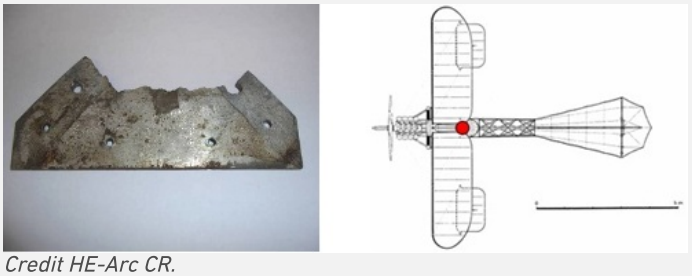
AIRCRAFT FRONT FASTENING PLATE VHS-497 (2) - AL CU SN ZN SI ALLOY - MODERN TIMES

Artefact name	Aircraft front fastening plate VHS-497 (2)
Authors	Marianne. Senn (EMPA, Dübendorf, Zurich, Switzerland) & Christian. Degrigny (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland)
Url	/artefacts/595/

The object



Credit HE-Arc CR.

Fig. 1: Fastening plate from the front of the Dufaux IV (left) and top view of the aeroplane showing its location (red dot, right) (www.hepta.aero),

Description and visual observation

Description of the artefact	Metal fastening plate for the wooden construction of the front of the aeroplane, broken by use (Fig. 1) covered with a thin corrosion layer.
Type of artefact	Aeroplane part
Origin	Dufaux IV aeroplane
Recovering date	Biplane built by Henri and Armand Dufaux in 1909/10
Chronology category	Modern Times
chronology tpq	1909 A.D.
chronology taq	1910 A.D.
Chronology comment	
Burial conditions / environment	Outdoor to indoor atmosphere
Artefact location	Swiss Museum of Transport, Luzern, Lucerne
Owner	Swiss Museum of Transport, Luzern, Lucerne
Inv. number	VHS-497 (2)
Recorded conservation data	Not known

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Complementary information

Nothing to report.

Study area(s)



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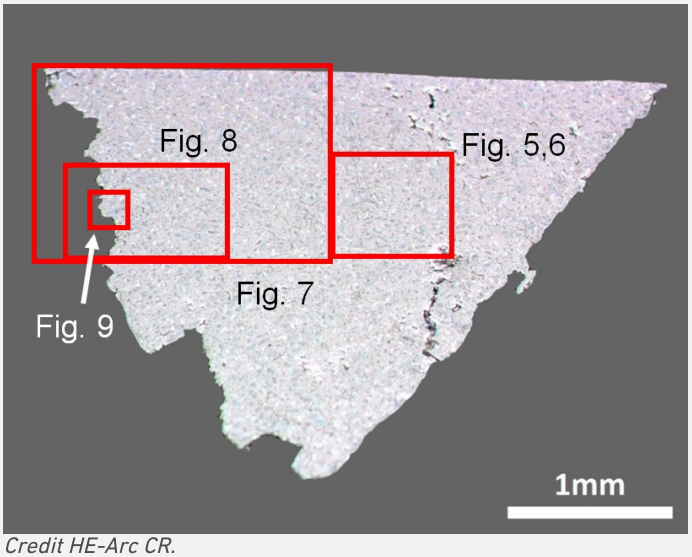
Fig. 2: Location of sampling area,

Binocular observation and representation of the corrosion structure

Stratigraphic representation: none.

MiCorr stratigraphy(ies) – Bi

Sample(s)



Credit HE-Arc CR.

Fig. 3: Micrograph of the cross-section of the sample taken from the front fastening plate showing the location of Figs. 5 to 9,

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Description of sample	The top part has been cut during sampling (Fig. 2). The more regular right side is the plate surface and the irregular side is the broken edge (Fig. 3). Dimensions: L = 4mm ; W = 4mm.
Alloy	Al Cu Sn Zn Si Alloy
Technology	As-cast
Lab number of sample	DUF-4
Sample location	Empa (Marianne Senn)
Responsible institution	Swiss Museum of Transport, Luzern, Lucerne
Date and aim of sampling	September 2007, metallography and alloy composition

Complementary information

Nothing to report.

Analyses and results

Analyses performed:
Metallography (unetched), Vickers hardness testing, SEM/EDS.

Non invasive analysis

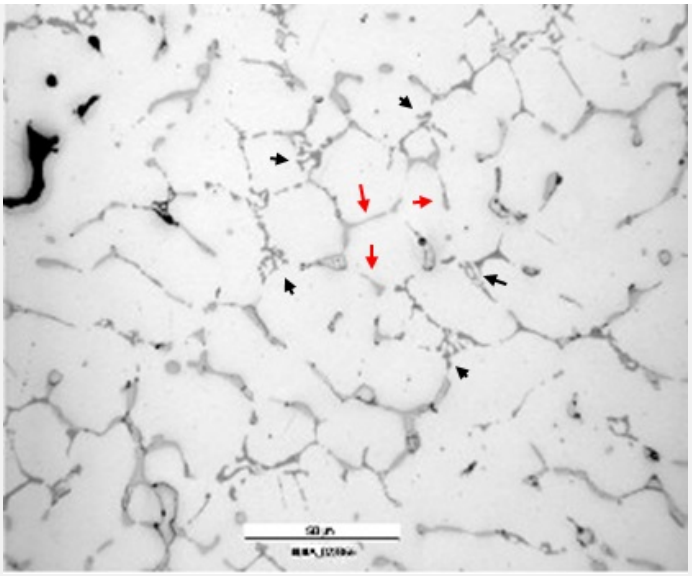
Metal

The metal is an aluminium alloy containing Cu, Sn, Zn and Si (Table 1). The unetched metal shows an as-cast structure consisting of the aluminium matrix with Sn (not soluble in Al) inclusions (Figs. 5 and 6), intermetallic compounds such as Al_2Cu (Fig. 5, red arrows) and clusters of Al,Fe,Cu & Si phases (Fig. 5, black arrows). There are porosities in the metal (Figs. 3 and 5). The average hardness of the metal is HV1 80.

Elements	Al	Cu	Sn	Zn	Si	Fe	O	Fe	Total
Metal (average)	89	4.6	3	1.6	1	<	0.8	<	100
Intermetallic compounds	45	55	<	<	<	<	<	<	100
Al,Fe,Si,Cu phase clusters	58	11	<	<	7.5	29	3.4	29	109
Sn inclusions	<	<	100	<	<	<	<	<	100

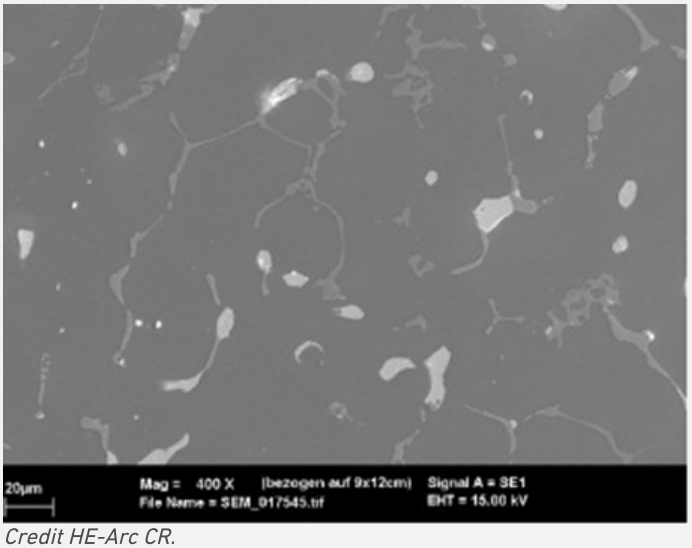
Table 1: Chemical composition (mass %) of the metal and inclusions (from Fig. 5). Method of analysis: SEM/EDS, Laboratory of Analytical Chemistry, Empa.

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Fig. 5: Micrograph of the metal sample from Fig. 3 (detail), unetched, bright field. The cast structure is revealed by light grey intermetallic compounds (Al2Cu, red arrows), dark-grey Al,Fe,Si & Cu phase clusters (black arrows) and Sn inclusions (nodules). On the top left some pores can be seen,



Credit HE-Arc CR.

Fig. 6: SEM image of the metal sample from Fig. 3 (detail), SE-mode, unetched. We observe in dark-grey the metal matrix, in medium-grey the intermetallic compound Al2Cu as well as Al,Fe,Si & Cu phase clusters and in light-grey the Sn inclusions,

Microstructure	Dendritic structure with inclusions
First metal element	Al
Other metal elements	Si, Cu, Zn, Sn

Complementary information

Nothing to report.

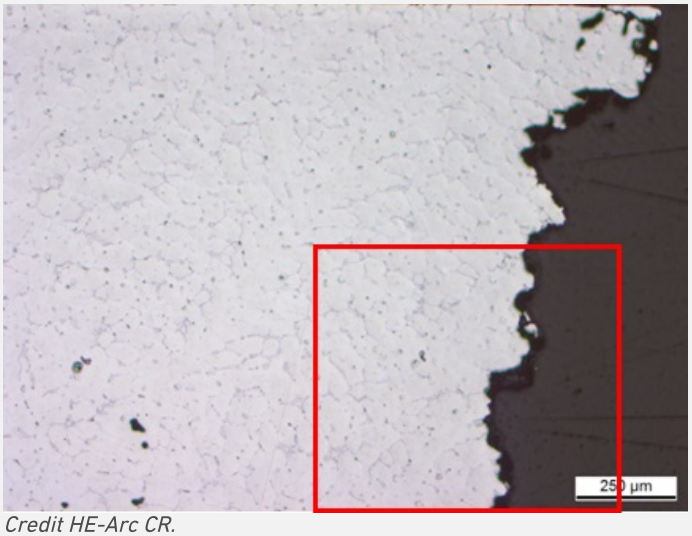
Corrosion layers

No corrosion layer can be seen on the metal surface (Figs. 3 and 7). Under polarized light small white and brown particles are visible on the broken edge (D1, Fig. 8). Their analysis reveals the presence of silica particles surrounded by dirt (Table 2 and Fig. 9). The metal surface is covered by a thin oxygen bearing skin (CP1, Fig. 9).

Elements	O	Al	Si	Cu	Total
Adherent particle (average of 3 similar analyses)	55	0.6	50	1.1	106

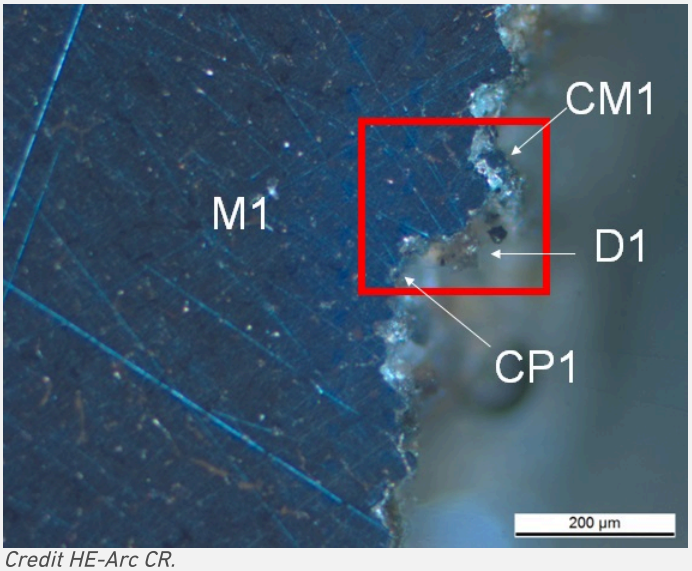
Table 2: Chemical composition (mass %) of the adhering particles to the metal surface (from Fig. 7). Method of analysis: SEM/EDS, Laboratory of Analytical Chemistry, Empa.

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Credit HE-Arc CR.

Fig. 7: Micrograph showing the metal - “corrosion products” interface from Fig. 3 (reversed picture, detail), unetched, bright field. We observe in white the metal matrix, in dark-grey Al,Fe, Si & Cu phase and light-grey Al2Cu intermetallic compounds. The micrograph of Fig. 8 is marked by a rectangle,



Credit HE-Arc CR.

Fig. 8: Micrograph from Fig. 7 (detail) and corresponding to the stratigraphy of Fig. 4, unetched, polarised light. We observe in grey the metal matrix and blue-brown the adherent material. The area selected for elemental chemical distribution (Fig. 9) is marked by a rectangle,

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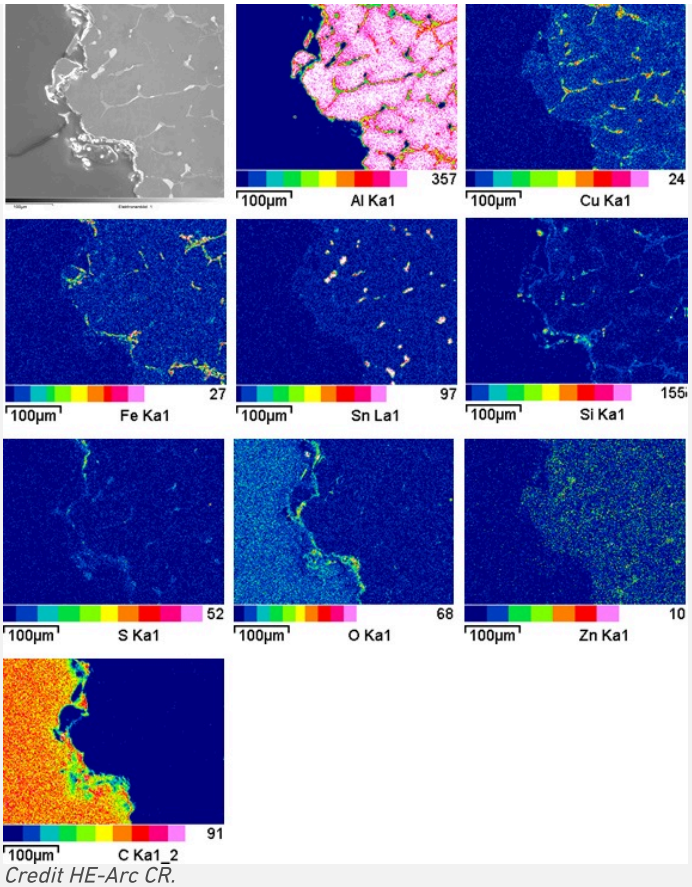


Fig. 9: SEM image, BSE-mode, and elemental chemical distribution of the selected area from Fig. 8 (reversed picture, detail). Method of examination: SEM/EDS, Laboratory of Analytical Chemistry, Empa,

Credit HE-Arc CR.

Corrosion form	Passive
Corrosion type	None

Complementary information

Nothing to report.

MiCorr stratigraphy(ies) – CS

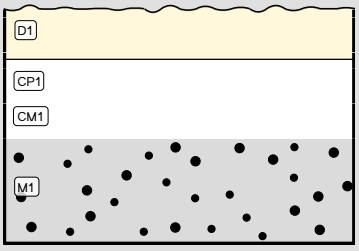


Fig. 4: Stratigraphic representation of the sample taken from the front fastening plate in cross-section using the MiCorr application. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation. This representation can be compared to Fig. 8, Credit HE-Arc CR.

Synthesis of the binocular / cross-section examination of the corrosion structure

Corrected stratigraphic representation: none.

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Conclusion

Although not common at the beginning of the 20th, this Al-Cu-Sn-Zn-Si cast alloy was used on the Dufaux IV plane. No corrosion layer has been found on the metal surface except adherent silica-rich particles and the thin oxidised skin typical of Al alloys. The presence of these materials can be explained by the regular maintenance of the metal, probably using silicon carbide abrasive paper.

References

References on object and sample
References object 1. Rumo, L. (2008) Analyse et caractérisation des alliages constitutifs de l'avion Dufaux IV. Mémoire Filière conservation-restauration, Haute Ecole art appliqués, La Chaux-de-Fonds, 101-105. **References sample** 2. Rumo, L. (2008) Analyse et caractérisation des alliages constitutifs de l'avion Dufaux IV. Mémoire Filière conservation-restauration, Haute école art appliqués, La Chaux-de-Fonds, 101-105.
References on analytic methods and interpretation

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