Deliverable Report

Deliverable Title:

New alloys produced for HPDC process

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Deliverable nature	Demonstrator
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Authors	Ruggero Zambelli (Raffmetal)
Contributors	Manel da Silva (Eurecat), Claudio Mus (Endurance)
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Technical References

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Project full title	Substitution of Critical Raw Materials on Aluminium Alloys for electrical vehicles
Call	H2020-SC5-2020-2
Grant number	101003785
Project website	salemaproject.eu
Coordinator	Fundacion Eurecat

[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003785

Document history

V	Date	Author (Affiliation)	Actions& Approvals
V1	27.05.2022	Manel da Silva (Eurecat)	Template with proposal of content
V2	05.08.2022	Ruggero Zambelli (Raffmetal)	First draft and compilation
V2	15.-19.08.2022	Manel da Silva (Eurecat) Claudio Mus (Endurance)	Review
Final	23.08.2022	Hannah Arpke (Eurecat)	Finalisation and preparation for submission

Summary

This document describes the method followed by RAFF to industrially produce a significant quantity of partially recycled HPDC alloys with low CRM content following the methodology developed in WP3, using scrap supplied by COMET and the micro-additives selected in WP1.

New low-silicon and Si-free HPDC alloys will also be produced with small variations in the alloying elements, within the composition ranges outlined in WP2.

The substitution of critical raw materials (CRM) by converting scrap and commonly available materials as the main source of alloying elements, in the production of high performance aluminium alloys for electric vehicles is one of the main objectives of the SALEMA project.

Thanks to the study of the effects of micro-additives and their combinations in alloys in WP1, the design of new HPDC alloys in WP2, the selection of end-of-life types of scrap, with a high CRM content, indicated by COMET and the study and adaptation of the melting production processes developed in WP3, has made it possible to identify and produce about 1 ton. of:

- 6 different variants of partially recycled alloys with low CRM content;
- 6 different variants of newly developed low CRM content alloys;

All 12 variants of high performance alloys will be analyzed and tested to determine their performance, their sliding and solidification properties required to create the demonstrators identified in the project.

Deliverable 4.1 should be a guide to consider in the supply of partially recycled and low CRM aluminium alloys in ingots for the HPDC manufacturing process.

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Disclaimer

Abbreviations

Abbreviation / Acronyms	Description
WP	Work Package
WPL	Work Package Leader
LIBS	Laser-induced breakdown spectroscopy
ROI	Region of interest
CCD	Charge-coupled device
GUI	Graphical user-interface
WEEE	Waste from electrical and electronic equipment
SVM	Support Vector Machines
XRT	X-rays transmission

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1. Introduction and Background

In WP4 of SALEMA project, the pilots regarding HPDC will be implemented and the new HPDC alloys validated. It is a WP deboted to the assessment of the new alloys developed within the project, by manufacturing and characterizing the final properties of two HPDC demonstrators with important mechanical requirements produced in two pilot plants implemented in industrial sites.

Task 4.1 consists of the production of new partially recycled and low CRM content aluminium alloys for HPDC process. It will be used the scrap provided by COMET and the micro-additions selected in WP1 and it will be followed the methodology developed in WP3.

- Production of 3 different variants of AlSi10MnMg0.2 alloy with higher level of some impurities than the standard alloy
- Production of 3 different variants of AlSi10MnMg0.3 alloy with higher level of some impurities than the standard alloy
- Production of 4 different variants of a newly developed AlSi8MnMg alloy
- Production of 2 different variants of a newly developed AlMg3 alloy

This task of WP4 will produce and provide the raw material required to perform the rest of the tasks of the WP.

1.1. Objectives of task and deliverable

The objective of this first task of WP4 is to produce industrially a significant amount of material (about 1 Tn) of the SALEMA alloys developed in WP1 and WP2 to validate their performance during the whole WP. The present document is a collection of information regarding the production of these alloys, the demonstrators that correspond to Deliverable 4.3

2. Alloy production

2.1. Selection of the different alloy

Considering the results obtained in the alloy development activities of WP1 and WP2, a total of 12 alloy variants (Table 1) were selected for further analysis and validation for HPDC process.

AlSi10MnMg0.3	***Si***	***Fe***	***Cu***	***Mn***	***Mg***	***Cr***	***Ni***	***Zn***	***Pb***	***Sn***	***Ti***	***Co***
Variant 1	9-11,5	0-0,2	0-0,03	0,45-0,65	0,25-0,35	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 2	9-11,5	0-0,2	0,05-0,1	0,45-0,65	0,25-0,35	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 3	9-11,5	0-0,2	0,05-0,1	0,45-0,65	0,25-0,35	0-0,03	0-0,03	0,1-0,15	0-0,03	0-0,03	0,05-0,15	
AlSi10MnMg0.2												
Variant 1	9-11,5	0-0,2	0-0,03	0,45-0,65	0,15-0,25	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 2	9-11,5	0,2-0,3	0-0,03	0,45-0,65	0,15-0,25	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 3	9-11,5	0,2-0,3	0,05-0,1	0,6-0,8	0,15-0,25	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
AlSi8MnMg0.3												
Variant 1	7,5-8	0-0,2	0-0,03	0,6-0,7	0,15-0,25	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 2	7,5-8	0-0,2	0-0,03	0,6-0,7	0,25-0,35	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 4	8,5-9	0-0,2	0,2-0,3	0,6-0,7	0,15-0,25	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	
Variant 4	8,5-9	0-0,2	0,2-0,3	0,6-0,7	0,25-0,35	0-0,03	0-0,03	0-0,07	0-0,03	0-0,03	0,05-0,15	

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AlMg												
Variant 1	0,2-0,3	0-0,15	0-0,05	0,8-1,1	2,6-2,8	0-0,03	0-0,03	0-0,08	0-0,03	0-0,03	0-0,1	0,3-0,4
Variant 2	0,2-0,3	0-0,15	0-0,05	0,9-1,2	2,1-2,3	0-0,03	0-0,03	0-0,08	0-0,03	0-0,03	0-0,1	0,3-0,4

Table 1: Chemical composition of the 12 variants selected for further development within HPDC process

2.2. Alloy production process

About 1 Ton of each alloy variant was produced in format of ingots of 8 kg, that were all put together in a pallet of about 1 Ton. in order to be delivered to Eurecat to conduct the tests of Task 4.2. In **Error! Reference source not found.** are presented pictures taken to the ingots produced for each variant. Variants of the same alloy were produced and delivered to Eurecat all together, following the same order of Table 1.

Figure 1: Pictures of the AlSi10MnMg0,3 pallets produced for the different alloy variants- from left to right Variant1 – Variant2 – Variant3

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Figure 2: Pictures of the AlSi10MnMg0,2 pallets produced for the different alloy variants

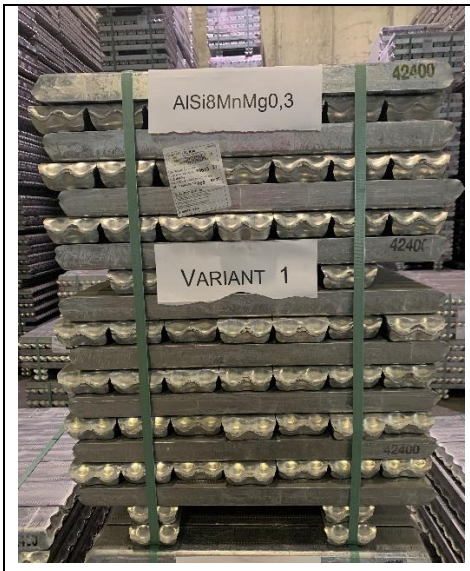

Figure 3: Pictures of the AlSi8MnMg0,3 pallets produced for the different alloy variants

The weights of the single pallet are

AlSi10MnMg0,3

Variant 1: **960** Kg

Variant 2: **951** Kg

Variant 3: **961** Kg

AlSi10MnMg0,2

Variant 1: **962** Kg

Variant 2: **962** Kg

Variant 3: **963** Kg

AlSi8MnMg0,3

Variant 1: **965** Kg

Variant 2: **961** Kg

Variant 3: **965** Kg

Variant 4: **962** Kg

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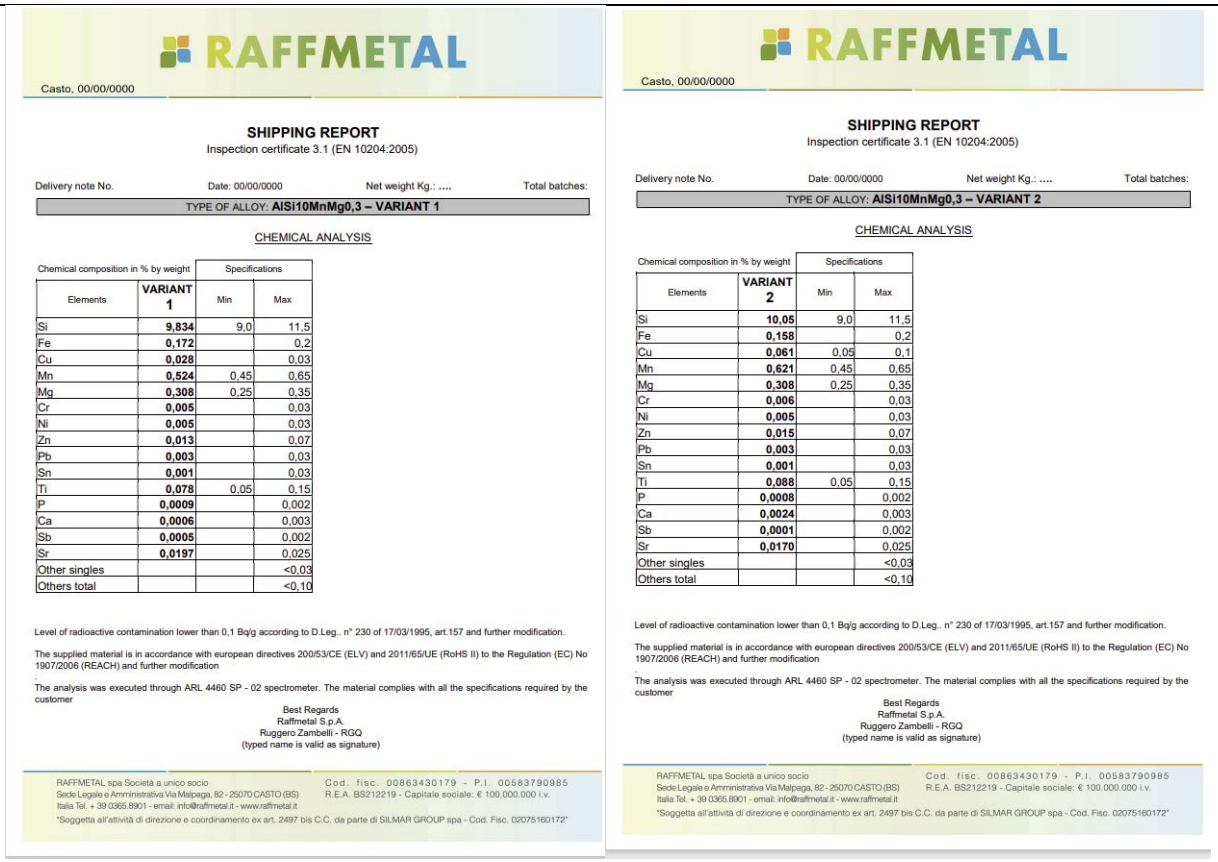
2.3. Alloy quality certification

Raffmetal control the composition of each of their produced batch following their quality control procedure. In the figure 2 the product quality certificates for each alloy variant produced are shown in a shipping report in according to *Inspection certificate 3.1* (EN 10204:2005).



RAFFMETAL

Casto, 00/00/0000

SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: .... Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,3 – VARIANT 1**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 1	Min	Max
Si	**9,834**	9,0	11,5
Fe	**0,172**		0,2
Cu	**0,028**		0,03
Mn	**0,524**	0,45	0,65
Mg	**0,308**	0,25	0,35
Cr	**0,005**		0,03
Ni	**0,005**		0,03
Zn	**0,013**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,078**	0,05	0,15
P	**0,0009**		0,002
Ca	**0,0006**		0,003
Sb	**0,0005**		0,002
Sr	**0,0197**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

The supplied material is in accordance with european directives 200/53/CE (ELV) and 2011/65/UE (RoHS II) to the Regulation (EC) No 1907/2006 (REACH) and further modification

The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

Best Regards
Raffmetal S.p.A.
Ruggero Zambelli - RGQ
(typed name is valid as signature)

RAFFMETAL spa Società a unico socio
Sede Legale e Amministrativa Via Malpaga, 82 - 25070 CASTO (BS)
Italia Tel. + 39 0365.8901 - email: info@raffmetal.it - www.raffmetal.it
Cod. fisc. 00863430179 - P.I. 00583790985
R.E.A. BS212219 - Capitale sociale: € 100.000.000 i.v.
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SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: .... Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,3 – VARIANT 2**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 2	Min	Max
Si	**10,05**	9,0	11,5
Fe	**0,158**		0,2
Cu	**0,061**	0,05	0,1
Mn	**0,621**	0,45	0,65
Mg	**0,308**	0,25	0,35
Cr	**0,006**		0,03
Ni	**0,005**		0,03
Zn	**0,015**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,088**	0,05	0,15
P	**0,0008**		0,002
Ca	**0,0024**		0,003
Sb	**0,0001**		0,002
Sr	**0,0170**		0,025
Other singles			<0,03
Others total			<0,10

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Figure 4: Inspection certificate 3.1 for the different AlSi10MnMg0,3 alloy variants

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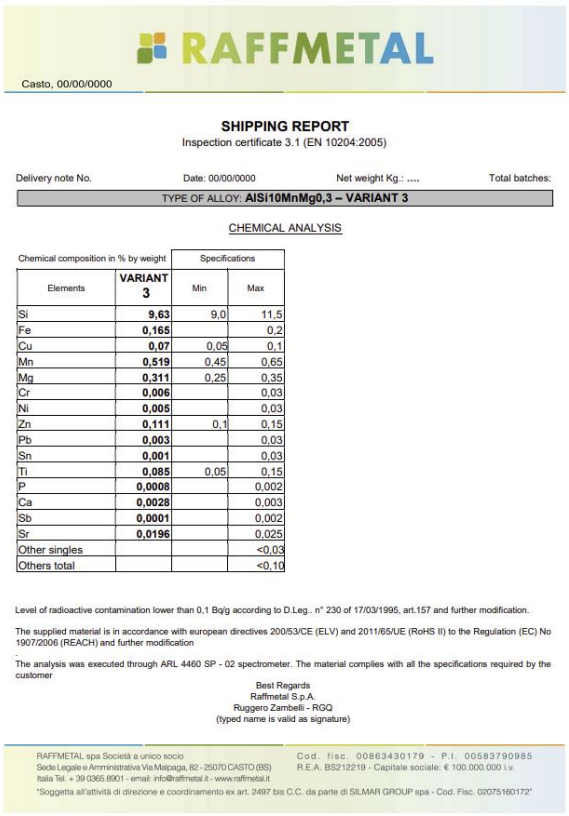

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SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: .... Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,3 – VARIANT 3**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 3	Min	Max
Si	**9,63**	9,0	11,5
Fe	**0,165**		0,2
Cu	**0,07**	0,05	0,1
Mn	**0,519**	0,45	0,65
Mg	**0,311**	0,25	0,35
Cr	**0,006**		0,03
Ni	**0,005**		0,03
Zn	**0,111**	0,1	0,15
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,085**	0,05	0,15
P	**0,0008**		0,002
Ca	**0,0028**		0,003
Sb	**0,0001**		0,002
Sr	**0,0196**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

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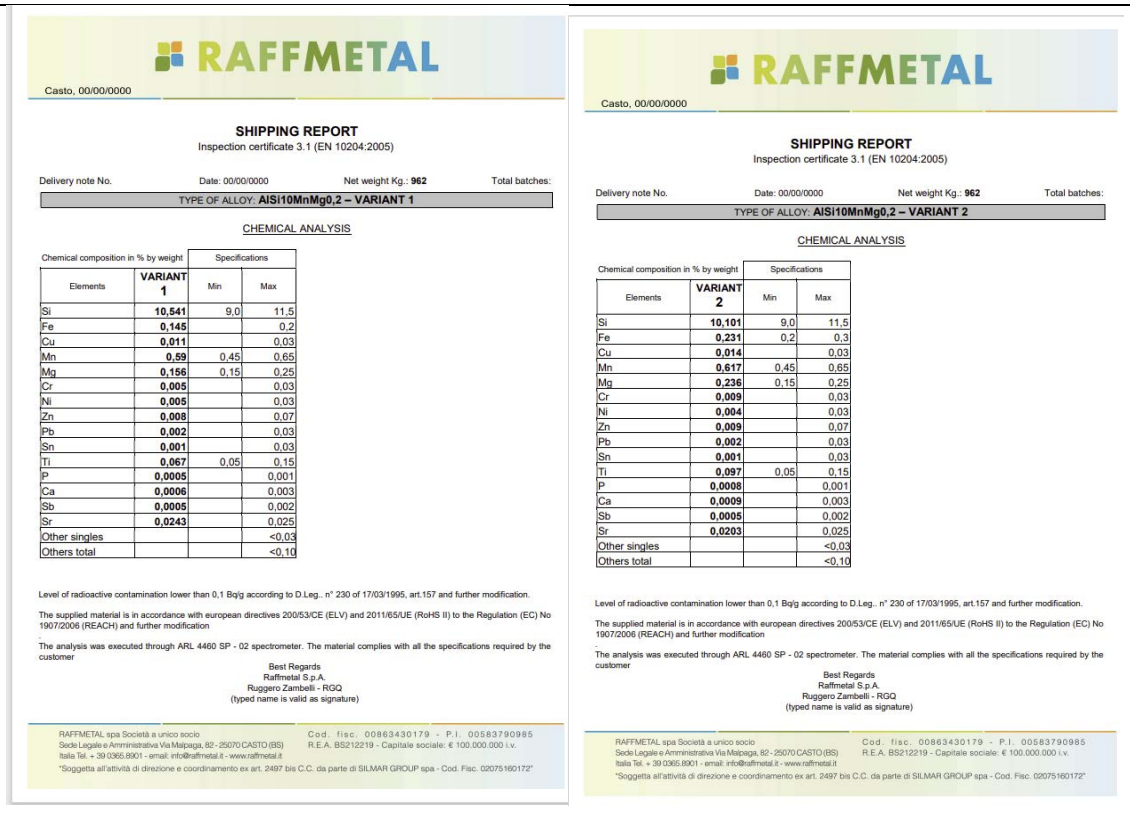
*Figure 5: Inspection certificate 3.1 for the different **AlSi10MnMg0,3** alloy variants*



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Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **962** Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,2 – VARIANT 1**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 1	Min	Max
Si	**10,541**	9,0	11,5
Fe	**0,145**		0,2
Cu	**0,011**		0,03
Mn	**0,59**	0,45	0,65
Mg	**0,156**	0,15	0,25
Cr	**0,005**		0,03
Ni	**0,005**		0,03
Zn	**0,008**		0,07
Pb	**0,002**		0,03
Sn	**0,001**		0,03
Ti	**0,067**	0,05	0,15
P	**0,0005**		0,001
Ca	**0,0006**		0,003
Sb	**0,0005**		0,002
Sr	**0,0243**		0,025
Other singles			<0,03
Others total			<0,10

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Delivery note No. Date: 00/00/0000 Net weight Kg.: **962** Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,2 – VARIANT 2**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 2	Min	Max
Si	**10,101**	9,0	11,5
Fe	**0,231**	0,2	0,3
Cu	**0,014**		0,03
Mn	**0,617**	0,45	0,65
Mg	**0,236**	0,15	0,25
Cr	**0,009**		0,03
Ni	**0,004**		0,03
Zn	**0,009**		0,07
Pb	**0,002**		0,03
Sn	**0,001**		0,03
Ti	**0,097**	0,05	0,15
P	**0,0008**		0,001
Ca	**0,0009**		0,003
Sb	**0,0005**		0,002
Sr	**0,0203**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

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The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

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Raffmetal S.p.A.
Ruggero Zambelli - RGQ
(typed name is valid as signature)

RAFFMETAL spa Società a unico socio
Sede Legale e Amministrativa Via Malpaga, 82 - 25070 CASTO (BS)
Italia Tel. + 39 0365.8901 - email: info@raffmetal.it - www.raffmetal.it
Cod. fisc. 00863430179 - P.I. 00583790985
R.E.A. BS212219 - Capitale sociale: € 100.000.000 i.v.
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Figure 6: Inspection certificate 3.1 for the different AlSi10MnMg0,2 alloy variants

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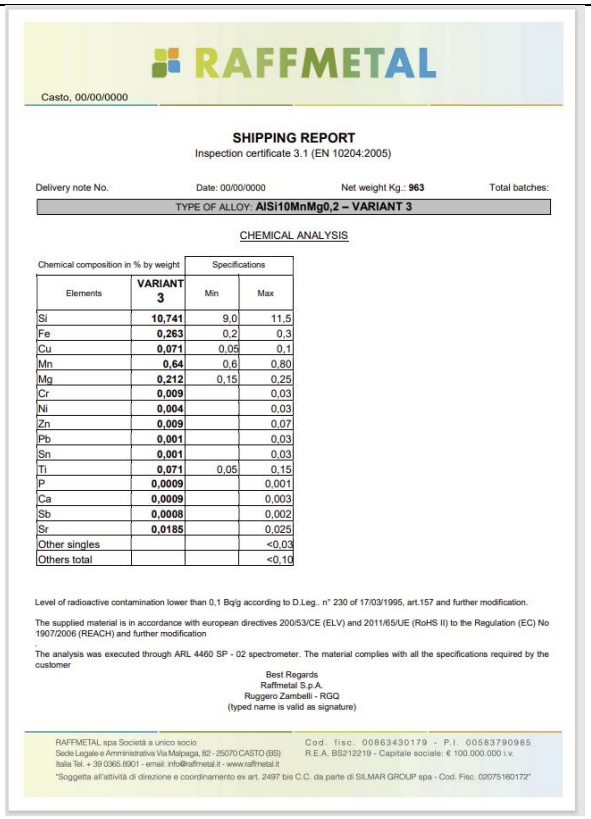

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SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **963** Total batches:

TYPE OF ALLOY: **AlSi10MnMg0,2 – VARIANT 3**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 3	Min	Max
Si	**10,741**	9,0	11,5
Fe	**0,263**	0,2	0,3
Cu	**0,071**	0,05	0,1
Mn	**0,64**	0,6	0,80
Mg	**0,212**	0,15	0,25
Cr	**0,009**		0,03
Ni	**0,004**		0,03
Zn	**0,009**		0,07
Pb	**0,001**		0,03
Sn	**0,001**		0,03
Ti	**0,071**	0,05	0,15
P	**0,0009**		0,001
Ca	**0,0009**		0,003
Sb	**0,0008**		0,002
Sr	**0,0185**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

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Raffmetal S.p.A.
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(typed name is valid as signature)

RAFFMETAL spa Società a unico socio
Sede Legale e Amministrativa Via Malpaga, 82 - 25070 CASTO (BS)
Italia Tel. + 39 0365.8901 - email: info@raffmetal.it - www.raffmetal.it
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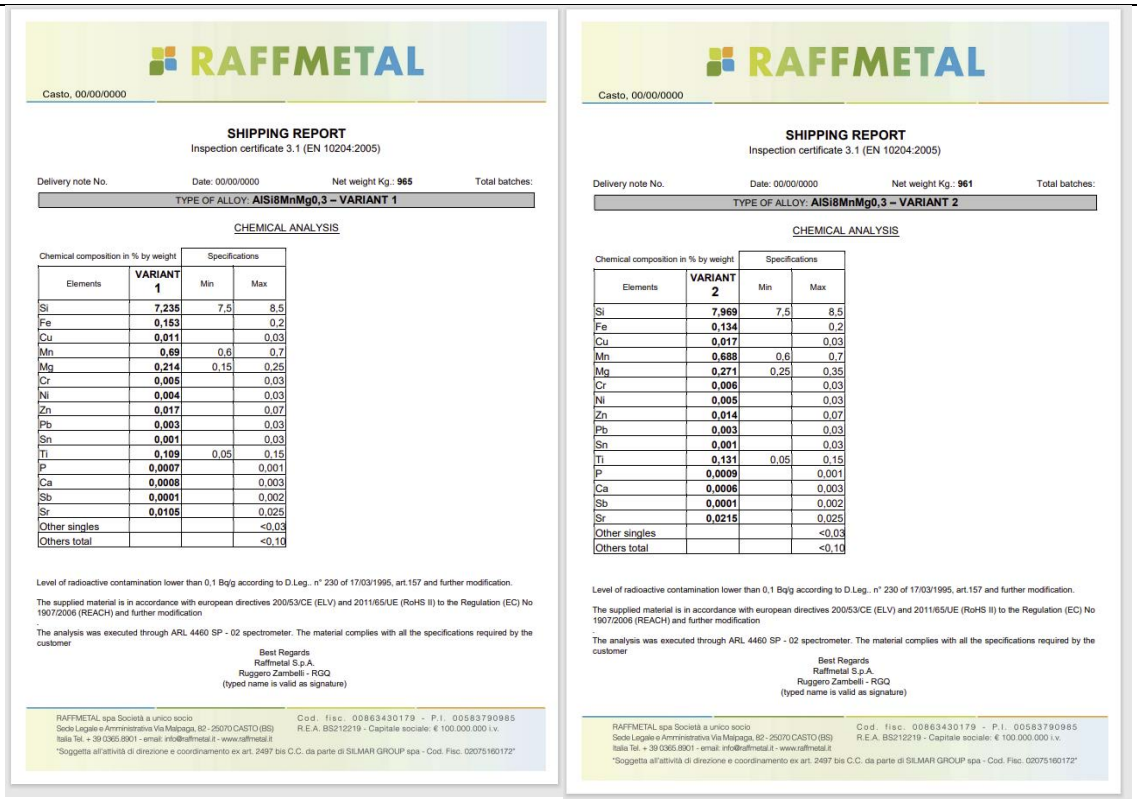
Figure 7: Inspection certificate 3.1 for the different AlSi10MnMg0,2 alloy variants



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Casto, 00/00/0000

SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **965** Total batches:

TYPE OF ALLOY: **AlSi8MnMg0,3 – VARIANT 1**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 1	Min	Max
Si	**7,235**	7,5	8,5
Fe	**0,153**		0,2
Cu	**0,011**		0,03
Mn	**0,69**	0,6	0,7
Mg	**0,214**	0,15	0,25
Cr	**0,005**		0,03
Ni	**0,004**		0,03
Zn	**0,017**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,109**	0,05	0,15
P	**0,0007**		0,001
Ca	**0,0008**		0,003
Sb	**0,0001**		0,002
Sr	**0,0105**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

The supplied material is in accordance with european directives 200/53/CE (ELV) and 2011/65/UE (RoHS II) to the Regulation (EC) No 1907/2006 (REACH) and further modification

The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

Best Regards
Raffmetal S.p.A.
Ruggero Zambelli - RGQ
(typed name is valid as signature)

RAFFMETAL spa Società a unico socio
Sede Legale e Amministrativa Via Malpaga, 82 - 25070 CASTO (BS)
Italia Tel. + 39 0365.8901 - email: info@raffmetal.it - www.raffmetal.it
Soggetta all'attività di direzione e coordinamento ex art. 2497 bis C.C. da parte di SILMAR GROUP spa - Cod. Fisc. 02075160172

Cod. fisc. 00863430179 - P.I. 00583790985
R.E.A. BS212219 - Capitale sociale: € 100.000.000 i.v.

RAFFMETAL

Casto, 00/00/0000

SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **961** Total batches:

TYPE OF ALLOY: **AlSi8MnMg0,3 – VARIANT 2**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	VARIANT 2	Min	Max
Si	**7,969**	7,5	8,5
Fe	**0,134**		0,2
Cu	**0,017**		0,03
Mn	**0,688**	0,6	0,7
Mg	**0,271**	0,25	0,35
Cr	**0,006**		0,03
Ni	**0,005**		0,03
Zn	**0,014**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,131**	0,05	0,15
P	**0,0009**		0,001
Ca	**0,0006**		0,003
Sb	**0,0001**		0,002
Sr	**0,0215**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

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The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

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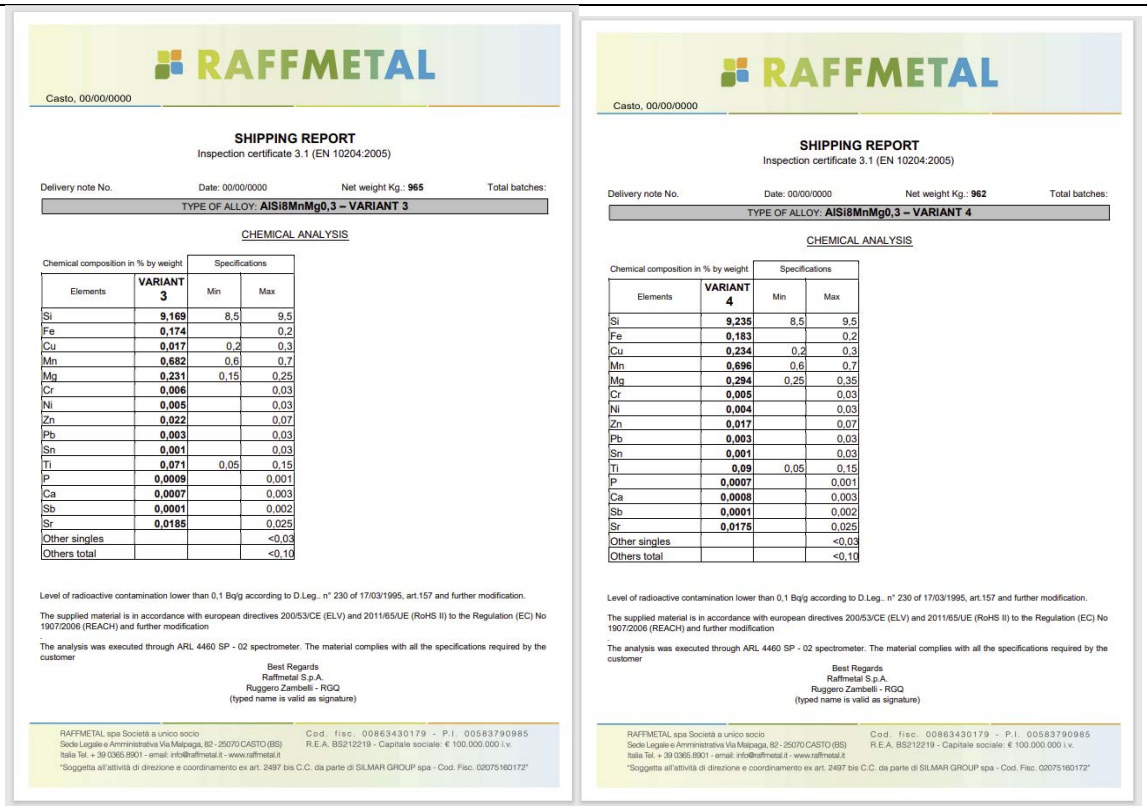
Figure 8: Inspection certificate 3.1 for the different AlSi8MnMg0,3 alloy variants

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003785



RAFFMETAL

Casto, 00/00/0000

SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **965** Total batches:

TYPE OF ALLOY: **AlSi8MnMg0,3 – VARIANT 3**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	**VARIANT 3**	Min	Max
Si	**9,169**	8,5	9,5
Fe	**0,174**		0,2
Cu	**0,017**	0,2	0,3
Mn	**0,682**	0,6	0,7
Mg	**0,231**	0,15	0,25
Cr	**0,006**		0,03
Ni	**0,005**		0,03
Zn	**0,022**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,071**	0,05	0,15
P	**0,0009**		0,001
Ca	**0,0007**		0,003
Sb	**0,0001**		0,002
Sr	**0,0185**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

The supplied material is in accordance with european directives 200/53/CE (ELV) and 2011/65/UE (RoHS II) to the Regulation (EC) No 1907/2006 (REACH) and further modification

The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

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Raffmetal S.p.A.
Ruggero Zambelli - RQQ
(typed name is valid as signature)

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RAFFMETAL

Casto, 00/00/0000

SHIPPING REPORT
Inspection certificate 3.1 (EN 10204:2005)

Delivery note No. Date: 00/00/0000 Net weight Kg.: **962** Total batches:

TYPE OF ALLOY: **AlSi8MnMg0,3 – VARIANT 4**

CHEMICAL ANALYSIS

Chemical composition in % by weight		Specifications	
Elements	**VARIANT 4**	Min	Max
Si	**9,235**	8,5	9,5
Fe	**0,183**		0,2
Cu	**0,234**	0,2	0,3
Mn	**0,696**	0,6	0,7
Mg	**0,294**	0,25	0,35
Cr	**0,005**		0,03
Ni	**0,004**		0,03
Zn	**0,017**		0,07
Pb	**0,003**		0,03
Sn	**0,001**		0,03
Ti	**0,09**	0,05	0,15
P	**0,0007**		0,001
Ca	**0,0008**		0,003
Sb	**0,0001**		0,002
Sr	**0,0175**		0,025
Other singles			<0,03
Others total			<0,10

Level of radioactive contamination lower than 0,1 Bq/g according to D.Leg.. n° 230 of 17/03/1995, art.157 and further modification.

The supplied material is in accordance with european directives 200/53/CE (ELV) and 2011/65/UE (RoHS II) to the Regulation (EC) No 1907/2006 (REACH) and further modification

The analysis was executed through ARL 4460 SP - 02 spectrometer. The material complies with all the specifications required by the customer

Best Regards
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Ruggero Zambelli - RQQ
(typed name is valid as signature)

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Figure 9: Inspection certificate 3.1 for the different AlSi8MnMg0,3 alloy variants

3. Conclusions and Outlook

A small amount (about 1 Tn each) of aluminium ingots were produced for each alloy variant selected for HPDC, that will be used for further analysis and alloy development, on the subsequent tasks of WP4.

Single lots (1 Ton.) of the 12 variants were produced following the indications of this document and were provided to EUT to perform all the analyzes and tests to determine their performance.

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003785