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SPREP
Secretariat of the Pacific Regional Environment Programme

PacWastePlus
PACIFIC WASTE MANAGEMENT

This initiative is supported by **PacWastePlus**-a 72 month project funded by the European Union (**EU**) and implemented by the Secretariat of the Pacific Regional Environment Programme (**SPREP**) **to sustainably and cost effectively improve regional management of waste and pollution.**

Palau End-of-Life Tire Technical Booklet for Construction Projects

January 2025

This Waste data collation, analysis and reporting for the Cook Islands National Waste Audit Analysis Report was guided by the overarching Regional Waste Data Collection, Monitoring, and Reporting (DCMR) Framework for the Pacific Island Countries and Territories (PICT).

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Acknowledgment: SPREP through the PacWastePlus Programme engaged MRA Consulting Group (MRA) to undertake comprehensive research to determine the possible uses or processing options that exist for end-of-life tyres (existing technologies, uses, processes or management activities), assess each use or option for suitability in the Pacific, and highlight the associated benefit(s) and potential issues with its implementation.

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Our vision: A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures.

PacWaste Plus Programme

The Pacific – European Union (EU) Waste Management Programme, PacWaste Plus, is a 72-month programme funded by the EU and implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) to improve regional management of waste and pollution sustainably and cost-effectively.

About PacWaste Plus

The impact of waste and pollution is taking its toll on the health of communities, degrading natural ecosystems, threatening food security, impeding resilience to climate change, and adversely impacting social and economic development of countries in the region.

The PacWaste Plus programme is generating improved economic, social, health, and environmental benefits by enhancing existing activities and building capacity and sustainability into waste management practices for all participating countries.

Countries participating in the PacWaste Plus programme are: *Cook Islands, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu*.

Key Objectives

Outcomes & Key Result Areas

The overall objective of PacWastePlus is "*to generate improved economic, social, health and environmental benefits arising from stronger regional economic integration and the sustainable management of natural resources and the environment*".

The specific objective is "*to ensure the safe and sustainable management of waste with due regard for the conservation of biodiversity, health and wellbeing of Pacific Island communities and climate change mitigation and adaptation requirements*".

Key Result Areas

- **Improved** data collection, information sharing, and education awareness
- **Policy & Regulation** - Policies and regulatory frameworks developed and implemented.
- **Best Practices** - Enhanced private sector engagement and infrastructure development implemented
- **Human Capacity** - Enhanced human capacity

Learn more about the PacWaste Plus programme by visiting

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PacWastePlus PACIFIC WASTE MANAGEMENT

www.pacwasteplus.org

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Glossary

Terminology	Definition
Dock	Anything a marine vessel can moor to e.g. marina, wharf, pier, quay etc.
End-of-life tires (ELT)	A tire that is deemed no longer capable of performing the function for which it was originally made.
Marine Vessel	Any water going vessel
SPREP	Secretariat of the Pacific Regional Environment Programme, the Client for this report.
Tire	A vulcanised rubber product designed to be fitted to a wheel for use on, or already fitted to, motorised vehicles and non-motorised trailers towed behind motorised vehicles.

1. Introduction

This booklet is designed to provide practical, step-by-step guidance to construction companies on reusing End-of-Life Tires (ELTs) in two specific applications:

- Marine Vessels and Dock Bumpers and,
- House Foundations and Wall Supports.

The purpose of this booklet is to outline the requirements for utilising ELTs in these applications, ensuring compliance with relevant engineering standards and industry best practices. The guidance includes:

- Pre-Treatment Requirements: Basic steps needed to select and prepare ELTs for use.
- Processing Requirements: Detailed instructions for processing pre-treated ELTs for specific applications.
- Engineering Standards: Relevant standards to ensure safety, durability, and environmental compliance.
- Cost Considerations: Estimated capital and operational costs.
- Monitoring Requirements: Guidelines for ongoing inspection and maintenance.

ELTs are a versatile material with significant potential for use in construction projects. This booklet provides clear and concise guidance to help construction teams implement these solutions effectively. Designed with hands-on professionals in mind, the information is presented in a straightforward manner, using simple language and practical examples to ensure accessibility and ease of on-site application.

Figure 1: Used Tire Fender *(Used Aircraft Tires)*

2. Marine Vessels and Dock Bumpers

2.1 Method of Utilisation

ELTs can be tied to the sides of marine vessels or boat docks/jetties as an effective and affordable alternative to built-in fenders or external custom-made bumpers. Marine vessel bumpers act to prevent damage from collisions.

Tires can be fastened to the marine vessel or dock using ropes or chains (Figure 1, Figure 2 & Figure 3).

10–40 tires can be used per marine vessel depending on the vessel and tire sizes.

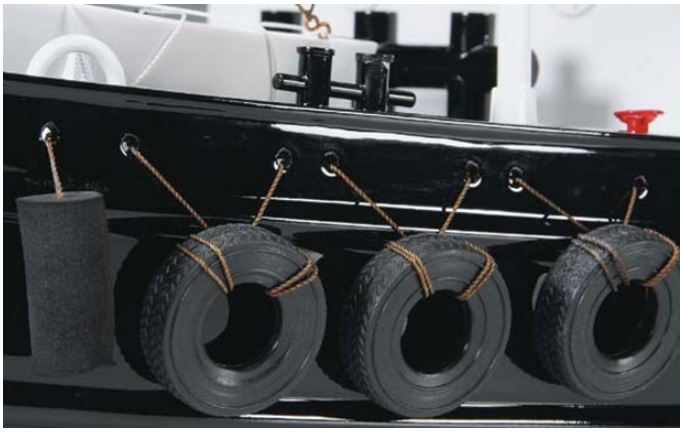


Figure 2: Tugboat tire fender rope tying example (Boatbuilding Blog 2008).

Figure 3: ELT chained to dock as bumper.

2.1.1 ELT selection

- For large ships:
    - Truck or aircraft ELTs are recommended for their appropriate relative size. Appropriate sizes could include for example: between 205 and 600mm tires inclusive (tire width measured from sidewall to sidewall).
- For small boats and launch boats:
    - Passenger Car or motorcycle ELTs are recommended for their appropriate relative size. Appropriate sizes could include for example: between 165 and 205mm tires inclusive (tire width measured from sidewall to sidewall).

Once an appropriate tire type is selected, collect the appropriate number of tires necessary for the size of the vessel. Ensure that all ELTs used on one vessel are the same size.

2.1.2 Rope and chain choice

Ensure all ropes and chains used on marine vessels are corrosion/rust resistant and marine grade. When Choosing fastening ELT as fenders, the following are recommended:

- Polypropylene, polyester, and/or nylon ropes due to their durability and flexibility.
- Stainless steel chains due to their corrosion resistant nature.

2.1.3 Fastening method

There are several effective and acceptable fastening methods that can be used to securely attach ELTs to marine vessels and docks, some recommended options are presented below.

Rope fastening options:

- Ringbolt hitch as shown in Figure 4, the ringbolt hitch is an effective knotting method which wraps the entire ELT with rope- increasing its durability and aesthetic properties.
- Double bayonet knot, cow hitch knot, clove hitch knot, bowline knot and double fisherman's knot are all acceptable rope knotting methods for the fastening of ELTs to vessels. Example shown in Figure 2.

Figure 4: Ringbolt hitching on ELT *(Clayton 2021)*

Chain fastening options:

- To fasten an ELT to a vessel or dock using a chain, holes (to the size of the chain) should be drilled in the bead of the tire. One, Two or Four holes can be drilled depending on the fastening method. For vessels, either cross chain connection shown in Figure 5 left or two hole hanging method shown in Figure 5 right is acceptable. For Docks, a single hole can be drilled for a simple chain fastening method such as shown in Figure 3.

ELTs can be attached to the vessel via low-lying reliable structures on the vessel such as railings or handrails as shown in Figure 1 and Figure 3 or installed brackets for the securement of the fenders such as in Figure 5 left.

Figure 5: Chain fastening for ELTs *(VRAKKING)*

2.2 Pre-Treatment Requirements

It is suggested that ELTs be treated according to the steps outlined in Figure 6 and below before they can enter the processing stage and be used.

ELTs used as marine vessel fenders should meet all pre-treatment requirements including:

- Be whole, intact tires.
- Contain no potential hazards embedded in or amongst the ELT such as exposed steel wires etc.
- Not have been exposed to fire or extreme temperatures; ensure there are no visible signs or smells of smoke, burned rubber or deformation from heat.

ELTs that do not meet the above requirements should be rejected and disposed at Tire Recycling Facility at the M Dock.

Figure 6: Pre-processing Steps for ELT whole tire use

2.3 Processing Requirements

The following processing requirements for ELTs used as marine and dock bumpers are recommended.

- It is recommended that drainage holes be drilled in whole ELTs to ensure drainage and mitigate water collecting to ensure no additional weight added to the tire fender from accumulated water. Drill 1-5 holes in the bottom of the tire using a 10 -20mm diameter drill. Ensure standard tool safety handling procedures are followed including the proper securement of the object, the use of PPE, exclusion zones and maintenance of tools.
- Tires are flammable. Tires should be stored in a stable condition in cool, dry, ventilated areas away from open flames and heat sources. It is recommended that firefighting equipment always be on hand when handling and processing tires.

2.4 Applicable Engineering Standards

There is no applicable engineering standard required for the use of whole ELTs for marine vessel fenders.

It is essential to adhere to recognised general and safe handling methods throughout the process.

To ensure safety and quality:

- Follow common industry practices e.g. wash hands after handling ELTs.
- Use appropriate tools and equipment e.g. as recommended by manufacturers.
- Ensure proper protective equipment (PPE) is used.

2.5 Capital Cost

ELT pre-treatment requires:

- **Tire washing facility** – (Hardstand area: approx. US$18-38 per m^2, Pressure washer: approx. US$150, Sump tank: approx. US$1200)

ELT processing requires:

- **Miscellaneous** – Power drill, drill bits: approx. US$50-300 per drill (cost varies brand and quality dependant)

2.6 Operational Cost

Labour – 3-5 persons- standard, unskilled workers: Palau minimum wage US$4.25 per hour

Administration – visual monitoring one person- skilled supervisor: Palau minimum wage US$4.25 per hour

Utilities – water & electricity: cost varies project dependant.

Consumables – fire safety equipment & PPE: approx. US$180 per worker, per year.

By-Products Disposal – nil: unused tires should be returned to the stockpile. Sump waste – oil, grease and grit should be disposed of to landfill: zero fees, excess water can be discharged.

2.7 Monitoring Requirements

The following monitoring requirements are recommended during the pre-treatment and processing stages of ELTs as marine vessel fenders.

- Pre-treatment: minimal monitoring is required during the pre-treatment stages; however, regular quality control checks are to be conducted by a suitably experienced professional to ensure project standards are met. If deemed unfit tires should be rejected and disposed at tire Recycling Facility at the M Dock.
- Processing: periodic checks by a professional are recommended during processing to verify quality and ensure efficacy of the final product.

3. House Foundations

3.1 Method of Utilisation

ELTs can be used as pier foundations for small buildings by being stacked and filled with sand, dirt, or gravel. As shown in the example in Figure 7 & Figure 8, two different sized tires are stacked on a metal plate with a single column mounted to the top. In this application, one load bearing post is mounted per pair of tires.

The following steps outline the construction process for the *Critical Concrete* tire pier foundation shown in Figure 7 & Figure 8. These foundations and the measurements presented were used for the reinforcement of house walls to assist the load bearing for a roof and can carry approx. 2,400kg equivalent of 5291.09 lbs. For more information and a video tutorial visit: https://criticalconcrete.com/tyre-foundations/

Note: *These steps are intended to guide construction workers to understanding how ELT house foundations can be built. Replications of these steps should be designed and confirmed by a qualified structural engineer.*

- **Analysis of the ground** to ensure soil has sufficient bearing capacity. If necessary, reinforce the soil for example by adding a layer of compressed gravel, dig deeper or use a wider tire.
- A **Metal plate** (thickness 20mm) is added to the base of the foundation. Four threaded rods should be first welded to the plate to attach a socket later. A breathable and waterproof membrane can be placed first (atop the soil and under the metal plate) for increased durability. The metal plate and weld joints are then painted with anti-corrosive paint.
- The **Columns** are constructed using two 120mm x 240mm construction plywood beams glued and screwed together.
- A **Steel Socket** is constructed to fix the column with the foundation using four (12mm in diameter) threaded rods (Figure 9 left). To ensure alignment with multiple columns, use a wooden guide to secure the rods position while filling the tires shown in Figure 9 right.
- **Fill the tires** (ensuring same sized tires are used) with gravel or other earth materials such as sand, this can be done by hand or shovel. Ensure thorough compression, it is recommended to fill the tires intermittently and compress using a crowbar and piece of wood until tire is filled completely (Figure 9 right).

Note: *watch this video for more information on adequately compressing the foundation tire: Packing Car Tyre Foundations (Car Tyre Foundations #4) (https://www.youtube.com/watch?v=K8Vlz6qNCfU).*

- **Installation of the socket** shown in Figure 10 is completed using a 300x 300mm steel base plate which has four holes to be fixed with the threaded rods from the foundation (holes should line up with the position of the threaded rods and should be 1mm bigger in diameter than the rods to facilitate their insertion). Then, two steel 150mm x 200mm brackets are welded to the plate and hold the column with two horizontal threaded rods.
- **Installation of the columns,** ensuring that the foundation is level, place the 240mm x 240mm columns into the socket and secure with horizontal threaded rods (Figure 7).

Figure 7: Tire House Foundation Support *(Critical Concrete 2019)*

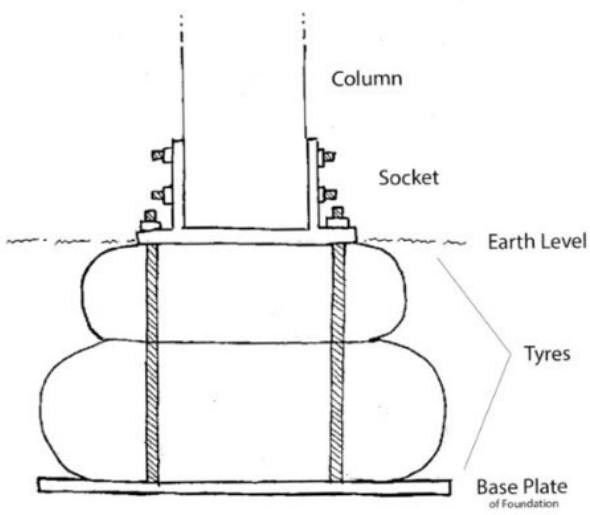


Figure 8: Diagram of Small building foundation using tires *(Critical Concrete 2019)*

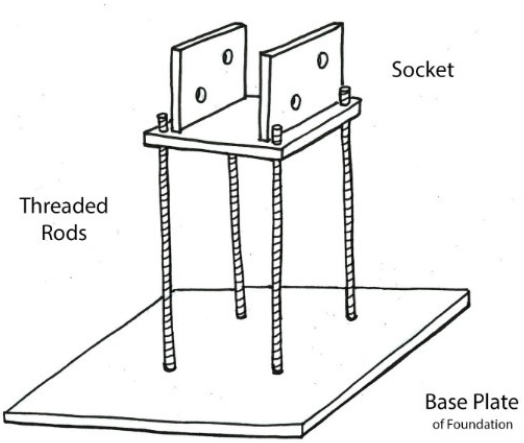
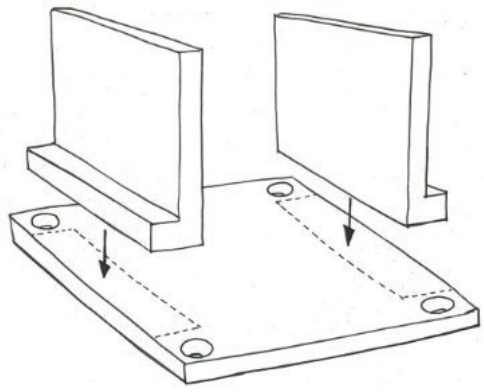


Figure 9: ELT house foundation socket design *(Critical Concrete 2019)*



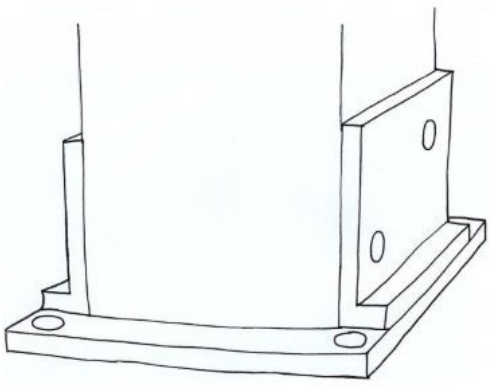


Figure 10: ELT house foundation base plate and bracket socket design *(Critical Concrete 2019)*

3.2 Pre-Treatment Requirements

Pre-treatment steps should be fulfilled before ELTs can enter the processing stage. These steps are outlines in Figure 11 below.

It is recommended that ELTs for use as house foundation meet all pre-treatment requirements including:

- Be whole, intact tires.
- Not have been exposed to fire or extreme temperatures; ensure there are no visible signs or smells of smoke, burned rubber or deformation from heat.

ELTs that do not meet the above requirements should be rejected and disposed of at the Tire Recycling Facility at the M Dock.

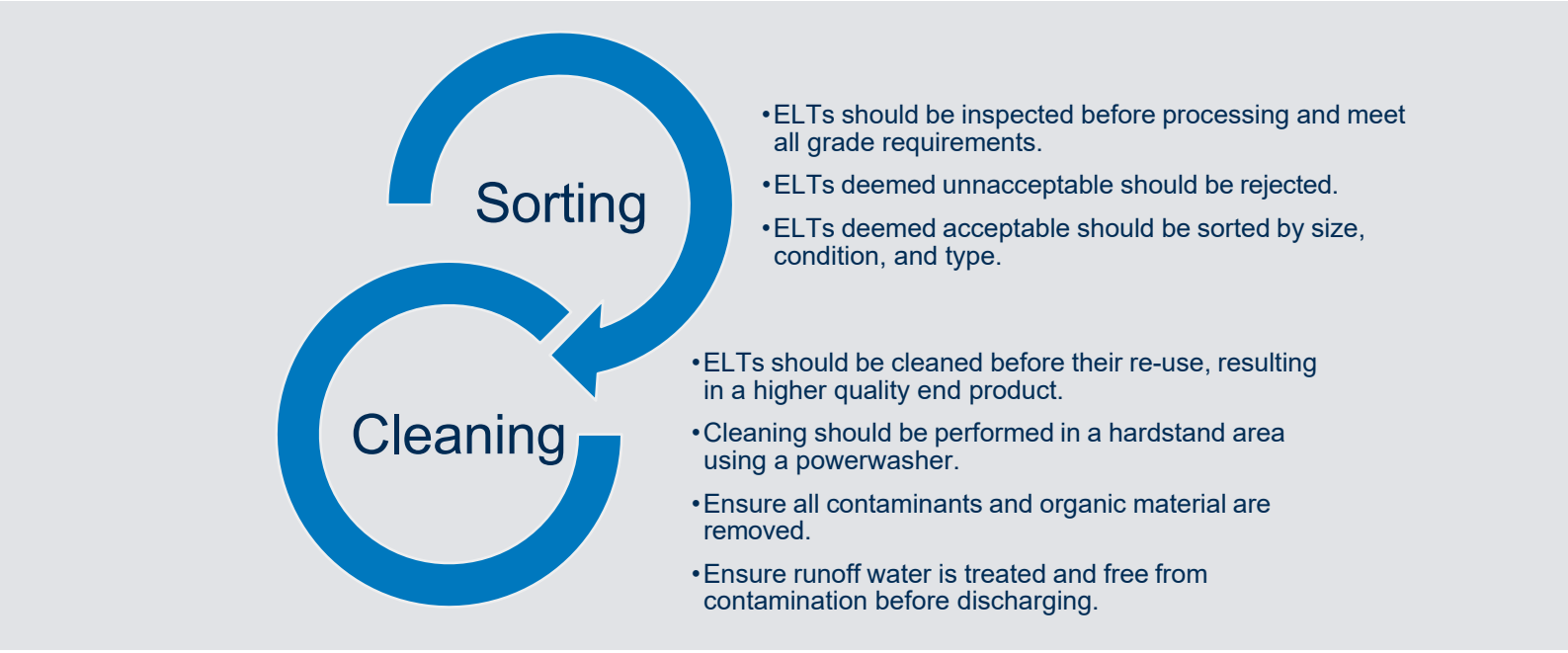


Figure 11: Pre-processing Steps for ELT whole tire use.

3.3 Processing Requirements

There is no further processing requirements for ELTs used as house foundations.

- Tires are flammable. Tires should be stored in a stable condition in cool, dry, ventilated areas away from open flames and heat sources. Firefighting equipment should always be on hand when handling and processing tires.

3.4 Applicable Engineering Standards

There is no applicable engineering standards required for the use of whole ELTs as house foundations. However, house foundation project specific engineering designs, processing and quality controls must be approved by a qualified structural engineer.

It is essential to adhere to recognised general and safe handling methods throughout the process.

To ensure safety and quality:

- Follow common industry practices e.g. wash hands after handling ELTs.
- Use appropriate tools and equipment e.g. as recommended by manufacturers.
- Ensure proper protective equipment (PPE)

3.5 Capital Cost

ELT pre-processing requires:

- **Tire washing facility** (Hardstand area: approx. US$18-38 per m^2, Pressure washer: approx. US$150, Sump tank: approx. US$1200)

3.6 Operation Cost

Labour – 3-5 persons- standard, unskilled workers: Palau minimum wage US$4.25 per hour

Administration – visual monitoring one person- skilled supervisor: Palau minimum wage US$4.25 per hour

Utilities – water & electricity: cost varies project dependant.

Consumables – fire safety equipment & PPE: approx. US$180 per worker, per year.

By-Products Disposal – nil: unused tires should be returned to the stockpile. Sump waste – oil, grease and grit must be disposed of to landfill: zero fees, excess water can be discharged.

3.7 Monitoring requirements

The following monitoring requirements are recommended during the pre-treatment and processing stages of ELTs as house foundations.

- Pre-treatment: minimal monitoring is required during the pre-treatment stages; however, regular quality control checks are to be conducted by a suitably experienced professional to ensure project standards are met. If deemed unfit, ELT should be rejected and disposed at the Tire Recycling Facility at M Dock.

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