Use of Electrical Conductivity in Milk

- Milk electrical conductivity (**EC**) is a measurement that relates to the ionic composition in milk (balance of positive and negative ions).
- Mastitis affects secretory cell function and ionic balance in milk, and has been suggested as one of the possible causes of an increase in EC (due to increase in the concentration of sodium and chloride basically).
- It is important to understand that causes other than mastitis may also cause an increase in EC. Factors such as environmental temperature and heat stress (EC increases with higher temperature of milk, which relates to body temperature); high animal activity (sometimes related to cows on heat) and low milk fat (cows off feed, with acidosis, fatty liver, ketosis or displaced abomasum) have been related to higher EC levels. Events such as diseases (milk fever or pneumonia for example), vaccinations and udder singeing have been reported to cause an increase in EC. Therefore, EC should not be interpreted in isolation of what happens on the rest of the farm.
- Minimize exposure of cows to environments with faecal contamination, moisture or organic matter, because they will increase pathogen load and as a consequence increase the risk of pathogens entering and infecting the udder.
- Monitoring of EC has been suggested as an indirect indicator of mastitis in dairy herds. Its potential use and adoption rely on being a relatively accessible technology, with rapid on-farm measurement and indication. It applies the management by exception principle.
- Given that mastitis occurs at quarter level, EC would be more effective if measured per quarter (which is the case in AMS). In conventional dairies, EC is usually measured at udder level. Although the frequent monitoring of consecutive milkings could overcome this issue, no clear management procedure has yet been put in place to use EC values as an aid for mastitis detection.
- Some herd management softwares do not use the traditional unit (mS/cm) to express EC, but convert it to some other reference unit.
- The absolute value of EC is usually not as useful as the relative value of EC, obtained by comparing within cow measurements (previous measurements). In this way, a particular measurement is compared with either the average of several days (usually 7 or 10 days), the overall or composite cow average or in comparison to the highest or lowest recorded value in a defined period of time.
- There is a large variation between herds, and therefore detection models based on one herd may not be fully applicable when translated to other herds. Furthermore, a large between cow variability in milk yield and EC has even been reported for healthy cows.
- The use of EC for accurate detection of clinical and subclinical mastitis is highly variable, and a higher than desired level of false positives has sometimes been reported (cows appear on a report as possibly infected cows, but have no clinical or sub-clinical indication of mastitis).

- The occurrence of some false positive alerts in a conventional milking system is generally not a significant issue, given that the operator is already in the pit, making it easier to check individual cows. The issue is the increased attention time spent on each cow during checking, and corresponding increase in total milking time. However, the occurrence of a significant number of false positive alarms reduces the farmers trust in the technology and can eventually result in complete disuse of the tool in some cases.
- False negatives can also occur, by which cows with clinical signs (swollen quarter, clots in milk) or sub-clinical mastitis (high SCC) do not appear in the report, given that they have an increase in EC which is below the threshold level for example.
- Most commercial companies provide consolidation of information into graphs or reports where different filtering or algorithms (using default values but often these default values can also be customised/modified) allow identification of cows with higher risk of suffering sub-clinical or clinical mastitis.
- The user is required to regularly monitor the report, interpret it and decide which cows need to be checked using other methods (stripping or CMT). Ideally most of the cows on the report would have either sub-clinical or clinical mastitis, and no infected cow would be missing from the reports.
- On average, the proportion of cows checked is somewhere around 40% of those that appear in a report. Most of the times intuition guides the decision of which cows need checking.
- From a survey study in the Netherlands, of the cows that were checked by the farmer (farmer only checked 3% of alarms, which is very low), almost 70% had clinical mastitis, 15% had sub-clinical and the remainder (15%) were false alarms. The researchers involved in this study checked every single alarm, and found 10% clinical cases, 30% sub-clinical and 60% false alarms. The farmer had detected 100% of the sub-clinical cases but had missed 74% of the clinical cases.
- The definition of alarm or threshold levels varies from farm to farm. Default settings are useful but can require frequent adjustment and interpretation. As time and experience with the technology increases farmers are likely to become more comfortable with ‘tweaking’ the thresholds (some farmers use 115% increase in relative EC and 25-40% drop in milk yield for example). Modifications of setting should always be done in consultation with the herd management specialist of the equipment provider given that a parameter might affect more than one factor.
- Whenever possible, use an index of sustained increase of EC in last “x” amount of milkings, to avoid random increases which could be due to systemic causes.
- Lower limits ensure getting more of the truly infected cows, but also cause higher numbers of false positives. There is a risk of trade-off with a farmer trying to balance minimising the number of false positive alerts and missing a clinical mastitis case.
- The ideal situation is to try and avoid having a list of many cows, amongst which most of them would be false positives, because it makes the filtering to detect priority cows for checking difficult.
- EC usually increases the milking before clinical mastitis is detected, but reports have also shown an increase up to 3 days prior to the event. Feedback from farmers was that milk yield decreases usually start occurring 2 – 3 days prior to the increase in EC.
- Attention should also be placed on signs such as milk clots in milk filter or high BMSCC.

- Using only one criteria has not proven to be very successful, therefore some other criteria that farmers could consider at the time of deciding whether or not to check a cow are:
  - Milk production decrease (some days prior to clinical signs)
  - Failure in milking (incomplete, kick-off, blockage, etc)
  - History of teat damage (identify repeated cases)
  - Age (older cows have a naturally higher EC level)
  - Days in milk (late lactation cows have higher EC than early lactation herdmates)
  - Lower milk production (related to lower EC)
  - Combine with colour indication when possible for highest accuracy.
  - Cows in heat (leave them as non-priority cows to look at)
  - Cull cows (leave them as non-priority cows to look at)
  - Number of alerts in last 96 h and focus on cows with more than 1 session with high EC / low milk yield
- Increase in EC occurred independently of the mastitis agent causing pathogen. Yet, there is some indication that the type of pathogen causing mastitis could affect the EC response. It has been reported that milk from quarters sub-clinically infected with *S. aureus* had a higher conductivity than milk with subclinical infection by *S. uberis*, *S. dysgalaetia* and *E. coli* which had lower EC values.
- The recommendation is to monitor the cow for some days after the alert, because she might be sub-clinical and may start to show clinical symptoms a couple of days later.
- The EC measuring device should be adequately installed and calibrated in order to work according to manufacturer's recommendations and obtain reliable EC measurements.
- Some of the suggested operation procedures:
  - Start with default setting regarding thresholds and reporting. Modify and check the impact on number and certainty of cows that appear on the report with alarm levels.
  - The morning milking has been suggested as the best time to assess changes in different on-line measurements. EC relates to time of milking (am / pm), therefore farmers should try to compare with same milking of previous days.
  - Try to check all cows that appear on a report. One way of doing this is have a list prior to milking, or set some type of alarm to be able to identify the cow when she enters the milking parlour (voice alert, light indication, text). Strip her if it is not common routine, or give extra attention during stripping, and/or perform a rapid mastitis test. Use paint to identify that cow and check her for the following 2 – 3 days. Monitor close up those cows, because at that stage their immune system might be fighting against the disease in a sub-clinical phase.

Key messages:

- EC is only an indicator of mastitis (several other factor cause an increase in EC). Should only be used as an additional tool to improve udder health management.
- Variation between herds and cows requires adaptation to each farm which should be done by gradual modification of threshold levels, and adequate monitoring.
- EC should not be analysed in isolation. Consider other cow and system factors that could be affecting EC.

Disclaimer: This document has been written to provide dairy farmers with more information on how they could potentially optimize the use of conductivity meters in conventional milking systems. We hope it will be updated progressively if needed. Additional information referring to scientific publications can be provided if needed.

The authors acknowledge the help provided by farmers, consultants, veterinarians, commercial companies and researchers to put together this document.