1. What is mastitis?
Mastitis is the most common and costly disease in dairy herds. In many cases the farmer is only aware of the clinical cases observed during milking, although a large number of cows may be subclinically infected with bacteria.

Mastitis is an inflammation in the mammary gland primarily caused by bacterial infections. When bacteria are growing, they release metabolites and toxins that stimulate the defense mechanisms in the cow. The inflammation response leads to a migration of white blood cells from the peripheral bloodstream into the udder. The Somatic Cell Count of the milk, which includes white blood cells, bacteria and somatic cells, increases from normally less than 100,000 cells/ml or less per udder quarter up to several million per ml. The increased cell count due to the inflammation is accompanied by a release of several enzymes, among these NAGase and Lactate Dehydrogenase (Sandholm et al., 1995, Ingvartsen 2001). The enzymes will be released from cells that have been damaged in the combat between bacteria and white blood cells. The more severe the inflammatory response, the higher activity of the enzymes.

The pathological consequences of mastitis are tissue damage and alteration of secretory function. This leads to reduced milk yields and changes in milk composition. A correct estimation of the loss in milk yield is difficult, since non-infected udder quarters tend to compensate for the decrease in yield of the infected quarter, but the daily milk yield from the affected quarter can drop 9 kg, and a gradual increase after the mastitis case will last for up to 30 days (Rasmussen, 2006), in some cases of E. coli mastitis the milk production in the affected quarter may go on total halt. As can be seen from figure 1, the milk composition will be altered. Fat and lactose levels are dropping, while total protein levels change only slightly. Serum proteins are increasing and casein are decreasing leading to deteriorated cheese making quality. The milk concentrations of ions like sodium chloride are increasing resulting in an increased milk electrical conductivity. This can be used for early warning in automated milking, but the increase in electrical conductivity appears after the rise in NAGase and LDH.

Figure 1. Changes in milk components as related to increase in Somatic Cell Count, indicative of mastitis (Sandholm et al, 1995).
It has been reported that clinical mastitis rates are generally 20-50 treated cases/100 cows per year. Subclinical infection levels are 5-35% of quarters infected by a major pathogen bacteria.

The clinical mastitis is rather easy to detect for the farmer. The symptoms are clotting and discoloration of the milk, and the gland can become hard, red or swollen. In severe cases the cow has fever and loss of appetite. The subclinical mastitis can be more difficult to detect, since both the milk and udder can appear rather normal, while the Somatic Cell Count in the milk increases. The major issue associated with visual detection of mastitis is that in many cases the inflammation has already been present for some time, resulting in poor treatment results, and the cow becoming a chronic mastitis case. Therefore, early detection of mastitis, before severe tissue damage has occurred is the best way to improve udder health. Early detection may also means that less antibiotics used for less days will save money to the farmer.

With the advent of automatic milking udder health can be monitored by electrical conductivity, measured for each quarter. The major issue with monitoring electrical conductivity (and milk yield from each quarter) appears to be related to the present stage of development of the software to process the data, in the sense that the user is presented with a number of false alarms (Kamphuis et al., 2010).

Recent economic analyses point to an average loss per case of clinical mastitis of approximately 143 € (Bar et al, 2008). The costs were composed of 92 € because of milk yield losses, 11 € because of increased mortality, and 40 € because of treatment-associated costs.

2. Herd Navigator™ and detection of mastitis

The Herd Navigator™ concept differs greatly from traditional mastitis detection, where the diagnosis is either based on clinical signs or in a robotic milking situation, changes in electrical conductivity and/or a rise in Somatic Cell Count (the DeLaval OCC). The milk component used to monitor udder health in Herd Navigator™ is the enzyme Lactate Dehydrogenase (LDH) which is released into the milk in the affected quarter during inflammation. LDH is well correlated to the Somatic Cell Count (figure 3). Somatic Cells are typically white blood cells that arrive in the quarter to combat the bacterial infection and hence an indicator of the severity of the infection. Unfortunately the Somatic Cell Count can fluctuate due to a number of cow factors (heats, heat stress, changes in feeding etc.), and therefore it is not always the best measure of an active infection, where LDH is increasing in an active infection and hence a better measure of mastitis.

![Figure 2](image)

Figure 2. Clinical mastitis can best be described as “the iceberg”. The purple cow is the one being detected as a mastitis cow, but underneath are several subclinically infected cows (the grey cows). Adapted after Nelson Philpot, Mastitis Management, 1978.

![Figure 3](image)

Figure 3. The correlation between Somatic Cell Count (blue line) and LDH (red line) is very high, indicating that LDH is a good indicator of mastitis (Chagunda et al., 2005, based on 11,893 data records).
Testing of the mastitis model in a Danish research herd showed a sensitivity of approximately 80%. Some cases will go undetected, because they develop very rapidly. This is the case of some E. coli cases that may develop between two milkings. But most of the mastitis alarms will appear up to 4.5 days before clinical signs, leaving time to further investigate the case. The specificity of the model, which is the ability to only issue mastitis alarms on true mastitis cases is 98%. An example of the model’s ability to detect mastitis can be seen from figure 5. The cow had a very high risk for mastitis at day 40, but clinical signs appeared as late as day 50, where the cow was treated.

![Figure 5](image_url)

The mastitis model takes into account the degree of deviation in LDH from the baseline value, based on the cow’s own development. This means that differences in LDH-concentration has the highest impact on mastitis risk when LDH concentrations are rising steeply from the baseline value.
Herd Navigator™ used with DeLaval VMS systems can also deliver a quarter specific mastitis alarms. If differences in electric conductivity between quarters are of a certain magnitude, the probably affected quarter will also be part of the mastitis alarm. This will narrow down the bacteria culture to one quarter. In parlour milking, CMT- or DCC testing of quarters from a mastitis alarm cow can also guide the user to the quarter most likely at risk.

In order to optimize mastitis management in a Herd Navigator™ herd we recommend a Standard Operating Procedure to be developed in cooperation with the herd veterinarian. A typical Standard Operating Procedure (SOP) for mastitis alarms may follow a pattern outlined in figure 6. Once the alarm is issued, a milk sample can be collected and analyzed. According to the culture result the cow will be treated or left untreated.

Figure 6. Example of a Standard Operating Procedure (SOP) for mastitis management, used in Denmark. The SOP should be adapted the specific herd based on experience and the herd veterinarian’s advice, and of course according to local legislation. It can be developed in the user interface.

Table 1 shows results from a Danish test herd where on-farm culture was started in late 2009. Based on culture results and mastitis history, the majority of mastitis alarm cows were left untreated. Despite a decrease of 56 % in mastitis treatments the Bulk Milk Tank Somatic Cell Count was decreasing in 2010, compared to the same time period in 2009 (Bennedsgaard & Blom, 2011). The major cause of this change can be attributed to a better cure rate in treated cows, due to the early warning. The use of the system saves money, for treatments but also in terms of saved milk due to less treatments and a shorter withdrawal period for treated cows. In the case herd, the value of milk from cows not treated had a value of € 7,400.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Per cent</th>
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<tbody>
<tr>
<td>Herd Navigator™ alarm and treatment</td>
<td>54</td>
<td>39</td>
</tr>
<tr>
<td>Herd Navigator™ alarm, no treatment</td>
<td>82</td>
<td>59</td>
</tr>
<tr>
<td>No alarm, treated</td>
<td>2</td>
<td>2</td>
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Table 1. Herd Navigator™ mastitis alarms and mastitis treatments December 2009-March 2010 in a 277 cow herd with robotic milking (Bennedsgaard & Blom, 2011).

### 3 Treatment of mastitis with Herd Navigator™

Treatment for mastitis can not be outlined here, as there are large differences in antibiotics available and practices used between territories. As we anticipate that treatment will be instituted earlier in a Herd Navigator™ herd, the treatment protocol may be limited to intramammary infusions of antibiotics, reducing antibiotic use and milk withdrawal time compared to e.g. intramuscular injections of antibiotics. This is currently being investigated in Danish test herds.
4 References


