Cleveland Steel and Tube LCA Technical Report: Confidential Internal Use

Life Cycle Analysis (LCA): recovered and refurbished coated steel tubes

This report outlines a comparative analysis of the environmental impacts of reused coated steel tubes and against a benchmark of how these compare to prime steel welded tubes.

Project code: Giraffe CST 01
Project date: Feb – April 2018
ISBN: Internal Document
Presentation Date: April 2018

Cleveland Steel and Tubes Ltd (CST) recovers and refurbishes old steel tubes primarily from the oil and gas industry and make them fit for reuse. The company was established in 1973 as a founder member of the Bianco Group of companies. CST hold stock of approximately 65,000 tonnes of tube, available from their purpose built facility which covers of 50 acres in North Yorkshire, UK.

Giraffe Innovation Ltd was founded in 1998 and is an award winning environmental management and technical consultancy. Giraffe was described by The Guardian newspaper business pages as *'one of the UK's top green businesses'* due to its extensive experience in delivering a wide range of sustainability driven projects to UK and global organisations.

Summary

This report details the life cycle analysis (LCA) of the reuse of coated steel tubes by Cleveland Steel and Tubes Ltd (CST) compared to prime (virgin) steel and recycled product[1]. The LCA covers the key lifecycle stages of recovery, treatment and distribution of 5 CST steel tube products:

- Concrete coated: Coated with 2 tonnes of concrete and 144kg of polyethylene;
- Plastic coated: Coated with 144kg of polyethylene;
- Epoxy coated: Coated with an estimated 21kg of epoxy;
- Bitumen coated: Coated with 192kg of bitumen; and
- Uncoated.

The tubes are recovered predominantly from the steel, oil and gas industry and sourced and shipped to CST's North Yorkshire facility for treatment from the UK and as far away as Dubai and St Petersburg. During refurbishment the various coatings are removed by CST, and the tube shot blasted if required. These are then sold to a client for use.

There is no technical, legal or practical reasons steel tubes cannot be reused/repurposed. Over the last 40 years these products have proven to work where cost effective testing exists to prove material properties and traceability which shows they are at least as good as new (prime) product. This study calculates the environmental benefit of reuse and extended product life – key tenants of the Circular Economy (CE).

The comparative assessment (Section 8.0) uses a functional unit of a welded steel tube (refurbished, non-prime, and prime steel[2] tube) which is 12 m long, 610 mm diameter and 16 mm wall thickness (uncoated weight totals 2.879t). The LCA takes the key material processing, logistics and operational aspects into account along with the disposal of the generated waste. The results of the CST refurbished product[3] are compared to those published by the World Steel Association (WSA) for a prime welded steel tube of the same weight and transported to the client the same distance (400km). **The results show that CST products present a significant environmental benefit (average saving) over prime steel product (Table 1).**

Impact category	Unit	Virgin steel tube	Concrete tube	Plastic tube	Epoxy tube	Bitumen tube	Uncoated coated tube	Average saving
Acidification (fate not incl.)	kg SO_2 eq	17.99	3.64	2.51	2.45	3.46	2.00	84%
Eutrophication	kg PO_4 eq	1.75	0.51	0.36	0.63	1.47	0.28	63%
Global warming (GWP100a)	kg CO_2 eq	7725	365	277	275	293	212	96%
Photochemical oxidation	kg C_2H_4 eq	2.19	0.13	0.09	0.09	0.09	0.07	96%
Ozone layer depletion (ODP)	kg CFC-11 eq	-3.25E-06	1.01E-04	8.15E-05	8.08E-05	6.34E-05	3.98E-05	-2157%
Abiotic depletion	kg Sb eq	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	95%
Abiotic depletion, fossil fuels	MJ	83,551	8,407	6,814	6,751	5,411	3,290	93%
Water	M^3	1010	1.82	1.22	1.21	1.09	0.722	99%

Table 1: GWP comparison of recycled tubes versus prime steel

[1] Steel tubes that are recovered and smelted back into new steel tubes. The figures for recycled product do not include smelting data.
[2] Prime steel is virgin steel produced by mills.
[3] Using primary data from CST

The results of the global warming potential (GWP)[4] (expressed as carbon dioxide equivalent – CO_2e) of the refurbished tubes are compared to an equivalent uncoated prime steel tube (highlighted yellow Table 1). The virgin steel tube has a GWP of 7725kgCO_2e. The equivalent recovered steel tube with the coating removed has a significantly better environmental impact (CO_2e) with **indicative savings for all CST tubes of between 95% - 97%**. **This analysis substantiates numerically (CO_2e) the environmental and 'carbon' claims currently made on the CST website[5].**

The CST products outperform prime steel products across all environmental impacts except for ozone depletion potential[6], which increased by a significant percentage, due to emissions from transportation and burning of heavy oil for the flamer used to remove/soften coatings, although the values for this are insignificant compared to the overall results.

In all cases the transportation of the tube from the supplier to CST and onward distribution accounted for a significant portion of the overall impact across all the environmental impact categories with only a few exceptions. For instance, the burning of the oil used in the removal of the bitumen, plastic and epoxy coatings from tubes was also a major contributor to the fossil fuel and ozone depletion impacts. When compared to a virgin steel tube the Global warming (GWP100a), Photochemical oxidation, Abiotic depletion and Abiotic depletion, fossil fuels were more than 90% reduced in all the tubes. Acidification reduced by more than 80%, Eutrophication was at least 60% except for the bitumen coated tube where it was only 15.9% lower due to the land filling of the bitumen. Tubes sourced within the UK have up to an 8% reduction in GWP than those sourced internationally (location dependent).

An alternative end of life route for old tubes is the potential to recover, smelt and form the steel back into new tubes. This would involve:

- Collection of the old tube;
- Reducing the size of the tube
- Melting the tube
- Forming sheets of steel.
- Bending and welding the tube

Recycling old tubes back into new tubes (see section 8.6) is a viable alternative to refurbishing and reusing old tubes however, the CST products would still present significantly higher environmental benefits. The sheet rolling of 2.879t of steel alone would have a carbon footprint of 1.232tCO_2e which is 0.867tCO_2e higher than refurbishing the concrete coated tube. The back hauling (200km), sheet rolling and welding of a new tube alone has a 253% increase in carbon footprint compared to a CST refurbished concrete coated tube. All of the other impacts of recycling the tubes were higher than for refurbishing.

CST could achieve further reductions in CO_2e and improve overall resource efficiency by making the flamer (used to remove polyethylene, epoxy, bitumen (softening)) more efficient by heating the tube along its length rather than relying upon heating it from one end and allowing for the heat to be conducted along the length of the tube. This could be achieved by mechanically rotating the tube during the flaming process. Efficiencies in this process could reduce the GWP impact further by up to 3.6%.

The LCA model for this study was developed in Sima Pro v8.5 (2018) LCA software using data primarily from the Ecoinvent v3.4 database (Ecoinvent, 2017), which is stated to be the World's largest LCA database with over 10,000 processes within the database.
The environmental impacts measured in this analysis by Giraffe Innovation include:

[4] A measure of the release of greenhouse gas (GHG) emissions into the atmosphere.
[5] https://www.cleveland-steel.com/sustainability/
[6] The characterization factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer.

- Global warming Potential: A measure of the release of greenhouse gas (GHG) emissions into the atmosphere;
- Ozone depletion: The characterization factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer;
- Acidification: Describes the acidifying effect of substances;
- Eutrophication: Nitrates and phosphates are essential for life but increased concentrations in water can encourage excessive growth of algae, reducing the oxygen within the water and damaging ecosystems;
- Photochemical oxidant formation: Photochemical Ozone Creation Potential (POCP, also known as summer smog) for emission of substances to air
- Abiotic depletion: This is the depletion due to extraction of minerals and fossil fuels;
- Abiotic depletion, fossil fuels: The characterization factor of fossil depletion is the amount of extracted fossil fuel extracted;
- Cumulative energy demand: This is the energy demand in MJ taken from nature and it is divided into 5 impact categories.

The analysis covers the impacts required for an environmental product declaration (EPD) including energy demand and water use. Therefore, CST could transpose this LCA into an EPD without significant further work. **The full LCA Results are given in Section 7.0 and the comparison of each CST tube to a virgin steel tube are given in Section 8.0.**