TO	:	TAMA staff, customers and stakeholders
SUBJECT	:	First progress report on the utilization of steel pallets - April 2024
DATE	:	26-04-24
BY	:	E.C.C.

Summary

This first report on the use of steel pallets has been issued by TAMA, aiming to provide information that will allow decisions to be made on the medium- and long-term feasibility of using pallets made from scrap steel instead of wood. For this purpose, the report has been structured as follows:

- Impact of wood on carbon footprint.
- Opportunity to reduce environmental impact.
- Opportunity to use scrap and others as raw material.
- Engineering design of steel pallets.
- Operational characteristics of metalworking companies with no serial or batch production.
- Opportunity for hazardous waste reduction.
- Cost comparison of steel vs. wood pallets. Disadvantages.
- Safety considerations.
- Advantages and opportunities for the use of steel pallets.
- Conclusions and recommendations.

Through our culture and values, and a series of metrics, this report reflects significant progress in our commitment to sustainability, which strengthens TAMA's position as a sustainability benchmark in the Peruvian metalworking industry and lays the grounds for future efforts in this field.

For more information about TAMA, please visit our website at www.tamaingenieros.pe

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1. Impact of wood on carbon footprint

Wood consumption is included in TAMA's indirect greenhouse gases emissions, according to ISO 14064:2018 and the Greenhouse Gas Protocol GHG Protocol Accounting and Reporting Guidelines.
According to pages 16 and 17 of Appendix N°1, you will find more details in this regard. In TAMA, we have the opportunity to reduce our carbon footprint by 815 tons of CO2, representing 32% of TAMA's total GHG emissions, taking 2023 as the baseline year. Likewise, in Appendix N°2 you may see the certificate issued by the Peruvian Ministry of the Environment "Organizational Carbon Footprint Report" for TAMA INGENIEROS SAC.

2. Opportunity to reduce environmental impact

At TAMA, we estimate that our share of the Peruvian market is less than 1% of the total volume of steel consumption.
Likewise, for every 100 tons processed, there is an average of 10 to 12% of scrap, with the behavior shown in Figures 1 and 2.

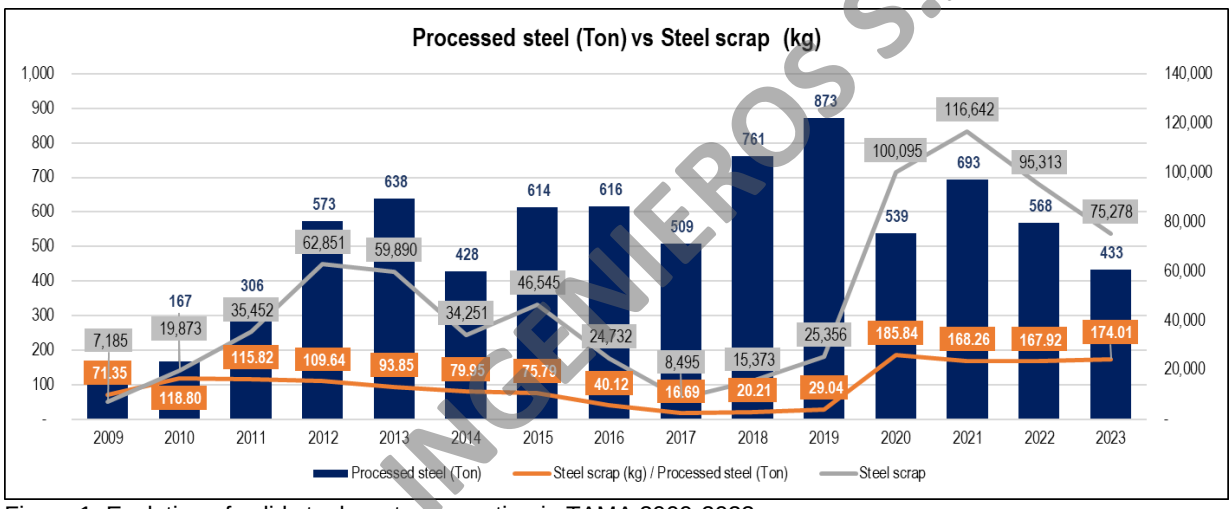


Figure 1. Evolution of solid steel waste generation in TAMA 2009-2023.

N°	COD. SAP	DESCRIPTION	UND	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	1850131	Carbon steel scrap	Kg	4,897	15,006	26,202	43,397	46,145	26,732	32,453	14,267	-	25	5,542	72,186	83,233	68,714	46,507
2	1850132	Steel scrap (small scraps)	Kg	-	-	-	-	-	-	-	-	-	-	800	-	3,480	350	4,683
3	1850133	Steel scraps (discs with low rotation)	Kg	167	-	3,490	11,364	9,005	940	142	-	4,840	3,398	-	1,930	1,170	630	12,879
4	1850134	Second use steel, bad conditions (rusted, deformed, etc)	Kg												-	-	50	-
5	1850135	Metal powder	Kg	1,873	4,356	4,864	6,566	4,178	5,230	7,900	6,060	900	8,950	8,150	19,040	13,878	17,450	5,661
6	1850136	Metal chips (machining and drilling waste)	Kg	-	247	896	914	331	875	5,016	4,230	2,140	2,980	7,070	6,340	8,344	2,497	1,201
7	1850137	Stainless steel scrap	Kg	248	264	-	610	231	474	1,034	175	615	20	1,997	420	430	190	146
8	1850138	Bronze (nozzles, bushings, etc)	Kg	-	-	-	-	17	10	-	191	-	-	26	-	48	5	2
9	1850139	Copper (wires, etc)	Kg	-	-	-	43	5	-	-	4	48	-	85	-	70	345	89
10	1850140	Aluminum	Kg	-	-	-	15	-	5	17	21	-	-	3	-	20	14	223
11	1850141	Other special steel (hardox)	Kg	-	-	-	-	-	-	-	-	-	-	1,797	180	6,107	5,433	4,200
12	1850142	Paper	Kg	14	24	40	153	119	410	220	224	377	310	355	456	186	565	430
13	1850143	Carton	Kg	-	-	8	93	-	-	-	-	-	-	-	356	601	674	514
14	1850144	Plastics	Kg	-	-	-	14	-	-	-	-	-	-	-	13	333	593	475
15	1850145	Hazardous waste	Kg	-	-	-	-	-	-	-	-	15	-	21	-	-	526	1,210
16	1850146	Miscellaneous waste	Kg	-	22	-	-	-	-	-	-	-	180	3,130	9	-	103	821
17	NA	Non-usable waste	Kg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	460
		Total waste (kg)		7,199	19,919	35,500	63,169	60,031	34,676	46,782	25,172	8,935	15,863	28,976	100,929	117,899	98,138	79,501
	**	**Total steel waste (kg)**	**Kg**	**7,199**	**19,919**	**35,500**	**63,169**	**60,031**	**34,676**	**46,782**	**25,172**	**8,935**	**15,863**	**28,976**	**100,929**	**117,899**	**98,138**	**79,501**
		Total other metal waste		-	-	-	58	22	15	17	216	48	-	114	-	138	364	314
		Paper		14	24	40	153	119	410	220	224	377	310	355	456	186	565	430
		Carton		-	-	8	93	-	-	-	-	-	-	-	356	601	674	514
		Plastics		-	-	-	14	-	-	-	-	-	-	-	13	333	593	475
		Hazardous waste		-	-	-	-	-	-	-	-	15	-	21	-	-	526	1,210
		Miscellaneous usable waste (WEEE, glass)		-	22	-	-	-	-	-	-	-	180	3,130	9	-	103	821
		Non-reusable waste																460
		Manufacturing weight (tons)	Ton	101	167	306	573	638	428	614	616	509	761	873	539	693	568	433
		Steel waste (Kg) / Manufactured Weight (Ton)	Kg/Ton	71.49	119.08	115.97	110.20	94.07	80.95	76.18	40.83	17.55	20.85	33.18	187.39	170.07	172.90	183.77
		Scrap Steel Ratio (Kg) / Manufactured Weight (Kg)	Kg/kg	4.86%	8.97%	8.56%	7.57%	7.23%	6.24%	5.28%	2.31%	0.00%	0.00%	0.63%	13.40%	12.01%	12.11%	10.75%

Figure 2. TAMA's solid steel waste generation breakdown 2009-2023.

According to Appendix N°3 “T-GI-F-21 Trees estimation report”, TAMA has calculated that for every

100 tons of steel manufactured products delivered, seven trees of 0.81mØ x 17.90 m in height are needed, taking from 7 to 10 years to mature (if the environmental conditions and nutrients are optimal, since in other cases such as in southern Peruvian region of Puno, for example, a tree can take up to 30 years to reach that size).

3. Opportunity to use scrap and others as raw material

Our company has a coding system designed for the traceability of the different types of by-products produced, which is shown in Figure 3:

Cod Familia	Cod Clase Comp	Cod Sub Clase	Cod Sub ClaseComp	NomSubClase
185	18501	31	1850131	Carbon steel scrap
185	18501	32	1850132	Steel scrap (small scraps)
185	18501	33	1850133	Steel scraps (discs with low rotation)
185	18501	34	1850134	Second use steel, bad conditions (rusted, deformed, etc)
185	18501	35	1850135	Metal powder
185	18501	36	1850136	Metal chips (machining and drilling waste)
185	18501	37	1850137	Stainless steel scrap
185	18501	38	1850138	Bronze (nozzles, bushings, etc)
185	18501	39	1850139	Copper (wires, etc)
185	18501	40	1850140	Aluminum
185	18501	41	1850141	Other special steel (hardox)
185	18501	42	1850142	Paper
185	18501	43	1850143	Carton
185	18501	44	1850144	Plastics
185	18501	45	1850145	Hazardous waste
185	18501	46	1850146	Miscellaneous waste
185	18501	47	1850147	Others

Figure 3. Classification of waste generated by the activities at TAMA.

Looking at our history, a major part of by-products traded is scrap steel and secondary steel. Given that TAMA's production is diverse, in many cases dual products are kept in our warehouses (“dual” is a term we use to refer to the surplus material of steel plates or shapes of commercial sizes, that is not employed in the manufacture process but is still reusable due to their dimensions).

Over time, the leftover material has been "stored", rusting to a level equal to or greater than SSPC level C. When this level of corrosion is reached, this material is no longer suitable for our fabrications, and becomes scrap steel or second grade steel and subsequently sold at the market price of "scrap".

Corrosion level C is defined according to the SSPC-VIS / ISO 8501-01 standard, as stated in TAMA's General Terms and Conditions of Sales T-GC-DC-05, clause 13 (See detail in Figure 4):

13. CORROSION PROTECTION

TAMA may procure steel with rust grade “A” & “B”, according to the SSPC-VIS / ISO 8501-1 standard and -in exceptional cases under Client approval- with rust grade “C”. Conductivity test, chlorides test, air quality test and roughness test will be performed every three months to control of our shot blasting process, according to ASTM D4940, SSPC Guide 15, ASTM D4285, ASTM D4417, correspondingly.The coating inspection for release will be based in the SSPC-PA2 (level 3) standard, which defines the area to be inspected and the dry film thickness range. In relation to the coating guarantee, it will not include inalterability, system permanence, color permanence, or other characteristics of the coating. TAMA standard does not include special tests such as Holiday test nor adherence test. In the event that the Client requests the supply of an extra quantity of coating for touch-ups on site, such as thinner, solvents, diluents, coating, etc., the Client will be responsible for its packaging.

Figure 4. Clause 13 of the General Terms and Conditions of Sale T-GC-DC-05.

The following figures shows different types of "duals", scrap, and even material previously considered as scrap that can be used in the manufacture of steel pallets.

- Figure 5, in yellow is the "scrap" that shall currently be used to manufacture steel pallets.
- Figure 6 and 7, in yellow, which was previously considered as "dual", but due to its geometry, it even causes safety risks during handling and transportation.
- Figure 8 and 9, a finished product, and how its disc shapes "scrap" shall be then be used as baseplates for steel pallets.
- Figure 10 and 11, different examples of non-commercial beams, which are left over in smaller lengths, and eventually rust, then lose their value and should be sold at scrap price (TAMA's facility is located in Ate, Lima district with dry weather. Rust becomes more critical in metalworking factories located near the Lima coast, such as Lurin, Chilca, etc.)

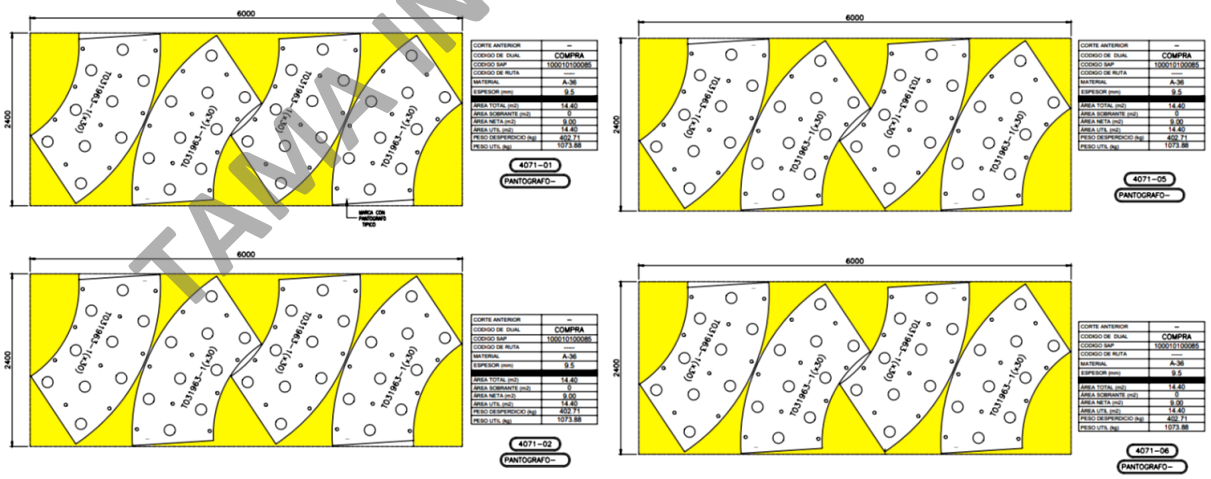
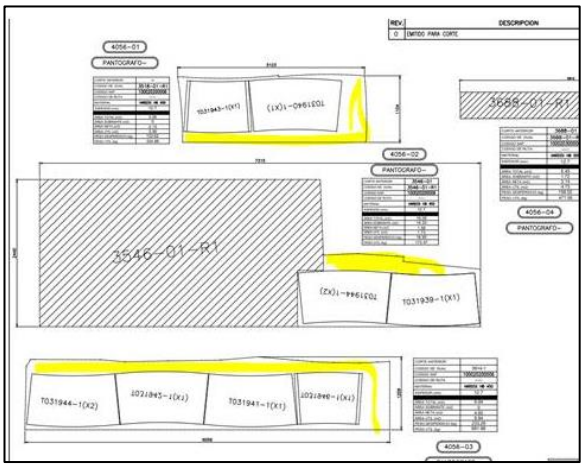
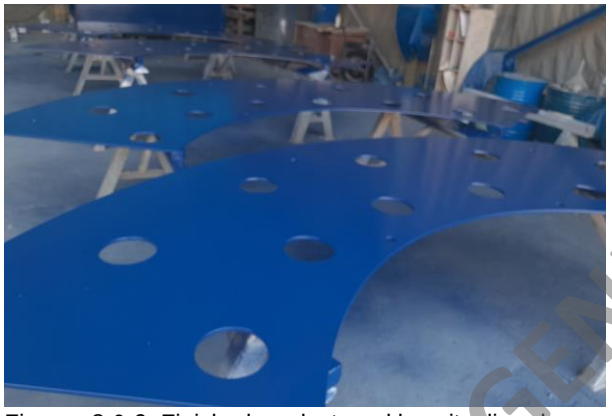


Figure 5. In yellow, the "scrap" that shall currently be used to manufacture steel pallets.



Figures 6 & 7. In yellow, what was previously considered as "dual", but even causes safety risks during handling and transportation.



Figures 8 & 9. Finished product, and how its disc shapes "scrap" shall be then be used as baseplates for steel pallets.

Figures 10 & 11. Non-commercial steel, stored as "dual", after years it is sold as second-hand material at "scrap" prices.

4. Engineering design of steel pallets

The design is based on the following concepts:

- The pallet should be modular; therefore, we have proposed typical 600x600 mm modules or their multiples. This allows the manufacture of modules that can be assembled and configured in new dimensions.
- According to Appendix N°4 (10 typical packing cases, out of which we propose that pallets could cover the needs from case 2 to 9), which is based on our Packing Procedure T-AB-PT-05, it was concluded that the best way was to reduce this to two types of pallets: light/semi-heavy, and heavy pallets.
- Only one type of steel beam is used for the pallet supporting columns. In this case, a 2 ½"Ø steel pipe, which is left over from a regular fabrication job for a steel mill, is used. In this way, the fitting out of the principal beams (V1 and V4) and secondary beams (V2 and V5) is carried out more efficiently, since they all have similar dimensions.
- The above-mentioned will allow the fabrication with Assistant and Official class staff (lower labor cost), duly supervised.
- The design is for forklift or equivalent use only. Do not hoist.

Four files in Appendix N°5 provide the typical drawings for type A (light and semi-heavy) and type B (heavy) steel pallets, together with their related structural calculation report and nameplate drawings.

It is important to mention that according to Appendix N°7, a reference study on the fabrication of light steel pallets (public access document: https://www.sciencedirect.com/science/article/pii/S0264127522000466), steel pallets are expected to have a life expectancy of no less than 20 years (page 13).

Likewise, due to the strongness of the pallets (according to the calculation report, they have a safety factor of approximately 20x), the life expectancy is higher for the pallets manufactured by TAMA.

An opportunity for engineering improvement:

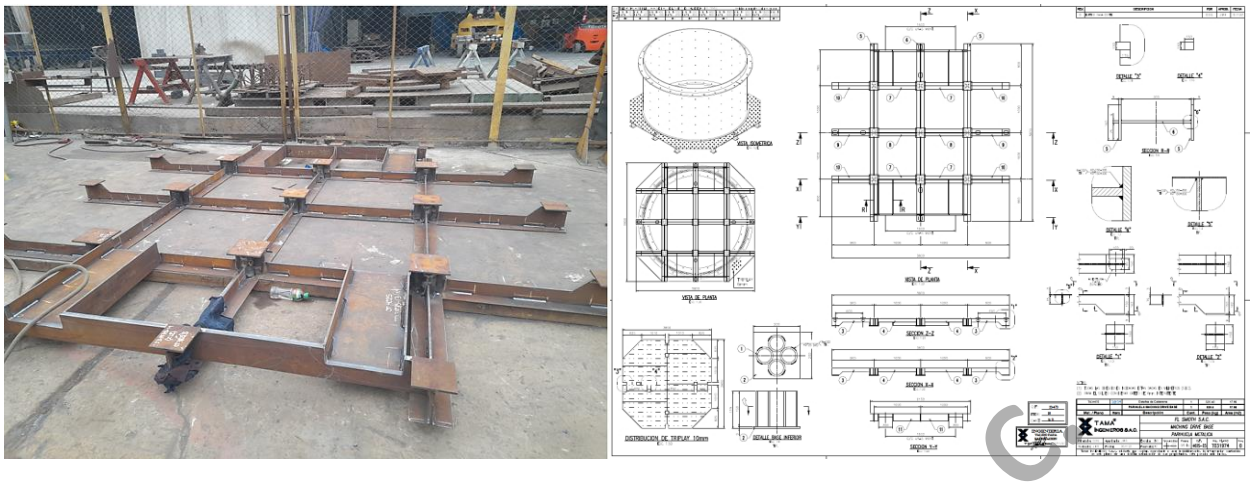
- TAMA has improved the pallet design for beams V1, V2, V4, V5, to be able to use greater thicknesses than shown in the drawings, decreasing the camber, to comply with the load expectations without the need for the pallets to be highly robust. See in Figure 12, 13 the high robustness of these elements that reduces costs and allows the production of more beams (m²) using similar resources.
- See in Appendix N°6 three files, including the new optimized design with beams V1, V2 for light/semi-heavy pallets and V4, V5 for heavy pallets. The safety factor decreases to 7.5x and 10.8x, but in favor is that these elements are often obtained from tri-standard beams that have a yield stress of 50 ksi. As of June 2024, this new design will be in use in TAMA.
- It is estimated that with this design, we will be able to manufacture 30% more steel pallets, using the same steel volume.


Figures 12 & 13. Manufacturing of robust steel pallets

Background on 2023: Previous design (outdated):

In 2023 TAMA delivered several products, with made-to-order pallets as shown in figures 14, 15, and 16, but this implied to manufacture with unique material, and with higher resources of man-hours and consumables.

Figure 14. Custom-designed steel pallets



Figures 3. Design of non-standard steel pallets.

5. Operational characteristics of metalworking companies with no serial or batch production

As shown in Figure 17, during a year there are months with less workload. Therefore, it is possible to take advantage of these periods to produce steel pallets to balance the factory's workload. This is an important argument for metalworking companies to be able to tolerate the "opportunity cost" of manufacturing this type of pallet (cost issues should be considered).

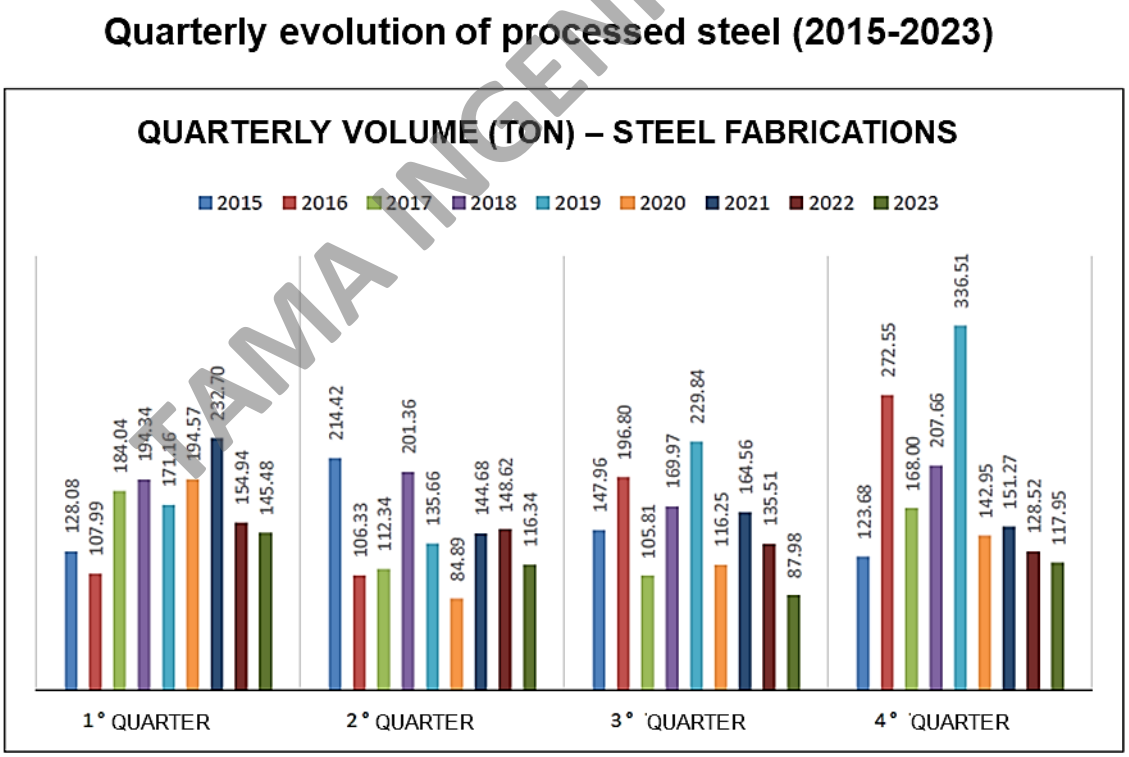


Figure 4. Quarterly evolution of processed steel from 2015 to 2023.

6. Opportunity for hazardous waste reduction

According to Appendix N°8, TAMA's 2023 hazardous waste management certificate, more than 90% of the hazardous waste is generated by the use of paints (their containers and other contaminated materials resulting from coating operations).
It is estimated that steel pallets can be painted using leftover paint, avoiding the segregation of contaminated materials as paint containers, see Fig. 18.

Figure 5. Hazardous solid waste record, 2023.

7. Cost comparison of steel vs. wood pallets. Disadvantages.

In this section, a 2.4m x 1.2m heavy steel pallet (type B) is analyzed.

As can be seen in Appendix N° 9, a steel pallet costs 4.23 times more than a similar wooden equivalent. And if the raw material is charged at a "scrap" price, the ratio turns out to be 2.83 times.

In other words, from a purely economic point of view and in the short term, this option of manufacturing steel pallets is not viable.

However, with our new design proposed in Appendix No. 6, the weight of the pallets will be reduced, but the cost of consumables and labor will increase.

We have identified the following disadvantages:

7.1. "Scrap" is no longer sold

In the Peruvian metalworking industry, it is common practice for the owners and/or managers of companies to sell metal scrap and leftovers from their operations in an unregistered way (e.g. without an invoice), thus receiving an undeclared income and having additional profits. And if the scrap is sold under formal conditions (with an invoice to registered segregation companies), they do not receive any additional income.

Considering that more than 95% of metalworking companies start their activities as an entrepreneurial venture (i.e. without capital and/or support from a parent company), these practices are common and take root over time.

However, historically, in the metalworking industry in Peru, it is by selling "scrap" and its low regulations, that many companies have been exposed to acts of corruption by their employees, even selling new material ("cut to size") as "scrap".

It should also be noted that steel accounts for an average of 40% to 48% of the direct cost of manufacturing.

7.2. Non recognized costs

In their evaluation processes, customers usually only evaluate costs or final prices, so there would be no incentive to carry out this additional work. Considering the low contribution margin of the metalworking industry, and the fact that costs are usually not well controlled, this initiative would not be attractive since it would result in higher costs.

7.3. Losses due to opportunity costs

For every 100 net tons of steel sold, there are approximately ten tons of steel for pallets, though not all of them are used at 100%, so it is estimated that six tons are destined for pallets.

If a metalworking company produces 1000 tons per year, then it will have 60 tons of steel available for pallets.

Assuming an average of 70 kg/m² of weight (between both types of pallets), then we have an average of 857 m² of pallets.

The number of man-hours required to manufacture a metal compared to a wooden one is approximately 6 times more man-hours.

In brief:

- 12,000 man-hours to manufacture 857 m² of steel pallets.
- 2,350 man-hours to manufacture 857 m² of wooden pallets.

That is to say, there are 9,650 hh of workers, who give up producing steel in fabrications for sale and this can represent the loss of a contribution margin, or 64 tons per year (if there is an excess of work), which means that a contribution margin of $147,500 per year could be lost.

A company that produces 1,000 tons per year, could be in a range of annual revenues of 4.5 to 6 million dollars, on average.

7.4. Misuse: End user avoids pallet turnover

The purpose of these pallets is that they can be used repeatedly, as they are robust in their design, they can be expected to have several years of life. However, it is likely that the end user (mining, iron and steel industry, etc.) uses them as an element for storing goods and does not contribute to the turnover of the pallets, and thus does not contribute to reducing the need for new wooden pallets.

8. Safety considerations

As of the date of issuance of this report (April 26, 2024), TAMA has shipped several metallic pallets and we have the following feedback from some end users (mining industry):

a. The pallets are too heavy. On average, the most conservative case is that the pallet has an average weight per square meter of 100 kg/m² (3 or 4 times more than a wooden pallet). However, considering the type of service it can be used for, as well as the equipment used to handle it, this should not represent a major concern. Each package has a packing list (containing the number of pieces and total weight), and each pallet has a nameplate with dimensions, net weight, and manufacturing date, so that the operator is provided with all the necessary information to carry out his/her work safely. See fig. 19.

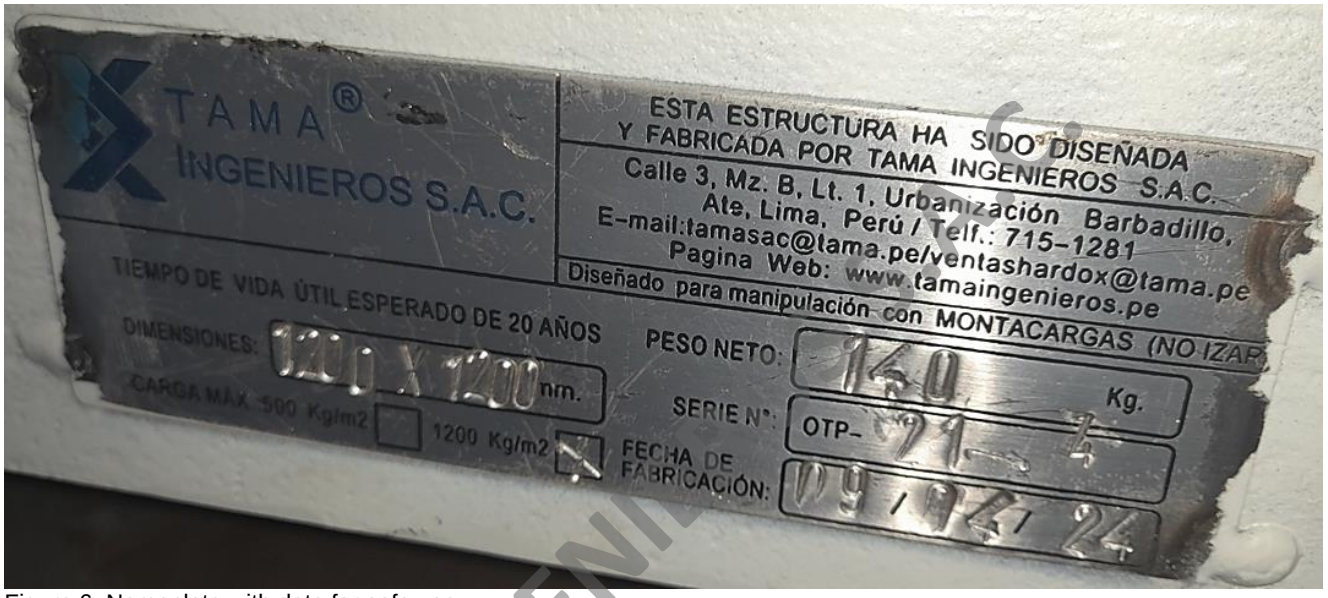


Figure 6. Nameplate with data for safe use.

b. The procedures of the mine warehouses indicate that steel pallets are not to be used, only wooden pallets are allowed, because when handling the load, they can "slip" and generate a falling risk. As can be seen in the calculation memory and drawings in Appendix No. 6, we have:
   - For mechanical issues there are no problems with the assigned load, the safety factors are above 20.
   - The pallets are symmetrical. They have support columns every 600 mm.
   - The design guarantees a contact every 600 mm between the forks and the main beams V1 or V4, depending on the type of pallet either on the X-X or Y-Y axis.
   - The clearances between the floor and the bottom of the main beams V1 and V4 (space for the fork access) are 150 mm and 175 mm respectively, which are adequate spaces for handling.

   In this regard, during use at TAMA, to date there has been no falling risk or any risk of slipping from the forks.

   It is recommended to follow the instructions given in the forklifts' user manuals.

Figures 20 & 21. Steel pallet handling with forklift.

9. Advantages and opportunities for the use of steel pallets

a. The main advantage is that pallets can be reused for many years, thus reducing the need to produce wooden pallets.
b. If customers can share this information with other metalworking companies, who can contribute to improve the design and manufacture their own pallets, there would be a multiplying effect, and in a few years, we could have in the market plenty of steel pallets being reused for packaging.

   The estimated opportunity in the Peruvian market (companies that manufacture products similar to TAMA's and, therefore, the need for pallets as shown in Appendix N°4, cases 2 to 9), is calculated as follows:
   - An annual consumption between 15,000 to 20,000 tons per year.
   - If in the short term (next 3 years), it is assumed that 20% of the metalworking producers manufacture these pallets, at a ratio of 6% of steel available for pallets, there would be an annual potential of 180 to 240 tons of steel pallets per year. This is equivalent to at least 2,570 m² of pallets (with the new design in Appendix N°6, the quantity can be increased by up to 30%).
   - If an average consumption of 5 trees per 100 tons of production is taken as an average, this is equivalent to a saving of more than 180 trees of 0.81mØ x 17.90 m in height per year. With the multiplier effect due to the reuse of the steel pallets over time.
c. A non-tangible commercial advantage is that the pallets include a nameplate, creating brand value for the steel manufacturer.
d. To date, we are already shipping products with these pallets, as shown in Figures 22, 23 and 24.
e. It is important to mention, but without going into further details, that the savings in the use of a tree in Peru have greater relevance, because of the impact on biodiversity that this involves (compared to another tree of equivalent volume in a country like Canada or the USA, which also have important forests under authority controls, traceability, etc.) Likewise, by no longer using wood for pallets, the incentive for illegal activities in Amazonian forests will be reduced.

Figure 22,23 & 24. Products shipped in March 2024 with steel pallets.

10. Conclusions and recommendations

a. TAMA recommends customers to analyze this information with their technical professionals in order to find opportunities for improvement, for example, improve the proposed design (Appendix N°6) and costs.
b. Currently, we are freezing the manufacturing of steel pallets, as well as the delivery of products using these pallets (we have more than 25 m² in stock with the first design according to Appendix N°5). We are waiting for our customers' feedback, in order to resume production by the end of June 2024, with the design according to Appendix N°6 and being sure that this design will be accepted in our customers' warehouses.
c. The parties who receive this information can share it, especially with metalworking companies, in order to comply with the objective outlined in section 9. We understand that if larger markets such as Chile, Brazil, Mexico join this initiative, it could have an important impact in Latin America (our Amazon).
d. TAMA recommends customers to improve payment conditions, with the current rates and the payment of invoices at 90 or 180 days, a high financial interest is generated affecting the competitiveness of metalworking companies. Likewise, TAMA recommends keeping continuous work assignments, a metalworking company without financial strength can not afford to invest resources in this kind of initiatives.
e. Some of TAMA's customers have better bargaining power with respect to the final customer (mostly the mining industry). Using this information, we request that the current procedures, which only accept wood packaging, be reviewed.
f. Analyze other opportunities for improvement, for example, ask the customer to review their packaging procedures. In the last two years, customers have requested that all their products be covered with a plastic stretch film, without performing an analysis to segment the products to be packaged. In TAMA's opinion, this practice may be applied to a product made of special materials such as stainless steel, coating, machining (which, due to its characteristics in contact with dust or other contaminants, may generate cracks, pitting, scratches, etc.), but does not apply for a painted product, which given the nature of its use, the paint is basically a "brand presentation", and when it is put into service in seconds or minutes, the paint is removed (liners type coatings, wear spare parts, fatigue, etc.)

Appendix N°1

T-GG-F-09 TAMA Carbon Footprint 2023

TAMA INGENIEROS S.A.C.

Steel Transformation for Mining and Agroindustry

“TECHNOLOGY DEVELOPMENT FOR A BETTER LIFE QUALITY”

TAMA®
INGENIEROS S.A.C.

CARBON FOOTPRINT
TAMA INGENIEROS S.A.C
2023

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SUMMARY

This presentation summarizes the results obtained from the calculation of TAMA's greenhouse gas (GHG) emissions for the year 2023, carried out by the consulting firm A2G.

The information shown in this report corresponds to the period from January 1 to December 31, 2023

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METODOLOGY

- Methodological guidelines of ISO 14064-1:2018.
- Calculation methods outlined in the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Inventories.

For the calculation of GHG emissions:

The general formula for calculating greenhouse gas (GHG) emissions is used:

$$Emisiones\_GEI = \sum_i Nivel\_Actividad_i \times Factor\_Emisión_i$$

Where:

Activity_Level: This is the required information. Generally it refers to a single piece of information such as: consumption of fuel consumption, electricity consumption, paper consumption, etc.

Emission_Factor: This is the GHG emission per unit of the Activity Level.

i: Corresponds to cases at the activity level. For example: types of fuel, types of raw material, etc.

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RESULTS

Total GHG emissions generated by TAMA in 2023 accounted for **2,488.03 tons of $CO2_e$**

GHG emission sources	GHG emissions tCO_2	GHG emissions tCH_4	GHG emissions $tN\ Oe_2$	GHG emissions $tCO\ e_2$	%
Category 1: Direct GHG emissions	**12.67**	**0.02**	**0.18**	**12.87**	**0.52%**
Own fuel consumption of stationary equipment	0.19	-	-	0.19	
Own fuel consumption of mobile equipment	12.2	0.02	0.18	12.41	
Fire extinguishers	0.17	-	-	0.17	
Lubricants	0.10	-	-	0.10	
Category 1 Biogenic emissions	-	-	-	-	
Category 2: Indirect GHG emissions caused by for imported energy.	**35.41**	**0.05**	**0.06**	**35.52**	**1.43%**
Electricity consumption	35.41	0.05	0.06	35.52	
Category 3: Indirect GHG emissions caused by transportation	**45.43**	**0.04**	**0.32**	**45.79**	**1.84%**
Air travel	3.07	-	0.02	3.09	
Overland travel	0.36	-	-	0.36	
Local mobility	0.58	-	-	0.58	
Transportation of goods	4.48	-	0.06	4.54	
Solid waste transportation	0.07	-	-	0.07	
Transportation home - work	36.87	0.04	0.24	37.15	
Category 4: Indirect GHG emissions by products used by the organization.	**2,393.82**	**0.01**	**0.01**	**2,393.84**	**96.21%**
Electric power: T&D loss	4.49	0.01	0.01	4.51	
Water consumption	0.09	-	-	0.09	
Paper consumption	0.22	-	-	0.22	
Purchase of materials and supplies	2,389.02	-	-	2,389.02	
Solid waste generation	-	-	-	-	
Total	**2,487.33**	**0.12**	**0.57**	**2,488.02**	**100.00%**

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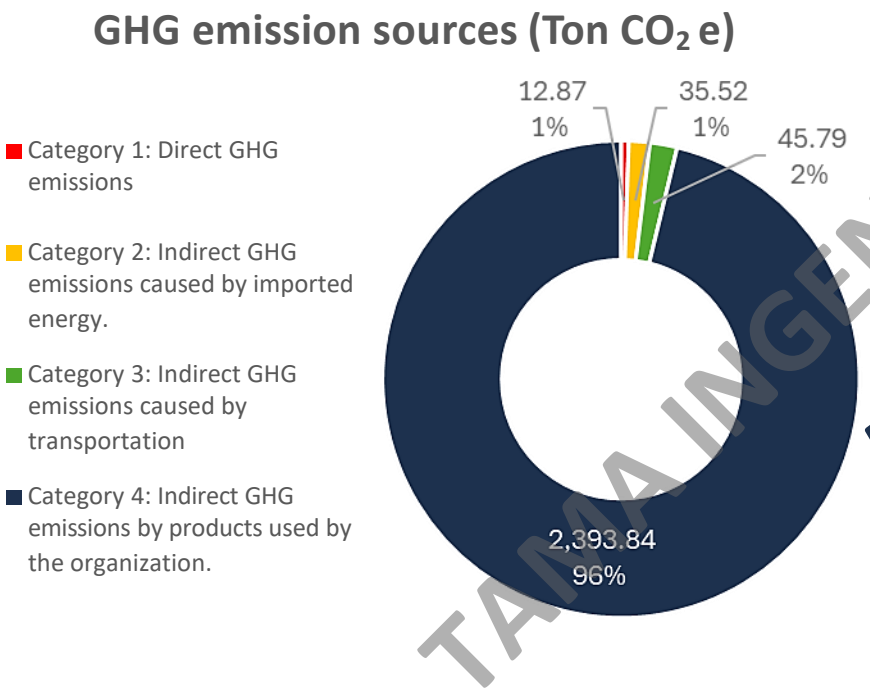
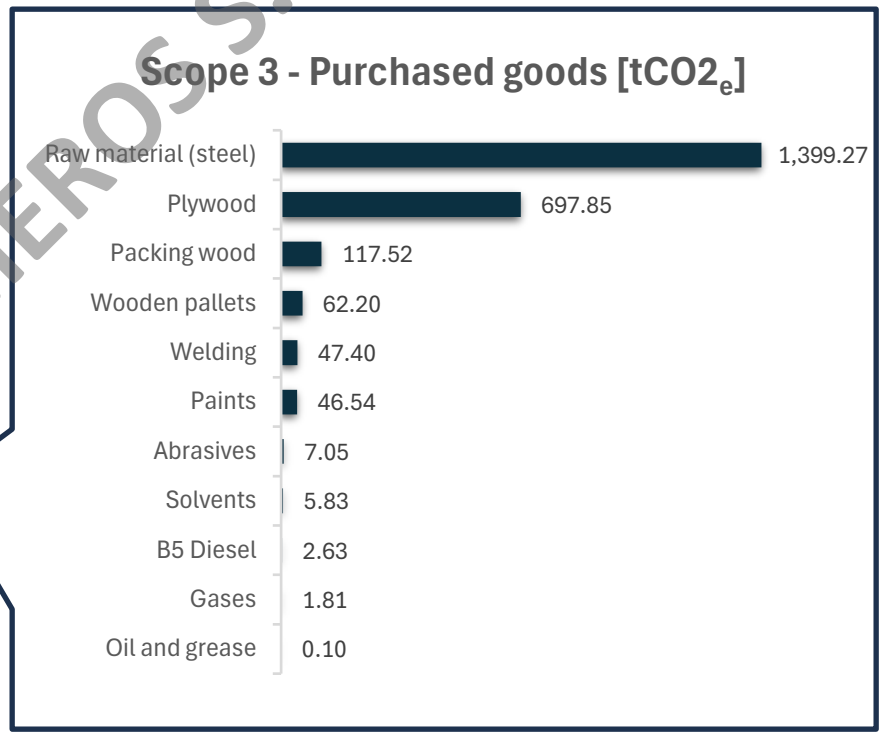
RESULTS

Total GHG emissions generated by TAMA in 2023 accounted for **2,488.03 tons of $CO2_e$**





There is a high component of raw materials (steel) and wood (plywood, packaging, flooring) in TAMA's indirect emissions.

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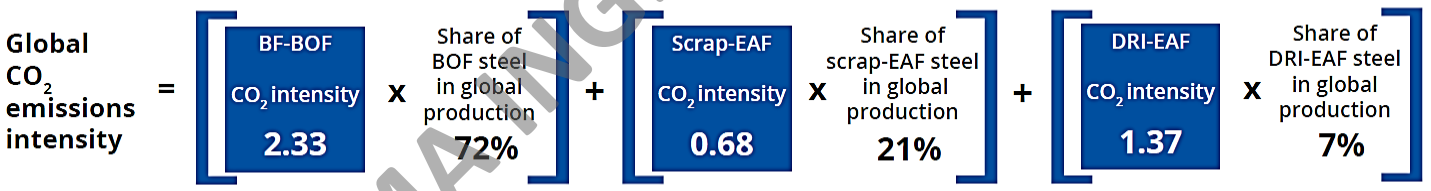
INDIRECT GHG EMISSIONS FROM STEEL PURCHASES

The World Steel Association (Worldsteel) is an institution that brings together approximately 150 steel producers representing 85% of the world's production, and collects and reports sustainability kpi's of the steel industry such as CO_2 emissions.

Calculation approach for global CO_2 emissions intensity, 2022 onwards



Methods: (BF-BOF) Furnace-B sic Oxygen; (Scrap+EAF) Scrap + Electric Arc Furnace; (DRI) Direct reduced iron
The % are relative to the share of steel by method of production worldwide.

Source: https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report/

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INDIRECT GHG EMISSIONS FROM STEEL PURCHASES

According to Worldsteel, in 2022, for every ton of steel produced in China, between **1.3 to 2.1 tons of CO_2** were emitted.

Ecoinvent®, a global institution that compiles databases of CO2 emissions from energy, supplies, chemicals, metals, agriculture, waste management, transportation, etc., states that the emission factor is **2.5 Ton CO_2 /Ton Steel**.

Emissions by steel raw material$_{TAMA}$ = 558.3 Ton x 2.5 Ton CO_2 /Ton = **1,399 Ton CO_2.**

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EMISSIONS STANDARDS

Main approaches to emissions management:

ISO 14064:2018 Standard for the quantification, verification and reporting of greenhouse gas emissions.	GHG Protocol GHG Protocol Accounting and Reporting Guidance: Guidelines for companies measuring and reporting their GHG emissions.
Category 1: Direct GHG emissions and removals	**Scope 1**: Direct GHG emissions.
Category 2: Indirect GHG emissions from imported energy.	**Scope 2**: Indirect GHG emissions from imported energy.
Category 3: Indirect GHG emissions from transportation.	**Scope 3**: All other indirect emissions occurring in the organization's value chain, including ISO 14064 categories 3, 4, 5 and 6.
Category 4: Indirect GHG emissions from products used by the organization.	
Category 5: Indirect GHG emissions associated with the use of the organization's products.	
Category 6: Indirect GHG emissions from other sources not included in categories 2 to 5.	

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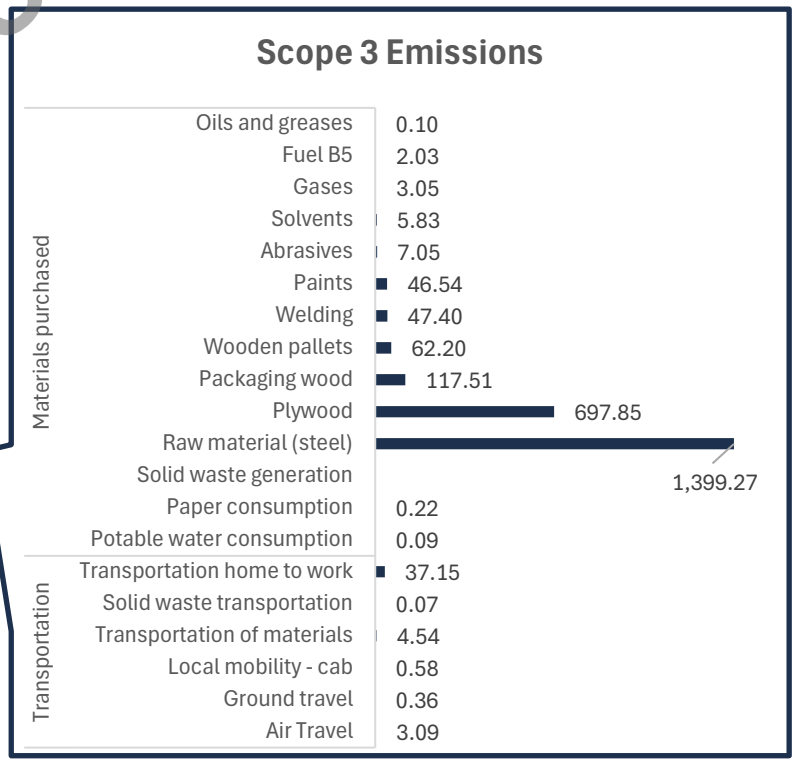
IMPACT ON SBTi TARGETS

Looking ahead to SBTi in 2030, 96% of TAMA's footprint is represented by indirect emissions from purchased materials (raw materials and consumables).

GHG Protocol	GHG TAMA 2023 (tCO_2e, %)	Sources
Scope 1: Direct GHG emissions	12.87 0.52%	Fuel (forklifts, truck) and fire extinguishers.
Scope 2: Indirect GHG emissions from imported energy.	35.52 1.43%	Electricity
Scope 3: All other indirect emissions occurring in the organization's value chain, including ISO 14064 categories 3, 4, 5 and 6	2,439.63 98.06%	Ground transportation (freight, cabs, local travel, home-work), water, paper, solid waste, and purchased materials (2,389 Ton CO_2)
	2,488.02 100%	



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REGISTRATION IN THE CARBON FOOTPRINT PLATFORM OF THE PERUVIAN MINISTRY OF ENVIRONMENT

https://huellacarbonoperu.minam.gob.pe/huellaperu/#/listadoInscritos/99

TAMA® INGENIEROS S.A.C.

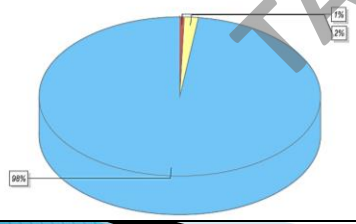
REGISTRATION IN THE CARBON FOOTPRINT PLATFORM OF THE PERUVIAN MINISTRY OF ENVIRONMENT

Performed on April 02, 2024 and published on April 03, 2024.

The figures reported by ministry differ slightly from the report issued by the consultant due to the use of other emission factors for each source.

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas	12.86	0.5 %
Categoría 2 – Emisiones indirectas por energía	40.27	1.6 %
Otras categorías – Otras emisiones indirectas	2,439.31	97.9 %

Gráfico: Participación por categoría



PERÚ Ministerio del Ambiente — Herramienta Huella de Carbono Perú

REPORTE DE HUELLA DE CARBONO

1.- DESCRIPCIÓN DE LA ORGANIZACIÓN:

Razón Social: TAMA INGENIEROS SAC

Sector Comercial: C: Industrias manufactureras

Sub-sector: Fabricación de productos metálicos para uso estructural

Actividades: Metalmecánica

Periodo de reporte: 2023

2.- RESUMEN DE RESULTADOS:

La organización TAMA INGENIEROS SAC, generó:

2,493 tCO_2e

Además, por quema de biomasa 0.37 tCO2 y 0.000 tHCFC.

Se ha considerado una incertidumbre: Razonable.

El enfoque de consolidación del límite de información ha sido CONTROL OPERATIVO al 100%.

El enfoque para las emisiones indirectas por energía importado es el BASADO EN LA UBICACIÓN.

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NEXT STEPS: SBTi

- Climate targets for TAMA emissions reductions must be approved by the Science Based Targets iniciative (SBTi).
- SBTi is the institution with the most recognized method for the approval of climate roadmaps.
- The SBTi targets are science-based and in line with the Paris Agreement on climate change.
- TAMA form sent on 09ABR2024.

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

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NEXT STEPS: SBTi

How some well-known companies set their science based targets:

Company	Target
FLSmidth	"FLSmidth A/S commits to reduce absolute scope 1 and 2 GHG emissions 100% by 2030 from a 2019 base year. FLSmidth A/S commits to reduce downstream scope 3 GHG emissions 56% per revenue from use of sold products over the same time frame. FLSmidth A/S also commits that 30% of its suppliers by spend covering purchased goods and services, will have science-based targets by 2025"
Metso	"Metso Outotec commits to reduce absolute scope 1 and 2 GHG emissions 50% by 2030 from a 2019 base year. Metso Outotec commits to reduce scope 3 GHG emissions from the use of sold products as well as upstream and downstream transportation 20% by 2025 from a 2019 base year. Metso Outotec commits that 30% of its direct suppliers by spend covering purchased goods and services, will have science-based targets by 2025"
SSAB	"SSAB commits to reduce absolute scope 1 and 2 GHG emissions 35% by 2032 from a 2018 base year"
Weir Group PLC (The)	"The Weir Group PLC commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2030 from a 2019 base year. The Weir Group PLC also commits to reduce absolute scope 3 GHG emissions from use of sold products 15% within the same timeframe"

Fuente: https://sciencebasedtargets.org/target-dashboard

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

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OTHER COMPANIES

COMPANY / YEAR	Category 1	Category 2	Category 3		Total TCO2e	SOURCE OF INFORMATION
			Transportation, wáter, paper	Other		
TAMA INGENIEROS S.A.C. 2023	12.87	35.52	50.61	2,389.02	2,488.03	Consult. A2G
HAUG S.A. 2022	Resultados no publicados en HC MINAM					
VULCO 2020	921.37	210.39	715.50		1,847.26	MINAM
VULCO 2021	1,298.77	271.18	235.74	4,069.23	5,874.92	
VULCO 2022	1,371.66	319.28	2,612.89	612.83	4,916.66	
FLSMIDTH S.A.C. 2020 (Perú)	25.35	28.33	0.27		53.95	
TUBOS Y PERFILES METALICOS SA 2021	914.65	467.64	-		1,382.29	
TUBOS Y PERFILES METALICOS SA 2022	821.67	659.13		1,142.46	2,623.26	
CPPQ S.A. 2019	2,829.35	2,583.86	8,239.71		13,652.92	
CPPQ S.A. 2021	2,290.54	2,762.38	6,788.22	143,310.00	155,151.14	
CPPQ S.A. 2022	2,003.92	2,533.94	6,786.58	128,299.51	139,623.95	
FERROSA 2019	53.83	592.60	11.84		658.27	
FERROSA 2020	36.56	414.79	1.02		452.37	
FERROSA 2021	103.55	694.91	2.11		800.57	
JOY GLOBAL (KOMATSU) S.A.C. 2021	312.55	382.10	605.23		1,299.88	
JOY GLOBAL (KOMATSU) S.A.C. 2022	191.79	435.29	916.82		1,543.90	
CERRADURAS NACIONALES S.A.C. 2020	51.82	793.69	3.34		848.85	
PRODAC SA 2019	7,182.28	3,176.08	716.72		11,075.08	
FLSMIDTH S.A.C. 2022 (Global)		38,079.00		5,461.00	43,540.00	REPORTE ANUAL FLS*
FLSMIDTH S.A.C. 2023 (Global)		38,022.00		5,430.00	43,452.00	
METSO 2019 (Global)	39,492.00	83,338.00	203,000.00	2,329,000.00	2,654,830.00	REPORTE ANUAL METSO*
METSO 2020 (Global)	36,918.00	7,995.00	144,000.00	2,898,000.00	3,086,913.00	
METSO 2021 (Global)	43,204.00	9,186.00	152,000.00	3,326,000.00	3,530,390.00	
METSO 2022 (Global)	43,868.00	5,076.00	164,000.00	3,486,000.00	3,698,944.00	

(*) Globally, Metso reports all emissions throughout the life cycle of its equipment, while FLS does not (in general, category 3 emissions account for 70% of all organizations that measure them).

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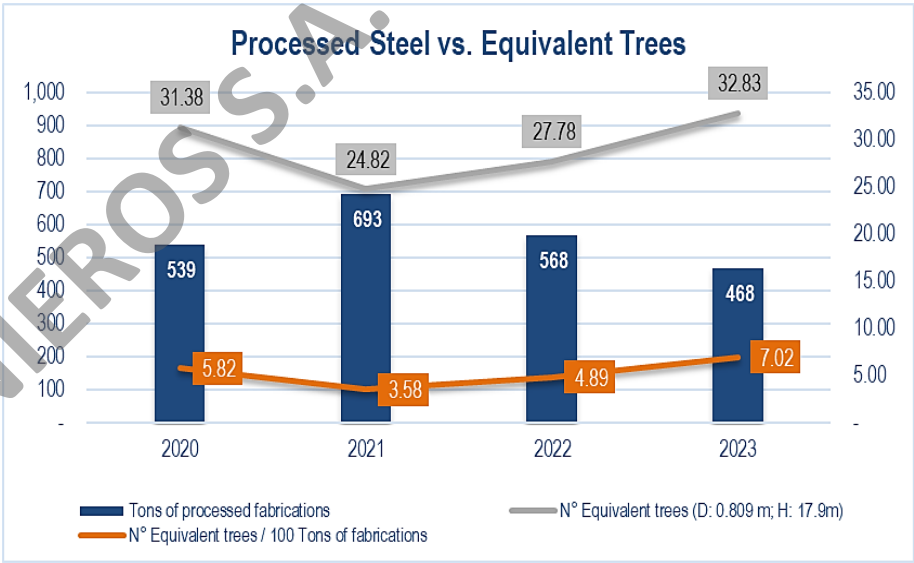
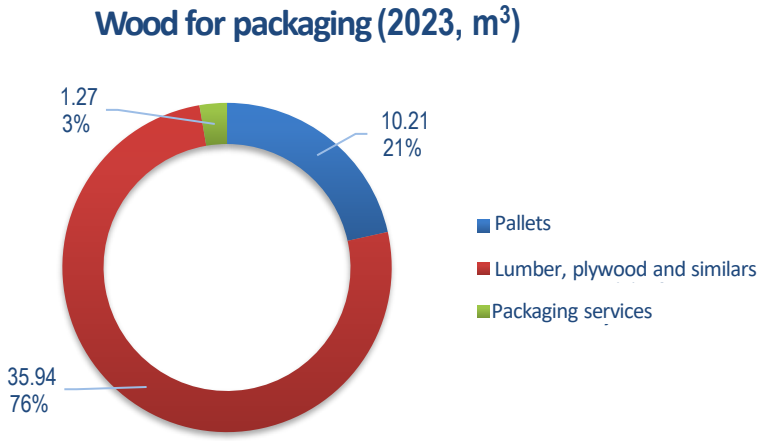
EMISSIONS FROM WOOD PACKAGING MATERIALS

- In 2023, 47.43m^3 of wood were purchased (lumber, plywood, pallets and third-party packaging services), equivalent to 32.8 standing trees*.
- In 2023, for every 100 tons of steel manufactured, seven trees
- 76% percent of the wood was purchased in the form of billets.(*)

- (*) Diameter 0.81m and Height 17.90m.





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NEXT STEPS

Reduction in Scope 3 indirect emissions:

1. Quantify the future reduction opportunities with the manufacture of metal pallets (if the purchase of plywood and wood for TAMA packaging is stopped, 815 tons less of CO2 would be emitted).

2023	Vol (m^3)	Ton CO_2
Pallets	10.21	62.2
Plywood	2.57	697.85
Timber	33.37	117.51
Services	1.27	
Total	47.43	877.56

Reduction opportunity: 815 Ton CO_2

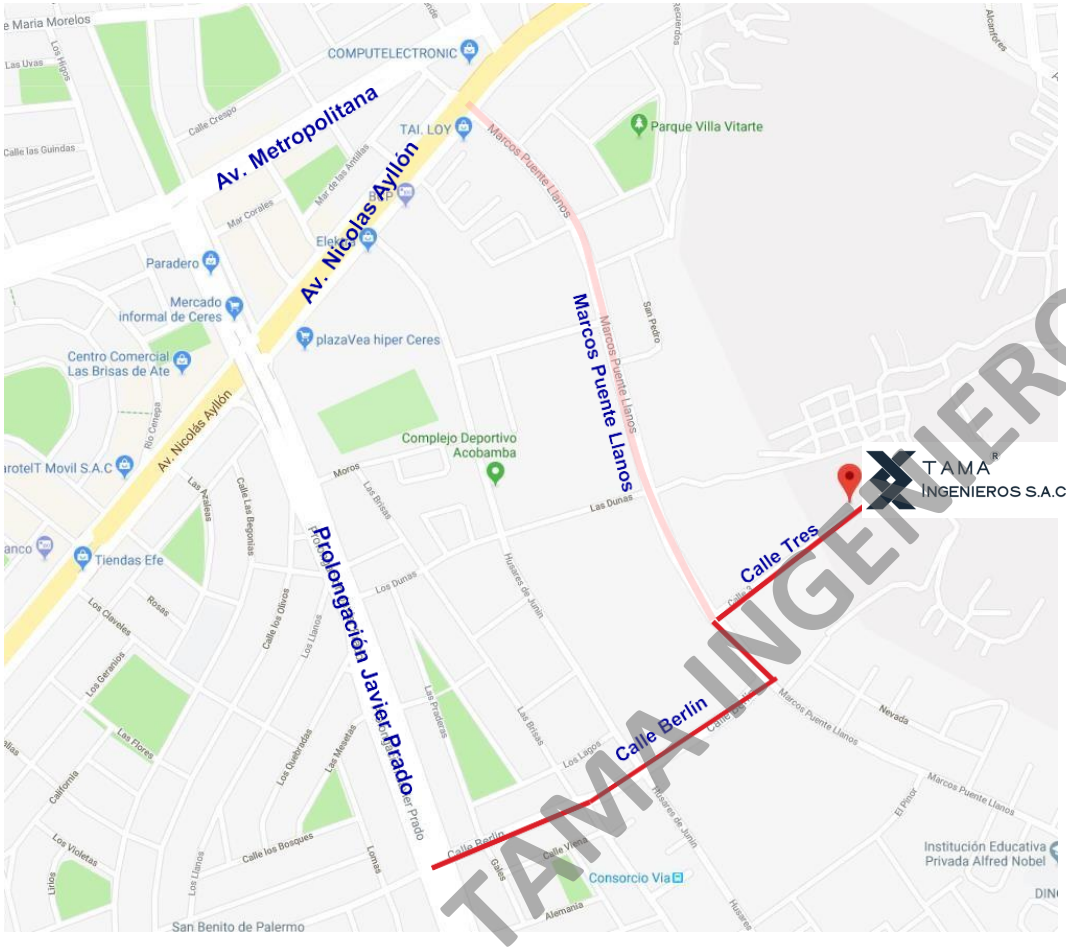
2. Encourage the use of SSAB steel that emits 1.43 Ton CO2 /Ton steel, compared to the global average (2.5 Ton CO2 /Ton steel), as well as working with raw material suppliers that measure their carbon footprint.

Reduction in Scope 1 and 2 emissions

3. Fuel (forklift, truck, etc.) and electricity consumption.

TAMA® INGENIEROS S.A.C.

LOCATION AND CONTACTS



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tamasac@tama.pe

Website: www.tamaingenieros.pe

TAMA®
INGENIEROS S.A.C.

THANK YOU

Visión y Misión

“Technology Development for a Better Life Quality”

Our slogan:

“HERE SAFETY IS A HABIT, NOT AN OPTION, OUR FAMILIES WAIT FOR US”

Our motto:

“IN TAMA INGENIEROS, THE SAFETY COMES FIRST”

Appendix N°2

TAMA Carbon Footprint Report 2023

PERÚ Ministerio del Ambiente

HUELLA DE CARBONO PERÚ

REPORTE DE HUELLA DE CARBONO ORGANIZACIONAL

REPORTE DE HUELLA DE CARBONO

1.- DESCRIPCIÓN DE LA ORGANIZACIÓN:

Razón Social: TAMA INGENIEROS SAC

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2,493 tCO_2e

Además, por quema de biomasa 0.37 tCO2 y 0.000 tHCFC.

Se ha considerado una incertidumbre: Razonable.

El enfoque de consolidación del límite de información ha sido CONTROL OPERATIVO al 100%.

El enfoque para las emisiones indirectas por energía importado es el BASADO EN LA UBICACIÓN.

Los resultados del presente inventario de GEI por límite organizacional son:

Tabla: Límite organizacional y emisiones de GEI respectivas.

Instalación o actividad	Total GEI [tCO2e]
TAMA INGENIEROS S.A.C. ATE. LIMA. PERÚ	0.00
ATE. LIMA. PERÚ	2,492.44

Este reporte de emisiones de GEI de TAMA INGENIEROS SAC, para el año 2023, es el resultado del uso de la Huella de Carbono Perú del Ministerio del Ambiente. En el proceso de cálculo y reporte se siguieron protocolos y metodologías estandarizadas: NTP ISO 14064-1:2020,GHG Protocol Corporate Accounting and Reporting Standard, Directrices del IPCC de 2006 para inventarios nacionales de GEI (GL2006) y el Quinto Reporte del IPCC (AR5).

3. INVENTARIO DE GEI

3.1. Emisiones GEI de la organización.

Las emisiones de gases de efecto invernadero (GEI) de todas las sedes de TAMA INGENIEROS SAC, para el año 2023, se muestran en la siguiente tabla y gráfica, donde se aprecia que el 98% de las emisiones corporativas se generan en las fuentes que corresponden a Categoría 3:

Tabla: Emisiones totales de GEI por categoría

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas	12.86	0.5 %
Categoría 2 – Emisiones indirectas por energía	40.27	1.6 %
Otras categorías – Otras emisiones indirectas	2,439.31	97.9 %

Gráfico: Participación por categoría

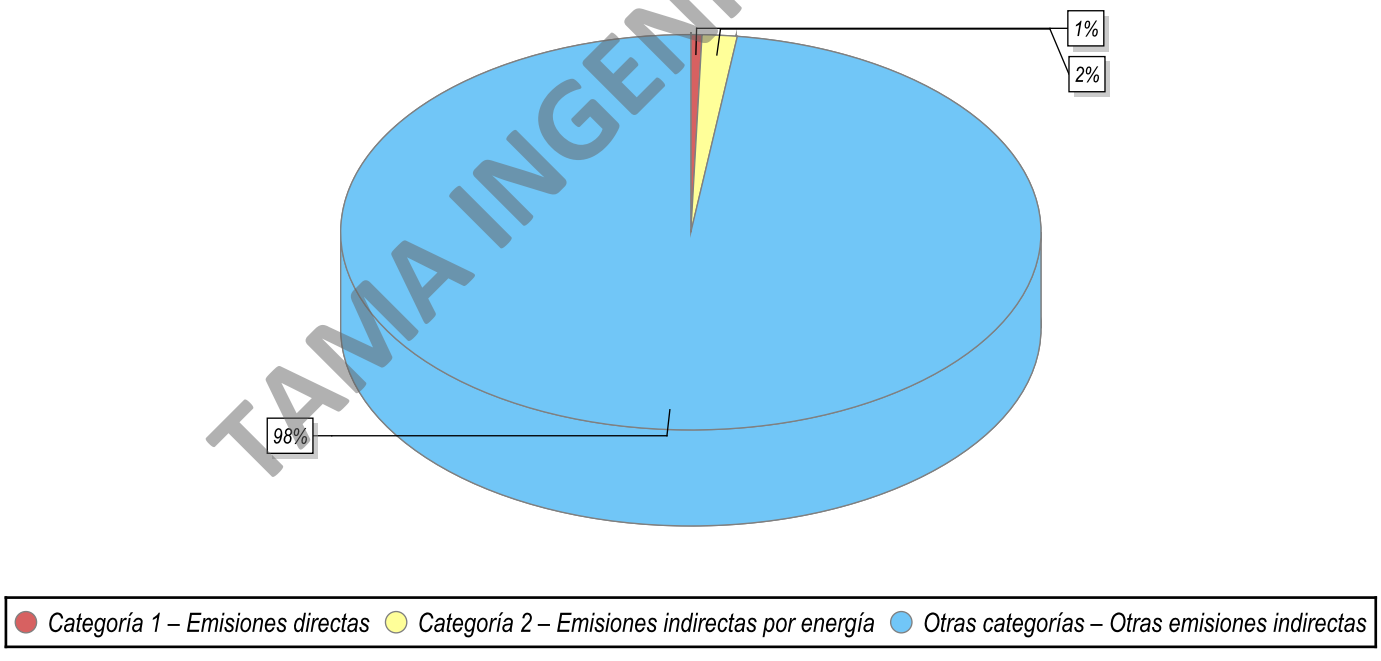

Tabla: Emisiones de tCO2e por fuente y categoría

Categoría	Dióxido de carbono (tCO2)	Metano (tCH4)	Óxido Nitroso (tN2O)	Hidrofluoro-carbono (tHFC)	Perfluoro-carbono (tPFC)	Hexafluoruro de azufre (tSF6)	Trifluoruro de nitrógeno (tNF3)	Emisiones GEI (tCO2e)
Categoría 1 – Emisiones directas								

Categoría	Dióxido de carbono (tCO2)	Metano (tCH4)	Óxido Nitroso (tN2O)	Hidrofluoro-carbono (tHFC)	Perfluoro-carbono (tPFC)	Hexafluoruro de azufre (tSF6)	Trifluoruro de nitrógeno (tNF3)	Emisiones GEI (tCO2e)
Combustión de fuentes fijas	0.19	0.00	0.00	0	0	0.00	0.00	0.19
Fuentes fijas biogénicas	0.00	0.00	0.00	0	0	0.00	0.00	0.00
Combustión de fuentes móviles	12.21	0.00	0.00	0	0	0.00	0.00	12.40
Fuentes móviles biogénicas	0.00	0.00	0.00	0	0	0.00	0.00	0.00
Otras fuentes	0.00	0.00	0.00	0	0	0.00	0.00	0.27
Categoría 2 – Emisiones indirectas por energía								
Consumo de energía eléctrica	39.90	0.00	0.00	0	0	0.00	0.00	40.03
Pérdidas por transmisión de electricidad	0.03	0.00	0.00	0	0	0.00	0.00	0.03
Pérdidas por distribución de electricidad	0.21	0.00	0.00	0	0	0.00	0.00	0.21
Otras categorías – Otras emisiones indirectas								
Transporte de insumos	2.26	0.00	0.00	0	0	0.00	0.00	2.26
Transporte de productos	2.63	0.00	0.00	0	0	0.00	0.00	2.63
Transporte aéreo	2.63	0.00	0.00	0	0	0.00	0.00	2.63
Transporte terrestre	0.96	0.00	0.00	0	0	0.00	0.00	0.97

Categoría	Dióxido de carbono (tCO2)	Metano (tCH4)	Óxido Nitroso (tN2O)	Hidrofluoro-carbono (tHFC)	Perfluoro-carbono (tPFC)	Hexafluoruro de azufre (tSF6)	Trifluoruro de nitrógeno (tNF3)	Emisiones GEI (tCO2e)
Transporte colaboradores: Casa-Trabajo	41.11	0.00	0.00	0	0	0.00	0.00	41.44
Consumo de agua	0.18	0.00	0.00	0	0	0.00	0.00	0.18
Consumo de papel	0.23	0.00	0.00	0	0	0.00	0.00	0.23
Disposición final de residuos sólidos	0.00	0.01	0.00	0	0	0.00	0.00	0.15
Otras fuentes	0.00	0.00	0.00	0	0	0.00	0.00	2,388.82

Tabla: Emisiones de los gases GEI por fuentes y categoría.

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas		
Combustión de fuentes fijas	0.19	0.00 %
Fuentes fijas biogénicas	0.00	0.00 %
Combustión de fuentes móviles	12.40	0.49 %
Fuentes móviles biogénicas	0.00	0.00 %
Otras fuentes	0.27	0.01 %
Categoría 2 – Emisiones indirectas por energía		
Consumo de energía eléctrica	40.03	1.60 %
Pérdidas por transmisión de electricidad	0.03	0.00 %

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Pérdidas por distribución de electricidad	0.21	0.00 %
Otras categorías – Otras emisiones indirectas		
Transporte de insumos	2.26	0.09 %
Transporte de productos	2.63	0.10 %
Transporte aéreo	2.63	0.10 %
Transporte terrestre	0.97	0.03 %
Transporte colaboradores: Casa-Trabajo	41.44	1.66 %
Consumo de agua	0.18	0.00 %
Consumo de papel	0.23	0.00 %
Disposición final de residuos sólidos	0.15	0.00 %
Otras fuentes	2,388.82	95.84 %
TOTAL HUELLA DE CARBONO	2,492.44	

3.2. Emisiones GEI por instalaciones o actividades

ATE. LIMA. PERÚ

La instalación / actividad ATE. LIMA. PERÚ, generó en el año 2023:

2,492 tCO_2e

Las emisiones de gases de efecto invernadero (GEI) de la sede ATE. LIMA. PERÚ de TAMA INGENIEROS SAC, para el año 2023, se muestran en la siguiente tabla y gráfica,donde se aprecia que el 98% de las emisiones corporativas se generan en las fuentes que corresponden a Categoría 3:

Tabla: Emisiones totales de GEI por categoría

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas	12.86	0.5 %
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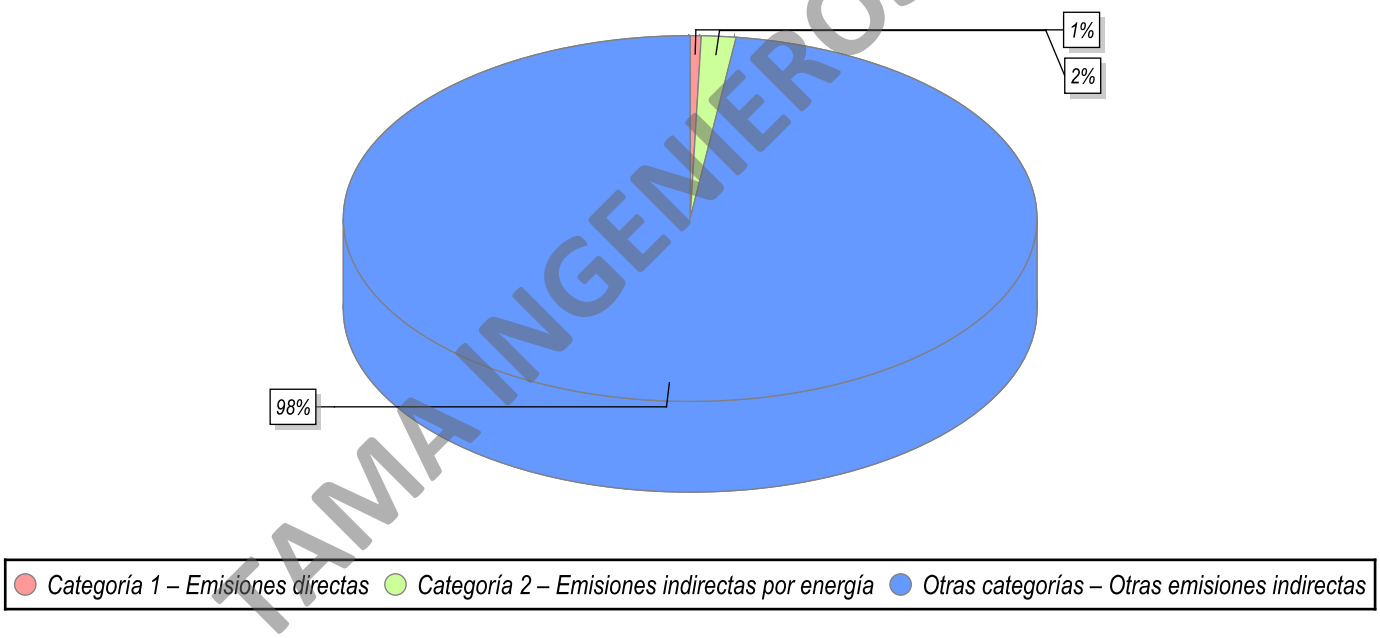
Gráfico: Participación por categoría



Las emisiones de GEI reportadas por fuentes de emisión identificadas, se presentan en la siguiente tabla:

Tabla: Emisiones GEI por fuentes

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas		
Combustión de fuentes fijas	0.19	0.0 %
Fuentes fijas biogénicas	0.00	0.0 %

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Combustión de fuentes móviles	12.40	0.5 %
Fuentes móviles biogénicas	0.00	0.0 %
Otras fuentes	0.27	0.0 %
Categoría 2 – Emisiones indirectas por energía		
Consumo de energía eléctrica	40.03	1.6 %
Pérdidas por transmisión de electricidad	0.03	0.0 %
Pérdidas por distribución de electricidad	0.21	0.0 %
Otras categorías – Otras emisiones indirectas		
Transporte de insumos	2.26	0.1 %
Transporte de productos	2.63	0.1 %
Transporte aéreo	2.63	0.1 %
Transporte terrestre	0.97	0.0 %
Transporte colaboradores: Casa-Trabajo	41.44	1.7 %
Consumo de agua	0.18	0.0 %
Consumo de papel	0.23	0.0 %
Disposición final de residuos sólidos	0.15	0.0 %
Otras fuentes	2,388.82	95.8 %
TOTAL HUELLA DE CARBONO	2,492.44	

TAMA INGENIEROS S.A.C. ATE. LIMA. PERÚ

La instalación / actividad TAMA INGENIEROS S.A.C. ATE. LIMA. PERÚ, generó en el año 2023:

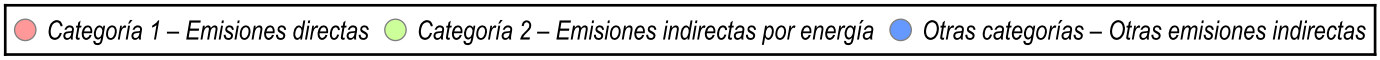
0 tCO_2e

Las emisiones de gases de efecto invernadero (GEI) de la sede TAMA INGENIEROS S.A.C. ATE. LIMA. PERÚ de TAMA INGENIEROS SAC, para el año 2023, se muestran en la siguiente tabla y gráfica,donde se aprecia que el 0% de las emisiones corporativas se generan en las fuentes que corresponden a

Tabla: Emisiones totales de GEI por categoría

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas	0.00	0.0 %
Categoría 2 – Emisiones indirectas por energía	0.00	0.0 %
Otras categorías – Otras emisiones indirectas	0.00	0.0 %

Gráfico: Participación por categoría



Las emisiones de GEI reportadas por fuentes de emisión identificadas, se presentan en la siguiente tabla:

Tabla: Emisiones GEI por fuentes

Categoría	Emisiones GEI [tCO2e]	Participación General (%)
Categoría 1 – Emisiones directas		
Combustión de fuentes fijas	0.00	0.0 %
Fuentes fijas biogénicas	0.00	0.0 %
Combustión de fuentes móviles	0.00	0.0 %
Fuentes móviles biogénicas	0.00	0.0 %
Otras fuentes	0.00	0.0 %
Categoría 2 – Emisiones indirectas por energía		
Consumo de energía eléctrica	0.00	0.0 %
Pérdidas por transmisión de electricidad	0.00	0.0 %
Pérdidas por distribución de electricidad	0.00	0.0 %
Otras categorías – Otras emisiones indirectas		
Transporte de insumos	0.00	0.0 %
Transporte de productos	0.00	0.0 %
Transporte aéreo	0.00	0.0 %
Transporte terrestre	0.00	0.0 %
Transporte colaboradores: Casa-Trabajo	0.00	0.0 %
Consumo de agua	0.00	0.0 %
Consumo de papel	0.00	0.0 %
Disposición final de residuos sólidos	0.00	0.0 %
Otras fuentes	0.00	0.0 %
TOTAL HUELLA DE CARBONO	0.00	

4. EXCLUSIONES

La organización no presenta exclusiones

5. INDICADORES DE DESEMPEÑO

Año	Unidad	t CO2 / unidad
2023	Producción-peso (Toneladas)	5.33

6. ACCIONES DE MITIGACIÓN DE GEI

Appendix N°3 T-GI-F-21

Estimation of the volume of wood used in TAMA and equivalent number of trees

TO	:	E.C.C.
SUBJECT	:	Estimation of the volume of wood used in TAMA and equivalent number of trees.
DATE	:	09/04/2024
BY	:	R.V.V.

Summary

This report describes the method and assumptions required to estimate the amount of wood consumed at TAMA in its various packaging applications, in the form of trees. For this purpose, the amount of wood used in the period 2020-2023 (in cubic meters, m^3) in strips, pallets and in packaging services was estimated based on the purchases registered in the ERP SAP in that period, and in addition, the amount of useful wood obtained from a tree and that manages to be converted into a packaging input such as, for example, wooden pallets were analyzed. To this end, national research was reviewed to establish: the tree species commonly used for pallets, the typical dimensions of the species before felling, felling efficiency, sawmill efficiency, and the number of years that elapse before a tree is felled.

Thus, this study determined that the diameter or height of a tree does not determine its cutting age, but rather the time of greatest productive efficiency, which in the case of *Pinus radiata* (one of the most commonly used species for the manufacture of pallets) fluctuates between 7 to 10 years. In Puno, an investigation determined that 33 years was the optimum logging age for plantations of this species. In addition, the following measurements were established for a typical *Pinus radiata* tree based on studies in Peru: Diameter at breast height (D_{ap}) of 0.81m and Commercial Height (H_C) of 17.90m.

Among the main findings, it was determined that for every m3 of tree felled, only 24.16% of the wood is used for packaging. In addition, in 2023, 47.43m^3 of wood was used in TAMA in the form of laths, stringers and packaging, which was equivalent to 32.8 standing trees considering the measurements of a typical tree. This means that, in 2023, for every 100 tons of steel processed in fabrications, seven trees had to be felled.

Finally, a significant potential for a reduction of up to 75.8% of wood volume in the form of lumber was estimated if TAMA's custom-made packaging were to be replaced by packaging made from surplus steel.

Table of contents

1. Introduction

At TAMA, wood is consumed mainly for use in the manufacture of packaging for finished products. Thus, wood strips and pallets are used and, in addition, packaging services are contracted to suppliers, especially for export shipments. For this reason, it is necessary to have a way to quantify these consumptions and, in addition, to translate these consumptions into number of trees, in order to represent more graphically in TAMA's reports the impact of the use of wood in the felling of forests. Thus, the aim is to answer the following questions: How many trees does the wood used in TAMA equal? and How long did a tree have to grow before it was felled?

2. Timber yield of a tree

In order to analyze the timber yield of a tree, i.e. the amount of useful wood converted into final product with respect to the standing tree, two instances must be distinguished:

a. Yield from the standing tree converted to logs, which involves felling the tree, cutting it into smaller segments for handling and transport to a sawmill.
b. Yield of logs converted to commercial lumber, which involves the cutting and utilization plan for each log in a sawmill.

2.1. Yield of standing tree converted to logs

To estimate the harvestable volume of timber, the commercial height, and the diameter of the tree at the height of the farmer's chest are estimated. According to the "Forest Producer's Manual. How to cube our timber" prepared by the United Nations Office on Drugs and Crime [1], it is necessary to know the Dap measurement (diameter at breast height, taken at 1.30 m from the base) and the commercial height (H_c) of the tree, i.e. the height up to where the trunk is straight. In addition, the shape factor (f), a reduction factor that corresponds to the ratio between the volume of the tree and the volume of a reference geometric solid such as a cone or a cylinder, must be taken into account. [2] which is a characteristic of each species and fluctuates between 0.65 and 0.75.

Figure 1. Measurements of a standing tree. Background: Palcazú, province of Oxapampa, department of Pasco. Note: Images taken from:
(1) "Forest Producer's Handbook. How we cube our wood", by United Nations Office on Drugs and Crime, 2017. Retrieved from https://www.unodc.org/documents/bolivia/DIM_Manual_Como_cubicamos_la_madera.pdf
(2) "Yanesha Community Reserve", by Andina, 2023. Retrieved from https://andina.pe/agencia/noticia-reserva-comunal- yanesha-celebra-su-34-efemeride-conservando-un-tesoro-natural-y-cultural-890701.aspx

In this way it is possible to estimate the volume of a standing tree [3]:

$$Vol\ (r) = \frac{\pi\ x\ Dap^2}{4}\ x\ Hc\ x\ 0.65 \qquad \text{(Equation E1)}$$

Where:

Vol (r): Log volume (m^3)
H_c: Commercial height (m)
D_{ap}: Diameter at breast height (m)
π: 3.1416
Form factor: 0.65

However, once the tree has been felled and cut, the actual measurements are taken. When the logs arrive at the sawmill, the net usable volume of the logs is re-measured, discounting cracks, rotten areas, and other defects. In this way, the decrease in the volume of timber placed in the plant with respect to the volume measured at the felling and cutting stage is - on average - 32.54%. Or, to put it another way, the yield between the felled tree and the log in the plant is 67.46%, according to a study carried out by Frisk and Córdova [4], the results of which are summarized in Table 1.

Similarly, in Table 2, Valencia [3] determined that yield varies as a function of D_{ap} diameter.

Table 1.
Yield between the tree lying and the log placed in sawmill

Species	Inventory (standing)m^3/ha	Felling and logging m^3/ha	Logs planted m^3/ha	Yield Standingtree - Log
Tornillo	38	65	30	46.15%
White Machimango	9	10	8	80.00%
Black Moena	7	6	5	83.33%
Chimicua	5	5	4	80.00%
Ana caspi	4	4	4	100.00%
Marupá	4	4	4	100.00%
Sacha uvilla	4	3	3	100.00%
Masha Cedar	4	3	3	100.00%
Other	31	26	24	92.31%
Average [4]	**106**	**126**	**85**	**67.46%**

Note: Taken from "Estudio de rendimiento potencial y extracción forestal en el bosque nacional Alexander Von Humboldt. Project PNUD/FAO/PER/78/003 Improvement of forest extraction and transformation systems" by Frisk and Córdova [4].

Table 2.
Yield between the tree lying and the log placed in sawmill

Category	Diam.	Logging (m^3)	Carryforward (m^3)	Transportation (m^3)	Performance
I	.8-.89	425.038	351.717	339.392	79.85%
II	.9-.99	1328.87	1004.579	1004.219	75.57%
III	1-1.09	1021.214	771.919	783.717	76.74%
IV	1.1-1.19	873.867	651.059	652.012	74.61%
V	1.2-1.29	544.88	396.041	388.508	71.30%
VI	MAS 1.39	412.277	332.153	322.425	78.21%
Average [3]		**4606.146**	**3507.468**	**3490.273**	**75.77%**

Note: Obtained from "Determination of the conversion coefficient from standing tree to sawmill yard log of the *shihuahuaco* species (*dipteryx spp*.)" by Valencia [3].

Some of the variables that influence logging yields are due to the fact that in many cases the felled trees fall in a different direction than desired, which causes cracks in the trunks and loss of some

logs, reducing their yield. Another cause of low yields in some trees are the phytosanitary problems of certain species such as hollows, knots, and rotting, as well as the presence of fins in the species, which leads to an overestimation of the initial diameter, thus making it difficult to calculate the volume of the tree [3].

Figure 2. Common defects in the log yard: gaps or cracks due to poor fall direction. Obtained from "Determination of the conversion coefficient of the standing tree to log in the sawmill yard, of the *shihuahuaco* species (dipteryx spp.)" by Valencia[3].

For estimation purposes, we will work with the yield between the felled tree and the sawmill log of 75.77% [3].

2.2. Log yield to useful wood

At this stage, the yield is measured as the ratio between the volume of lumber resulting from sawmilling and the volume of sawn logs. After the logs arrive at the sawmill, they are cut into different sizes for trading or processing into final product.
In this phase, performance measurement is influenced by a greater number of variables,

- Log diameter, length, and taper: it has been determined that as log diameters decrease, sawlog yielddecreases [5].
- Presence of knots, resin pockets, pith in the logs.
- In a conventional sawmilling process, sawmilling is carried out without grading, which leads to lowyields.
- Oversizing of the pieces to be cut can represent up to 10 % of the total volume of unplaned greenlumber [6].
- Cutting method: when using a circular saw the yield of sawn timber was 33%, while, when using aportable sawmill with band saw the yield was 52.75% [7].
- The variation in thickness of sawn lumber, which depends on the mechanical precision of thesawing equipment [6].
- The characteristics of the species, quality of the logs, condition of the machinery, cutting pattern,type of saw, quality and dimensions of the products produced, operator skill and ability.

Llactas [7] and Silva [8] maintain that the species *Ficus insipida* and *Pinus radiata* are among the most commonly used for the production of pallets. Their most common commercial names are *ojé, pino, bolaina blanca, almendro, cachimbo blanco, capirona, machimango blanco, zapote, huimba, manchinga, mashonaste, panguana, pashaco* and *yacushapana*. Both authors determined the sawmill yields in Peru for the manufacture of sawn pallets and reported that they ranged from 31.88 to 50.43%. In Ecuador, yields of up to 15.08% were obtained as shown in Table 2 [9].

It should be taken into account that the yield also depends on the type of sawn pieces; in the particular

case of wood for pallets, the yield is relatively lower than average because its production requires smaller sized blocks and planks compared to other types of commercially used pieces, as shown in Annex 1, where yields of up to 66% are observed [7].

Table 3.
Yields of roundwood for the manufacture of pallets

N°	Research	Species	Performance	Remarks
5	Llactas (2023)	Various (*Ficus insipida* or Ojé, Diplotropis or Chontaquiro)	31.88%	Pallets in EAN model 1.00 m x 1.20 m x 0.15 m. (57.40 kg) and Standard model 1.00m. x 1.20 m x 0.15 m (32.04 kg). Huánuco, Peru.
6	Silva (2023)	Pinus Radiata	46.26%	Plantations in the city of Cajamarca, palletsfor export on the model conventional of 1.00 m x 1.20 m x 0.15 m.
7	Silva (2023)	Pinus Radiata	48.04%	Quality A (good)
8	Silva (2023)	Pinus Radiata	42.60%	Quality B (fair to poor)
9	Silva (2023)	Pinus Radiata	50.43%	Large diameter
10	Silva (2023)	Pinus Radiata	45.30%	Medium diameter
11	Silva (2023)	Pinus Radiata	42.00%	Small diameter
33	Cevallos et al. (2017).	*Pinus radiata*	34.94%	Log-to-block performance, band saw. Ecuador
34	Cevallos et al. (2017).	*Pinus radiata*	43.29%	Block-to-board performance
35	Cevallos et al. (2017).	*Pinus radiata*	15.08%	Log to board yield

Note: Adapted from [8], [7], [9]

For estimation purposes, we will work with a roundwood yield of 31.88% [8].

Figure 3 summarizes the sawmill manufacturing processes that explain the losses due to back-cutting (cutting into smaller logs), bark removal, saw capacity, and the dimensions of the pieces used to assemble the sawn timber.

Figura 5. Diagrama de corte para diámetro 32.

Figure 3. Backcutting, cutting diagram, sawing, and assembling of pallets.
Note: Taken from [3].

Consequently, the yield to be taken into account to answer the question "How many trees does the wood used in TAMA equal?" is that which covers both stages: the yield of the standing tree converted to logs (75.77%) and the yield of logs to useful wood (31.88%).

Table 4.
Yield of standing tree for the manufacture of pallets

Yield of standing tree converted to logs (a)	Log yield to usable wood(b)	Yield from standing tree to useful wood, pallet (axb)
75.77%	31.88%	24.16%

According to the approximation in Table 4, the total yield of each cubic meter of standing tree wood is 0.2416m^3 of useful wood as a wood product: 0.2423m^3 is lost a s a result of holes, knots and rotting that are detected after felling the tree, and 31.88% of the rest is lost due to inefficiencies in the sawing process. In summary, for the manufacture of pallets, each m^3 of standing tree is converted into 0.2416m^3 of wood pallets.

2.3. Typical dimensions of a tree

Llactas [7] and Silva [8] reported the species *Ficus insipida* (*Oje*) or *Pinus radiata* as the most used for the manufacturing of pallets. The characteristics of both species, in general, are the following:

***Ficus insipida*:** Major tree of 45 m total height, with a dominant crown and cylindrical shaft with diameters at breast height (D_{ap}) of 50 to 150 cm. It has large branches of 48 to 50 cm in diameter diámetro [11]. Llactas [7] identified in Table 5 log diameters that averaged 0.81 m in greatest diameter and 0.71 m in smallest diameter, which gives an idea of the felling diameter.

Table 5.
Characteristics of the *Oje* tree logs used to produce pallets.

N	Species (commonname)	Largest diameter(m)	Minor diameter (m)	Length (m)	Volume(m^3)
25	*Oje*	0.78	0.68	6.00	2.511
43	*Oje*	0.73	0.54	6.40	2.027
46	*Oje*	0.99	0.82	6.40	4.117
47	*Oje*	0.87	0.81	6.40	3.547
48	*Oje*	0.97	0.87	6.40	4.254
49	*Oje*	1.05	0.84	6.40	4.489
50	*Oje*	0.94	0.84	6.40	3.982
51	*Oje*	0.53	0.50	3.36	0.700
53	*Oje*	0.84	0.81	6.30	3.368
54	*Oje*	0.50	0.47	6.40	1.182
106	*Oje*	0.73	0.67	6.40	2.463
107	*Oje*	0.78	0.71	6.40	2.790

Note: Taken from [8].

Pinus Radiata: Species up to 40 m tall, with a main axis and regularly spaced secondary branches, with a well-defined pyramidal crown [7]. Silva [8] identified log diameters ranging from 0.14m to 0.43m.

No information has been reported on the height of *Oje* trees that are felled, since the research on

pallets has been carried out in sawmills, i.e. roundwood, logs, or felled timber. For the purposes of this study, it is necessary to establish a typical tree measurement to serve as an equivalence parameter, so measurements of felling of other types of trees were taken. Thus, Valencia [3] for the determination of the conversion coefficient from standing tree to sawmill log of the *shihuahuaco* species in Iñapari; Madre de Dios analyzed a sample of 360 trees of this species with average diameters of 1.12m and commercial height of the standing tree of 17.90m on average as shown in Table 6 [3].
Taking this study as a reference for the commercial height and the study of Llactas [7], the following dimensions of diameter and height have been established for the calculations of this report:

Diameter breast height (D_{ap}) : 0.81m
Commercial Height (H_c) : 17.90m
Usable volume (m^3) : 5.98m^3 (See Equation 1)

Table 6.
Diameter at Breast Height and Commercial Height of a sample of the *shihuahuaco* species.

Clase Diamétrica		*N° individuos*	*Diámetro altura de pecho (dap)*		*Altura Comercial (HC)*		*Coeficiente de conversión*	
Rango	*Categoría*		*Promedio (m)*	*Coeficiente Variabilidad (%)*	*Promedio (m)*	*Coeficiente Variabilidad (%)*	*Promedio*	*Coeficiente Variabilidad (%)*
[0.80m a 0.89m]	I	46	0.88	13.3	17.13	12.1	1.114	26.4
[0.90 m a 0.99m]	II	125	0.94	12.8	17.75	14.4	0.997	32.4
[1m a 1.09m]	III	83	1.08	14.1	17.9	12.7	0.966	30.9
[1.10m a 1.19m]	IV	57	1.14	13.8	18.33	12.7	0.951	39
[1.20m a 1.29m]	V	31	1.24	17.1	18.42	14.4	0.871	36.2
[1.30m a más >	VI	18	1.45	18.2	18.66	11.5	0.885	26.7
Total		360	1.12	35	17.9	13.5	0.981	33.2

Note: Taken from [3].

2.4. Growth characteristics of a Pinus radiata tree

According to the research "Modeling of the diametric growth of *Pinus radiata* d. Don and *Pinus oocarpa schiede ex schltdl* in the department of Junín, through dendrochronological techniques" [12] carried out in the rural communities of Tingo Paccha and Acopalca, the *Pinus radiata* species requires between 4 to 5 years to reach its maximum diametric decrease rate (called mean annual increment or MAI) of 1.63 to 1.76 cm/year, with maximum theoretical diameters between 46 and 54cm. Likewise, he determined that the biological cutting turn (TBC, or modeled life time where it is decided that the species reached its maximum growth rate and it is more efficient to cut it at that time [13]) of *Pinus radiata* was relatively short between 7 and 10 years (Other investigations referred to by [12] report higher TBCs such as Argentina, 12 years; Spain, 15 to 25 years; Chile, 21 years;Australia, 60 years, Puno, 33 years [14]).
Another study reported that in Camacani, Puno, at 13 years of age the pines reached an average height of 12m [14].
In Ecuador, another source reported that the mean annual increment of *Pinus radiata* species in height is 1.22 m. and in diameter 1.68 cm [15].

The differentiation in ages and growth rates among trees of the same species depends mainly on the availability of nutrients and light: in places where tree growth is restricted by the lack of nutrients or sunlight, trees can reach greater ages and become longer-lived, while in places where there is agood supply of nutrients and light, forests reach short ages, and consequently, the age of trees is not a function of their diameter or height [16]. In other words, the greater the availability of nutrients and sunlight, the younger the trees reach their TBC [17].
In this study, the *Pinus radiata* plantations did not have any silvicultural treatment (also called thinning, a process that consists of gradually reducing the number of trees in a plantation to concentrate growth on the best individuals [18]).
Relating these data to those in Table 6 [3], it can be seen that trees felled with diameters greater than 80 cm took much longer than 10 years to reach those measurements. In Puno, it was even determined that 33 years was the theoretical optimum logging age for *Pinus radiata* plantations [14].

Table 7.
Life history and silvicultural traits of two pine species.

Rasgos[a]	*Pinus radiata*		*Pinus oocarpa*	
	Acopalca	*Tingo Paccha*	*Ingenio*	*Colpar*
A_{max}	54 cm	46 cm	88 cm	89cm
t_{vital}	47 años	37 años	299 años	200 años
$t_{0.5}$	24 años	21 años	142 años	36 años
$Edad_{Max.\ ICA}$	5 años	4 años	4 años	5 años
ICA_{Max}	1.76 cm año^{-1}	1.89 cm año^{-1}	9.19 cm año^{-1}	8.54 cm año^{-1}
$Edad_{Max\ IMA}$	10 años	7 años	8 años	8 años
IMA_{Max}	1.63 cm año^{-1}	1.76 cm año^{-1}	6.93 cm año^{-1}	6.35 cm año^{-1}
TCAP	1.16 cm año^{-1}	1.25 cm año^{-1}	0.62 cm año^{-1}	1.44 cm año^{-1}
TCRP	24.28 cm año^{-1}	31.71 cm año^{-1}	0.84 cm año^{-1}	0.44 cm año^{-1}
TBC	10 años	7 años	8 años	9 años

Nota. Asíntota del diámetro ($^{a}A_{max}$); lapso vital (t_{vital}); vida media ($t_{0.5}$); edad a la que alcanza el ICA máximo ($Edad_{max\ ICA}$); máximo valor del ICA (ICA_{max}); edad a la que alcanza el IMA máximo ($Edad_{max\ IMA}$); máximo valor del IMA (IMA_{max}); tasa de crecimiento absoluta ponderada (TCAP); tasa de crecimiento relativa ponderada (TCRP); turno biológico de corta (TBC).

Note: Taken from [12].

3. Wood consumption at TAMA

3.1. Wood consumption at TAMA

TAMA uses wood in three different forms: wood strips and panels, wooden pallets, and packaging:

a. **Wood strips and panels**, group containing wood strips, plywood and OSB boards used to manufacture packaging and boxes for finished product shipment:
   - Wooden strips: Including wooden products in their different forms (strips, boards, etc.).
   - Plywood: Panels formed by different layers of glued and pressed wood usually marketed in 4'x 8'formats in thicknesses of 4, 6 and 10mm. For example, TAMA often uses 3" x 4" x 10' oak strips.
   - OSB (Oriented Strand Board) panels made of wood chips pressed in perpendicular layers and bonded with resin applied at high pressure and temperature.

b. **Wooden pallet**, according to TAMA's Packaging Procedure T-AB-PT-05, the pallets of recurrent use in TAMA are of the 1100 x 1300 mm format, and have the components detailed in Table 8. The typical volume of wood contained in each pallet is 0.031m^3.

c. **Packaging services**, through which a supplier specialized in the manufacture of custom-made wooden crates and closed boxes is contracted, usually for export shipments because they are made of treated wood.

Information on the consumption of each type of wood was obtained from SAP purchase records from 2020 to 2023.

Table 8.
Measuring of a 1100 x 1300 mm.

Piece	Qty	Thickness (m)	Width (m)	Length (m)	Vol (m^3)
Top tables	4	0.019	0.184	1.3	0.018
Lower transversals	3	0.0762	0.0508	1.1	0.013
Unit volume of wood in pallet 1100 x 1300					**0.031**

3.1.1. Wood consumption in strips

The laths and panels were cubed based on the measurements of each piece purchased (LxWxH) in cubic meters as shown in Table 9. Details can be found in Annex 2.

Table 9.
Volume calculation of wood strips and panels (m^3 of wood)

Description	UM	2020	2021	2022	2023
Wood	m3	29.63	26.40	20.92	33.37
Plywood	m3	2.54	1.36	1.28	1.69
OSB (oriented strand board)	m3	-	-	-	0.88
Total	**m3**	**32.17**	**27.76**	**22.21**	**35.94**

3.1.2. Wood consumption in pallets

The cubic capacity of the pallets was based on the measurement of the pieces that compose them, details of which are shown in Table 6. Each 1100x 1300mm stave contains 0.031m3 of wood (see Table 8).

(a) Strips and panels

(b) Wooden pallets

(c) Packaging services

Figure 4. Forms of wood consumption for packaging in TAMA.

Table 10.
Cubing of 1100 x 1300 wood stakes (m3 of wood)

Part	Qty.	Thickness (m)	Width (m)	Length (m)	Vol (m3)
Top tables	4	0.0190	0.1840	1.30	0.018
Lower transversals	3	0.0762	0.0508	1.10	0.013
Unit volume of wood per pallet 1100 x 1300mm					**0.031**

3.1.3. Wood consumption in packaging

In order to estimate the amount of wood consumed in the form of packaging services, someestimates were made based on the cost of the services performed and the dimensions of the boxes prepared. In 2023 the amount of wood amounted to 1.27 m3, as summarized in Table 11 and Figure 5, the detail is shown in Annex 3.

Table 11.
Estimated volume of timber received through packaging services (m^3 of timber)

Description	UM	2020	2021	2022	2023
Amount USD	US$	9111.90	3,970.00	67,546.98	36,012.35
Packed volume (Lx A x H; m3)	m3	1.30	0.90	37.66	29.28
Packing wood volume (m3, e=8mm)	**m3**	**0.19**	**0.07**	**1.83**	**1.27**

Note: The cubic capacity of wood was estimated based on the area of the wooden boxes (packaging) multiplied by a thickness e=8mm (Detail in Annex 3) for the cases in which the dimensions and weights of finished product were available (mainly from the year 2023). In all other cases, an estimate was made based on the value of the service.

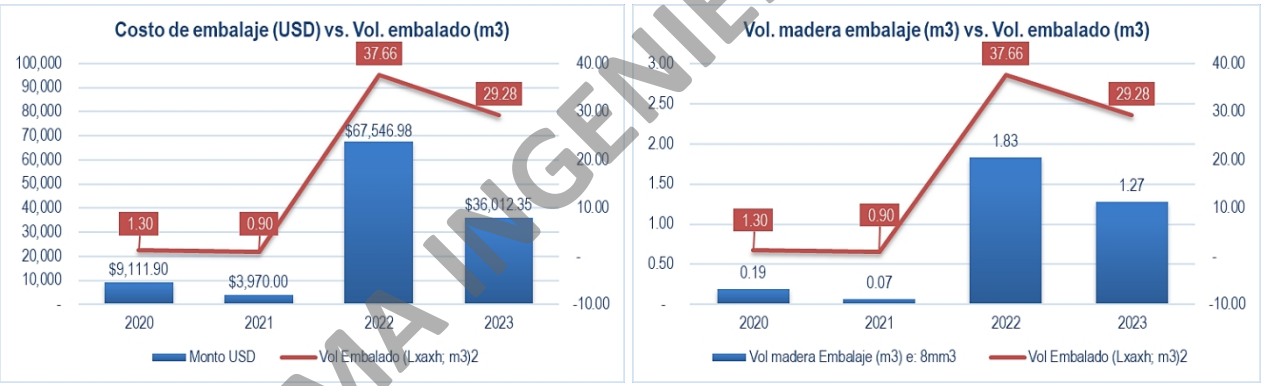


Figure 5. Cost of packaging, packed volume, and wood used (2020-2023, in m^3).

Table 12 shows the estimated volumes of wood used in TAMA in its different forms (lumber, lumber strips and packaging) during the period 2020-2023. According to it, 76% of the wood was acquired in the form of lumber, 22% as 1100x1300 lumber and 3% in the form of packaging. In particular, it is possible to highlight that there is an important potential for a reduction of up to 75.8% of wood consumption in strips if the custom-made packaging is replaced by steel packaging. As for the wooden pallets, it is expected that they will continue to be used at TAMA because they are of second use, and as for the packaging, in general, according to customers' requirements, they are made of treated wood for export purposes.

Table 12.
Estimated volume of wood used in TAMA (m3) in the form of pallets, strips, and packaging.

Description	UM	2020	2021	2022	2023
Wooden pallets	m3	12.97 (28.6%)	8.02 (22.4%)	16.1 (40.1%)	10.21 (21.5%)
Wooden strips	m3	32.17 (71%)	27.76 (77.4%)	22.21 (55.3%)	35.94 (75.8%)
Wood Packaging	m3	0.19 (0.4%)	0.07 (0.2%)	1.83 (4.6%)	1.27 (2.7%)
Total Strips + Pallets +Packaging	**m3**	**45.33 (100%)**	**35.85 (100%)**	**40.13 (100%)**	**47.43 (100%)**

To obtain the number of equivalent trees, the volume of useful standing timber that had to be felled was determined based on the efficiency of Table 4 (196.34 m^3 of standing tree were necessary to obtain 47.43m^3 of pallet). Then, taking into account the harvestable volume of a typical tree described in section 2.3 (5.98m^3 for a tree of 0.81m diameter and 17.90m commercial height), it was determined how many trees the wood used in TAMA was equivalent to, as shown in Table 13. Thus, the amount of timber used in the form of lumber, pallets, and packaging in 2023 in TAMA was equivalent to 32.8 standing trees.

In addition, the ratio of number of trees per 100 tons of steel produced could be obtained from the steel production data at TAMA. In 2023, for every 100 tons of steel, the harvestable wood from 7.59 trees was used (Figure 6).

Table 13.
Estimated number of trees used

Description	UM	2020	2021	2022	2023
Vol. standing timber	m3	187.66	148.41	166.13	196.34
Volume of round tree Type tree (m3)	m3	5.98			
N° Typical trees (Dia 0.809 m; Alt Com: 17.9m)	Und	31.38	24.82	27.78	32.83
Tons processed steel (fabrication)	Ton	539	693	568	468
N° trees / 100 Ton processed	**Und / Ton**	**5.82**	**3.58**	**4.89**	**7.02**

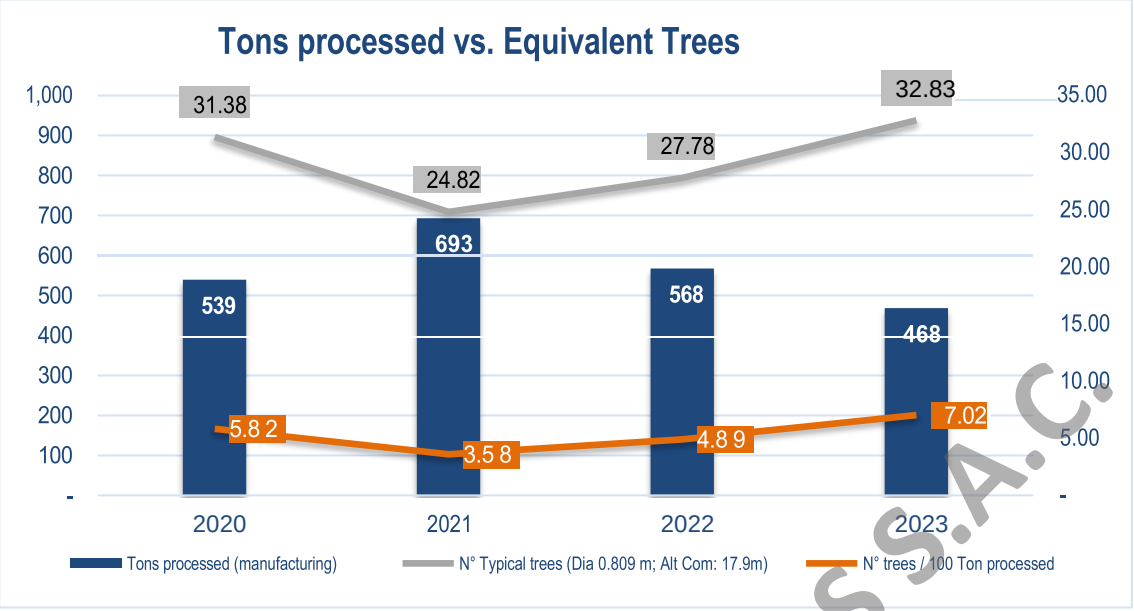


Figure 6. Number of equivalent trees per 100 tons of steel processed (2020-2023).

3.2. Case study

A typical tree of 0.81mØ x 17.90m high, if it were a cylinder, would have 9.22m^3 of wood. Due to its shape, a factor of 0.65 is introduced for its cubage, so the volume of wood cut from a typical tree would be 9.22 x 0.65 = 5.98 m^3 (See section 2.1).
Due to its yield, from these 5.99m^3 of cut wood, 5.99m^3 x 24.16% = 1.45m^3 of useful wood as a finished product, for example, pallets (See Table 4).
TAMA used 47.43m^3 of timber in 2023, for which 47.43 m^3 /1.45m^3 = 32.83 trees of 0.81mØ and 17.90m in height (See Table 12 and Table 13).

4. Conclusions

a. The amount of wood used in the form of lumber, pallets, and packaging in 2023 in TAMA (47.43m3) was equivalent to 32.8 typical trees, standing. Seventy-six percent of the wood was purchased in the form of lumber.

b. The following measurements of a typical tree were established based on reference studies in Peru: Diameter breast height ($_{Dap}$) = 0.81m and Commercial height ($_{Hc}$) = 17.90m.

c. It was determined that the age of the trees is not a function of their diameter or height, but of the availability of nutrients and sunlight, so that, according to evidence in forests in Junín, the *Pinus radiata* species requires between 7 to 10 years to reach its cutting age. In Puno, an investigation determined that 33 years was the optimum logging age for *Pinus radiata* plantations.

d. It was determined that the yield of a standing tree converted to logs is 75.77% and the yield of logs to useful wood is 31.88%. In other words, the combined yield is 24.16%, which indicates that for each m^3 of tree felled, only 24.16% is used as useful wood for packaging.

e. In 2023, for every 100 tons of steel processed in manufacturing, seven trees will have to be felled.

f. There is a significant potential for a reduction of up to 75.8% of wood volume in the form of lumber if custom-made packaging were to be replaced by packaging made from surplus steel.

References

[1] UNODC, "Manual para el Productor Forestal. Cómo cubicamos nuestra madera," 2017. [Online]. Available: https://www.unodc.org/documents/bolivia/DIM_Manual_Como_cubicamos_la_madera.pdf. [Accessed 27 febrero 2024].

[2] L. Lozano and J. Bonilla, "Factor de forma para árboles del Bosque Seco Tropical (bs-T) en el norte del Departamento del Tolima – Colombia," vol. 27, no. 2, pp. 344 - 353, 2022.

[3] G. Valencia, "Determinación del coeficiente de conversión del árbol en pie a troza en patio del aserradero, de la especie shihuahuaco (dipteryx spp.)," 2017. [Online]. Available: https://repositorio.lamolina.edu.pe/bitstream/handle/20.500.12996/2697/K50-V34-T.pdf?sequence=1&isAllowed=y. [Accessed 20 febrero 2024].

[4] T. Frisk and N. Córdova, "Estudio de rendimiento potencial y extracción forestal en el bosque nacional Alexander Von Humboldt. Proyecto PNUD/FAO/PER/78/003 Mejoramiento de los sistemas de extracción y transformación forestal," *Nota técnica N° 17.*, pp. Lima, Perú. 28 p. , 1979.

[5] R. Quirós, O. Chinchilla and M. Gómez, "Rendimiento en aserrío y procesamiento primario de madera proveniente de plantaciones forestales Agronomía Costarricense,," *Agronomía Costarricense,* vol. 29, no. 2, julio-diciembre, pp. 7-15, 2005.

[6] F. Berrospi and J. Herrera, "Influencia de la variación del corte sobre el rendimiento y los ingresos económicos de la industria de aserrío," 2014. [Online]. Available: https://repositorio.lamolina.edu.pe/bitstream/handle/20.500.12996/2363/K50-B47-T.pdf?sequence=1. [Accessed 27 febrero 27].

[7] E. Llactas, "Rendimiento de la madera rolliza en la elaboración de Pallets en la Morada, Huánuco," 2014. [Online]. Available: https://repositorio.unas.edu.pe/bitstream/handle/20.500.14292/2560/TS_ELF_2023.pdf?sequence=1&isAllowed=y#:~:text=Los%20resultados%20evidencian%20que%20el,m3%20equivalente%20a%2027%2C550%20pt.. [Accessed 27 febrero 2024].

[8] C. Silva, "Rendimiento de la madera rolliza de pinus radiata d. Don, en la manufactura de parihuela para la agroexportacion," 2023. [Online]. Available: https://repositorio.lamolina.edu.pe/handle/20.500.12996/5743.

[9] E. Cevallos, X. Lara, J. Morocho, M. Davalos, E. Salazar and S. Lara, "Estudio de tiempos y rendimiento en la transformación de trozas de madera de Pinus radiata D. Don (Pino) en tablas para la elaboración de pallets," 2017. [Online]. Available: https://eujournal.org/index.php/esj/article/view/9144/8683. [Accessed 27 febrero 2024].

[10] Confederación Peruana de la Madera, "Compendio de información técnica de 32 especies forestales. Tomo II.," 2008. [Online]. Available: https://cdn.www.gob.pe/uploads/document/file/1458597/2.%20Compendio%20de%20información%20tecnica%20de%2032%20especies%20Forestales%20Tomo%20II.pdf.pdf.

[11] B. Guerra, "Modelación del crecimiento diamétrico de Pinus radiata d. Don y Pinus oocarpa schiede ex schltdl en el departamento de Junín, a través de técnicas dendrocronológicas," 2023. [Online]. Available: https://repositorio.uncp.edu.pe/bitstream/handle/20.500.12894/8931/T010_72451488_T%20%20%20%20%20Brayan%20Guerra_compressed.pdf?sequence=4&isAllowed=y. [Accessed 5 marzo 2024].

[12] Ecosistemaglobal, "Qué es la clase artificial de edad y el turno de corta," 2023. [Online]. Available: https://ecosistemaglobal.org/2023/11/08/que-es-la-clase-artificial-de-edad-y-el-turno-de-corta/. [Accessed 5 noviembre 2024].

[13] R. Lopez and M. Gonzales, "Crecimiento del Pinus radiata en Puno-Perú.," *Revista Forestal del Perú,* Vols. 10(1-2), no. 1-2, pp. 1-6, 2014.

[14] Ecuador Forestal, "Ficha Técnica No. 13 Pino (Pinus radiata)," 2013. [Online]. Available: https://ecuadorforestal.org/fichas-tecnicas-de-especies-forestales/ficha-tecnica-no-13-pino-pinus-radiata/. [Accessed 5 marzo 2024].

[15] J. Brienen R. and A. Zuidema P., "Relating tree growth to rainfall in Bolivian rain forests: a test for six species using tree ring analysis," *Oecologia,* vol. 146, no. 1, pp. 1-12, 2005.

[16] D. W. Stahle, P. T. Mushove, M. K. Cleaveland, F. A. Roig and G. Haynes, "Management implications of annual growth rings in Pterocarpus angolensis from Zimbabwe," *Forest Ecology and Management,* vol. 124, no. 2-3, pp. 217-229, 1999.

[17] A. Meza and G. Torres, "El raleo: una operación silvicultural fundamental," *Kurú: Revista Foresta,* vol. 3, no. 8, pp. 1-3, 2006.

[18] C. Silva, "Rendimiento de la madera rolliza de pinus radiata d. Don, en la manufactura de parihuela para la agroexportacion," 2023. [Online]. Available: https://repositorio.lamolina.edu.pe/handle/20.500.12996/5743. [Accessed 27 febrero 2024].

APPENDIX 1: LOG TO BOARD YIELD RESEARCH

N°	Research	Species	Final Product	Yield	Remarks
1	Sulca (2021)	Pinus tecunumanii	Piezas de una pulgada de espesor	50.90%	Unmanaged 18-year-old plantation from Chontabamba. Band sawmill in the city of Oxapampa-Pasco. Average log diameter was 26.92cm and lengths were distributed mainly between 2.44m (8') and 3.05m (3.05m).
2	Sulca (2021)	Pinus tecunumanii	Piezas de una pulgada de espesor	13.70%	between 2.44m (8') and 3.05m (10').
3	Sulca (2021)	Pinus tecunumanii		29.40%	Quality 1
4	Sulca (2021)	Pinus tecunumanii		7.80%	Quality 2
5	Llactas (2023)	Varias (Ficus insipida u Ojé, Diplotropis o Chontaquiro)	Pallets	31.88%	
6	Silva (2023)	Pinus radiata	Pallets	46.26%	Plantations in the city of Cajamarca, conventional 1.00 m x 1.20 m x 0.15 m pallets.
7	Silva (2023)	Pinus radiata	Pallets	48.04%	Quality A
8	Silva (2023)	Pinus radiata	Pallets	42.60%	Quality B
9	Silva (2023)	Pinus radiata	Pallets	50.43%	Diameter G
10	Silva (2023)	Pinus radiata	Pallets	45.30%	Diameter M
11	Silva (2023)	Pinus radiata	Pallets	42.00%	Diameter P
12	Murara et al. (2005)	Pinus taedam Brasil		44.93%	Conventional sawmilling
13	Murara et al. (2005)	Pinus taedam Brasil		53.60%	Optimized sawmilling (18-44cm diameter logs)
14	Dirección General Forestal y de Fauna Silvestre (INRENA, 2005)	Pinus taedam Brasil		52.00%	Plantation timber
15	Yepes & Linares (2007) obtuvieron	Tornillo (Cedrelinga cateniformis) en Loreto		30.00%	Use of band saw for logs with average diameters of 20-60cm, thinned from a 30 year old plantation forest.
16	Arroyo (2010)	Eucalipto (Eucalyptus globulus)	Piezas de 1" a 5" de espesor.	65.00%	Logs of 27.8cm average diameter for logs from an agroforestry plantation in the Mantaro Valley, with band sawing.
17	Yalico (2012)	Eucalyptus saligna		65.50%	Forest plantations and agroforestry systems in the Pasco region, using band sawing.
18	Yalico (2012)	Junglas neotropica		55.80%	
19	Llavé (2008)	Tectona grandis, Chanchamayo,	Piezas de 1" y 2" de espesor.	48.00%	Logs ranging from 13.5 cm to 41.1 cm in diameter from the thinning of a teak plantation, bandsawing
20	Montenegro (2015)	Pinus patula de 22 años	Piezas de ¾" y 1" de espesor	43.00%	25.1cm diameter logs from the thinning of a plantation in Porcon-Cajamarca, band sawing
21	Vilches (2005)	Pinus radiata	Piezas varias	60.00%	Logs from diameter class 30-36cm, 575 logs of 5 meters long distributed between diameter classes 30 to 36 cm using band sawing, in the Valdivia-Chile zone.
22	Esteves et al. (2010)	Pinus elliottii		66.00%	Average diameter was 34cm, portable bandsaw sawmill
23	Ortiz et al. (2016)	Pinus, Pinus ayacahuite, P. Oaxacana y P. Oocarpa		48.27%	Band saw in the Oaxaca-Mexico region. Natural forest (where no silvicultural practices were carried out),
24	Orozco et al. (2016)	Pinus leophylla		44.84%	Using bandsaw, for the area of Durango, Mexico.
25	Orozco et al. (2016)	Pinus strobiformis		49.40%	
26	Orozco et al. (2016)	Pinus durangensis		43.18%	

N°	Research	Species	Final Product	Yield	Remarks
27	Orozco et al. (2016)	Pinus teocote		47.47%	
28	Valerío (2009)	Araucaria angustifolia		49.20%	Forest plantations in Paraná, Brazil
29	Aldás (2014)	Pinus radiata		45.00%	Band saw, plantations in Ecuador
30	Aldás (2014)	Pinus radiata		35.00%	Circular saw
31	Guerra (2016)	Pinus oocarpa		54.31%	Logs from natural forest, band saw
32	Guerra (2016)	Pinus oocarpa		53.33%	Logs from silvopastoral systems in Honduras
33	Cevallos et al. (2017)	Pinus radiata	Pallets	34.94%	Block log, band saw. Ecuador
34	Cevallos et al. (2017)	Pinus radiata	Pallets	43.29%	Block to board
35	Cevallos et al. (2017)	Pinus radiata	Pallets	15.08%	Log to board
36	Huarcaya (2011)	Myroxylon balsamun		22.75%	Natural forest in the Iñapari-Madre de Dios area, using main band saw.
37	Huarcaya (2011)	Dipteryx micrantha		37.12%	
38	Wong (2014)	Dipteryx micrantha (shihuahuaco) y	Decking (pisos, revestimiento)	42.77%	Natural forest, band saw
39	Ramírez (2019)	Copaifera reticulata		42.20%	
40	Ramírez (2019)	Ceiba pentandra	Piezas desde 1" a 4"	45.40%	Natural forest, logs from forest concessions in the province of Tahuamanu in Madre de Dios, using a band saw
41	Gonzales (2018) determinó	Huimba negra (Ceiba samauma)	Piezas de espesores variables	51.27%	Tahuamanu in Madre de Dios, using band sawing.
42	Ccahuana (2007)	Caoba (Swietenia macrophylla)		39.62%	Natural forest, first quality logs, Ucayali, sawing with bandsaw and obtaining
43	Canchanya (2011)	Leche caspi (Brosimum utile)	Piezas diversas	63.10%	Natural forest, sawmilling in Tahuamanu-Madre de Dios using band saw.
44	Yepes & Linares (2007)	Tornillo (Cedrelinga cateniformis) en Loreto		30.00%	Raleo, sierra cinta, para trozas cuyos diámetros promedios fueron de 20-60cm, plantación forestal de 30 años
45	Bermúdez et al. (2006)	Gmelina arborea		63.40%	Thinning, band sawing, for logs with average diameters of 20-60cm, 30 years old forest plantation.
46	Quirós et al. (2005)	Gmelina arborea,		39.00%	Sawmilling of logs with smaller diameters (16-24cm) from a forest plantation in Costa Rica, band saw.
47	Quirós et al. (2005)	Acacina mangium		30.00%	
48	Quirós et al. (2005)	Terminalia ivorensis		27.00%	

APPENDIX 2: CONSUMPTION OF WOODEN STRIPS FOR PACKAGING MANUFACTURE IN TAMA 2020-2023

Clase	Factor (m3 x Und)	CodItem	DescItemOC	Und				m3			
				2020	2021	2022	2023	2020	2021	2022	2023
MADERA	0.00590	120050100012	MADERA ROBLE 1" X 3" X 10´	9.00				0.05	-	-	-
MADERA	0.00787	120050100013	MADERA ROBLE 1" X 4" X 10	533.00	191.00	103.00	17.00	4.19	1.50	0.81	0.13
MADERA	0.01180	120050100014	MADERA ROBLE 1" X 6" X 10´	627.00	955.00	728.00	784.00	7.40	11.27	8.59	9.25
MADERA	0.00787	120050100015	MADERA ROBLE 2" X 2" X 10			12.00		-	-	0.09	-
MADERA	0.01180	120050100016	MADERA ROBLE 2" X 3" X 10		2.00			-	0.02	-	-
MADERA	0.01574	120050100017	MADERA ROBLE 2" X 4" X 10´	172.00	44.00	20.00		2.71	0.69	0.31	-
MADERA	0.02360	120050100019	MADERA ROBLE 3" X 4" X 10´	350.00	357.00	328.00	517.00	8.26	8.42	7.74	12.20
MADERA	0.03146	120050100020	MADERA ROBLE 4" X 4" X 10	37.00	4.00			1.16	0.13	-	-
TRIPLAY	0.01888	120050100023	TRIPLAY 4´ X 8´ X 6MM	76.00	27.00	14.00	19.00	1.43	0.51	0.26	0.36
TRIPLAY	0.02832	120050100024	TRIPLAY 4 X 8 X 10 MM	39.00	30.00	36.00	39.00	1.10	0.85	1.02	1.10
MADERA	0.03068	120050100029	MADERA ROBLE 3" X 4" X 13´				3.00	-	-	-	0.09
MADERA	0.02360	120050100030	MADERA ROBLE 2" X 6" X 10´	137.00	77.00			3.23	1.82	-	-
MADERA	0.00787	120050100031	MADERA ROBLE 1" X 4" X 10´ C/TRATAMIENTO TERMICO	9.00				0.07	-	-	-
TRIPLAY	0.02832	120050100032	TRIPLAY 4´ X 8´ X 4MM				8.00	-	-	-	0.23
MADERA	0.02360	120050100033	LISTON DE MADERA DE 3" X 4" X 10´ C/ TRATAMIENTO TERMICO	1.00				0.02	-	-	-
MADERA	0.00619	120050100034	LISTON DE MADERA DE 2" X 4" X 1200MM C/TRATAMIENTO TERMICO	6.00				0.04	-	-	-
MADERA	0.00774	120050100035	LISTON DE MADERA DE 3" X 4" X 1000MM C/TRATAMIENTO TERMICO	1.00				0.01	-	-	-
MADERA	0.01534	120050100036	MADERA CACHIMBO 1" X 6" X 13´	30.00				0.46	-	-	-
MADERA	0.04090	120050100037	MADERA CACHIMBO 4" X 4" X 13´	12.00				0.49	-	-	-
MADERA	0.03068	120050100038	MADERA CACHIMBO 2" X 6" X 13´	8.00				0.25	-	-	-
MADERA	0.01652	120050100044	MADERA CACHIMBO 1" X 6" X 14´	30.00				0.50	-	-	-
MADERA	0.04406	120050100045	MADERA CACHIMBO 4" X 4" X 14´	12.00				0.53	-	-	-
MADERA	0.03304	120050100046	MADERA CACHIMBO 2" X 6" X 14´	8.00				0.26	-	-	-
MADERA	0.03097	120050100049	MADERA ROBLE 4" X 5" X 2400mm		30.00			-	0.93	-	-
MADERA	0.05899	120050100050	MADERA ROBLE 5" X 6" X 10´		6.00			-	0.35	-	-
MADERA	0.03934	120050100051	MADERA ROBLE 4" X 5" X 10		20.00	19.00	4.00	-	0.79	0.75	0.16

Clase	Factor (m3 x Und)	CodItem	DescItemOC	Und				m3			
				2020	2021	2022	2023	2020	2021	2022	2023
MADERA	0.02832	120050100052	MADERA CACHIMBO 3" X 4" X 12		6.00			-	0.17	-	-
MADERA	0.01416	120050100053	MADERA CACHIMBO 1" X 6" X 12		22.00			-	0.31	-	-
MADERA	0.01416	120050100054	MADERA ROBLE 1" X 6" X 12´			74.00	240.00	-	-	1.05	3.40
MADERA	0.02832	120050100055	MADERA ROBLE 3" X 4" X 12´			10.00	12.00	-	-	0.28	0.34
MADERA	0.00394	120050100056	MADERA ROBLE 1" X 2" X 10´			10.00		-	-	0.04	-
MADERA	0.04719	120050100057	MADERA ROBLE 4" X 5" X 12´			12.00		-	-	0.57	-
MADERA	0.01534	120050100058	MADERA ROBLE 1" X 6" X 13´			25.00	107.00	-	-	0.38	1.64
MADERA	0.05114	120050100059	MADERA ROBLE 4" X 5" X 13´			6.00	4.00	-	-	0.31	0.20
MADERA	0.03068	120050100060	MADERA PANGUANA 3" X 4" X 13´				4.00	-	-	-	0.12
MADERA	0.04719	120050100061	MADERA CAMUNGO 4" X 5" X 12´				6.00	-	-	-	0.28
MADERA	0.01416	120050100062	MADERA CAMUNGO 1" X 6" X 12´				28.00	-	-	-	0.40
MADERA	0.02360	120050100063	MADERA ALMENDRO 3" X 4" X 10´				12.00	-	-	-	0.28
MADERA	0.01180	120050100064	MADERA ALMENDRO 1" X 6" X 10´				12.00	-	-	-	0.14
MADERA	0.05114	120050100065	MADERA ALMENDRO 4" X 5" X 13´				12.00	-	-	-	0.61
MADERA	0.01534	120050100066	MADERA ALMENDRO 1" X 6" X 13´				150.00	-	-	-	2.30
MADERA	0.01180	120050100067	MADERA ALMENDRO 1" X 6" X 10´				48.00	-	-	-	0.57
MADERA	0.01534	120050100068	MADERA CUMALA 1" X 6" X 13´				8.00	-	-	-	0.12
MADERA	0.00944	120050100069	MADERA ROBLE 1" X 6" X 8´				16.00	-	-	-	0.15
MADERA	0.05506	120050100070	MADERA ROBLE 4" X 5" X 14´				8.00	-	-	-	0.44
MADERA	0.01888	120050100071	MADERA ROBLE 1" X 6" X 16´				24.00	-	-	-	0.45
OSB	0.05271	120050100072	MADERA TRATADA OSB x 18mm x 1210mm x 2420mm				8.00	-	-	-	0.42
OSB	0.02570	120050100073	MADERA TRATADA OSB x 18mm x 1180mm x 1210mm				8.00	-	-	-	0.21
OSB	0.01050	120050100074	MADERA TRATADA OSB x 18mm x 241mm x 2420mm				4.00	-	-	-	0.04
OSB	0.00512	120050100075	MADERA TRATADA OSB x 18mm x 241mm x 1180mm				4.00	-	-	-	0.02
OSB	0.04392	120050100076	MADERA TRATADA OSB x 15mm x 1210mm x 2420mm				2.00	-	-	-	0.09
OSB	0.02142	120050100077	MADERA TRATADA OSB x 15mm x 1180mm x 1210mm				2.00	-	-	-	0.04
OSB	0.02089	120050100078	MADERA TRATADA OSB x 15mm x 1180mm x 1180mm				1.00	-	-	-	0.02
OSB	0.04283	120050100079	MADERA TRATADA OSB x 15mm x 1180mm x 2420mm				1.00	-	-	-	0.04
MADERA	0.01888	120050100081	MADERA ROBLE 3" X 4" X 8´				4.00	-	-	-	0.08
		Total general		**2097.00**	**1771.00**	**1397.00**	**2116.00**	**32.17**	**27.76**	**22.21**	**35.94**

APPENDIX 3: PACKAGING SERVICES 2020-2023

CodItem	DescItemOC	udMcompra	2020	2021	2022	2023
130601000001	EMBALAJE-NACIONAL-Caja de Madera	UND	865.70			
	SVT EMBALAJE-NACIONAL-Caja de Madera (T028588: ITEM 1), Inc. Traslado	UND		2,980.00		
130602000001	EMBALAJE-NACIONAL-Servicio de embalaje	UND	300.00			
130612000001	CAJA DE MADERA PARA EXPORTACIÓN - 0.62MX0.80M X0.4M capacidad para soportar 80 kgs	UND	270.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 0.62MX0.80MX0.61M capacidad para soportar 150 kgs	UND	160.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 0.7MX1M X0.6 M capacidad para soportar 100 kgs	UND	180.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 2.1m(Largo) x 0.4 m(Alto) capacidad 70 kgs	UND	378.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 3.9m(Largo) x 0.4 m(Alto) capacidad 128 kgs	UND	2,052.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 4.1m(Largo) x 0.4 m(Alto) capacidad 140 kgs	UND	2,520.00			
	CAJA DE MADERA PARA EXPORTACIÓN - 1m x 1.2mx 0.6 m INLET SPOOL+REPAD Y 4 CARTELAS	UND	225.00			
	FABRICACIÓN DE CAJA DE EXPORTACIÓN 610X592X239 T030511 ITEM: 1	UND				315.00
	FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.0M X 1.0M C/ TRATAMIENTO TÉRMICO	UND				679.00
	FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.2M X 1.2M C/ TRATAMIENTO TÉRMICO	UND				2,352.00
	FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.5M X 1.5M C/ TRATAMIENTO TÉRMICO	UND				495.00
	SERV. DE EMBALAJE DE EXPORTACIÓN PARA CHUTE DE FINOS EMB_001	UND				16,965.00
	SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 760mm x 1361mm x 1576mm S/P ITEM: 1	UND				2,764.50
	SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 818mm x 1361mm x 1416mm S/P ITEM: 2@6	UND				1,401.65
	SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 932mm x 1361mm x 1416mm S/P ITEM: 2@6	UND				1,421.05
	SERV. DE EMBALAJE PARA EXPORTACIÓN - CAJA DE MADERA (1556 x 2359 x 618) T029327-0 ITEM: 1	UND			2,313.91	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) T029129-0 ITEM: 1	UND			7,574.50	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) T029129-0 ITEM: 2	UND			9,124.50	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA TIPO1) T028911-1 ITEM: 1	UND			16,403.33	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA TIPO2) T028911-1 ITEM: 2	UND			16,403.33	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) - 1500x800x300 T029314 ITEM: 1	UND			924.07	
	SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERATIPO 3) T028911-1 ITEM: 3	UND			12,713.33	
	SERV. DE EMBALAJE PARA EXPORTACIÓN (CAJA DE MADERA CERRADA S/P T029199)	UND			2,090.00	
	SERV. DE EMBALAJE Y FABRICACIÓN DE CAJA DE EXPORTACIÓN 150 x 370 x 370 T030816 ITEM: 1	UND				345.00
	SERV. DE FAB. DE CAJA PARA EMBALAJE DE EXPORTACIÓN 750 x 1140 x 5000 - VAPOR DOME - T031482 ITEM: 1	UND				3,140.00
	SERV. DE FABRICACIÓN CAJA PARA EXPORTACIÓN 1984mm x 1340mm x 1621mm - FEED SPOUT S/P T031962-1	UND				2,409.15
	SERV. DE FABRICACIÓN CAJA PARA EXPORTACIÓN 720mm x 770mm x 580mm S/P T031938-0 ITEM: 1	UND				505.00
	Serv. modificación caja de exportación	UND		990.00		
	SVT - SERV. DE FABRICACIÓN DE CAJA PARA EXPORTACIÓN 1.25mX1.25mX3.350m T025839-0 ITEM: 1	UND				3,220.00
	SVT EMBALAJE-EXPORTACION-CAJA DE MADERA 1MX1MX 1.6M	UND	2,161.20			
Total general			**9,111.90**	**3,970.00**	**67,546.97**	**36,012.35**

APPENDIX 4: ESTIMATED VOLUME OF PACKAGING SERVICES 2020-2023

DescItemOC	Dimens embalaje			Cant	Vol Embalado (Lxaxh;m³)	UDM	OT	2020		2021		2022		2023	
	L (mm)	a (mm)	h (mm)					Monto USD	Ratio USD/Vol embalado	Monto USD5	Ratio USD/Vol madera	Monto USD8	Ratio USD/Vol madera	Monto USD5	Ratio USD/Vol madera
SVT EMBALAJE-EXPORTACION-CAJA DE MADERA 1MX1MX 1.6M	1,000	1,000	1,600	2	1.60	UND	OTS-003159/Serv. de mecanizado	2161.2	1,350.75						
EMBALAJE-NACIONAL-Caja de Madera				3	-	UND	OTC-002997/Divisor rotatorio	865.7							
EMBALAJE-NACIONAL-Servicio de embalaje				1	-	UND	OTC-002997/Divisor rotatorio	300							
CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 2.1m(Largo) x 0.4 m(Alto) capacidad 70 kgs	1,100	2,100	400	1	0.92	UND	OTC-003071 7 / DUCTO DE SUCCION 405-6-294	378	409.09						
CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 3.9m(Largo) x 0.4 m(Alto) capacidad 128 kgs	1,100	3,900	400	4	1.72	UND	OTC-003071 7 / DUCTO DE SUCCION 405-6-294	2052	1,195.80						
CAJA DE MADERA PARA EXPORTACIÓN - 1.1m(Ancho) x 4.1m(Largo) x 0.4 m(Alto) capacidad 140 kgs	1,100	4,100	400	4	1.80	UND	OTC-003071 7 / DUCTO DE SUCCION 405-6-294	2520	1,396.90						
CAJA DE MADERA PARA EXPORTACIÓN - 1m x 1.2mx 0.6 m INLET SPOOL+REPAD Y 4 CARTELAS	1,000	1,200	600	1	0.72	UND	OTC-003090 / Inlet spool, repads & gusset	225	312.50						
CAJA DE MADERA PARA EXPORTACIÓN - 0.62MX0.80M X0.4M capacidad para soportar 80 kgs	620	800	400	2	0.20	UND	OTC-003098 / Sectores de disco	270	1,360.89						
CAJA DE MADERA PARA EXPORTACIÓN - 0.62MX0.80MX0.61M capacidad para soportar 150 kgs	620	800	610	1	0.30	UND	OTC-003098 / Sectores de disco	160	528.82						
CAJA DE MADERA PARA EXPORTACIÓN - 0.7MX1M X0.6 M capacidad para soportar 100 kgs	700	1,000	600	1	0.42	UND	OTC-003098 / Sectores de disco	180	428.57						
Serv. modificación caja de exportación				1	-	UND	OTC-003292/Discharge end Trunnion liner 41"x69.8"			990					
SVT EMBALAJE-NACIONAL-Caja de Madera (T028588: ITEM 1), Inc. Traslado				1	-	UND	OTC-003554/Sandwheel 72x16 Trunnion			2980					
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA TIPO1) T028911-1 ITEM: 1				3	-	UND	OTC-003582/Gear guards & parts					16,403			
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA TIPO2) T028911-1 ITEM: 2				3	-	UND	OTC-003582/Gear guards & parts					16,403			
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERATIPO 3) T028911-1 ITEM: 3				3	-	UND	OTC-003582/Gear guards & parts					12,713			
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) T029129-0 ITEM: 1				1	-	UND	OTC-003594/Gear Guards					7,575			
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) T029129-0 ITEM: 2				1	-	UND	OTC-003594/Gear Guards					9,125			
SERV. DE EMBALAJE PARA EXPORTACIÓN (CAJA DE MADERA CERRADA S/P T029199)				1	-	UND	OTC-003602/Manual Lift					2,090			
SERV. DE EMBALAJE PARA EXPORTACION (CAJA CERRADA DE MADERA) - 1500x800x300 T029314 ITEM:	1,500	800	300	1	0.36	UND	OTC-003664/Clamp ring					924	2,567		

DescItemOC	Dimens embalaje			Cant	Vol Embalado (Lxaxh;m³)	UDM	OT	2020		2021		2022		2023	
	L (mm)	a (mm)	h (mm)					Monto USD	Ratio USD/Vol embalado	Monto USD5	Ratio USD/Vol madera	Monto USD8	Ratio USD/Vol madera	Monto USD5	Ratio USD/Vol madera
1															
SERV. DE EMBALAJE PARA EXPORTACIÓN - CAJA DE MADERA (1556 x 2359 x 618) T029327-0 ITEM: 1	1,556	2,359	618	1	2.27	UND	OTC-003665/Splash ring					2,314	1,020		
SERV. DE EMBALAJE DE EXPORTACIÓN PARA CHUTE DE FINOS EMB_001				-	-	UND	OTC-003879/Chute de Finos							16,965	
SERV. DE EMBALAJE Y FABRICACIÓN DE CAJA DE EXPORTACIÓN 150 x 370 x 370 T030816 ITEM: 1	150	370	370	1	0.02	UND	OTC-003883/Plate, Seal, Lower							345	16,801
FABRICACIÓN DE CAJA DE EXPORTACIÓN 610X592X239 T030511 ITEM: 1	610	592	239	1	0.09	UND	OTC-003901/Liner 500HB							315	3,650
SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 760mm x 1361mm x 1576mm S/P ITEM: 1	760	1,361	1,576	2	1.63	UND	OTC-003955/Liners 450-500 HB							2,765	1,696
SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 818mm x 1361mm x 1416mm S/P ITEM: 2@6	818	1,361	1,416	1	1.58	UND	OTC-003955/Liners 450-500 HB							1,402	889
SERV. DE EMBALAJE EN CAJA DE MADERA PARA EXPORTACIÓN - CAJA 932mm x 1361mm x 1416mm S/P ITEM: 2@6	932	1,361	1,416	1	1.80	UND	OTC-003955/Liners 450-500 HB							1,421	791
SERV. DE FAB. DE CAJA PARA EMBALAJE DE EXPORTACIÓN 750 x 1140 x 5000 - VAPOR DOME - T031482 ITEM: 1	750	1,140	5,000	1	4.28	UND	OTC-003973/Vapor Dome Weldment							3,140	735
SVT - SERV. DE FABRICACIÓN DE CAJA PARA EXPORTACIÓN 1.25mX1.25mX3.350m T025839-0 ITEM: 1				1	-	UND	OTC-004045/Mecanismo de Flotación DR500							3,220	
SERV. DE FABRICACIÓN CAJA PARA EXPORTACIÓN 720mm x 770mm x 580mm S/P T031938-0 ITEM: 1	720	770	580	1	0.32	UND	OTC-004054/Repuestos de Zaranda y Liners							505	1,571
SERV. DE FABRICACIÓN CAJA PARA EXPORTACIÓN 1984mm x 1340mm x 1621mm - FEED SPOUT S/P T031962-1	1,984	1,340	1,621	1	4.31	UND	OTC-004060/Feed Spout							2,409	559
FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.0M X 1.0M C/ TRATAMIENTO TÉRMICO						UND	OTC-003989 Silenciadores y Soportes							679	
FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.2M X 1.2M C/ TRATAMIENTO TÉRMICO						UND	OTC-003989 Silenciadores y Soportes							2,352	
FABRICACIÓN DE PALLETS PARA EXPORTACIÓN DE 1.5M X 1.5M C/ TRATAMIENTO TÉRMICO						UND	OTC-003989 Silenciadores y Soportes							495	
Total					**24.33**			**9,111.90**	**6,983.32**	**3,970.00**		**67,546.98**	**1,793.45**	**36,012.35**	**1,229.82**

Appendix N°4 T-GI-F-21

Packaging types: 10 cases

PARA	:	GERENTE COMERCIAL
TEMA	:	CASOS TIPICOS DE EMBALAJE
FECHA	:	01-12-23
REALIZADO POR	:	E.C.C.

Según lo explicado, se tiene 10 casos según fig 1 adjunta, pero solo se requiere embalaje metálico para 08 casos, a los cuales se les debe generar su código.

- La nomenclatura para los diversos embalajes, puede ser según los siguientes códigos:

- E1 Se usa parihuela de madera para piezas pequeñas y livianas
- E2 para piezas medianas y livianas
- E3 para piezas grandes y livianas
- E4 para piezas pequeñas y semipesadas
- E5 para piezas medianas y semipesadas
- E6 para piezas grandes y semipesadas
- E7 para piezas pequeñas y pesadas
- E8 para piezas medianas y pesadas
- E9 para piezas grandes y pesadas
- E10 para elementos que solo necesitan tacos de madera.

Se considera pieza mediana y pesada para un elemento vista desde planta, donde en cualquiera de sus ejes X o Y, tenga una medida mayor a 1000mm
Se considera una pieza semipesada, cuando el peso de la pieza pueda ser entre 300 a 500 kg/m²
Se considera una pieza pesada, cuando el peso de la pieza pueda ser entre 500 a 1200 kg/m²

Tener en cuenta que algunas piezas pueden ser medianas y livianas, pero se puede apilar unas encima de otras, generando una bulto semipesado o pesado.

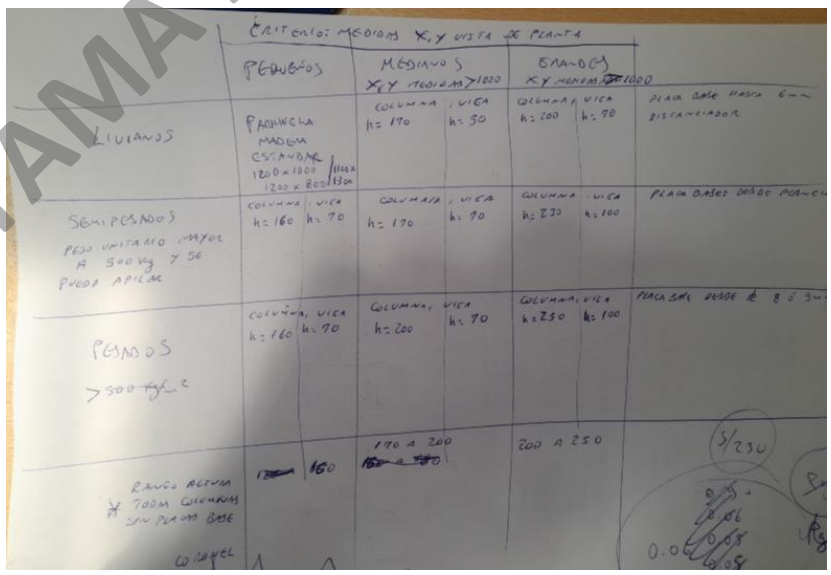


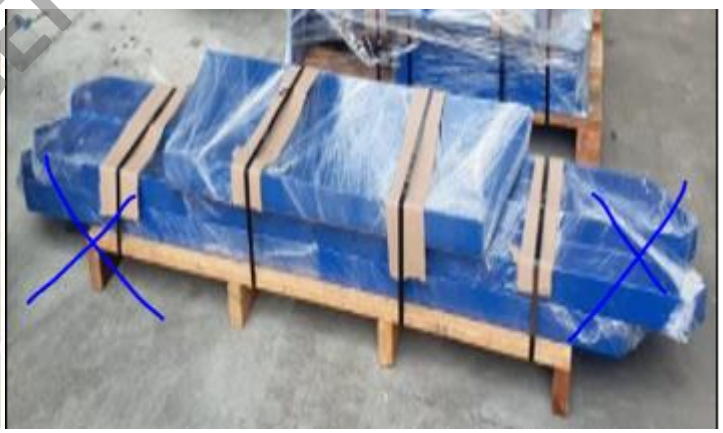
Fig.1

ALGUNOS EJEMPLOS DE TIPO DE PRODUCTOS:

EMBALAJE TIPO E1 (parihuelas estándar, hasta un máximo de 1.2 ton):

EMBALAJE TIPO E2:

Ojo, en la estructura en azul, según procedimiento T-AB-PT-05 es incorrecto, ya que siempre el embalaje debe superar en 50mm la pieza. Salvo que se tenga un acuerdo con el cliente para piezas tipo estructuras, donde si es aceptable solo el uso de tacos.



EMBALAJE TIPO E3:

EMBALAJE TIPO E4:

EMBALAJE TIPO E5:

EMBALAJE TIPO E6:

EMBALAJE TIPO E7:

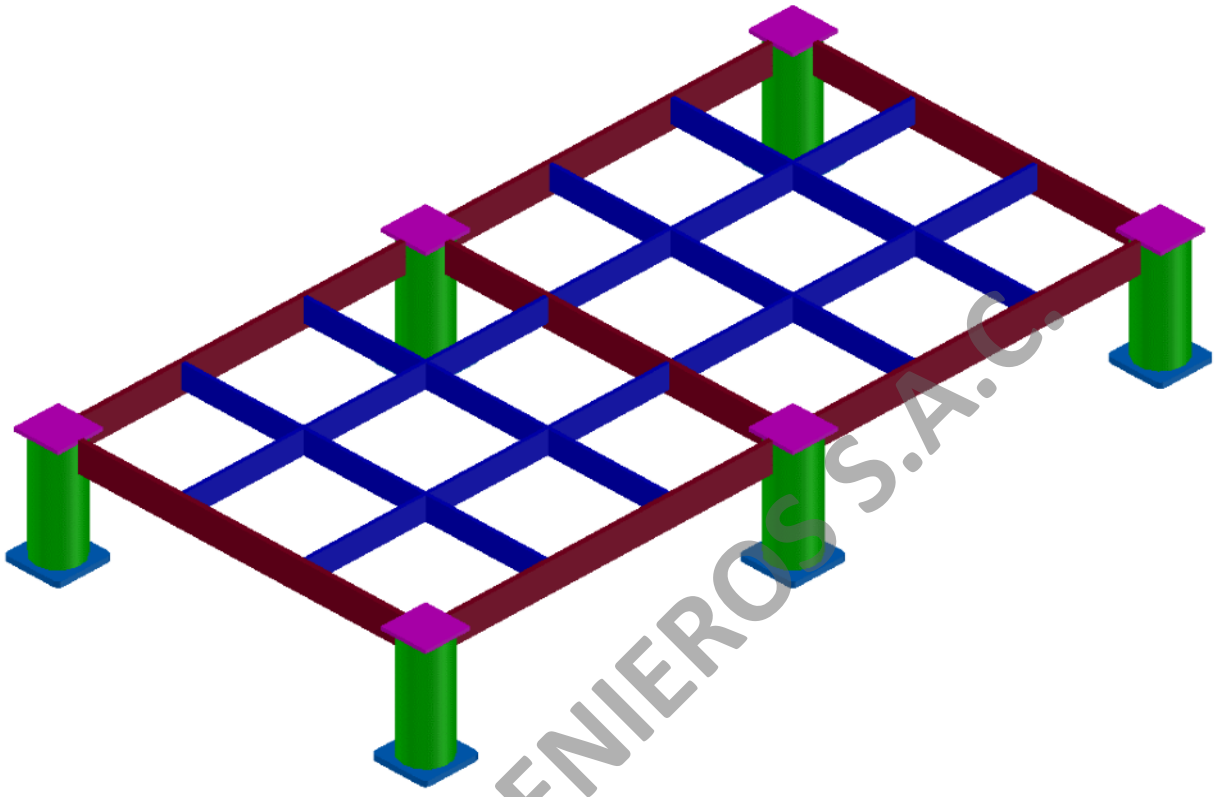
EMBALAJE TIPO E8:

EMBALAJE TIPO E9:

EMBALAJE TIPO E10 (previo acuerdo con el cliente):

Appendix N°6

Steel Pallet Calculation Report (Rev. D)



PARIHUELAS METÁLICAS

ELEMENTOS FINITOS

CLIENTE: TAMA INGENIEROS S.A.C.

OC: INTERNA

Aprobado por : J.M.	Fecha: 21/03/2024	Firma:
Revisado por : J.M.	Fecha: 20/03/2024	Firma:
Preparado por : O.C.	Fecha: 20/03/2024	Firma:

Nº	Revisiones	Por	Fecha
C	Emitido para aprobación	J.M.	20/03/2024
B	Emitido para aprobación	J.M.	20/03/2024
A	Emitido para revisión interna	J.M.	20/03/2024

CALCULO No.	REVISION No.	FECHA.
MC-T-CT-003-24	C	20/03/2024

ÍNDICE

1.- DESCRIPCION GENERAL

1.1 OBJETIVO.

- Diseñar y calcular las parihuelas metálicas para la validacion de los elementos estructurales y optimizacion de material (el comportamiento estructural de la parihuela metálica) , brindando seguridad para sus condiciones operativas. Calculado mediante elementos finitos FEA.
- El programa Solidworks 2022 fue utilizado para su validacíon

1.2 CODIGOS Y ESTANDARES.

ASTM *American Society for Testing and Materials*

1.3 REFERENCIAS.

*) T-GI-F-21 Embalaje de metal actual

*) T-GI-F-21 Embalaje de metal

*) T-GI-F-21 Tipos de embalaje 10 casos

*) Zacchei_Design of new modular metal pallets_ Experimental validation and life cycle analysis

1.4 CONSIDERACIONES PARA EL DISEÑO.

Se tiene las siguientes consideraciones, tipos de Parihuelas:

DESIGNACIÓN	DESCRIPCIÓN	TIPO (Material)
E1	Para piezas livianas y semipesadas.	(Parihuela de acero)
E2	Para piezas pesadas	(Parihuela de acero)

1.5 MATERIALES.

- Planchas de acero en material ASTM A36 / ASTM A572 Gr.50 / ASTM A709 Gr.50

	Yield Point (min.)		Tensile Strength (min.)	
	ksi	Mpa	ksi	Mpa
ASTM A36	36	250	58-80	400-550
ASTM A572 Gr.50	50	345	65	450
ASTM A709 Gr.50	50	345	65	450

Fig. 01: Propiedades de los materiales

1.6 CRITERIO DE DISEÑO POR METODO DE ELEMENTOS FINITOS

- El análisis considera una modelación mediante el software de elementos finitos SolidWorks Simulation
- El criterio de aprobación del análisis estructural del Soporte del contratorque estará basado en la tensión de Von Mises.
- Existen cuatro terorías sobre la falla o ruptura. A) Von Mises B)Tresca C)Morh y D)Máximo normal.
- Los resultados experimentales indican que, de todas estas teorías sobre la ruptura, en los materiales dúctiles la que da resultados más adaptados a la realidad es la teoría de distorsión máxima de **Von Mises (criterio de diseño)**

Tensión de Von Mises

La tensión de Von Mises es una magnitud física proporcional a la energía de distorsión. En ingeniería estructural se usa en el contexto de las teorías de fallo como indicador de un buen diseño para materiales dúctiles.

La tensión de Von Mises puede calcularse fácilmente a partir de las tensiones principales del tensor, tensión en un punto de un sólido deformable, mediante la expresión:

$$\sigma_{VM} = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}}$$

Siendo σ1, σ2, σ3, la tensiones principales y habiéndose obtenido la expresión a partir de la energía de distorsión en función de las tensiones principales:

$$E_{def,dist} = \frac{1}{6G}\left[\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}\right]$$

La tensión de Von Mises y el criterio de fallo elástico asociado debe su nombre a Richard Edler von Mises (1913) propuso que un material dúctil sufría fallo elástico cuando la energía de distorsión elástica rebasaba cierto valor. Sin embargo, el criterio fue claramente formulado con anterioridad por Maxwell en 1865 más tarde también Huber (1904), en un artículo en polaco anticipó hasta cierto punto la teoría de fallo de Von Mises. Por todo esto a veces se llama a la teoría de fallo elástico basada en la tensión de Von Mises como teoría de Maxwell-Huber-Hencky-von Mises y también teoría de fallo.

En consecuencia se prevé que ocurrira la fluencia cuando:

$$\sigma_{VM} \geq \sigma_{Fluencia\ acero} \quad \ldots\ldots (Criterio\ de\ Diseño)$$

2.- Diseño por Metodo de Elementos Finitos

2.1 Calculo de aplicación de fuerzas en la parihuela metálica

Dimensiones : Medidas generales y ubicación de cargas

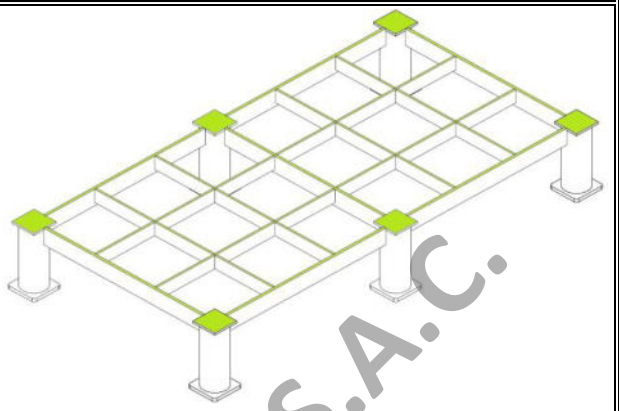
La fuerza "F" se aplica depende del tipo de parihuela:

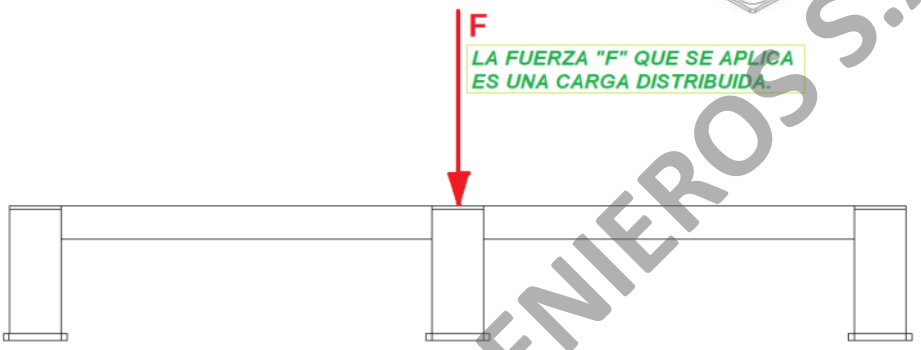
$$W=mg$$

Datos:

m = masa : …. *Kg*

g = gravedad : …. *m/s2*





Calculos :

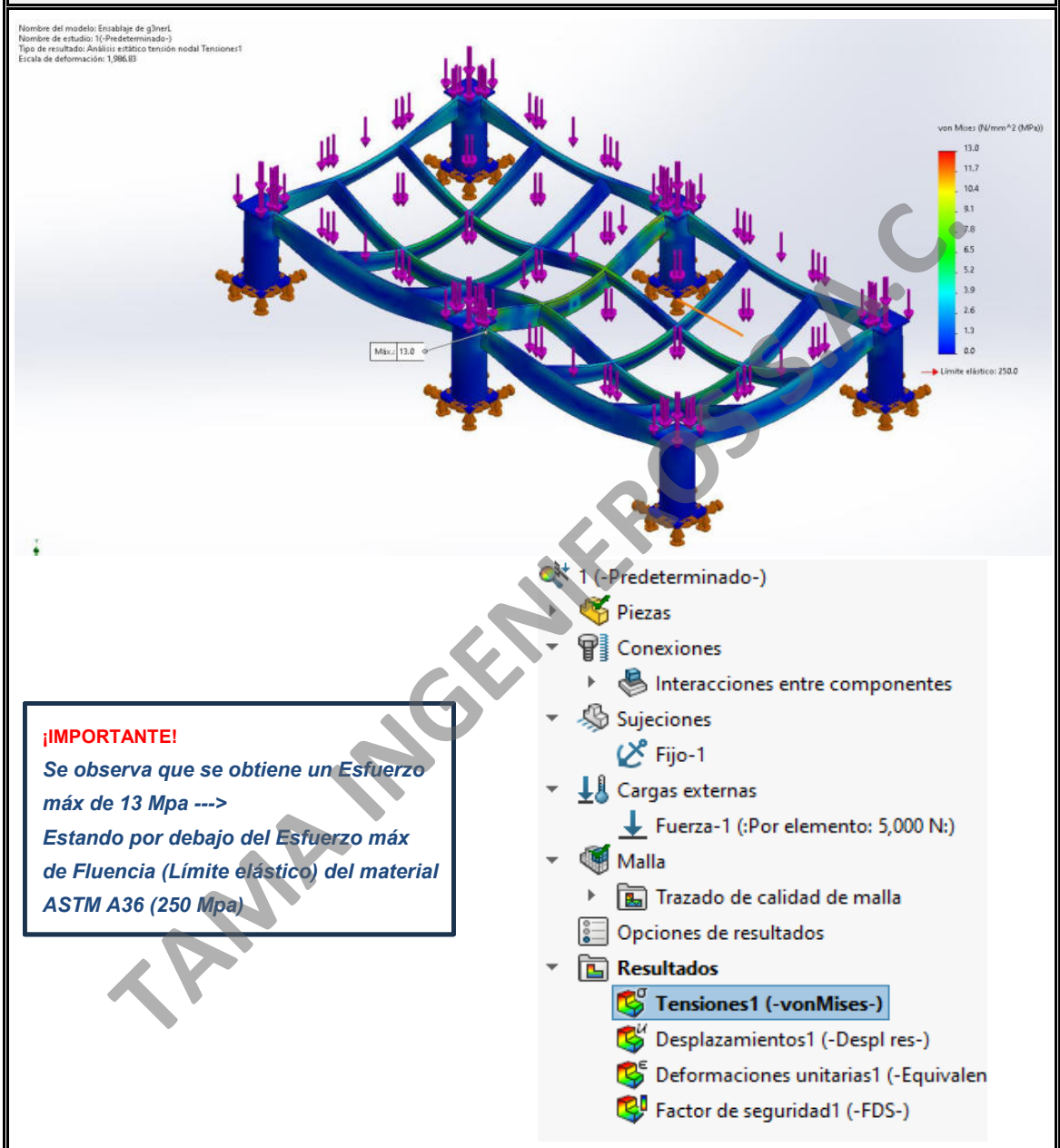
La fuerza "F" se aplica depende del tipo de parihuela, de acuerdo a la siguiente tabla:

PARIHUELAS METÁLICAS		CARGA MÁX.
LIVIANAS - SEMIPESADAS ≤ 500 Kg/m2	E1	500 Kg/m2
PESADAS (500-1200 Kg/m2)	E2	1200 Kg/m2

3.- Diseño por Metodo de Elementos Finitos (Parihuela E1)

3.1 Simulación de la parihuela metálica : *Se considera la simulación en las condiciones mas críticas*

Resultados : Tensiones de Von Mises



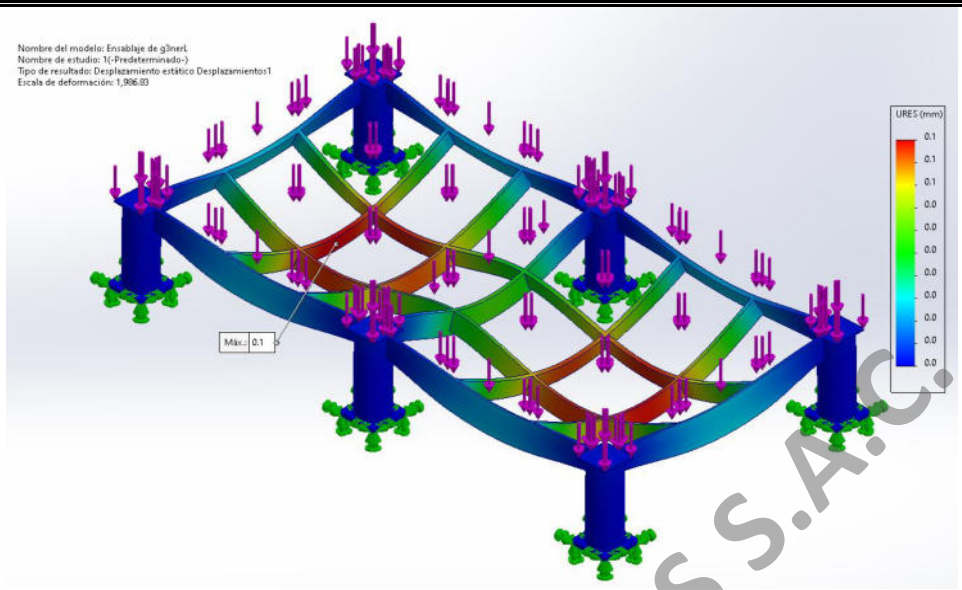
¡IMPORTANTE!

Se observa que se obtiene un Esfuerzo máx de 13 Mpa --->

Estando por debajo del Esfuerzo máx de Fluencia (Límite elástico) del material ASTM A36 (250 Mpa)

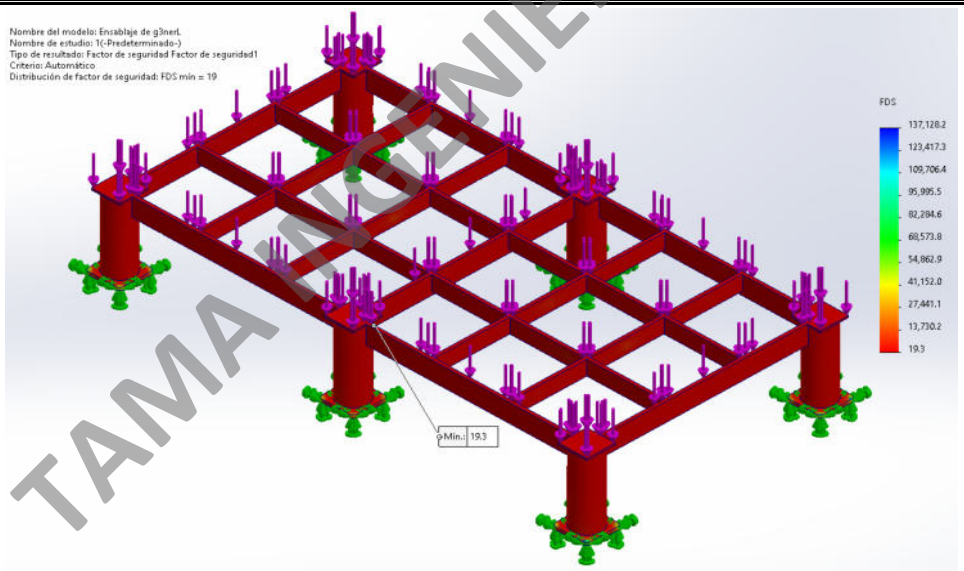
Tensión de Von Mises Max:	13	Mpa
Tensión de Von Mises Min:	0.000	Mpa

Resultados : Desplazamiento



Desplazamiento Max:	0.100	mm
Desplazamiento Min:	0.000	mm

Resultados : Factor de seguridad FDS



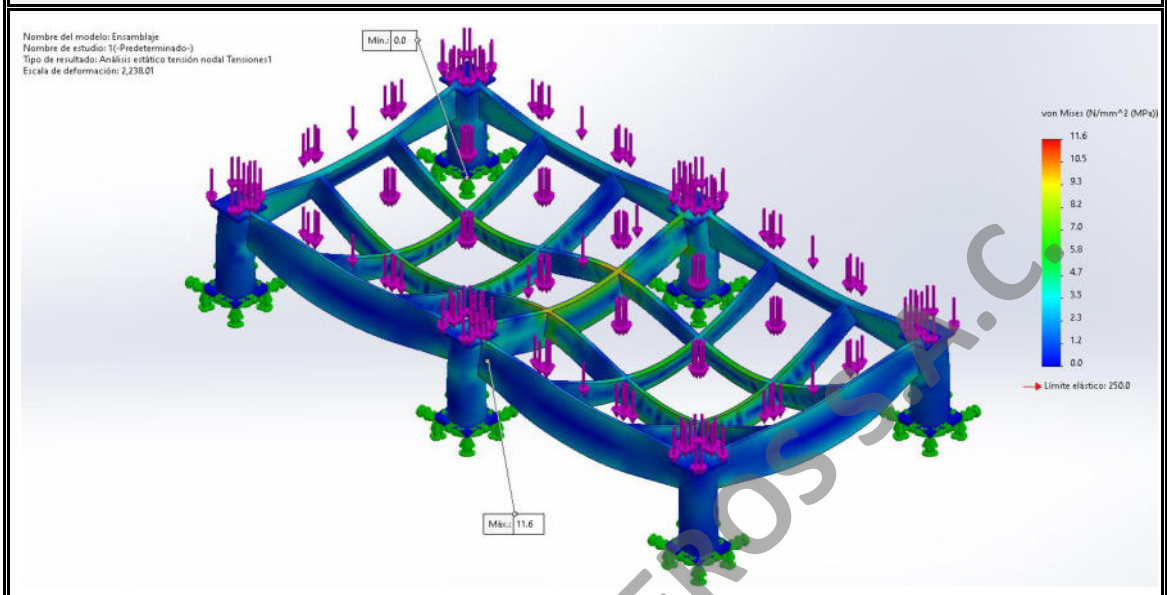
Se observa un factor de seguridad de 19.3

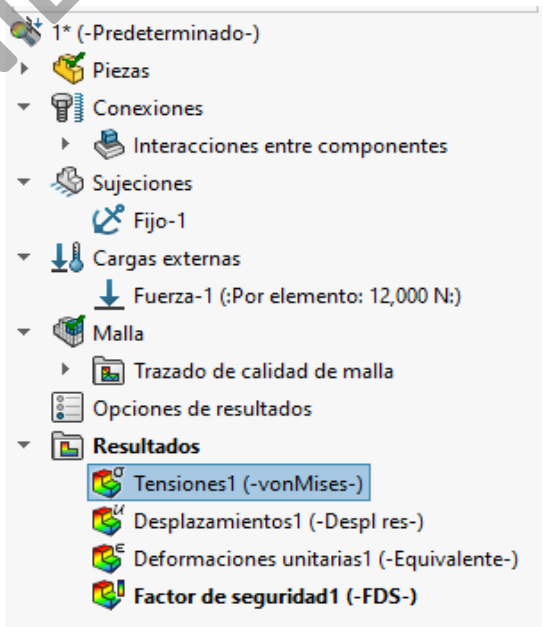
Factor Seguridad Min: 19.3

4.- Diseño por Metodo de Elementos Finitos (Parihuela E2)

4.1 Simulación de la parihuela metálica : *Se considera la simulación en las condiciones mas críticas .*

Resultados : Tensiones de Von Mises





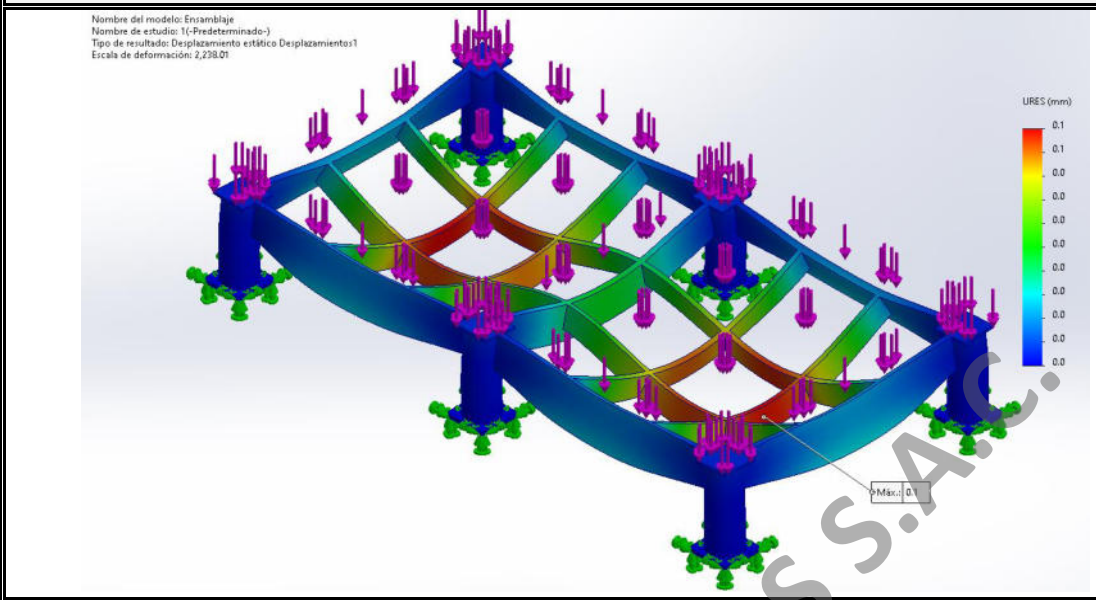
¡IMPORTANTE!

Se observa que se obtiene un Esfuerzo máx de 74.6 Mpa --->

Estando por debajo del Esfuerzo máx de Fluencia (Límite elástico) del material ASTM A36 (250 Mpa)

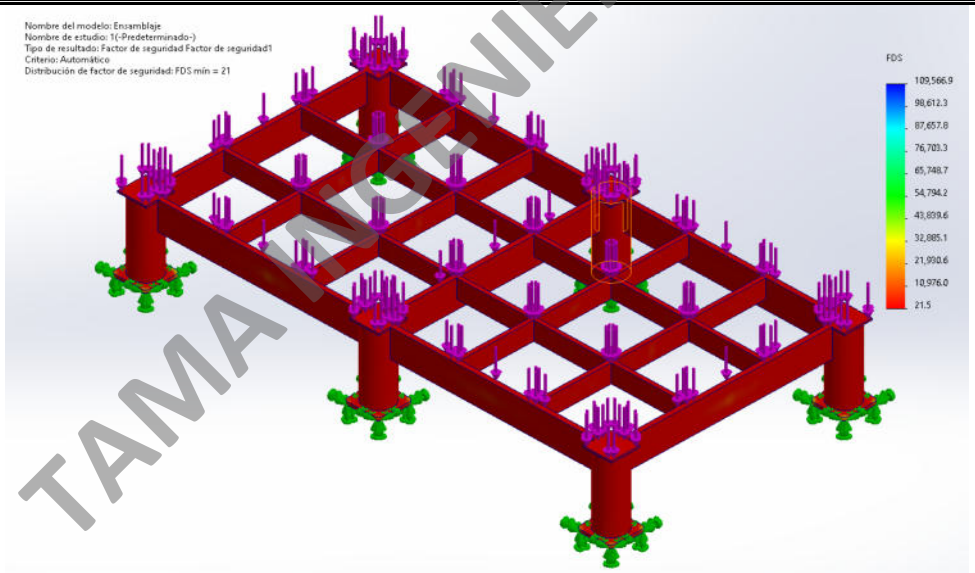
Tensión de Von Mises Max:	11.6	Mpa
Tensión de Von Mises Min:	0.00	Mpa

Resultados : Desplazamiento



Desplazamiento Max:	0.100	mm
Desplazamiento Min:	0.000	mm

Resultados : Factor de seguridad FDS



Se observa un factor de seguridad de 21.5

Factor Seguridad Min: 21.5

5- Conclusiones

De acuerdo a los resultados obtenidos en en acapite anterior Simulación de Parihuela Metálica se tiene:

-Parihuela "E1"

- La tensión máxima de Von Misses calculado es de **13 Mpa**, siendo este valor menor a 250 Mpa para el material analizado ASTM A36.
- El factor de seguridad mínimo calculado es de **19.3** por lo cual se asegura que el esfuerzo de Von mises(Esfuerzo calculado) no supera el esfuerzo de fluencia del material.

-Parihuela "E2"

- La tensión máxima de Von Misses calculado es de **11.6 Mpa**, siendo este valor menor a 250 Mpa para el material analizado ASTM A36.
- El factor de seguridad mínimo calculado es de **21.5** por lo cual se asegura que el esfuerzo de Von mises(Esfuerzo calculado) no supera el esfuerzo de fluencia del material.

6.- Recomendaciones

Se recomienda pintar la parihuela para evitar la corrosión.

7.- Anexos

* Parihuela Metálica Liviana - Semipesada (E1) - PLANO: T0323526 R.0
* Parihuela Metálica Liviana - Pesada (E2) - PLANO: T0323527 R.0
* Placa de Identificación - PLANO: T032528 R.0

PRECISION CLASE "A"	TOLERANCIAS ADMISIBLES PARA MEDIDAS DE LONGITUD EN CALDERERIA (ISO 13920)									Medidas nominales (valores en mm.)
	más de 30 hasta 120	más de 120 hasta 400	más de 400 hasta 1000	más de 1000 hasta 2000	más de 2000 hasta 4000	más de 4000 hasta 8000	más de 8000 hasta 12000	más de 12000 hasta 16000	más de 16000 hasta 20000	más de 20000
	±1	±1	±2	±3	±4	±5	±6	±7	±8	±9

REV.	DESCRIPCION	POR	APROB.	FECHA
0	EMITIDO PARA SU FABRICACION	O.D.G.	E.S.M	20.02.24

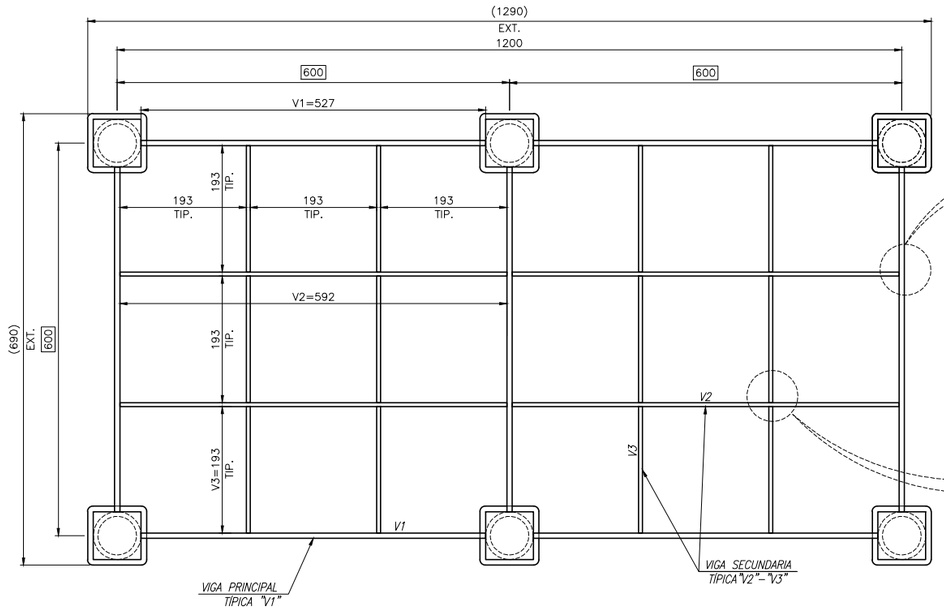
TAMA® INGENIEROS S.A.C.

ESTA ESTRUCTURA HA SIDO DISEÑADA Y FABRICADA POR TAMA INGENIEROS S.A.C.
Calle 3, Mz. B, Lt. 1, Urbanización Barbadillo, Ate, Lima, Perú / Telf.: 715-1281
E-mail:tamasac@tama.pe/ventastechardox@tama.pe
Página Web: www.tamaingenieros.pe
Diseñado para manipulación con MONTACARGAS (NO IZAR)

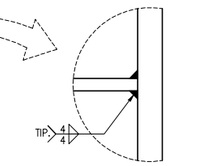
TIEMPO DE VIDA ÚTIL ESPERADO DE 20 AÑOS — PESO NETO: Kg.
DIMENSIONES: mm. — SERIE N°: OTP-
CARGA MÁX.:500 Kg/m2 ☐ 1200 Kg/m2 ☐ — FECHA DE FABRICACION: / /

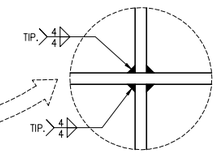
INGENIERIA VALIDO PARA FABRICACION
V°B° Fecha: 02/04/24

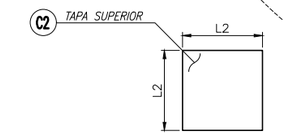
O.T.P: 19
O.T.P.: 20

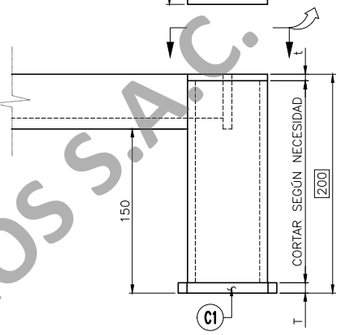


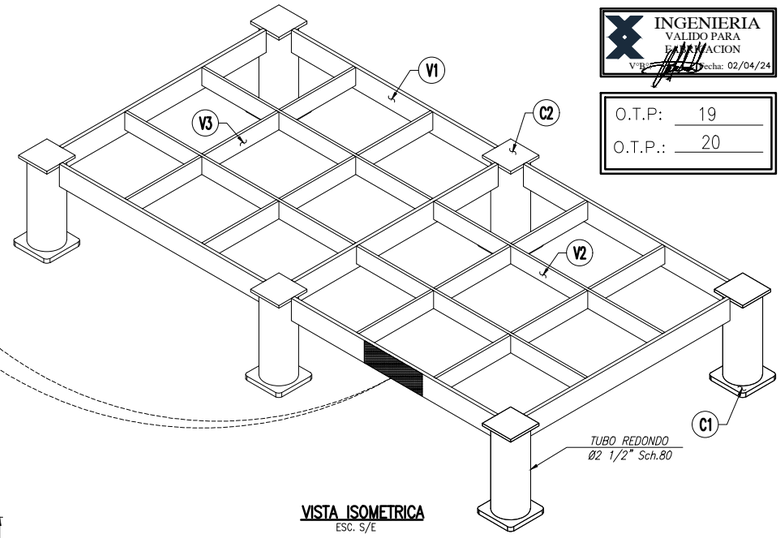
VISTA DE PLANTA
ESC. 1:1



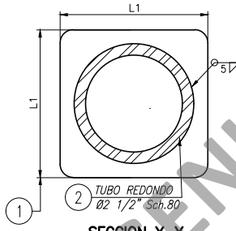




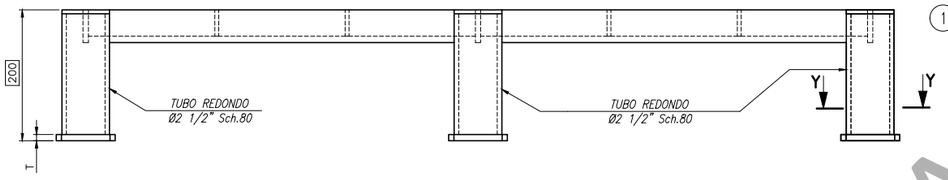




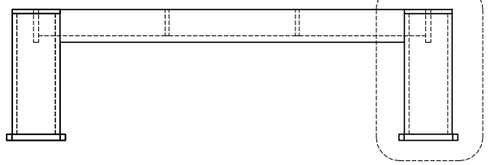
VISTA ISOMETRICA
ESC. S/E



SECCION Y-Y
ESC. 1:2



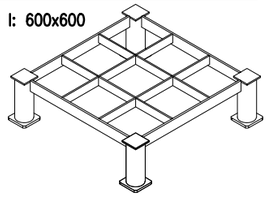
VISTA FRONTAL
ESC. 1:1



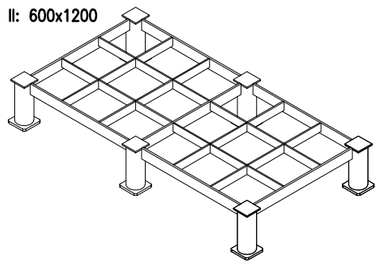
VISTA LATERAL
ESC. 1:1

TIPOS DE PARIHUELAS METÁLICAS :

TIPO I: 600x600



TIPO II: 600x1200



TIPO III: 1200x1200

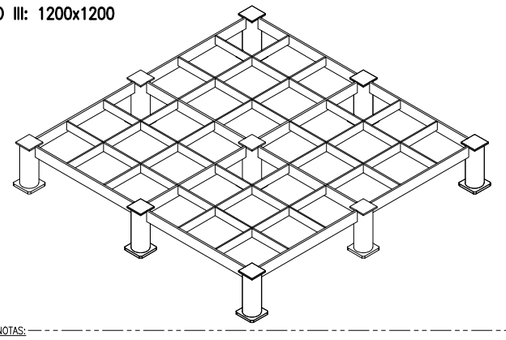
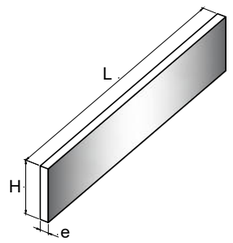
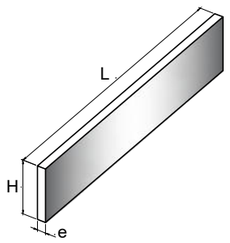


PLATE "V1"



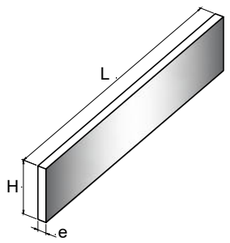
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	50	527	83333	2133	1.65
2	9.5	50	527	98958	3572	1.96
3	10	50	527	104167	4167	2.06

PLATE "V2"



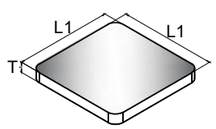
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	6	40	592	32000	720	1.12
2	8	40	592	42667	1707	1.49
3	9.5	40	592	50667	2858	1.76

PLATE "V3"



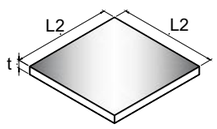
N°	e	H	3 L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	6	40	193	32000	720	0.36
2	8	40	193	42667	1707	0.48
3	9.5	40	193	50667	2858	0.57

PLATE "C1"



N°	T	L1	L1	Peso (Kg)
1	6	90	90	0.38
2	8	90	90	0.50
3	9.5	90	90	0.60
4	10	90	90	0.63

PLATE "C2"



N°	t	L2	L2	Peso (Kg)
1	4.5	73	73	0.18
2	5	73	73	0.20
3	6	73	73	0.25

NOTAS:
1. TODAS LAS DIMENSIONES INDICADAS ESTÁN DADAS EN MILÍMETROS (mm), SALVO INDICACIÓN CONTRARIA.
2. ELIMINAR FILOS & REBABAS 0.25 x 45°.
3. LONGITUD VARIABLE, SE DEFINE EN CAMPO.

PARIHUELAS METÁLICAS		
TIPO	DESCRIPCIÓN	CARGA
E1	PARIHUELA PARA PIEZAS LIVIANAS Y SEMI PESADAS	≤500Kg/m2

TAMA® INGENIEROS S.A.C.

TAMA INGENIEROS S.A.C.
PARIHUELA METÁLICA LIVIANA-SEMI PESADA(TIPO A)
ARREGLO GENERAL

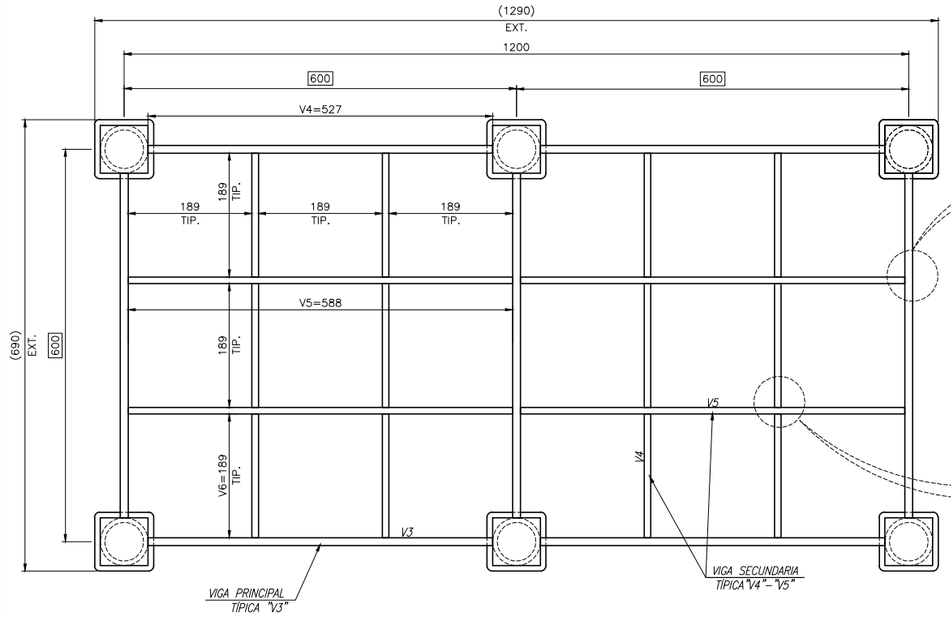
Dibujado: O.D.G.	Aprobado: E.C.C.	Escala: IND.	Proyeccion	Peso:	O.T.	No. PLANO	Rev.
Revisado: E.S.M.	Fecha: 22.03.24	Formato: A1		---	****_**	T032526	1

PRECISION CLASE "A"	TOLERANCIAS ADMISIBLES PARA MEDIDAS DE LONGITUD EN CALDERERIA (ISO 13920)									Medidas nominales (valores en mm.)
	más de 30 hasta 120	más de 120 hasta 400	más de 400 hasta 1000	más de 1000 hasta 2000	más de 2000 hasta 4000	más de 4000 hasta 8000	más de 8000 hasta 12000	más de 12000 hasta 16000	más de 16000 hasta 20000	más de 20000
	±1	±1	±2	±3	±4	±5	±6	±7	±8	±9

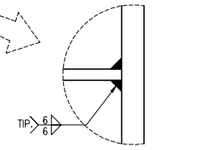
REV.	DESCRIPCION	POR	APROB.	FECHA
1	SE AGREGA LA DENOMINACIÓN "TIPO B", "V4", "V4" Y "V5"	O.D.G.	E.C.C.	02.04.24

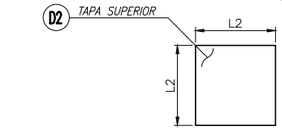
INGENIERIA
VALIDO PARA FABRICACION
V°B°: Fecha: 02/04/24

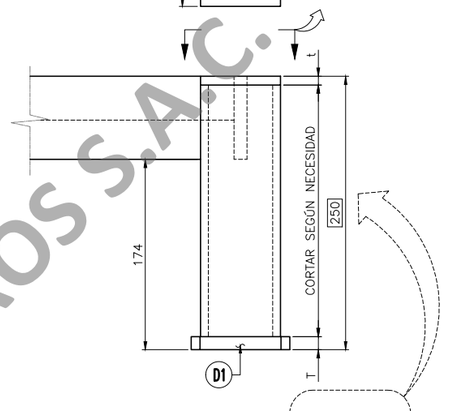
O.T.P: 21
O.T.P.: 22

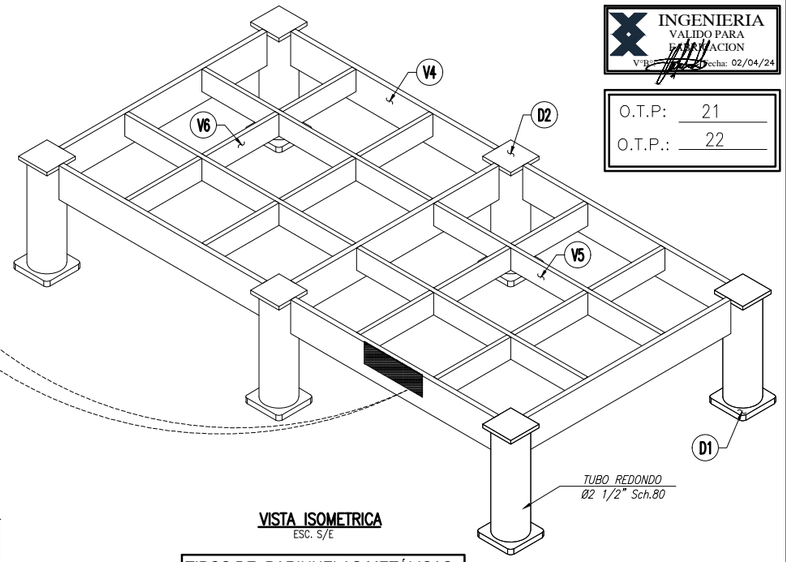


VISTA DE PLANTA
ESC. 1:5

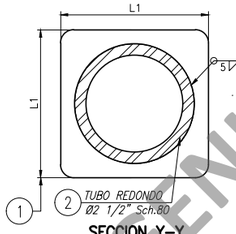




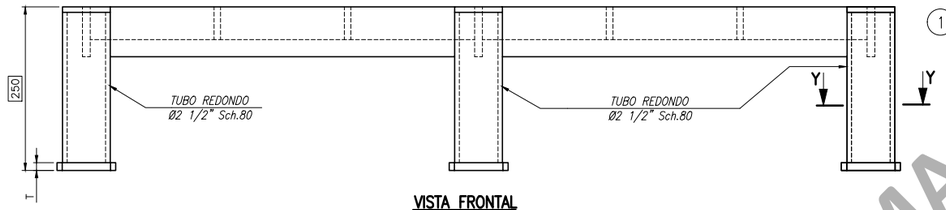




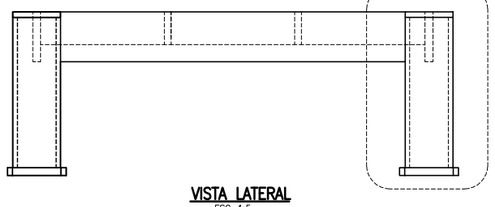
VISTA ISOMETRICA
ESC. S/E



SECCION Y-Y
ESC. 1:2



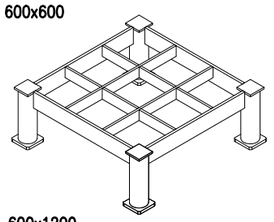
VISTA FRONTAL
ESC. 1:5



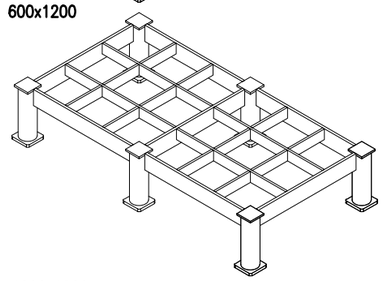
VISTA LATERAL
ESC. 1:5

TIPOS DE PARIHUELAS METÁLICAS :

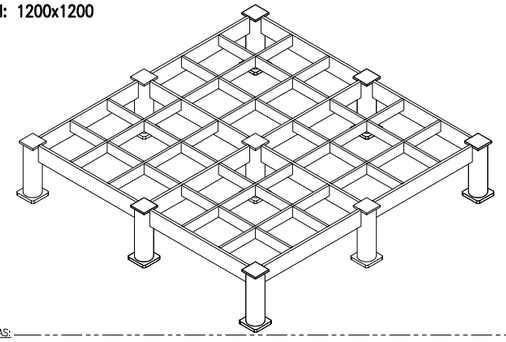
TIPO I: 600x600



TIPO II: 600x1200

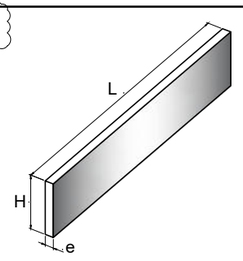


TIPO III: 1200x1200



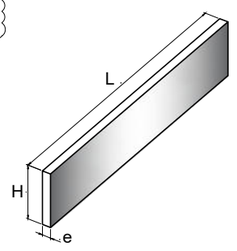
NOTAS:
1. TODAS LAS DIMENSIONES INDICADAS ESTÁN DADAS EN MILÍMETROS (mm), SALVO INDICACIÓN CONTRARIA.
2. ELIMINAR FILOS & REBABAS 0.25 x 45°.
3. LONGITUD VARIABLE, SE DEFINE EN CAMPO.

PLATE "V4"



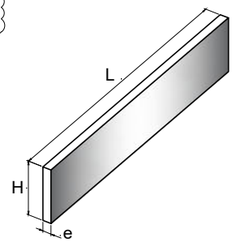
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	12	76	527	438976	10944	3.77
2	16	76	527	585301	25941	4.63
3	19	76	527	695045	43440	5.34
4	25	76	527	914533	98958	6.20

PLATE "V5"



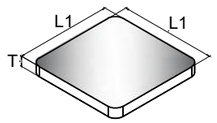
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	50	588	83333	2133	1.47
2	10	50	588	104167	4167	1.84
3	12	50	588	125000	7200	2.21

PLATE "V6"



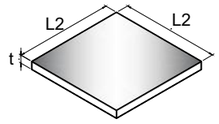
N°	e	H	3 L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	50	189	83333	2133	0.47
2	10	50	189	104167	4167	0.59
3	12	50	189	125000	7200	0.71

PLATE "D1"



N°	T	L1	L1	Peso (Kg)
1	12	90	90	0.75
2	16	90	90	1.00
3	19	90	90	1.20
4	25	90	90	1.58
5	32	90	90	2.00

PLATE "D2"



N°	t	L2	L2	Peso (Kg)
1	8	73	73	0.33
2	10	73	73	0.42
3	12	73	73	0.50

PARIHUELAS METÁLICAS		
TIPO	DESCRIPCIÓN	CARGA
E2	PARIHUELA PARA PIEZAS PESADAS	≤1200Kg/m2

TAMA® INGENIEROS S.A.C.

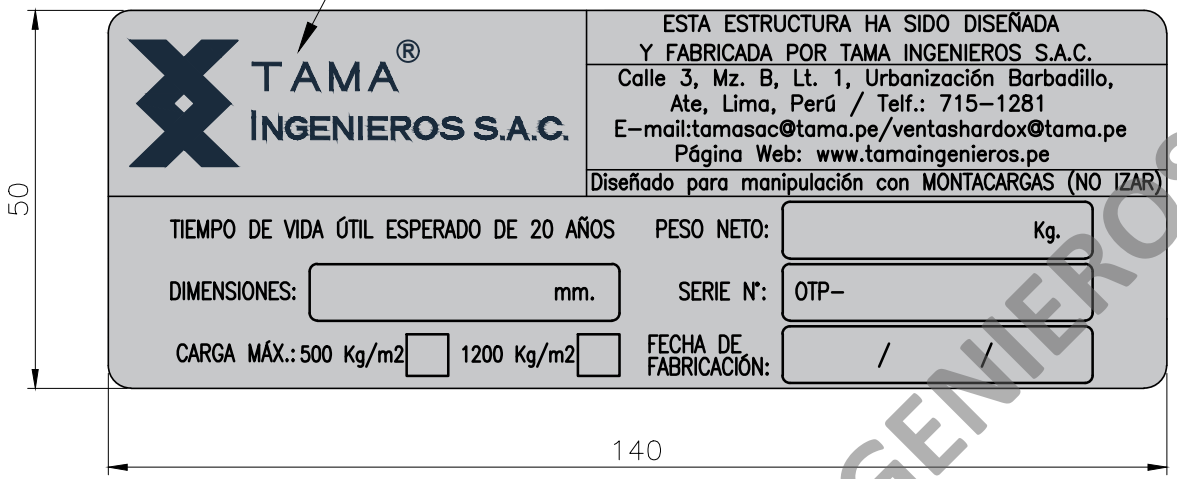
TAMA INGENIEROS S.A.C.
PARIHUELA METÁLICA PESADA (TIPO B)
ARREGLO GENERAL

Dibujado: O.D.G.	Aprobado: E.C.C.	Escala: IND.	Proyeccion	Peso: ---	O.T. ****-**	No. PLANO T032527	Rev. 1
Revisado: E.S.M.	Fecha: 02.04.24	Formato: A1					

PRECISION CLASE "A"	TOLERANCIAS ADMISIBLES PARA MEDIDAS DE LONGITUD EN CALDERERIA (ISO 13920)									Medidas nominales (valores en mm.)
	màs de 30 hasta 120	màs de 120 hasta 400	màs de 400 hasta 1000	màs de 1000 hasta 2000	màs de 2000 hasta 4000	màs de 4000 hasta 8000	màs de 8000 hasta 12000	màs de 12000 hasta 16000	màs de 16000 hasta 20000	màs de 20000
	±1	±1	±2	±3	±4	±5	±6	±7	±8	±9

REV.	DESCRIPCION	POR	APROB.	FECHA
0	EMITIDO PARA FABRICACIÓN	O.D.G.	E.C.C.	26.02.24

VER NOTA DEL LOGO



INGENIERIA
VALIDO PARA
FABRICACION
V°B°: Fecha: 27/02/24

ENSAYOS NO DESTRUCTIVOS	
INSPECCION VISUAL (VT)	100%

ITEM (1)
ESC. 1:1

NOTAS:
1. TODAS LAS DIMENSIONES EN mm, SALVO INDICACION CONTRARIA.
2. PARA UBICACION VER PLANO: T032526-T032527

- TEXTO (BAJO RELIEVE FONDO NEGRO)
- ALTURA DE LETRA: 2mm

NOTAS PARA EL LOGO

1.- TODAS LAS DIMENSIONES EN mm. SALVO INDICACION CONTRARIA
2.-COLOR DEL LOGO: AZUL ACERO, RAL 5011
3.-TIPO DE LETRA PARA "TAMA": DOTUM
4.-TIPO DE LETRA PARA"INGENIEROS S.A.C.": ARIAL UNICODE MS

Código / #Parte	Mat. / Plano	Item	Descripción	Cant.	Peso (kg)	Area (m2)
110330100332	AISI304	1	PLACA DE IDENTIFICACIÓN PL.2mm x 50 x 140	1	0.11	0.01
			PARIHUELAS METÁLICAS	**1**	**0.1**	**0.01**

TAMA® INGENIEROS S.A.C.

TAMA INGENIEROS S.A.C.

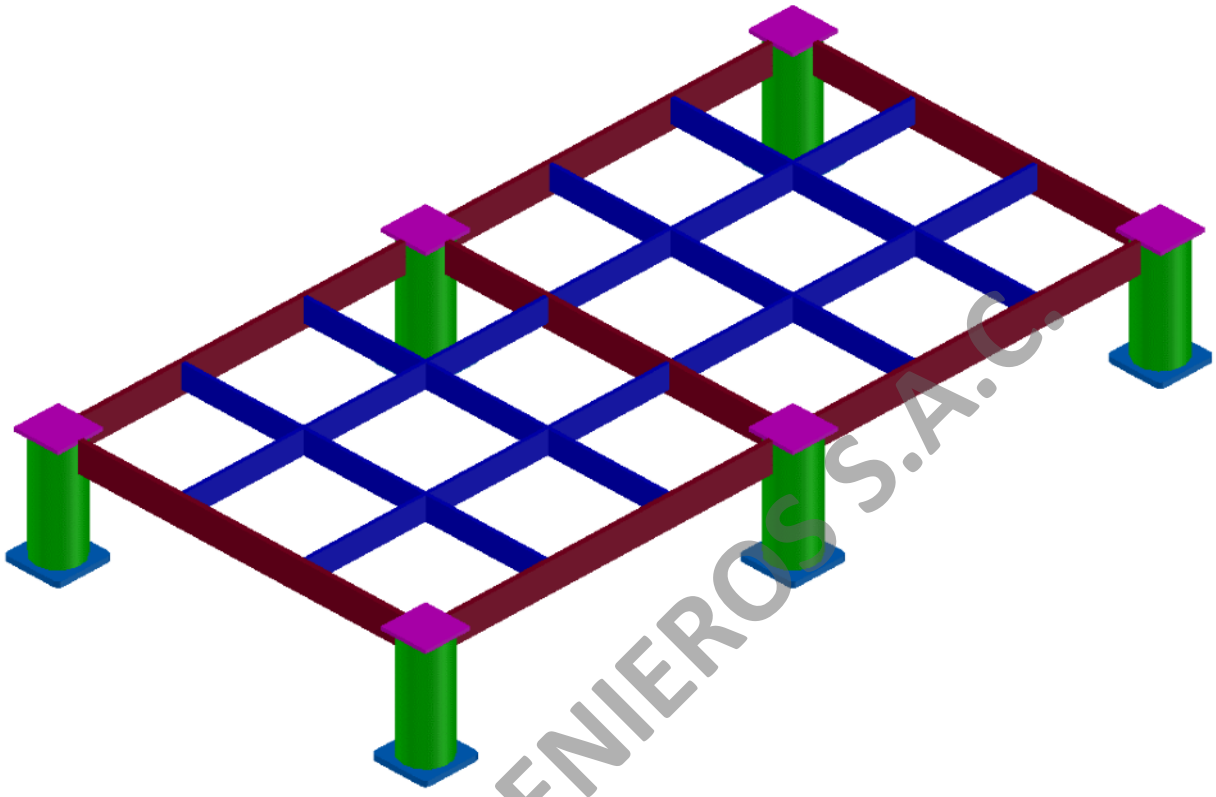
PARIHUELAS METÁLICAS

PLACA DE IDENTIFICACIÓN

Dibujado: O.D.G.	Aprobado: E.C.C.	Escala: IND.	Proyeccion	Peso:	O.T.P.:	No. PLANO	Rev.
Revisado: E.S.M.	Fecha: 26.02.24	Formato: A2		0.1 Kg.	XXX-24	T032528	0

Appendix N°5

Steel Pallet Calculation Report (Rev. C)



PARIHUELAS METÁLICAS

ELEMENTOS FINITOS

CLIENTE: TAMA INGENIEROS S.A.C.

OC: INTERNA

Aprobado por : J.M.	Fecha: 25/04/2024	Firma:
Revisado por : J.M.	Fecha: 23/04/2024	Firma:
Preparado por : O.C.	Fecha: 22/04/2024	Firma:

Nº	Revisiones	Por	Fecha
D	Emitido para aprobación - se actualiza peraltes de vigas "V"	J.M.	25/04/2024
C	Emitido para aprobación	J.M.	20/03/2024
B	Emitido para aprobación	J.M.	20/03/2024
A	Emitido para revisión interna	J.M.	20/03/2024

CALCULO No.	REVISION No.	FECHA.
MC-T-CT-003-24	D	25/04/2024

ÍNDICE

1.- DESCRIPCION GENERAL

1.1 OBJETIVO.

- Diseñar y calcular las parihuelas metálicas para la validacion de los elementos estructurales y optimizacion de material (el comportamiento estructural de la parihuela metálica) , brindando seguridad para sus condiciones operativas. Calculado mediante elementos finitos FEA.
- El programa Solidworks Simulation 2022 fue utilizado para su validacíon

1.2 CODIGOS Y ESTANDARES.

ASTM *American Society for Testing and Materials*

1.3 REFERENCIAS.

*) T-GI-F-21 Embalaje de metal actual

*) T-GI-F-21 Embalaje de metal

*) T-GI-F-21 Tipos de embalaje 10 casos

*) Zacchei_Design of new modular metal pallets_ Experimental validation and life cycle analysis

1.4 CONSIDERACIONES PARA EL DISEÑO.

Se tiene las siguientes consideraciones, tipos de Parihuelas:

DESIGNACIÓN	DESCRIPCIÓN	TIPO (Material)
E1	Para piezas livianas y semipesadas.	(Parihuela de acero)
E2	Para piezas pesadas	(Parihuela de acero)

1.5 MATERIALES.

- Planchas de acero en material ASTM A36 / ASTM A572 Gr.50 / ASTM A709 Gr.50

	Yield Point (min.)		Tensile Strength (min.)	
	ksi	Mpa	ksi	Mpa
ASTM A36	36	250	58-80	400-550
ASTM A572 Gr.50	50	345	65	450
ASTM A709 Gr.50	50	345	65	450

Fig. 01: Propiedades de los materiales

1.6 CRITERIO DE DISEÑO POR METODO DE ELEMENTOS FINITOS

- El análisis considera una modelación mediante el software de elementos finitos SolidWorks Simulation
- El criterio de aprobación del análisis estructural del Soporte del contratorque estará basado en la tensión de Von Mises.
- Existen cuatro terorías sobre la falla o ruptura. A) Von Mises B)Tresca C)Morh y D)Máximo normal.
- Los resultados experimentales indican que, de todas estas teorías sobre la ruptura, en los materiales dúctiles la que da resultados más adaptados a la realidad es la teoría de distorsión máxima de **Von Mises (criterio de diseño)**

Tensión de Von Mises

La tensión de Von Mises es una magnitud física proporcional a la energía de distorsión. En ingeniería estructural se usa en el contexto de las teorías de fallo como indicador de un buen diseño para materiales dúctiles.

La tensión de Von Mises puede calcularse fácilmente a partir de las tensiones principales del tensor, tensión en un punto de un sólido deformable, mediante la expresión:

$$\sigma_{VM} = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}}$$

Siendo σ1, σ2, σ3, la tensiones principales y habiéndose obtenido la expresión a partir de la energía de distorsión en función de las tensiones principales:

$$E_{def,dist} = \frac{1}{6G}\left[\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}\right]$$

La tensión de Von Mises y el criterio de fallo elástico asociado debe su nombre a Richard Edler von Mises (1913) propuso que un material dúctil sufría fallo elástico cuando la energía de distorsión elástica rebasaba cierto valor. Sin embargo, el criterio fue claramente formulado con anterioridad por Maxwell en 1865 más tarde también Huber (1904), en un artículo en polaco anticipó hasta cierto punto la teoría de fallo de Von Mises. Por todo esto a veces se llama a la teoría de fallo elástico basada en la tensión de Von Mises como teoría de Maxwell-Huber-Hencky-von Mises y también teoría de fallo.

En consecuencia se prevé que ocurrira la fluencia cuando:

$$\sigma_{VM} \geq \sigma_{Fluencia\ acero} \quad \ldots\ldots (Criterio\ de\ Diseño)$$

2.- Diseño por Metodo de Elementos Finitos

2.1 Calculo de aplicación de fuerzas en la parihuela metálica

Dimensiones : Medidas generales y ubicación de cargas

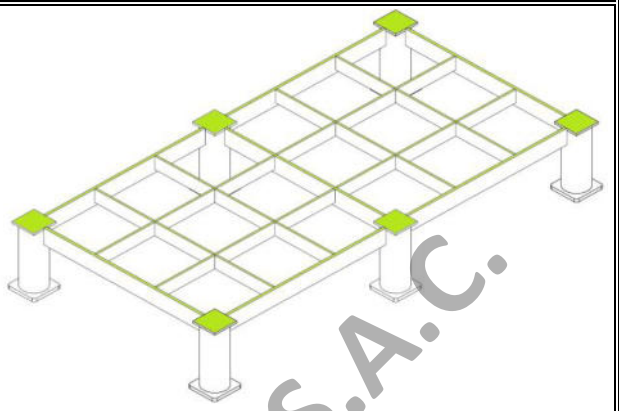
La fuerza "F" se aplica depende del tipo de parihuela:

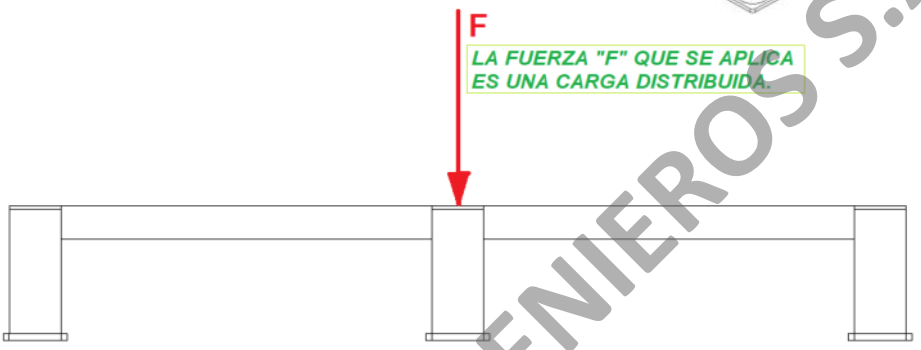
$$W=mg$$

Datos:

m = masa : …. *Kg*

g = gravedad : …. *m/s2*





Calculos :

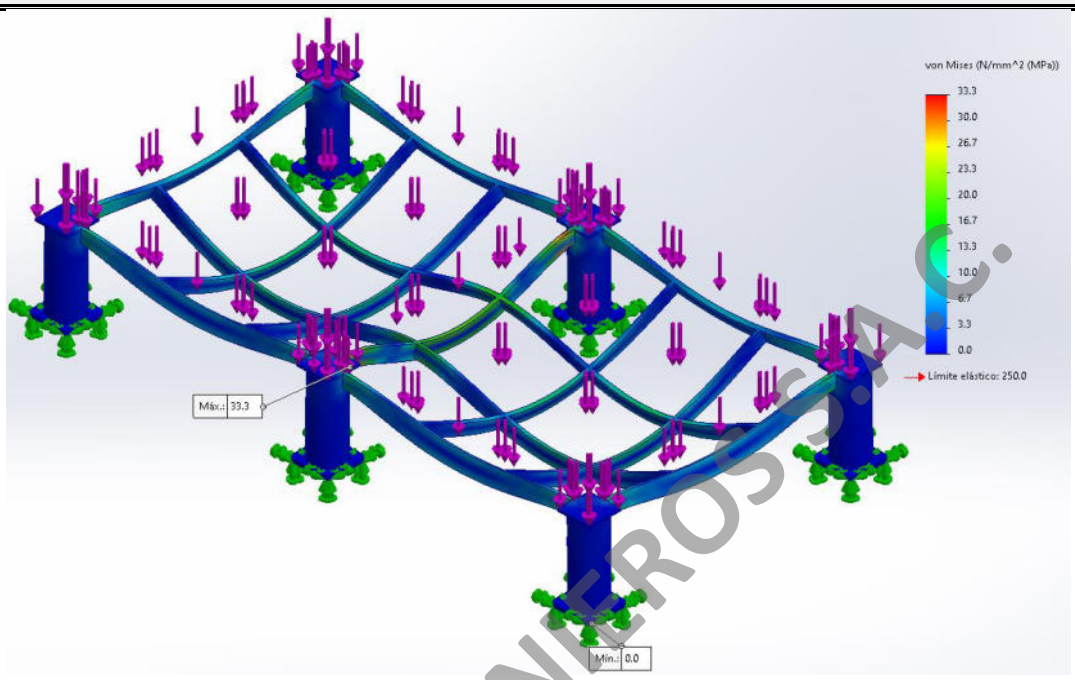
La fuerza "F" se aplica depende del tipo de parihuela, de acuerdo a la siguiente tabla:

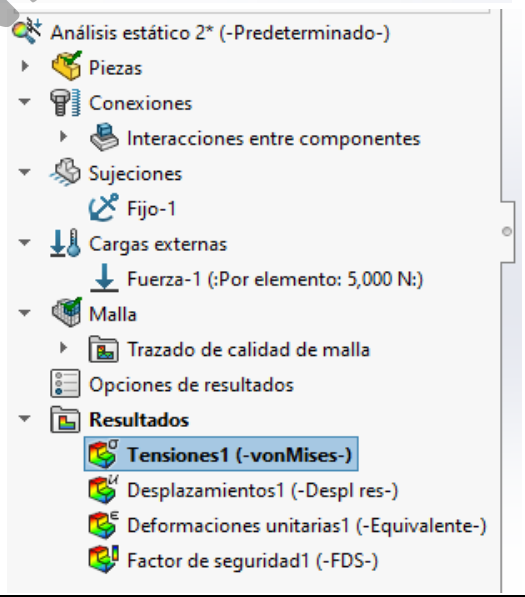
PARIHUELAS METÁLICAS		CARGA MÁX.
LIVIANAS - SEMIPESADAS ≤ 500 Kg/m2	E1	500 Kg/m2
PESADAS (500-1200 Kg/m2)	E2	1200 Kg/m2

3.- Diseño por Metodo de Elementos Finitos (Parihuela E1)

3.1 Simulación de la parihuela metálica : *Se considera la simulación en las condiciones mas críticas*

Resultados : Tensiones de Von Mises





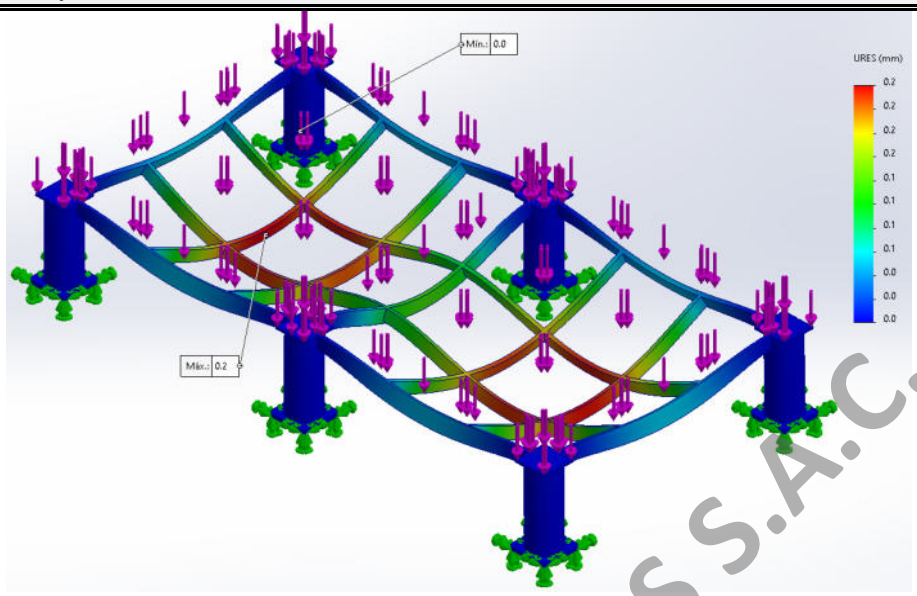
¡IMPORTANTE!

Se observa que se obtiene un Esfuerzo máx de 33.3 Mpa --->

Estando por debajo del Esfuerzo máx de Fluencia (Límite elástico) del material ASTM A36 (250 Mpa)

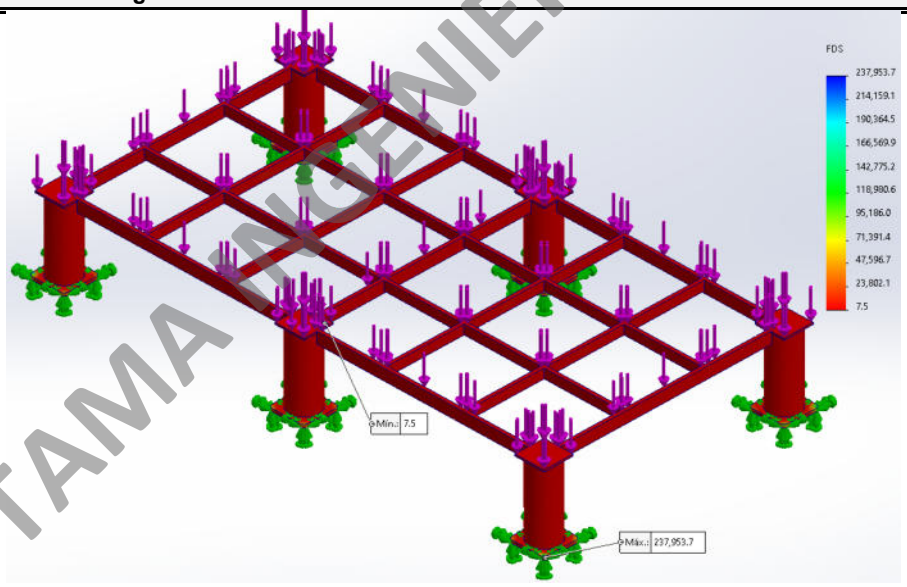
Tensión de Von Mises Max:	33.3	Mpa
Tensión de Von Mises Min:	0.000	Mpa

Resultados : Desplazamiento



Desplazamiento Max:	0.200	mm
Desplazamiento Min:	0.000	mm

Resultados : Factor de seguridad FDS



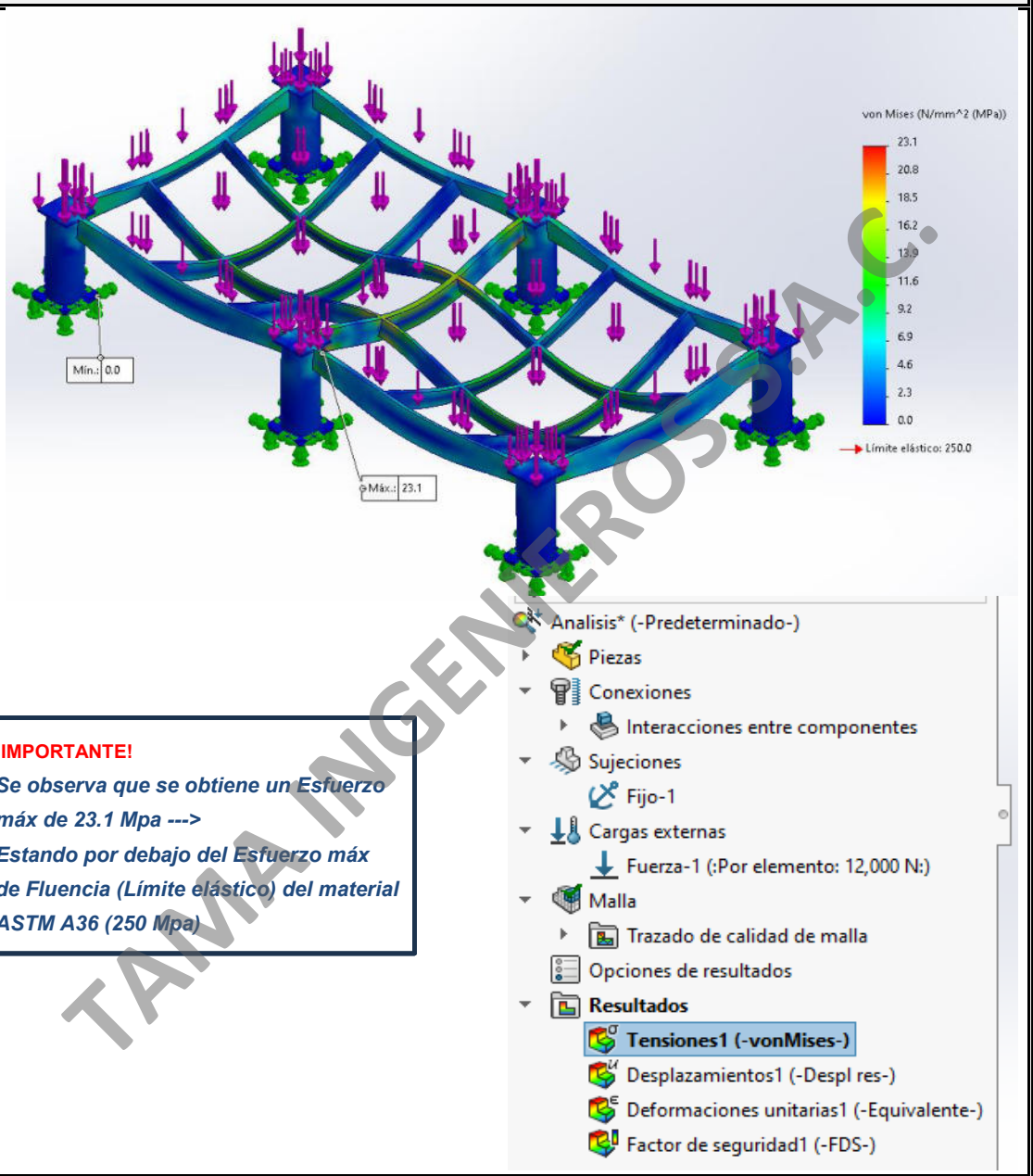
Se observa un factor de seguridad de 7.5

Factor Seguridad Min: 7.5

4.- Diseño por Metodo de Elementos Finitos (Parihuela E2)

4.1 Simulación de la parihuela metálica : *Se considera la simulación en las condiciones mas críticas .*

Resultados : Tensiones de Von Mises

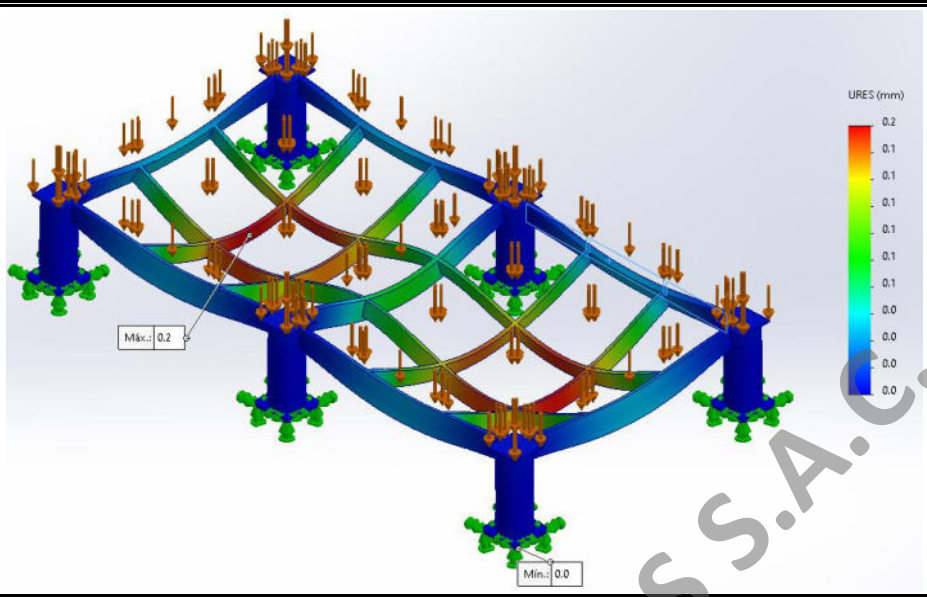


¡IMPORTANTE!

Se observa que se obtiene un Esfuerzo máx de 23.1 Mpa ---> Estando por debajo del Esfuerzo máx de Fluencia (Límite elástico) del material ASTM A36 (250 Mpa)

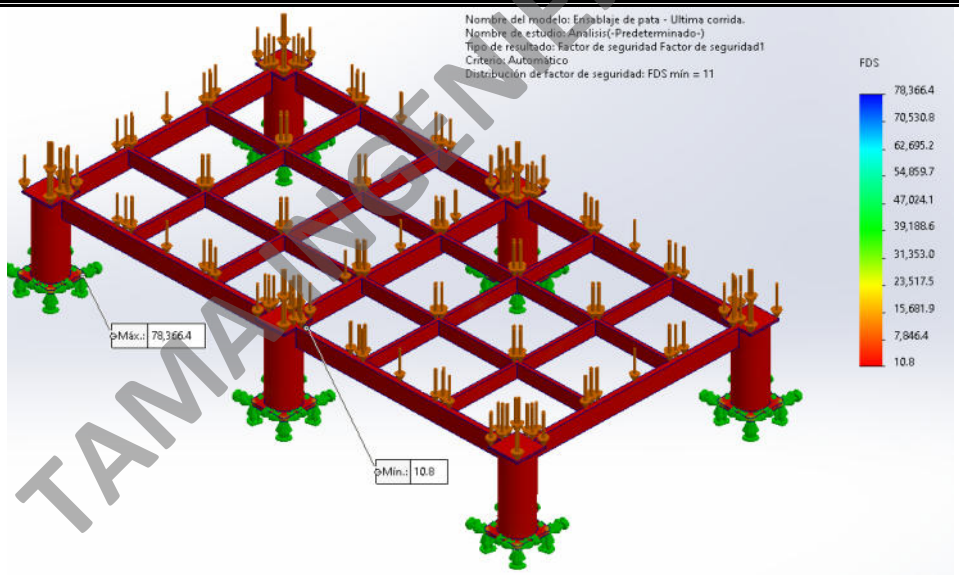
Tensión de Von Mises Max:	23.1	Mpa
Tensión de Von Mises Min:	0.00	Mpa

Resultados : Desplazamiento



Desplazamiento Max:	0.200	mm
Desplazamiento Min:	0.000	mm

Resultados : Factor de seguridad FDS



Se observa un factor de seguridad de 10.8

Factor Seguridad Min: 10.8

5- Conclusiones

De acuerdo a los resultados obtenidos en en acapite anterior Simulación de Parihuela Metálica se tiene:

-Parihuela "E1"

- La tensión máxima de Von Misses calculado es de **33.3 Mpa**, siendo este valor menor a 250 Mpa para el material analizado ASTM A36.
- El factor de seguridad mínimo calculado es de **7.5** por lo cual se asegura que el esfuerzo de Von mises(Esfuerzo calculado) no supera el esfuerzo de fluencia del material.

-Parihuela "E2"

- La tensión máxima de Von Misses calculado es de **23.1 Mpa**, siendo este valor menor a 250 Mpa para el material analizado ASTM A36.
- El factor de seguridad mínimo calculado es de **10.8** por lo cual se asegura que el esfuerzo de Von mises(Esfuerzo calculado) no supera el esfuerzo de fluencia del material.

El análisis realizado se ha desarrollado con material ASTM A-36 (esfuerzo de fluencia de 250 Mpa); considerando que también se usaran las planchas y perfiles en Gr.50 (esfuerzo de fluencia de 350 Mpa); para fabricar las parihuelas metálicas el factor de seguridad se incrementará entre 30-40%

6.- Recomendaciones

Se recomienda pintar la parihuela para evitar la corrosión.

7.- Anexos

* Parihuela Metálica Liviana - Semipesada (E1) - PLANO: T0323526 R.2
* Parihuela Metálica Liviana - Pesada (E2) - PLANO: T0323527 R.2
* Placa de Identificación - PLANO: T032528 R.0

PRECISION CLASE "A"	TOLERANCIAS ADMISIBLES PARA MEDIDAS DE LONGITUD EN CALDERERIA (ISO 13920)									Medidas nominales (valores en mm.)
	más de 30 hasta 120	más de 120 hasta 400	más de 400 hasta 1000	más de 1000 hasta 2000	más de 2000 hasta 4000	más de 4000 hasta 8000	más de 8000 hasta 12000	más de 12000 hasta 16000	más de 16000 hasta 20000	más de 20000
	±1	±1	±2	±3	±4	±5	±6	±7	±8	±9

REV.	DESCRIPCION	POR	APROB.	FECHA
2	SE ACTUALIZA LOS VALORES DE LAS VIGAS V1, V2 Y V3	O.D.G.	E.C.C.	25.04.24

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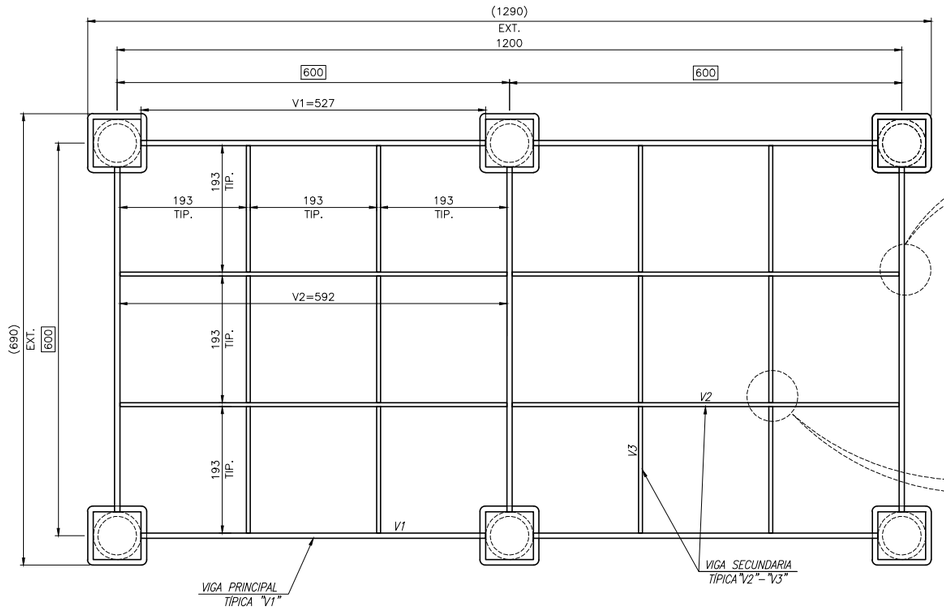
ESTA ESTRUCTURA HA SIDO DISEÑADA Y FABRICADA POR TAMA INGENIEROS S.A.C.
Calle 3, Mz. B, Lt. 1, Urbanización Barbadillo, Ate, Lima, Perú / Telf.: 715-1281
E-mail:tamasac@tama.pe/ventasheardox@tama.pe
Página Web: www.tamaingenieros.pe
Diseñado para manipulación con MONTACARGAS (NO IZAR)

TIEMPO DE VIDA ÚTIL ESPERADO DE 20 AÑOS | PESO NETO: Kg.
DIMENSIONES: mm. | SERIE Nº: OTP-
CARGA MÁX.:500 Kg/m2 ☐ 1200 Kg/m2 ☐ | FECHA DE FABRICACION: / /

INGENIERIA VALIDO PARA FABRICACION V°B° Fecha: 25/04/24

C.I.F.: P28
C.I.F.: P29



VISTA DE PLANTA
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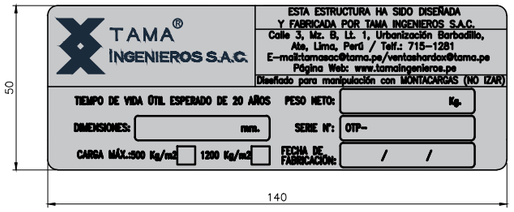
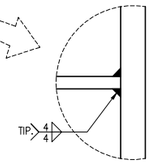
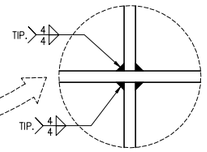
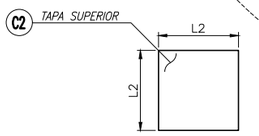
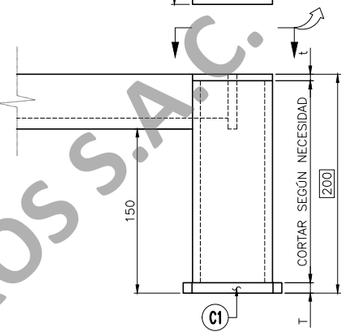
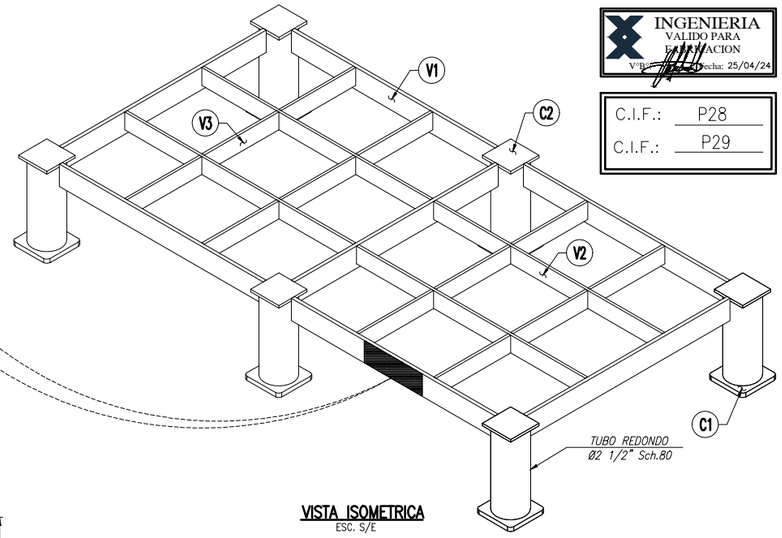




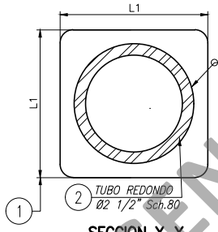




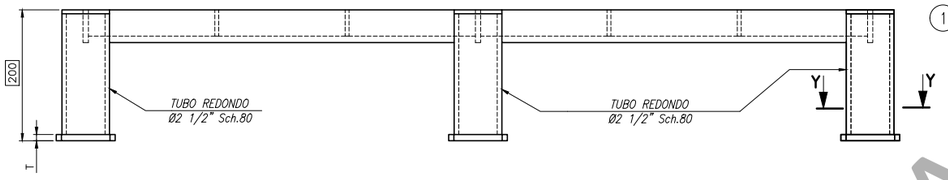




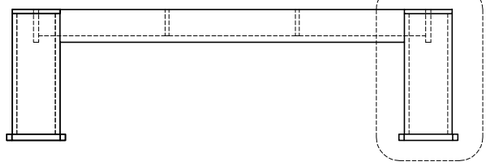
VISTA ISOMETRICA
ESC. S/E



SECCION Y-Y
ESC. 1:2



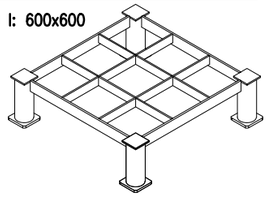
VISTA FRONTAL
ESC. 1:1



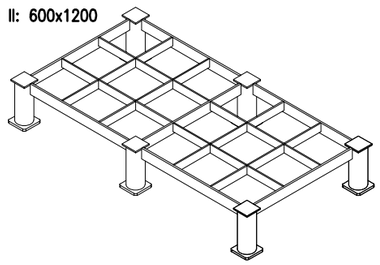
VISTA LATERAL
ESC. 1:1

TIPOS DE PARIHUELAS METÁLICAS :

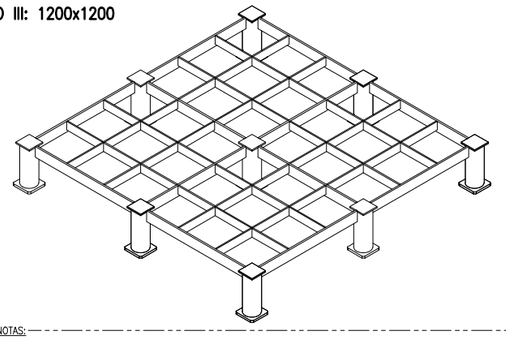
TIPO I: 600x600



TIPO II: 600x1200

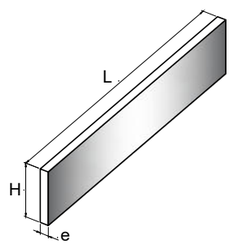


TIPO III: 1200x1200



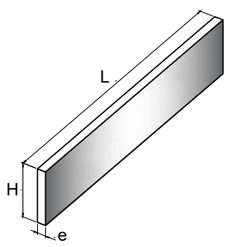
NOTAS:
1. TODAS LAS DIMENSIONES INDICADAS ESTÁN DADAS EN MILÍMETROS (mm), SALVO INDICACIÓN CONTRARIA.
2. ELIMINAR FILOS & REBABAS 0.25 x 45°.
3. LONGITUD VARIABLE, SE DEFINE EN CAMPO.

PLATE "V1"



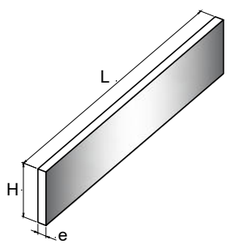
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	30	527	18000	1280	0.99
2	9.5	25	527	12369	1786	0.98
3	10	25	527	13020	2083	1.03

PLATE "V2"



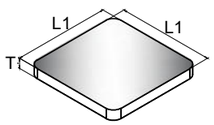
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	6	25	592	7812	450	0.69
2	8	20	592	5333	853	0.74
3	9.5	20	592	6333	1429	0.88

PLATE "V3"



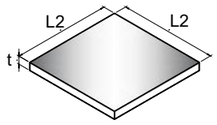
N°	e	H	3 L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	6	25	193	7812	450	0.22
2	8	20	193	5333	853	0.24
3	9.5	20	193	6333	1429	0.28

PLATE "C1"



N°	T	L1	L1	Peso (Kg)
1	6	90	90	0.38
2	8	90	90	0.50
3	9.5	90	90	0.60
4	10	90	90	0.63

PLATE "C2"



N°	t	L2	L2	Peso (Kg)
1	4.5	73	73	0.18
2	5	73	73	0.20
3	6	73	73	0.25

PARIHUELAS METÁLICAS		
TIPO	DESCRIPCIÓN	CARGA
E1	PARIHUELA PARA PIEZAS LIVIANAS Y SEMI PESADAS	≤500Kg/m2

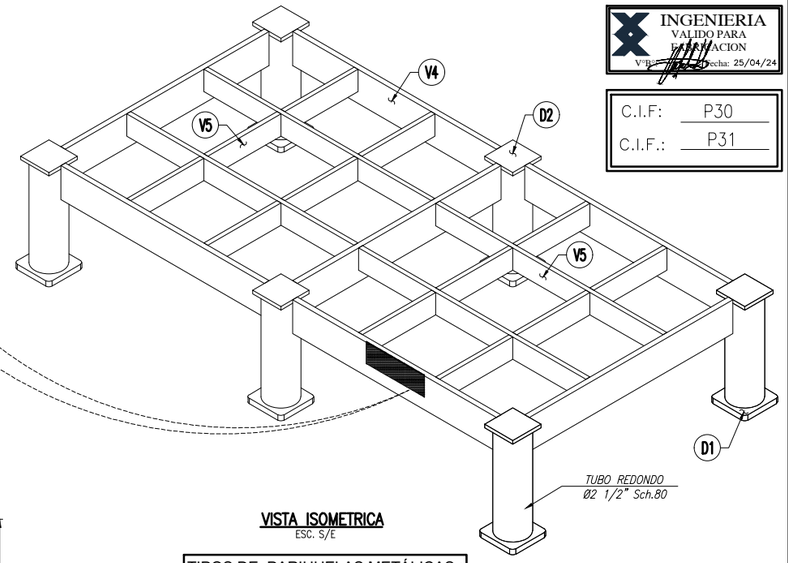
TAMA® INGENIEROS S.A.C.

TAMA INGENIEROS S.A.C.
PARIHUELA METÁLICA LIVIANA-SEMI PESADA(TIPO A)
ARREGLO GENERAL

Dibujado: O.D.G.	Aprobado: E.C.C.	Escala: IND.	Proyeccion	Peso:	O.T.	No. PLANO	Rev.
Revisado: E.S.M.	Fecha: 25.04.24	Formato: A1		---	****_**	T032526	2

PRECISION CLASE "A"	TOLERANCIAS ADMISIBLES PARA MEDIDAS DE LONGITUD EN CALDERERIA (ISO 13920)									Medidas nominales (valores en mm.)
	más de 30 hasta 120	más de 120 hasta 400	más de 400 hasta 1000	más de 1000 hasta 2000	más de 2000 hasta 4000	más de 4000 hasta 8000	más de 8000 hasta 12000	más de 12000 hasta 16000	más de 16000 hasta 20000	más de 20000
	±1	±1	±2	±3	±4	±5	±6	±7	±8	±9

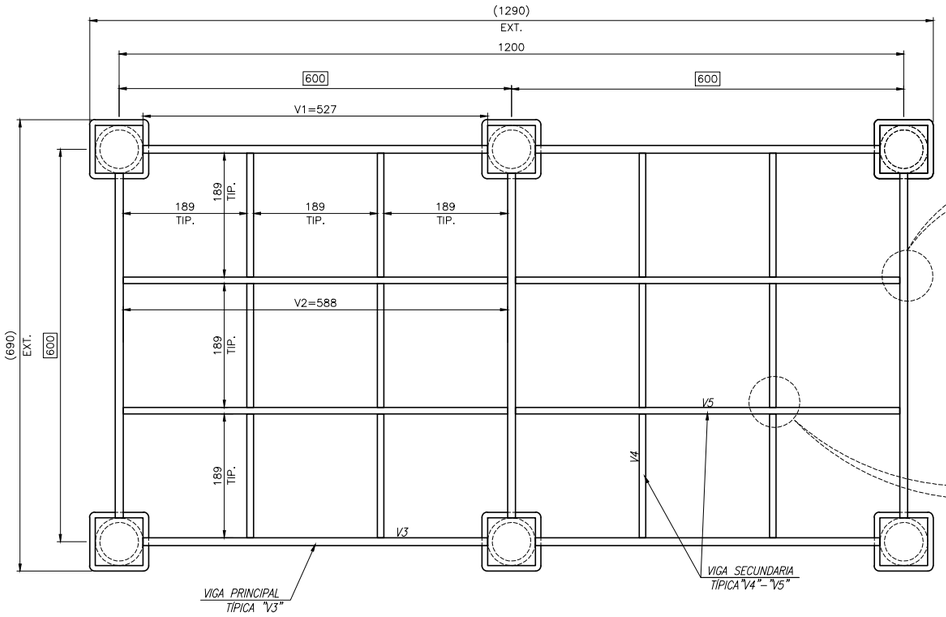
REV.	DESCRIPCION	POR	APROB.	FECHA
2	SE ACTUALIZA LOS VALORES DE LAS VIGAS V4, V5 Y V6	O.D.G.	E.C.C.	25.04.24



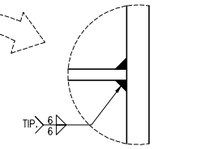
VISTA ISOMETRICA
ESC. S/E

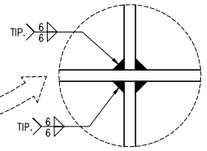
INGENIERIA
VALIDO PARA FABRICACION
V°B°: Fecha: 25/04/24

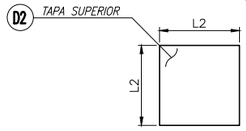
C.I.F: P30
C.I.F.: P31

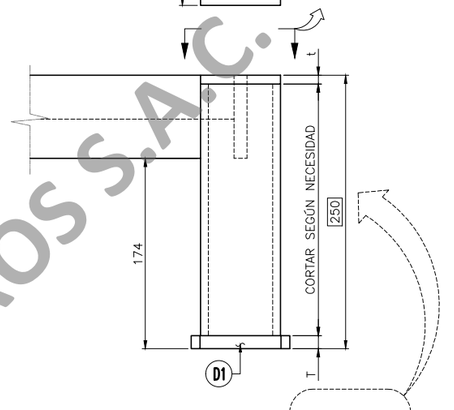


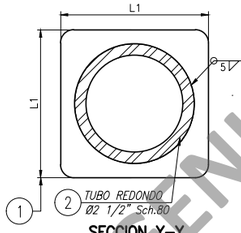
VISTA DE PLANTA
ESC. 1:5



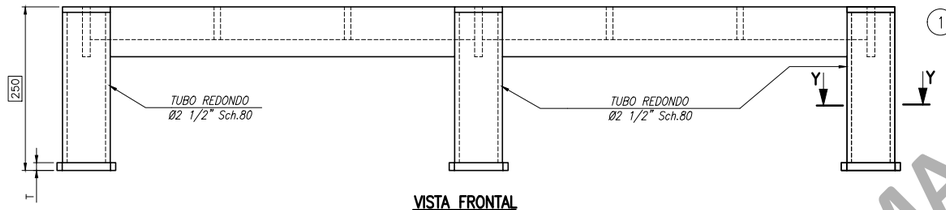




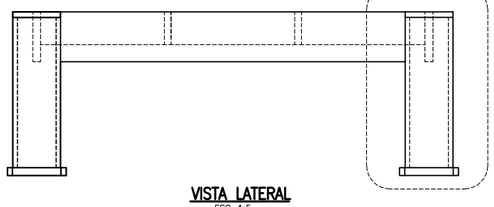




SECCION Y-Y
ESC. 1:2



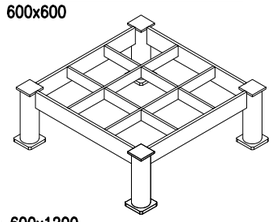
VISTA FRONTAL
ESC. 1:5



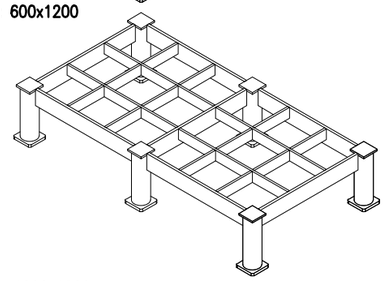
VISTA LATERAL
ESC. 1:5

TIPOS DE PARIHUELAS METÁLICAS :

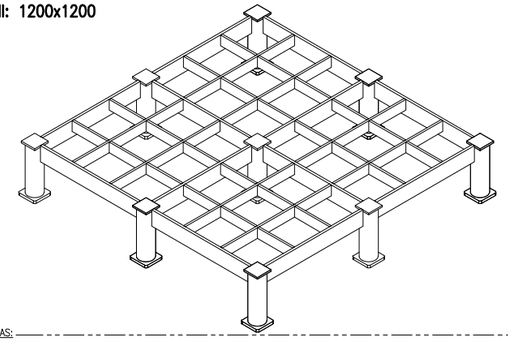
TIPO I: 600x600



TIPO II: 600x1200

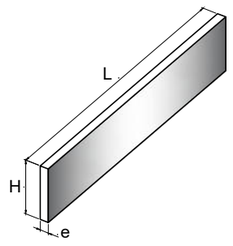


TIPO III: 1200x1200



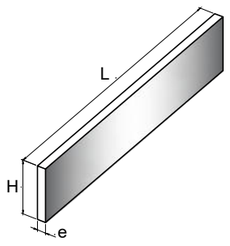
NOTAS:
1. TODAS LAS DIMENSIONES INDICADAS ESTÁN DADAS EN MILÍMETROS (mm), SALVO INDICACIÓN CONTRARIA.
2. ELIMINAR FILOS & REBABAS 0.25 x 45°.
3. LONGITUD VARIABLE, SE DEFINE EN CAMPO.

PLATE "V4"



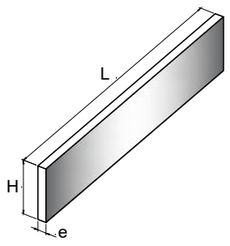
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	12	45	527	91125	6480	2.23
2	16	45	527	121500	15360	2.97
3	19	40	527	101333	22863	3.14
4	25	40	527	133333	52083	4.13

PLATE "V5"



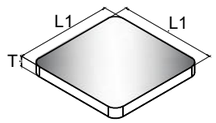
N°	e	H	L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	35	588	28583	1493	1.29
2	10	30	588	22500	2500	1.38
3	12	30	588	27000	4320	1.66

PLATE "V6"



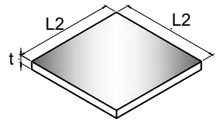
N°	e	H	3 L	Ix-x (mm4)	Iy-y (mm4)	Peso (Kg)
1	8	35	189	28583	1493	0.41
2	10	30	189	22500	2500	0.44
3	12	30	189	27000	4320	0.53

PLATE "D1"



N°	T	L1	L1	Peso (Kg)
1	12	90	90	0.75
2	16	90	90	1.00
3	19	90	90	1.20
4	25	90	90	1.58
5	32	90	90	2.00

PLATE "D2"



N°	t	L2	L2	Peso (Kg)
1	8	73	73	0.33
2	10	73	73	0.42
3	12	73	73	0.50

PARIHUELAS METÁLICAS		
TIPO	DESCRIPCIÓN	CARGA
E2	PARIHUELA PARA PIEZAS PESADAS	≤1200Kg/m2

TAMA® INGENIEROS S.A.C.

TAMA INGENIEROS S,A,C,
PARIHUELA METÁLICA PESADA (E2)
ARREGLO GENERAL

Dibujado: O.D.G.	Aprobado: E.C.C.	Escala: IND.	Proyeccion	Peso:	O.T.	No. PLANO	Rev.
Revisado: E.S.M.	Fecha: 25.04.24	Formato: A1		---	****_**	T032527	2

Appendix N°8

Hazardous waste management certificate 2023

DIACHPERU
OPERADOR AMBIENTAL

CERTIFICADO DE MANEJO DE RESIDUOS PELIGROSOS

Mediante el presente documento, el suscrito, Julio Cesar Quito Aróstegui Gerente General de la empresa **DIACHPERU S.A.C** debidamente registrado ante el Ministerio del Ambiente **(MINAM)** Registro Autoritativo de Empresa Operadora de Residuos Sólidos **EO-RS 0020-18-150716.**

Certifica que la empresa:

TAMA INGENIEROS S.A.C.

Ubicada en el domicilio fiscal **Calle 03 Mz B Lt 1 Urb. Barbadillo Ate - Lima – Lima,** con **RUC 20508969512** ha contratado los servicios de nuestra representada como EMPRESA OPERADORA DE RESIDUOS, referente a la recolección y transporte de los siguientes residuos industriales peligrosos.

SEDE: ATE

LUGAR DE RECOLECCIÓN: CALLE 03 MZ B LOTE 1

ITEM	NOMBRE DEL RESIDUO	UNIDAD	CANTIDAD	FECHA DE RECOLECCION
01	Trapos con pintura	KG	12.00	15 de diciembre 2023

Los residuos citados fueron retirados de sus instalaciones para su disposición final en el relleno de seguridad "Huaycoloro" de PETRAMÁS SAC, dentro de lo establecido en el Decreto Legislativo N.º 1278 Ley de Gestión Integral de Residuos Sólidos y el Decreto Supremo N.º 014 - 2017 MINAM, mediante registro EO-RS-0026-20-150716, ubicado en la Quebrada Huaycoloro Km.7, Distrito San Antonio, Provincia de Huarochirí y Departamento de Lima.

DIACHPERU S.A.C.
Julio C. Quito Arostegui
GERENTE GENERAL

Calle Beta Mz V Lt 7Asoc. Prop. del Parq. Industrial El Asesor Ate –Lima
Telf.: [01] 480-2735 Cel.923196167
RUC 20517783910
Correo: diachperu@hotmail.com / compras@diachperu.com / contactenos@diachperu.com
Página Web: www.diachperu.com

DIACHPERU
OPERADOR AMBIENTAL

CERTIFICADO DE MANEJO DE RESIDUOS PELIGROSOS

Mediante el presente documento, el suscrito, Julio Cesar Quito Aróstegui Gerente General de la empresa **DIACHPERU S.A.C** debidamente registrado ante el Ministerio del Ambiente (**MINAM**) Registro Autoritativo de Empresa Operadora de Residuos Sólidos **EO-RS 0020-18-150716.**

Certifica que la empresa:

TAMA INGENIEROS S.A.C.

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SEDE: ATE

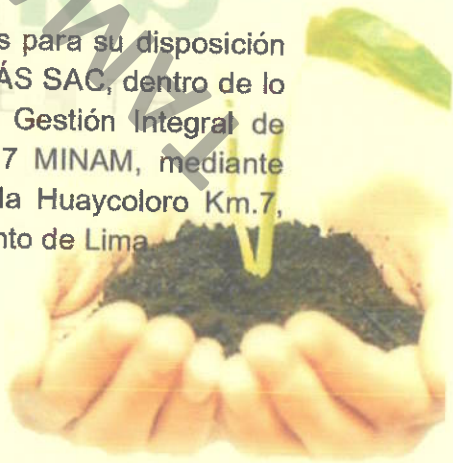
LUGAR DE RECOLECCIÓN: CALLE 03 MZ B LOTE 1

ITEM	NOMBRE DEL RESIDUO	UNIDAD	CANTIDAD	FECHA DE RECOLECCION
01	Baldes, spray , cartón y plástico contaminados	KG	20.00	15 de diciembre 2023

Los residuos citados fueron retirados de sus instalaciones para su disposición final en el relleno de seguridad "Huaycoloro" de PETRAMÁS SAC, dentro de lo establecido en el Decreto Legislativo N.° 1278 Ley de Gestión Integral de Residuos Sólidos y el Decreto Supremo N.° 014 - 2017 MINAM, mediante registro EO-RS-0026-20-150716, ubicado en la Quebrada Huaycoloro Km.7, Distrito San Antonio, Provincia de Huarochirí y Departamento de Lima.

DIACHPERU S.A.C.

Julio C. Quito Arostegui
GERENTE GENERAL



Calle Beta Mz V Lt 7Asoc. Prop. del Parq. Industrial El Asesor Ate –Lima
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Página Web: www.diachperu.com

DIACHPERU
ÓPERADOR AMBIENTAL

CERTIFICADO DE MANEJO DE RESIDUOS PELIGROSOS

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Certifica que la empresa:

TAMA INGENIEROS S.A.C.

Ubicada en el domicilio fiscal **Calle 03 Mz B Lt 1 Urb. Barbadillo Ate - Lima – Lima** con **RUC 20508969512,** ha contratado los servicios de nuestra representada como EMPRESA OPERADORA DE RESIDUOS, referente a la recolección y transporte de los siguientes residuos industriales peligrosos.

SEDE: ATE

LUGAR DE RECOLECCIÓN: CALLE 03 MZ B LOTE 1

ITEM	NOMBRE DEL RESIDUO	UNIDAD	CANTIDAD	FECHA DE RECOLECCION
01	Líquidos refrigerantes	KG	70.00	15 de diciembre 2023

Los residuos citados fueron retirados de sus instalaciones para su disposición final en el relleno de seguridad "Huaycoloro" de PETRAMÁS SAC, dentro de lo establecido en el Decreto Legislativo N.° 1278 Ley de Gestión Integral de Residuos Sólidos y el Decreto Supremo N.° 014 - 2017 MINAM, mediante registro EO-RS-0026-20-150716, ubicado en la Quebrada Huaycoloro Km.7, Distrito San Antonio, Provincia de Huarochirí y Departamento de Lima.

DIACHPERU S.A.C.

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DIACHPERU
OPERADOR AMBIENTAL

CERTIFICADO DE MANEJO DE RESIDUOS PELIGROSOS

Mediante el presente documento, el suscrito, Julio Cesar Quito Aróstegui Gerente General de la empresa **DIACHPERU S.A.C** debidamente registrado ante el Ministerio del Ambiente (**MINAM**) Registro Autoritativo de Empresa Operadora de Residuos Sólidos **EO-RS 0020-18-150716.**

Certifica que la empresa:

TAMA INGENIEROS S.A.C.

Ubicada en el domicilio fiscal **Calle 03 Mz B Lt 1 Urb. Barbadillo Ate - Lima – Lima** con **RUC 20508969512,** ha contratado los servicios de nuestra representada como EMPRESA OPERADORA DE RESIDUOS, referente a la recolección y transporte de los siguientes residuos industriales peligrosos.

SEDE: ATE

LUGAR DE RECOLECCIÓN: CALLE 03 MZ B LOTE 1

ITEM	NOMBRE DEL RESIDUO	UNIDAD	CANTIDAD	FECHA DE RECOLECCION
01	Líquidos solventes y restos pinturas	KG	1,099.00	15 de diciembre 2023

Los residuos citados fueron retirados de sus instalaciones para su disposición final en el relleno de seguridad "Huaycoloro" de PETRAMÁS SAC, dentro de lo establecido en el Decreto Legislativo N.° 1278 Ley de Gestión Integral de Residuos Sólidos y el Decreto Supremo N.° 014 - 2017 MINAM, mediante registro EO-RS-0026-20-150716, ubicado en la Quebrada Huaycoloro Km.7, Distrito San Antonio, Provincia de Huarochirí y Departamento de Lima.

DIACHPERU S.A.C.

Julio C. Quito Arostegui
GERENTE GENERAL

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Página Web: www.diachperu.com

DIACHPERU
OPERADOR AMBIENTAL

CERTIFICADO DE MANEJO DE RESIDUOS PELIGROSOS

Mediante el presente documento, el suscrito, Julio Cesar Quito Aróstegui Gerente General de la empresa **DIACHPERU S.A.C** debidamente registrado ante el Ministerio del Ambiente (**MINAM**) Registro Autoritativo de Empresa Operadora de Residuos Sólidos **EO-RS 0020-18-150716.**

Certifica que la empresa:

TAMA INGENIEROS S.A.C.

Ubicada en el domicilio fiscal **Calle 03 Mz B Lt 1 Urb. Barbadillo Ate - Lima – Lima,** con **RUC 20508969512** ha contratado los servicios de nuestra representada como EMPRESA OPERADORA DE RESIDUOS, referente a la recolección y transporte de los siguientes residuos industriales peligrosos.

SEDE: ATE

LUGAR DE RECOLECCIÓN: CALLE 03 MZ B LOTE 1

ITEM	NOMBRE DEL RESIDUO	UNIDAD	CANTIDAD	FECHA DE RECOLECCION
01	Latas de pintura	KG	9.00	15 de diciembre 2023

Los residuos citados fueron retirados de sus instalaciones para su disposición final en el relleno de seguridad "Huaycoloro" de PETRAMÁS SAC, dentro de lo establecido en el Decreto Legislativo N.° 1278 Ley de Gestión Integral de Residuos Sólidos y el Decreto Supremo N.° 014 - 2017 MINAM, mediante registro EO-RS-0026-20-150716, ubicado en la Quebrada Huaycoloro Km.7, Distrito San Antonio, Provincia de Huarochirí y Departamento de Lima.

DIACHPERU S.A.C.

Julio C. Quito Arostegui
GERENTE GENERAL

Calle Beta Mz V Lt 7Asoc. Prop. del Parq. Industrial El Asesor Ate –Lima
Telf.: [01] 480-2735 Cel.923196167
RUC 20517783910
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Appendix N°9
Steel Pallet Costs

TAMA® INGENIEROS S.A.C.

M A T E R I A L E S									
Descripción Por equipo	Ancho (m)	Largo (m)	Cant. Unit.	Dimensión Total	Area m²	Peso Unit.	Peso Kg. Total	Costo Unit. $	Costo Total $
Placa base pl. 16x90x90	0.09	0.09	18	0.1 m²	0.3 m²	126 kg/m²	18.31	0.90	16.48
Tubo 2 1/2"Ø Sch 80 S/C A-53 Gr.B		0.23	18	4.1 m	1.4 m²	11 kg/m	47.24	1.25	59.05
Placa superior pl. 10x73x73	0.073	0.073	18	0.1 m²	0.2 m²	79 kg/m²	7.53	0.90	6.78
Viga V4 PL. 19x76x527	0.076	0.527	18	0.7 m²	1.4 m²	149 kg/m²	107.53	0.90	96.77
Viga V5 PL. 10x50x588	0.05	0.588	16	0.5 m²	0.9 m²	79 kg/m²	36.93	0.90	33.23
Viga V6 PL. 10x50x189	0.05	0.189	48	0.5 m²	0.9 m²	79 kg/m²	35.61	0.90	32.05
Desperdicio al . %			0%					283.52	$ -
Parihuela 1.2x2.4, área 2.88 m²			**1**		**5.15**		**253.14**		**244.36**
						kg/m²	**87.9**		**0.965**
Placa de identificación			1					4.76	$ 4.76
Componentes			**1**		**0.00**		**0**		**4.76**
Habilitado/Armado			1						
Consumibles CIF		2	253					0.090	$ 22.78
Soldadura Kg. 1.5%	0		3.80					7.80	$ 29.62
Aplicación de Pintura Ext. 4 MILS		1	5.1					3.80	$ 19.56
Consumibles de fabricación			**1**						**71.96**
Mano de obra hh			50.6					4.6	$ 232.89
Mano de obra			**1**						**232.89**
Otros :									
Otros			253					0.20	$ 50.63
Ingeniería & Inspección			**1**						**50.63**
Total parihuela metálica			**1**		**5.15**		**253.14**		**604.60**
									2.388

Se considera un costo $/hh menor al mercado, por que la mayoria de trabajadores es oficial y ayudante

TAMA® INGENIEROS S.A.C.

M A T E R I A L E S									
Descripción Por equipo	Ancho (m)	Largo (m)	Cant. Unit.	Dimensión Total	Area m²	Peso Unit.	Peso Kg. Total	Costo Unit. $	Costo Total $
Madera roble 1"x6"x8'	0.152	2.4	8	2.9 m²	5.8 m²	18 kg/m²	52.17	6.60	52.80
Madera roble 3"x4"x4'	0.076	1.2	4	0.4 m²	0.7 m²	72 kg/m²	26.34	6.00	24.00
Desperdicio al 12. %			12%					87.93	$ 10.55
Parihuela 1.2x2.4, área 2.88 m²			**1**		**6.57**	**kg/m²**	**78.51** **27.3**		**87.35** **1.113**
Placa de identificación			1						$ -
Componentes			**1**		**0.00**		**0**		**0.00**
Habilitado/Armado			1						
Consumibles CIF		**1**	79					0.045	$ 3.53
Soldadura Kg. .0%	0		0.00					7.80	$ -
Pintura m² @ MIL (DFT) Ext. (m2)			6.6					0.00	$ -
Granallado Ext. m² SSPC-SP 5/6/10		**1**	0.0			78.51		0.00	
Aplicación de Pintura Ext. 4 MILS		**1**	0.0			78.51		3.80	$ -
Consumibles de fabricación			**1**						**3.53**
Mano de obra hh			7.9					4.6	$ 36.11
Mano de obra			**1**						**36.11**
Otros :									
Otros			79					0.20	$ 15.70
Ingeniería & Inspección			**1**						**15.70**
Total parihuela madera			**1**		**6.57**		**78.51**		**142.70** **1.818**

Se considera un costo $/hh menor al mercado, por que la mayoria de trabajadores es oficial y ayudante

TAMA® INGENIEROS S.A.C.

M A T E R I A L E S									
Descripción Por equipo	Ancho (m)	Largo (m)	Cant. Unit.	Dimensión Total	Area m²	Peso Unit.	Peso Kg. Total	Costo Unit. $	Costo Total $
Placa base pl. 16x90x90	0.09	0.09	18	0.1 m²	0.3 m²	126 kg/m²	18.31	0.18	3.33
Tubo 2 1/2"Ø Sch 80 S/C A-53 Gr.B		0.23	18	4.1 m	1.4 m²	11 kg/m	47.24	0.18	8.60
Placa superior pl. 10x73x73	0.073	0.073	18	0.1 m²	0.2 m²	79 kg/m²	7.53	0.18	1.37
Viga V4 PL. 19x76x527	0.076	0.527	18	0.7 m²	1.4 m²	149 kg/m²	107.53	0.18	19.57
Viga V5 PL. 10x50x588	0.05	0.588	16	0.5 m²	0.9 m²	79 kg/m²	36.93	0.18	6.72
Viga V6 PL. 10x50x189	0.05	0.189	48	0.5 m²	0.9 m²	79 kg/m²	35.61	0.18	6.48
Desperdicio al . %			0%					283.52	$ -
Parihuela 1.2x2.4, área 2.88 m²			**1**		**5.15**		**253.14**		**46.07**
						kg/m²	**87.9**		**0.182**
Placa de identificación			1					4.76	$ 4.76
Componentes			**1**		**0.00**		**0**		**4.76**
Habilitado/Armado			1						
Consumibles CIF		2	253					0.090	$ 22.78
Soldadura Kg. 1.5%	0		3.80					7.80	$ 29.62
Aplicación de Pintura Ext. 4 MILS		1	5.1			#¡REF!		3.80	$ 19.56
Consumibles de fabricación			**1**						**71.96**
Mano de obra hh			50.6					4.6	$ 232.89
Mano de obra			**1**						**232.89**
Otros :									
Otros			253					0.20	$ 50.63
Ingeniería & Inspección			**1**						**50.63**
Total parihuela metálica			**1**		**5.15**		**253.14**		**406.31**
									1.605

Se considera un costo $/hh menor al mercado, por que la mayoria de trabajadores es oficial y ayudante

Señores:	**TAMA INGENIEROS S.A.C**		**13 de Marzo de 2024**
Dirección	Calle 03 Mz. A Lt 6B Urb. Barbadillo - Ate		**Tipo de Trabajo:**
Atención	Sr. [redacted]	**RUC:** 20508969512	Placas de Acero
Tel.:	**715-8626 / 715-8627 Anexo 180 / 946 219 948**		**Persona Contacto:**
Email :	[redacted]z@tama.pe		[redacted]

Estimado Cliente:
Por medio de la presente lo saludamos y le hacemos llegar nuestra siguiente cotización:

CANTIDAD	Und medida	DESCRIPCIÓN	PRECIO UNIT.	VALOR VENTA
100	Unid	Placa de Acero Inoxidable C-304 de: 1.5 x 50 x 140 mm, Fondo natural, texto negro logo TAMA INGENIEROS grabado en bajo relieve de color AZUL DATOS EN BLANCO - esquinas semiboleadas 	S/ 18.00	S/. 1800.00