Example 2: Inactivation of *B. subtilis* spores

For the inactivation of *B. subtilis* spores is A = 9.5 x 10^{37} min^{-1} and E = 287.4 kJ/mol. Calculate the holding time for a liquid enriched with spores at 115°C, so that a death ratio of 10^6 will be reached.

Solution:

cal/mol (1 cal = 4.184 J)

cal/(mol.K)

At 115°C

$$k = 9.5 \times 10^{37} \exp(-68690/(1.9872 \cdot 388)) \text{ and}$$

$k = 0.1937$ $\ln(N_0/N) = kt$ and $\ln(10^6) = 0.1937\ t$

therefore $t = 13.82/0.1937 = 71.3$ min

Example 4: Scaling-up sterilisation

For a 10 L laboratory bioreactor a sterilisation criteria of $\nabla = 50$ is sufficient. Which is the minimum sterilisation criteria, if the process is scaled-up to a 1000 L reactor?

Solution:

If N constant:

$$\nabla_{1000L} = \ln(100 \cdot N_0/N), \text{ or}$$
$$\nabla_{1000L} = \ln(N_0/N) + \ln 100, \text{ or}$$
$$\nabla_{1000L} = \nabla_{10L} + 4.6$$

Therefore for the bigger scale a sterilisation criteria of 54.6 is necessary.

General: $\nabla_{\text{bigger reactor}} = \nabla_{\text{smaller reactor}} + \ln(V_{\text{biggerreactor}} / V_{\text{smallerreactor}})$

Example 3: Sterilisation of a bioreactor

In a bioreactor 10000 L of medium was sterilised at 120°C. The time/ temperature profile for this process is summarised in the following table:

Practical comments:

- Sterilisation effect below 100°C can be neglected (only ca. 2% on total lethality)
- Heating and cooling rates are considered constant

With 1°C/min

115	79	0.483
120	91	1.47
120	101	1.47
115	104	0.483
110	107	0.154
100	114	0.0143

Calculate ∇ *ges (=* ∇*heating +* ∇*holding +* ∇*cooling)!*

Use the following table!

Example 3: Sterilisation of a bioreactor

Tabelle 2.3. Werte für k und ∇_{ges} aus Daten, die mit *B. stearothermophilus* gewonnen wurden. $A = 4,93 \cdot 10^{37}$; $E = 282,1$ kJ/mol

Temperatur, °C	k	Kumulativer Wert von ∇
100	0,0143	–
101	0,0182	0,0325
102	0,0232	0,0558
103	0,0296	0,0854
104	0,0376	0,1229
105	0,0477	0,171
106	0,0604	0,231
107	0,0765	0,308
108	0,0967	0,404
109	0,122	0,526
110	0,154	0,681
111	0,194	0,875
112	0,244	1,12
113	0,307	1,43
114	0,385	1,81
115	0,483	2,29
116	0,605	2,90
117	0,757	3,66
118	0,945	4,60
119	1,18	5,78
120	1,47	7,25
121	1,83	9,08
122	2,28	11,36
123	2,83	14,19
124	3,51	17,70
125	4,35	22,05
126	5,39	27,45
127	6,67	34,11
128	8,24	42,36
129	10,18	52,54
130	12,55	65,08

Solution

- Heating: 100°C – 120°C: 37 min
- Holding: 120°C : 10 min
- Cooling: 120°C-100°C: 13 min

From Table: k120 is 1.47

∇ 120 = 7.25

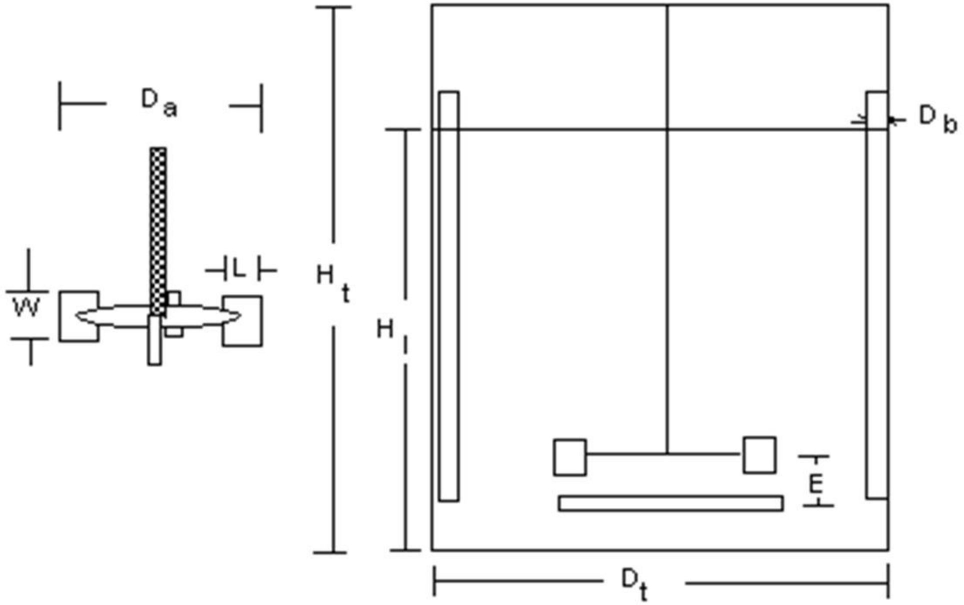
∇heating = 1.85 x 7.25 = 13.41 (because 1.85 = 37/20)

∇hold=k x t = 1.47 x 10 =14.71

∇cooling = 0.65 x 7.25 = 4.71 (0.65 = 13/20)

-→ ∇total = 32.82

Example 1: Calculate the dimensions of the reactor



A stirred tank bioreactor is approximately cylindrical in shape.
It has a total volume (V_t) of 100 000 litres.

The geometry of the reactor is defined by the following ratios

D_t:H_t	0.50
D_a:D_t	0.33
D_b:D_t	0.10

Calculate: D_t, H_t, D_a, D_b

Example 1: Calculate the dimensions of the reactor

Convert the volume to SI units.

The volume of the reactor in SI units is 100 m^3

(This is a very important step - Always use SI units!!!!)

Use the equation describing the volume of a cylinder

$$V_t = \pi \frac{D_t^2}{4} H_t$$

Since $H_t = 2 \times D_t$

$$V_t = \pi \frac{D_t^2}{4} 2D_t \qquad V_t = \pi \frac{D_t^3}{2}$$

Our equation becomes

$$D_t = \left(\frac{2V_t}{\pi} \right)^{\frac{1}{3}}$$

Example 1: Calculate the dimensions of the reactor

Substituting in our value of V_t, we get D_t, H_t, D_a, D_b

$D_t = \quad 4 \text{ m}$

$H_t = 2 \text{ x } D_t = 8 \text{ m}$

$D_a = D_t /3 = 1.33 \text{ m}$

$D_b = D_t /10 = 0.4 \text{ m}$