have clear targets, so that implications can be checked against priorities. Consider these examples:

- A rotary is built to reduce the time spent milking, but it is more difficult to spend extra time with individual cows.
- An entry race is built to assist cow-flow, but it adds extra cost and creates an area of 'dead space'.

Think about the implications of sizing the dairy for peak milk production or lower milk production, i.e. late stage lactation. Seasonal milking herds will need to consider:

- During peak production, a milker can handle more clusters, due to longer milk out times.
- During times of lower milk production, milking out takes less time, so the number of clusters that can be comfortably handled by one milker is reduced.

Consider the future implications of a proposed design choice and try to build in flexibility. Flexibility may be required to cope with the following:

- changes in herd numbers;
- increases in average production;
- the availability of skilled labour;
- changes over time in the average size of cows in the herd; and
- changes to feeding in the bail due to automation or increased quantities.

Sometimes the implications of a choice may mean a new option is canvassed. In other situations, it might be better to go with the original idea, but manage the implication. This might be done by employing more labour or taking on additional debt, etc. Clear milk harvesting targets make these decisions easier.

Understand limitations

Every element of the milk harvesting system has its limitations. The challenge is to design a milk harvesting system that promotes good cow-flow into and out of the dairy, and one where the number of clusters is matched to the milking labour.

- Depending on the amount of milk produced by the herd, milk out times span a limited range.
- Different types of dairies have different cluster 'idle' times and this can impact on efficiency.
- Milkers perform milking tasks within certain time frames – automation can help reduce work routine times, but so too can a careful review of work practices.

Understanding milk-flow rates, and the limits to equipment and labour performance, means expectations are realistic and maximum efficiency is achieved.

Seek expert advice

The complex nature of dairy planning means collating a broad range of information. Seeking out expert advice can help fill gaps in the technical details and manage the 'information overload' syndrome. Consider obtaining expert advice from the following:

- concreters and dairy builders;
- milking machine equipment suppliers;
- milk harvesting consultants;
- laneway and fencing contractors; and
- electricians and plumbers.

Revisit initial decisions

Designing something as complex and integrated as a new dairy may not be a linear process. It is more likely to be a process of preliminary choices, followed by a number of reviews, as more specific information is gathered. The final decision may be some time down the track.

- It is important not to get locked into decisions too early – reflect on and review preliminary choices before committing to anything specific.
- Try to be open minded about dairy type – start with the requirements then choose the dairy to meet these.
- Expect that priorities may change as more information is collected – this often happens as the implications of choices become clearer.

Dairy type

The bottom line is that there is no single dairy type that is right for everyone. This is borne out from survey data collected from 1000 farmers in the Australian industry; it shows substantial numbers of all dairy types are still in current use.

Table 8.1: Dairy types in Australia (1998-2000).

Dairy type	Percentage of all dairy types
Herringbone – swingover	50%
Herringbone – double up	30%
Rotary	10%
Walk Through	10%

Source: Improving Labour Productivity Project (DAV428) DRDC 2002.

If well designed, most types of dairy can provide a productive working environment that is both cow and milker friendly.

Some consideration should be given to the return expected from the capital outlay in the new facility. Clearly, the capital does not 'work' very hard if it sits unused for 20 hours per day.

Chapter 10 – Doing the sums.

Industry representatives have provided some of the advantages and disadvantages of each dairy type that can help with the decision-making process. Broad details relating to automatic milking installations (robotic milking) are also provided.

Swingover herringbone

Swingover dairies are the most common dairy type in Australia and the cheapest to build.

Table 8.2: Swingover dairy — positives & negatives.

Positives	Negatives
Usually the cheapest – fewer clusters than a double up	Highline or midline only – higher vacuum level means greater potential for teat end damage than a lowline system
Little idle cluster time	Can be a cluttered working environment, especially if milkers are tall
Highest cows per cluster per hour rate – cows exit and enter while other side is milking	Frequently observed significant over milking
Narrower shed compared to a double up	Swingovers are not ideally suited to ACRs and their use can complicate the milking routine
A lower number of clusters means that it is cheaper to automate than a double up or rotary for ACRs, milk meters, etc	Installation of ACRs is more complicated – best achieved with the rams located on swinging arms or sliding tracks
If dairy has sufficient room, can increase capacity by converting to a double up in the future	Cluster alignment may be more difficult to get right due to 'dragging' of milkline – particularly if cow is not in exactly the correct position
Time from cows entering dairy to cluster attachment is longer – can lead to better milk let-down	Slow-milking cows slow down the whole dairy (all the clusters)
Cows are in full view of the milker while in the dairy	
Often possible to walk into the pit at the same level as the vat room floor	

Source: National Milk Harvesting Centre.

Converting a swingover

Converting a swingover to a double up results in a cow throughput increase of about 30%, assuming that the labour is available to handle the extra units. This general rule of thumb is influenced by many factors and a detailed analysis is warranted.

Dairy size, p179.

Double up herringbone

While more expensive than swingovers to build, a third of dairies in Australia are double ups.

Table 8.3: Double up dairy – positives & negatives.

Positives	Negatives
⦰ Usually a more spacious, uncluttered, brighter, airier pit ⦰ Shorter shed compared to swingover for the same number of clusters ⦰ Can be a lowline milkline ⦰ Lower milking system vacuum levels possible compared to swingover ⦰ Ideally suited to ACRs ⦰ Cows are in full view of the operator while in the dairy ⦰ Often possible to walk into the pit at the same level as the vat room floor	⦰ If a conversion from a swingover, the pit can be crowded, due to a narrow pit ⦰ More cluster idle time than swingover dairies ⦰ Higher capital investment (more clusters) than required in a swingover dairy for the same cow/hour throughput ⦰ Slow milking cows can hold up an entire side of the dairy (half the clusters)

Source: National Milk Harvesting Centre.

Figure 8.1: A clean, well-maintained double up dairy.
Source: National Milk Harvesting Centre.

Rapid exit herringbone

One variation on the herringbone-style dairy is the rapid exit dairy. In this system, the entire side of cows can exit by stepping forward and off the milking platform.

- This variation is seen more commonly on double up dairies, but is also used in some swingover dairies.
- Rapid exit allows quick batch exit of a side of cows. In a rapid exit double up, for example, cow exit times can be cut from 4 seconds a cow to under a second per cow in sheds with good cow-flow.
- Shed construction costs are increased, as the shed needs to be wider and higher, but the result is a bright and airy dairy.

Table 8.4: Rapid exit dairy – positives & negatives.

Positives	Negatives
Faster cow exit times than traditional herringbone dairies	A much wider and higher building is required
Generally good cow entry times and cow-flow	More expensive to build than a standard swingover or double up herringbone
Generally bright and airy working environments	More moving parts – potential OH&S hazard
Is possible to walk at floor level from the milk room into the milking pit in many of these dairies	If two exit races are used, automation of drafting requires two of everything
Cows are in full view of the milker while in the dairy	More moving parts, requiring more maintenance

Source: National Milk Harvesting Centre.

Careful consideration needs to be given to whether the dairy is long enough to make the time saved in reducing exit times worth the increased capital cost.

Figure 8.2: Cows leaving in a batch from a rapid exit dairy in Queensland.

Source: National Milk Harvesting Centre.

Rotary dairies

Rotary dairies are a popular choice for those milking 300 or more cows. Rotaries can be very time efficient if all parts of the work routine are efficient.

Table 8.5: Rotary dairy — positives & negatives.

Positives	Negatives
Cows come to the milker – nil entry and exit times if the system is working well	Expensive to build and automate, due to the number of stalls and clusters
Usually a lowline milkline	Problem with repetitive tasks being completed (OH&S issues)
Little walking is required of the milker	Difficult for the milkers to see the cows for at least some of the milking
Slow cows do not hold up more than one cluster	Without automation, it requires at least two milkers
Platform speed sets the milking rate (a positive and a negative!)	Herd health issues can become challenging for some managers
Automatic ID is easy to install	More moving parts, requiring more maintenance
Automatic feeding systems are economical to install	Often operated too fast for comfortable operation, making the milking task unpleasant
Generally a bright and airy working environment	Using automation, a one-milker operation maybe possible, but cows are not seen or checked after milk out – this can lead to herd health issues
Cows generally like to get on to the platform	Cows frequently milked out before they get to the cluster removal station
Platform speed can be varied with the herd's stage of lactation	If much udder preparation needs to be done on the platform, throughput can suffer
Is possible to walk at floor level from the milk room into the milking area	Clusters are often attached before let-down on rotary dairies – newer rotary dairies have longer entrance races
Good for clean cows that do not need much udder preparation	
Easy to delay 'cupping-up' until after milk 'let-down'	

Source: National Milk Harvesting Centre.

Figure 8.3: Many rotary dairies have a bright and airy working environment.
Source: National Milk Harvesting Centre.

Automatic milking installations

It is likely that many Australian herds will be milked by 'robots' by 2020. However, it is unlikely that automatic milking installations will be an economic proposition for many Australian farms for at least another 5 years.

Table 8.6: Automatic milking installations – positives & negatives.

Positives	Negatives
Potential for increased milk production through increased milking frequency	Large capital investment required
Potential for time savings, as cows voluntarily go through all parts of the milking process and the equipment and milking area are automatically cleaned	Requires sophisticated technical support – service and maintenance infrastructure still being developed in Australia
No repetitive milking tasks to undertake	Requires substantial changes to farm management system, especially grazing management
Milking labour costs reduced	Different range of management and computer skills needed

Source: National Milk Harvesting Centre.

Cows tend to interact well with automatic milking installations. Cow behaviour has greatly improved on many farms installing these systems with the cows becoming much quieter to handle.

Quick Note – 5.8 Automatic milking installations.
Automatic milking installations, p238.

Dairy size

Determining the number of clusters a new dairy needs is a matter of answering a series of questions. The first series of questions relates to a farm's milk harvesting targets.

- How many cows will need to be milked?
- How many people will be milking?
- How long should milking take?
- How many times per day will the herd be milked?
- How much milk will cows be producing on average and at peak?
- What type of dairy is the preliminary choice?

Once these questions have been answered, it is a matter of finding the best size to fit the parameters.

It is important to strike the right balance between what the equipment can do and what the milker can handle, given the amount of milk produced by the cows and the type of dairy they are working in. Of course, knowing whether one, two or more people (operators) will normally milk is important too.

Sizing the dairy to get the right balance between labour and equipment is generally a compromise, particularly in seasonally calving systems.

When the experts size a dairy, they generally use a series of calculations based on theoretical or ideal capabilities at or near the peak of season. First, the theoretical number of cows a cluster can milk in an hour is estimated. Then, a milker's work routine time is factored in.

Cluster throughput

The milk harvesting targets are set to help determine the size that the dairy must be to service the farm's needs. Once set, the number of cows that need to be milked an hour will determine the number of clusters required in the dairy.

The number of cows the equipment can milk in an hour is influenced by two things – the time that a typical cluster is attached to each cow (the 'milk out time') and the time taken between removing the clusters from one cow and attaching them to another (the 'cluster idle time').

Both the milk out time and the cluster idle time make up the 'unit time'. To determine the number of cows a cluster can milk out in an hour, it is necessary to work out the unit time.

Unit time = milk out time + cluster idle time

Milk out time

The time that it takes to milk the cow depends on how much milk the cow gives at a milking and the milk-flow rate. Milk out time is the major proportion of the unit time and various methods are used to predict it.

The estimated maximum milk out time will largely determine the upper limit to the number of cows that can be milked by a cluster in an hour.

- In herringbone dairies (particularly double up types), the last cow to finish milking in each batch of cows determines the maximum milk out time of the whole batch.
- In rotary dairies, the maximum milk out time is equivalent to the time taken for the platform to rotate between the 'cups on' and 'cups off' work stations. The difference in rotary dairies is that the milk out time can be changed by varying the speed of rotation, so that a certain proportion of cows have not completed milking by the time they get to the 'cups off' position.

The longest milking cow in each batch limits batch milk out times. That is why maximum cow milk out times are used to estimate batch milking times, rather than average cow milk out times.

No matter which type of dairy, the longest milking cow can be either:

- a high-yielding cow milking at a 'normal' milk-flow rate – high yielding cow model; or
- an average-yielding cow milking at a 'slow' milk-flow rate – slow milking cow model.

These different models are used in different circumstances to estimate milk out times.

Year-round calving herds

In year-round calving herds, cows in the same batch will be giving very different yields. The maximum milk out time can be calculated by estimating the volume of the highest yielding cow in each batch and using the high yielding cow model.

Countdown Downunder tells us that if clusters are attached to plump teats, 95% of cows should milk out according to the milking times described in Table 8.7. These figures can be used to predict the maximum milk out time of batches in a year-round calving herringbone dairy.

Table 8.7: An estimate of the milk out time in year-round calving herds using the high-yielding cow model for a herringbone dairy.

Highest yielding cow in each batch – litres per milking	Milk flow rate of herds – litres per minute	95% of cows milk out time – minutes
10	1.7	6
15	2.1	7
20	2.5	8

Source: Based on Countdown Downunder milk out times.

The maximum milk out time in rotary dairies can also be predicted using this table. The rotation speed is adjusted to ensure a set proportion of cows are milked out in the time it takes to travel between 'cups on' and 'cups off' positions – giving the milk out time.

Seasonally calving herds

In seasonally calving herds, the maximum milk out time per batch can be estimated more accurately by the slowest milking cow in the group. The extent to which this is true largely depends on the farm's culling policy, the method used to determine when clusters are removed from cows and the patience of the milker.

However, for our purposes of estimating the maximum milk out time of each batch, it is appropriate to apply the slow milking cow model – a cow yielding an average volume at a slow milking speed.

Research at the National Milk Harvesting Centre on slow milking cows in a seasonally calving experimental herd monitored the average milking speed of slow milking cows over a lactation.

Table 8.8: An estimate of milk out time in seasonally calving herds based on research at the National Milk Harvesting Centre.

Average cow yield per milking – litres	Milk flow rate of slow milking cows – litres per minute	Maximum milk out time – minutes
10	1.7	6
15	1.8	8.3
20	2.2	9

Source: National Milk Harvesting Centre.

In practice, the maximum milk out times of each batch can be substantially different from those calculated in these guidelines. Milk out time depends on many factors, not the least being the procedures that individual farmers have in dealing with the longest milking cows in each batch.

Milking the cow, p108.

Cluster idle time

The type of dairy will impact on the cluster idle time – the time the cluster is 'idle' between being taken off one cow and being attached to the next cow. It is appropriate to consider the minimal cluster idle time when this figure is to be used in conjunction with the maximum milk out time, in order to estimate the unit time.

- Swingover dairies have a very short cluster idle time. It is commonly about 15 seconds from when the cluster is removed from one cow to attachment to the next cow.
- In double up dairies, the time between cluster removal from one cow to attachment to the next cow is longer. It must include the time taken to remove the cluster and spray the longest milking cow, emptying and then refilling the dairy with the next batch of cows and, finally, preparing and reapplying the clusters to (on average) half the cows in the next batch. The cluster idle time varies with the length of the dairy (related to number of clusters on each side) and is commonly 2½ to 4 minutes or more.
- In rapid exit double up dairy types, the cluster idle time is shorter than other double ups, as the time taken to empty a batch of cows is reduced to between 15 and 30 seconds, saving at least half a minute on cluster idle time (more in longer dairies).
- In rotary dairies, the time from cluster removal to attachment is commonly 1 to 1.5 minutes.

Table 8.9: Example cluster idle time for various dairy types.

Dairy type	Cluster idle time
Swingover	0.25 minutes approx. (15 seconds)
Double up	Up to 10 clusters aside – 2.5 minutes plus Up to 20 clusters aside – 3.5 minutes plus
Rapid exit double up	Up to 10 clusters aside – 2 minutes plus Up to 20 clusters aside – 3 minutes plus
Rotary	1 to 1.5 minutes

Source: National Milk Harvesting Centre.

When working out the unit time using the maximum milk out time, it is necessary to use the minimum cluster idle time. That is the time from when the cluster from the longest-milking cow is removed and then reattached to the next cow.

Unit time

The unit time is calculated by working out the following:

- The maximum milk out time – based on the longest milking cow in each batch.
- The minimum cluster idle time – the type and length of the dairy effects the cluster idle time.
- Unit time = milk out time + cluster idle time.

For example:

- In a year-round calving herd, if the highest yielding cow in each batch gives 20 litres/milking in a swingover dairy, then the estimated unit time would be 8.25 minutes. That is 8 minutes (milk out time) + 0.25 minutes (cluster idle time).
- In a seasonally calving herd, if average milk production was 15 litres a milking and the dairy was a 20 a side double up, then the estimated unit time would be 11.8 minutes. That is 8.3 minutes (milk out time) + 3.5 minutes (cluster idle time).

In rotary dairy types, the unit time is equal to the time taken for one rotation of the platform – the milk out time plus the cluster idle time between 'cups off' and 'cups on' work stations.

Cluster throughput is determined by the unit time and is expressed as cows/cluster/hour.

Cows/cluster/hour = 60 minutes divided by unit time in minutes.

- In the above swingover example of a 8.25 minute unit time, each cluster can only milk out 7.3 cows in one hour (60 minutes divided by 8.25 minute unit time = 7.3 cows/cluster/hour). No more and generally less in real life.
- In the above double up example of a 11.8 minute unit time, each cluster can only milk out no more than 5 cows in one hour (60 minutes divided by 11.8 minute unit time = 5 cows/cluster/hour).
- If each rotation of a rotary platform takes 10 minutes, that is equivalent to a 10 minute unit time, where each cluster can milk out 6 cows per hour (60 minutes divided by 10 minute unit time = 6 cows/cluster/hour).

Beware of using simple cluster throughput 'rules of thumb' to estimate the equipment output when sizing a dairy. Industry estimates such as swingover dairies should milk about 7 cows per cluster per hour, a double up about 5 cows per cluster per hour and a rotary about 5.5 cows per cluster per hour are based on 'average' unit times. A more accurate estimate of equipment performance for the planned system can be gained by working through tables 8.7, 8.8 and 8.9 and 8.10.

The unit time is an important figure to know when sizing a dairy. Once the unit time is calculated, it is possible to estimate the number of clusters the new dairy may need (see Table 8.10).

Number of clusters = number of cows per hour x unit time ÷ 60

Using the same examples:
If the herd size in the future was to be around 200 cows and the desired total time spent milking was 2 hours maximum, the milking system would need to milk 100 cows each hour, so ...

- If the dairy planned was to be a swingover with a unit time of 8.25 minutes, the dairy would need to have 14 clusters (100 cows per hour x 8.25 minutes ÷ 60 = 13.8 clusters).
- If the dairy planned was to be a double up with a unit time of 11.8 minutes, the dairy would need to have 20 clusters (100 cows per hour x 11.8 minutes ÷ 60 = 19.6 clusters).
- A rotary dairy is sized in a similar way. A 500-cow herd with a desired cluster throughput of 250 cows per hour and a unit time of 10 minutes would need 42 clusters (250 cows per hour x 10 minutes ÷ 60 = 41.7 clusters). An allowance for stall use efficiency also must be factored in.

These examples are a bit simplistic, but the basic principles are still used – with allowances made for the labour.

Sizing a herringbone, p189; Sizing a rotary, p190.

Equipment output

- The following table (Table 8.10) gives the theoretical equipment output in cows per hour determined from various unit times and cluster numbers. It assumes a 'steady state' of operation.
- For rotary dairies, an allowance must be made for the first rotation at a milking where the platform is filling and no cows are exiting the dairy.
- The time spent filling and then emptying on the first and last runs in large double up dairies can also be significant. This needs to be factored in when calculating equipment outputs on these dairy types too.

Table 8.10: Equipment output (cows/hour) at 'steady state' – calculated from the unit time and number of clusters.

Unit time	Number of clusters in the dairy					
(mins)	10	15	20	25	50	60
7	86	129	171	214	429	514
8	75	113	150	188	375	450
9	67	100	133	167	333	400
10	60	90	120	150	300	360
11	55	82	109	136	273	327
12	50	75	100	125	250	300
13	46	69	92	115	231	277
14	43	64	86	107	214	257

Source: National Milk Harvesting Centre.

It is interesting to note that this table can be used in two ways. It can be used to estimate the number of cows that can theoretically be milked in each hour or the number of clusters required.

It would be a mistake to think that this was all that was involved in working out the number of clusters required for a new dairy. The figures above do not take into account that clusters do not attach themselves and people's workloads must be considered! The following section shows how a milker's work routine needs to be added to the equation.

Milker throughput

The second part of the equation, when calculating the ideal number of clusters, is to determine how many cows a milker can handle in a given time period.

The questions to ask include:

- How long does it take one milker to milk one cow?

This answer is influenced by the number of tasks a milker has to perform during milking. It also depends on how long each task takes to complete. The answer will provide the work routine time and helps answer the next question too.

- How many work routines can one milker complete in one hour?

Once the time of a milker's work routine is established, it is possible to calculate the number of cows a milker can milk per hour (cows/operator/hour).

Work routine time

The work routine time is the time required to complete all the milking tasks for an individual cow.

- Tasks in the work routine include cow entry, feeding, teat preparation, cluster attachment, cluster removal, teat disinfection, cow exit and other miscellaneous duties.

The milking work routine, p91.

A typical example of a work routine time from a herringbone dairy is given in Table 8.11.

Table 8.11: Example of work routine time for an operator in a herringbone dairy.

Task	Secs/cow
Cow entry	3
Feeding	1
Teat preparation	2
Cluster attachment	10
Cluster removal	5
Teat disinfection	3
Cow exit	3
Miscellaneous	3
TOTAL WORK ROUTINE TIME	30 secs

Source: National Milk Harvesting Centre.

The 'miscellaneous' time allocated in the work routine may be milker idle time – time where efficiencies could be gained. However, time also needs to be allocated to deal with contingencies such as drafting, correcting cup slips and the like. It is important to strike the right balance to reduce milker stress. Estimates of 10% of the total work routine time are commonly used.

In rotary dairies, the operators at the 'cups on' and 'cups off' positions act independently, so the work routine for each cow is divided between the two operators. An example of a work routine time for a rotary dairy is given in the table below.

Table 8.12: Example of work routine time for the 'cups on' and 'cups off' operators in a rotary dairy.

Task	'Cups on' secs/cow	'Cups off' secs/cow
Cow entry	0	
Feeding	0	
Teat preparation	1	
Cluster attachment	8	
Cluster removal		4
Teat disinfection		3
Cow exit		0
Miscellaneous	1	1
TOTAL WORK ROUTINE TIME	10 secs	8 secs

Source: National Milk Harvesting Centre.

As in this example, it is generally the 'cups on' operator that is the busiest. However, in some larger rotary dairies where 2 milkers attach clusters, the operator removing the clusters and teat spraying can be the busiest.

Labour output

The overall labour output (cows/hour) of a herringbone dairy can be estimated if the work routine time (WRT) and number of operators are known.

Herringbone labour output (cows/hour) = 60 ÷ WRT x 60 x number of operators

For example:

- From the example herringbone work routine time of 30 seconds above, a single milker could handle 120 cows/hour (that is 60 ÷ 30 secs x 60 x 1 operator), while 2 milkers could handle 240 cows/hour (that is 60 ÷ 30 secs x 60 x 2 operators).

Table 8.13: Estimated herringbone labour output (cows/hour) based on work routine time.

Work routine time (secs/cow)	1 operator	2 operators
15	240	480
20	180	360
25	144	288
30	120	240
35	102	204
40	90	180

Source: National Milk Harvesting Centre.

Using the table above, it is possible to estimate what the theoretical maximum labour output could be given an estimated work routine time. That is the number of cows, in theory, milkers could handle in an hour given their work routine times. Reality is usually more complicated than theory and so performance in practice is likely to be less than this theoretical maximum.

The overall labour output (cows/hour) of a rotary dairy is limited by the operator that has the most work to do. The same simple equation from herringbone dairies can be used for each work station, as the 'cups on' and 'cups off' operators act independently of one another.

To calculate the output of a rotary it is first necessary to calculate the number of cows that the 'cups on' and 'cups off' operators can handle independently at each work station.

Labour performance 'cups on' (cows/hour) = 60 ÷ WRT x 60 x number of operators at 'cups on'.

Labour performance 'cups off' (cows/hour) = 60 ÷ WRT x 60 x number of operators at 'cups off'.

Using the work routine time of the slowest operator, the overall labour output can be estimated for rotary dairies (Table 8.14).

For example, using the work routine time examples from Table 8.13:

- A 10 second work routine time for a single 'cups on' operator gives a maximum 'cups on' labour performance of 360 cows per hour (that is 60 ÷ 10 secs x 60 x 1 operator).
- An 8 second work routine time for a 'cups off' operator gives a maximum 'cups off' labour performance of 450 cows/hour (that is 60 ÷ 8 secs x 60 x 1 operator).
- In this example, the 'cups on' operator limits the performance of both 'cups on' and 'cups off' work stations, and so the overall labour output is limited to 360 cows/hour.

Table 8.14: Estimated rotary labour output (cows/hour) at each work station based on work routine time.

Work routine time (secs/cow)	1 operator at a work station	2 operators at a work station
6	600	1200
8	450	900
10	360	720
12	300	600
15	240	480
18	200	400

Source: National Milk Harvesting Centre.

The overall labour performance on rotary dairies is limited by the work station ('cups on' or 'cups off' position) that can handle the lowest number of cows in an hour.

Appendix 2 – Working out work routine time, p257.

Maximising dairy efficiency

Dairies run most efficiently when the capacity of the equipment to milk the cows (equipment output) matches the capacity of the labour to milk the cows (labour output). That means people are not waiting for the equipment to finish and the equipment is being fully utilised, not idle and waiting for the milkers to catch up.

Dairy efficiency is maximised when the equipment and labour are balanced.

One of the key aims when planning a dairy is to balance the equipment output (Table 8.10) with the labour output (Tables 8.13 and 8.14) by calculating the expected unit time and the expected milking work routine time.

Sizing a herringbone

Once the unit time and the work routine time are known, the number of clusters that an operator can handle can be calculated. This is the last step in sizing a herringbone dairy.

- The idea is to determine how many milking positions a milker can handle – the number of work routine times that can be fitted into the time that each unit is 'busy' with a cow.
- The calculation must take into account working at a comfortable pace, without excessive over-milking or waiting around for cows to finish.
- In a herringbone, ideally, once the milker has finished attaching the cluster to the last cow in the batch, the first cows should be ready for cluster removal and teat disinfection.

The calculation for clusters per operator is:
unit time (in minutes) multiplied by 60, divided by work routine time (in seconds).

For example:

- An operator of a swingover dairy with a unit time of 8.25 minutes and a work routine time of 40 seconds could theoretically handle 12 clusters (8.25 x 60 ÷ 40 seconds = 12 clusters).
- An operator in a double up dairy with a unit time of 11.8 minutes and a work routine time of 30 seconds could theoretically handle 23 clusters (11.8 minutes x 60 ÷ 30 seconds = 23 clusters).
- The expected number of clusters that an operator can handle given various unit times and work routine times is given in Table 8.15.

Clusters/operator = unit time (mins) x 60 ÷ work routine time (secs)

Table 8.15: Theoretical 'clusters per operator' values calculated from unit time and work routine time for herringbone dairies.

Unit time (mins)	Work routine time 15 secs	20 secs	25 secs	30 secs	35 secs	40 secs
7	28	21	17	14	12	11
8	32	24	19	16	14	12
9	36	27	22	18	15	14
10	40	30	24	20	17	15
11	44	33	26	22	19	17
12	48	36	29	24	21	18
13	52	39	31	26	22	20
14	56	42	34	28	24	21

Source: National Milk Harvesting Centre.

This table assumes a 'steady' work state has been reached and generally excludes the first and last runs of the dairy, when the equipment is not fully utilised. This table shows what is theoretically possible, which is useful when sizing a herringbone dairy. However, a perfectly balanced system is rarely seen in practice because the unit time and work routine time both vary through the season.

This calculation is only appropriate for herringbone dairies – where the work routine tasks are not divided between the operators. Clusters per operator is not a particularly useful tool for sizing rotary dairies.

Sizing a rotary

The number of clusters on a rotary dairy is usually based on the rotation speed and the unit time – with the labour resources being allocated to match the workload.

Step one — rotation speed

The first step is to work out the rotation speed, based on the number of cows that are required to be milked in an hour.

The rotation speed is usually expressed in seconds per stall. That is the time it takes for 1 stall position to rotate past a certain point. The maximum theoretical output (cows/hour) of a rotary dairy is a function of the rotation speed of the rotary platform (Table 8.16).

- Rotation speed = 3600 divided by the required platform output.

Number of seconds per stall = 3600 ÷ cows/hour

The cows/hour output figure used to calculate the rotation speed has to take into consideration factors that limit the efficiency of stall use on each rotation. Factors that reduce the efficiency of stall use and so reduce the maximum theoretical output include:

- cows that go around twice;
- empty stalls; and
- stopping the platform.

The rotation speeds required to achieve various cows/hour outputs are shown in Table 8.16. Cows/hour outputs are affected by the efficiency of stall use on the platform and figures adjusted for stall use efficiency should be used when working out the rotation speed.

These are 'steady state' outputs. Outputs are lower in the first hour of a milking as a full rotation is required before the first cows exit the platform after start up. This is taken into consideration when calculating the total herd milking time in the third step.

Table 8.16: Theoretical outputs (cows/hour) calculated from rotation speed at 'steady state'.

Rotation speed (secs/stall)	Stall use efficiency				
	100% efficient (theoretical maximum)	95% efficient	90% efficient	85% efficient	80% efficient
7	514	489	463	437	411
8	450	428	405	383	360
9	400	380	360	340	320
10	360	342	324	306	288
11	327	311	295	278	262
12	300	285	270	255	240
13	277	263	249	235	222
14	257	244	231	219	206
15	240	228	216	204	192

Source: National Milk Harvesting Centre.

Measurements taken in Australian dairies indicate that most rotary dairies operate at about 85% of their calculated maximum theoretical output. This takes in to consideration cows going around twice, empty stalls and stoppages.

The rotation speed is important to estimate from the outset as certain activities must be undertaken within the time that it takes for 1 stall position to rotate past a certain point. These activities must be performed properly within this timeframe for the rotary platform to function.

The activity that takes the longest time limits the rotation speed of the rotary. The most rate limiting activities that must be undertaken on a rotary platform are (in order):

- The time it takes at the 'cups on' position to prepare teats and attach the cluster – a minimum of 8-9 seconds is required to do a careful job in a sustainable manner.
- The time it takes at the 'cups off' position to remove the clusters and disinfect teats – a minimum of 6 seconds is required to do a good job here.
- The time available for each cow to enter onto the platform – generally a minimum of 5-6 seconds, although some large rotary dairies manage to load cows in little more than 4 seconds.

Automation or increasing the number of operators at the 'cups on' or 'cups off' positions allows for faster rotation speeds – sometimes rotation speeds are only limited by the time that it takes for a cow to load onto the platform.

Step Two — number of clusters

The second step is to use the predicted unit time to calculate the number of clusters required on the platform.

- The unit time can be predicted from the anticipated milk out time and the cluster idle time – unit time = milk out time + cluster idle time.
- The anticipated cluster idle time must allow enough time for the idle clusters to move between the 'cups off' position and the 'cups on' position – generally a minimum of 7 stall positions or 7 x the rotation speed in seconds per stall.

The number of clusters required on the platform can be easily calculated from the expected unit time once the rotation speed per stall (and so the required cows/hour output) has been decided (Table 8.17).

Number of clusters = 60 x unit time (minutes) ÷ number of seconds per stall (secs/cow)

The milk out time required is the critical factor in the overall unit time when sizing rotary dairies.

- The time taken to travel between the 'cups on' and 'cups off' positions must be adequate for most cows to be completely milked without significant over-milking. That makes up the 'milk out' time on rotary dairies.
- The unattached clusters between 'cups off' and 'cups on' are idle and the time taken for them to travel this distance makes up the 'cluster idle time' on rotary dairies.
- Having the 'cups on' and 'cups off' positions close to the bridge where the cows enter and leave the platform minimises the overall unit time and so reduces the number of clusters that are needed in the dairy.

Maximising the proportion of the clusters in the dairy that are between the 'cups on' and 'cups off' positions (i.e. milking cows) will help minimise the number of clusters required in the dairy for a given rotation speed.

Sometimes the rotation speed is dictated by factors other than milk out time, such as the time required for the cows to eat their allocation of feed. In this case, the time required to eat the feed on the platform replaces the 'milk out time' component of the unit time.

Unit time in a rotary dairy is effectively the time it takes for one complete revolution of the platform.

Table 8.17: Number of clusters required on a rotary platform calculated from the anticipated unit time and rotation speed.

Rotation speed (secs/stall)	Unit time 7 minutes	8 minutes	9 minutes	10 minutes	11 minutes	12 minutes
7	60	69	77	86	94	103
8	53	60	68	75	83	90
9	47	53	60	67	73	80
10	42	48	54	60	66	72
11	38	44	49	55	60	65
12	35	40	45	50	55	60
13	32	37	42	46	51	55
14	30	34	39	43	47	51
15	28	32	36	40	44	48

Source: National Milk Harvesting Centre.

Many rotary dairies have too many clusters idle and so must have more clusters to compensate. Calm stockhandling and long entry races ensure cows are let-down for milking prior to moving onto the platform – minimising unit time and the number of clusters required for a given rotation speed.

Final step — check herd milking time

The last step is to check that the herd's milking time from first cow in to last cow out is acceptable, taking into consideration the lower outputs in the first hour of operation.

- No cows exit the platform during the first revolution of a rotary platform at each milking, that lowers the cows/hour output for the first hour of operation.

That is calculated from the theoretical cows/hour output figure, including the correction for stall-use efficiency (Table 8.16) and the predicted unit time.

Herd milking time (minutes) = number of cows to be milked ÷ cows/hour output x 60 + unit time

For example:

- A 600-cow herd with an output of 340 cows/hour (9 seconds per stall at 85% stall use efficiency) and a unit time of 10 minutes, would take 116 minutes from the first cow entering the platform until the last cow exiting the platform (600 ÷ 340 x 60 + 10 = 116 minutes). That is just under 2 hours.

Rounding up ...

Clear targets and priorities are the starting point for planning an efficient milk-harvesting system.

A clear understanding of the advantages and disadvantages of each dairy type can really help with the decision-making process.

Efficient dairies correctly match their equipment performance with their labour performance by working out the cluster unit time and the milker's work routine time.

Further information ...

Countdown Downunder Technote 6.1 – milking speed.

National Milk Harvesting Centre – Unpublished data from Shorter Milking Times experiment used to estimate milk flow rates of slow milking cows (2001).

National Milk Harvesting Centre – Unpublished data from Labour Productivity project which monitored farm batch times on farms with good milk harvesting productivity (2000).

National Milk Harvesting Centre – Improving labour productivity in milk harvesting on Australian dairy farms: final report (DAV 428) (2002).