ENVIRONMENTAL SCIENCE ASSOCIATES

California

Santa Susana Field Laboratory

Ropeway feasibility study

02	23/10/2015	27	Added planning, par 8.1 and 10	Cattaneo	Contin
01	18/09/2015	21	Added paragraph 6	Cattaneo	Contin
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1 FOREWORD

This feasibility study has been prepared by Leitner S.p.A - Agudio material transportation division, technical competence center specialized in material transportation systems on ropes.

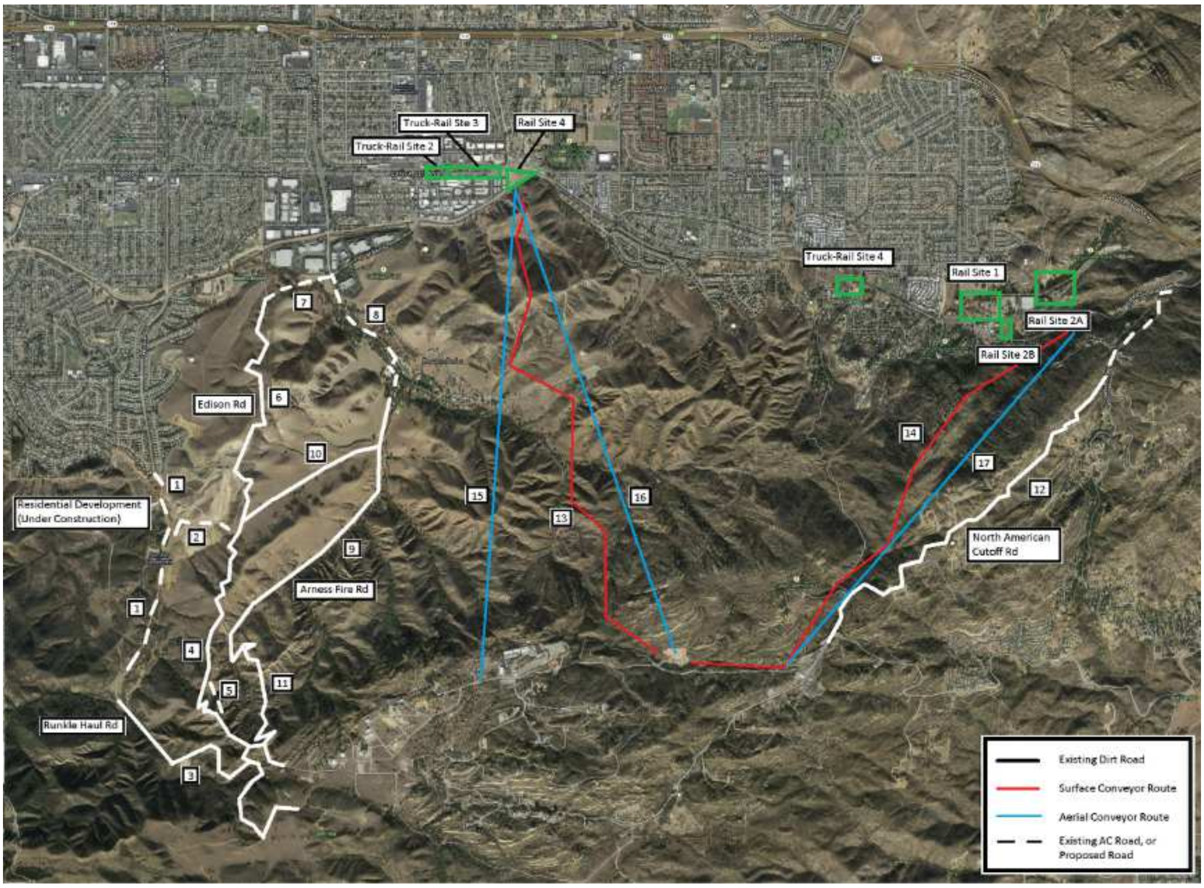
The feasibility study analizes the application of two different rope hauled systems (Material Ropeway and Flyingbelt) to transport the soil removed from Santa Susana Field Laboratory during the remediation activities.

Basis of the study is the transportation downhill of the soil removed from the site.

For each technical solution, ropeways and Flyingbelt, the possibility of a bi-directional transportation has been investigated (for details see the general technical description).

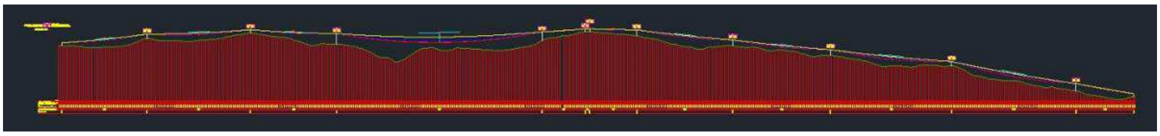
2 PROJECT OVERVIEW

According to the map received from the Client three possible routes have been investigated: 15, 16 and 17.



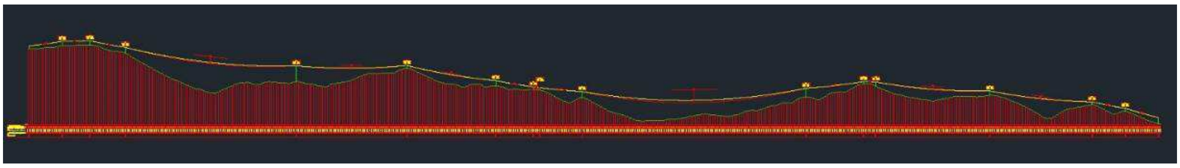
Each profile has been analysed in order to evaluate the suitability to install a rope hauled system and pro-and-cons of each profile:

➢ Section 17: this is the best route for both ropeway and Flyingbelt due to the regular slope.



➢ Section 16: along this route there are large valleys with high rises and slope changes; a ropeway along this route requires very high supporting towers and bigger and heavier ropes to guarantee the stability of the system. Moreover, along this route the Flyingbelt is not feasible because the rise and slope angle in some sections is higher than the maximum allowed for the transported material.

➢ Section 15: this route has valleys but not as large and deep as section 16, therefore it is possible to design a ropeway or a Flyingbelt even if more and taller support towers are required to make the section more regular.



3 KEY ASSUMPTIONS

Based on the input data received from ESA (total amount of 1,466,000 BCY and 735 BCY/day approx.) we made the following calculation:

- 1,466,000 BCY tot
- 21 days/month
- 735 BCY/day approx.
- 8 hours/day
- 92 BCY/h
- 138 ton/h approx. - We assumed 170 ton/h as design parameter

<u>Notes:</u>

(1) *According to this data, the transportation system will be in operation for approx 8 years. and at the end of the remediation project the system will be dismantled with minimum impact on the surrounding environment.*

(2) *According to the information received from ESA, the excavated soil has NO special containment requirements; therefore it will be transported in bulk.*

(3) *The ropeway it is designed to operate for 8 hours/day at a constant flow rate; therefore suitable storages at loading and unloading stations must be foreseen as decoupling points between:*

- *excavation operations and ropeway loading at the uphill station*
- *ropeway unloading and train loading operations at downhill station.*

4 INTRODUCTION TO ROPEWAY AND FLYINGBELT

4.1 Ropeway

The basic configuration of the material ropeway is a bi-directional system on route 17 with loading (rotary feeder) and unloading (ground grid) systems installed in both up-hill and downhill stations (see typical layout of the stations).

The system is fully automated and it is easily possible to switch from a mono-directional (up-hill or downhill) to a bi-directional system.

Moreover, as an option, it will be possible to insert a washing section (approx. 6 meters long) for buckets before loading clean soil. The washing section will be equipped with high-pressure nozzles and drying fans, it will be in-line and buckets will not stop in that section.

Buckets can be coupled with a cover in order to minimize dust dispersion and material spillage during transportation.

Details about line calculation and ropeway technical data are provided in the annex documents.

4.2 Flyingbelt

The basic configuration of the Flyingbelt is the down-hill direction on route 17.

The option of a bi-directional system able to bring both, removed and clean soil has been investigated. This solution is more complex in terms of loading and unloading stations due to the need of increasing the distance between the belts in order to place the loading system of the clean soil. The bi-directional Flyingbelt can work to transport downhill the material or to bring soil in both directions at the same time, but not to bring uphill only.

The option that is maximizing the flexibility and independence of the two systems is to install two separate Flyingbelt (one for removed soil and one for clean soil) that can be placed along the same route or in two different routes (i.e. 17 and 15).

A great advantage of the Flyingbelt is to connect the loading point with the unloading point with one single belt instead of a series of conventional overland conveyors after the other minimizing the number of stops due to failure of rubber belt and/or idlers and/or electrical motors maximizing the availability of the system.

Details about Flyingbelt technical data are provided in the annex document.

5 CONSTRUCTABILITY

High flexibility of both the material transportation system, makes it possible during the detailed engineering to change the number and the position of supporting towers in order to reach easily accessible points.

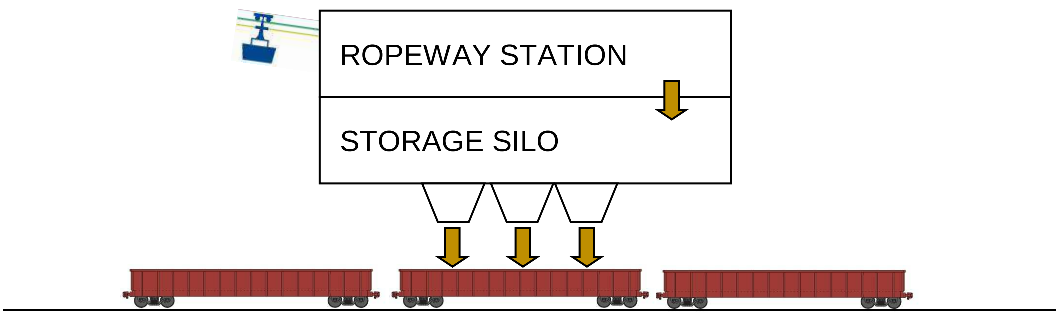
In the event that easy line access is not be possible, alternatives such as temporary access road, helicopters or temporary cable cranes/ropeways could be investigated to transport equipment (cranes and excavators) and material (concrete and steel structures).

For the preliminary study of this phase, and for CAPEX estimate, the assumption of easy access has been utilized, a detailed constructability report, with the relevant cost estimate, will be prepared during the detailed engineering.

6 UNLOADING BAY

As a result of the feasibility study, the preferred route, for both the ropeway and the Flyingbelt, is route #17 which arrives at Rail site #2B where material is stored and then loaded on a train:

In order to minimize the handling of contaminated material it is possible to discharge directly from the ropeway into a horizontal silo and then into gondola railcars with the end result being a multi-level ropeway station:



For more details about the multi-level station see the relevant attachment.

This multi-level solution also minimizes the surface area required for the station+storage, which is an important aspect to take into account considering the shape of Rail site #2B (which is a small a strip of land beside the existing railway).

From a civil works point of view, this solution is more demanding because the concrete structure must be designed to withstand the tensions of the ropes and not simply the weight of the ropeway and the stored material.

Of course, as an option it is also possible to study a horizontal configuration with storage beside the ropeway and a lighter civil structure.

Note:

There are several aspects to be evaluated in order to achieve the optimal solution: ropeway, material handling, available land, new railway design, typology of gondola cars, etc. Therefore, a multi-disciplinary workshop is recommended to review the assumptions to this feasibility study.

Since the ropeway is designed as bi-directional, able to bring clean soil uphill, a conveyor system to bring material from the storage area into the automatic rotating feeder is expected.

7 ESTIMATED CAPEX

7.1 Ropeway

In the CAPEX estimate the electromechanical supply of all the equipment required for the realization of the ropeway as well as all the relevant services is included.

Below is a short description of what is included in the estimate:

7.1.1 Services

SERVICES - Detailed engineering preparation, including: Line calculation; Calculation notes with loads acting on foundations; Layouts: general, loading point, unloading point, intermediate stations; Equipment data sheet; Instrument list; Control philosophy; Electrical wiring diagrams; User manual and maintenance manual.

SERVICES - Rope stringing including installation and tensioning of ropes executed by a team of skilled and certified technicians with specialized tools (Linear winch, Pressure pulley winch, Special grip with tackles, Track and hauling rope reel stand with brake). These tools must be operated by erection specialists, in order to guarantee the safety of the erection operation and the performances of ropeway.

SERVICES - Erection and installation activity performed by skilled field engineers and the the required mechanical / electrical manpower.

SERVICES – Pre-commissioning, commissioning and final load test executed by skilled field engineers and the required mechanical / electrical manpower.

Training of Client personnel appointed for operation and maintenance of the system.

7.1.2 Electromechanical supply

The estimate includes all the electromechanical equipment that will be installed inside the stations and along the line (battery limits are the foundations of the stations, the external walls of the stations and the foundations of supporting towers):

- Stations: Driving devices, winches; Tensioning devices; Rotating loading distributors; Offloading devices
- Line: Lattice structure of the towers; Saddles and rollers; Ropes
- Vehicles: Detachable grips; Plastic wheels for carriage; Hangers and buckets
- Electrical and control system including: power system with MCC, Inverters, AFE filters and PLC; Field motors; Field instruments, cables and wires between MCC/PLC and field motors/instruments

7.1.3 Civil works

Concrete works engineering (design, calculation reports, drawings, certification with local authorities) and execution (Foundations of supporting towers and loading/unloading stations)

7.1.4 Exclusions

The following goods and services are not included in this estimation:

- Buildings
- Electrical transformer(s) 440V – 60 Hz;
- Lighting system for night operation
- Alarming and firefighting system
- Any device to feed the rotary feeder (belts, hoppers, etc);
- Any device to collect and handle the unloaded material (belts, hoppers, etc)
- Storage of material before loading and after unloading
- Bridges or other protection structures for roads or other public ways;
- Not ordinary works to access foundations of supporting towers (roads, helicopter, cablecranes/ropeways)
- Local planning permission and operating permit;
- Local taxes and import duties for imported equipment from Italy.
- Operation and maintenance of the ropeway

7.1.5 Ropeway estimated CAPEX

The estimated budget CAPEX for detailed engineering services, supply of the electromechanical equipment CIF Los Angeles main port and supervision to installation, commissioning and start-up of the above described bi-directional Ropeway on route 17 is:

US$ 9.350.000,00 ± 15% - VAT excluded

Note: The price in US$ has been calculated on the basis of an exchange rate US$/euro of 1.1 and it is based on the price in euro of 8.500.000 euro, therefore the final price in US$ must be revised according to changes in such rate.

For installation, transport at site and civil works (excluding the multi-level unloading station) we estimate on the basis of our experience in similar projects and additional 20-25%.

Note: Civil works estimation is based on European standards for non-seismic areas.

7.2 Flyingbelt

In the CAPEX estimate, the electromechanical supply is inclusive of all the equipment required for the realization of the ropeway as well as all the relevant services.

Following a short description of what is included in the estimate:

7.2.1 Services

SERVICES - Detailed engineering preparation, including: Line calculation; Calculation notes with loads acting on foundations; Layouts: general, loading point, unloading point, intermediate stations; Equipment data sheet; Instrument list; Control philosophy; Electrical wiring diagrams; User manual and maintenance manual.

SERVICES - Rope stringing including installation and tensioning of ropes executed by a team of skilled and certified technicians with specialized tools (Linear winch, Pressure pulley winch, Special grip with tackles, Track and hauling rope reel stand with brake). These tools must be operated by erection specialists, in order to guarantee the safety of the erection operation and the performances of ropeway.

SERVICES - Erection and installation activity done by skilled field engineers and the required mechanical / electrical shift manpower.

SERVICES – Pre-commissioning, commissioning and final load test executed by skilled field engineers and required mechanical / electrical manpower.

Training of Client personnel appointed for operation and maintenance of the system.

7.2.2 Electromechanical supply

The estimate includes all the electromechanical equipment that will be installed inside the stations and along the line (battery limit are the foundations of the stations, the external walls of the stations and the foundations of supporting towers).

The following electromechanical equipment is included: Saddles and rollers; Tower metallic structure; Inspection platforms and protections; Ropes; Belt; Rollers and all mechanical devices for belt running; Upper covering for the entire belt length; Driving devices for belt and maintenance vehicle; Tensioning devices; Electric cables from electric delivery point; Electric cabinets with LV inverters; Electronic devices for belt and maintenance vehicle control; Spare parts kit.

7.2.3 Civil works

Concrete works engineering (design, calculation reports, drawings, certification with local authorities) and execution (Foundations of supporting towers and loading/unloading stations)

7.2.4 Exclusions

The following goods and services are not included in this estimation:

- Buildings
- Electrical transformer(s) 440V – 60 Hz;
- Lighting system for night operation
- Alarming and firefighting system
- Any device to feed the rotary feeder (belts, hoppers, etc);
- Any device to collect and handle the unloaded material (belts, hoppers, etc)
- Storage of material before loading and after unloading
- Bridges or other protection structures for roads or other public ways;
- Not ordinary works to access foundations of supporting towers (roads, helicopter, cablecranes/ropeways)
- Metal detectors or any other system to avoid the presence of metallic objects on the Flyingbelt.
- De-dusting filters, pipes, dust hoods, fans, silencers, etc..
- Local planning permission and operating permit;
- Local taxes of duties for imported equipment from Italy.
- Operation and maintenance of the ropeway

7.2.5 Flyingbelt estimated CAPEX

The estimated budget CAPEX for detailed engineering services, supply of the electromechanical equipment CIF Los Angeles main port and supervision to installation, commissioning and start-up of the above described downhill monodirectional Flyingbelt on route 17 is:

US$ 7.150.000,00 ± 15% - VAT excluded

Note: The price in US$ has been calculated on the basis of an exchange rate US$/euro of 1.1 and it is based on the price in euro of 6.500.000 euro, therefore the final price in US$ must be revised according to changes in such rate.

For installation, transport at site and civil works we estimate on the basis of our experience in similar projects and additional 15-20%

Note: The percentage relevant to installation and civil works is lower due to the fact that loading and unloading stations are smaller and faster to install.

Note: Civil works estimation is based on European standards for non-seismic areas.

The estimated budget CAPEX for detailed engineering services, supply of the electromechanical equipment CIF Los Angeles main port and supervision to installation, commissioning and start-up of the above described bi-directional Flyingbelt on route 17 is:

US$ 9.900.000,00 ± 15% - VAT excluded

Note: The price in US$ has been calculated on the basis of an exchange rate US$/euro of 1.1 and it is based on the price in euro of 9.000.000 euro, therefore the final price in US$ must be revised according to changes in such rate.

For installation, transport at site and civil works we estimate on the basis of our experience in similar projects and additional 15-20%.

8 TIME SCHEDULE

The estimated time to put into operation the system is 24 months approx.

Only for reference, the 24 month can be divided into:

- Engineering: 4-6 months from contract signature
- Material delivery at site: 10-14 months from contract signature
- Erection and installation: 18-22 months from contract signature
- Commissioning and start-up: 24 months from contract signature

For more detail see the attached project planning.

8.1 DETAILS ON ERECTION TEAMS COMPOSITION

The presence of the following erection skilled teams is required (refer to the planning for a better comprehension of the teams)

Station and towers preassembly and erection, teams CL1, CL2:

2 teams, each one composed by:

- 1 chief erector: senior erector (min. 10 years experience) English speaking
- 6 workers: capable to read drawings, use lifting devices with safety, use field measuring devices (i.e. digital inclinometer, meter), using power tools/electrical tools (wheel grinders, screwers, torque wrench); minimum 4 persons must be experienced in working in height; minimum 1 person must be experienced in high pressure hydraulic circuits wiring.
- 1 crane operator.

The 2 teams will be supervised by 1 or 2 Agudio senior erector (AG1 and AG2).

Assuming standard accessibility conditions to the erection areas (roads) and standard assembly means (cranes and not helicopters or temporary ropeways), each team must have at disposal 1 mobile crane 80 Tons x meter, 1 telescopic handler 3 Tons with fixed operator platform, a complete set of standard mechanical tools as mentioned before.

Electrical wiring, team CL3:

1 team, composed by:

- 1 chief electrician: senior electrician (min. 10 years experience) English speaking.

- 1 worker: will be capable to read drawings, electrical schemes and must be experienced in electrical wiring.

The team will be supervised by 1 or 2 Agudio senior electrical engineer (AG1 and AG2).

Ropes team CL4:

1 teams, composed by:

- 1 chief erector: senior erector (min. 10 years experience in ropes deployment and stringing) English speaking

- 10 workers: will be capable to read drawings, use lifting devices with safety, use field measuring devices (i.e. digital inclinometer, meter), using power tools/electrical tools (wheel grinders, screwers, torque wrench); minimum 3 persons must be experienced in ropes deployment and stringing; minimum 2 person must be experienced in the use of hydraulic winches.

The personnel of this team could be part of the teams CL1, CL2.

The team will be supervised by 1 or 2 Agudio senior erector (AG1 and AG2).

Assuming standard accessibility conditions to the erection areas (roads) and standard assembly means (cranes and not helicopters or temporary ropeways), the team must have at disposal min. 3 winches 10 Tons, a complete set of tackles up to 1200 kN tension and suitable for ropes up to 55 mm diameter, a complete set of pulleys, slings, tirfor etc…

9 ESTIMATED OPEX

Based on real cost from similar ropeways the following operation costs can be foreseen for 21 days/month, 8 hours/day operation:

Spare parts

Cost of spare parts (ropeway bi-directional): 225.000 US$/year

Cost of spare parts (Flyingbelt mono-directional): 165.000 US$/year

Cost of spare parts (Flyingbelt bi-directional): 275.000 US$/year

Maintenance hours: due to the fact that both the ropeway or flyingbelt will operate only 8 hours per day and 5 days per week, the inspection and minor maintenance intervention can be done on regular base during daily and weekly stops. For major intervention at 20 days per year stop must be foreseen

Energy consumption

Energy consumption: see tech data table provided for each solution

Personnel

Number of operators: even if the operation of both systems is fully automated a minimum of 1 person in each station is suggested to supervise the correct operation, mainly for loading/unloading operations.

10 NOISE LEVELS ON SIMILAR INSTALLATIONS

In 2009 Agudio commissioned a noise survey on an industrial aerial ropeway built in Italy in a cement production plant connecting the quarry to the production plant.

The result shows that ropeway technology has a really limited noise generation along the line. The highest levels of noise have been measured inside the loading and unloading station (due to the bucket movement, rollers and mainly material loading and unloading operation), but noise can be contained into the buildings in order to be compliant with local regulation in terms of noise pollution.

Noise measurements (LAIeq) were undertaken on the following ropeway sections:

- Along run of ropeway.

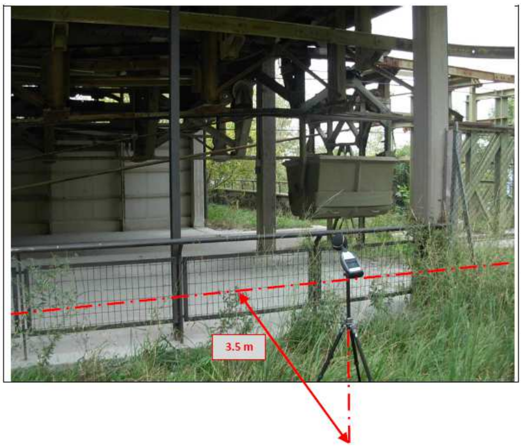
Pylon A: 62.3 dB

Pylon B: 60.5 dB

Between pylon A and B: 60.2 dB

- Bucket loading station (7 points)

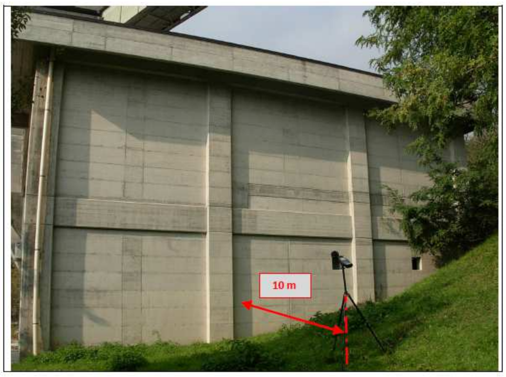
Incoming buckets 01 and 02: 83.7 dB



Inside: 80.9 dB

Outside 01: 76.6 dB

Outside 02: 65.3 dB

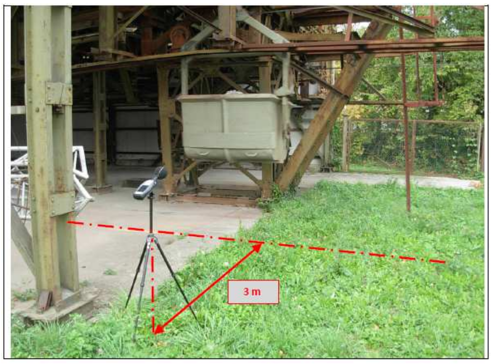


Outside 03: 71.0 dB

Inside 04: 93.1 dB

- Main drive house

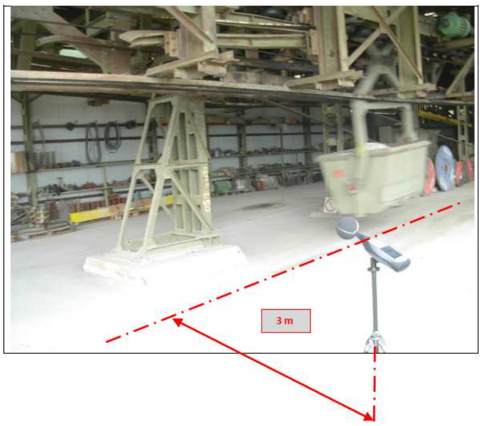
Incoming buckets: 83 dB



Inside: 83 dB

Inside – control room: 78.8 dB

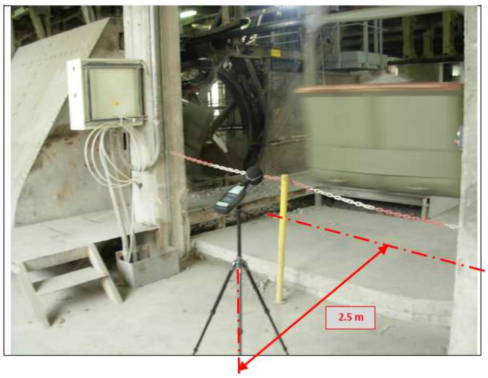
Outcoming buckets 01 and 02: 85.4 dB



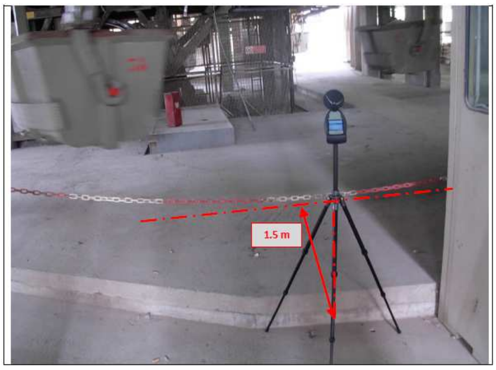
- Bucket off-loading station

Incoming buckets: 86.8 dB

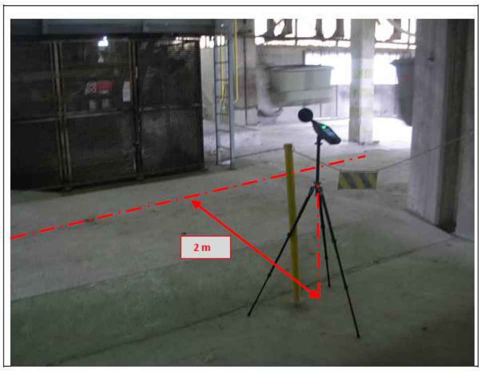
Inside 01: 92.9 dB



Inside 02: 92.1 dB



Inside 03: 88.5 dB



Note: In the stations the noise lever is affected by the loading and offloading operations, therefore different noise levels can be measured according the design, size, percentage of loading and location in the station.

During normal operation no personnel is working inside the station but personnel is supervising the operation inside the control room.

DATI TECNICI
TECHNICAL DATA

UBICAZIONE MOTRICE / POSITION OF DRIVE	MONTE / TOP	
UBICAZIONE TENDITRICE / POSITION OF TENSIONING	VALLE / BOTTOM	
LUNGHEZZA ORIZZONTALE / HORIZONTAL LENGTH	3631,3	m
DISLIVELLO / VERTICAL RISE	171,3	m
LUNGHEZZA SVILUPPATA / DEVELOPED LENGTH	3653,2	m
NUMERO SOSTEGNI / NUMBER OF TOWERS	10	
DIAMETRO FUNI PORTANTI / CARRYING ROPES DIAMETER	42	mm
DIAMETRO FUNI TRAENTI / HAULING ROPES DIAMETER	28	mm
NUMERO DI FUNI PORTANTI PER LA VIA DI CORSA / NUMBER OF CARRYING ROPES FOR RUNWAY	2	
POTENZA MAX. AZIONAMENTO PRINCIPALE / POWER MAX. OF MAIN DRIVE	280	kW
PORTATA TOTALE DEL SISTEMA PER OGNI SENSO DI MARCIA / TOTAL CAPACITY OF THE SYSTEM FOR EACH DIRECTION	340 - 500	t/h t/h
PORTATA PER OGNI SENSO DI MARCIA DEL SINGOLO IMPIANTO / CAPACITY FOR EACH DIRECTION FOR EVERY SINGLE SYSTEM	170 - 250	t/h t/h
VELOCITÀ IMPIANTO / OPERATING SPEED	4	m/s m/s
VELOCITÀ MASSIMA PASSAGGIO SOSTEGNO / MAX. SPEED CROSSING TOWER	4	m/s m/s
NUMERO TOTALE DEI VEICOLI / NUMBER OF CARRIERS	2	
CAPACITÀ DEL VEICOLO / CAPACITY OF THE VEHICLE	1,3	t t
TEMPO TOTALE / TOTAL TIME	1000	s s

DATA / DATE	NOME / NAME	CONTR. / CHECKED
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TLF ESA Ropeway - PROFILE 17

PAESE / COUNTRY: USA

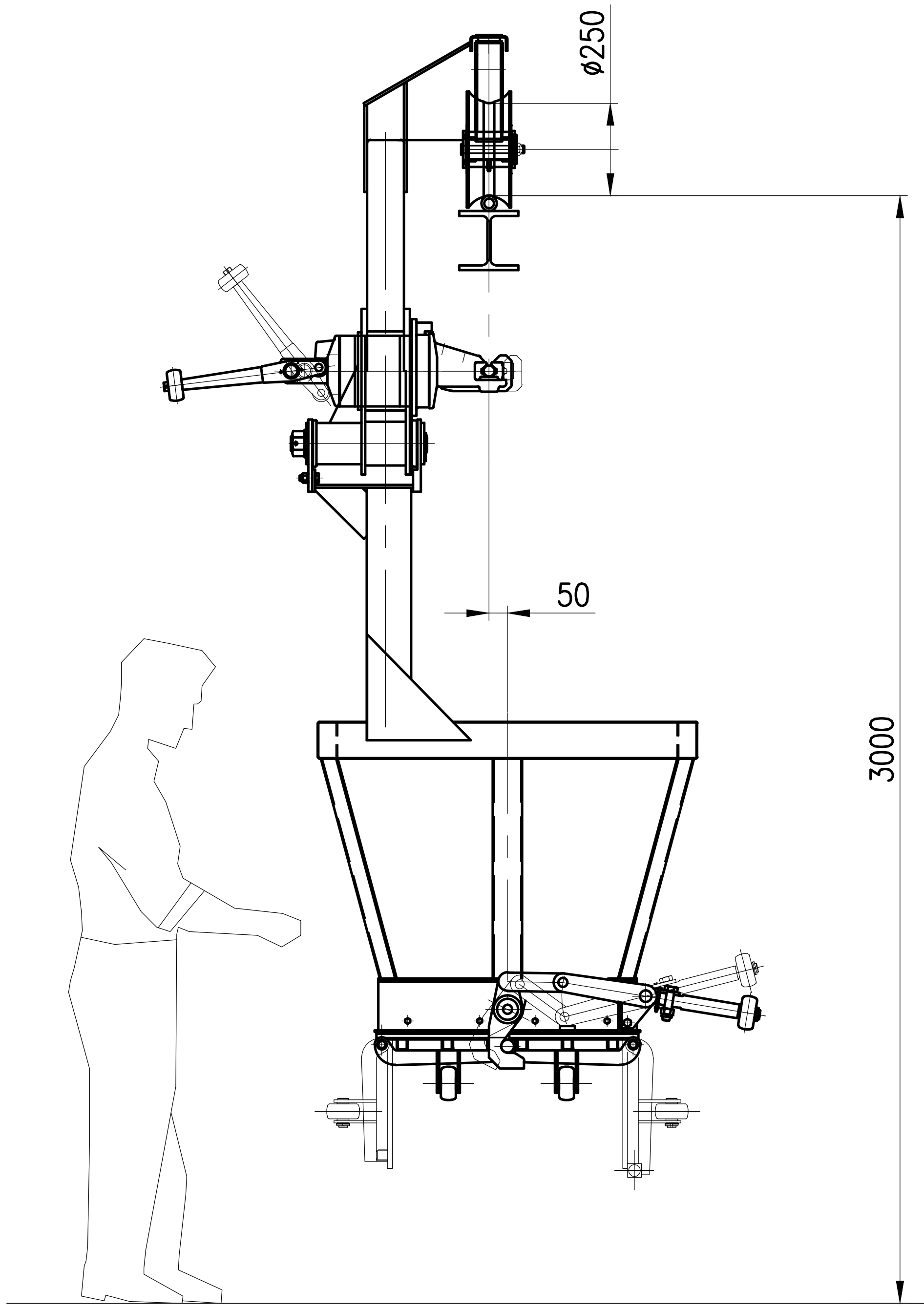
PROFILO LONGITUDINALE
LONGITUDINAL PROFILE

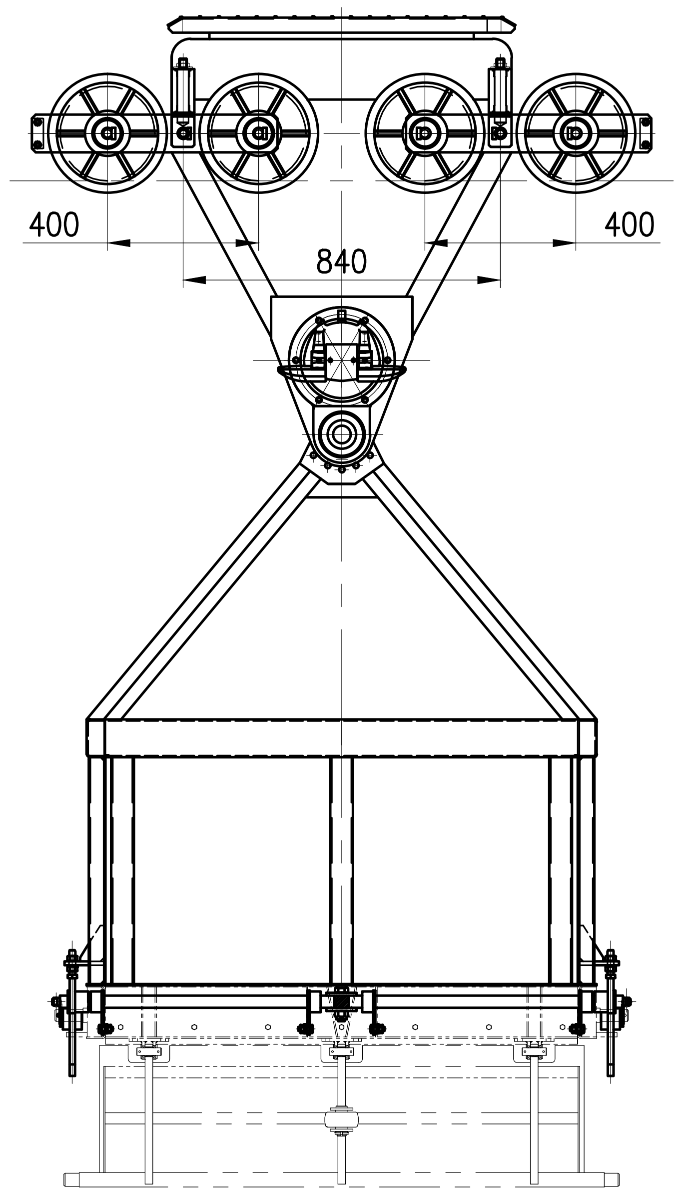
-

LEITNER ropeways

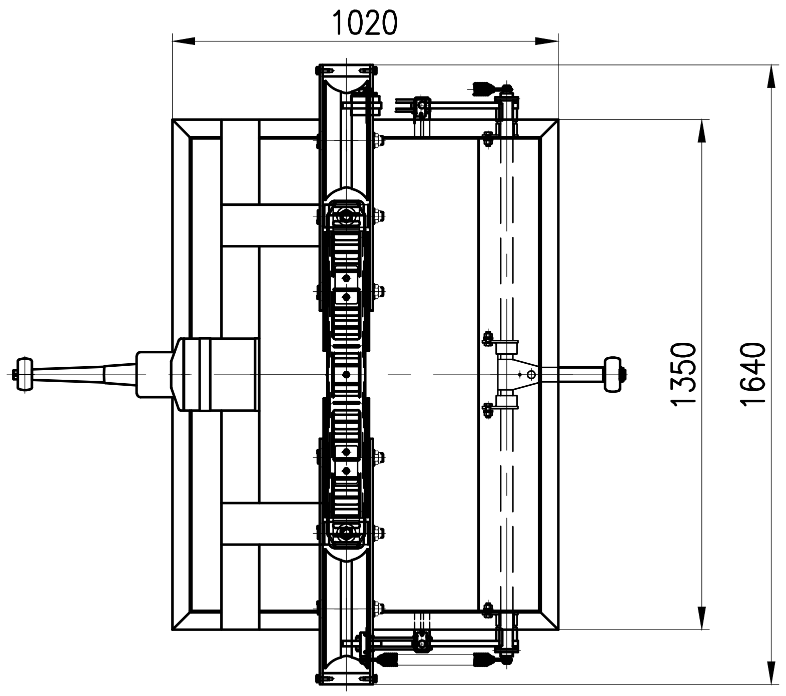
FORMATO / FORMAT: FF	DISEGNATO / DESIGNED BY: Morra	CONTR. DA / CHECKED BY: Charrere
DATA / DATE: 31/07/2015	DISEGNO / DRAWING: 77008175/00	
SCALA / SCALE: 1:2000		

ONLY FOR OFFER PROJECTS





NOTE: ALL DIMENSIONS ARE IN mm
NOTA: TUTTE LE DIMENSIONI SONO IN mm



REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION: TLF ESA Ropeway

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION:
ASSIEME VEICOLO
VEHICLE ASSEMBLY

-

LEITNER ropeways

FORMATO / FORMAT	DISEGNATO / DESIGNED BY	CONTR. DA / CHECKED BY
A3	Dallo	Cena

DATA / DATE: 03/08/2015

SCALA / SCALE: 1:20

DISEGNO / DRAWING: 77008177/00

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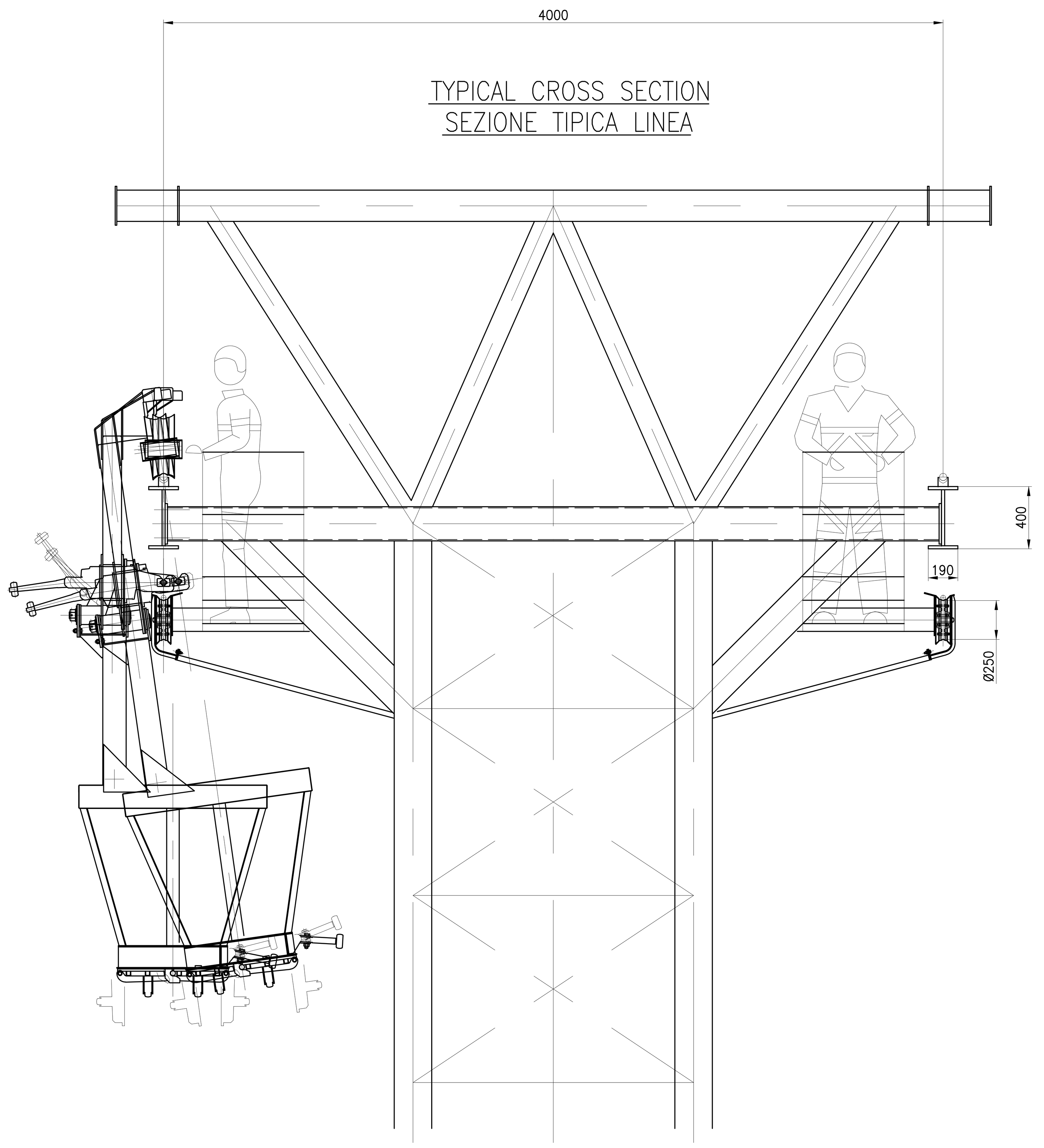
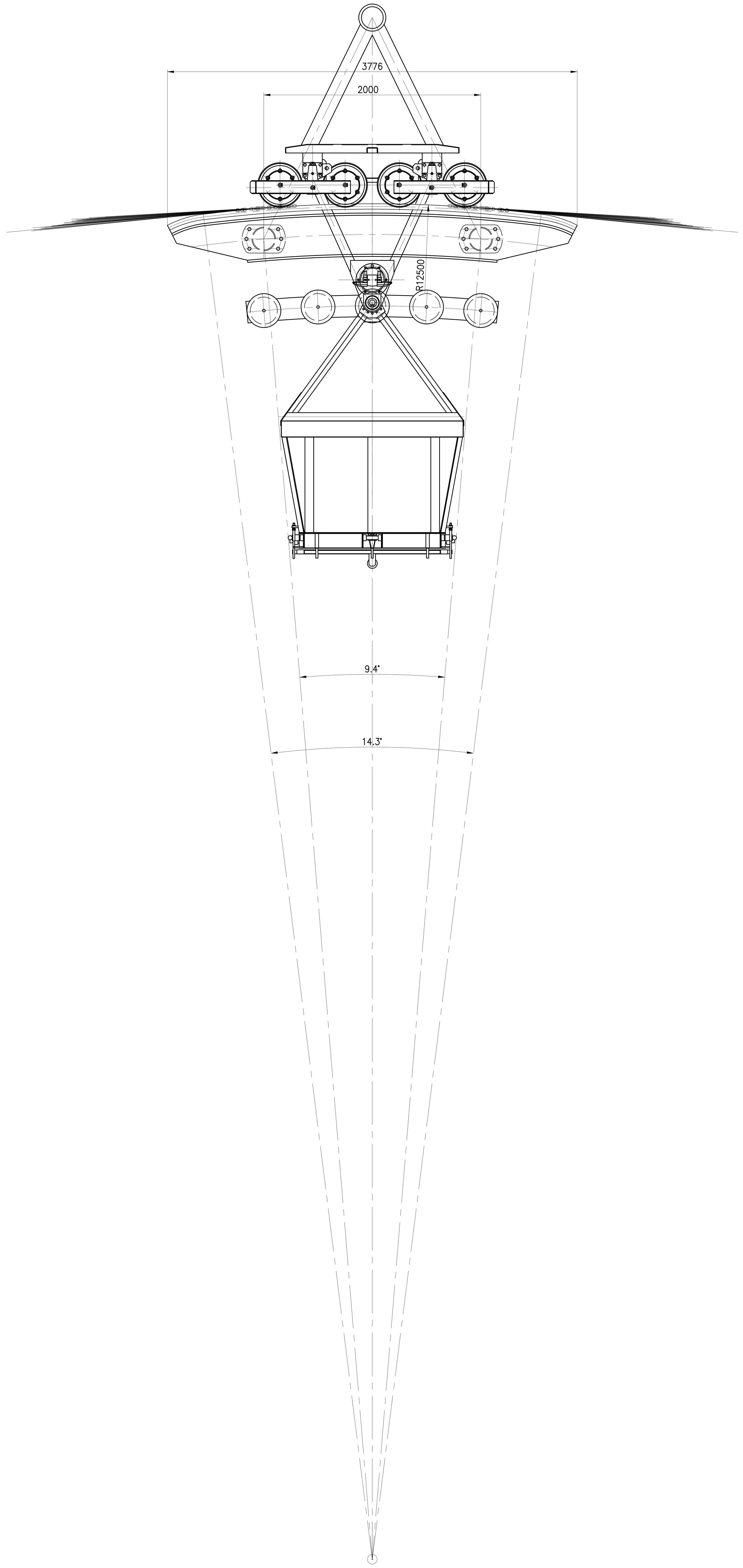
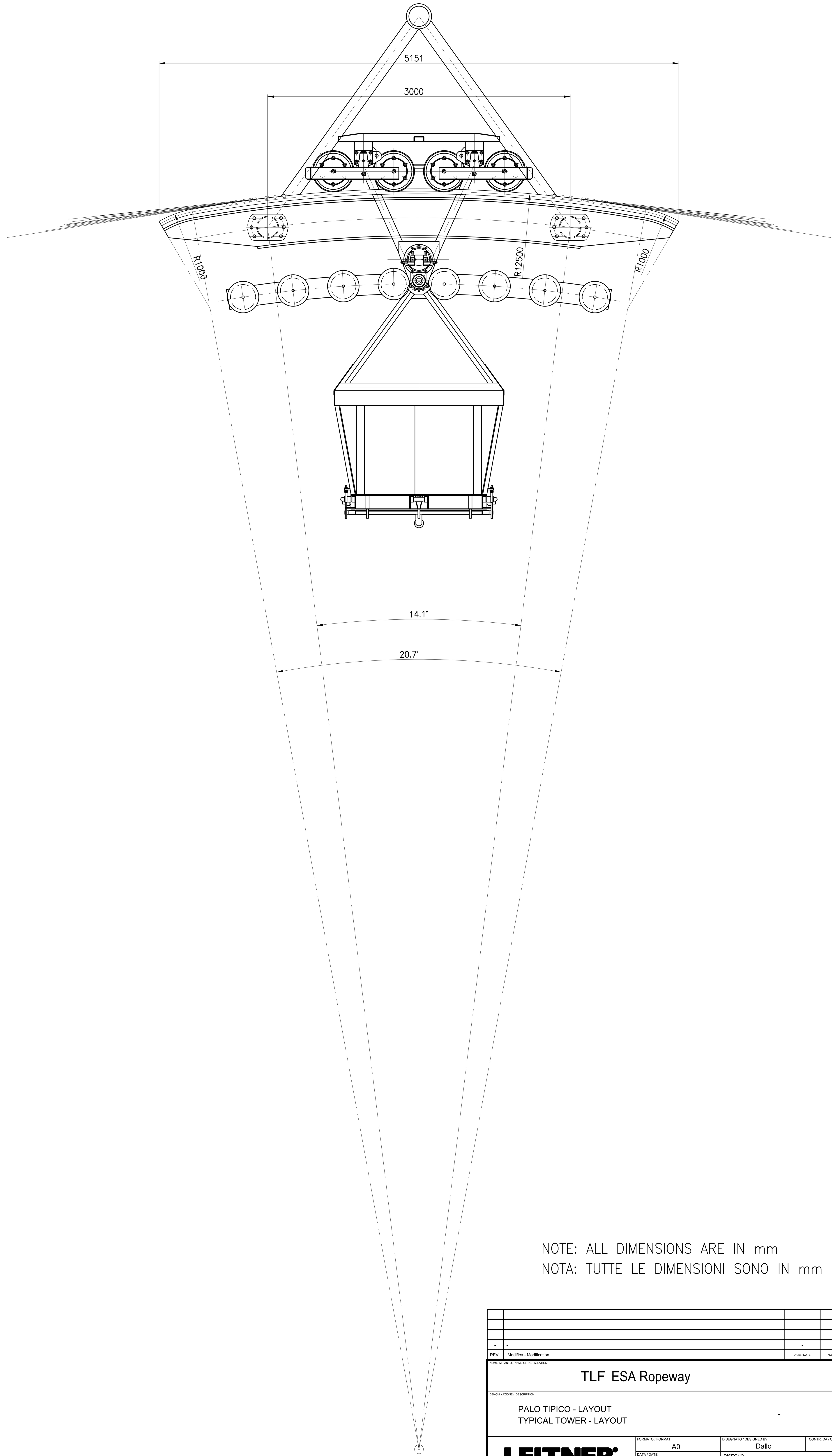
TYPICAL CROSS SECTION
SEZIONE TIPICA LINEA



SADDLE TYPE "S"
SCARPA TIPO "S"



SADDLE TYPE "L"
SCARPA TIPO "L"



NOTE: ALL DIMENSIONS ARE IN mm
NOTA: TUTTE LE DIMENSIONI SONO IN mm

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION	PAESE / COUNTRY
TLF ESA Ropeway	USA

DENOMINAZIONE / DESCRIPTION
PALO TIPICO - LAYOUT
TYPICAL TOWER - LAYOUT
-

LEITNER ropeways	FORMATO / FORMAT: A0	DISEGNATO / DESIGNED BY: Dallo	CONTR. DA / CHECKED BY: Cena
	DATA / DATE: 03/08/2015	DISEGNO DRAWING: 77008178/00	
	SCALA SCALE: 1:20		

 ONLY FOR OFFER PROJECTS

DATI TECNICI
TECHNICAL DATA

UBICAZIONE MOTRICE POSITION OF DRIVE	MONTE TOP	
UBICAZIONE TENDITRICE POSITION OF TENSIONING	VALLE BOTTOM	
LUNGHEZZA ORIZZONTALE HORIZONTAL LENGTH	3928,6	m
DISLIVELLO VERTICAL RISE	171,5	m
LUNGHEZZA SVILUPPATA DEVELOPED LENGTH	3691,5	m
NUMERO SOSTEGNI NUMBER OF TOWERS	14	
DIAMETRO FUNI PORTANTI CARRYNG ROPES DIAMETER	42	mm
DIAMETRO FUNI TRAENTI HAULING ROPES DIAMETER	30	mm
NUMERO DI FUNI PORTANTI PER LA VIA DI CORSA NUMBER OF CARRYNG ROPES FOR RUNWAY	1	
POTENZA MAX. AZIONAMENTO PRINCIPALE POWER MAX. OF MAIN DRIVE	325	kW
PORTATA TOTALE DEL SISTEMA PER OGNI SENSO DI MARCIA TOTAL CAPACITY OF THE SYSTEM FOR EACH DIRECTION	340 - 500	t/h t/h
PORTATA PER OGNI SENSO DI MARCIA DEL SINGOLO IMPIANTO CAPACITY FOR EACH DIRECTION FOR EVERY SINGLE SYSTEM	170 - 250	t/h t/h
VELOCITÁ IMPIANTO OPERATING SPEED	4	m/s m/s
VELOCITÁ MASSIMA PASSAGGIO SOSTEGNO MAX. SPEED CROSSING TOWER	4	m/s m/s
NUMERO TOTALE DEI VEICOLI NUMBER OF CARRIERS	140	
CAPACITÁ DEL VEICOLO CAPACTY OF THE VEHICLE	1,3	t t
TEMPO TOTALE TOTAL TIME	1100	s s

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION

TLF ESA Ropeway - PROFILE 15

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION

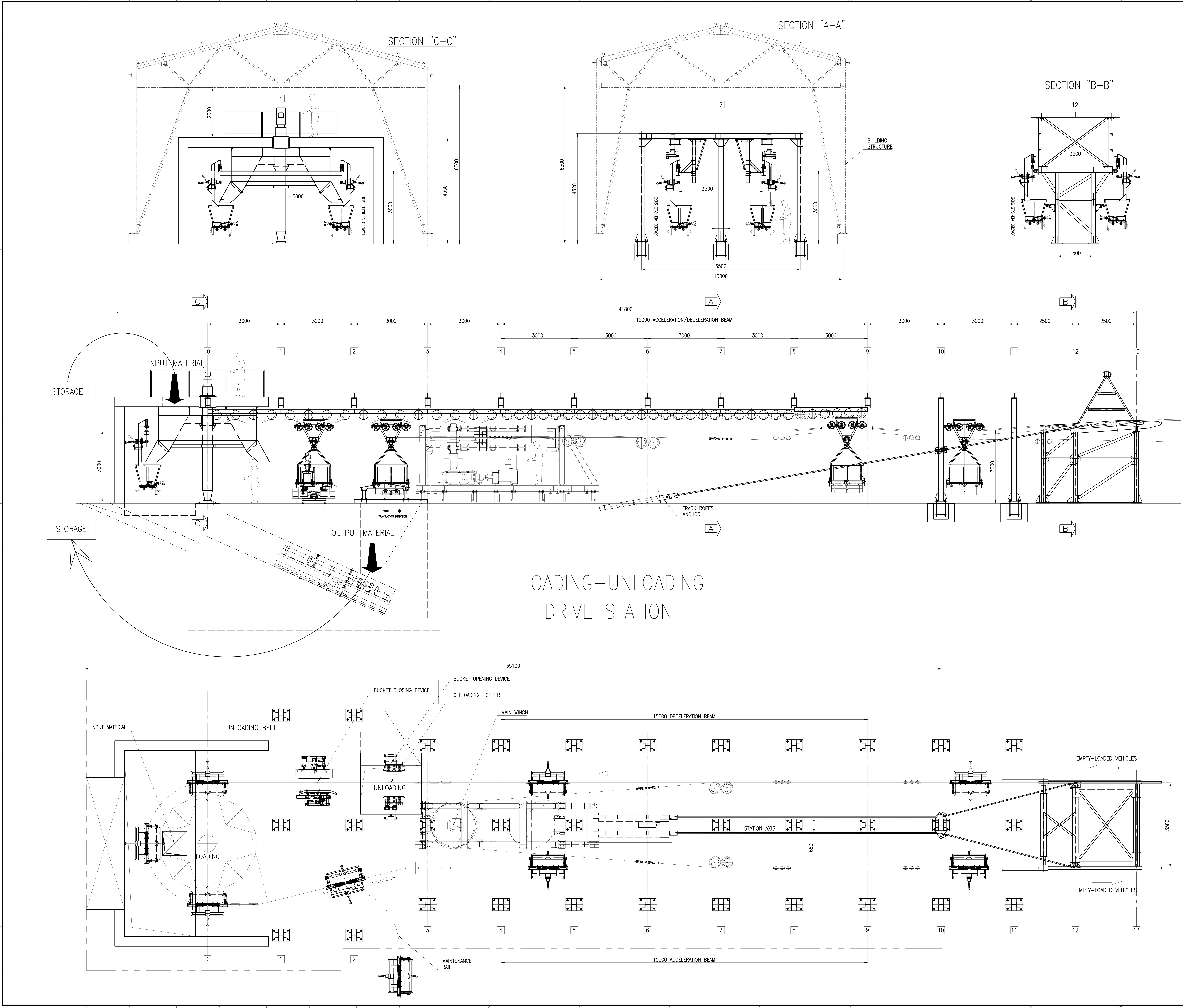
PROFILO LONGITUDINALE
LONGITUDINAL PROFILE

-

LEITNER ropeways

FORMATO / FORMAT: FF
DATA / DATE: 31/07/2015
SCALA / SCALE: 1:2000
DISEGNATO / DESIGNED BY: Morra
CONTR. DA / CHECKED BY: Charrere
DISEGNO / DRAWING: 77008179/00

ONLY FOR OFFER PROJECTS

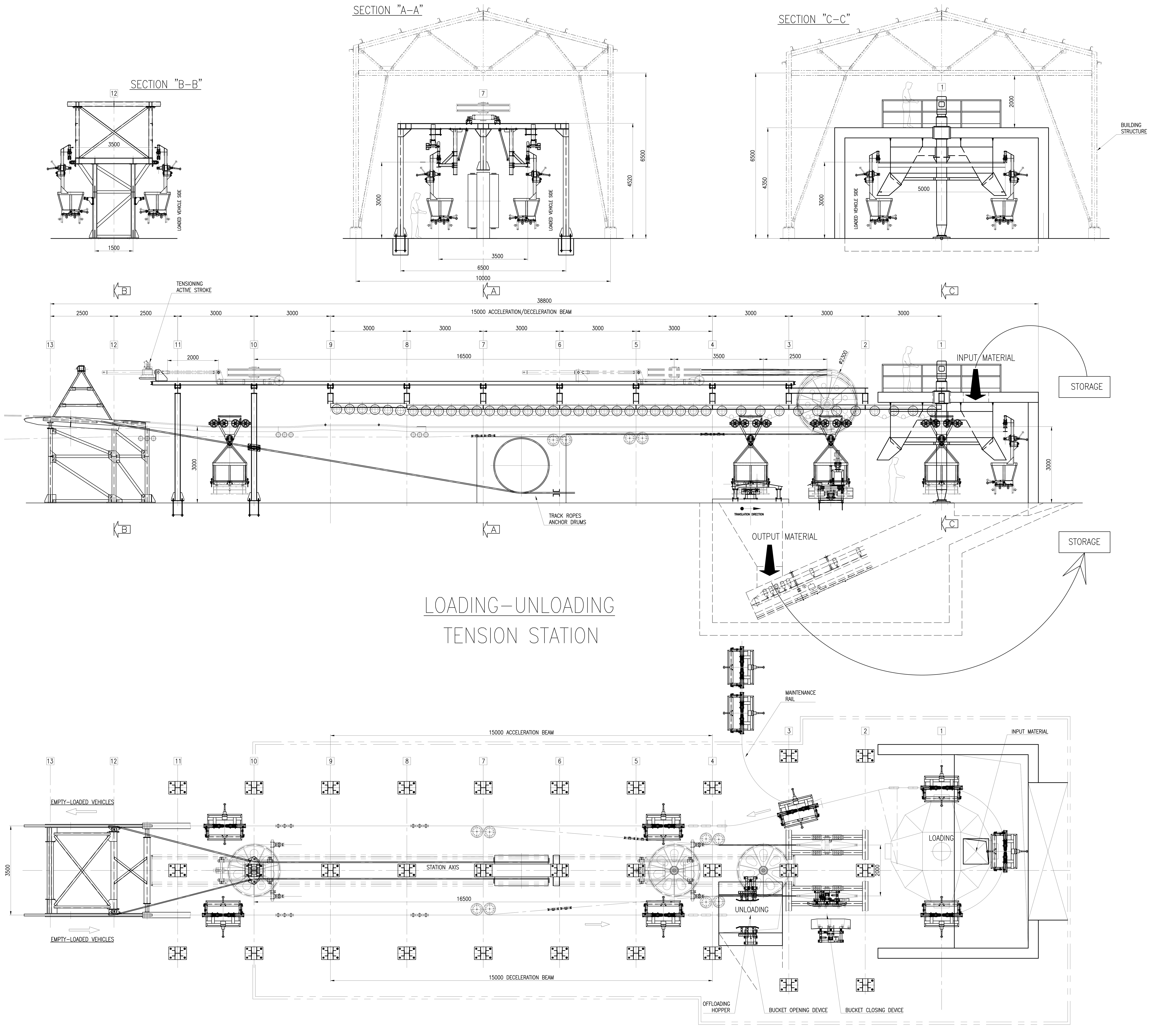


NOTE: ALL DIMENSIONS ARE IN mm
NOTA: TUTTE LE DIMENSIONI SONO IN mm

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION: TLF ESA Ropeway	PAESE / COUNTRY: USA
DENOMINAZIONE / DESCRIPTION: STAZIONE MOTRICE CARICO-SCARICO DRIVE LOADING-OFFLOADING STATION	-
FORMATO / FORMAT: A0	DISEGNATO / DESIGNED BY: Dallo
DATA / DATE: 03/08/2015	CONTR. DA / CHECKED BY: Cena
SCALA SCALE: 1:50	DISEGNO DRAWING: 77008183/00

ONLY FOR OFFER PROJECTS



NOTE: ALL DIMENSIONS ARE IN mm
NOTA: TUTTE LE DIMENSIONI SONO IN mm

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION: TLF ESA Ropeway

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION:
STAZIONE TENDITRICE CARICO-SCARICO
TENSIONING LOADING-OFFLOADING STATION
-

LEITNER ropeways

FORMATO / FORMAT: A0
DISEGNATO / DESIGNED BY: Dallo
CONTR. DA / CHECKED BY: Cena
DATA / DATE: 03/08/2015
SCALA / SCALE: 1:50
DISEGNO / DRAWING: 77008185/00

ONLY FOR OFFER PROJECTS

NOTE: ALL DIMENSIONS ARE IN mm

NOTA: TUTTE LE DIMENSIONI SONO IN mm

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
01	DIRECT LOADING FITTING OF SILOS/RAILCAR	18/09/2015	Bodoni	Cena

NOME IMPIANTO / NAME OF INSTALLATION: TLF ESA Ropeway

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION:
STAZIONE TENDITRICE CARICO-SCARICO
TENSIONING LOADING-OFFLOADING STATION

FORMATO / FORMAT: A1	DISEGNATO / DESIGNED BY: Dallo	CONTR. DA / CHECKED BY: Cena
DATA / DATE: 03/08/2015	DISEGNO DRAWING: 77008185/01	
SCALA SCALE: 1:100		

LEITNER ropeways

ONLY FOR OFFER PROJECTS

NOTE: ALL DIMENSIONS ARE IN mm
NOTA: TUTTE LE DIMENSIONI SONO IN mm

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION

SSFL PROJECT ESA FLYINGBELT

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION

LAYOUT GENERALE DI IMPIANTO
GENERAL LAYOUT OF INSTALLATION

-

LEITNER ropeways

FORMATO / FORMAT: -
DATA / DATE: 06/08/2015
SCALA / SCALE: 1:50
DISEGNATO / DESIGNED BY: Sessa
CONTR. DA / CHECKED BY: Cena
DISEGNO / DRAWING: 77008238/00

ONLY FOR OFFER PROJECTS

DATI TECNICI
TECHNICAL DATA

UBICAZIONE MOTRICE POSITION OF DRIVE	MONTE TOP	
UBICAZIONE TENDITRICE POSITION OF TENSIONING	VALLE BOTTOM	
LUNGHEZZA ORIZZONTALE HORIZONTAL LENGTH	3928,6	m
DISLIVELLO VERTICAL RISE	171,5	m
LUNGHEZZA SVILUPPATA DEVELOPED LENGTH	3691,5	m
NUMERO SOSTEGNI NUMBER OF TOWERS	10	
DIAMETRO FUNI PORTANTI CARRYNG ROPES DIAMETER	35	mm
LARGHEZZA NASTRO BELT WIDTH	650	mm
NUMERO DI FUNI PORTANTI PER LA VIA DI CORSA NUMBER OF CARRYNG ROPES FOR RUNWAY	4	
POTENZA MAX. AZIONAMENTO PRINCIPALE POWER MAX. OF MAIN DRIVE	325	kW
PORTATA TOTALE DEL SISTEMA TOTAL CAPACITY OF THE SYSTEM	170	t/h t/h
VELOCITÁ IMPIANTO OPERATING SPEED	2.5	m/s m/s
VELOCITÁ VEICOLO MANUTENZIONE MAX. SPEED MAINTENANCE VEICHLE	2.0	m/s m/s
RIEMPIMENTO MAX NASTRO MAX. BELT FILLING	35%	

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	

NOME IMPIANTO / NAME OF INSTALLATION

SSFL PROJECT ESA FLYINGBELT - PROFILE 17

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION

PROFILO LONGITUDINALE
LONGITUDINAL PROFILE

-

LEITNER ropeways

FORMATO / FORMAT: -	DISEGNATO / DESIGNED BY: Sessa	CONTR. DA / CHECKED BY: Cena
DATA / DATE: 06/08/2015	DISEGNO DRAWING: 77008247/00	
SCALA SCALE: 1:2000		

ONLY FOR OFFER PROJECTS

REV.	Modifica - Modification	DATA / DATE	NOME / NAME	CONTR. / CHECKED
-	-	-	-	-

NOME IMPIANTO / NAME OF INSTALLATION

TLF ESA Ropeway

PAESE / COUNTRY: USA

DENOMINAZIONE / DESCRIPTION

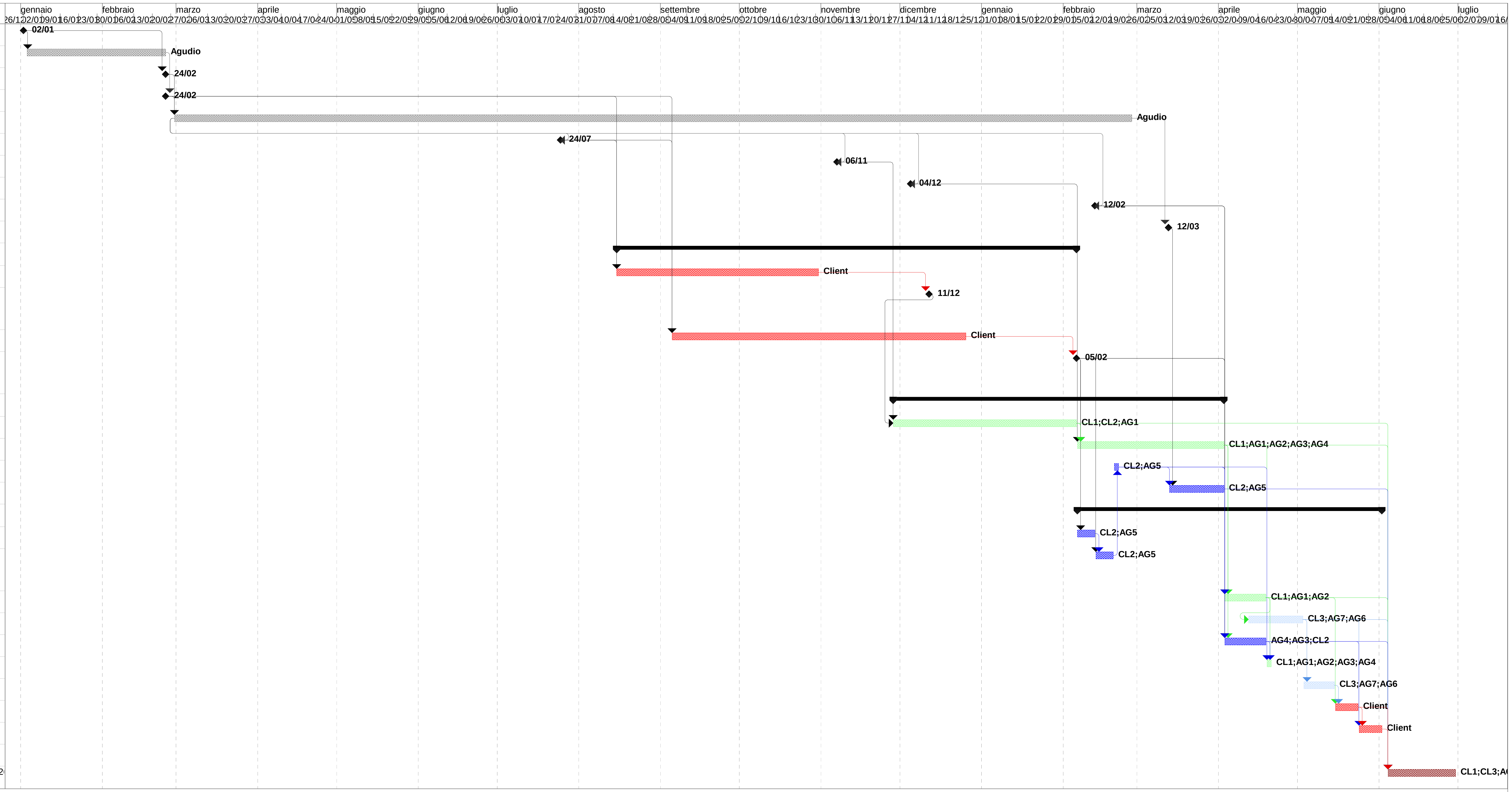
STAZIONE TENDITRICE CARICO-SCARICO - PLANIMETRIA
TENSIONING LOADING-OFFLOADING STATION-PLAN

LEITNER ropeways

FORMATO / FORMAT	A2
DATA / DATE	18/09/2015
SCALA / SCALE	1:1000
DISEGNATO / DESIGNED BY	Bodoni
CONTR. DA / CHECKED BY	Cena
DISEGNO / DRAWING	77008825/00

ONLY FOR OFFER PROJECTS

ID		Nome attività	Durata	Inizio	Fine	Predecessori
1		Order placement	0 g	lun 02/01/17	lun 02/01/17	
2		Preliminary design	39 g	mar 03/01/17	ven 24/02/17	1FI+1 g
3		Letter of Credit opening	0 g	ven 24/02/17	ven 24/02/17	1FI+40 g
4		Approval of preliminary design	0 g	ven 24/02/17	ven 24/02/17	2
5		Detailed design and manufacturing	260 g	mar 28/02/17	lun 26/02/18	3FI+1 g;4FI+1 g
6		Concrete anchoring delivery	0 g	lun 24/07/17	lun 24/07/17	5IF+105 g
7		Towers delivery	0 g	lun 06/11/17	lun 06/11/17	5IF+180 g
8		Ropes delivery	0 g	lun 04/12/17	lun 04/12/17	5IF+200 g
9		Stations and electrical eq. Delivery	0 g	lun 12/02/18	lun 12/02/18	5IF+250 g
10		Buckets delivery	0 g	lun 12/03/18	lun 12/03/18	5FI+10 g
11		**Civil works**	**125 g**	**mar 15/08/17**	**lun 05/02/18**	
12		Towers concrete foundations on site	55 g	mar 15/08/17	lun 30/10/17	6FI+15 g;4
13		Towers concrete foundations ready for erection	0 g	lun 11/12/17	lun 11/12/17	12FI+30 g
14		Stations concrete foundations on site	80 g	mar 05/09/17	lun 25/12/17	6FI+30 g;4
15		Stations concrete foundations ready for erection	0 g	lun 05/02/18	lun 05/02/18	14FI+30 g
16		**Line**	**90 g**	**mar 28/11/17**	**lun 02/04/18**	
17		Towers preassembly and erection	50 g	mar 28/11/17	lun 05/02/18	7;13FI-10 g
18		Ropes stringing	40 g	mar 06/02/18	lun 02/04/18	17;8;15
19		Winch positioning	2 g	mar 20/02/18	mer 21/02/18	23
20		Vehicles assembly	15 g	mar 13/03/18	lun 02/04/18	10;19
21		**Stations**	**84 g**	**mar 06/02/18**	**ven 01/06/18**	
22		Front station structures (loading station)	5 g	mar 06/02/18	lun 12/02/18	15
23		Front station structures (offloading station)	5 g	mar 13/02/18	lun 19/02/18	22;15
24		Loading station mech. assembly	12 g	mar 03/04/18	mer 18/04/18	9;18;19;15
25		Loading station el. wiring	15 g	gio 12/04/18	mer 02/05/18	24FI-5 g
26		Offloading station mech. assembly	12 g	mar 03/04/18	mer 18/04/18	9;15;18;19
27		Hauling rope splicing	2 g	gio 19/04/18	ven 20/04/18	19;18;24;26
28		Offoading station el. wiring	8 g	gio 03/05/18	lun 14/05/18	25
29		Loading station building assembly	7 g	mar 15/05/18	mer 23/05/18	24;28
30		Offloading station building assembly	7 g	gio 24/05/18	ven 01/06/18	29;26;25
31						
32		**Start up and commissioning**	20 g	lun 04/06/18	ven 29/06/18	25;17;18;20;24;2



Progetto: Planning TLF ESA Data: gio 22/10/15	Attività		Riepilogo		Cardine esterno		Attività manuale		Riepilogo manuale		Attività esterne		Scadenza	
	Divisione		Riepilogo progetto		Cardine inattiva		Solo-durata		Solo inizio		Cardine esterno			
	Cardine		Attività esterne		Riepilogo inattiva		Riporto riepilogo manuale		Solo-fine		Avanzamento			

ENVIRONMENTAL SCIENCE ASSOCIATES

California

Santa Susanna Ropeway

Line calculation and device sizing

00	11/08/2015	25	Document issued	Morra	Contin
Rev.	**Date**	**Pages**	**Review**	**Issued by**	**Checked by**

CONTENTS

1 FOREWORD

This report relates to the dimensioning of the main electromechanical components constituting the main haulage loop drives and station automatisms, including:

- Track ropes;
- Haul rope;
- Haulage loop main winch.

2 LINE CALCULATION

Line calculation is completed with a sophisticated Excel procedure edited and tested by our company, programmed using VBA logics according to respected anchored ropes theory with concentrated load procedure.

2.1 Input data

Rated capacity of the system	250	Ton/h
Empty vehicle weight	750	kg
Full loaded vehicle weight	2050	kg
Track rope diameter – A side	42	mm
Track rope diameter – B side	42	mm
Haul rope diameter	28	mm
Friction carriage wheels – track rope	0.8	%
Speed	4	m/s

2.2 Calculation conditions

Excel procedure considers the following working conditions:

1. Side A loaded vehicles – Side B empty vehicles;
2. Side A empty vehicles – Side B empty vehicles;
3. Side A empty vehicles – Side B loaded vehicles;
4. Side A loaded vehicles – Side B loaded vehicles;
5. Loaded vehicles only on positive inclination span, on both sides.

All that loading conditions are verified on the following running conditions:

1. Regime;
2. Acceleration at 0,15 m/s^2
3. Deceleration at 0,5 m/s^2

2.3 Excel routine

2.3.1 *General input*

DESCRIPTION

Help

Plant Description	Santa Susanna material ropeway
Place	California
Municipality	
District	
Note 1°	Capacity 250 t/h
Note 2°	

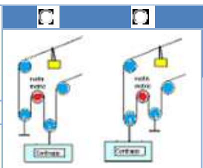
CABLE CARRIER (values for the single rope)

DESCRIPTION		ASCENT	DESCENT			
Diameter	mm	42	42	No. Ropes Round	1	
Massa unitaria della fune	kg/m	9,90	9,90	No. Back Ropes	1	
Section	mm2	1176,00	1176,00			
Modulus Of Elasticity	N/mm2	150000	150000	Unit resistance N/mm2	1860	1860
Reference load for Safety	kN	2187,36	2187,36	Coeff. stranding	1,00	1,00
					Anchored Rope	
Rope-Rope Seat (in the tower) friction coeff.		0,10	0,10			
Coefficient Of Linear Expansion		0,0000120			Counterweight rope at the beginn	
Setting tension value (per branch)	kN	445,000	445,000		Rope counterweight at the end of	

Rope (values for the single rope)

Nr.Funi 1

DESCRIPTION				
Diameter	mm	28,00		
Massa unitaria della fune	kg/m	3,25		
Section	mm2	369,00		
Modulus Of Elasticity	N/mm2	120000		
Coefficiente di attrito rulli-fune traente		0,020	0,020	
Reference load for Safety	kN	723,24		
Setting tension value (per branch)	kN	72,000		



Counterweight to the left	
Counterweight to the right	
Anchored Hauling Rope	
1960	Res Unit. N/mm2
1,00	Coeff. stranding

CAR

Mass of the vehicle load	kg	2050	N ° x rope trolley wheels		4
Mass of the empty vehicle	kg	750	Distance-shoe cart	(mm)	500,00
Carrier Equidistance	m	75,00	Offset clamp	(mm)	200,00
Coefficient of friction roller-bearing rope		0,008	Lifting rope	(mm)	120,00

POWER UNIT — Fixed Crab / Mobile Crab

Slide running speed on steady state condition	m/s	4,00
Power Unit Efficiency		0,85
Avvolgimento totale puleggia motrice	°	180,00

Winch left / Winch right

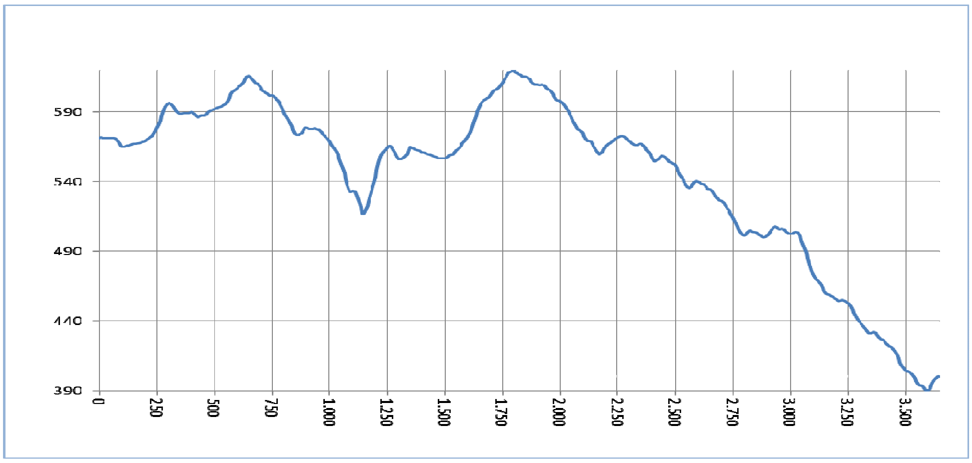
TIME AND FRICTION IN TRANSIT STATION

Power Take-Off in Station	N	0,01	Time of transit vehicles went Station (s)	200
Downstream Station Carrying Deviation	rad	0,15	Time of transit vehicles return station (s)	200
Upstream Station Carrying Deviation	rad	0,15		

AERIAL HAULING ROPE SUPPORTS

Mass of single AHRS	kg	0,00

2.3.2 Ground coordinate input



2.3.3 Towers coordinate input

Tower N°	Tower Code	Progr. Rope Distance (m)	Rope Height (m)
1	SC	10,70	581,66
2	S1	299,64	611,32
3	S2	649,21	626,01
4	S3	941,71	613,13
5	S4	1637,30	618,94
6	S5a	1783,55	628,87
7	S5b	1798,55	628,87
8	S6	1958,33	625,56
9	S7	2282,94	591,79
10	S8	2614,68	558,83
11	S9	3024,89	518,87
12	S10	3445,81	444,69
13	SSC	3642,00	410,41

2.3.4 Track ropes section data

Total N °	2	Side went	Return side	Puller type
Start by supporting N °	Order to support N °	Nominal pull of laying (KN)	Nominal pull of laying (KN)	1 = fixed anchorage 2 = at the beginning 3 = end of the tract
1	6	445,00	445,00	1
6	13	610,00	610,00	1

2.4 Verifications

2.4.1 Ropes safety factors

- Maximum temperature 60°C

CARRYING ROPE GOING SIDE				CARRYING ROPE RETURN SIDE				HAULING ROPE				Descrizione delle condizioni di verifica della linea: ipotesi di carico in linea condizioni di moto e temperatura ambiente
Tensione Max	Ks min	Tensione Min	Ks max	Tensione Max	Ks min	Tensione Min	Ks max	Tensione Max	Ks min	Tensione Min	Ks max	
kN	2,83	kN	4,27	kN	2,82	kN	4,24	kN	4,12	kN	13,80	
697,56	3,14	668,21	3,27	537,86	4,07	517,52	4,23	134,96	5,36	86,35	8,38	Load Round Branch - Branch Return Empty Temperature °C 60 A Regime : Forward run
541,10	4,04	516,75	4,23	537,86	4,07	517,52	4,23	106,11	6,82	83,82	8,63	Empty Round Branch - Branch Return Empty Temperature °C 60 A Regime : Forward run
541,10	4,04	516,75	4,23	689,53	3,17	669,16	3,27	149,23	4,85	83,82	8,63	Empty Round Branch - Branch Back Load Temperature °C 60 A Regime : Forward run
697,56	3,14	668,21	3,27	689,53	3,17	669,16	3,27	149,23	4,85	99,15	7,29	Branch Round Load - Load Class Return Temperature °C 60 A Regime : Forward run
604,63	3,62	577,29	3,79	657,63	3,33	635,74	3,44	135,13	5,35	86,43	8,37	Round Branch - Branch Return: Load Imposed Temperature °C 60 A Regime : Forward run
701,90	3,12	672,46	3,25	536,44	4,08	516,02	4,24	127,12	5,69	87,56	8,26	Load Round Branch - Branch Return Empty Temperature °C 60 in acceleration m/sec2 0,15 : Forward run
542,63	4,03	518,26	4,22	536,44	4,08	516,02	4,24	112,10	6,45	79,24	9,13	Empty Round Branch - Branch Return Empty Temperature °C 60 in acceleration m/sec2 0,15 : Forward run
542,63	4,03	518,26	4,22	685,39	3,19	664,91	3,29	163,00	4,44	79,24	9,13	Empty Round Branch - Branch Back Load Temperature °C 60 in acceleration m/sec2 0,15 : Forward run
701,90	3,12	672,46	3,25	685,39	3,19	664,91	3,29	163,00	4,44	89,07	8,12	Branch Round Load - Load Class Return Temperature °C 60 in acceleration m/sec2 0,15 : Forward run
607,46	3,60	580,05	3,77	654,93	3,34	633,08	3,46	127,30	5,68	87,63	8,25	Round Branch - Branch Return: Load Imposed Temperature °C 60 in acceleration m/sec2 0,15 : Forward run
683,38	3,20	654,32	3,34	543,00	4,03	522,78	4,18	175,37	4,12	75,36	9,60	Load Round Branch - Branch Return Empty Temperature °C 60 In deceleration m/sec2 0,50 : Forward run
535,98	4,08	511,75	4,27	543,00	4,03	522,78	4,18	115,83	6,24	75,36	9,60	Empty Round Branch - Branch Return Empty Temperature °C 60 In deceleration m/sec2 0,50 : Forward run
535,98	4,08	511,75	4,27	704,16	3,11	684,08	3,20	121,21	5,97	76,35	9,47	Empty Round Branch - Branch Back Load Temperature °C 60 In deceleration m/sec2 0,50 : Forward run
683,38	3,20	654,32	3,34	704,16	3,11	684,08	3,20	175,37	4,12	76,35	9,47	Branch Round Load - Load Class Return Temperature °C 60 In deceleration m/sec2 0,50 : Forward run
595,45	3,67	568,20	3,85	666,81	3,28	644,80	3,39	167,83	4,31	52,43	13,80	Round Branch - Branch Return: Load Imposed Temperature °C 60 In deceleration m/sec2 0,50 : Forward run

- Minimum temperature 0°C, 32°F

CARRYING ROPE GOING SIDE				CARRYING ROPE RETURN SIDE				HAULING ROPE				Descrizione delle condizioni di verifica della linea: ipotesi di carico in linea condizioni di moto e temperatura ambiente
Tensione Max	Ks min	Tensione Min	Ks max	Tensione Max	Ks min	Tensione Min	Ks max	Tensione Max	Ks min	Tensione Min	Ks max	
kN	2,83	kN	4,27	kN	2,82	kN	4,24	kN	4,12	kN	13,80	
770,51	2,84	741,40	2,95	624,62	3,50	604,54	3,62	134,85	5,36	86,41	8,37	Load Round Branch - Branch Return Empty Temperature °C 0 A Regime : Forward run
627,31	3,49	602,91	3,63	624,62	3,50	604,54	3,62	106,02	6,82	83,90	8,62	Empty Round Branch - Branch Return Empty Temperature °C 0 A Regime : Forward run
627,31	3,49	602,91	3,63	763,60	2,86	743,75	2,94	148,97	4,85	83,90	8,62	Empty Round Branch - Branch Back Load Temperature °C 0 A Regime : Forward run
770,51	2,84	741,40	2,95	763,60	2,86	743,75	2,94	148,97	4,85	99,35	7,28	Branch Round Load - Load Class Return Temperature °C 0 A Regime : Forward run
684,51	3,20	657,36	3,33	732,67	2,99	711,17	3,08	134,98	5,36	86,46	8,36	Round Branch - Branch Return: Load Imposed Temperature °C 0 A Regime : Forward run
774,25	2,83	745,08	2,94	623,47	3,51	603,34	3,63	127,00	5,69	87,61	8,25	Load Round Branch - Branch Return Empty Temperature °C 0 in acceleration m/sec2 0,15 : Forward run
628,51	3,48	604,08	3,62	623,47	3,51	603,34	3,63	112,02	6,46	79,47	9,10	Empty Round Branch - Branch Return Empty Temperature °C 0 in acceleration m/sec2 0,15 : Forward run
628,51	3,48	604,08	3,62	759,99	2,88	740,05	2,96	162,83	4,44	79,47	9,10	Empty Round Branch - Branch Back Load Temperature °C 0 in acceleration m/sec2 0,15 : Forward run
774,25	2,83	745,08	2,94	759,99	2,88	740,05	2,96	162,83	4,44	89,62	8,07	Branch Round Load - Load Class Return Temperature °C 0 in acceleration m/sec2 0,15 : Forward run
686,86	3,18	659,65	3,32	730,39	2,99	708,92	3,09	127,14	5,69	87,67	8,25	Round Branch - Branch Return: Load Imposed Temperature °C 0 in acceleration m/sec2 0,15 : Forward run
758,43	2,88	729,55	3,00	628,56	3,48	608,61	3,59	175,28	4,13	75,38	9,59	Load Round Branch - Branch Return Empty Temperature °C 0 In deceleration m/sec2 0,50 : Forward run
623,41	3,51	599,07	3,65	628,56	3,48	608,61	3,59	115,88	6,24	75,38	9,59	Empty Round Branch - Branch Return Empty Temperature °C 0 In deceleration m/sec2 0,50 : Forward run
623,41	3,51	599,07	3,65	776,03	2,82	756,48	2,89	120,87	5,98	76,42	9,46	Empty Round Branch - Branch Back Load Temperature °C 0 In deceleration m/sec2 0,50 : Forward run
758,43	2,88	729,55	3,00	776,03	2,82	756,48	2,89	175,28	4,13	76,42	9,46	Branch Round Load - Load Class Return Temperature °C 0 In deceleration m/sec2 0,50 : Forward run
676,90	3,23	649,86	3,37	740,48	2,95	718,88	3,04	167,87	4,31	52,58	13,75	Round Branch - Branch Return: Load Imposed Temperature °C 0 In deceleration m/sec2 0,50 : Forward run

2.4.2 *Efforts to pulley*

- Maximum temperature 60°C, 140°F

Side went	LATO RITORNO	Vel.	Acc.	Maximum voltage traction	Driving voltage side went	Driving voltage side return	Peripheral force driving	Ratio of adhesion	Total voltage reference (2*t)	voltage (T+t)
max				**175366**	**170713**	**153811**	**74567**	**3,08**	**144001**	**251399**
min				**106109**	**79244**	**53405**	**-100283**	**1,07**	**143999**	**189576**
		m/s	m/s^2	N	N	N	N		N	N
Office	Empty	4,00	0,00	134964	115382	100763	-4738	1,15	143999	216145
Empty	Empty	4,00	0,00	106109	86487	100986	14499	1,17	144000	189848
Empty	Office	4,00	0,00	149227	86487	136868	50382	1,58	144000	226403
Office	Office	4,00	0,00	149227	105724	136868	31144	1,29	143999	251087
osed loading b		4,00	0,00	135133	124440	93350	-21688	1,33	144000	220273
Office	Empty	4,00	0,15	127119	89075	108306	19231	1,22	143999	206869
Empty	Empty	4,00	0,15	112104	79244	108306	29062	1,37	144000	189931
Empty	Office	4,00	0,15	162999	79244	153811	74567	1,94	144000	236062
Office	Office	4,00	0,15	162999	89075	153811	64736	1,73	143999	251399
osed loading b		4,00	0,15	127302	112412	105336	1890	1,07	144000	220229
Office	Empty	4,00	-0,50	175366	170713	76382	-84658	2,23	144001	247095
Empty	Empty	4,00	-0,50	115829	111841	75359	-34046	1,48	144000	189576
Empty	Office	4,00	-0,50	121210	111841	76350	-30238	1,46	144000	194215
Office	Office	4,00	-0,50	175366	165244	76350	-80850	2,16	144001	250101
osed loading b		4,00	-0,50	167827	164541	53405	-100283	3,08	144000	220439

- Minimum temperature 0°C, 32°F

Side went	LATO RITORNO	Vel.	Acc.	Maximum voltage traction	Driving voltage side went	Driving voltage side return	Peripheral force driving	Ratio of adhesion	Total voltage reference (2*t)	voltage (T+t)
max				**175282**	**170552**	**153668**	**74197**	**3,08**	**144001**	**251181**
min				**106024**	**79472**	**53424**	**-100903**	**1,07**	**143999**	**189505**
		m/s	m/s^2	N	N	N	N		N	N
Office	Empty	4,00	0,00	134849	115149	100760	-5371	1,14	143999	215909
Empty	Empty	4,00	0,00	106024	86719	100921	14202	1,16	144000	189763
Empty	Office	4,00	0,00	148973	86719	136726	50007	1,58	144000	226133
Office	Office	4,00	0,00	148973	106293	136726	30433	1,29	143999	250884
osed loading b		4,00	0,00	134983	124471	93393	-22232	1,33	144000	220082
Office	Empty	4,00	0,15	126998	89624	108242	18618	1,21	143999	206612
Empty	Empty	4,00	0,15	112018	79472	108242	28770	1,36	144000	189841
Empty	Office	4,00	0,15	162829	79472	153668	74197	1,93	144000	235793
Office	Office	4,00	0,15	162829	89624	153668	64044	1,71	143999	251181
osed loading b		4,00	0,15	127142	112430	105386	1368	1,07	144000	220033
Office	Empty	4,00	-0,50	175282	170552	76373	-85357	2,23	144001	246925
Empty	Empty	4,00	-0,50	115884	112003	75378	-34360	1,49	144000	189505
Empty	Office	4,00	-0,50	120870	112003	76424	-30629	1,47	144000	193943
Office	Office	4,00	-0,50	175282	165653	76424	-81627	2,17	144001	249949
osed loading b		4,00	-0,50	167866	164613	53424	-100903	3,08	144000	220260

2.4.3 Power and other parameters

- Maximum temperature 60°C, 140°F

Side went	Return side	Vel.	Acc.	Total mass line	stop spontaneo us	Forza total peripheral	Maximum motor power	Moving the tensioner	minimum voltage	Maximum towing self-help	Maximum self-help haul + 40%
max				223172	0,69	74567	351	5305	72000	0,890	1,146
min				96688	-0,47	-111135	-341	4109	52426	0,669	0,878
		m/s	m/s²	kg	m/sec2	N	kW	mm	N	N	N
Office	Empty	4,00	0,00	159930	0,09	-14619	-16	4587	71999	0,669	0,878
Empty	Empty	4,00	0,00	96688	-0,15	14499	68	5075	72000	0,669	0,878
Empty	Office	4,00	0,00	159930	-0,32	50382	237	4874	72000	0,724	0,946
Office	Office	4,00	0,00	223172	-0,14	31144	147	4309	71999	0,724	0,946
osed loading b		4,00	0,00	159930	0,19	-31090	-74	4362	72000	0,740	0,965
Office	Empty	4,00	0,15	159930	-0,12	19231	90	4371	71999	0,702	0,919
Empty	Empty	4,00	0,15	96688	-0,30	29062	137	5080	72000	0,702	0,919
Empty	Office	4,00	0,15	159930	-0,47	74567	351	5103	72000	0,782	1,017
Office	Office	4,00	0,15	223172	-0,29	64736	305	4320	71999	0,782	1,017
osed loading b		4,00	0,15	159930	0,04	-7076	9	4265	72000	0,701	0,918
Office	Empty	4,00	-0,50	159930	0,59	-94331	-288	5305	72000	0,826	1,069
Empty	Empty	4,00	-0,50	96688	0,38	-36812	-116	5073	72000	0,719	0,940
Empty	Office	4,00	-0,50	159930	0,22	-35490	-103	4109	72000	0,719	0,940
Office	Office	4,00	-0,50	223172	0,41	-91342	-275	4298	72000	0,826	1,069
osed loading b		4,00	-0,50	159930	0,69	-111135	-341	4690	52426	0,890	1,146

- Minimum temperature 0°C, 32°F

Side went	Return side	Vel.	Acc.	Total mass line	stop spontaneo us	Forza total peripheral	Maximum motor power	Moving the tensioner	minimum voltage	Maximum towing self-help	Maximum self-help haul + 40%
max				223172	0,70	74197	349	3637	72000	0,804	1,043
min				96688	-0,46	-111189	-343	2452	52584	0,589	0,779
		m/s	m/s²	kg	m/sec2	N	kW	mm	N	N	N
Office	Empty	4,00	0,00	159930	0,09	-14389	-18	2923	71999	0,60	0,80
Empty	Empty	4,00	0,00	96688	-0,15	14202	67	3280	72000	0,59	0,78
Empty	Office	4,00	0,00	159930	-0,31	50007	235	3209	72000	0,66	0,87
Office	Office	4,00	0,00	223172	-0,14	30433	143	2782	71999	0,66	0,87
osed loading b		4,00	0,00	159930	0,19	-31078	-76	2747	72000	0,67	0,88
Office	Empty	4,00	0,15	159930	-0,12	18618	88	2707	71999	0,62	0,82
Empty	Empty	4,00	0,15	96688	-0,30	28770	135	3283	72000	0,62	0,82
Empty	Office	4,00	0,15	159930	-0,46	74197	349	3435	72000	0,72	0,94
Office	Office	4,00	0,15	223172	-0,29	64044	301	2791	71999	0,72	0,94
osed loading b		4,00	0,15	159930	0,04	-7044	6	2650	72000	0,63	0,83
Office	Empty	4,00	-0,50	159930	0,59	-94180	-290	3637	72000	0,76	0,99
Empty	Empty	4,00	-0,50	96688	0,38	-36759	-117	3279	72000	0,63	0,84
Empty	Office	4,00	-0,50	159930	0,22	-35579	-104	2452	72000	0,63	0,84
Office	Office	4,00	-0,50	223172	0,41	-91179	-278	2771	72000	0,76	0,99
osed loading b		4,00	-0,50	159930	0,70	-111189	-343	3079	52584	0,80	1,04

2.5 Carrying ropes verification

Due to the calculated value shown in the tables above, we will proceed with OITAF verifications.

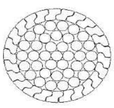
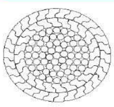
2.5.1 *Strength checks*

Below is shown the track rope security grade as established at 2.1.6.2 point of “Quaderno 8” OITAF

Maximum tension on track ropes is obtained with full loaded veichle in line and minimum temperature.

CARRYING ROPE				Descrizione delle condizioni di verifica della linea: ipotesi di carico in linea condizioni di moto e temperatura ambiente
Tensione Max	Ks min	Tensione Min	Ks max	
kN	2,84	kN	2,95	
770,51	2,84	741,40	2,95	Load Round Branch - Branch Return Empty Temperature °C 0 A Regime : Forward run

Rope mechanical characteristics are shown in the following table:

Formazione Construction Construction Konstruktion	Diametro Diameter Diamètre Durchmesser	Sezione Met. area Section Querschnitt	Massa Mass Masse Gewicht	Carico somma Additional breaking force Force de rupture calculé Rechnerische Bruchkraft			Forza di rottura minima Min breaking force Force de rupture minimale Mindestbruchkraft		
				GRADE			GRADE		
				1470	1670	1860	1470	1670	1860
	mm	mm²	kg/m	kN	kN	kN	kN	kN	kN
	26	453	3.81	666	756	842	599	681	758
	28	498	4.19	732	831	926	658	748	833
	29	545	4.59	801	909	1013	720	818	912
	30	594	5.00	873	991	1104	785	892	994
	32	645	5.43	948	1077	1199	853	969	1079
	33	698	5.88	1026	1165	1298	923	1049	1168
	34	753	6.34	1107	1258	1401	996	1132	1261
	36	810	6.82	1191	1353	1507	1072	1218	1357
	37	870	7.32	1279	1453	1618	1151	1307	1456
	38	931	7.84	1369	1555	1732	1232	1400	1559
	40	995	8.38	1463	1661	1851	1316	1495	1665
	34	788	6.64	1159	1317	1466	1043	1185	1320
	36	848	7.14	1246	1416	1577	1122	1274	1419
	37	909	7.66	1337	1519	1691	1203	1367	1522
	38	973	8.19	1430	1625	1810	1287	1462	1629
	40	1039	8.74	1527	1734	1932	1374	1561	1739
	41	1106	9.31	1626	1847	2058	1464	1663	1852
	42	1176	9.90	1729	1964	2188	1556	1768	1969
	44	1248	10.51	1835	2084	2321	1651	1876	2089
	45	1322	11.13	1943	2208	2459	1749	1987	2213
	46	1398	11.77	2055	2335	2600	1850	2101	2340
	48	1476	12.43	2170	2465	2746	1953	2219	2471

Maximum tension is:

$T_{max} \approx 770{,}5$ kN

Which equals a safety factor (rope resistance grade of 1860 N/mm^2) of:

$K = Cs / T_{max} = 2188 / 770.5 = 2.839 > 2.8$

In accordance with that is provided on point 2.1.6.2 of “Quaderno 8” OITAF.

2.5.2 T/Q ratio

Vehicle boogie is composed by 4 plastic wheels, so maximum load supported by each one is:

Full loaded vehicle weight $P_{veic} = 2050*9.81 = 20110$ N

Load supported by each wheel $q = 20110/4 = 5028$ N

Minimum track rope tension for that loading condition is obtained in the lower part of the line with maximum temperature, as shown below:

CARRYING ROPE				Descrizione delle condizioni di verifica della linea: ipotesi di carico in linea condizioni di moto e temperatura ambiente
Tensione Max	Ks min	Tensione Min	Ks max	
kN	3,14	kN	3,27	
697,56	3,14	668,21	3,27	Load Round Branch - Branch Return Empty Temperature °C 60 A Regime : Forward run

Minimum tension (60°C, 140°F) $T_{min} = 697560$ N

So ratio between minimum track rope tension and maximum wheel load is:

$T_{min} / q = 697560 / 5028 = 138 > 50$

In accordance with that is provided on point 2.1.6.4 of “Quaderno 8” OITAF.

2.6 Hauling loop

2.6.1 General Information

Hauling loop is made by a spliced rope loop which on vehicles is attached via an automatic clamp system.

As shown in previous paragraphs, hauling loop tensioning is done with an hydraulic counterweight system, which consist of two deviation pulleys from the station level to an higher one, a horizontal sledge with movable sheave and a hydraulic actuator with dedicated control unit able to give the right tension as the rope moves forward and backward on the sledge. Actuator fixed point is adjustable in order to compensate thermal and elastic elongation of hauling loop.

Counterweight entity is evaluated as 144 kN; therefore each rope side receives a constant tension value of 72 kN, acting in the downstream station.

The upstream station is conversely placed with the winch, with its double groove driving bullwheel on which the haul rope wraps itself for an angle of about 340°.

Obviously haul rope configuration, function of loading and running condition are all considered, and calculated automatically by the Excel routine together.

2.6.2 Haul rope verification

Due to the line calculation parameter results, we proceed with stability verification of haul rope.

2.6.2.1 Maximum tension and security grade

Haul rope maximum tension is obtained in event of emergency braking with deceleration ratio of 0,5 m/s^2, with full loaded buckets on both side of the line and maximum temperature (maximum trajectory gradient condition).

Related value is:

HAULING ROPE				Descrizione delle condizioni di verifica della linea: ipotesi di carico in linea condizioni di moto e temperatura ambiente
Tensione Max	Ks min	Tensione Min	Ks max	
kN	4,12	kN	9,60	
175,37	4,12	75,36	9,60	Branch Round Load - Load Class Return Temperature °C 0 In deceleration m/sec2 0,50 : Forward run

T_{max} = 175370 N

Remembering the entire haul rope breaking value (considering effective metallic section), minimum safety factor obtained is:

$Ks = Cs / T_{max} = 723000 / 175370 = 4,12 > 4$

In accordance with that is provided on point 2.1.6.2 of “Quaderno 8” OITAF.

2.6.3 *Drive bullwheel adherence*

From the previous verification, this is known that maximum adherence ratio occurs in event of mechanical emergency braking, on maximum temperature and with full loaded buckets only on negative line slope, for each side (very cautionary condition).

Going side	Return side	Vel.	Acc.	Maximum voltage traction	Driving voltage side went	Driving voltage side return	Peripheral force driving	Ratio of adhesion	Total voltage reference	voltage
									(2*t)	(T+t)
		m/s	m/s²	N	N	N	N		N	N
Imposed loading bays		4,00	-0,50	167827	164541	53405	-100283	3,08	144000	220439

Adhesion ratio in that condition is:

T/t = 164541 / 53405 = 3,08

Keeping a static friction coefficient between rope and drive bullwheel groove liner of 0.2, the available grip ratio is:

$$e^{f\cdot\alpha} = e^{0.2\cdot\frac{340}{180}\pi} = 3.28 > 3.08$$

and the minimum needed wrapping angle is:

(ln 3,08) / 0,20 = 5,63 rad = 322° < di 340° (characteristic wrap angle of the installation), so adherence is correctly insured.

3 MAIN WINCH DIMENSIONING

3.1 Introduction

The main winch elements are verified below on a preliminary basis, with particular focus on the dimensions of electric motors, gearboxes, couplings and emergency brakes.

The following values relevant for dimensioning are extracted from line calculations and slightly rounded up.

Maximum peripheral force at full-rate	50,4 kN
Maximum peripheral start-up force	74,6 kN

By analyzing line conformation and distribution of loads always present on the same side, it can be inferred that the peripheral force of the cycle to be considered for the purpose of fatigue and component durability is equal to the maximum full-rate peripheral force.

The winch assembly has the following features:

- a drive bullwheel with groove base diameter of 1700 mm, a double groove coated with soft material with brake band for emergency and service brakes;
- a single-groove return bullwheel lined with soft material, groove base diameter 1700 mm;
- slow drive pulley shaft turning on supports, provided with double roller crown pivoting bearings; the shaft is made with the drive bullwheel using DOBIKON type lock ring elements.;
- elastic joint on low-speed shaft;
- a gearbox, right angle shaft, provided with lubricating pump, intercooler, oil circulation pressure transducer and filter;
- negative modulated action hydraulic service brake, acting on brake band integral with drive bullwheel;
- negative modulated action hydraulic emergency brake, acting on brake band integral with drive bullwheel;
- a hydraulic unit for modulated service brake control;
- a hydraulic unit for modulated emergency brake control;
- elastic joint on high-speed shaft;
- electric motor with separated servo ventilation system, including filter and anemometric relay; the motor is equipped with speedometer encoder and thermal paste.

3.2 Main drive elements

The dimensioning of main winch elements is verified on a preliminary basis according to line calculation results. Verification specifically relates to dimensioning of electric motor, gearbox, couplings and brakes.

The maximum rotation speed of the bullwheel is:

$$n_2 = \frac{v \cdot 60}{2 \cdot \pi \cdot R_P} = \frac{4 \cdot 60}{2 \cdot \pi \cdot \frac{1.728}{2}} = 44{,}2\ rpm$$

On loaded line conditions, the maximum start-up torque of the gearbox slow shaft is equal to:

$$C_{\max} = (T - t)_{\max} \cdot \frac{D_p}{2} = 74{,}6 \cdot \frac{1{,}728}{2} = 64{,}5\ kNm$$

$$P = C_{\max} \cdot \omega = C_{\max} \cdot \frac{2 \cdot \pi \cdot n}{60} = 64{,}5 \cdot \frac{2 \cdot \pi \cdot 44{,}2}{60} = 298{,}5\,kW$$

These values have been taken into consideration for the static dimensioning of the winch components.

The following power and torque values are obtained in full-rate conditions:

$$C = (T - t) \cdot \frac{D_p}{2} = 50{,}4 \cdot \frac{1{,}728}{2} = 43{,}5\ kNm$$

$$P = C \cdot \omega = C \cdot \frac{2 \cdot \pi \cdot n}{60} = 43{,}5 \cdot \frac{2 \cdot \pi \cdot 44{,}2}{60} = 201{,}3\,kW$$

These values have been taken into consideration for the lifetime dimensioning of the winch components.

3.2.1 Gearbox

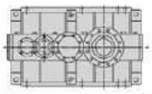
The main gearbox selected is a right-angle shaft device with three reduction stages:

The following aspects were taken into consideration for gearbox selection:

- one-way motion
- rotating speed of the slow shaft end n=47,7 rpm

Below is an excerpt from the Rossi Riduttori catalogue indicating the gearbox type selected.

7 - Potenze e momenti torcenti nominali (assi paralleli)
7 - Nominal powers and torques (parallel shafts)



n_{N2}	n_1 min⁻¹	i_N	Grandezza riduttore - Gear reducer size P_{N2} kW, M_{N2} kN m, ... //									
			400	401	450	451	500	501	560	561	630	631
45	1 400	31,5	404 87,1 3/31,6	464 99,8 3/31,6	517 116 3/32,9	593 133 3/32,9	742 166 3/32,8	853 191 3/32,8	1 040 232 3/32,8	1 190 267 3/32,8	1 520 327 3/31,6 ▲	1 760 379 3/31,6 ▲
	1 250	28	394 86,3 3/28,7	452 99 3/28,7	511 113 3/29,1	569 126 3/29,1	787 172 3/28,7	904 198 3/28,7	1 050 234 3/29,1	1 130 251 3/29,1	1 570 330 3/27,4	1 820 382 3/27,4
	1 120	25	405 87 3/25,2	464 99,8 3/25,2	452 99 2/25,7	519 114 2/25,7	731 154 2/24,8	845 178 2/24,8	992 217 2/25,7	1 140 250 2/25,7	–	–

According to the data shown in the table, here are the service factors obtained.

- Output rotating speed $N_2 = n \cdot i = 44{,}2 \cdot 31.5 = 1392 \;\; rpm$
- Power service factor $f_{sP} = \frac{P_{N2}}{P} = \frac{517}{298{,}5} = 1{,}73$
- Torque service factor $f_{sT} = \frac{M_{N2}}{C} = \frac{116}{64{,}5} = 1{,}79$

The nominal characteristics of the gearbox are related to a minimum life of the gearbox of 25000 h.

Average square power in working mode is about 200 kW so forced cooling system, with pump and intercooler, is not needed.

3.2.2 Electric motor

According to the requirements of the line calculation in terms of power installed, here is an excerpt of the technical catalogue for *3 phase AC motors SICME MOTORI* in which is underlined the selection made.

DATI ELETTRICI E PRESTAZIONI					ELECTRICAL DATA AND PERFORMANCES						ELEKTRISCHE DATEN UND LEISTUNGEN					
	n_n 580 rpm f_n 19.3 Hz		n_n 1000 rpm f_n 33.3 Hz		n_n 1500 rpm 5) f_n 50 Hz 1)		n_n 1800 rpm f_n 60 Hz		n_n 2200 rpm f_n 73.3 Hz		n_n 2600 rpm f_n 86.6 Hz		IP54 – IC416			
Motor Type	P_n Kw M_n Nm	A (400V) η %	P_n Kw M_n Nm	A (400V) η %	P_n Kw M_n Nm	A (400V) η %	P_n Kw M_n Nm	A (400V) η %	P_n Kw M_n Nm	A (400V) η %	P_n Kw M_n Nm	A (400V) η %	n_{max} Rpm	M_{max} Nm	J Kgm²	W Kg
BQCr 280M	**119** 1964	240 84,5	**196** 1874	362 92,1	**280** 1785	502 94,9	**336** 1785	601 95,2					3000 1) 4500 2)	3200	4,34	1420

The following continuous operating parameters, considering an efficiency of the whole system as *η=0.85*, are determined on the basis of the selection:

$$C_{El} = \frac{C}{\eta} = \frac{\frac{(T-t)\cdot\frac{D_p}{2}}{i}}{\eta} = \frac{\frac{50{,}4\cdot\frac{1{,}728}{2}}{31{,}5}}{0.85} = 1626\ Nm < 1785\,Nm$$

$$P_{El} = \frac{P}{\eta} = \frac{C\cdot\omega}{\eta} = \frac{C\cdot\frac{2\cdot\pi\cdot n}{60}}{\eta} = \frac{43{,}5\cdot\frac{2\cdot\pi\cdot 44{,}2}{60}}{0.85} = 237\,kW < 280\,kW$$

This high-efficiency motor guarantees a minimum peak torque of 2 times the nominal torque for 60 s. It’s verified that the motor can accelerate the ropeway even in the worst load conditions:

$$C_{El,MAX} = \frac{C_{MAX}}{\eta} = \frac{\frac{(T-t)_{MAX}\cdot\frac{D_p}{2}}{i}}{\eta} = \frac{\frac{74{,}6\cdot\frac{1{,}728}{2}}{31.5}}{0.85} = 2407\ Nm < 2\cdot 1785\,Nm = 3570\,Nm$$

3.3 Couplings

The connection couplings between gearbox and respective connected mechanical components are verified in the following paragraph.

3.3.1 *Slow coupling*

The slow coupling between gearbox and bullwheel shaft must be capable of supporting the entire torque supplied by the motor force.

The application here described contemplates the use of a pin-type elastic coupling as illustrated in the following excerpt from the Flender catalogue.

Size	Rated torque for buffer type			Torsional stiffness at 50 % capacity utilization for buffer type			Assembly	Permitted shaft misalignment at speed n = 1500 rpm [1]		
	65 ShoreA	**80 ShoreA**	90 ShoreA	65 ShoreA	**80 ShoreA**	90 ShoreA	Gap dimension	Axial	Radial	Angle
	T_{KN} Nm	T_{KN} Nm	T_{KN} Nm	$C_{Tdyn\,50\,\%}$ kNm/rad	$C_{Tdyn\,50\,\%}$ kNm/rad	$C_{Tdyn\,50\,\%}$ kNm/rad	ΔS mm	ΔK_a mm	ΔK_r mm	ΔK_w Degree
105	120	**200**	200	8	**13**	20	1.0	0.2	0.2	0.11
125	210	**350**	350	14	**24**	36	1.0	0.2	0.2	0.10
144	300	**500**	500	25	**42**	62	1.0	0.23	0.23	0.09
162	450	**750**	750	31	**54**	80	1.5	0.25	0.25	0.09
178	570	**950**	950	48	**83**	125	1.5	0.27	0.27	0.09
198	780	**1300**	1300	67	**116**	177	1.5	0.29	0.29	0.08
228	1300	**2200**	2200	102	**176**	260	1.5	0.3	0.3	0.08
252	1650	**2750**	2750	143	**246**	366	1.5	0.34	0.34	0.08
285	2600	**4300**	4300	220	**380**	540	1.5	0.36	0.36	0.07
320	3300	**5500**	5500	300	**520**	760	1.5	0.4	0.4	0.07
360	4700	**7800**	7800	350	**610**	910	1.5	0.43	0.43	0.07
400	7500	**12500**	12500	650	**1100**	1650	1.5	0.48	0.48	0.07
450	11000	**18500**	18500	900	**1560**	2300	1.5	0.52	0.52	0.07
500	15000	**25000**	25000	1350	**2300**	3500	1.5	0.57	0.57	0.07
560	23500	**39000**	39000	1740	**3000**	4500	2.0	0.62	0.62	0.06
630	31000	**52000**	52000	2600	**4500**	7080	2.0	0.68	0.68	0.06
710	50000	**84000**	84000	4000	**7000**	10500	2.0	0.75	0.75	0.06
800	66000	**110000**	110000	6000	**10500**	16100	2.0	0.84	0.84	0.06
900	90000	**150000**	150000	8250	**14000**	21700	2.5	0.93	0.93	0.06

Assuming the use of a Flender Rupex 800 coupling, the following service factors are obtained:

$$full\ \ rate\ \ condition \qquad f_S = \frac{M_t}{C} = \frac{110}{43.5} = 2{,}53$$

$$start - up\ \ condition \qquad f_{S\min} = \frac{M_t}{C_{\max}} = \frac{110}{64{,}5} = 1{,}71$$

3.3.2 *Fast coupling*

The fast coupling between fast gearbox shaft and drive shaft is a pin-type elastic coupling.

The coupling is chosen according to the gearbox transmission ratio which in the two cases listed above must guarantee good performance.

The application below, describes the use of a pin-type elastic coupling as illustrated in the following excerpt from the Flender catalogue.

Size	Rated torque for buffer type			Torsional stiffness at 50 % capacity utilization for buffer type			Assembly	Permitted shaft misalignment at speed n = 1500 rpm [1)]		
	65 ShoreA	**80 ShoreA**	90 ShoreA	65 ShoreA	**80 ShoreA**	90 ShoreA	Gap dimension	Axial	Radial	Angle
	T_{KN} Nm	T_{KN} Nm	T_{KN} Nm	$C_{Tdyn\,50\,\%}$ kNm/rad	$C_{Tdyn\,50\,\%}$ kNm/rad	$C_{Tdyn\,50\,\%}$ kNm/rad	ΔS mm	ΔK_a mm	ΔK_r mm	ΔK_w Degree
105	120	**200**	200	8	**13**	20	1.0	0.2	0.2	0.11
125	210	**350**	350	14	**24**	36	1.0	0.2	0.2	0.10
144	300	**500**	500	25	**42**	62	1.0	0.23	0.23	0.09
162	450	**750**	750	31	**54**	80	1.5	0.25	0.25	0.09
178	570	**950**	950	48	**83**	125	1.5	0.27	0.27	0.09
198	780	**1300**	1300	67	**116**	177	1.5	0.29	0.29	0.08
228	1300	**2200**	2200	102	**176**	260	1.5	0.3	0.3	0.08
252	1650	**2750**	2750	143	**246**	366	1.5	0.34	0.34	0.08
285	2600	**4300**	4300	220	**380**	540	1.5	0.36	0.36	0.07
320	3300	**5500**	5500	300	**520**	760	1.5	0.4	0.4	0.07
360	4700	**7800**	7800	350	**610**	910	1.5	0.43	0.43	0.07
400	7500	**12500**	12500	650	**1100**	1650	1.5	0.48	0.48	0.07
450	11000	**18500**	18500	900	**1560**	2300	1.5	0.52	0.52	0.07
500	15000	**25000**	25000	1350	**2300**	3500	1.5	0.57	0.57	0.07
560	23500	**39000**	39000	1740	**3000**	4500	2.0	0.62	0.62	0.06
630	31000	**52000**	52000	2600	**4500**	7080	2.0	0.68	0.68	0.06
710	50000	**84000**	84000	4000	**7000**	10500	2.0	0.75	0.75	0.06
800	66000	**110000**	110000	6000	**10500**	16100	2.0	0.84	0.84	0.06
900	90000	**150000**	150000	8250	**14000**	21700	2.5	0.93	0.93	0.06

Assuming the use of a Rupex 285 coupling, the following service factors are obtained:

$$full\ \ rate\ \ condition \quad f_S = \frac{M_t}{C/i} = \frac{4{,}3}{43{,}5/31{,}5} = 3{,}00$$

$$start-up\ \ condition \quad f_{S\min} = \frac{M_t}{C_{\max}/i} = \frac{4{,}3}{64{,}5/31{,}5} = 2{,}09$$

3.4 Brakes

Two identical braking systems are installed, first as service brake, and the second one as emergency brake.

The ropeway is almost self-braking fully loading in conditions, because of the slope of the track and due to the unidirectional movement. The main function of the brakes is to keep the ropeway stopped.

We verify that each brake is able to keep the ropeway stopped with full load: this means that the minimum braking torque generated by the callipers must be larger than the torque with full load decelerating at 0,5 m/s^2, 96 kNm.

The braking pads act on the drive bullwheel with a radius of 0,80 m; so the minimum braking force must be:

$$F_{fre} = \frac{C_{2MAX,fr}}{R_{fr}} = \frac{96}{0{,}80} = 120\,kN\,.$$

We choose a brake type AG5-150, which is able to guarantee a braking force range from 97.3 kN to 125 kN.

The modulated hydraulic unit is designed for a continuous regulation of the hydraulic pressure.

ENVIRONMENTAL SCIENCE ASSOCIATES

California

Santa Susanna Ropeway

General Technical Description

00	08/08/2015	34	Document issue	Morra	Contin
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CONTENTS

1 FOREWORD

The present preliminary project concerns the realization of an aerial material transportation ropeway with hourly capacity of 170 t/h up to 250 t/h, capable of transport inert materials from one side to the other on both runways completely automatically.

That installation will be realized in Santa Susanna field, Simi Valley, California.

2 APPLICABLE RULES

The whole Leitner Poma of America Inc. design and supply will follow the Directive Machine EN 2006/42/CE

For special equipment, which design is not covered by EN norms, the construction and operation of material ropeways is regulated by:

O.I.T.A.F. (International Organizations for Transportation by Rope) – BOOK 8: recommendations for the construction and operation of material handling unidirectional and reversible ropeway installations, cable cranes and material handling funiculars.

We recommend applying these recommendations for the protection of workers on the installation.

All metallic structures will be calculated according to Eurocode 3 (1993-1-1, 2005 Design of steel structure).

3 MEASUREMENT UNITS

All the following calculations are made with the measurement's units of International System.

Hereinafter, the main conversion factors:

- **Length:**

Inches – meters:

1”= 2.54 cm = $2.54 \cdot 10^{-2}$ m

1 m = 39.37 “

Feet – meters:

1’ = 0.3048 m

1m = 3.28’

- **Force**

Newton - pound

1 p = 4.4482 N	1k = 4.4482 kN
1 N = 0.225 p	1 kN = 0.225 k

- **Moment**

Newtonmeter - poundfoot

1 p’ = 1.356 Nm

1 Nm = 0.737 p’

- **Pressure and tension**

N/mm^2 – psi

1 psi = $6.895\ 10^{-3}\ N/mm^2$

1 ksi = $6.895\ N/mm^2$

1 N/mm^2 = 0.145 ksi = 145 psi

4 TECHNICAL FEATURES OF THE SYSTEM

The technical features of the system are:

Station A altitude	[masl]	582
Station B altitude	[masl]	410
Horizontal length	m	3630
Difference of level	m	172
Cars along line	n	120
Loaded car weight	kg	2050
Empty car weight	kg	750
Useful load	kg	1300
Wheels per vehicle	n	4
Full-rate speed	[m/s]	4
Hourly capacity (max)	[p/h]	250
Interdistance for capacity 170 t/h	s	27.5
	m	110
Interdistance for capacity 250 t/h	s	18.8
	m	75
Main electric motor power	[kW]	280
Track rope diameter (loaded side)	[mm]	42
Haulage line diameter	[mm]	28
Haulage counterweight	[kN]	144
Supports along line	n	10

5 STATIONS

5.1 LOADING BAY

The loading bay is characterized by the presence of devices for loading rocky material into wagons. The rotating loader is provided with four loading outlets arranged in the four quadrants of the lower circular section of the loader.

The rotation speed of the rotating loader is proportional to the haul rope speed. Loader rotation creates accurate spacing without requiring additional adjustment or accumulation devices because of the presence of the translation system.

An essential condition for this to occur is that there must be one car at each loader outlet.

With this regard, a spacing segment is arranged at loader inlet. It is operated by a specific AC motor, managed electronically by an inverter device managed by PLC which cancels out car delays by increasing the transfer speed of queuing wagons.

Again in the perspective of never stopping the loading system, two car accumulation substations are provided on empty side, in addition to the spacing segment described above. Wagons are queued waiting to the dispatched to the rotating loader in the accumulation substations.

Further pneumatic batteries are installed at the beginning and end of the outlet station near the sliding rail to manage deceleration and acceleration of bucket until they are clamped to the haulage rope. The track ropes from the line are diverted by specific fixed shoes made of metal and anchored by two filled socket on the exiting bar.

The vehicle wheels rest on a rail forming the entire station turn-around instead of on the track rope when the tire batteries receive the car.

5.2 UNLOADING BAY

Material contained in the wagons is unloaded at the terminal station of the ropeway.

Similarly to devices previously described, all acceleration/deceleration transients and transfers of wagons within the station are managed by automatic tire beams.

This bay contains an unloading body opening system and a lower wall closing system.

The opening system is passive: it consists of a cam which moves up a control level as a consequence of the advancement of the car. This allows the opening of the lower walls and the release of material by effect of its own weight.

Material is unloaded from the lower part of the bucket, which is normally closed by two walls locked in closed position by means of a mechanical ratchet system.

After having crossed the deceleration and opening zone of the clamp, the wagon proceeds at constant speed towards the unloading zone, where a fixed cam is located which causes the complete emptying by gravity into the opening present in the floor.

After having completed the station turn-around at constant speed actuated by the tire beams integrated in the turn-around itself, the wagon (still open) reaches a hydraulically actuated closing device of the walls which closes and locks them. The wagon then proceeds, again at constant speed, towards the acceleration beam and respective clamp closing cam to resume its travel towards the loading station.

Here follow the aspects that lead to the chosen of the unloading system proposed;

- It does not required a tilting system for unloading.
- Stability during the download; small parts moving and so little inertia is involved in the unloading process, all that things take part in the general stability of the system.
- Global security of the vehicle on line; one of the worst side effect of the tilting systems is that the centre of gravity of the bucket is not aligned with the articulation pins. In case of loss of the bucket locking system, due to the dynamic effects it may cause not only the loss of the bulk but also the derailment of the vehicle.
- Simple mechanism for opening and closing system;
- Multiple unloading stations; in the station is possible to provide several hoppers and unload the material where required just by fitting the opening cam.

Active wall closing system.

An electric device pushes the bottom walls and locks them.

5.3 STATION MECHANISMS

5.3.1 Introduction

Station mechanical dimensioning is described in the document DV240244_00.

All station mechanisms and structures, such as rails, acceleration and deceleration devices, switches, car guides, safety devices, clamp maneuvering mechanisms, haul rope diversion rollers etc. are fixed to a metallic structure supported by a reinforced concrete platform.

Gantry structure connected along the line axis, from which secondary structures supporting the sliding rail at regular distance from the secondary shelf structures, is realized in both stations. A beam resting on the top of the gantries support the beams.

The clamping and unclamping screws are fixed to a pair of pillars, in turn connected to the upper crossbars.

Consequently, the main structure is only subjected to the loads from the transisting cars and from the rope diversion belonging to the haulage loop. The deviation and anchoring of the track ropes do not concern any metallic structure in any manner but are designed to relieve onto the station concrete platforms only.

The winch in the upstream station is aligned along the line axis of the facing segment. The supporting structure of the constructive elements of the winch is independent from the gantry structure supporting the entire station. This second structure is directly connected to the reinforced concrete platform by means of anchor bolts.

The haul rope tensioning system is hydraulically counterweighted with slide and idle pulley. The entire slide rests on the previously introduced upper crossbars.

A brief description of each device is provided below. Refer to DV240244 for electromechanical dimensioning details.

5.3.2 Guide rails, rope path

The sliding rail of cars is supported directly from the main metallic structure and contoured to adapt to the profile of the wheel guaranteeing an optimal path without risk of derailing.

The track rope at station inlet is diverted downwards and inwards by a shoe which addresses it towards the anchoring drums or poured socket fixed anchors.

The car is guided at the end of the deceleration ramp by means of guides along the entire motorized beam segment. These guides are meant to stabilize the cab during transit and during loading/unloading operations.

5.3.3 Car actuation

The acceleration and deceleration tire beams are provided with tires working on the clutch shoe at the top of the car carrier trucks.

The wheels are each one connected to the following by means of V-belts which mesh with cast-iron pulleys of equal diameter. Each set of wheels is driven by an electric drive synchronized with the haulage rope speed.

The movement of cars along the station turn-around is guaranteed by groups of wheels connected by belts or toothed wheels in the same way as the main beams. Each group is actuated by variable speed drive gear motors controlled by the system according to the haul rope speed.

These devices are present in both terminal stations.

5.3.4 *Clamp maneuvering*

Clamps are maneuvered at station inlet and outlet by means of fixed cams.

The clamp is opened by means of direct pushing along a variably oriented plane according to the cam profile. The clamp is characterized by the presence of a dead point and consequently does not return spontaneously to closing position after the action of the cam ceases. For this reason, the actuating lever of the clamp must be accompanied along the remaining course in order to ensure gradual clamp movement without interfering dynamic effects.

The haul rope is guided by specific upper rollers moves on the vertical plane between the open clamp jaws. For clamping and unclamping, the rope speed is equal to that of the clamp and consequently there is no disruptive dynamic effect or jaw wear.

In the clamping and unclamping zone, the vehicle translation wheel is shaped to make the clamp move slightly crosswise to facilitate entrance and exiting of the rope into the clamp without rubbing against the jaws.

Both the position of the rope and that of the clamp are controlled in all significant points by specific shapes. Any incorrect geometric configuration causes the system to be immediately stopped.

Refer to the dedicated technical document for a detail description of the station safety devices.

6 STATION SAFETY DEVICES

6.1 MAIN STATION CLAMP CONTROL AND SAFETY DEVICES

A series of electromechanical devices are installed in each station to monitor correct performance of acceleration, deceleration, clamping and unclamping operations.

These devices consist of mechanical elements which control micro switches or break bars thus checking coherence of shape and positions and proximity micro switches which indicate car presence or mechanical rotation to the control system.

For the sake of simplicity, the devices are described from station inlet to station outlet. The electromechanical devices are described first followed by proximity switches.

ELECTROMECHANICAL CONTROL DEVICE

SunHaul rope positioning control onto the haul rope

PROXIMITY SENSOR CONTROL Pulse generator

This device is fitted on both sides of the station. This device generates the rope speed signal exploited to verify the correct deceleration of the installation during the stopping transition and, together with the “anti-collision device” it monitors the slowdown of the vehicles.

The pulse generator device is composed by a proximity that detects the motion from the haul rope.

Presence of the clamp-control. Where fitted, this device controls the physical presence of the clamp. It’s composed by two proximity closet to the acceleration tire beam, and detects the presence of the clamp when the vehicle is passing by.

In case of abnormal signalization, it determines the stop of the system.

ANTICOLLISION DEVICE

Detects the passage of the vehicle in several points of the tire beam; the signal given by the proximities is compared with haul rope speed; if the instant speed of the vehicle is different by the theoretical speed the electronic equipment adjusts in order to avoid the gap.

In the event of major anomalies the installation is stopped.

7 LINE

7.1 TRACK ROPE ANCHORING

Use of anchored track ropes in one-way continuous two-rope system has a number of advantages with respect to track ropes with counterweights. Firstly, extra rope can be accumulated on both ends of the segment to allow at least two track rope steps. This procedure considerably extends rope life because it avoids constantly stressing the same points as the car passes over line supports. The anchoring consists in the connection to a fixed position by means of a poured socket on one end of the rope and a friction drum on the other.

The rope connection solution, by means of friction drum, is frequently used in passenger ropeway systems. The friction anchoring drum is usually made of concrete covered in wood to increase the safety coefficient and protect the rope itself. After having made at least three turns around the drum, the rope is fixed by means of a pair of screw terminals onto a contrast beam to overcome the residual draw on the rope itself.

The spare rope is connected on a metallic structure coiler arranged near the winding drum.

Drums have a diameter of 2100 mm and to comply with regulatory rope diameter/wire diameter ratios (OITAF Booklet 8_2006 § 2.1.6.6):

$2100 / 60 = 50 \geq 50$

After running the rope in excess, the fixed anchoring assembly is replaced and a new poured socket terminal is installed to allow the new connection to the anchoring point.

The track rope anchor on a fixed point may be implemented with a rope tension monitoring device. A hydraulic cylinder connected to a closed circuit is used to monitor internal pressure and consequently the tension of the concerned rope branch.

7.2 RAIL GUIDE NEEDLE

Devices suited to maintain continuity of the car runway must be used at track rope interruptions in stations and anchoring tensioning points. Rope continuity must be guaranteed in order to ensure transit of cars without triggering typical dynamic phenomena which could compromise stability. Devices called “tensioning tongues” are used at these points.

These devices consist of a shoe which accommodates the track rope and diverts it towards the anchoring point. A pair of plates arranged by the side of the show work as interface between the track rope itself and the rail downstream of the tensioning tongue.

7.3 LINE SHOES

The minimum radii of line shoes comply in all cases with clause 2.1.7.10 of OITAF Booklet 8_2006, which requires the following radii for a 60 mm rope:

R42 x 150 = 6300 mm for shoes on which rope is wound and unwound and on which vehicles transit

42 x 50 = 2100 mm for shoes on which the rope is stationary.

The shoe curvature requirement is respected in turn so as not to exceed the centrifuge acceleration limit to which the car is fixed at about the reference value of 2.5 m/s^2, so minimum useful radius for line shoes (using a maximum centrifuge acceleration value of 2 m/s^2) is 8000 mm:

$$a = \frac{v^2}{R} = \frac{4^2}{8} = 2.00\, m/s^2$$

An important indication is provided by OITAF in § 2.1.6.4, according to which the ratio between minimum tension and nominal load of longitudinal axis of the rope itself determined by the passage of the car (including contribution provided by the haulage rope) must not be lower than 50.

A delicate situation with regards to this requirement occurs at supports where there is a high diversion of the haul rope. A collateral effect related to a situation of this type is represented by an early localized decay of both the track rope and the haulage rope.

Where necessary, it is recommended to evaluate which supports are critical from the point of view mentioned above during the executive step and to intervene consequently. A solution is that of designing a support provided with fixed shoes and high rollers suited to limit track rope diversion and consequent load weighing on the track rope.

8 VEHICLE CARS

The capacity of each car is 0.82 m^3, which considering a transported material density of $\approx 1.6\, ton / m^3$ is equivalent to a transported weight of approximately 1300 kg.

Each car consists of the following main elements:

– an upper vehicle with four load-bearing wheels jointed to two rocker arms fitted on a frame for connecting to the body

– a negative type clamp with rope inlet from the top

– an integrated suspension with loading body jointed to vehicle near the clamp

The system will be equipped with a total of 120 cars in total.

The upper vehicle is provided with four load-bearing wheels articulated on two rocker arms, fixed in turn to two vertical pins. The latter joint allows the passage of the car on low curvature rails on the horizontal plane. This solution allows greatly reduced rail dimensions at station turn-around. The supporting frame is provided with a friction shoe for driving cars on the station turn-around.

The wheels, made of *Nylatron gsm*, have many advantages with respect to traditional steel wheels. These include simple construction, quiet rolling and lack of rubber coated ring, in addition to high reliability.

The wheel groove geometry is such to allow the passage of wheels in the critical line and station points on both rope sections and on the tensioning tongues.

The vehicle is made to maintain a fixed distance of approximately 500 mm between the track rope axis and the upper edge of the haul rope by means of an electrically welded frame structure. The lower part of the frame can accommodate the haul rope clamping system.

A friction shoe, on which the horizontal axis tires of the acceleration and deceleration devices work, is fixed to the top of the vehicle.

8.1 CLAMP

The clamp consists of a pair of jaws, one of which is mobile along a direction orthogonal to the line.

The clamp configuration is such to allow the rope in and out from the top. A solution of this type is fundamental in a system without line rollers in order to guarantee a high car clamping to the haulage loop safety. The absence of line rollers causes high loads imposed by the haulage loop on the clamp when the cars pass onto the supports. Mechanical components of a traditional clamp with opening facing downwards would need to be over-dimensioned to guarantee equal safety standard

The clamping force is provided by pack of appropriately dimensioned Belleville washers to guarantee a minimum sliding safety coefficient equal to 1.5 taking into account all forces acting on the car and possible rope diameter reduction during operation.

The haulage rope is clamped by means of steel jaws made of steel which is milder than that of the rope. The jaws are characterized by rack angles such to follow the angular variations of the rope in the segments comprised between one car and the next.

8.2 LOADING BODY BUCKET

The loading body is fixed and integrated with the suspension. It is joined to the vehicle near the clamp.

Made of structural steel, as the other parts of the car, it has a wall closing system in the lower part. The walls are held in position by means of a safety locking system.

The closing system comprises a number of joints and levers with a dead center mechanism. A recall spring allows the system to keep in position until an external force of a given entity (passage of the car on an opening cam) intervenes to determine opening.

9 WINCH AND HAULAGE ROPE

9.1 GENERAL DESCRIPTION

The ropeway line will be driven by the haulage loop, which can be positioned in the upstream station. This location maximizes grip adherence.

The winch is in an axis with the line and completely above ground, as indicated in greater detail in the station drawings.

Winch components:

– horizontal double groove driven bullwheel with grooves coated with plastic material, specifically designed for these applications to maximize haulage rope life, diameter 1700 mm with haulage rope winding of approximately 340°; a brake band is flanged onto the outer crown for the service and emergency brake

– single-groove counter-pulley aligned with drive bullwheel, also coated with plastic material

– upper bullwheel support frame directly anchored to a reinforced concrete partition

– two hydraulic type brakes working on the brake disc, one for service brake and one for emergency brake

– a pin-type elastic coupling connecting reducer to drive bullwheel shaft

– a right-angle axis reducer with slow vertical outlet shaft

– an alternating current electric motor connected to reducer by means of a pin-type elastic coupling

– control and safety devices

– base frame integral to reinforce concrete base by means of bolts.

The system can be run at any speed from 0 to 4 m/sec with this configuration.

9.2 BRAKING SYSTEM

Braking system is sized according to guarantee a deceleration ratio of 0.5 m/s^2. Considering the length of the line, the number of line towers and buckets, is better to let the installation stop by itself because adding an external supplementary braking force it would cause instability of the system.

The brakes installed on the winch are redundant, as required by the "Quaderno 8" OITAF at § 2.1.8.5 and just one brake is enough for the stop of the installation during the out of operation. The main winch is provided with the following brakes:

electric service brake, actuated by the electric motor supplied by alternating current; the electric service brake is activated by all braking controls which are not related to electric motor fault or to its control device;

mechanical modulated service brake, consisting in negative-type hydraulic brake calipers acting directly on the machined band on the edge of the drive motor; the mechanical service brake is activated directly by all braking controls which are not addressed to the electric service brake and indirectly in case of failure or insufficient operation of the electric service brake;

Mechanical emergency brake, consisting in negative hydraulic brake caliper also acting directly on the brake disc integral with the edge of the drive pulley. The emergency brake acts directly in case of excessive mechanical speed of the system or in case of breakage of the transmission and indirectly in case of failure or insufficient operation of the mechanical service brake.

All main winch brakes can provide a minimum deceleration of 0.4 m/sec^2 in the worst load conditions.

Two operating ramps are installed for modulated brakes: one “rapid” ramp calibrated to a value of approximately 0.4 m/sec², to be used in all cases in which a limited braking distance is essential (particularly for anti-collision, entry monitoring and clamp monitoring devices) and one “normal” ramp calibrated to a value of approximately 0.2 m/sec², to be used in all other cases.

9.3 SERVICE AND EMERGENCY BRAKES

The braking system consists for each system of one negative unit designed and made by AGUDIO (AG5 self-centering model). One clamp is the service brake and the other clamp is the emergency brake.

The negative effect braking unit is characterized by a hydraulic cylinder containing a Belleville washer pack which apply their action to the brake shoe by pressing the same against the brake band. At the same time, on the opposite side, the second shoe, inserted in a fixed body, comes into contact with the brake band and applying the brakes to the rotating system at the same time.

The cylinder and fixed body are kept joined by six threaded tie-rods.

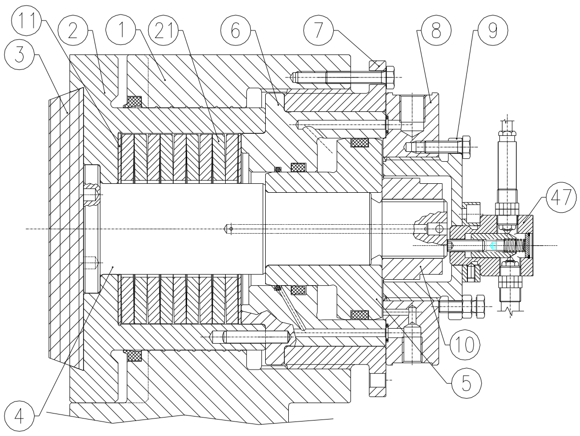
The braking unit is designed to allow very easy braking force adjustment by means of the adjustment ring nut without pressing force when the brake is open.

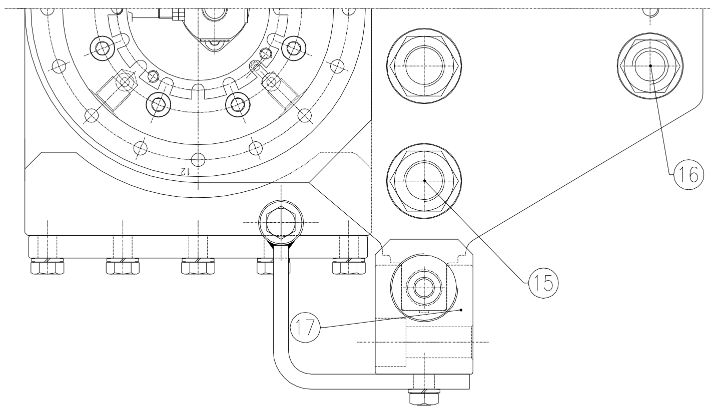
The entire brake body is mobile within two guides allowing the unit to be perfectly aligned on the brake disc axis and consequently eliminating axial forces which could cause a bending moment on the brake disc.

Two cylinders containing Belleville washers which are maintained aligned with the body of the disc brake by means of an appropriate adjustment are installed in opposition position by the side of the guides.

Replacing the brake shoes is simple: remove the two shoe containment locators, eject the shoe laterally from the dovetail housing and replace it with a new shoe. Finally, refit the two locators.

When the brake is opened, the pressurized fluid enters through hole A and reaches the chamber of cylinder 6, causing the brake to open. The pin 4 and the shoe holder 2 slide, moving away from the disc until stopping against the shoe holder 2 with the body of the cylinder 6. In low pressure, the springs 8 work on the shoe holder 2 which is freed and moved towards the disc, pressing the shoe 3 against the friction surface.





1	Rolled steel unit body with shoe holder sliding seat, cylinder piston and adjustment ring nut.
2	Shoe holding sliding within the unit and containing the Belleville washer pack.
3	Dovetail brake shoe.
4	Shoe return pin.
5	Opening piston with seal.
6	Brake and reaction opening cylinder for Belleville washers with seals.
7	Ring nut for adjusting the shoe position with respect to brake disc and gripping and braking force.
8	Pressurized fluid distributor and breather bottom.
9	Braking force adjustment ring nut.
10	Lock nut of piston on pin.
11	Belleville washers resting washer.
15 -16	Unit securing tie-rods.
17	Brake unit floating guide.
21	Belleville washers
47	Brake shoe wear monitoring unit.

9.4 WINCH BRAKING HYDRAULIC UNIT

The unit will be made in compliance with current laws and with modern components of leading international brands.

Special features include:

- complete splitting of service and emergency sections with identical positioning on external drive pulley band and the same calibration settings
- adoption of controlled deceleration for both brakes (modulated braking)
- intermittent operation of pumps with possibility of exchanging supplies
- possibility of cutting out proportioning solenoid valves by means of an electrically controlled device
- pressure transducers for supplying pump on/off pressure, enable pressure and pressure to be displayed on monitor
- various quick coupling inlets for manual pump insertion.

9.5 ELECTRIC ALTERNATING CURRENT MOTORS

The motor is of the three-phase asynchronous type to which reducer is coupled by means of a quick pin-type elastic coupling.

Each motor is provided with encoder.

9.6 HAUL ROPE BULLWHEELS

Each segment of the system is provided with a drive bullwheel for diverting the haulage rope in the stations and four return bullwheels in which one in the drive station and three in the return station. The bullwheel arrangement is shown on the station layout drawings.

The bullwheels of the haulage rope have groove bottom diameter of 1700 mm: the ratios required by OITAF are thus respected:

$$\frac{D}{d} = \frac{1700}{28} = 60,7 > 60$$

All bullwheels (drive and diverting, upstream and downstream) will be provided with devices suited to prevent the removal of rope from bullwheels and to maintain trim also in case of rolling bearing failure (electric control). The bullwheels will be protected by appropriate guides to prevent foreign bodies from getting accidentally inserted between groove and haulage rope.

The diverting bullwheels are equipped with the following safety and control devices, as required by technical standards in force:

- ice-scraper device
- safety protections.

All bullwheels are made of electrically welded metal structures, with groove deeper than the rope diameter and with the same groove coated with a soft material seal.

All bullwheel bearings (return and deviation) have a working life of at least 50,000 hours.

Space and speed transducer are fitted on the hub of some deviation bullwheels.

A downhill station bullwheel is fitted on a slide integral with a tensioning rope which is in turn connected to the existing counterweight. The length of the slide is sufficient to manage the stroke needed for operation and thermal and elastic elongations of the haulage rope.

ENVIRONMENTAL SCIENCE ASSOCIATES

California

Santa Susanna Flyingbelt

General Technical Description

00	06/08/2015	20	Document issue	Contin	Cattaneo
Rev.	**Date**	**Pages**	**Review**	**Issued by**	**Checked by**

CONTENTS

1 FLYINGBELT GENERAL DESCRIPTION

Flyingbelt is an aerial conveyor belt set in a deep, semi-circular trough combining the advantages of traditional, long-distance conveyors such as:

- use of standard components;
- stability in windy conditions;
- use of multiple motor drums (on the same side);
- booster advancement systems (intermediate drives);
- ease of maintenance.

with the advantages of a ropeway, such as:

- straight itinerary (overcome obstacles and difficult terrains);
- use of towers and pressure frame supports;
- less and light supporting structure (only ropes);
- safe installation (not accessible by people other than maintenance people);

Other benefits of the Flyingbelt are:

- **Reduced visual impact**: the Flyingbelt has less supporting structures than a standard conveyor belt with a visual impact considerably reduced.
- **Low OPEX and maintenance costs**: power consumption is reduced compared to other solutions and maintenance can be done “on line” with a dedicated vehicle specifically designed for these operations.
- **Energy efficiency**: Compared with standard transportation by truck, Flyingbelt is much more efficient, power requirements are very low and in some cases, for downhill transportation, even produce a positive return.

- **CO2 reduction**: the efficiency of the system can be evaluated as CO_2 reduction compared to standard transportation system by truck.

1.1 LOADING AND UNLOADING STATIONS

The layout of the loading and the offloading stations has been defined according to the line profile and to optimize the loading and offloading facilities.

We propose the loading point and the related mechanics at the ground level, laying on a concrete foundation, so that the Flyingbelt equipment and the loading facilities is easily accessible.

The offloading pulley is suspended on a metallic structure at the top of the offloading bay. Loading / Unloading hoppers, feeding belts, trippers etc… are not included in the present offer. Limit of our supply are:

- the loading point of the of Flyingbelt;
- the offloading pulley of the Flyingbelt,

The material has to be loaded in pre-weighed flow, tolerance accepted is 2%.

Material must be free from metallic parts: metal detectors, overbands or other means to avoid presence of metal have to be installed in the loading systems.

1.2 BELT SUSPENSION SYSTEM

The belt system consists mainly of:

- 4 track ropes, lock coil type, with “Z” form wires, fixed anchored to drums at both ends;
- Garlands of rollers for belt suspension with control rope centring means, according to the Vackem patent, whose rights for employment with aerial cables are exclusives of Agudio. These garlands are connected to the track ropes by means of support frames with friction grips.
- Steelcord belt.

The patent-pending Vackem system allows a superior sectional capacity higher than 34-40% compared to a three-roller 30° trapezoidal trough.

The rollers are mounted on shielded roller bearings, and then do not require any greasing operations along the line.

The upper brim of the belt is protected by a covering for the whole length of the conveyor.

All lubricants are biodegradable.

1.3 DRIVE UNITS

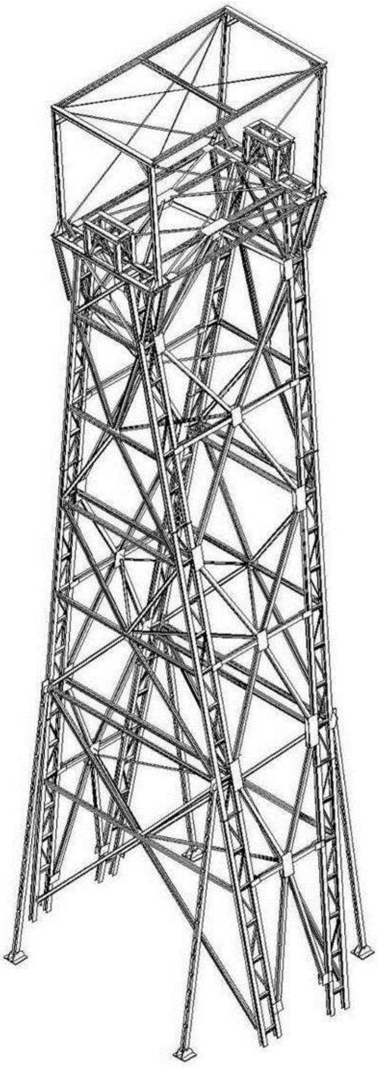
The Flyingbelt has 2 drive units, each one of them located at the extreme stations.

Elastic couplings will be put between shaft end and slow shaft of the gearbox, as well as between quick shaft of the gearbox and motor shaft.

No braking system is foreseen, since the natural stop of the conveyor is guaranteed in every load and temperature condition.

1.4 LINE

The line has one modular tower.



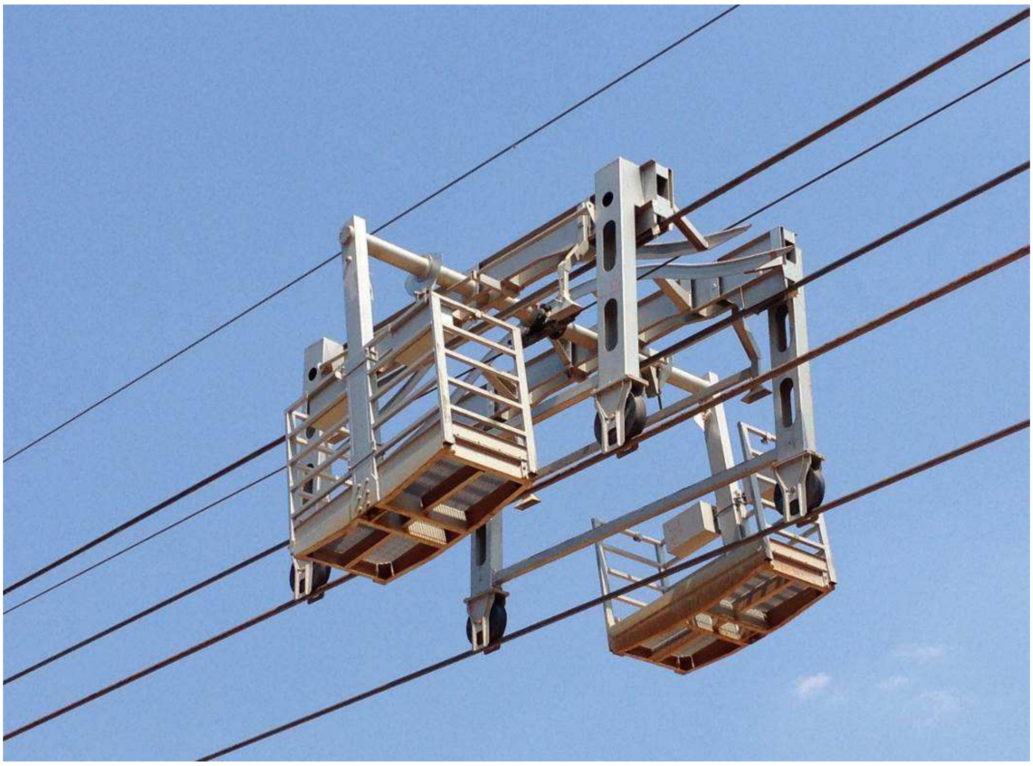
The tower module is composed by:

- A saddle that gives to the 4 track ropes a deviation of 8°;
- A head, that supports the rollers of the hauling rope;
- The lattice structure of the tower;
- The concrete foundation.

The structures will be hot dip-galvanized.

1.5 MAINTENANCE VEHICLE

For the operations of mounting, maintenance, inspection, the conveyor has a dedicated vehicle, moved by a spliced haul rope; configured the same as the vehicle for jig-back ropeways.



The vehicle consists of 2 platforms, supported by a 4-wheel trolley moving on the 2 upper track ropes and connected by grips to the haul rope. The maximum speed of the vehicle is 2.0 m/s.

The command of the vehicle is on board with a radio-device.

The maintenance vehicle does not need dedicated track ropes, since it moves on the same track ropes which support the belt mechanics.

The haul rope is moved by an electric winch located on the top of the tail structures.

1.6 POWER SYSTEM

All motors for belt and maintenance vehicle winch work with alternating current and are controlled with an inverter, in order to adjust the speed, the accelerations and decelerations in an optimal way.

Because the conveyors run downhill and produce energy, our inverter is equipped with A.F.E. (Active Front End) filters, so that this power can feed the electrical network without a power factor correction. The generated power can be used to feed the mine, or feedback the electrical grid.

The power cabin is pre-assembled in a 20 feet container containing modular electric cabinets with main switch-board and starters (MCC), inverters and AFE filters to be placed nearby the loading point.

1.7 CONTROL SYSTEM

The overall control of the system is done with a PLC and field instruments required to control the safe operation of the belt and manage start-up, shut down, alarms and blocks in any working condition.

Instrumentation control system will be suitable for data acquisition, such as analogical and digital signals, coming from field equipment and instruments.

The control system (PLC) is pre-assembled in a dedicated panel inside the power container.

The operation of the maintenance vehicle is done on board with a radio system. A fixed control panel at the loading station enables the movement of the trolley in case of failure of the radio system. In order to ensure the safety of the working personnel, in case of failure of remote control system, it is possible the handling of the winch command panel.

For maintenance personnel safety, the design and operation of the vehicle is in compliance with regulations for people transportation on ropeways.

2 SYSTEM CALCULATION

The following information describes the main technical features and shows the main calculation reports for the line sizing.

Three different conveyors have been calculated, based on the profile #17 with the same towers locations and heights, considering the transport in the following directions:

- Downhill;
- Uphill;
- Downhill + Uphill, utilized on the same belt.

2.1 MAIN TECHNICAL FEATURES

Transport direction		**Uphill**	**Downhill**	**Uphill + downhill**	**mm**
Horizontal length		3631			m
Difference in height		-176			m
Track rope diameter (lock coil type, R_{min} 1760 N/mm^2)		4 x 35	4x35	4x40	mm
Material		Sandstones, shales, pebbles			
Nominal capacity		200	170	170+170	tons/h
Grain size		≤ 200			mm
Bulk density		≥ 1.40			tons/m^3
Belt width		650	650	650	mm
Belt carcass		ST 1250	ST 2000	ST 2000	N/mm
Rubber quality		Y 6+6	Y 6+6	Y 6+6	
Belt speed		2.5	2.5	2.5	m/s
Belt filling		35%	30%	30%	
Drive pulley location		Tail + Head	Tail + Head	Tail + Head	
Take-up location		Head	Head	Bottom	
Take-up value		45	145	50	kN
Installed power		132 + 132	132 + 264	160 + 320	kW
Power consumption (<0 if generated power)	Full load uph.	/	364	432	kW
	Full load downh.	164	/		kW
	Empty belt	216	235	285	kW
Power of maintenance vehicle winch		30			kW
Speed of maintenance vehicle		2.0			m/s
Hauling rope diameter		20			mm
Operating temperature		-10 ÷ +40			°C
Max. wind pressure during operation		250 Pa (70 km/h)			
Max. wind pressure out of operation		1200 Pa (160 km/h)			