

Natural Grain Conservation by Grain Cooling

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Topics

Respiration of grain

Infestation Insects-mites-fungi

Grain cooling processes

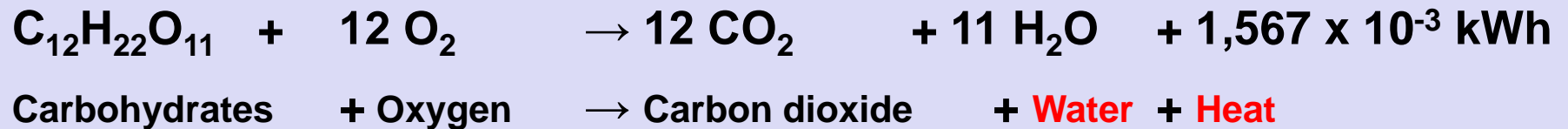
Drying effect

Cost-effectiveness of grain cooling

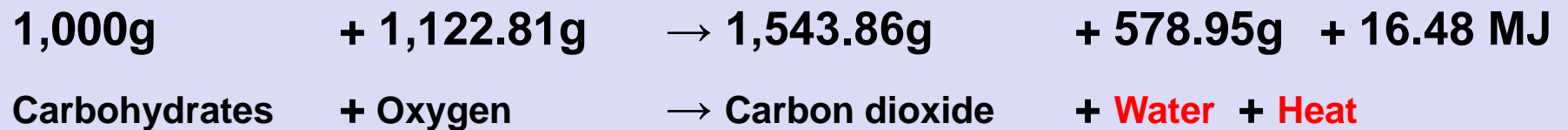
Summary

Grains live, breathe, and creates heat!

Grain respiration - the totals formula for the chemical process:

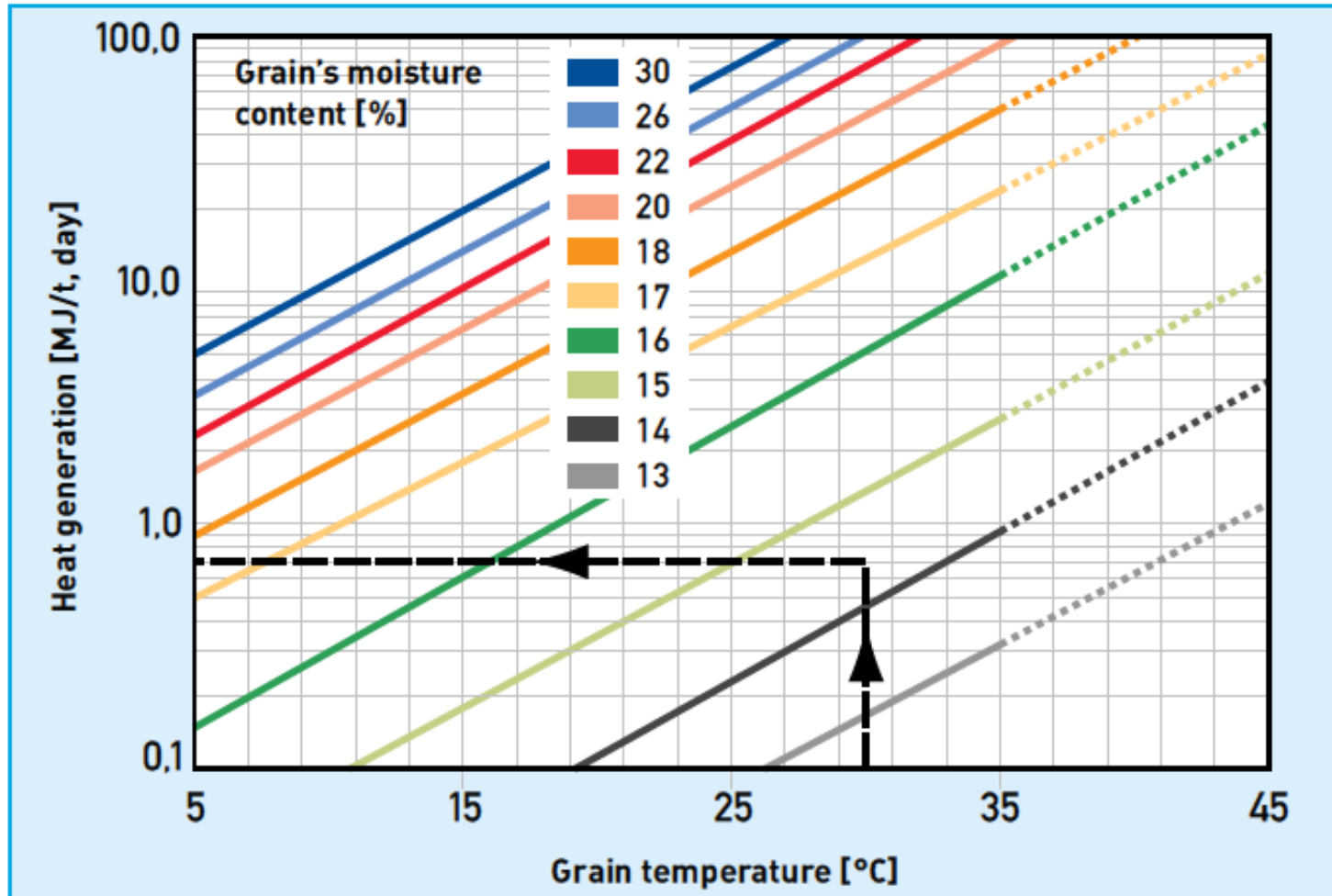


Mass balance for the respiration of 1 kg carbohydrates:



This process depends on the product moisture level and temperature.

Natural Grain Conservation by Grain Cooling



Source: Heat build-up, modification based on Jouin

Natural Grain Conservation by Grain Cooling

Data	
Grain Type	Wheat
Moisture Content of Grain	14.5 [%]
Grain temperature	30 [°C]
Grain price	220 [EUR/t]
Storage period	4 [months]
Storage quantity	10,000 [t]
Formula	
$\text{Grain loss [t]} = \frac{\text{heat generation [MJ/t, day]} \times \text{storage period [day]} \times \text{storage quantity [t]}}{15,000 \text{ [MJ/t]} \times (1 - \text{moisture content of grain})}$	
Result	
	Grain loss [t] Monetary loss [EUR]
grain stored at 30°C	70,2 15,444
grain stored at 25°C	35,1 7.722
grain cooled to 10°C	minimal (< 1) -----

Loss of harvested grain

**180 – 360 million t grain according to the FAO,
(10-20% of world crops)**

--> 10% due to fungi

--> 80% due to insect pests

--> 10% due to rodents and birds

Insect pests



Kornkäfer
Sitophilus granarius
bis 4,7 mm groß

Grain weevil
Sitophilus granarius



Maiskäfer
Sitophilus zeamais
bis 4,5 mm groß

Maize weevil
Sitophilus zeamais



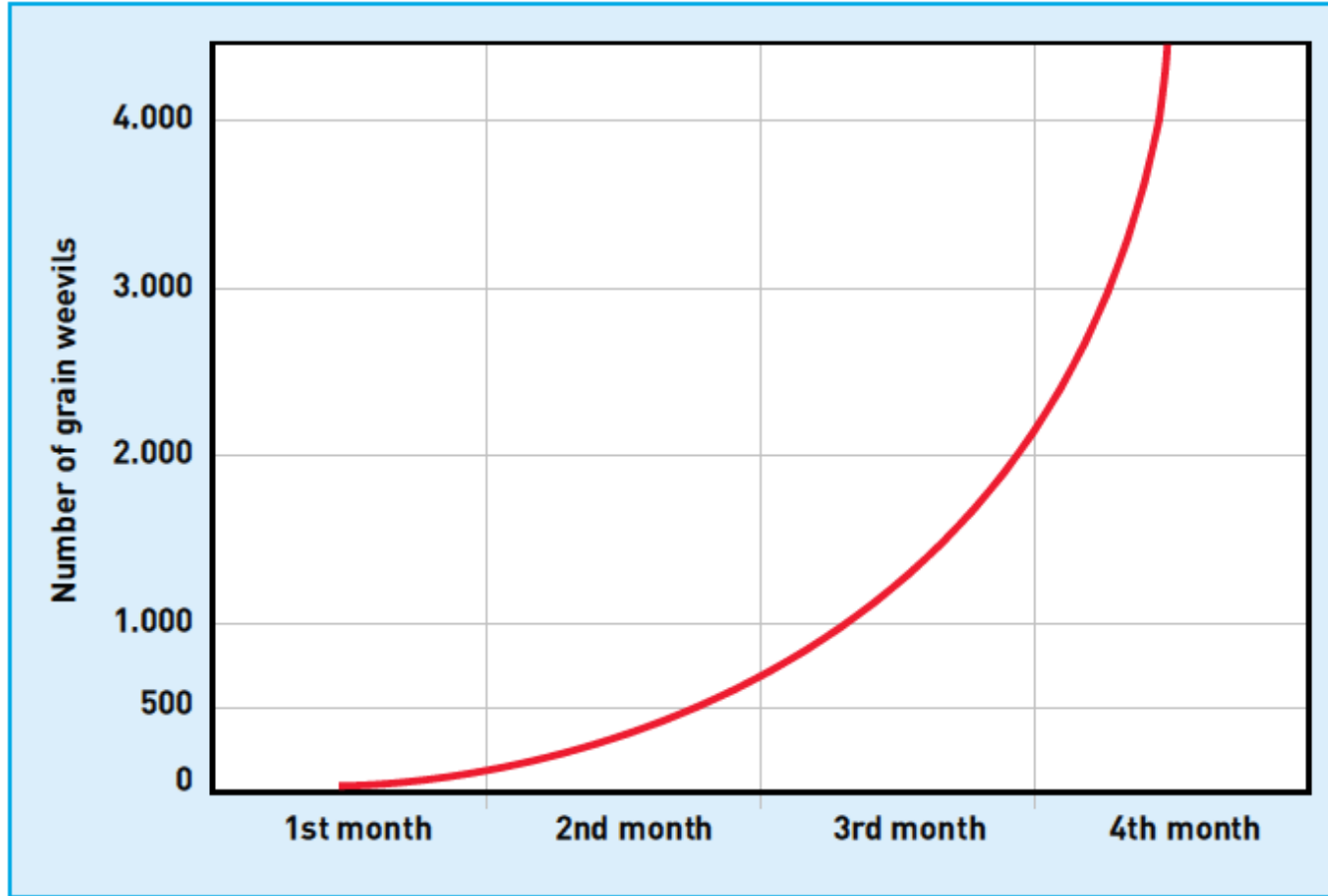
Reiskäfer
Sitophilus oryzae
bis 3,5 mm groß

Rice weevil
Sitophilus oryzae



Red flour beetle
Tribolium castaneum

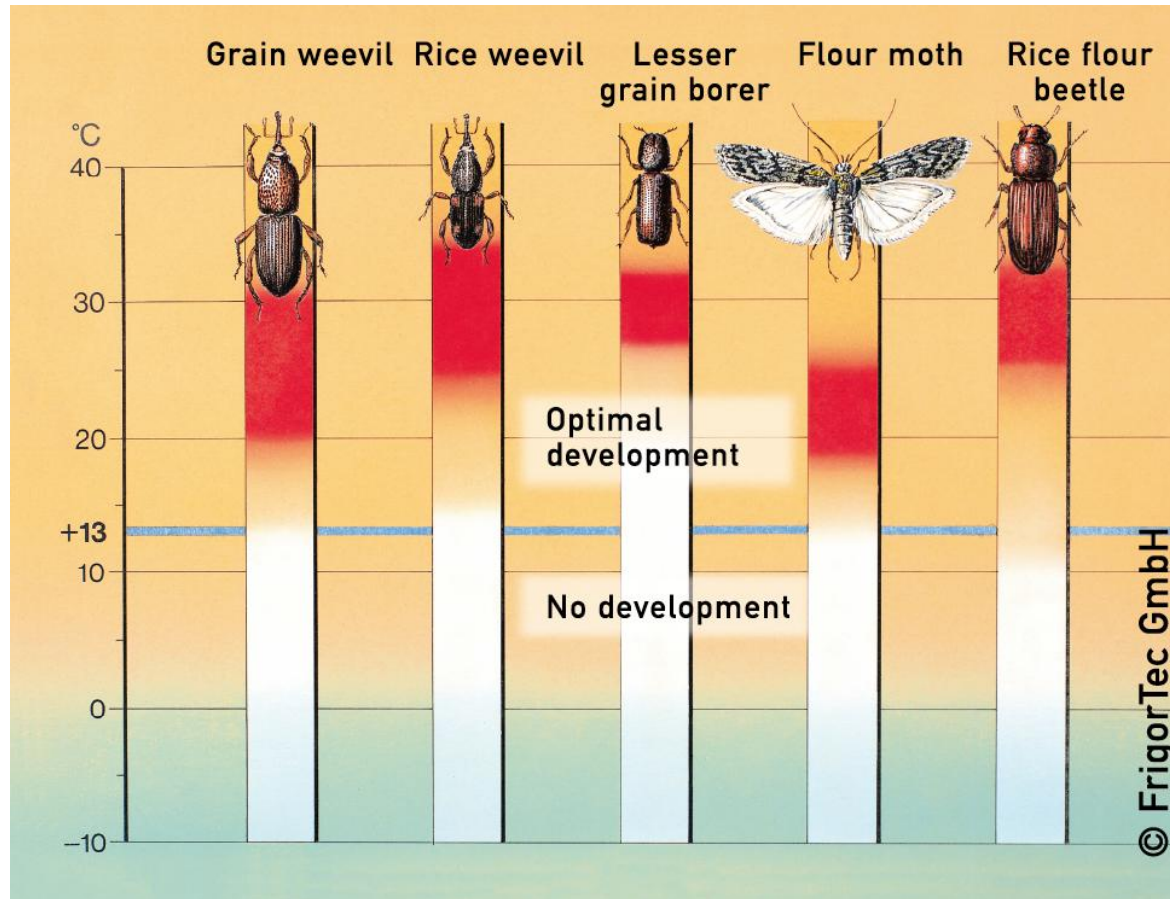
Grain weevil population growth



Insect infestation



Insect pest development



Cooling to prevent any loss in quality or weight caused by insect pests



Storage temperatures:

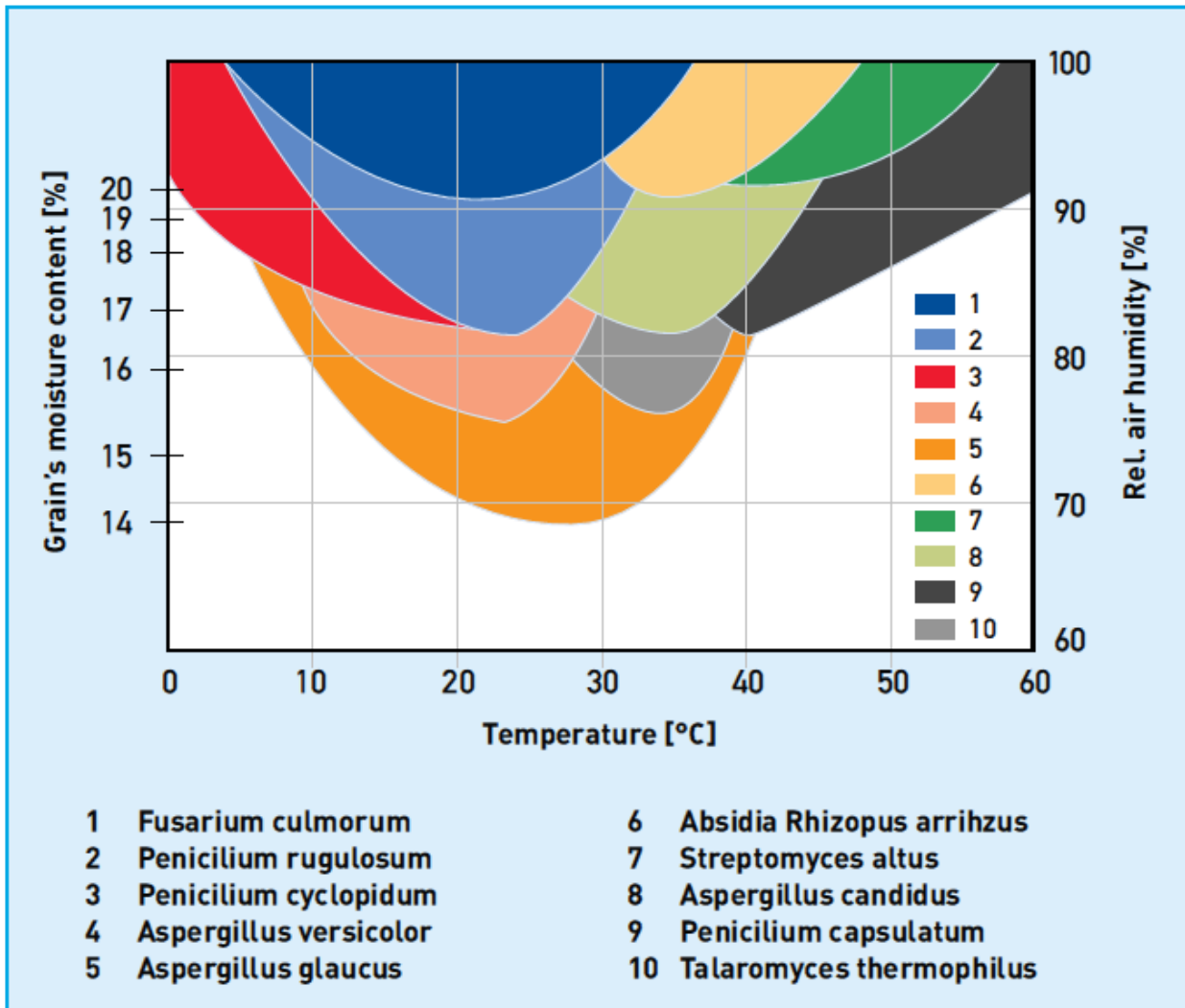
over 21 °C:

Optimal living environment for many insects!

under 13 °C:

The insect activity is suppressed and the insects no longer cause damage.

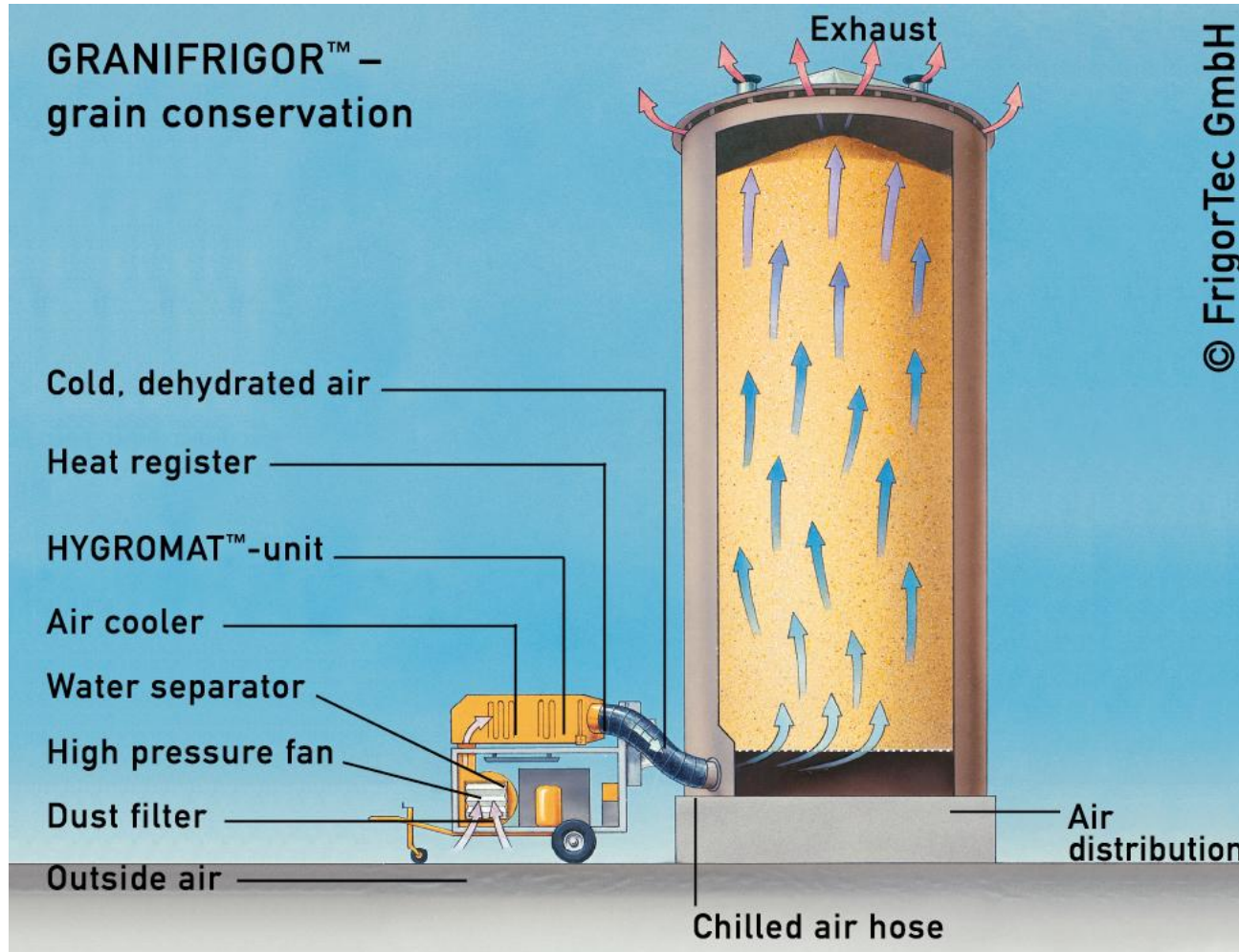
No chemical treatment is required!



Growth of microorganism

Source: Lacey J.

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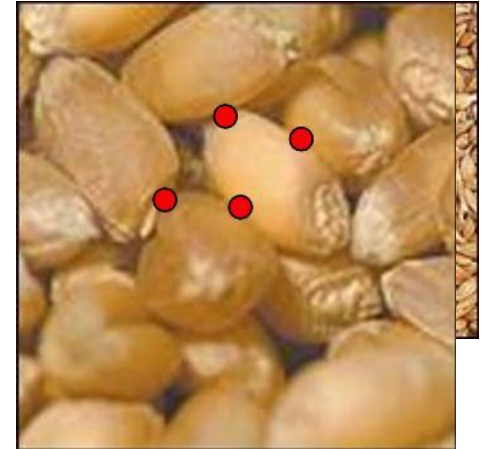
Energy required for cooling

Depends on: Ambient conditions,
product moisture content and temperature,
set points of chilled air temperature

Reference values: 3 - 5 kWh per ton (temperate zone)
8 - 12 kWh per ton (tropical regions)

Gradual re-warming

- **low convection of air between the kernels**
- **low conductivity of the kernel solid substance**
- **low grain moisture content**
- **only point contact of kernels**



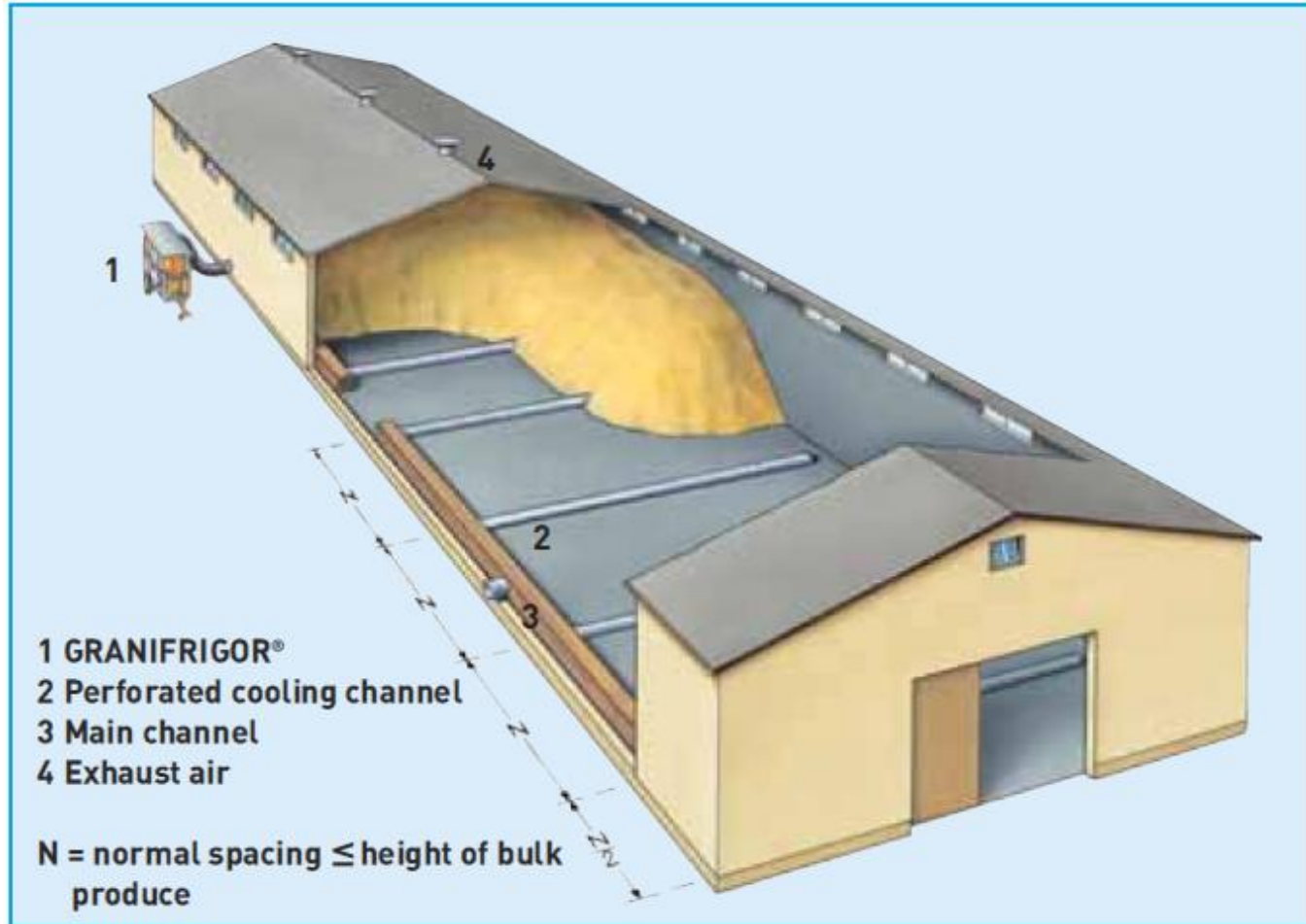
combination drying – cooling

...the cooling process removes moisture from the grain

- the drying capacity is increased
- the drying costs are reduced
- the product is handled gently
 - almost no kernel fissures

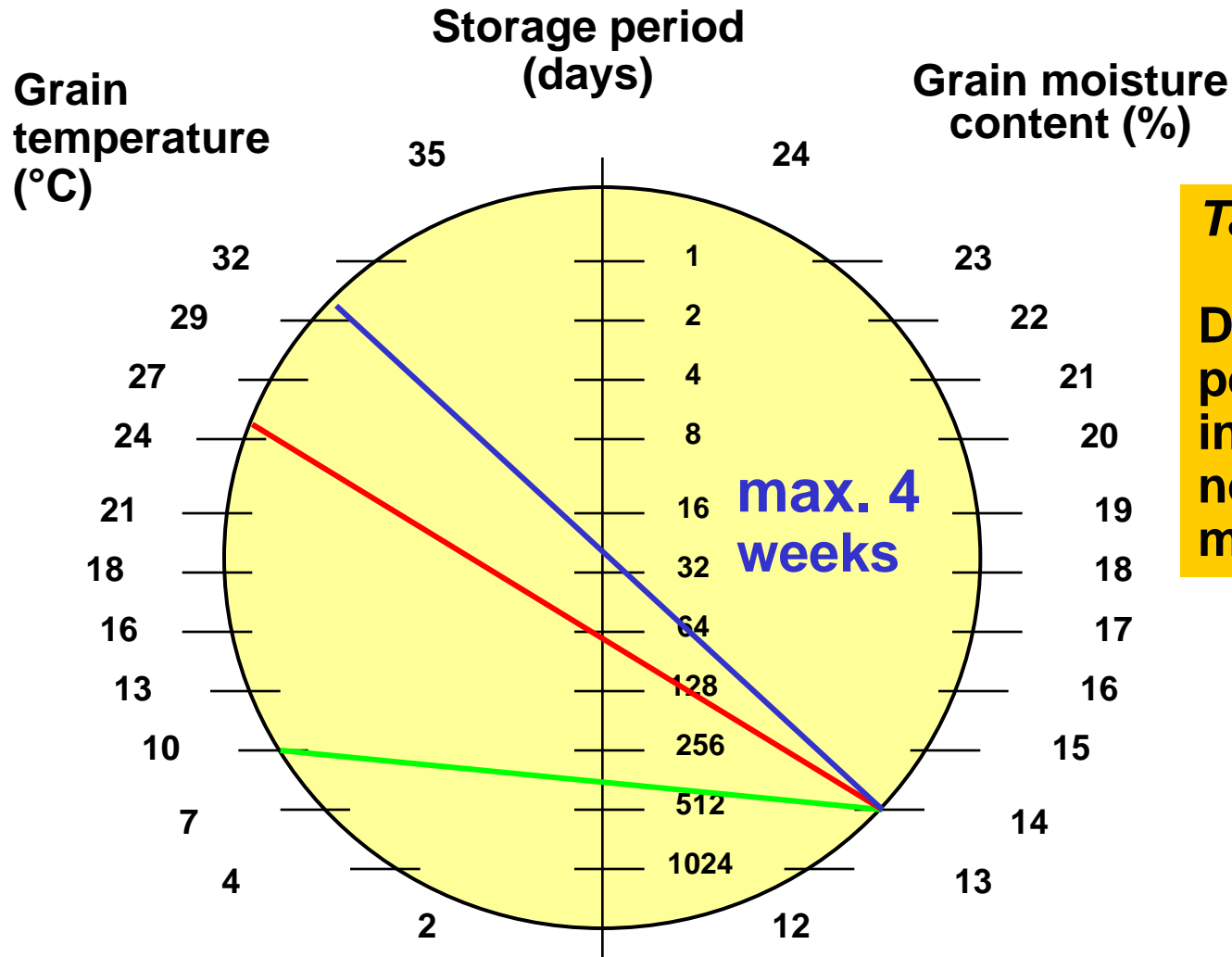
Losses resulting from "turning" grain

- Abrasion losses of approx. 0.03% per cycle
- Time investment of employees
- Empty compartments
- Temperature increase of approx. 1 K (°C)
- Additional energy expenditure (1 to 3 kWh/t)



Cooling a
flat storage
building

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Target values for grain!

During the storage period regular inspections and if necessary protective measures are required.

Cost-effectiveness of grain cooling

- Reduced expenditures for drying
- Almost no respiration losses
- No relocation necessary
- No chemical treatment
- No beetles & mites (suitable for organic products)
- No microorganism (no mycotoxins)
- Less fissuring
- Extended flexibility for best selling price

Advantages of grain cooling

- **Minimised respiration losses**
- **Protection against insects and mites**
- **No chemical treatment required**
- **Protection against microbes and any resulting mycotoxins**
- **No relocation required**
- **Drying effect**

Thank you for your attention!

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Cooling to the **point**