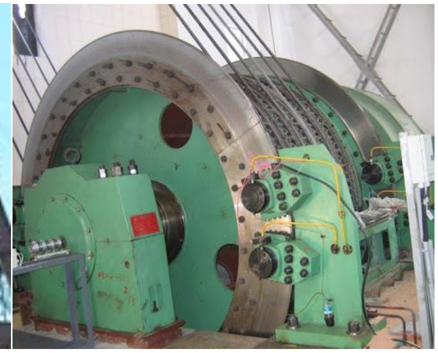

Internal Engineering Study - Project No. 1B Chimo Mine

Determination of maximum haulage capacity of the existing shaft infrastructure at the Chimo Mine

Summary of results of the study by PRB Mining Services Inc., April 2020

Characteristics of the existing shaft infrastructure at Chimo Mine:

- ✓ Depth of 914 m, 19 levels.
- ✓ Nominal excavated shaft section of 2.7 m x 6.0 m.
- ✓ Shaft compartments 1.5 m x 1.7 m framed with Douglas BC Fir.
- ✓ 3 compartments: 1 manway compartment and 2 hoisting compartments.

Complementary equipment additional to existing infrastructure:

- ✓ **Two skips with cage**, 20 tonnes capacity each in compartments no. 2 and no. 3. The height of the skip/cage being 14.3 m.
- ✓ **A Mary-Ann** cage for transportation of personnel installed in compartment no. 1 (replacing the manway) with 4-decks for 36 persons capacity.
- ✓ **A headframe**, 57.2 m tall from top of collar to center of sheave wheel with ore and waste bins.
- ✓ **A drum hoist** 5.08 m in diameter with a combined 4 880 HP_{RMS} AC motor capacity and 65 mm diameter cables (or a multi-cable hoist).

Productivity of existing Chimo Shaft infrastructure with complementary equipment:

Total weight suspended below the sheave wheel (tonne):	55.7
Hoist rope speed (feet / minute):	**2 200**
Skips hoisted per hour:	**28.9**
Tonnes hoisted per hour:	**492**
Number of tonnes hauled in 10 hours operation / 24 hours:	**4 921**
Number of tonnes hauled in 12 hours operation / 24 hours:	**5 905**

Conclusion:

With the installation of properly sized hoisting equipment, the shaft at the Chimo Gold Mine may have a hoisting capacity of 5,000 tonnes per day for a high tonnage production scenario.

An Overview of the Skipping Capacity in the Chimo Gold Mine Project Shaft

Prepared for:

Cartier Resources Inc.

1740, chemin Sullivan, Suite 1000

Val-d'Or (Québec) J9P 7H1

Prepared by:

Paul Bonneville, ing.

PRB Mining Services Inc.

April 2nd, 2020

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1 INTRODUCTION

Following several exploration programs Chimo Gold Mines started production in 1966 until 1967. The mine was later operated by Société Minière Louvem Inc. (<< Louvem >>) from 1978 to 1989, and finally by Cambior Inc. (<<Cambior>>) from 1989 to 1997 when the mine was closed and all infrastructures removed. The production rate at Chimo varied from 300 to 1 000 tonnes per day. The underground workings were accessed by a conventional timber shaft consisting of three 5’ 0’’ x 5’ 6” compartments in line. Portions of the shaft were sunk to four compartments during deepening phases. The shaft bottom is 914 metres. The shaft has four compartments from level 6 to level 8 representing 100 metres of shaft.

Production came mainly from the quartz rich zones. Significant low to mid grade gold quantities associated with arsenopyrite remain outside the quartz zones. GéoPointCom produced a mineral resource estimate for the Central Gold Corridor on November 5th, 2019. Using a cut-off grade of 2.5 gpt Au, the total MI&I resource totals 6.9M tonnes grading 3.9 gpt Au. Using a cut-off grade of 1.5 gpt, the total MI&I resource totals 14.6M tonnes grading 2.8 gpt Au.

Cartier Resources Inc. is contemplating the possibility of operating the mine under a high tonnage and low grade scenario using the existing production shaft. The production rate may be limited by the skipping capacity which may be produced in compartments as small as 5’ 0” x 5’ 6”. In January 2020, Gaétan Lavallière, vice-president of Cartier Resources Inc., has mandated PRB Mining Services Inc., who was retained, to estimate the potential skipping capacity using the existing production shaft on the Chimo Gold Mine Project Property (<< Chimo >>).

2 EXISTING HOISTING SYSTEMS IN QUEBEC

Table 2-1 presents characteristics of a few hoisting systems in Québec mines for comparison purposes relevant to Chimo's future needs for a high tonnage production.

Shaft	Hoist Type	Speed Design (fpm)	Speed Design (m/sec)	Speed Operating (fpm)	Speed Operating (m/sec)	Skip Capacity (kg)	Skip Weight (kg)	Ratio Capacity to Weight	Shaft Depth (m)	Headframe Height (m)	Guides Type
Laronde #3	drum	3 000	15,2	3 000	15,2	24 500	10 900	2,25	+6 000	53	steel
Goldex	friction	2 750	14,0	2 750	14,0	21 500	24 494	N.A	2726	65	steel
Westwood	drum	3 000	15,2	2 500	12,7	19 958	11 521	1,73	6360	71	steel
Doyon	drum	2 000	10,2	2 000	10,2	8 505	5 216	1,63	?	?	timber
Eleonor	drum	2 900	14,7	2 000	10,2	?	?	?	?	66	?
Niobec (before upgrade)	drum	2 800	14,2	2 000	10,2	16 511	9 072	1,82	740	?	timber
Niobec (after upgrade)	drum	2 800	14,2	?	?	19 000	?	?	740	?	?
Mosaic (Saskatchewan)	friction	?	?	3 500	17,8	45 359	?	?	?	?	cables

Notes: 1) Headframe height is from collar to sheave wheel center line.
2) Data obtained from various sources.

Table 2-1: Hoisting systems in Québec mines

Skipping speeds vary between 2 000 feet per minute and 3 500 feet per minute. Shafts operating at 2 000 feet per minute are equipped with timber guides. Shafts operating at 2 500 to 3 000 feet per minute have dedicated skipping compartments which are equipped with steel guides. Since there is no personnel transportation or level servicing in these compartments, their conveyances are not required to be equipped with a fall arrest system. The mine operating at 3 500 feet per minute (Potash mine in Saskatchewan) is equipped with cable guides.

The largest skips in Québec are located at the Laronde no. 3 shaft with a 24.5 tonnes capacity. They travel at a maximum speed of 3 000 feet per minute. That shaft is concrete lined equipped with steel sets spaced at 5.0 meters (16.4'). The dimensions of the skipping compartments are approximately 6' 0" x 6' 0". They are dedicated to skipping ore and waste. The shaft has a large service cage compartment equipped with a double deck cage used to transport all personnel, materials and consumables. Large items are brought underground using the ramp from surface. The height of headframes from collar to the sheave wheel varies from 53 m (175 ft) at the Laronde no. 3 shaft to 71 m (234 ft) at the Westwood shaft.

3 CHIMO SHAFT

The Chimo shaft is a conventional timber shaft sunk to a depth of 914 meters below collar. It was initially sunk in 1964 with 3 compartments in line to a depth of 183 meters. There later were 5 deepening programs with 3 and 4 compartments such that it has 3 compartments from surface to level 6, and from level 8 to level 14, and it has 4 compartments from level 6 to level 8. The shaft compartments are 5' 0''x 5' 6'' as shown on Figure 3-1 below. The shaft timber consists of BC (douglas) fir trimmed to 7 ¾" x 7 ¾". The timber sets are typically spaced 7' top/top. The timber guides dimensions are 3 ½" x 5 ½". Compartment # 1 is the manway. Compartments # 2 and # 3 are for the skip and cage conveyances. Compartment # 4 was for shaft deepening and is left vacant.

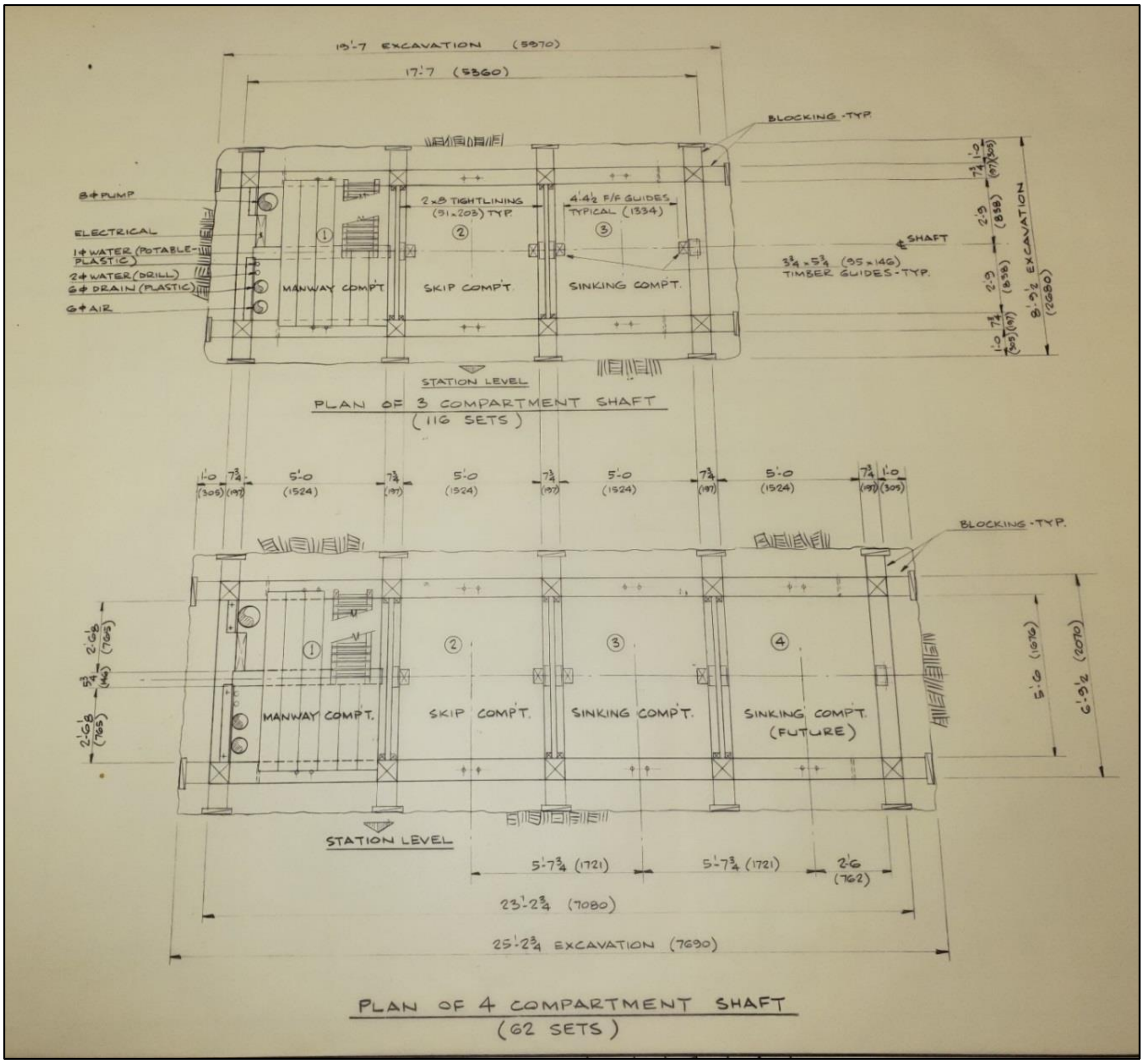


Figure 3-1: Chimo shaft plan – Drawing 4083-21-01-2000-1

Table 3-1 presents information on the shaft taken from Louvem drawing 02-335-002 and Redpath drawing 02-335-020 rev 3. Drawings showing a shaft section below level 17 spill pocket were not found. Elevations of level stations 18 and 19, and shaft bottom were taken from Cambior longitudinal drawings.

Level	Floor Elevation m	Depth Below Collar m	Set Nbr	Set Elevation m	Number Of Compartments	Between Levels Δ m	Comments
Collar	9,992.02	0.0	T.O.C [7]		3	0.0	
	9,991.71		1	9,991.71	3		
Collar Bottom	9,968.85		11	9,968.85	3		
1	9,916.80	75.2	35	9,917.09	3	75.2	Station pocket
2	9,878.50	113.5	52	9,878.61	3	38.3	Station pocket
3	9,823.87	168.2	79	9,823.16	3	54.6	Station pocket
4	9,780.00	212.0	99		3	43.9	Station pocket
5	9,735.50	256.5	120		3	44.5	Station pocket
6	9,688.00	304.0	142		4	47.5	Station pocket
7	9,641.60	350.4	164		4	46.4	
7 LP			174		4		Loading pocket
7 Spill			199		4		Spill pocket
8	9,588.00	404.0	189	9,588.13	3	53.6	
9	9,545.45	446.6	209	9,545.45	3	42.5	Lip pocket at set 215
10	9,513.45	478.6	224	9,513.45	3	32.0	Lip pocket at set 230
11	9,481.45	510.6	239	9,481.45	3	32.0	
11 LP	9,460.10		249		3		Loading pocket
11 Spill							Spill pocket
12	9,447.31	544.7	255	9,447.31	3	34.1	No lip pocket
13	9,415.30	576.7	270	9,415.30	3	32.0	No lip pocket
14	9,383.29	608.7	285	9,383.29	3	32.0	No lip pocket
15	9,351.28	640.7	300	9,351.28	3	32.0	No lip pocket
16	9,319.27	672.8	315	9,319.27	3	32.0	No lip pocket
17	9,287.26	704.8	330	9,287.26	3	32.0	
17 LP			340	9,265.92	3		Loading pocket
17 Spill			349	9,246.72	3		Spill pocket
18	9,210.00	782.0			3	77.3	
19	9,125.00	867.0			3	85.0	
19 LP	9,103.65	888.4			3		Preliminary estimation
19 Spill					3		Preliminary estimation
Shaft Bottom	9,078.00	914.0			3	47.0	

Notes:
1) Refer to Louvem drawing 02-335-011 for collar information.
2) Sets are distanced 2,1m top/top.
3) Information collar to level 7 taken from Louvem drawing 02-335-002.
4) Information level 7 to level 17 Spill pocket taken from Redpath drawing 02-335-020_3, July 1989.
5) Elevations of levels 18 and 19 and shaft bottom are measured from mine longitudinal drawings.
6) A shaft section drawing showing levels 18 and 19 and shaft bottom was not found.
7) T.O.C. means ''top of collar''.
8) LP means loading pocket
9) Spill means spill pocket
10) Distance from T.O.C. to level 19 LP = 888 metres
11) Shaft depth below collar = 914 metres
12) Portion of shaft @ 3 compartments = 814 metres
13) Portion of shaft @ 4 compartments = 100 metres

Table 3-1: Chimo shaft information

Level drawings show the existence of a crusher room on level 19. There is not a ramp joining the lower levels. The existence of a loading pocket and a spill pocket below level 19 may be inferred. The location of the loading pocket and the spill pocket below level 19 may be assumed to be the same as the position of the loading pocket and spill pocket below level 17. The lip of the loading pocket is estimated to be 888 meters below collar.

4 SKIP CAPACITY AND HEADFRAME HEIGHT

The dimensions of the Chimo shaft compartments are 5’ 0” between dividers and 5’ 6” between the wall plates. The current guides will be replaced by larger 6” x 8” guides. Using 6” x 8” guides, the space between guide faces is 4’ 0”. The space available for a conveyance is therefore 4’ 0” x 5’ 6” (1 219 mm x 1 676 mm). The typical clearance between a conveyance and wall plates is 3”. The box thickness of a bottom dump skip from outside of ribs to inside of liners is typically 3”. The distance from the inside of the skip box to the guide face is typically 8”. The inside area of a skip in the Chimo shaft is estimated to be 2’ 8” x 4’ 6” as shown on Figure 4-1. Thus, the skip would typically have an effective volume of 1.11 m^3 per metre box height and a capacity of 2.22 tonnes per m of box height, using a crushed rock density of 2.0 t/m^3.

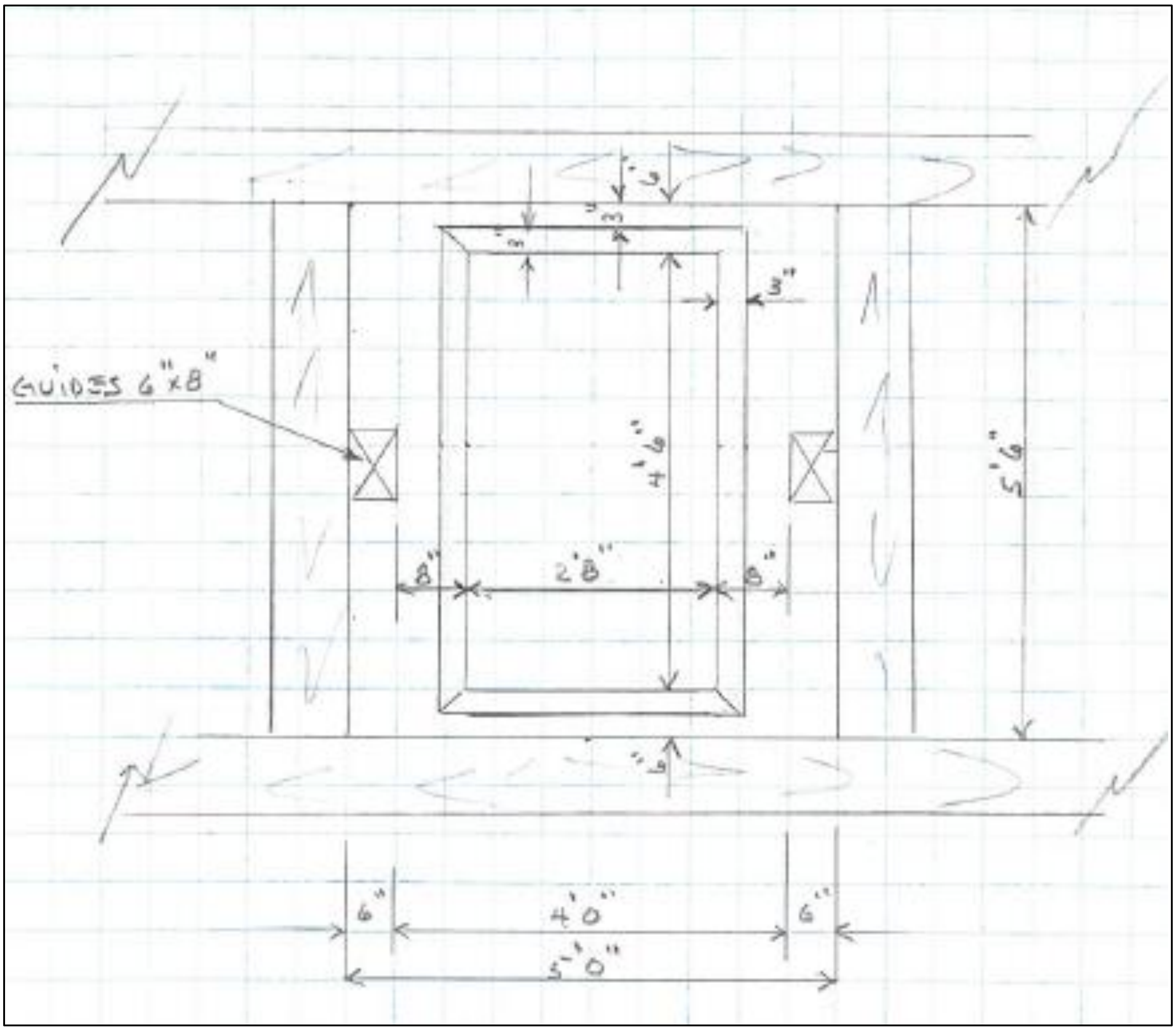


Figure 4-1: Plan view of a skip box in the Chimo shaft

The conveyance will be used for skipping and for servicing and will consist of a skip/cage combination. Measurements taken on a 15 tonnes capacity skip/cage conveyance for reference shows the cage portion to have a height of 2 454 mm and the skip bottom to lower wheels and the top of cage to rope pin attachment to have a height of 2 872 mm. Taking this as a reference, the total height of the conveyance from rope attachment to the lower wheels would be 5 566 mm plus the height of the skip box. The total length of the reference conveyance is 9 155 mm. It has a single deck cage.

The headframe in which the reference conveyance is used has a height of 52 metres from top of collar to the centre of the sheave wheel. The distance from top of collar to the dump lip is 32 metres allowing to dump into an ore bin and a waste bin. Taking the total length of the reference conveyance, the height of the reference headframe, and the height of the skip box, the height of the headframe may be estimated for specific skip capacities.

Table 4-1 shows estimated conveyance lengths for the Chimo shaft and headframe height for various skip capacities. The table shows that a skip/cage conveyance with a single deck and a 30 tonnes capacity would require a headframe of 62 metres high which is within the range of headframe heights of table 1. Also, the addition of one or two cage decks would be possible if necessary.

Skip	Height			Headframe	
Capacity	Skip	Cage/Other	Total	Height	
(tonnes)	(mm)	(mm)	(mm)	(m)	(ft)
réf.	N/A	5325	9155	52,0	171
15 t	6757	5325	12082	54,9	180
20 t	9009	5325	14334	57,2	188
25 t	11261	5325	16586	59,4	195
30 t	13514	5325	18839	61,7	202

Notes: 1) Compartment dimensions 5' 0'' x 5' 6''
2) Guides 6'' x 8''
3) Skip box inside area = 2' 8'' x 4' 6''
4) Unit skip volume = 1,11 m3/m skip box
5) Unit skip capacity = 2,22 tonnes/m skip box
6) Crushed ore density = 2,0 tonnes/m3
7) Height of reference headframe = 52m
(top of collar to sheave wheel centre line)

Table 4-1: Height of headframe vs skip capacity

5 SKIPPING CYCLE

The skipping operation consists of two skips suspended to a hoist travelling in opposite directions between the loading station in the shaft and the dump station in the headframe on surface. As one skip travels up to surface to be emptied, the other travels down to the loading station to be loaded.

In this report, a cycle refers to a skip moving from the rest position at the headframe dump down to the loading pocket and be loaded. A typical skipping cycle is composed of the following steps:

The cycle begins when the skip at the surface dump is in fully dumped position and the skip at the loading pocket is loaded.

The skip at surface travels downward at creep speed out of the dump station. The skip is out of the dump station when the control wheels have exited the scroll plates. Creep speed for computer-controlled hoists is typically set at 180 feet per minute. At the same time, the loaded skip travels the same distance upward.

Once the empty skip is out of the dump station, both skips accelerate to reach full speed. The acceleration depends on the hoist and the motor size but is generally between 1.5 and 2.5 ft/sec^2.

The skips travel at full speed until it is time to decelerate as they approach their destinations.

The skips decelerate to creep speed before the loaded skip reaches the dump station. Creep speed is typically reached 6 feet below the dump station entrance (i.e. when the skip control wheels are 6 feet below the scroll plates in the dump station).

The skips travel at creep speed until the loaded skip reaches the fully dumped position. At this point the empty skip is positioned at the loading pocket ready to be loaded.

The skip at the loading station is loaded before initiating its run up to the surface dump station.

The skipping cycle for Chimo was estimated using the parameters presented on Table 5-1.

Parameter	Value
Acceleration	2,0 ft/sec^2
Deceleration	2,0 ft/sec^2
Creep speed	180 ft/min
Creep distance to exit	2,74 metres
Creep distance of entry	4,60 metres
Total cycle run	935 metres
Full speed	Variable
Loading time	15 sec

Table 5-1: Skipping parameters for Chimo cycle estimation

The skipping run profile for the Chimo estimation is presented in Table 5-2. The total run distance is 935 metres (3 068 feet).

	Elevation		Distance	
	Metric	Imperial	Metric	Imperial
Description	m	ft	m	ft
Control wheel skip empty	35,0	115	0	0
Scroll plates bottom	32,5	107	2,5	8
Shaft collar	0,0	0	32,5	107
Loading station	-900,0	-2 953	900,0	2 953
Total run			935,0	3 068

Table 5-2: Skip run profile

Cycle times were estimated for speeds ranging from 2 000 ft/min to 3 000 ft/min. The results are presented in Table 5-3. The cycle estimate details are presented in appendix 2. The estimated cycle time ranges from 131 to 109 seconds for speeds from 2 000 and 3 000 ft/min respectively. The nominal number of cycles ranges from 27.5 to 33.1 skips per hour.

		Hoist speed (feet/minute)				
Description	Unit	2 000	2 200	2 400	2 600	3 000
Elapsed time						
1st acceleration to creep speed	(sec)	1,5	1,5	1,5	1,5	1,5
Exit at creep speed	(sec)	3,0	3,0	3,0	3,0	3,0
2nd acceleration to full speed	(sec)	15,2	16,8	18,5	20,2	23,5
Distance travelled at full speed	(sec)	74,7	64,7	56,1	48,6	35,9
1st decelleration to creep speed	(sec)	15,2	16,8	18,5	20,2	23,5
Entry at creep speed	(sec)	5,0	5,0	5,0	5,0	5,0
2nd deceleration to stop	(sec)	1,5	1,5	1,5	1,5	1,5
Waiting (loading)	(sec)	15,0	15,0	15,0	15,0	15,0
Total	(sec)	131,0	124,4	119,1	114,9	108,9
Cycles per hour	(skip/hr)	27,5	28,9	30,2	31,3	33,1
Distance travelled						
Distance during 1st acceleration	(feet)	2,3	2,3	2,3	2,3	2,3
Exit at creep speed	(feet)	9,0	9,0	9,0	9,0	9,0
Distance during 2nd accelaration	(feet)	275,5	333,9	397,8	467,2	622,8
Distance at full speed	(feet)	2 489,2	2 372,5	2 244,8	2 105,9	1 794,8
Distance during 1st deceleration	(feet)	275,5	333,9	397,8	467,2	622,8
Entry at creep speed	(feet)	15,0	15,0	15,0	15,0	15,0
Distance during 2nd deceleration	(feet)	1,5	1,5	1,5	1,5	1,5
Total distance travelled	(feet)	3 068,0	3 068,0	3 068,0	3 068,0	3 068,0

Table 5-3: Cycle time vs hoisting speed

6 SKIPPING CAPACITY

Tables 6-1 and 6-2 present the estimated hourly and daily skipping capacities for various hoisting speeds and skip capacities based on the cycle times presented in table 6. An efficiency factor of 85% was applied to account for unpredictable interruptions to the skipping operation. The estimate assumed an average skipping time of 10 and 12 hours per day. An automated skipping operation overseen by the hoistman is assumed allowing skipping between shifts. A detailed hoist schedule pertinent to the project will be required to validate the assumed skipping time. The hoist schedule will allocate time for transportation of personnel, servicing levels with materials and consumables, skipping, shaft inspections, and hoist inspections and maintenance.

		Hoist speed (feet/minute)				
Skip capacity	**Unit**	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
Cycles per hour	(skip/hr)	27,5	28,9	30,2	31,3	33,1
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/hr)	350	369	385	399	422
20 tonnes skip	(tm/hr)	467	492	514	532	562
25 tonnes skip	(tm/hr)	584	615	642	666	703
30 tonnes skip	(tm/hr)	701	738	771	799	843

Table 6-1: Hourly capacity vs skip capacity and hoist speed

		Hoist speed (feet/minute)				
Capacité de skip	**Unité**	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
Average daily skipping time	(hrs/day)	12	12	12	12	12
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/day)	4 204	4 429	4 624	4 792	5 058
20 tonnes skip	(tm/day)	5 606	5 905	6 165	6 390	6 744
25 tonnes skip	(tm/day)	7 007	7 381	7 707	7 987	8 430
30 tonnes skip	(tm/day)	8 409	8 857	9 248	9 585	10 116
Average daily skipping time	(hrs/day)	10	10	10	10	10
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/day)	3 504	3 691	3 853	3 994	4 215
20 tonnes skip	(tm/day)	4 671	4 921	5 138	5 325	5 620
25 tonnes skip	(tm/day)	5 839	6 151	6 422	6 656	7 025
30 tonnes skip	(tm/day)	7 007	7 381	7 707	7 987	8 430
Notes: 1) Production numbers in shaded grey areas apply to timber and steel guides. Other production numbers apply to steel guides only.						

Table 6-2: Daily skipping capacity vs skip capacity and hoist speed

7 HOIST CHARACTERISTICS

Skipping operation was analysed for skips having capacities of 15 tonnes, 20 tonnes, 25 tonnes and 30 tonnes to determine hoist drum diameter, rope diameter and motor size. The analysis assumed a hoisting depth of 3 150 feet, a hoist speed of 2 160 feet per minute and an acceleration of 2.0 feet per second square. Wire ropes were selected using a safety factor of 7.5 at the rope attachment (weight of conveyance and allowable skip load) and 5.0 at the sheave wheel (weight of conveyance, allowable skip load, and rope when conveyance is at shaft bottom) in accordance with Québec regulations, articles 288, 289, and 289.1. Typical wire rope characteristics were taken from Wire Rope Industries' catalog on the company's web site (https://www.bridon-bekaert.com/en-us/steel-and-synthetic-ropes/underground-mining). The wire rope analysis and data sheets are presented in appendix 3.

The drum hoist diameter was determined using a drum diameter to cable diameter ratio (D/d) of 80:1 with the exception of 100:1 for full lock coil cables (regulations article 312). CANMET simulated skipping scenarios to provide a rough estimate of the motor size required (appendix 3). The simulation assumed a single-rope drum hoist and high resistance wire ropes of standard construction (no full lock coil cable was simulated). The results of the analysis are presented in Table 7-1.

The 15 tonnes skip would require a 58 mm diameter rope and a minimum hoist drum diameter of 4 580 mm (180 inches). The 20 to 30 tonnes skips would require a 65 mm diameter rope (each of different steel grade) and a minimum hoist drum diameter of 5 080 mm (200 inches). The 25 and 30 tonnes skips may require a full lock coil cable 65 mm in diameter. The hoist drum diameter for a 65 mm full lock coil rope would be 6 500 mm (256 inches). The 25 and 30 tonnes skips approach the limit of wire rope capacities such that a multi-rope (Blair) hoist would likely be preferred. This option was not analysed. The power requirements would be similar.

New hoists currently use AC motors. The simulation suggests the required AC motor power would be between 3 825 HP rms for 15 tonnes skips and 6 940 HP rms for 30 tonnes skips.

Description	Unit	SKIP CAPACITY 15 t	20 t	25 t	30 t
Depth below sheave	m	960	960	960	960
Hoist cable					
Diameter	mm	57	64	64	64
Type		HR	HR	HR	HR
Unit weight	kg/m	18,3	23,0	23,0	25,5
Total suspended weight	kg	17 615	22 057	22 057	24 509
Conveyance					
Skip weight	kg	8 845	11 612	13 889	16 666
Cage weight	kg	2 041	2 041	2 041	2 064
Load weight	kg	14 999	20 003	25 000	29 999
Loaded conveyance weight	kg	25 886	33 657	40 929	48 729
Total Supended load below sheave	kg	43 500	55 713	62 986	73 238
Speed	m/sec	11,0	11,0	11,0	11,0
Hoist					
D/d ratio		80	80	80	80
Drum diameter	mm	4 572	5 080	5 080	5 080
Power required					
AC motor	HP rms	3 825	4 879	5 874	6 936
DC motor	HP rms	3 124	4 581	5 515	6 512
Ventilated	HP rms	3 344	4 266	5 135	6 064

Table 7-1: Hoist configuration for various skip capacities

8 DISCUSSION

8.1 GUIDES VS HOIST SPEED

Shaft guides in Québec typically consist of timber (BC douglas fir) of 6'' x 8'' dimensions or of hollow structural steel (HSS) 6'' x 8''. The application of timber guides is limited to a hoist speed of 2 200 ft/min and lighter loads otherwise they tend to deteriorate rapidly and need to be replaced often. Steel guides are used for higher speeds and high loads.

Timber guides should be limited to a maximum hoisting speed of 2 200 feet per minute and 20 tonnes skips. Steel guides are not used at speeds higher than 3 000 feet per minute.

8.2 FALL ARREST SYSTEMS

Québec regulations (S-2.1, r.14 - Règlement sur la santé et la sécurité du travail dans les mines) stipulate that the maximum speed at which personnel may be transported in a mine shaft is 1 500 feet per minute. This is referred to as maximum man riding speed. The hoist skipping speed may be higher, but the hoist speed is limited to 1 500 feet per minute when in man riding mode.

Article 323 of the Québec regulations stipulates that a conveyance suspended to a single-rope drum hoist used to transport personnel must be fitted with a fall arrest system in case of rope rupture. The fall arrest system must have the capacity to stop the combined weight of the conveyance and of the allowable number of persons travelling downward at maximum man riding speed (1 500 fpm). This, however, does not apply to a conveyance suspended to a multi-rope drum hoist (Blair hoist).

All personnel transportation conveyances in Québec and Ontario currently operate on timber guides. The use of steel guides is limited to shaft compartments where conveyances are dedicated to hoisting rock only (skipping only). The fall arrest systems consist of a spring-loaded mechanism which, when released, sets steel blades into the guides cutting the timber until the conveyance is fully stopped. The blades are commonly referred to as ''dogs''. The capacity of 6'' x 8'' timber guides to resist a fall arrest system is 15 000 lbs (6 818 kg) per guide. The dimensions of the Chimo shaft conveyance compartments are 5' 0'' x 5' 6''. With 6'' x 8'' guides installed, the distance between guide faces is 4' 0'' and the distance between wall plates is 5' 6''. Compartments of these dimensions are fitted with two guides. Large service compartments, like at the Laronde no. 3 shaft, are fitted with four guides.

Fitting the Chimo conveyance compartments with two guides limits the total weight of the conveyance (skip-cage) and its allowable number of persons to 30 000 lbs (13 636 kg).

Québec regulations (article 331) stipulates that the maximum number of persons allowed in a cage with a floor area smaller than 1.86 m^2 is 5.25 per m^2. A cage in the Chimo shaft compartment would have an approximate area of 1.62 m^2. A 2-deck cage would be allowed to transport a maximum of 18 persons. A 4-deck cage would be allowed to transport 36 peoples. For a high tonnage operation, a large cage capacity will be essential to transport personnel in a timely fashion and maximize skipping time.

Approximate skip capacities were estimated for a cage-skip conveyance travelling in a 2 guides compartment (appendix 4). The estimate used a skip capacity to skip weight ratio of 1.8, a cage weight of 390 lbs per person, and a personnel weight of 200 lbs per person. The estimate resulted in a skip capacity of 15.8 tonnes for a 2-deck cage, a skip capacity of 11.5 tonnes for a 3-deck cage, and a skip capacity of 7.2 tonnes for a 4-deck cage. The exercise is not accurate but provides an overview of the limitations of fitting the compartments with 2 timber guides. It is unlikely that a 2 guides configuration will accommodate the skipping, the material servicing and the personnel transportation requirements for a high tonnage operation.

Skip capacities were also estimated assuming a 4 timber guides scenario where the maximum weight limitation is 60 000 lbs (27 273 kg). The exercise resulted in a skip capacity of 30 tonnes for a 4-deck cage. There may not be sufficient space to fit a 4-guides fall arrest system on a conveyance of this size. The distance of 5' 6" between the timber wall plates limits the space in which the dogs may function. A conversation is ongoing with conveyance manufacturers on this subject.

FLSmidth Systems has developed a fall arrest system for steel guides. It is called the **Cage Guardian Safety Brake** (https://www.flsmidth.com/en-gb/products/cage-guardian-safety-brake). It is currently designed for a cage conveyance only. None are currently in operation in Canada. The deceleration system is an integral part of the cage. It does not use friction on the steel guides to decelerate. Rather, deceleration works within the system itself (see video at the following link: https://www.flsmidth.com/en-gb/products/cage-guardian-safety-brake#data-fancybox). Discussions are ongoing with FLSmidth Systems to apply the system to a cage-skip conveyance. A bottom dump skip would normally be preferred for Chimo. The system cannot be applied to a bottom dump skip/cage configuration. It may, however, be applied to an arc gate skip/cage configuration. Most skips in operation in Québec are of bottom dump design. Arc gate skips have an inherent obstruction around the arc gate and tend to have hang-ups when used with damp material. FL Smidth Systems opined that the arc gate skip may be an option where ore is crushed.

Wabi Iron & Steel Corp is developing a fall arrest system for steel guides. It is called **Lock-N-Load** (http://www.wabicorp.com/mine-equipment-division/lock-%c2%adn-%c2%adload/). It is an electric/hydraulic system activated by a slack rope situation where the conveyance is sitting on an obstruction or a rope rupture. It can also be activated by a button to hold the conveyance in position such as at a station to load or unload the cage. This can save time servicing stations by eliminating the need to chair the cage to chains in order to keep the conveyance level as the hoist cable stretches or retracts as a load is added or removed. The system is used in a few Ontario mines to timber guides as conveyance chairing system, not as a fall arrest system.

Pamphlets of these systems may be found in appendix 5. Permitting for use in Québec of both the Cage Guardian Safety Brake and the Lock-N-Load systems needs to be addressed. Québec regulations do not mention any type of fall arrest systems. Québec regulations (article 326) simply stipulate that it must be designed by a reputable engineer and a free fall test must conducted before its first use. A free fall test consists of locking the fall arrest system and letting the conveyance fall until it reaches the permitted man-riding speed (i.e. 1 500 feet per minute for Chimo) before engaging the fall arrest system. After being put into service, the fall arrest system must to be periodically inspected and drop tested (dropped from rest position).

An alternative would be to use a multi-rope hoist in which case a fall arrest system is not required because the second rope will take the load in case of failure. There is currently not any multi-rope hoist in operation in Québec or Ontario.

8.3 Service and Personnel Transportation

A high tonnage and low-grade production scenario will require a significant effort in personnel transportation and delivery of materials and consumables underground. This will have a huge impact on the time that can be dedicated to skipping of ore and waste to surface. The Chimo shaft has three small compartments of which one is a manway. The hoisting system should be selected to skip ore and waste in the least possible time. Longer skips at higher speeds are to be preferred.

The use of long skips at high speeds will require the use of steel guides. Guide alignment of the steel guide is crucial to reduce impact from the skip load to the guides and timber. The shaft timber will require a realignment to be within acceptable tolerances. After realignment, running tests with an accelerometer can identify areas to be corrected. The shaft timber will also need to be reinforced to resist impact from skips travelling in the shaft. Further study will be necessary to address this subject.

A steel structure may be preferable to the timber structure in place. In this case, the shaft end plates and dividers could consist of hollow structural steel (HSS) members pinned to the shaft walls at a relatively low cost compared to excavating and equipping a new shaft.

The manway in the compartment no. 1 should be replaced with a mary-ann cage conveyance dedicated to personnel transportation. This conveyance may not be used for servicing materials and consumables to levels underground. It may only be used to transport small tools workers worn on workers' belts or bags (articles 53, 54, and 55 of the Québec regulations S-2.1, r.14). This hoisting system must be separate from the skipping system (hoist in a separate building).

The mary-ann conveyance could handle all transportation of personnel day and night removing a significant burden from the skipping system. A mary-ann cage with 4 decks could fit 36 persons.

9 CONCLUSIONS

The analysis for the Chimo shaft concluded that a hoisting system operating at speeds between 2 000 feet per minute and 3 000 feet per minute can have a skipping rate of 27 skips per hour up to 33 skips per hour respectively.

Using skips between 15 and 30 tonnes at a speed between 2 000 and 3 000 feet per minute may have a production rate between 350 tonnes per hour to 843 tonnes per hour. The existing timber structure with timber guides will be adequate for skips of up to a 20 tonnes capacity at speeds up to 2 200 feet per minute for a production rate of 492 tonnes per hour therefore 5 905 tm/day (12 hours/day) or 4 921 tm/day (10 hours/day). At higher speeds up to 3 000 feet per minute, steel guides should be used and the shaft timber may require reinforcement.

Use of a 15 tonnes skip would require a 57 mm diameter rope. The hoist drum would have a minimum diameter of 4 572 mm (180 inches). CANMET's simulation suggests a 3 825 HP rms AC motor would be required.

Use of 20, 25 and 30 tonnes skips would require 65 mm diameter ropes of different steel grades. The hoist drum would have a minimum diameter of 5 080 mm (200 inches). If a full lock coil rope is used for the 25 and 30 tonnes skips, the hoist drum would have a minimum diameter of 6 500 mm (256 inches). CANMET's simulations suggest AC motor size of 4 880 HP rms, 5 880 HP rms and 6 940 HP rms respectively for the 20, 25, and 30 tonnes skips scenarios.

A high tonnage and low-grade production scenario will require a significant effort in transportation of personnel and delivery of materials and consumables underground. This will have a significant impact on the time that can be dedicated to skipping of ore and waste to surface. Longer skips and higher speeds are to be preferred.

Also, the manway should be replaced with a multi-deck mary-ann conveyance handling all transportation of personnel which would provide more time to the production hoist for skipping and servicing. A cage with 4 decks could fit 36 persons.

Use of longer skips would require steel guides and would require timber reinforcement or timber replacement with steel end plates and dividers pinned to the shaft walls. Since workers will be travelling in the skipping compartments and longer skips are preferred, use of a multi-rope hoist should be considered so a fall arrest system would not be necessary.

10 REFERENCES

- S-2.1, r.14 - Règlement sur la santé et la sécurité du travail dans les mines, http://legisquebec.gouv.qc.ca/fr/ShowDoc/cr/S-2.1,%20r.%2014/

- NI 43-101Technical Report and Mineral Resource Estimate, Chimo Mine Project, Central Gold Corridor, GéoPointCom, July 2019, https://ressourcescartier.com/wp-content/uploads/2018/07/191218_NI43-101_Chimo-Mine-Project_Res.-Est_EN.pdf

APPENDIX 1

Skip Capacity and Height of Headframe Analysis

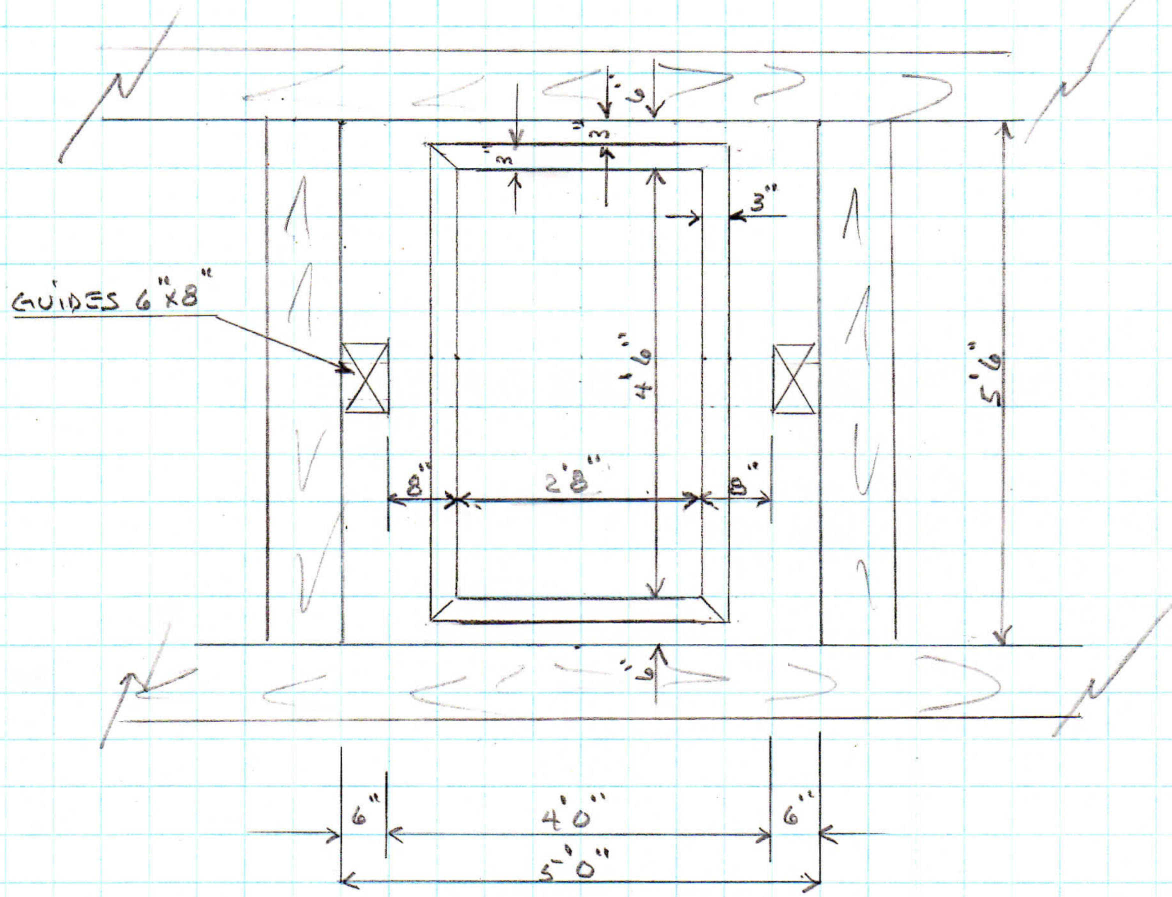
Services Miniers PRB Inc.
Projet Chimo
Headframe Height
Skip Length vs Skip Capacity
r20200218

Skip	Height			Headframe	
Capacity	**Skip**	**Cage/Other**	**Total**	**Height**	
(tonnes)	**(mm)**	**(mm)**	**(mm)**	**(m)**	**(ft)**
réf.	N/A	5325	9155	52,0	171
15 t	6757	5325	12082	54,9	180
20 t	9009	5325	14334	57,2	188
25 t	11261	5325	16586	59,4	195
30 t	13514	5325	18839	61,7	202

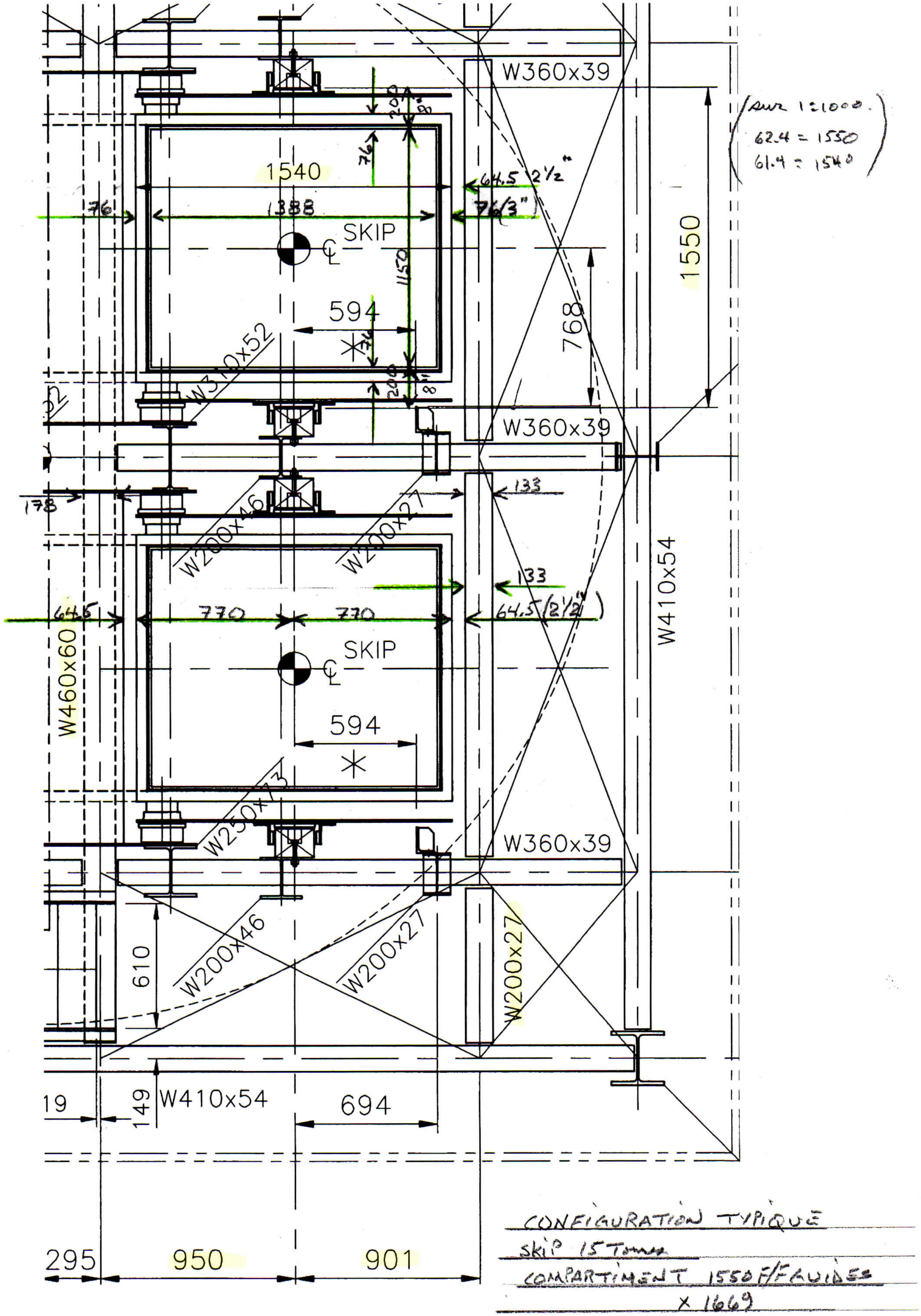
Notes:
1) Compartment dimensions 5' 0'' x 5' 6''
2) Guides 6'' x 8''
3) Skip box inside area = 2' 8'' x 4' 6''
4) Unit skip volume = 1,11 m3/m skip box
5) Unit skip capacity = 2,22 tonnes/m skip box
6) Crushed ore density = 2,0 tonnes/m3
7) Height of reference headframe = 52m
(top of collar to sheave wheel centre line)

AIRE EFFECTIF D'UN SKIP.
DANS UN COMPARTIMENT 5'0" x 5'6"

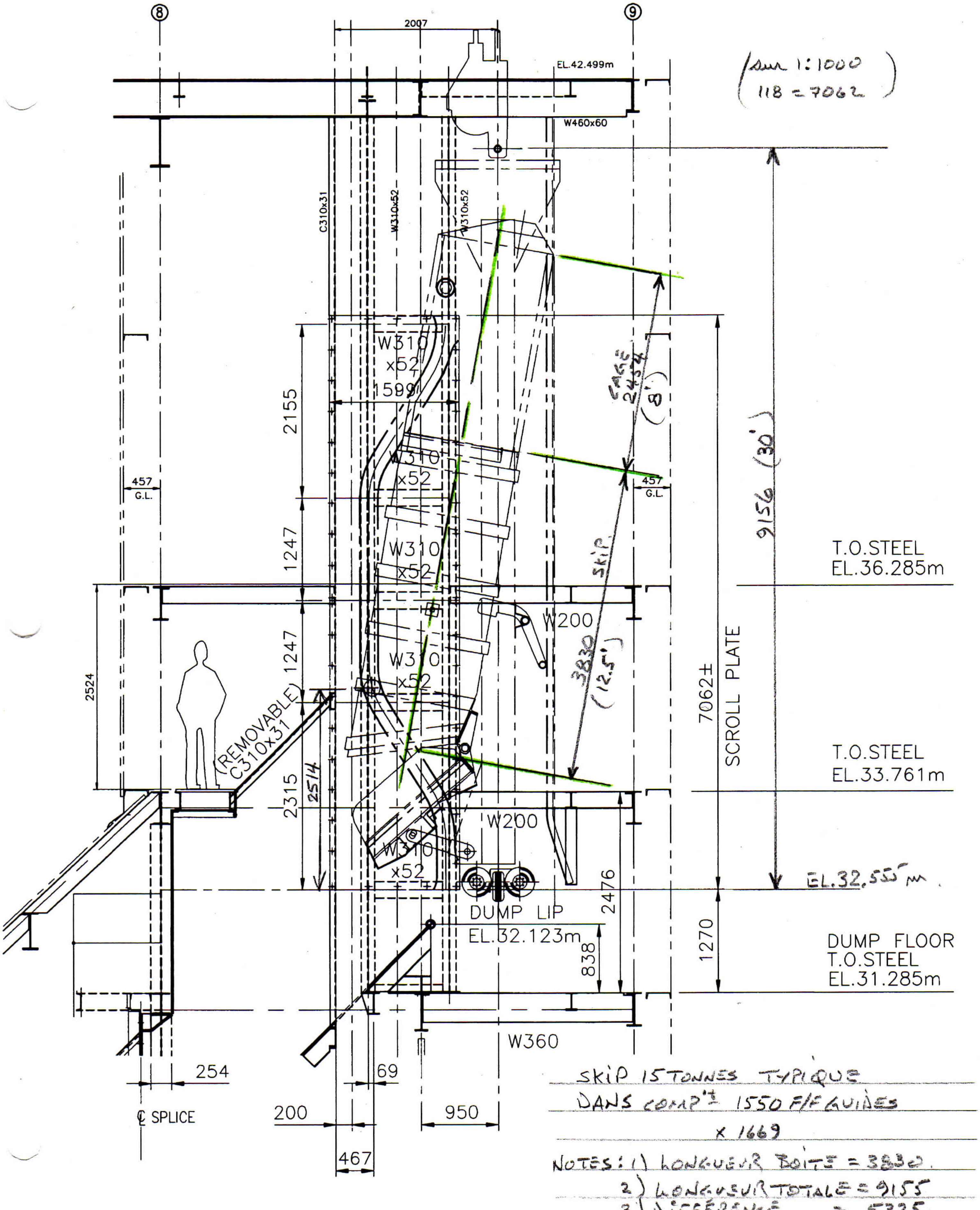
(17 Fév 2020)



NOTES:
1) compartiment 5'0" x 5'6"
2) Guides de sapin douglas 6"x8" ou acier HSS 200x152 (6"x8")
3) Aire intérieur du skip = 2'8" x 4'6"
4) Distances des wall plates et des guides sont basé sur un skip typique et pourrait être différent selon le fabricant
5) volume = 12 pi^3/pi = 1.11 m^3/m
6) capacité = 2.22 tonnes/m (σ = 2.0 t/m^3)



W360x39
(sur 1:1000.
62.4 = 1550
61.4 = 1540)
200
8"
76
1540
64.5 2½"
76/3"
76
1388
SKIP
1550
1150
594
768
W310x52
W360x39
178
133
W200x46
W200x27
133
W410x54
64.5
770
770
64.5 (2½")
SKIP
W460x60
594
W250x73
W360x39
610
W200x46
W200x27
W200x27
19
149
W410x54
694
295
950
901
CONFIGURATION TYPIQUE
SKIP 15 Tonnes
COMPARTIMENT 1550 F/F GUIDES
x 1669



8
9
2007
EL.42.499m
W460x60
(sur 1:1000
118 = 7062)
C310x31
W310x52
W310x52
W310
x52
1599
2155
W310
x52
457
G.L.
457
G.L.
CAGE
2434
(8')
9156 (30')
1247
W310
x52
SKIP
T.O.STEEL
EL.36.285m
W200
1247
W310
x52
3830
(12.5')
2524
(REMOVABLE)
C310x31
7062±
SCROLL PLATE
T.O.STEEL
EL.33.761m
2315
2514
W200
W310
x52
EL.32.555 m
DUMP LIP
EL.32.123m
2476
838
1270
DUMP FLOOR
T.O.STEEL
EL.31.285m
W360
254
69
℄ SPLICE
200
950
467
SKIP 15 TONNES TYPIQUE
DANS COMP'T 1550 F/F GUIDES
x 1669
NOTES: 1) LONGUEUR BOITE = 3830.
2) LONGUEUR TOTALE = 9155
3) DIFFERENCE = 5325.

SECTION C-C

APPENDIX 2

Cycle Time Analysis

Services Miniers PRB Inc.
Projet Chimo
Hoisting Capacity
Cycle Time & Productivity Estimation Summary
r20200225 Anglais

1,0 Cycle time and travel distance

		Hoist speed (feet/minute)				
Description	**Unit**	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
Elapsed time						
1st acceleration to creep speed	(sec)	1,5	1,5	1,5	1,5	1,5
Exit at creep speed	(sec)	3,0	3,0	3,0	3,0	3,0
2nd acceleration to full speed	(sec)	15,2	16,8	18,5	20,2	23,5
Distance travelled at full speed	(sec)	74,7	64,7	56,1	48,6	35,9
1st decelleration to creep speed	(sec)	15,2	16,8	18,5	20,2	23,5
Entry at creep speed	(sec)	5,0	5,0	5,0	5,0	5,0
2nd deceleration to stop	(sec)	1,5	1,5	1,5	1,5	1,5
Waiting (loading)	(sec)	15,0	15,0	15,0	15,0	15,0
Total	(sec)	131,0	124,4	119,1	114,9	108,9
Cycles per hour	(skip/hr)	27,5	28,9	30,2	31,3	33,1
Distance travelled						
Distance during 1st acceleration	(feet)	2,3	2,3	2,3	2,3	2,3
Exit at creep speed	(feet)	9,0	9,0	9,0	9,0	9,0
Distance during 2nd accelaration	(feet)	275,5	333,9	397,8	467,2	622,8
Distance at full speed	(feet)	2 489,2	2 372,5	2 244,8	2 105,9	1 794,8
Distance during 1st deceleration	(feet)	275,5	333,9	397,8	467,2	622,8
Entry at creep speed	(feet)	15,0	15,0	15,0	15,0	15,0
Distance during 2nd deceleration	(feet)	1,5	1,5	1,5	1,5	1,5
Total distance travelled	(feet)	3 068,0	3 068,0	3 068,0	3 068,0	3 068,0

2,0 Hourly production

		Hoist speed (feet/minute)				
Skip capacity	**Unit**	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
Cycles per hour	(skip/hr)	27,5	28,9	30,2	31,3	33,1
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/hr)	350	369	385	399	422
20 tonnes skip	(tm/hr)	467	492	514	532	562
25 tonnes skip	(tm/hr)	584	615	642	666	703
30 tonnes skip	(tm/hr)	701	738	771	799	843

Services Miniers PRB Inc.
Projet Chimo
Hoisting Capacity
Cycle Time & Productivity Estimation Summary
r20200225 Anglais

3,0 Production quotidienne moyenne

		Hoist speed (feet/minute)				
Capacité de skip	**Unité**	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
Average daily skipping time	(hrs/day)	12	12	12	12	12
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/day)	4 204	4 429	4 624	4 792	5 058
20 tonnes skip	(tm/day)	5 606	5 905	6 165	6 390	6 744
25 tonnes skip	(tm/day)	7 007	7 381	7 707	7 987	8 430
30 tonnes skip	(tm/day)	8 409	8 857	9 248	9 585	10 116
Average daily skipping time	(hrs/day)	10	10	10	10	10
Efficiency factor		85%	85%	85%	85%	85%
15 tonnes skip	(tm/day)	3 504	3 691	3 853	3 994	4 215
20 tonnes skip	(tm/day)	4 671	4 921	5 138	5 325	5 620
25 tonnes skip	(tm/day)	5 839	6 151	6 422	6 656	7 025
30 tonnes skip	(tm/day)	7 007	7 381	7 707	7 987	8 430

Notes: 1) Production numbers in shaded grey areas apply to timber and steel guides.
Other production numbers apply to steel guides only.

Services Miniers PRB Inc.
Projet Chimo
Hoisting Capacity
Cycle Time & Productivity Estimation
r20200225 Anglais

		imperial		**metric**	
1,0	**Input**				
	Low creep speed - 45 ft/min	0,75	ft/sec	0,2286	m/sec
	Creep speed - 180 ft/min	3,00	ft/sec	0,9144	m/sec
	Maximum speed to consider				
	- Option 2000 ft/min	33,3	ft/sec	10,2	m/sec
	- Option 2200 ft/min	36,7	ft/sec	11,2	m/sec
	- Option 2400 ft/min	40,0	ft/sec	12,2	m/sec
	- Option 2600 ft/min	43,3	ft/sec	13,2	m/sec
	- Option 3000 ft/min	50,0	ft/sec	15,2	m/sec
	Acceleration	2,0	ft/sec^2	0,6096	m/sec^2
	Decelaration	2,0	ft/sec^2	0,6096	m/sec^2
	Exit distance at creep speed	9,0	feet	2,74	m
	Entry distance at creep speed	15,0	feet	4,60	m
	Total run distance	3068,0	feet	935,0	m
	Waiting time for loading	15,0	sec	15,0	sec

2,0 Formulas

Temps d'accélération et de décélération (t)

$$t = (V2-V1) \div a$$

Temps de déplacement vitesse fixe (t)

$$t = V \div d$$

Distance de déplacement (d)

$$d = (V2+V1) \div 2 \times t$$

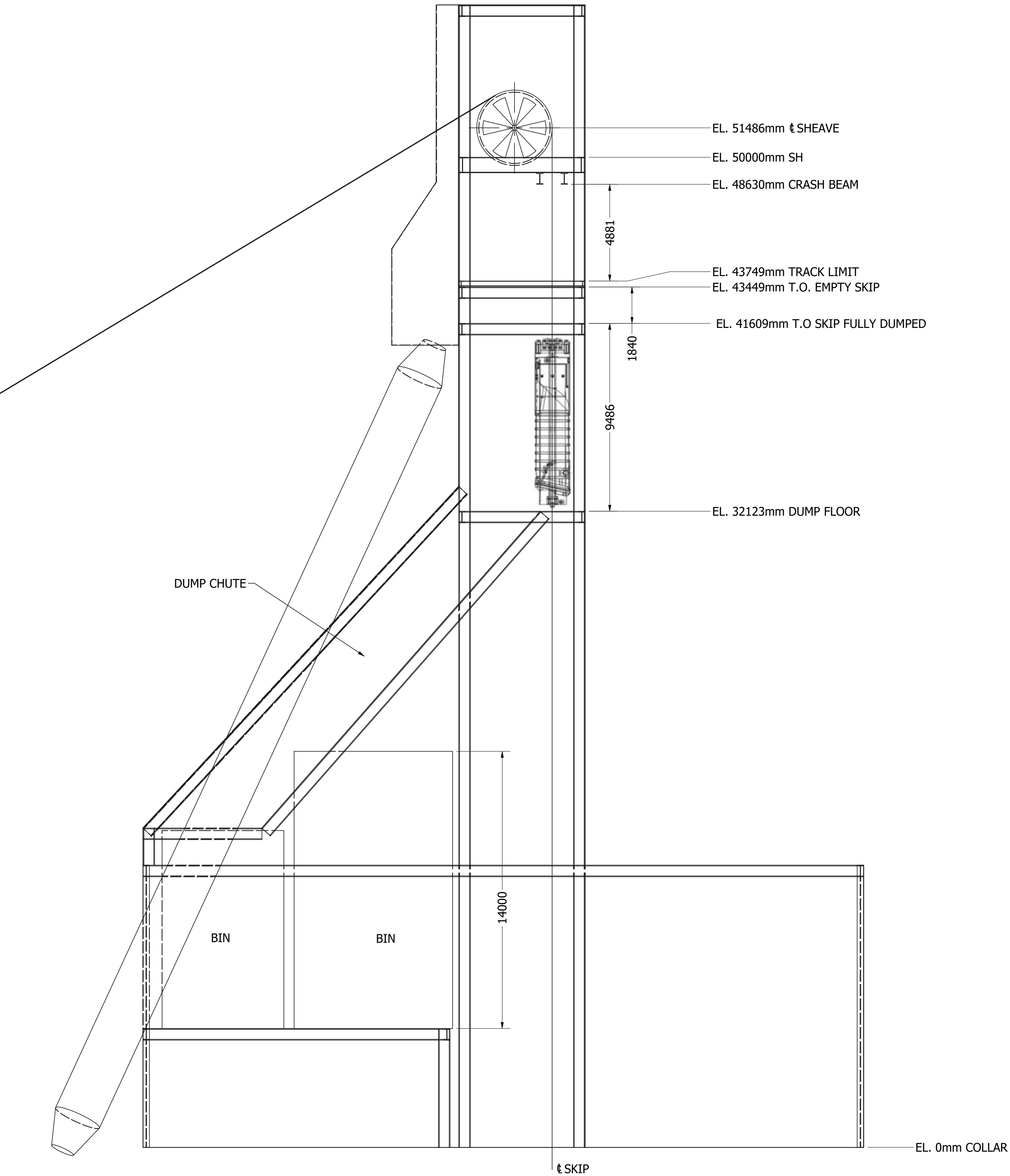
où: V2 est la vitesse à la fin
V1 est la vitesse au début
a est l'accélération ou décélération

3,0 Cycle time and productivity estimation

3,1	Acceleration from rest to creep speed (1st acceleration)		
	Acceleration time	1,50	sec
	Distance travelled	2,3	feet
3,2	Exit at creep speed		
	Distance travelled	9,0	feet
	Elapsed time	3,0	sec
3,3	Entry at creep speed		
	Distance travelled	15,0	feet
	Elapsed time	5,0	sec
3,4	Deceleration from creep speed to stop (2nd deceleration)		
	Time of deceleration	1,50	sec
	Distance travelled	1,5	feet

3,5	Acceleration to full speed (2nd acceleration)						
	Full speed	(ft/min)	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
		(ft/sec)	33,33	36,67	40,00	43,33	50,00
	Creep speed	(ft/sec)	3,00	3,00	3,00	3,00	3,00
	Acceleration	(ft/sec^2)	2,00	2,00	2,00	2,00	2,00
	Time of acceleration to full speed	(sec)	15,2	16,8	18,5	20,2	23,5
	Distance travelled	(feet)	275,5	333,9	397,8	467,2	622,8

3,6	Deceleration to creep speed (1st deceleration)						
	Full speed	(ft/min)	**2 000**	**2 200**	**2 400**	**2 600**	**3 000**
		(ft/sec)	33,33	36,67	40,00	43,33	50,00
	Creep speed	(ft/sec)	3,00	3,00	3,00	3,00	3,00
	Deceleration to creep speed (1st deceleration)	(ft/sec^2)	2,00	2,00	2,00	2,00	2,00
	Time of deceleration to creep speed	(sec)	15,2	16,8	18,5	20,2	23,5
	Distance travelled	(feet)	275,5	333,9	397,8	467,2	622,8
3,7	Run at full speed						
	Total run distance	(feet)	3 068,0	3 068,0	3 068,0	3 068,0	3 068,0
	Displacement of 1st acceration	(feet)	2,3	2,3	2,3	2,3	2,3
	Exit displacement at creep speed	(feet)	9,0	9,0	9,0	9,0	9,0
	Displacement of 2nd acceleration	(feet)	275,5	333,9	397,8	467,2	622,8
	Displacement of 1st deceleration	(feet)	275,5	333,9	397,8	467,2	622,8
	Entry displacement at creep speed	(feet)	15,0	15,0	15,0	15,0	15,0
	Displacement of 2nd deceleration	(feet)	1,5	1,5	1,5	1,5	1,5
	Displacement at full speed	(feet)	2 489,2	2 372,5	2 244,8	2 105,9	1 794,8
	Time elapsed at full speed	(sec)	74,7	64,7	56,1	48,6	35,9
3,7	Total cycle time						
	1st acceleration to creep speed	(sec)	1,5	1,5	1,5	1,5	1,5
	Exit at creep speed	(sec)	3,0	3,0	3,0	3,0	3,0
	2nd acceleration to full speed	(sec)	15,2	16,8	18,5	20,2	23,5
	Displacement at full speed	(sec)	74,7	64,7	56,1	48,6	35,9
	1st deceleration to creep speed	(sec)	15,2	16,8	18,5	20,2	23,5
	Entry at creep speed	(sec)	5,0	5,0	5,0	5,0	5,0
	2nd deceleration to stop	(sec)	1,5	1,5	1,5	1,5	1,5
	Waiting time (loading)	(sec)	15,0	15,0	15,0	15,0	15,0
	Total	(sec)	131,0	124,4	119,1	114,9	108,9
3,8	Production rate						
	Unit skipping cycles	(skip/hr)	27,5	28,9	30,2	31,3	33,1
	Nominal skipping capacity with:						
	15 tonnes skips	(tm/hr)	412	434	453	470	496
	20 tonnes skips	(tm/hr)	550	579	604	626	661
	25 tonnes skips	(tm/hr)	687	724	756	783	826
	30 tonnes skips	(tm/hr)	824	868	907	940	992
	Daily skipping capacity:						
	Average daily skipping time	(hrs/jr)	12	12	12	12	12
	Efficiency factor		85%	85%	85%	85%	85%
	15 tonnes skips	(tm/d)	4 204	4 429	4 624	4 792	5 058
	20 tonnes skips	(tm/d)	5 606	5 905	6 165	6 390	6 744
	25 tonnes skips	(tm/d)	7 007	7 381	7 707	7 987	8 430
	30 tonnes skips	(tm/d)	8 409	8 857	9 248	9 585	10 116
	Average daily skipping time	(hrs/jr)	10	10	10	10	10
	Efficiency factor		85%	85%	85%	85%	85%
	15 tonnes skips	(tm/d)	3 504	3 691	3 853	3 994	4 215
	20 tonnes skips	(tm/d)	4 671	4 921	5 138	5 325	5 620
	25 tonnes skips	(tm/d)	5 839	6 151	6 422	6 656	7 025
	30 tonnes skips	(tm/jr)	7 007	7 381	7 707	7 987	8 430



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APPENDIX 3

Hoist cable Analysis

And

CANMET Simulations

Services Miniers PRB Inc.
Projet Chimo
Skipping Capacity
Hoist Cable Selection
r20200326 Anglais

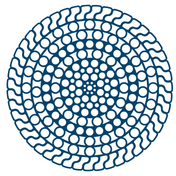
	Description	Unit	Skip Capacity 15 tm	20 tm	25 tm	25 tm	30 tm
0,0	Input						
	Profondeur de la molette au fond	m	1 000	1 000	1 000	1 000	1 000
	Ratio poids charge vs skip		1,8	1,8	1,8	1,8	1,8
1,0	Analysis at conveyance attachment						
1,1	Weight						
	Skip (load to weight ratio 1,8:1,0)	kg	8 333	11 111	13 889	13 889	16 667
	Cage	kg	4 550	4 550	4 550	4 550	4 550
	Attaches	kg	500	500	500	500	500
	Conveyor total	kg	13 383	16 161	18 939	18 939	21 717
	Load	kg	15 000	20 000	25 000	25 000	30 000
	Loaded conveyor	kg	28 383	36 161	43 939	43 939	51 717
1,2	Minimum nominal breaking force						
	Minimum safety factor		7,5	7,5	7,5	7,5	7,5
	Minimum breaking strength	kg	212 875	271 208	329 542	329 542	387 875
		KN	2 088	2 660	3 232	3 232	3 804
1,3	Selected hoist rope characteristics						
	Rope typical model		Tiger Dyform 34LR/PI			Lock Coil	Lock Coil
	Steel grade	N/mm2	1 770	1 770	1 860	High Grade	High Grade
	Diameter	mm	58	65	65	65	65
	Minimum breaking strength	KN	2 670	3 240	3 590	3 817	3 817
		kg	272 264	330 388	366 078	389 226	389 226
	Uni weight	kg/m	17,0	21,4	21,4	23,8	23,8
	Total weight (1 000 metres)	kg	17 000	21 400	21 400	23 800	23 800
2,0	Safety factors analysis						
2,1	At conveyance attachment (min. SF = 7,5)						
	Cable breaking strength	kg	272 264	330 388	366 078	389 226	389 226
	Weight under attachment	kg	28 383	36 161	43 939	43 939	51 717
	Safety factor		9,6	9,1	8,3	8,9	7,5
	check		ok	ok	ok	ok	ok
2,2	At the sheave wheel (min. FS = 5,0)						
	Cable breaking strength	kg	272 264	330 388	366 078	389 226	389 226
	Weight under sheave	kg	45 383	57 561	65 339	67 739	75 517
	Safety factor		6,0	5,7	5,6	5,7	5,2
	Check		ok	ok	ok	ok	ok
3,0	Minimum hoist drum diameter						
	Hoist rope diameter	mm	58	65	65	65	65
	Minimum Ratio D:d (regulation article 312)		80	80	80	100	100
	Drum minimum diameter	mm	4 640	5 200	5 200	6 500	6 500
		inches	183	205	205	256	256
		feet	15,2	17,1	17,1	21,3	21,3

Notes:

1) Hoist cables information are taken from Wire Rope Industries on line catalog (march 2020).
https://www.bridon-bekaert.com/en-us/steel-and-synthetic-ropes/underground-mining
2) Minimum safety factors are taken from Quebec regulations S-2.1, r.14 , articles 288 and 288.1
3) D = hoist drum diameter, d = hoist rope diameter.
4) Cables for 25 and 30 tonnes scenarios are near cable industry's limits. A blair hoist should be considered.
5) Conversion kg to KN KN/kg 0,009807

Tiger Full Lock

Winding Rope



Lay Type		Lay Direction		Finish		Core		
Ord	Langs	Right Hand	Left Hand	Bright	Galv	NFC	SFC	WSC
		•	•	•	•			

Available as standard. Variable Torque and Turn characteristics available by design

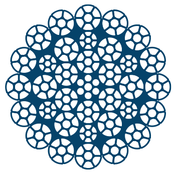
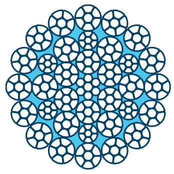
Nominal Diameter	Nominal Length Mass	Calculated Aggregate Breaking Force		Calculated Minimum Breaking Force	
		Standard Grade	Higher Grade	Standard Grade	Higher Grade
mm	kg/m	kN	kN	kN	kN
16	1.44	261	281	218	234
17	1.63	261	281	218	234
18	1.83	331	355	276	297
19	2.04	368	395	307	330
21	2.49	449	483	375	403
21.5	2.60	465	500	388	417
22	2.73	493	530	412	443
24	3.25	587	631	490	527
26	3.81	689	740	575	618
27	4.11	743	798	620	667
29	4.74	856	921	715	769
30	5.08	916	985	765	822
31	5.42	928	998	775	833
32	5.78	1043	1121	871	936
33	6.14	1109	1192	926	995
35	6.91	1246	1339	1040	1118
37	7.72	1398	1502	1167	1255
37.5	7.93	1422	1528	1187	1276
38	8.14	1468	1578	1226	1318
40	9.02	1634	1756	1364	1466
40.5	9.25	1668	1793	1393	1497
41	9.48	1715	1844	1432	1539
42	9.95	1798	1932	1501	1614
43	10.40	1880	2021	1570	1688
44	10.90	1974	2122	1648	1772
45	11.40	2068	2223	1727	1857
46	11.90	2162	2324	1805	1940
47	12.50	2244	2413	1874	2015
48	13.00	2350	2526	1962	2109
49	13.50	2443	2626	2040	2193
51	14.70	2655	2854	2217	2383
52	15.00	2738	2943	2286	2457
53	15.80	2867	3082	2394	2574
54	16.40	2972	3195	2482	2668
55	17.00	3055	3284	2551	2742
56	17.70	3195	3435	2668	2868
57	18.30	3313	3561	2766	2973
59	19.60	3501	3763	2923	3142
60	20.30	3630	3902	3031	3258
62	21.70	3865	4155	3227	3469
64	23.10	4123	4433	3443	3701
65	23.80	4253	4572	3551	3817

The nominal length mass values are for fully lubricated ropes.

Read Product Safety Instructions and Warnings on the use of steel wire rope before selecting or using this product.

Tiger Dyform 34LR/PI

Hoist Rope

Lay Type		Lay Direction		Finish		Core
Ord	Langs	Right Hand	Left Hand	Bright	Galv	WSC
•	•	•	•	•	•	•

Diameter	Approx Mass	Calculated Aggregate Breaking Force					Calculated Minimum Breaking Force				
		1570 N/mm²	1770 N/mm²	1860 N/mm²	1960 N/mm²	2160 N/mm²	1570 N/mm²	1770 N/mm²	1860 N/mm²	1960 N/mm²	2160 N/mm²
mm	kg/m	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
19	1.82	322	364	382	403	444	248	280	294	310	342
20	2.02	357	403	423	446	492	275	310	326	343	379
21	2.22	394	444	467	492	542	303	342	359	379	417
22	2.44	432	488	512	540	595	333	375	394	416	458
23	2.67	473	533	560	590	650	364	410	431	454	501
24	2.90	515	580	610	643	708	396	447	469	495	545
25	3.15	559	630	662	697	769	430	485	509	537	592
26	3.41	604	681	716	754	831	465	524	551	581	640
27	3.68	652	735	772	814	897	502	566	594	626	690
28	3.96	701	790	830	875	964	539	608	639	674	742
29	4.24	752	848	891	939	1030	579	652	686	723	796
30	4.54	804	907	953	1000	1100	619	698	734	773	852
31	4.85	859	969	1010	1070	1180	661	746	784	826	910
32	5.17	915	1030	1080	1140	1260	705	795	835	880	970
33	5.49	974	1090	1150	1210	1340	750	845	888	936	1030
34	5.83	1030	1160	1220	1290	1420	796	897	943	993	1090
35	6.18	1090	1230	1290	1360	1500	843	951	999	1050	1160
36	6.54	1150	1300	1370	1440	1590	892	1000	1050	1110	1220
37	6.91	1220	1380	1450	1520	1680	942	1060	1110	1170	1290
38	7.28	1290	1450	1530	1610	1770	994	1120	1170	1240	1360
39	7.67	1360	1530	1610	1690	1870	1040	1180	1240	1300	1440
40	8.08	1430	1610	1690	1780	1960	1100	1240	1300	1370	1510
41	8.50	1480	1670	1760	1850	2040	1140	1280	1350	1420	1570
42	8.92	1550	1750	1840	1940	2140	1200	1350	1420	1490	1650
43	9.35	1630	1840	1930	2040	2240	1250	1410	1490	1570	1730
44	9.79	1710	1920	2020	2130	2350	1310	1480	1560	1640	1810
45	10.2	1790	2010	2120	2230	2460	1370	1550	1630	1720	1890
46	10.7	1870	2100	2210	2330	2570	1440	1620	1700	1790	1980
47	11.2	1950	2200	2310	2430	2680	1500	1690	1780	1870	2060
48	11.6	2030	2290	2410	2540	2800	1560	1760	1850	1950	2150
49	12.1	2120	2390	2510	2640	2920	1630	1840	1930	2040	2240
50	12.6	2210	2490	2610	2750	3040	1700	1910	2010	2120	2340
51	13.2	2290	2590	2720	2870	3160	1770	1990	2090	2210	2430
52	13.7	2390	2690	2830	2980	3280	1840	2070	2180	2290	2530
53	14.2	2480	2790	2940	3090	3410	1910	2150	2260	2380	2630
54	14.7	2570	2900	3050	3210	3540	1980	2230	2350	2470	2730
55	15.3	2670	3010	3160	3330	3670	2050	2320	2430	2570	2830
56	15.9	2770	3120	3280	3460	3810	2130	2400	2520	2660	2930
57	16.4	2870	3230	3400	3580	3950	2210	2490	2620	2760	3040
58	17.0	2970	3350	3520	3710	4090	2280	2580	2710	2850	3150
59	17.6	3070	3460	3640	3840	4230	2360	2670	2800	2950	3250
60	18.2	3180	3580	3770	3970	4370	2450	2760	2900	3050	3370
61	18.8	3280	3700	3890	4100	4520	2530	2850	3000	3160	3480
62	19.4	3390	3830	4020	4240	4670	2610	2940	3090	3260	3590
63	20.1	3500	3950	4150	4380		2700	3040	3200	3370	
64	20.7	3620	4080	4280	4520		2780	3140	3300	3480	
65	21.4	3730	4210	4420	4660		2870	3240	3400	3590	

The nominal length mass values are for fully lubricated ropes.

Read Product Safety Instructions and Warnings on the use of steel wire rope before selecting or using this product.

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # **PRB_15T**

CAS #:	BASE	1	2	3	4	5
Profondeur de chargement (pi)	3150	3150				
Diamètre du câble (po)	2.25	2.00				
Nombre de couches	2.29	2.12				
Poids du câble dans le puits (lb)	38834	23300				
Poids du skip (lb)	19500	19500				
Poids de la cage (lb)	4500	4500				
Charge utile (lb)	33068	33068				
Poids maximal suspendu (lb)	95902	80368				
Charge maximale permise (lb)	79000	79000				
Vitesse (pi/s)	36.0	36.0				
Temps total pour le demi cycle (s)	131.5	131.5				
Tonnage (Tn/h)	453	453				
Type d'acier du câble	haute résistance	haute résistance				
Résistance du câble (lb)	600229	428000				
F.S. à la molette (min 5.0)	6.3	5.3				
F.S. à l'attache (min 8.5)	10.5	7.5				
Puissance requise						
"AC" (hp-rms)	3825	3327				
"DC" (hp-rms)	3591	3124				
Ventilé (hp- rms)	3344	2909				
Puissance actuelle (hp-rms)	3426	3426				

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_15T

CAS #:	BASE	6	7	8	9	10
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2.25					
Nombre de couches	2.29					
Poids du câble dans le puits (lb)	38834					
Poids du skip (lb)	19500					
Poids de la cage (lb)	4500					
Charge utile (lb)	33068					
Poids maximal suspendu (lb)	95902					
Charge maximale permise (lb)	79000					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	453					
Type d'acier du câble	haute résistance					
Résistance du câble (lb)	600229					
F.S. à la molette (min 5.0)	6.3					
F.S. à l'attache (min 8.5)	10.5					
Puissance requise						
"AC" (hp-rms)	3825					
"DC" (hp-rms)	3591					
Ventilé (hp- rms)	3344					
Puissance actuelle (hp-rms)	3426					

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_20T

CAS #:	BASE	1	2	3	4	5
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2.50					
Nombre de couches	2.53					
Poids du câble dans le puits (lb)	48627					
Poids du skip (lb)	25600					
Poids de la cage (lb)	4500					
Charge utile (lb)	44100					
Poids maximal suspendu (lb)	122827					
Charge maximale permise (lb)	79000					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	604					
Type d'acier du câble	haute résistance					
Résistance du câble (lb)	728368					
F.S. à la molette (min 5.0)	5.9					
F.S. à l'attache (min 8.5)	9.8					
Puissance requise						
"AC" (hp-rms)	4879					
"DC" (hp-rms)	4581					
Ventilé (hp- rms)	4266					
Puissance actuelle (hp-rms)	3426					

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_20T

CAS #:	BASE	6	7	8	9	10
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2.50					
Nombre de couches	2.53					
Poids du câble dans le puits (lb)	48627					
Poids du skip (lb)	25600					
Poids de la cage (lb)	4500					
Charge utile (lb)	44100					
Poids maximal suspendu (lb)	122827					
Charge maximale permise (lb)	79000					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	604					
Type d'acier du câble	haute résistance					
Résistance du câble (lb)	728368					
F.S. à la molette (min 5.0)	5.9					
F.S. à l'attache (min 8.5)	9.8					
Puissance requise						
"AC" (hp-rms)	4879					
"DC" (hp-rms)	4581					
Ventilé (hp- rms)	4266					
Puissance actuelle (hp-rms)	3426					

Ressources naturelles Canada / Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_25T

CAS #:	BASE	1	2	3	4	5
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2,5 ~~[illegible]~~					
Nombre de couches	2,53 ~~[illegible]~~					
Poids du câble dans le puits (lb)	48627					
Poids du skip (lb)	30619					
Poids de la cage (lb)	4550					
Charge utile (lb)	55115					
Poids maximal suspendu (lb)	138911					
Charge maximale permise (lb)	140000					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	755					
Type d'acier du câble	HR					
Résistance du câble (lb)	807050					
F.S. à la molette (min 5.0)	5.8					
F.S. à l'attache (min 8.5)	8.9					
Puissance requise						
"AC" (hp-rms)	5874					
"DC" (hp-rms)	5515					
Ventilé (hp- rms)	5135					
Puissance actuelle (hp-rms)	7988					

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_30T

CAS #:	BASE	1	2	3	4	5
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2.50					
Nombre de couches	1.64					
Poids du câble dans le puits (lb)	54032					
Poids du skip (lb)	36743					
Poids de la cage (lb)	4550					
Charge utile (lb)	66137					
Poids maximal suspendu (lb)	161462					
Charge maximale permise (lb)	164006					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	905					
Type d'acier du câble	HR					
Résistance du câble (lb)	858082					
F.S. à la molette (min 5.0)	5.3					
F.S. à l'attache (min 8.5)	8.0					
Puissance requise						
"AC" (hp-rms)	6936					
"DC" (hp-rms)	6512					
Ventilé (hp- rms)	6064					
Puissance actuelle (hp-rms)	8000					

Ressources naturelles Canada Natural Resources Canada

MACHINE À TAMBOUR DOUBLE

TABLEAU COMPARATIF - PRODUCTION (comp. gauche considéré)

TREUIL # PRB_30T

CAS #:	BASE	6	7	8	9	10
Profondeur de chargement (pi)	3150					
Diamètre du câble (po)	2.50					
Nombre de couches	1.64					
Poids du câble dans le puits (lb)	54032					
Poids du skip (lb)	36743					
Poids de la cage (lb)	4550					
Charge utile (lb)	66137					
Poids maximal suspendu (lb)	161462					
Charge maximale permise (lb)	164006					
Vitesse (pi/s)	36.0					
Temps total pour le demi cycle (s)	131.5					
Tonnage (Tn/h)	905					
Type d'acier du câble	HR					
Résistance du câble (lb)	858082					
F.S. à la molette (min 5.0)	5.3					
F.S. à l'attache (min 8.5)	8.0					
Puissance requise						
"AC" (hp-rms)	6936					
"DC" (hp-rms)	6512					
Ventilé (hp- rms)	6064					
Puissance actuelle (hp-rms)	8000					

APPENDIX 4

Skip Capacity vs Timber Guides Analysis

Services Miniers PRB Inc.
Projet Chimo
Hoisting capacity
Skip/cage capacity for timber guides
r20200204

1,0	**Input**					
	Guides					
	Assumed capacity of a 6" x 8" guide is 15 000 lbs					
	Capacity limit for					
	2 guides =	30 000	lbs	=	13 636	kg
	4 guides =	60 000	lbs	=	27 273	kg
	Cage					
	Maximum number of persons (article 331)				5,25	ch/m2/deck
	Nominal person weight				200	lbs/personne
	Assumed cage weight				390	lbs/personne
	Skip					
	Assumed load to skip weight ratio				1,8	
2,0	**Analysis for 2 guides**					
2,1	Max weight of skip/cage/allowable persons				30 000	lbs
2,2	Cage for 5' 0" x 5' 6" compartment					
a)	Charge utile des personnes					
	Number of decks				2	decks
	Floor area				1,62	m2/plancher
	Allowable number of persons				5,25	ch/m2/deck
	(S-2.1, r.14 article 331)				9	ch/deck
					18	ch total
	Weight of allowable number of persons				200	lbs/personne
					3 600	lbs Total
b)	Cage weight				7 020	lbs
c)	Total weight cage & persons				10 620	lbs
2,3	Skip					
	Max weight of skip/cage/allowable persons				30 000	lbs
	Less weight of cage & persons				10 620	lbs
	Allowable skip weight				19 380	lbs
	Assumed load to skip weight ratio				1,8	
	Maximum skip capacity				34 884	lbs
					15 856	kg
3,0	**Analysis for 4 guides**					
3,1	Max weight of skip/cage/allowable persons				60 000	lbs
3,2	Cage for 5' 0" x 5' 6" compartment					
a)	Charge utile des personnes					
	Number of decks				4	decks
	Floor area				1,62	m2/plancher
	Allowable number of persons				5,25	ch/m2/deck
	(S-2.1, r.14 article 331)				9	ch/deck
					36	ch
	Weight of allowable number of persons				200	lbs/ch
					7 200	lbs Total
b)	Cage weight				14 040	lbs
c)	Total weight cage & persons				21 240	lbs
3,3	Skip					
	Max weight of skip/cage/allowable persons				60 000	lbs
	Less weight of cage & persons				21 240	lbs
	Allowable skip weight				38 760	lbs
	Assumed load to skip weight ratio				1,8	
	Maximum skip capacity				67 830	lbs
					30 832	kg

APPENDIX 5

Fall Arrest Systems

Cage Guardian Brake System

Lock N Load System

Cage Guardian™ Safety Brake

Reliable cage-occupant protection

FLSmidth

WE DISCOVER POTENTIAL

Keep your people safe during suspension failure events

Suspension-failure events should never happen, but if they do, you want a safety brake system that you can count on. Unfortunately, not all safety brakes are up to the task. Wooden guides are subject to moisture and defect issues and have to be immediately replaced after every safety catch event. Add to that the fact that high-quality, consistent timber guides are becoming ever more difficult to obtain, and you're faced with some potentially dangerous and expensive problems.

Introducing the Cage Guardian™ Safety Brake solution from FLSmidth.

Built for control, longevity, reliability and low maintenance, the patent pending Cage Guardian Safety Brake system uses engineered steel guides and a self contained brake path. The end result? A reliable, *reusable* safety brake system that you can depend on.

Key benefits

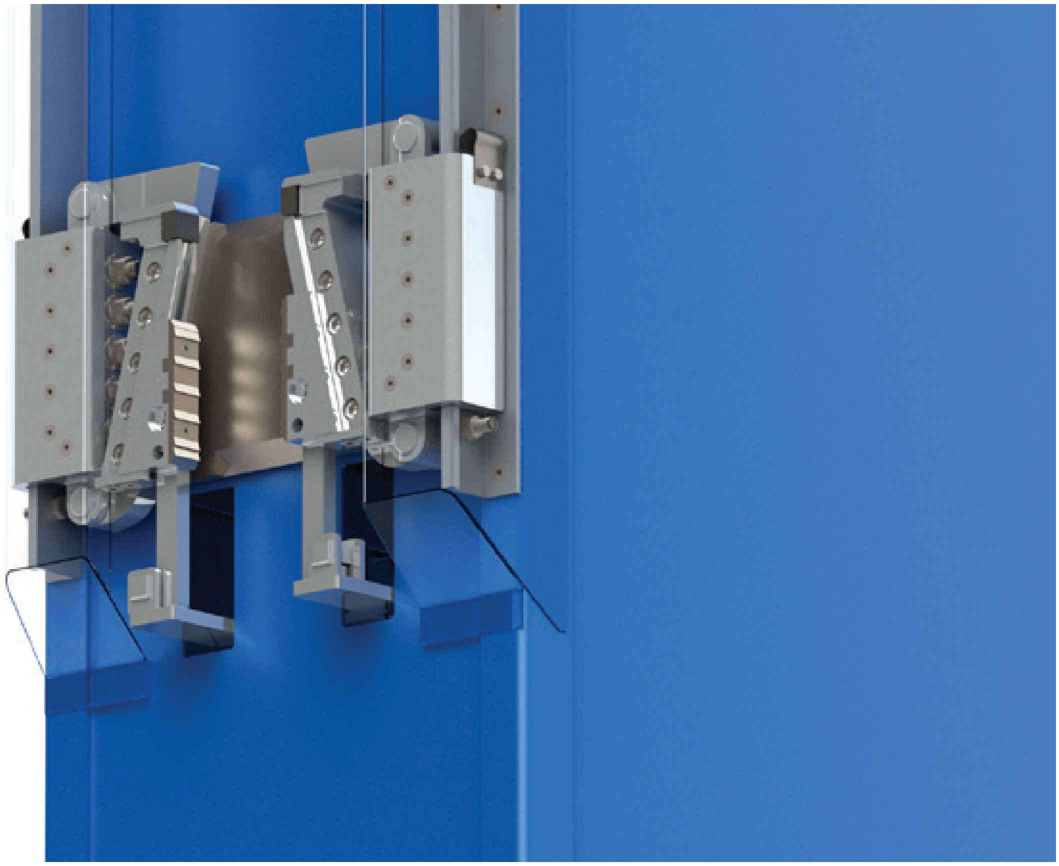
Actuates automatically upon suspension failure
Mechanical design ensures that the Cage Guardian Safety Brake system actuates automatically upon slack rope or other suspension failures.

Increased durability and reusability
Steel guides offer increased durability and reusability in the event of conveyance suspension failure. Simply retrieve the cage for later redeployment.

Meets strict mining safety regulations
The Cage Guardian Safety Brake solution is designed in accordance with some of the world's most stringent mine hoist safety regulations.

Incorporates multiple redundant mechanical systems
Using multiple redundant mechanical systems — free from hydraulic, pneumatic or electrical components relying on external energy sources, the Cage Guardian Safety Brake solution ensures a secure ride for materials and cage occupants.

Usable under all personnel conditions
Whether the conveyance is carrying a single occupant, a fully loaded cage or anything in between, the Cage Guardian Safety Brake system will always perform optimally.



Superior Safety

Your people put a lot of trust in safety brake systems. FLSmidth makes sure that our systems are worthy of that trust. That's why we free-fall test every brake before we allow them to be used; every brake we offer is officially documented and certified, so you know that it's up to the task before you trust it to protect your people. And, in the unlikely event that part of the brake fails, multiple redundant mechanical systems ensure that the conveyance (and everyone it's carrying) comes to a safe stop. The Cage Guardian Safety Brake system uses a progressively increasing brake force with average deceleration rates of .9g to 2g (9 to 20 m/s/s) (29.5 to 65.6 ft/s/s, meaning cage occupants are significantly less likely to experience the kinds of injuries that come from sudden stops.

Reduced maintenance and repair costs

Occupants should be your primary concern during suspension failure events. But your equipment and infrastructure is often at risk as well. Traditional safety catch systems can incur some serious damage, and when coupled with the day-to-day wear and corrosion of the mine-shaft environment, mining companies often end up spending significant amounts on safety catch repair and maintenance.

By employing engineered steel guides, the Cage Guardian Safety Brake system offers durability unmatched by safety catches and timber guides. And when slack-rope and rope-break events do occur, components are designed to deploy without taking any damage; simply retrieve the cage back to surface, inspect, and reset the brake in preparation for any further event(s). Durable and reusable, the Cage Guardian Safety Brake solution provides a cost-effective alternative to traditional safety brake repair and maintenance expenses.

Reliable mechanical design

You shouldn't have to depend on outside power sources to keep your people protected. The Cage Guardian Safety Brake system is completely mechanical. In the event of suspension failure, the weight of the cage itself causes the safety brake to actuate, holding the cage securely in place to await retrieval. There are no hydraulic, pneumatic or electrical components in the brakes themselves, and no external energy source is required.

This mechanical design not only allows for effective braking under all conditions, it also averts the risk of malfunction commonly associated with hydraulic and pneumatic components. This means a more secure system overall, as well as fewer repair costs for your business.

Bringing better solutions to light

in the cement and mining industries

The future is full of possibilities and you are leading the way. But it's never a straight journey and it's easy to lose sight of true potential. With an ally by your side who shares your ambitions and who sees your world from different angles, we will find the right way together.

For more than 135 years, we have challenged conventions and explored opportunities. Across more than 50 countries, we are 13,000 employees who combine our unique process-knowledge on projects, products and services to drive success. We develop the most advanced technology in our industries and offer market-leading product and service ranges.

Rooted in Danish values, we employ our knowledge and experience to navigate your complexity and bring better solutions to light. So no matter where in the world you are, we are here to help you discover new ground and achieve sustainable productivity enhancement.

We are the market-leading supplier of engineering, equipment and service solutions to customers in the global mining and cement industries.

We discover potential.

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FLSmidth

Vigerslev Allé 77
2500 Valby
Denmark

Tel +45 36 18 10 00
Fax +45 36 30 18 20

info@flsmidth.com

M 04-19 8000-4-ENG

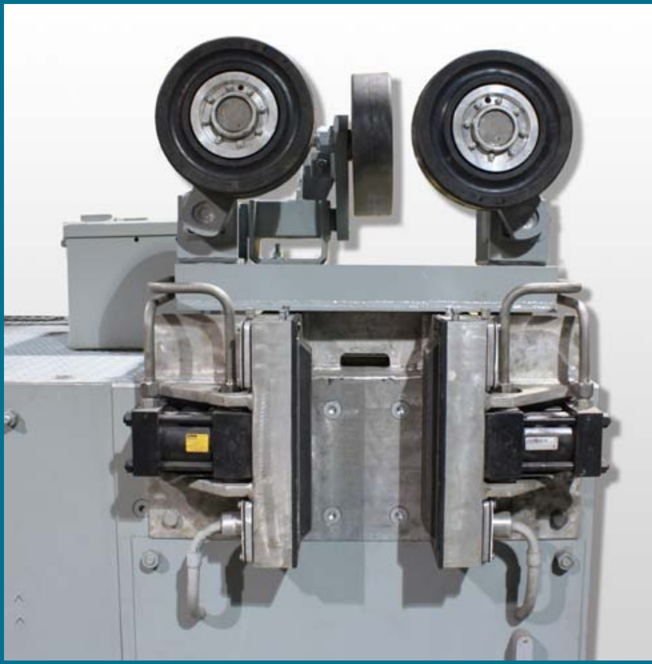
Lock-N-Load®

Cage with clamps

Cage Chairing

Holds cage steady during load transfer

- Fast clamping time (under one second)
- Advanced technology, lightweight hydraulic clamps (95 kg each)
- Battery powered – no external power source required
- Interlocked with hoist controls to prevent inadvertent activation or release



Lock-N-Load clamp

Underground Station Control Panel

Lock-N-Load® systems utilize the very latest technology to help improve safety and productivity when loading/off-loading cages. Very fast clamping times (under one second) provide for rapid loading of material. The ultra lightweight clamps minimize total system weight. Proportional control valves provide for a controlled clamp release on system deactivation as the conveyance takes up the resultant rope stretch. No external power source is required. Battery life in excess of 100 cycles expected under normal use.

ECAT Emergency Conveyance Arresting Technology

Safely arrests cage after rope severance or slack rope condition

- Replaces outdated "safety dogs"
- Operates with steel shaft guides
- Deceleration complies with Ontario OHSA 232(8)
- A single combined chairing and arresting system provides significant weight saving

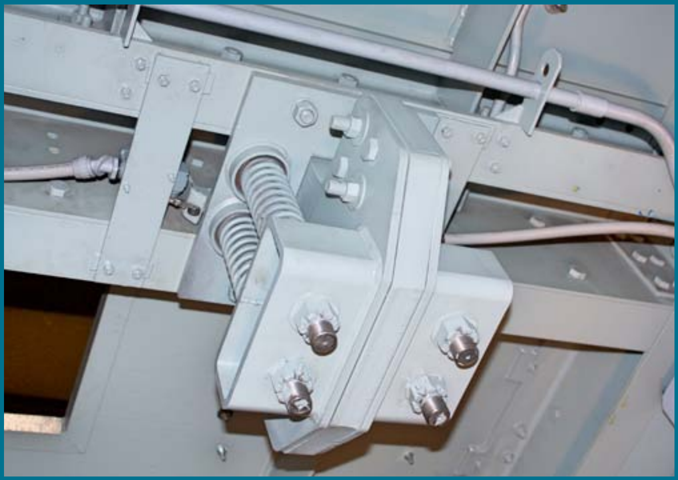
Using proven technology, the ECAT system has been designed to operate as simply as possible while providing an effective measure of protection in arresting the fall of a cage after rope severance.

Deceleration rates provided are tolerable to the human body and comply to Ontario OHSA regulations. The system has been comprehensively tested.

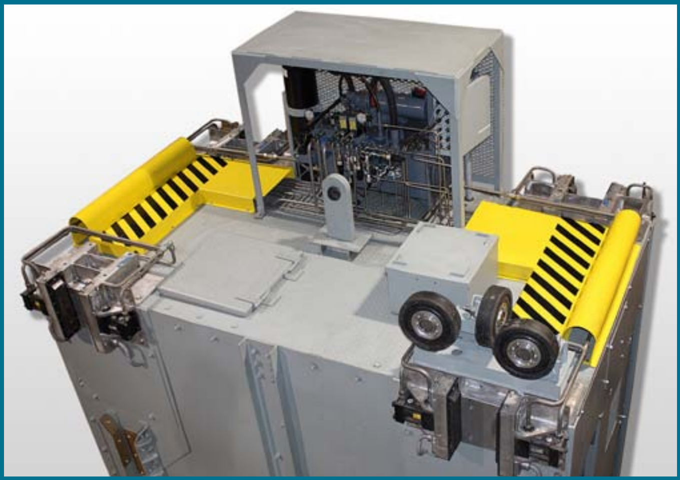
Rope severance is detected by a limit switch located in the drawbar, which triggers activation of the ECAT, and allows hydraulic pressure to be released from the accumulators to the hydraulic clamps.

Built-in redundancy includes:

- Two times clamp capacity safety factor
- Two independent hydraulic circuits
- Two (primary and secondary) fall arrest activation switches



ECAT activation mechanism



Top of cage

wabi
Reputation Earned

Wabi Iron & Steel Corp.
Head Office and Manufacturing Facility:
330 Broadwood Ave.
New Liskeard ON Canada P0J 1P0

Tel: 705.647.4383
Fax: 705.647.6954
E-mail: sales@wabicorp.com
Web: wabicorp.com