FLIR TECHNICAL GUIDE

Instructions
SPECIFICALLY CHOSEN SERVICE SOLUTIONS THAT ENHANCE PEOPLE, KNOWLEDGE AND PRODUCTION PRACTICES.

At Lallemand Animal Nutrition, high value is put on creating and maintaining strong customer relationships. Lallemand is raising the bar and setting new standards to benefit animals and create better customer experiences. Lallemand Forward represents our ideals while keeping an eye on the future.

LALLEMAND ANIMAL NUTRITION IS:

- At the forefront of providing modern yeast, bacteria and microbial solutions;
- Advancing toward a mutual goal with our customers to improve practices, optimize production and enhance satisfaction;
- Proving performance at every turn;
- A responsible and trustworthy partner;
- Growing as a company and as an industry leader;
- Investing in agriculture's next generation;
- Adding value to move customers and ourselves Forward.

RESEARCH AND DEVELOPMENT

No product is brought to market without a substantial base of research and proof of performance. Lallemand applies Forward-thinking to research which results in quality products with practical application.

EDUCATION, ON-FARM SERVICES AND INDUSTRY SUPPORT

Lallemand uses its company resources to better serve customers and partners - from our production facilities, to our experienced network of experts, to the energy and innovative spirit of our people. Lallemand supports the advancement of animal nutrition's current and future generations of innovators. Knowledge is paid Forward to help customers improve their practices.

We’re delivering specific solutions and services to drive you Forward.
1- FLIR

**WHAT IS IT?**

‘Forward Looking InfraRed’ technology now allows the measurement of surface temperature of ensiled crops (organic and conventional). This technology is widely used by firefighters (night vision, fire detection...), army (night vision), construction (insulation) and for medical operations, more recently for many other types of needs (vehicles, automation, police, customs...).

**HOW DOES IT WORK?**

All objects emit a certain amount of black body radiation in correlation with their temperatures. Generally speaking, the higher an object’s temperature, the more infrared radiation emitted as black-body radiation. A special camera can detect this radiation in a way similar to an ordinary camera does visible light. It works even in total darkness because ambient light level does not matter. However, contrary to popular beliefs, thermal cameras are not able to “see” or detect temperature radiations through a wall.

For use in temperature measurement, the warmest parts of the image are customarily coloured white, intermediate temperatures reds and yellows, and the coolest parts blue. A scale should be shown next to a false colour image to relate colours to temperatures.
HOW TO USE IT?

**FLIR B250**

- Adjust the settings
- Select the pictures
- Take the picture
- Adjust the focus
- InfraRed lens
- Optical lens
- Light

**FLIR E40BX**

- Adjust the settings
- Optical lens
- Light
- InfraRed lens
- Take the picture
2- TAKE THE PICTURE

TYPE OF BUNKER SILOS WE CAN EVALUATE

Measuring silage temperature with thermal imaging allows detection of aerobic instability spots within a bunker. Using a thermal camera is equal to using more than a thousand thermometers on the silo face. Obviously, and as thermal cameras measurement temperature on the surface only, silos have to be opened and with a sufficient front face.

I. Distance from the face

Distance from the object or surface may affect the measurement or the accuracy of the data. Adjusting the camera is essential not deviating temperature from the target. Then the color panel is adjusted to the min and max temperatures on the camera surface, therefore it’s quite important, for pairing or comparing pictures, that the proportion of sky and/or floor on the picture will be approximately the same (the sky being cold, -40°C, will have the dark blue, and the floor is affected by the solar radiation, in warm weather being red, in cold weather being blue).

II. Dig the silo face to get the inner temperature

Using the thermal imaging camera to take the surface temperature and measure silo stability is challenging sometimes. Indeed, ambient temperature and/or wind will affect the surface temperature and deviate from the real silage temperature (reflection of aerobic stability). As fermentations from aerobic spoilage occur in the first centimeters/meters of the bunker, it’s important to dig the silo face right before shooting FLIR picture in order to get the exact fermentation temperature. Then, if we take the temperature on the same spot after digging out the silo, we can clearly see the temperature cooling down (the colour tends to the blue) after few seconds or minutes depending the outside temperature.

III. Global view vs spot view

Thermal pictures can be made from different distances, whether we want to get the full silo face or one specific spot where silage is evolving. Taking one or another doesn’t really change the silo diagnostic, but both must be considered when interpreting the data and linked to the proportion of silage that is really stable and/or heating.
**Figure 1:** Distance from the face

![Diagram showing distance from the face.](image1)

**Figure 2:** Dig the silo face

![Diagram showing digging areas as good and bad.](image2)
IV. Spot temperature vs area temperature

Thermal cameras allow taking a spot temperature (marked by a cross on the screen) or an area temperature (marked by a square on the screen).

Using the spot temperature is handy to show a specific place on the silo face or feedbunk, for example just after digging out the face with a fork and then comparing that spot with the rest of the bunker.

Using the area temperature provides an average temperature on the measured area, plus the min and max. This allows predicting silage losses for instance, having a percentage of the whole silo face evolving after feeds out. To increase the accuracy of this option, it is preferable to use it just after the farmer feeds out a large part of the bunker face.

EXTERNAL FACTORS TO THE SYSTEM

- Different heat reflection from silage or concrete
- Environmental temperature
- Atmospheric absorption – radiation reduction that reaches the lens when crossing the atmosphere
- Observation angle – near 90 degrees, the emissivity can become almost zero, with no readings
- Wind speed – one spot that shows overheating, with a wind speed of 5m/s, has a temperature twice superior
- Rain and Snow – avoid using the thermal camera in these conditions
Figure 3: Taking a spot temperature

Figure 4: Using the area temperature
3- PICTURE INTERPRETATION

**WARNING**

Measuring silage temperature with thermal imaging allows detection of aerobic instability spots within a bunker. Using a thermal camera is equal to using more than a thousand thermometers on the silo face. Obviously, and as thermal cameras measurement temperature on the surface only, silos have to be opened and with a sufficient front face.

The color on the screen of the thermal camera is a guide for picture interpretation, giving a comparison of cold (dark blue) vs warm (dark red to white) spots on the photo. However, these colors do not always reflect the same temperatures and watching the temperature scale on the right side of the screen is essential!

For instance, shooting the same stable and cool silo with or without some sky on the photo will change the silo color. If the sky is on the picture the silo will appear red (sky is cold and always dark blue, hence the silo being warmer than the sky appears red). If the same silo is shot without sky, it will appear blue as the minimal temperature on the screen will be on the silo.

In conclusion, when we are analysing temperatures in a bunker using a thermal camera during the first months after ensiling, measuring higher temperatures in the core of the bunker than in the exterior one may be normal. It is usual to see a decrease of this temperature after the farmer feeds out silage to prepare the TMR. However, if after a while this temperature increases again in the feed bunk, we must consider the aerobic stability issues. (cf Silage Heating Diagnostic).
Examples

Physiological heat produced during normal fermentation - it is common to have until 15°C more temperature in the silage mass than the environmental temperature at the harvest time.

Abnormal heat produced by undesirable fermentation, due to oxygen penetration - it is common to have also an increase of the temperature in the TMR.
EXAMPLE OF USING IR PICTURE IN A FARM REPORT

Feed out comparison

Before feeding out, the silo looks cold so quite stable (blue color). The picture has been taken a few seconds after feed out, hence showing the inner side of the bunker (~20cm inside). It clearly shows the aerobic spoilage of the bunker face, due to secondary fermentation. This activity increases the temperature significantly (up to 32°C). After a few minutes, the silage cools down and become as cold as the left hand side of the bunker which has not been removed for a while.

Digging out the silo face allows for real assessment of the aerobic stability of this silo face. The lower part is very stable; silo is dark blue which means a bit more than 12.2°C. The upper part is generally unstable and digging out the face at one spot shows an intense aerobic activity with more than 42°C.

LALLEMAND ANIMAL NUTRITION
Effect of a cool ambient temperature

The silo face looks stable and cold when only looking at the color (no sky in the shooting). Silo face is generally cold but a lot influenced by the ambient temperature. It’s confirmed by the area fed out (square where the hand is digging the silo) which warm-up to up to 47°C. After few minutes, silage cools down (tends to blue on the IR pics) and follows the ambient temperature.
Effect of a warm ambient temperature

The silo face is generally yellow to red, so might be considered as warm. When digging holes in the bunker, it appears blue and fresh inside. In that case, it clearly shows that this bunker is influenced by the ambient temperature and warming up due to solar radiation on the silo face. However, the left hand side of the bunker (along the wall) is evolving due to higher solar radiation from long time. This can be explained as well by improper feed out method, where silage is left unpacked and exposed to air for a long time and then starts to foil.

Always check the temperature bar

These two pictures are shot at the same bunker, a few seconds one after the other. However, the left hand side bunker, the left hand side bunker looks much warmer than the right hand side. In that particular case, it’s really important to watch the temperature scale, noting that the bunker is still at the same temperature but the surrounding parameters have changed (proportion of the sky on the picture changes the minus temperature -7.4°C vs -12.7°C). Also in this picture, temperature of the telehandler stays the same, not changing the max.
The physiological temperature and the abnormal temperature

One of the end products of silage fermentation is, apart from the most important one, transformation of soluble sugars into acids, the production of heat. During colder time of the year and when the first bunkers of the season are starting to be opened, it is quite normal to get higher temperatures in some spots of the bunker than the environmental temperature (especially from November to February in the northern hemisphere for instance). This is called physiological temperature, and should not be misunderstood with aerobic stability problems.

The edges of the bunkers, along the walls or the plastic, are dangerous areas because they usually have a lower density and a higher porosity, hence having a higher oxygen penetration rate and higher risk for aerobic stability issues (increase of pH, T°C, Yeasts & Moulds, Alcohols).

During the first months of the bunker use, these exterior areas are usually colder than the interior ones. Even appearing strange in terms of fermentation and usual aerobic stability knowledge, the heat dissipation is higher in these areas than the inner side of the bunker due to a closer connection to the outside temperature. Obviously, management impacts this temperature and requires ideal face renewal periods and correct compaction.

The thermal conductivity of the silage mass is quite low, so it is difficult for all the temperature trapped in the bunker from the initial fermentation to escape. Some conditions make it easier or harder:

- Higher DM will take longer to dissipate the heat
- The bigger the bunker the more difficult it will be to dissipate
- The higher the compaction the harder it will be to dissipate
- The lower the temperature gradient between environmental temperature and bunker temperature, the more difficult it will be to dissipate heat.
COMMON ERRORS IN THERMAL IMAGING

- Incorrect focus - an incorrect focus is not professional and influences the temperatures taken. The errors in focusing cannot be solved with the use of the software.

- Occasional reflexes in the surface that we want to measure. How to avoid it? Keep moving and take the pictures from different places to get different angles.

- The spot to measure should exceed the “shooting target”.

THUMB RULES

- First, get a good picture.

- Don’t take pictures with strong wind.

- Don’t forget the scale and the colour scale.

- The spot to measure should cover the entire temperature shooting target. Aim the centre of the area you want to measure.

- Do not focus in angles superior to 45/50 degrees. Avoid 90 degree angles.
### Appendix: Examples of DM and Nutrient Losses Due to Aerobic Stability Issues

#### Temperature Increase

<table>
<thead>
<tr>
<th>Temp. in silage (°C)</th>
<th>OMD %</th>
<th>Recovery of Nel %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool</td>
<td>69</td>
<td>75</td>
</tr>
<tr>
<td>30 - 35</td>
<td>67</td>
<td>73</td>
</tr>
<tr>
<td>50 - 60</td>
<td>61</td>
<td>46</td>
</tr>
<tr>
<td>70 - 75</td>
<td>49</td>
<td>19</td>
</tr>
</tbody>
</table>

Over 35 °C nutritional value starts decreasing

---

#### Losses

<table>
<thead>
<tr>
<th>Temp. increase in silage, above ambient temp (°C)</th>
<th>Daily DM losses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20% DM content</td>
</tr>
<tr>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>10</td>
<td>3.2</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>-</td>
</tr>
</tbody>
</table>

*15th International Silage Conference, 2009*
Lallemand Animal Nutrition is committed to optimizing animal performance and well-being with specific natural microbial product and service solutions. Using sound science, proven results and knowledge from experience, Lallemand Animal Nutrition:

- Develops, manufactures and markets high value yeast and bacteria products including probiotics, silage inoculants and yeast derivatives.
- Offers a higher level of expertise, leadership and industry commitment with long-term and profitable solutions to move our partners Forward.

Lallemand Animal Nutrition Specific for your success