Dimensioning of underground bunkers for incineration plants

Prof. Werner Bidlingmaier & Dr.-Ing. Christian Springer

1 Bunker volume

$$V_b = \frac{T_S * D_n}{\rho}$$

with:
Ts: necessary storage time
ρ: waste density inside bunker
Dn: nominal throughput

Example:

Ts: 4 d equalling 96 h
ρ: 0.4 Mg/m^3
Dn: 20 Mg/h (2 furnaces à 10 Mg/h)

$$V_b = \frac{T_S * D_n}{\rho} = \frac{96h * 20\,Mg/h}{0.4\,Mg/m^3} = 4{,}800m^3$$

2 Bunker length

Bunker length means the longest side of the bunker. The delivery stations are situated on one side of it, the incineration line(s) on the other one.

Delivery stations: Their number depends on the employed vehicle type. Furthermore, it has to be considered that the nominal throughput, that is incinerated within 7 d x 24 h = 168 h, is delivered to the bunker within about 8 working hours – 2 hours of collection and driving time = 6 h on each working day (five-day working week), so within 30 hours. This ratio can be improved if the waste from more distant locations is disposed of through waste transfer stations and the large-capacity vehicles arrive at times when no collection vehicles are delivering. Commercial deliverers are not taken into consideration.

$$\frac{168h/W * 20\,Mg/h}{5work\ days/W} = 672\,Mg/d$$

Assumption:

- double-axle collection vehicles with a load capacity of 5 Mg
- 3 collection circuits/ vehicle and day
- unloading time of 10 min

Calculation of deliveries:

$$\frac{672\,Mg/d}{5\,Mg/Fz} = 135\,deliveries/d$$

Capacity of delivery station: 6 h/d x 60 min/10 min = 36 deliveries/delivery station number of delivery stations: 135 / 36 = 4

bunker length: 4 x 4 m = 16 m

length of delivery stations: 4 m

3 Calculation of furnace lines

space between furnace lines: 13 m
furnace width: 6 m

minimal building width (= bunker length): 13 m + 2 x 6 m = 25 m

4 Calculation of grab

determination of cycle criterion with 60 % filling in (36 min)
40 % relocating (24 min)

cycle time: 2.04 min

$$cycletime = \frac{36min}{2.04min} = 17.7$$

$$\frac{20\,Mg/h}{17.7cycles} = 1.13\,Mg/cycle$$

$$\frac{1.13\,Mg/cycle}{0.5\,Mg/m^3} = 2.26m^3(grabholdingcapacity)$$

selected grab holding capacity 3 m^3

control calculation: peak capacity (110 % = 22 Mg/h)

filling in: $\frac{22Mg/h}{1.5Mg} equals 14.7cycles \rightarrow 14.7 * 2.04min = 29.9min$

relocating: $\frac{22Mg/h}{1.5Mg} equals 14.7cycles \rightarrow 14.7 * 1.08min = 15.9min$

total time at peak capacity = 45.8 min < 50 min
bunker width: twice the grab width d = 4 m: b_B = 8 m
bunker depth: expanding building, h_b = 20 m: bunker length 30 m

$$h_b = \frac{Vb}{l * b} = \frac{4800}{25 * 8} = 24m$$

5 Slag discharge

Assumption:

ash content	27 %
unburned residues	1 %
humidification	4 %
	32 %

storage time: 4 d = 96 h

bulk density: 1.2 Mg/m^3

20 Mg/h * 96 h * 32 % = 614 Mg (produced slag)

The removal is done in large containers (19 Mg).

$$\frac{614 Mg}{19\, Mg/Cont.} = 32 Containers$$

Plant I

Example: 4-rope multi-jaw waste grab

The "MOHR-Mehrschalen-Müll-Greifer" is a multi-jaw grab that is designed especially for relocating waste. Depending on waste type it can be delivered as the closed, semi-closed or open type with sis jaws. The closing stroke uses a 5-strand rope in all sizes generating a good clamping force. The jaws are box-shaped.

Characteristics:

Optimal filling degree due to high clamping force	Low rope deterioration due to rope-guiding rollers
High jaw rigidity due to box shape	Self-regulating levers at lower roller block for compensating changes in strain
Tips of jaws low in deterioration due to manganese steel enforcement	Hinge points and rope pulleys can be relubricated
Simple mounting and demounting of roller blocks and jaws	Hardened hinge bolts and sleeves

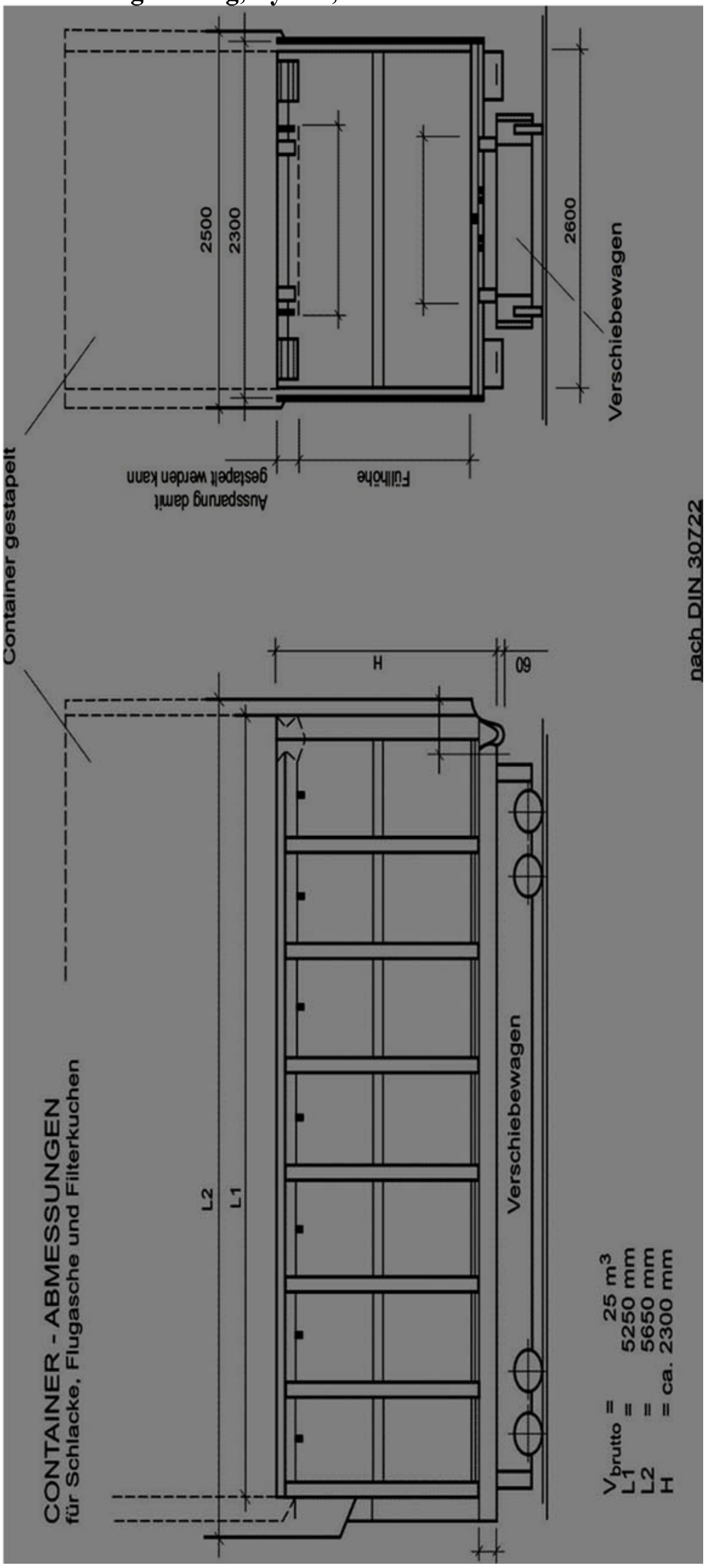
Grab capacity m^3	Weight kg	Dimensions mm				Rope in mm	Closing rope interval mm	Holding rope interval mm	Holding rope bolt mm	Closing stroke 5-strand mm	Max. rope length with open jaws in mm	Required ultimate crane load t*)
		A	B	C	D		a	b	c			
1.0	1800	2875	2150	2500	2850	12	330	100	20	6650	11850	2.5
1.5	2200	3000	2300	2600	3100	12	330	100	20	7250	12450	3.2
2	2450	3150	2500	2700	3600	14	370	120	25	6900	12550	4
2.5	2700	3300	2650	2900	3800	14	370	120	25	7800	13450	4
3	3200	3650	2850	3100	4000	17	420	120	30	8750	14850	5
4	4000	3850	3050	3350	4300	17	420	120	30	9250	15600	6.3
5	4800	4450	3550	3800	4600	22	530	150	35	9375	17150	8
6	5200	4650	3650	4000	4850	22	530	150	35	10250	18050	10
7	6200	4700	3800	3950	4900	24	530	180	50	10850	18700	10

*) assumed max. bulk density of waste in grab 0.6 t/m^3. Changes in construction excepted.

Prof. Werner Bidlingmaier & Dr.-Ing. Christian Springer

Plant II

Example: container dimensioning for slag, fly ash, and filter cake



Plant III

dimensioning guidelines for waste crane systems

1 dimensioning data

number of units	2, one of these 100 % reserve
waste amount	according to facility data Mg/h
operating point	max. peak performance Mg/h
waste density	in the bunker 0.4 - 0.5 Mg/m^3
	in the grab 0.5 - 0.6 Mg/m^3

2 Crane performance

100 % in 60 min for 1 crane system

for feeding the furnace lines	feeding 36 min	
for relocating and piling up	83 % correspondingly 50 min	relocating 14 min
for reserve and additional time	17 % correspondingly 10 min	

3 Crane speeds

	guiding value	mean value corresponds to
lifting and lowering	40 - 60 - 80 m/min	1 m/s
opening and closing	40 - 60 - 80 m/min	1 m/s
long travel	40 - 60 - 80 m/min	1 m/s
cross travel	30 - 40 - 50 m/min	0.66 m/s

The following time values are added in the calculation of cycle time for accelerations and deceleration:

long travel	+ 3 sec
lifting and lowering	each + 2 sec
opening and closing	each + 2 sec
cross travel	+ 2 sec

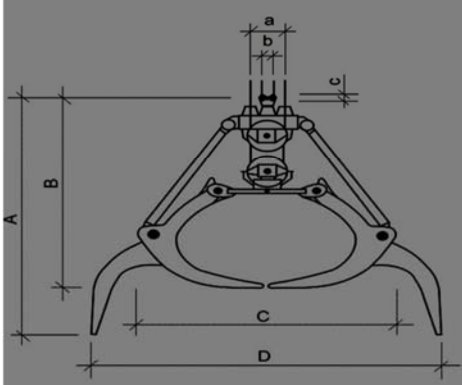
4 Weighing

automated weighing including attenuation of pendular motion 5 sec

5 Bulking

Duration of bulking of the compressed waste 40 sec
without bulking app. 60% of all processes
with bulking app. 40% of all processes

Example: dimensioning of orange peel bucket



Greiferinhalt m^3	Gewicht kg	Baumaße mm A	Baumaße mm B	Baumaße mm C	Baumaße mm D	Seil ø mm	Schließseilabstand mm a	Halteseilabstand mm b	Halteseilbolzen ø mm c	Schließhub 5-fach mm	max. Seillänge i. off. Gr. mm	erforderl. Krantraglast Mg*)
1,0	1800	2875	2150	2500	2850	12	330	100	20	6650	11850	2,5
1,5	2200	3000	2300	2600	3100	12	330	100	20	7250	12450	3,2
2	2450	3150	2500	2700	3600	14	370	120	25	6900	12450	4
2,5	2700	3300	2650	2900	3800	14	370	120	25	7800	13450	4
3	3200	3650	2850	3100	4000	17	420	120	30	8750	14850	5
4	4000	3850	3050	3350	4300	17	420	120	30	9250	15600	6,3
5	4800	4450	3550	3800	4600	22	530	150	35	9375	17150	8
6	5200	4650	3650	4000	4850	22	530	150	35	10250	18050	10
7	6200	4700	3800	3950	4900	24	530	180	50	10850	18700	10

*) Angenommenes max. Schüttgewicht des Mülls im Greifer 0,6 Mg/m^3