wardell-armstrong.com

ENERGY AND CLIMATE CHANGE
ENVIRONMENT AND SUSTAINABILITY
INFRASTRUCTURE AND UTILITIES
LAND AND PROPERTY
MINING AND MINERAL PROCESSING
MINERAL ESTATES
WASTE RESOURCE MANAGEMENT

ALTILIUM METALS LTD

BLACK MASS PROCESSESSING AND THE PRODUCTION OF CATHODE ACTIVE MATERIAL (CAM)

END OF WASTE ASSESSMENT

APRIL 2024

wardell armstrong

Wardell Armstrong
Sir Henry Doulton House, Forge Lane, Etruria, Stoke-on-Trent, ST1 5BD, United Kingdom
Telephone: +44 (0)1782 276 700 www.wardell-armstrong.com

DATE ISSUED:	**APRIL 2024**
JOB NUMBER:	**BM12446**
REPORT NUMBER:	**0006**
VERSION:	**V1.0**
STATUS:	**FINAL**

ALTILIUM METALS LTD

BLACK MASS PROCESSING AND THE PRODUCTION OF CATHODE ACTIVE MATERIAL

END OF WASTE ASSESSMENT

MARCH 2024

PREPARED BY:

Dominiqua Drakeford-Allen — Principal Waste & Resource Consultant

REVIEWED BY:

Alison Cook — Technical Director

APPROVED BY:

Alison Cook — Technical Director

CONTENTS

1 INTRODUCTION

1.1.1 Altilium Metals Ltd have commissioned Wardell Armstrong LLP in preparing a permit application for their site located at Unit 2 Plymbridge House, Estover Road, Plymouth, PL6 7PY.

1.1.2 Using state-of-the-art equipment, Alitilium Metals Ltd have designed their innovative process to treat waste black mass from end-of-life lithium-ion Electric Vehicle (EV) batteries to recover the constituent materials via sequential hydrometallurgical processes, and subsequently use the recovered materials in the production of metal oxide, namely cathode active material, for trial-scale supply to manufacturers of new EV batteries.

1.1.3 The first phase comprises the treatment of hazardous black mass to produce raw materials, which will then be refined to be used in the inorganic chemical production process. The inorganic chemical produced will be a multi-metal oxide/Cathode Active Material (also referred to as 'CAM').

1.1.4 This report has been prepared in order to assess and ascertain at which stage in the process the waste being treated ceases to be waste, and the site activities and process commences to be a production process for a product.

1.1.5 Section 2 sets out the definition of waste.

1.1.6 Section 3 provides the end of waste criteria and assessment.

1.1.7 Section 4 provides a summary of the end of waste assessment set out in this report.

2 DEFINITION OF WASTE

2.1.1 Waste is defined by Article 3.1 of the Waste Framework Directive as, "any substance or object which the holder discards or intents or is required to discard" and is interpreted in line with case law.

2.1.2 An important aspect in determining whether something has been discarded or not is whether the substance or object has certainty of use in the future.

2.1.3 The Environment Agency provides the following guidance[1] for when a material will not be waste:

[1] https://www.gov.uk/guidance/check-if-your-material-is-waste

- it is used for the same purpose for which it is designed – the use must not be subordinate or incidental to the original use;
- the previous holder intended it to be reused;
- no repair, or no more than a minor repair, is required when it is transferred from the previous holder to the new holder, and the previous holder knows this;
- any necessary repair is going to be done;
- its use is lawful;
- it is not managed in a way that indicates that it is a waste, for example it is not transported or stored in a way that could cause it to be damaged.

3 END OF WASTE ASSESSMENT

3.1 End of Waste Criteria

3.1.1 Article 6 of the Waste Framework Directive[2] sets out the criteria for when a material has been through a recovery process and has therefore ceased to be waste. Environment Agency guidance shows that a recovery process may be as simple as a check or test, to show that the material is suitable for use.

3.1.2 A material may cease to be waste if it complies with the following requirements of the directive.

6 (1) (a) the substance or object is to be used for specific purposes.

6 (1) (b) a market or demand exists for such a substance or object.

6 (1) (c) the substance or object fulfils the technical requirements for the specific purpose and meets the existing legislation and standards applicable to products.

6 (1) (d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.

3.1.3 In the following sections we consider how each of these criteria relate to materials processed and produced at the Altilium facility.

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705

3.2 Use for a Specific Purpose

3.2.1 Altilium propose to chemically treat black mass in order to extract the constituent materials, comprising refined lithium, manganese, cobalt and nickel. Black mass is considered to have been discarded as it has come from batteries that are no longer usable and requires treatment before the constituents can be reused. It is the lithium, manganese, cobalt and nickel that is the subject of this assessment.

3.2.2 Through multi-stage chemical and metallurgical processing, the constituent materials will be separated and refined from the black mass. Once recovered the constituent materials will be of better grade or equivalent of their original condition.

3.2.3 The hydrometallurgical extraction process devised by Altilium Metals Ltd is a broad-band process, enabling it to be applied to a number of different battery feedstocks including end-of-life NMC (Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2)), LCO (Lithium Cobalt Oxide ($LiCoO_2$)) and LFP (Lithium Iron Phosphate (LiFePO4 or LFP)) batteries in order to produce consistent metals/metal compounds for the production process.

3.2.4 These materials have a very specific use, in that they are all required in the production of CAM (multi-metal oxide) which requires these constituent minerals in order to produce the CAM.

3.3 Market or Demand

3.3.1 Moden economies rely on countless raw materials. Many minerals have important uses but have plentiful supply, functioning markets or an ability to be substituted. Those that don't have been defined as 'critical minerals' in the UK Government's Critical Minerals Strategy[3].

3.3.2 Minerals identified as having a critical status, meaning high economic vulnerability and high global supply risk are:

- Lithium;
- Graphite;
- Cobalt.

[3] Resilience for the Future: The UK's Critical Minerals Strategy - GOV.UK (www.gov.uk)

3.3.3 In addition, the following minerals are on the first watchlist, in that there are potentially increasing criticality due to rapidly growing demand or emerging global supply risk:

- Manganese;
- Nickel.

3.3.4 The Resilience for the Future: The United Kingdom's Critical Mineral Strategy[4] cites an example for the vulnerability of nickel. Nickel is traded in large global markets and has a diverse range of applications, giving supply chains a degree of resilience. However, Russia is a major supplier, and Russia's invasion of Ukraine caused significant disruption to nickel markets. Class 1 (high purity) nickel is an important metal for electric vehicle battery production, and as Russia continues its aggression in Ukraine, the criticality of nickel may rise over the coming year, hence it's inclusion in the watch list.

3.3.5 Lithium-ion batteries are comprised of metals including lithium, manganese, cobalt and nickel. Altilium's processes can recovery over 95% of these technology metals for direct use in new batteries.

3.3.6 The recovered metals or metal compounds therefore have a clear market and certainty of use.

3.4 Substance Fulfils the Technical Requirements

3.4.1 Following processing and chemical treatment, the substances will be reverted back to their raw material status, with equivalent purity or greater.

3.4.2 Substances will be graded, and for the purposes of the end specification requirements the following output materials from the processing of black mass will be of battery grade, conforming to the technical requirements for the production of CAM. The end purity of the substances is as follows:

- Nickel concentrate – battery grade nickel (or class 1) will contain more than 99.8% nickel content;
- Manganese sulphate – battery grade/high purity grade to be used in the cathode structure of CAM;

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1097298/resilience_for_the_future_the_uks_critical_minerals_strategy.pdf

- Lithium hydroxide – battery grade has a minimum of 99.9% purity;
- Cobalt sulphate – battery grade.

3.4.3 The extracted substances must meet the technical requirements for Altilium Metal Ltd's technical partners and the process is designed to meet these standards.

3.5 Use of the Substance Will Not Lead to Adverse Environmental or Human Health Impacts

3.5.1 The Environment Agency guidance on End of Waste suggests that materials should be compared against a comparator, that is a virgin material that could be used for the same purpose.

3.5.2 Through the chemical/metallurgical processing and treatment of black mass, materials produced will be of equivalent quality or better than those that could be purchased in the market (materials will be of battery grade, with very high purity). The metal salts will be equivalent to virgin metal salts on the market.

4 SUMMARY

4.1.1 Black mass is a shredded material which comprises of lithium, manganese, cobalt and nickel, and may have small amounts of residual solvents and plastics. It is not until black mass has undergone chemical treatment that these constituent materials can be refined, segregated out of the black mass and further refined. Therefore the black mass arrives to the site as a waste.

4.1.2 Lithium, manganese, cobalt and nickel are minerals which have been identified as being either critical or on a watch list under the UK Government's Critical Mineral Strategy, and as such the demand far outweighs the supply. The processes Altilium Metals Ltd propose to undertake will enable these minerals to be segregated out of the black mass and further refined, enabling the extraction of these raw materials which are of equivalent quality to virgin metal compounds which would otherwise be used.

4.1.3 Once extracted, these raw materials will then be used in the production of a new product (CAM).

4.1.4 The metals/metal compounds from the initial processing of the black mass can therefore be shown to be suitable for use and to have certainty of use and therefore they are no longer considered a waste.

wardell-armstrong.com

STOKE-ON-TRENT
Sir Henry Doulton House
Forge Lane
Etruria
Stoke-on-Trent
ST1 5BD
Tel: +44 (0)1782 276 700

BIRMINGHAM
Two Devon Way
Longbridge Technology Park
Longbridge
Birmingham
B31 2TS
Tel: +44 (0)121 580 0909

BOLTON
41-50 Futura Park
Aspinall Way
Middlebrook
Bolton
BL6 6SU
Tel: +44 (0)1204 227 227

BRISTOL
Temple Studios
Temple Gate
Redcliffe
Bristol
BS1 6QA
Tel: +44 (0)117 203 4477

BURY ST EDMUNDS
Armstrong House
Lamdin Road
Bury St Edmunds
Suffolk
IP32 6NU
Tel: +44 (0)1284 765 210

CARDIFF
Tudor House
16 Cathedral Road
Cardiff
CF11 9LJ
Tel: +44 (0)292 072 9191

CARLISLE
Marconi Road
Burgh Road Industrial Estate
Carlisle
Cumbria
CA2 7NA
Tel: +44 (0)1228 550 575

EDINBURGH
Great Michael House
14 Links Place
Edinburgh
EH6 7EZ
Tel: +44 (0)131 555 3311

GLASGOW
24 St Vincent Place
Glasgow
G1 2EU
Tel: +44 (0)141 428 4499

LEEDS
36 Park Row
Leeds
LS1 5JL
Tel: +44 (0)113 831 5533

LONDON
Third Floor
46 Chancery Lane
London
WC2A 1JE
Tel: +44 (0)207 242 3243

NEWCASTLE UPON TYNE
City Quadrant
11 Waterloo Square
Newcastle upon Tyne
NE1 4DP
Tel: +44 (0)191 232 0943

TRURO
Baldhu House
Wheal Jane Earth Science Park
Baldhu
Truro
TR3 6EH
Tel: +44 (0)187 256 0738

International office:

ALMATY
29/6 Satpaev Avenue
Hyatt Regency Hotel
Office Tower
Almaty
Kazakhstan
050040
Tel: +7(727) 334 1310

wardell armstrong