





Study for the determination of wire percentage, ash content and ash composition in minor and major elements for tires utilized in cement industry

Contract between Ecoelastika S.A. – CERTH/CPERI

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Scope



Determination of:

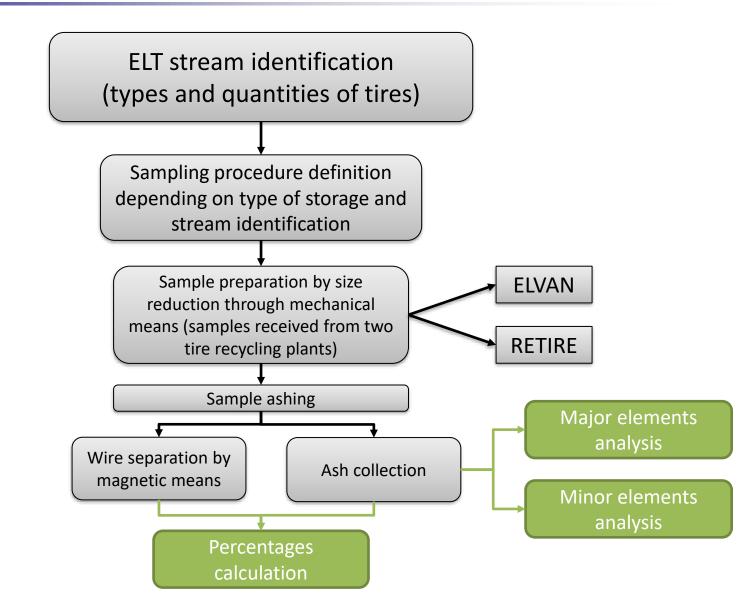
- wire content,
- Ash content, and
- Ash composition in minor elements
- Ash composition in major elements

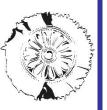
for tires utilized in cement industry



Study flowchart



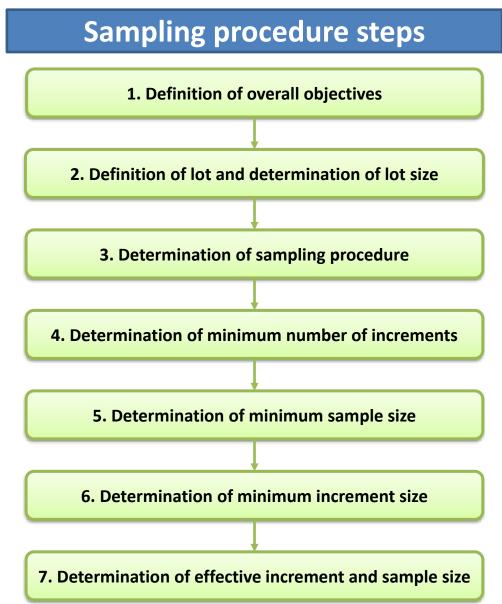




Sampling procedure definition



- Sampling procedure design and implementation was carried out according to standard EN 15442:2011 "Solid Recovered fuels – Methods for sampling"
- Lot derived from car tires and equals to a daily production of the plant
- Sampling of tire chunks with the dimensions of 50x50 mmxmm
- Effective (final) sample determined to be 36.45 kg
- The final sample gathered was 40kg and derived from two different tire recycling plants with the same initial setup for the production of chunks of 50x50 mmxmm





Samples gathered



Tire chunks (50x50 mmxmm) derived from the tire recycling plants of:

- ELVAN ABEE located in Attica Region (Southern Greece)
- RETIRE ABEE located in Drama Region (Northern Greece)

The quantities received from the two recycling plants were combined to compose the final sample for analysis





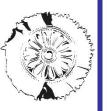




Standards used for analysis



| Analysis | Standards used | |
|-------------------------------|----------------|--|
| Sampling procedure | 15442:2011 | |
| Sample preparation | 15443:2011 | |
| Ashing procedure | ISO 1171: 2010 | |
| Ash content in major elements | 15410:2011 | |
| Ash content in minor elements | 15411:2011 | |



Samples ashing methodology



- Implementation of ISO 1171 for ashing with the following steps
 - Heating to 250°C in 40 min
 - Heating to 500°C in 120 min
 - Resting in 500°C for 40 min
 - Heating to 815°C in 50 min
 - Resting in 815°C for 60 min

This particular standard was used after a series of trials due to the low heating rate.

Other standards failed in that case due to the quick release of volatiles which drag particles of ash and char with them.

- Separation of wire with magnets and the help of air
- Weighting the sample before and after ashing, and after separation for determination of wire and ash percentage





Sample ashing: left: whole sample, right: after implementation of standard



Wire separated



Ash collected



Results – Wire and ash concentration



- Total of 20 ashing tests were carried out providing the requested results
- Average value of wire concentration is 15.42%
- Average value of ash concentration is 7.44%
- Total percentage of tire that can be considered as recycled after utilized in cement kilns 22.86%



Results – Major elements, Heavy metals



Major elements concentration

| Concentration in ash (% dry base) | | Concentration (mg/kg, Dry base) in the fuel | |
|-----------------------------------|---------|--|--------|
| Al ₂ O ₃ | 10.54 % | Al | 4,800 |
| CaO | 5.37 % | Ca | 3,300 |
| Fe ₂ O ₃ | 8.97 % | Fe | 5,400 |
| K ₂ O | 10.22 % | K | 5,300 |
| MgO | 8.51 % | Mg | 3,200 |
| Na ₂ O | 2.79 % | Na | 2,000 |
| P_2O_5 | n.d. | Р | n.d. |
| SiO ₂ | 26.65% | Si | 17,000 |
| TiO ₂ | n.d. | Ti | n.d. |
| SO ₃ | 26.97% | S | 9,300 |
| | | Total | 50,300 |

n.d.: not detected < 0.75 ppb

Heavy metals concentration

| | Concentration in ppm |
|----------------|----------------------|
| Antimony (Sb) | n.d. |
| Arsenic (As) | n.d. |
| Cadmium (Cd) | 10.48 |
| Chromium (Cr) | 39.62 |
| Cobalt (Co) | 1533.41 |
| Copper (Cu) | 484.22 |
| Lead (Pb) | 268.73 |
| Manganese (Mn) | 159.62 |
| Mercury (Hg) | n.d. |
| Nickel (Ni) | 89.61 |
| Thallium (TI) | n.d. |
| Vanadium (V) | n.d. |
| Zinc (Zn) | 18.39 |
| Total | 2.604,08 |

n.d.: not detected < 0.75 ppb



Conclusions



- Wire content in Greek car tires used in cement industries calculated to be 15.42%
- Ash content in Greek car tires used in cement industries calculated to be 7.44%
- Total percentage of tire that can be considered as recycled after utilized in cement kilns 22.86%
- The major elements with the highest concentration in the ash, are Silica (Si) and Sulphur (S) which represent more than 50% in the form of oxides, while Aluminum (Al) and Potassium (K) follow with around 10% each.
- Regarding heavy metals, more than 93% is composed of 4 out of 13 heavy metals:
 - Cobalt
 - Copper
 - Lead
 - Manganese

Thank you