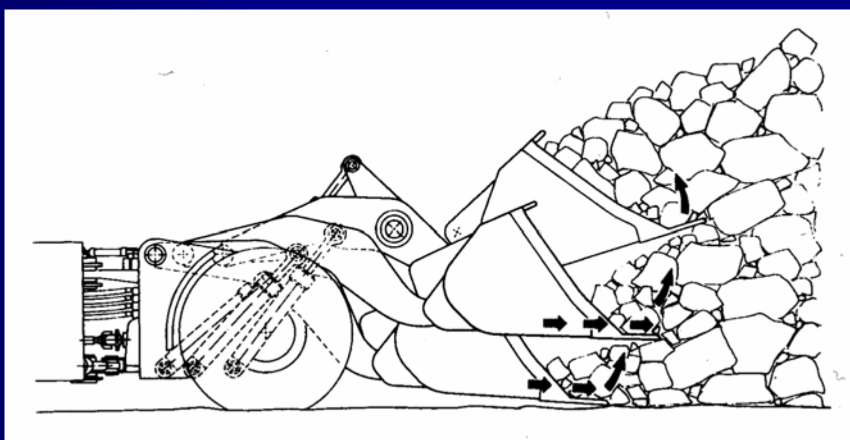
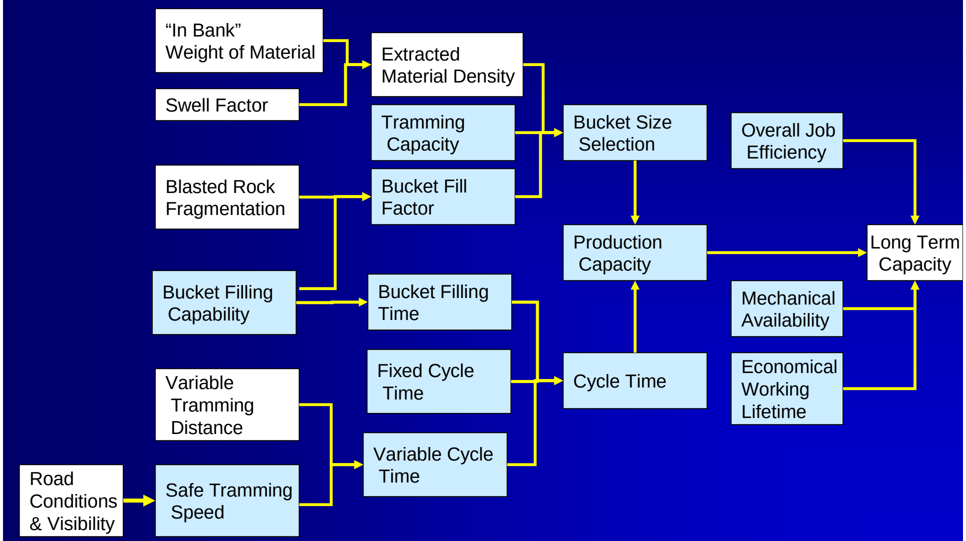
Load Haul Dump

Single-pass loading action

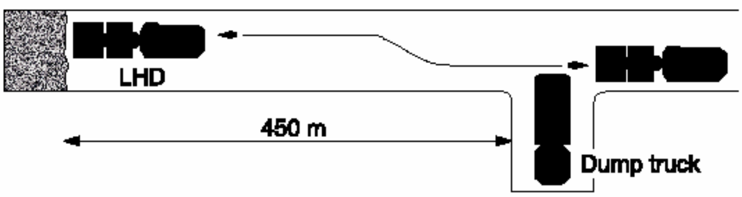


Engineering Tasks in Loading



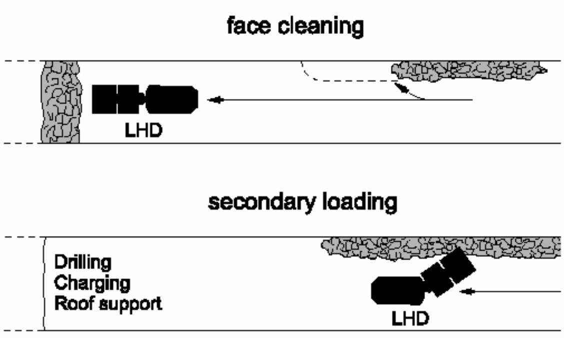
Loading systems I

Loading in narrow tunnel loading/turning niche.



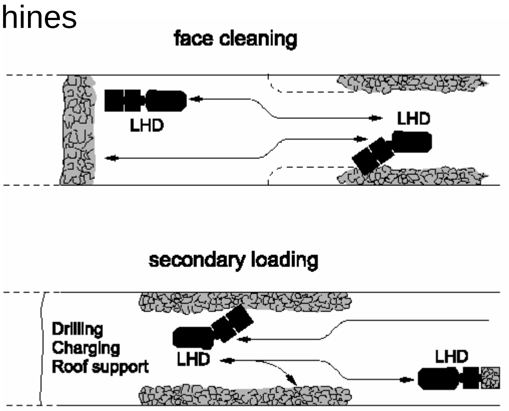
Loading systems II

Loading in large tunnel without loading niches with one LHD - machine

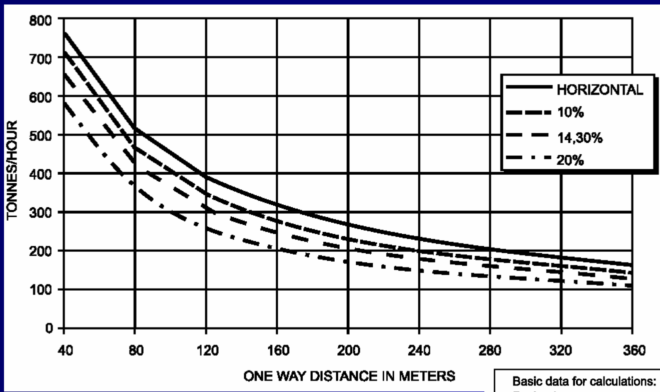


Loading systems III

Loading in large tunnel with two LHD - machines



Productivity of LHDs



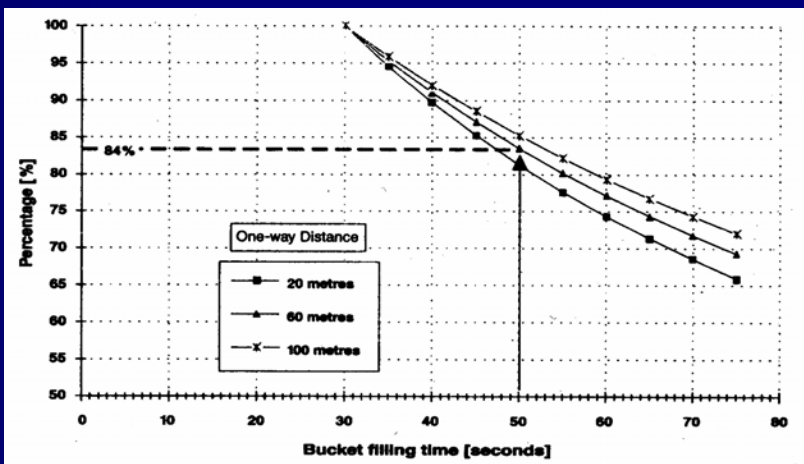
Basic data for calculations:

Payload 12 500 kg
Overall speed limit 10 km/h
Fixed cycle time 0.5 min

Fixed cycle time includes the time for filling, dumping, turning and accelerating.

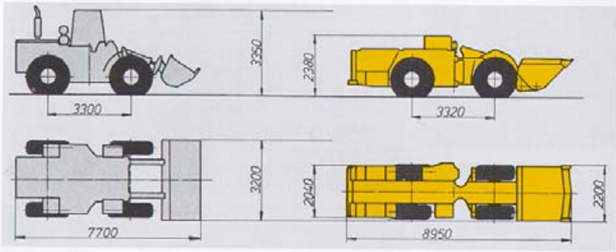
Slope / Grade	(%)	Horizontal/0	1:10 / 10	1:7 / 14.3	1:5 / 20
Loaded Speed	(km/h)	10	7,5	5,9	4,2
Empty speed	(km/h)	10	10	10	10

Bucket filling time/loading capacity



Model:	T150D	Max speed:	20 km/h	Mechanical availibility:	90 %
Payload:	14 000 kg	Rolling resistance:	3 %	Working efficiency:	80 %
Fixed cycle time:	0.5 min	Roadway grade:	0 %		

Technical Data LHD



Big choice...

Main data of GHH-Fahrlader with diesel drive

Type		LF-4.1	LF-6.3	LF-9.3	LF-12.3
Payload	mt	4.0	6.0	9.5	14.0
Bucket	m³	2.0–2.5	3.0–3.5	4.0–4.5	6.0–7.0
Engine rating	kW	63	102	170	204
Max. speed	km/h	19.3	26.1	30.5	30.8
Breakout force	kN	90	115	190	195
Operating weight	mt	12.1	16.9	21.7	34.4
Outer turning radius	mm	5,030	5,850	6,700	7,220
Length	mm	6,920	8,500	9,450	10,455
Width	mm	1,690	1,970	2,700	2,700
Max. height	mm	1,900	2,000	2,450	2,400
Tilting heigth	mm	1,760	1,500	1,890	1,955

Capital Cost LHD

Load-Haul-Dump and Coal Scoop Tractors (See further information in Appendix)

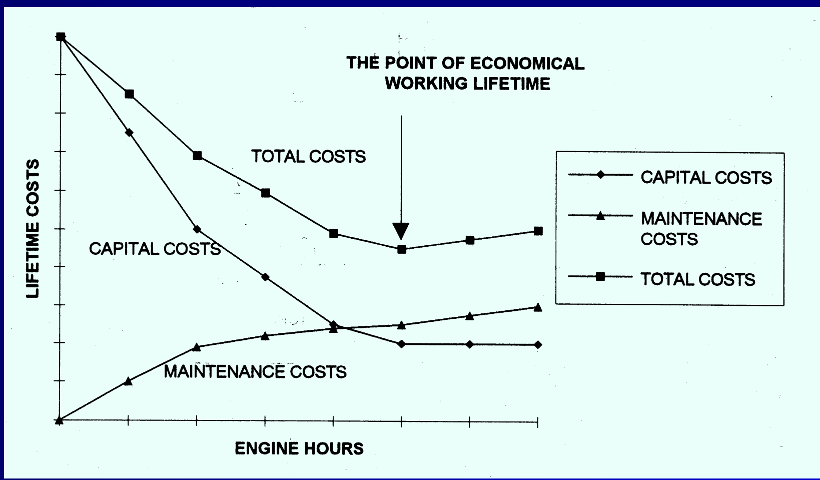
DESCRIPTION	SPECIFICATIONS Overall Width (in.)	Operator Height (in.)	WEIGHT (lbs)	MOTOR TYPE/INCL.		HP	CAPITAL COST
0.5 cu yd, Diesel-hardrock mine L-H-D	34	72		d	y	42	$101,500
1.0 cu yd, Diesel-hardrock mine L-H-D	48	72		d	y	55	130,800
1.5 cu yd, Diesel-hardrock mine L-H-D	50	73		d	y	55	154,100
2.0 cu yd, Diesel-hardrock mine L-H-D	58	76		d	y	82	163,100
2.5 cu yd, Diesel-hardrock mine L-H-D	61	78		d	y	81	172,900
4.0 cu yd, Diesel-hardrock mine L-H-D	78	68		d	y	139	243,300
6.0 cu yd, Diesel-hardrock mine L-H-D	103	78		d	y	185	271,700
7.0 cu yd, Diesel-hardrock mine L-H-D				d	y	231	308,300
8.5 cu yd, Diesel-hardrock mine L-H-D	98	102		d	y	277	539,900
13.0 cu yd, Diesel-hardrock mine L-H-D	120	100		d	y	375	811,300

Hoisting

Overhead 9.11

20/02/2006

Economical working lifetime of a loading machine

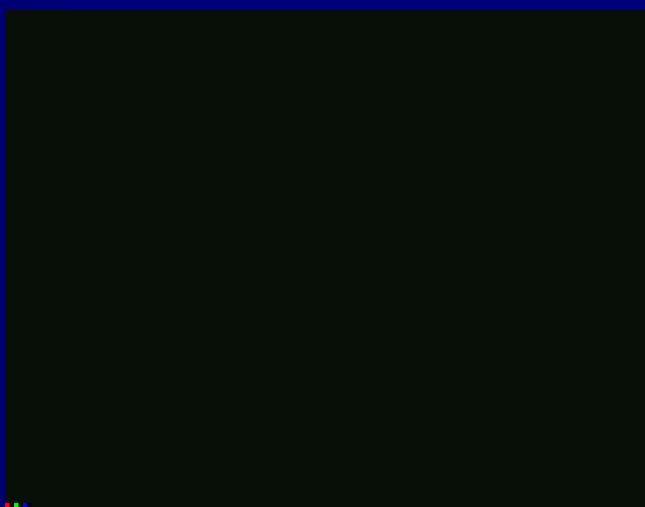


Hoisting

Overhead 9.12

20/02/2006

Loading Video



Hauling

Dump Truck

Capital Cost Truck

Trucks, Underground Ore and Coal Haulers (See further information in Appendix)

SPECIFICATIONS

DESCRIPTION	WEIGHT (lbs)	MOTOR TYPE/INCL.		HP	CAPITAL COST
Rear-dump, articulated, 5 ton capacity		d	y	82	$85,800
Rear-dump, articulated, 6 ton capacity		d	y	116	126,100
Rear-dump, articulated, 10 ton capacity		d	y	139	133,600
Rear-dump, articulated, 11 ton capacity		d	y	112	159,600
Rear-dump, articulated, 13 ton capacity		d	y	112	189,400
Rear-dump, articulated, 16 ton capacity		d	y	185	211,900
Rear-dump, articulated, 26 ton capacity		d	y	271	348,100
Rear-dump, articulated, 33 ton capacity		d	y	271	400,800
Rear-dump, articulated, 39 ton capacity		d	y	375	436,100
Rear-dump, articulated, 44 ton capacity		d	y	475	511,600

Cycle of LHD and Truck

LHD	Truck
Capacity: 8 t	Capacity: 24 t (rule of thumb use truck with 3-4 times of LHD bucket size)
t_{Load}: 0.5 min	t_{Load}: n *4 min (number of buckets in one truck)
t_{Haul}: 2 min	t_{Haul}: 8 min
t_{Damp}: 0.25 min	t_{Damp}: 1 min
t_{Driv}: 1.25 min	t_{Driv}: 6 min

Questions:

Calculate the hourly capacity of one LHD and one truck.

How many trucks are required to run the LHD at full capacity? Destinguish the resulting utilisation of the trucks.

Truck capacity Selection

Capacity LHD

$$\dot{Q}_{LHD} = \frac{payload}{t_{cycleLHD}} = 120\frac{t}{h}$$

Capacity Truck

$$\dot{Q}_{onetruck} = \frac{payload}{t_{cycletruck}} = 53{,}3\frac{t}{h}$$

Number of trucks:

$$\frac{\dot{Q}_{LHD}}{\dot{Q}_{onetruck}} = 2{,}25$$

→ Selection would be 3 trucks

Utilisation of the trucks:

$$\frac{\dot{Q}_{LHD}}{number_{trucks} \cdot \dot{Q}_{onetruck}} = 75\%$$

Homework: Try to find the optimum utilisation of trucks and LHD by varying truck
payload and the number of trucks!

Hauling in large Ore Mines

Hoisting

Overhead 9.19

20/02/2006

Basics of belt conveyors

Principle: The material is transported from a feeder to a delivery place by using an endless connected belt guided around two pulleys.

Drive unit: The propelling force is transtitted by friction from the driving pulley to the belt. The propelling force is equal to the sum of the resistances.

Hoisting

Overhead 9.20

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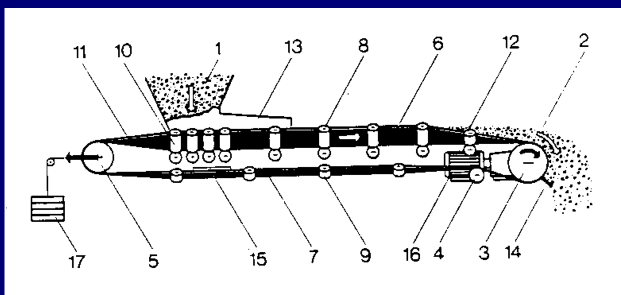
Set-up of Belt Conveyor



1. Material feeder
2. Discharge point
3. Driving pully and discharge pully
4. Snubbing pully
5. Return pully
6. Overstrand (burden strand)
7. Understrand (empty strand)
8. Overstrand - supporting idlers
9. Understrand - supporting idlers
10. Feeder idlers
11. Down toughing idlers
12. Up toughing idlers
13. Feeding chute
14. Cross scraper
15. Plough scraper
16. Drive unit
17. Tension (station/weight)

Hoisting

Overhead 9.21

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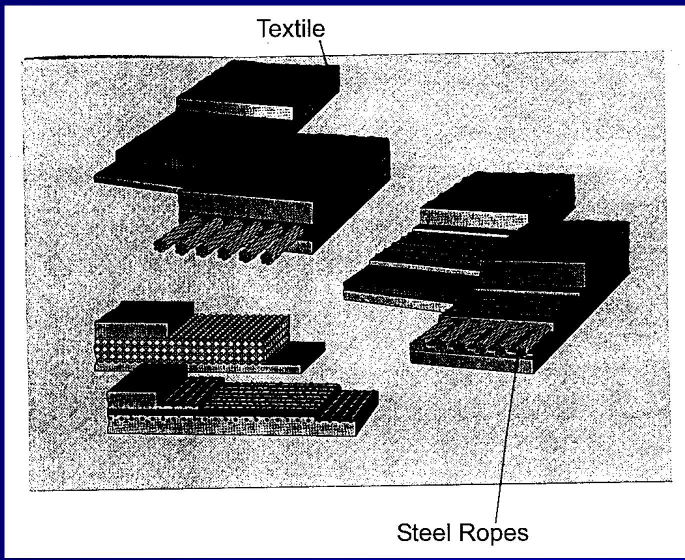
Inner Struture of Conveyor Belts



Hoisting

Overhead 9.22

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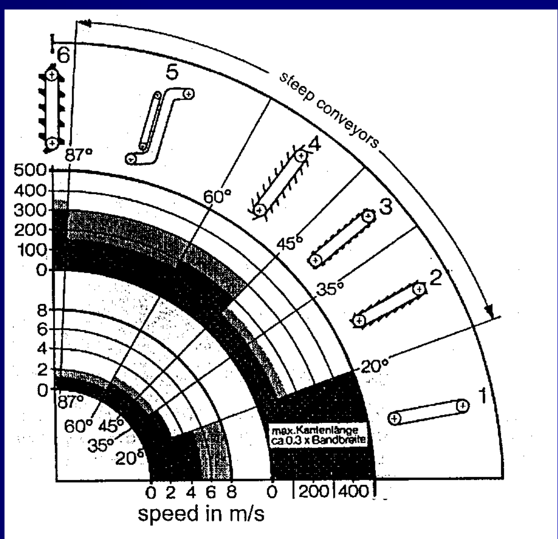
Conveyor Systems in Different Geometrical Situations



1. Regular Belts
2. Belts with some surface structure
3. Belts with strong surface structure
4. Belts with boxes
5. Belts with additional cover belt
6. Elevator Belts

Advantages/Disadvantages of continuous conveyors compared to other techniques of transportation (i. e. train, lorry)

Advantages:

+ Favourable energy consumption compared to rate of utilisation
+ Always ready (no downtime because of no transportation units - continuous system!)
+ Transportation of huge tonnage (especially conveyor belts)
+ Favourable costs of upkeep (i. e. repairs and maintenance)

Disadvantages:

- Little flexibility at runtime (i. e. fluctuation of the tonnage)
- High costs during times of low utilisation
- Relatively immovable
- Mostly straight conveyance
- Bunkers

Advantages/Disadvantages of Conveyor Belts

Advantages:

+ Transmission by rolling friction (less abrasion)
+ Far distances bridgeable (up to several kilometres)
+ Less noise during operation (important for the emission laws)
+ High transportation capacities possible
+ Continuous Operation

Disadvantages:

- Less stable than chain conveyors less stability (since they are not used in the excavation area)
- Relatively sensible by aggressive (corrosive) substances (i. e. transportation of acid power plant slag)

Haulage Capacity

The haulage capacity depends on the following factors:

- Kind of the material to be conveyed
- Bulk weight of the material
- Angle of repose/discharge
- Slope of the conveyor
- Width of the belt
- Transverse stability of the belt
- Belt speed

Simplified:

- Properties of the material
- Filling profile (cross section)
- Belt speed

Calculation of the theoretical haulage capacity

$$\dot{Q}(th) = A(fill) * v * \rho$$

P(th) = theoretical haulage capacity
A(fill) = theoretical filling cross section
V = speed of the conveyor belt

In this case are not regarded:

- fluctuations of the haulage capacity
- down times because of maintanance
- fluctuations of the transported material quality

Hoisting

Overhead 9.27

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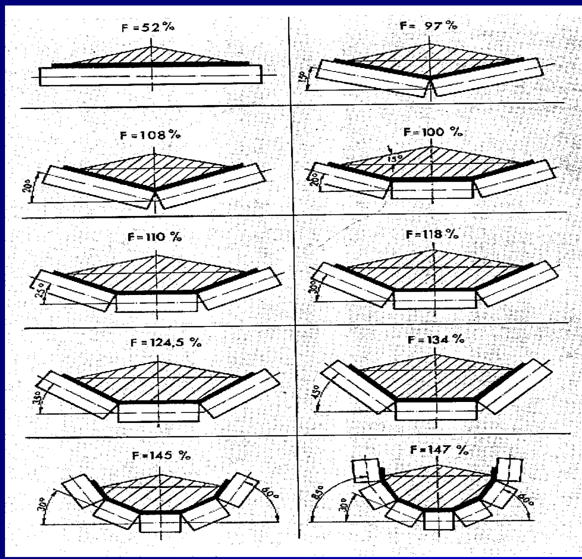
Positioning of Idlers



Hoisting

Overhead 9.28

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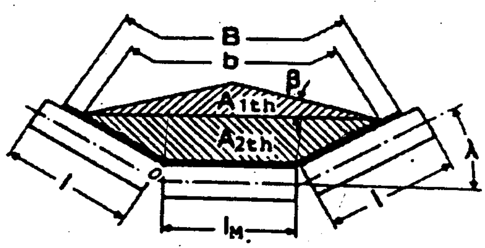
Theoretical filling cross section



$$A_{th} = A_{1,th} + A_{2,th}$$

$$A_{1,th} = [I_M + (b - L_M) * \cos\lambda] * (\tan\beta / 4)$$

$$A_{2,th} = [I_M + [(b - L_M)/2] * \cos\lambda] * [(b - L_M)/2 * \sin\lambda]$$

Hoisting

Overhead 9.29

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Properties of the transported material

Treansport material	Bulk density [t/m³]	Slope Angle (deg)	Maximal dipping [deg]
Waste	1,6 – 1,7	13	15
Slag, Ash (dry)	0,65 – 0,75	13	14
Slag Ash (wet)	0,9	13	16
Lignite (dry)	0,5 – 0,9	13	13 - 15
Lignite (wet)	0,9	13 - 18	16 - 18
Gypsium	1,35	13	16
Sand and gravel (wet)	2,0 – 2,4	13	18
Rocksalt, halite, mineral salt	1,2	13	16
Sand (wet)	1,4 – 1,9	13	18 - 22
Sand (dry)	1,3 – 1,4	13	14 - 18

Hoisting

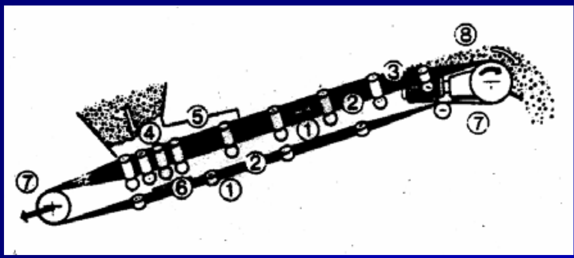
Overhead 9.30

20/02/2006

Conveyor belt speeds

Transported Material	Conveyor belt speed [m/s]	Practical using
Dusty coal, filter slag, housewaste	1,6	Power plant, waste burning plants
Coke, salt (not grinded), cement, chalk	1,7	Cement factories, coking plants, steel plants
Sand, gravel	1,3 – 2,1	Industrial mineral processing plants
Limestone	1,4 – 2,5	Industrial mineral processing plants
Grain, grinded coal, clay	1,3 – 3,8	Storage bins, silos, bearing places
Ore, coal	1,6 – 4,2	Underground mines
Bauxit, unwashed dump salt, phosphate	2,2 – 4,9	Power plants, chemical industry
Unwashed dump lignite, open pit overburden waste	2,7 – 6,5	Open pit mines

Rolling frictions



1. Walking resistance of the idlers
2. Walking resistance of the belt
3. Walking resistance of the transported material
4. Resistance of the feeder
5. Resistance of the chute
6. Resistance of the scraper
7. Rotation resistance of the belt
8. Angle of slope

Propelling force

The propelling force is equal to the circumferential force, which is the sum of the resistance to the motion:

$$F=F(h) + F(n) + F(sl) + F(s)$$

F = Force required
F(h) = Main forces (Resistances 1-3)
F(n) = Minor forces (Resistances 4-7)
F(sl) = Slope
F (s) = Special resistances (i. e. friction at the Plough scrapers)

Hoisting

Overhead 9.33

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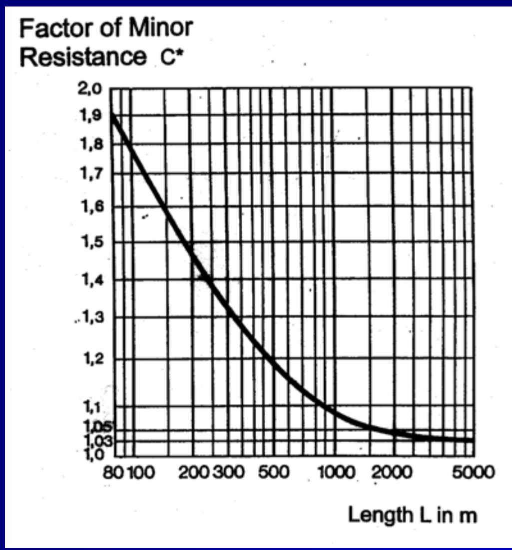
Factors



Hoisting

Overhead 9.34

20/02/2006

General Calculation Formula for the Resistance of Belt Conveyors

$$F_{o,u} = C * f * l * g[(m'_L + m'_B)\cos\alpha + m_{IO,U}] \pm l * g * (m'_L + m'_B) * \sin\alpha$$

FO = Tensile force required in the overstrand

C = Value for sum of the minor resistances

f = Value for the working conditions

g = gravity

m'_L = Mass of load [kg/m]

m'_B = Mass of the belt [kg/m]

m'_{IO} = Mass of the idlers in the overstand [kg/m]

Index U = understrand ; O = overstrand

Hoisting

Overhead 9.35

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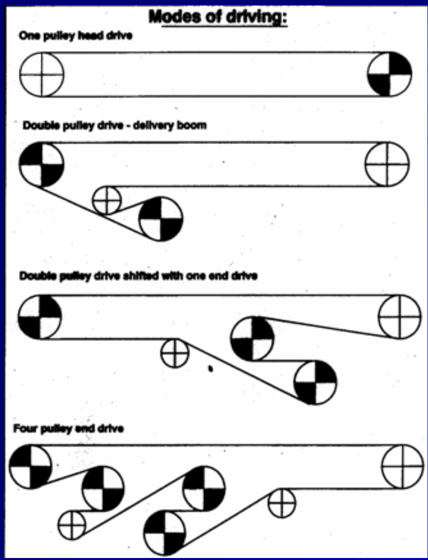
Modes of driving:



$$\frac{F_O}{F_U} \leq e^{\mu \hat{\alpha}}$$

Hoisting

Overhead 9.36

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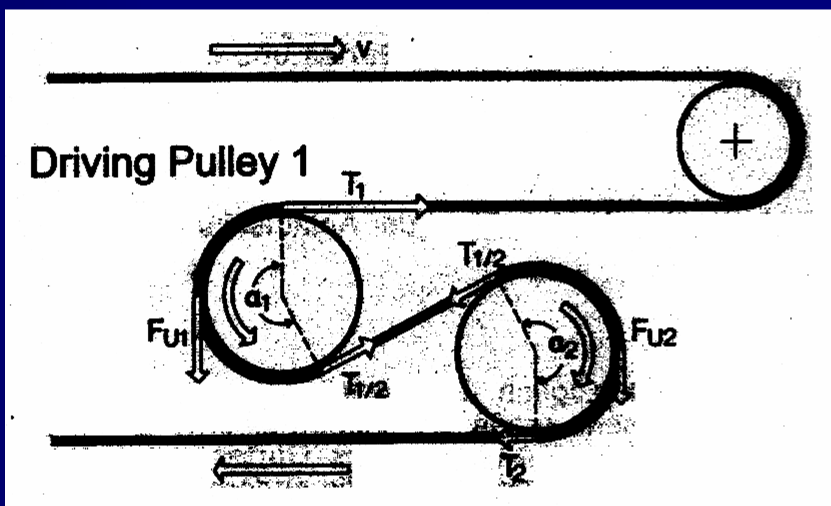
Forces at a Two-Pully-Drive



Hoisting

Overhead 9.37

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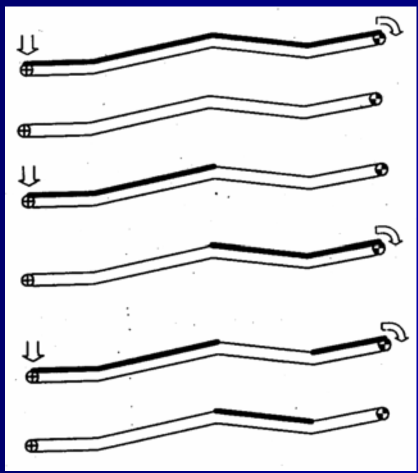
Filling Situation of a Belt Conveyor



a. constant filling

b. empty

c. starting haulage

d. ending haulage

1. Filling in climbing areas

2. Filling in dropping areas

Hoisting

Overhead 9.38

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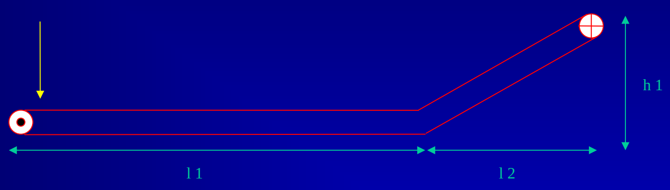
Exercise



l_1 =	750 m	m'_B =	30 kg/m
l_2 =	300 m	m'_{IO} =	20 kg/m
h =	50 m	m'_{IU} =	15 kg/m
$\dot{m}$ =	1000 t/h	C =	1,22
v =	2,5 m/s	g =	9,81 m/s
f =	0,02	η =	0,94

How much is the required driving power?

Hoisting

Hoisting

Tasks:

Transportation between the surface facilities and the underground workings

Elevation of ore and waste

Lowering of waste for backfilling

Raising and lowering of personnel and material

Components

- Surface plant:

Hoist room (headframe- or ground-mounted)
Hoist drum or sheave
Electrical and mechanical equipment
Hoist ropes

Headframe
Idler sheaves
Storage bins
Skip dump mechanism

Components

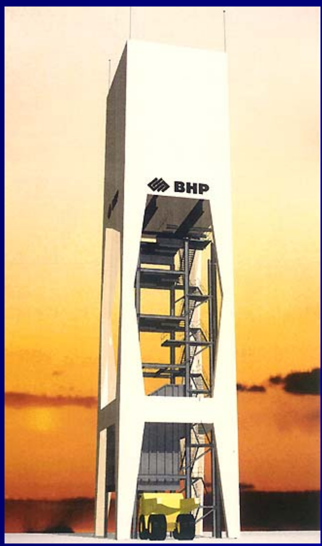
- Shaft plant:

Skips (bulk transport)
Cages and elevators (material, personnel)
Shaft guides (tracks for skips and cages)

- Underground plant:

Dump and storage bin
Crusher (if needed)
Loading pocket
Personnel and material-handling facilities

Headframe-mounted Hoist Room



Advantages:

Better for construction

Use of little space

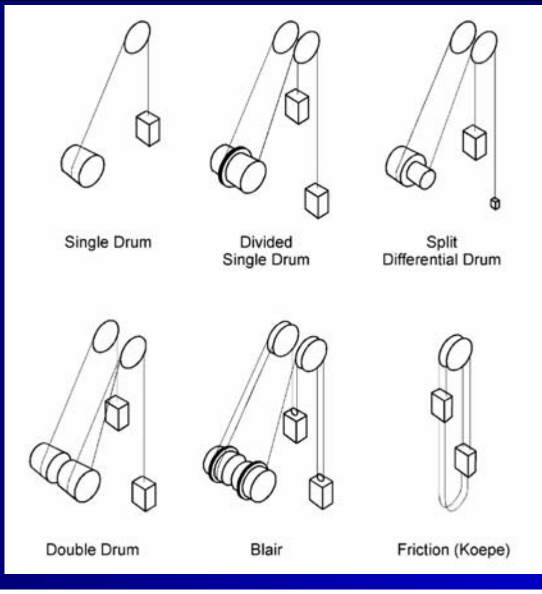
Ground-mounted Hoist Room

Advantages:

Parallel construction of hoist room and headframe

Better friction for friction hoisting

Types of Hoists



Friction Hoist (Koepe)

Rope is passed over the drive wheel but not stored

Force is transferred through friction

Used for single level hoisting

Use of a tail rope to balance the rope weight

+ High production and efficiency

+ Possibility to use multiple ropes

- Limited hoisting depth

- Danger of slip (limited capacity)

Hoisting

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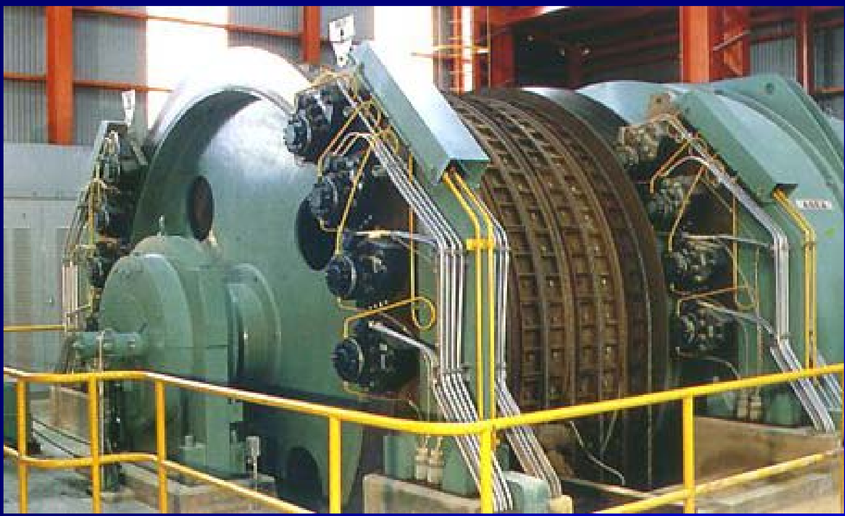
Friction Hoist (Koepe)



Hoisting

Overhead 9.48

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Drum Hoist

Rope is passed over the drive wheel and stored

Use of double drums possible for multi-level hoisting

+ Large hoisting depth

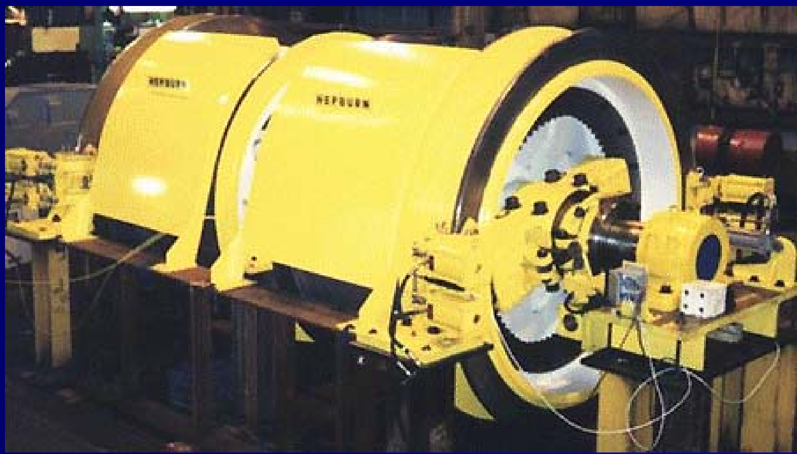
- Limited production and efficiency

Hoisting

Overhead 9.49

20/02/2006

Drum Hoist



Hoisting

Overhead 9.50

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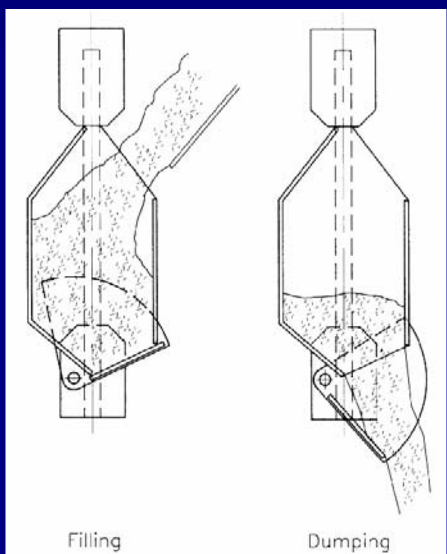
Skip Hoisting



Hoisting

Overhead 9.51

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Input Parameters

Following parameters are important for the selection of a hoisting system:

Production rate

Depth of shaft

Number of levels

Hoisting

Overhead 9.52

20/02/2006

Example

Olympic Dam mine, Australia, shaft 3

Capacity: 9 Mt/a (theoretically 1449 t/h)

Payload: 36.5 t

Hoisting depth: 854m

Hoisting speed: 16.5 m/s

Cycle time: 91 s

Energy consumption: 3.15 kWh/t

Ropes: 4 ropes of 44mm diameter

Hoisting

Overhead 9.53

20/02/2006

Hoisting in Open Pits

New concept for deep open pits

Lowering of operating costs for deep open pits with long haulage distances

Possible savings of haulage costs up to 60 %

Designed for up to 300 Mt/a production

Hoisting

Overhead 9.54

20/02/2006

Hoisting in Open Pits