HISPANO-SUIZA WATER PUMP - AL ALLOY - FRANCE

Artefact name Hispano-Suiza water pump

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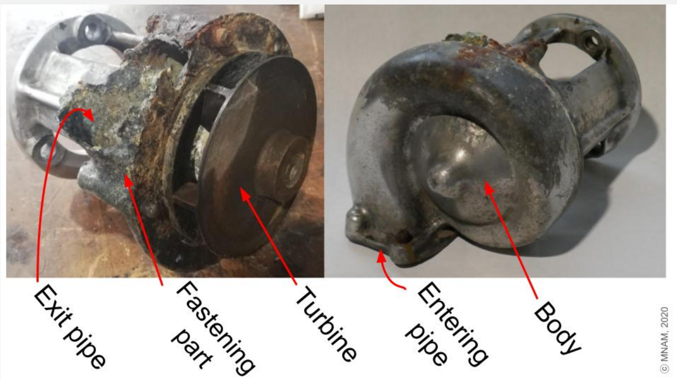
The object

Credit HE-Arc CR, E.Granget.

Fig. 1: Hispano-suiza water pump, unknown model,



Credit HE-Arc CR, E.Granget.

Fig. 2: Body, turbine, fastening part and pipes located on the Hispano water pump,

Description and visual observation

Description of the artefact

This Hispano-suiza water pump (Fig. 1), measuring around 15x15x20 cm, is made of 3 parts (Fig. 2):

> A body (or cover), shaped like a snail, containing the entering pipe,

> A turbine, inside the pump, connected through the fastening part to a rotating shaft of the engine,

> A fastening part, screwed on the body with steel screws and brass gasket-rings containing the exit pipe.

The exit pipe of the fastening part considered within this study is heavily corroded.

Type of artefact	Technical object
Origin	MNAM (Musée National de l'Automobile de Mulhouse), Mulhouse, Alsace, France
Recovering date	Unknown
Chronology category	None
chronology tpq	1920 A.D.
chronology taq	1930 A.D.
Chronology comment	
Burial conditions / environment	Outdoor to indoor atmosphere
Artefact location	MNAM (Musée National de l'Automobile de Mulhouse), Mulhouse, Alsace
Owner	MNAM (Musée National de l'Automobile de Mulhouse), Mulhouse, Alsace
Inv. number	None
Recorded conservation data	N/A

Complementary information

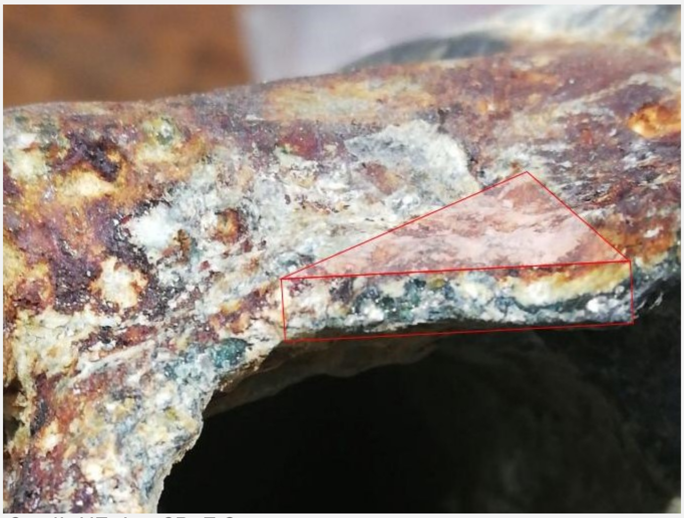
A combustion engine transforms thermal energy into kinetic energy. This process is imperfect and releases a lot of heat through the block of the engine. Therefore, these parts need to be cooled down. A cooling system circulating water between the block [hot] and a heat exchanger (or radiator) [cold] is frequently used to fulfill this function. The water flow in this circuit can be optimised by the use of a water pump. The water is sucked in from one pipe and pushed out from another one (Poulain, 1995, p.86).

This artefact is part of the "Materials for study Library" that the museum collected. It can therefore be sampled.

Study area(s)

Credit HE-Arc CR, E.Granget.

Fig. 3: Location of sampling area on the Hispano water pump,



Credit HE-Arc CR, E.Granget.

Fig. 4: Close-up view of the Hispano water pump, with the exit pipe sampling area,

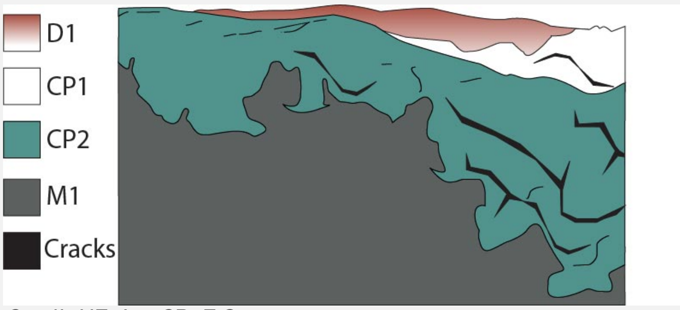
Credit HE-Arc CR, E.Granget.

Fig. 5: Close-up view of the corroded exit pipe of the disassembled Hispano water pump, showing the sampled area,

Binocular observation and representation of the corrosion structure

The schematic representation below gives an overview of the corrosion layers encountered on the corroded pipe of the fastening part of the pump (Fig. 6).

The CP strata show big cracks and can be removed with a bit of scratching (severable). CP2 has a green-blueish color. Over most of the corroded part there is a thick red-orange deposit. This is probably coming from the corroded steel screws, used to fasten the parts of the water-pump.

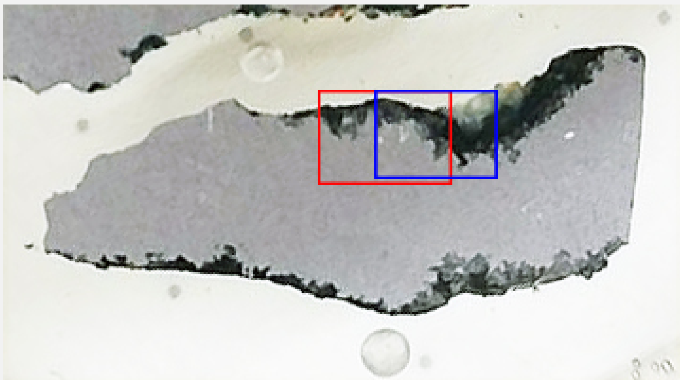


Credit HE-Arc CR, E.Granget.

Fig. 6: Stratigraphic representation of the corroded exit pipe of the water pump by macroscopic observation, M = metal, CP = corrosion product, D = deposit,

MiCorr stratigraphy(ies) – Bi

Sample(s)



Credit HE-Arc CR, E.Granget.

Fig. 7: Micrograph of the sample taken from the corroded exit pipe of the fastening part of the water pump (Figs. 3 to 5), showing the location of Figs. 8-9 in red and Figs. 11-15 in blue. This is a transversal cut of what is left of the exit pipe, severely consumed by corrosion,

Description of sample	A fragment of the exit pipe of the fastening part of the pump has been sampled and embedded as shown on Fig. 7. This is a transversal cut of what is left of the exit pipe, severely consumed by corrosion.
Alloy	Al Alloy
Technology	Cast
Lab number of sample	None
Sample location	HE-Arc CR, Neuchâtel, Neuchâtel
Responsible institution	MNAM (Musée National de l'Automobile de Mulhouse), Mulhouse, Alsace
Date and aim of sampling	31.12.2019 - Sampled for Metallography

Complementary information

During the sampling, the orange colored deposit layer (D1 on Fig. 6) was lost.

Analyses and results

Analyses performed on the body and fastening parts:
XRF with portable X-ray fluorescence spectrometer (Niton XL3t 950 Air Goldd+ analyser Thermo Fischer (voltage 50V, General metals mode with acquisition times 20s(main)/20s (Low) /20s (Light).

Analyses performed on the cross-section sampled from the corroded exit pipe:
Metallography (unetched), BF and DF imaging; SEM-EDS (20kV): SE and BSE imaging and semi-quantitative EDS analysis.

Non invasive analysis

None.

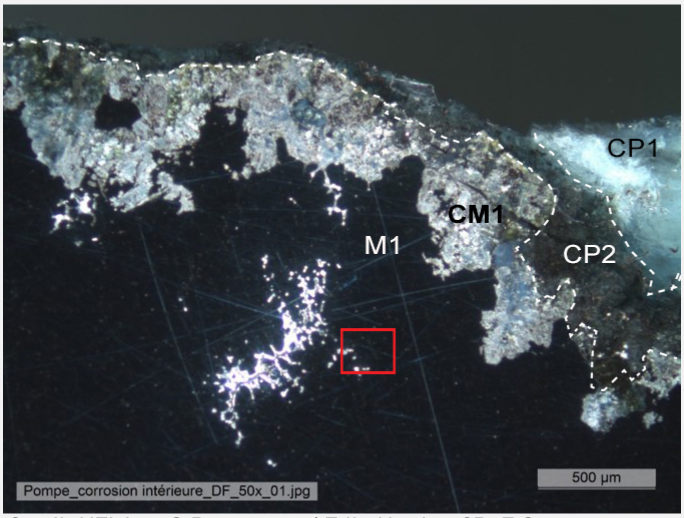
Metal

The porosity of this aluminium-copper alloy (Table 1) has been confirmed by optical (Figs. 8 and 9) and SEM observations on the cross-section of the fastening part's fragment (Fig. 10). The metal has a dendritic microstructure (Fig. 10).

Element	mass %
Al	95
Cu	4
Sn	0.5
Fe	0.5
Si	0.1

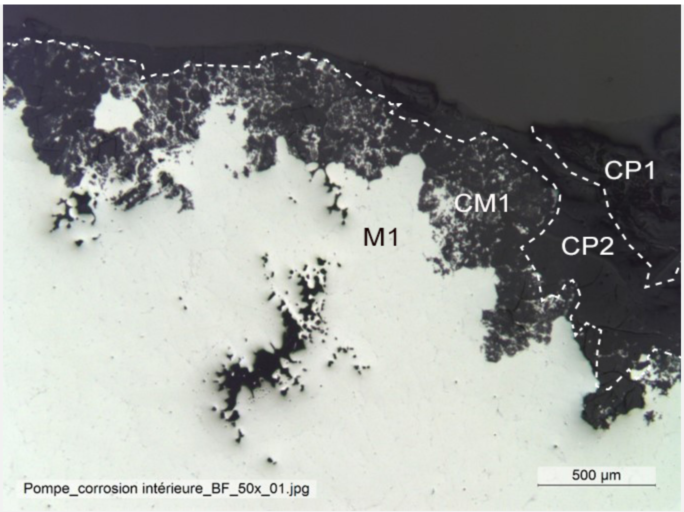
Table 1: Chemical composition (mass %) of the metal of the fastening part of the pump. Method of analysis: SEM/EDS, HE-Arc Ingénierie, S.Ramseyer.

Local analyses on each phase appearing on Fig. 10 showed that the main phase is composed of Al and the interdendritic phases are composed of Al, Cu and Fe as well as Sn precipitates. This distribution is given through EDS elemental chemical distributions (Figs. 12 to 14).



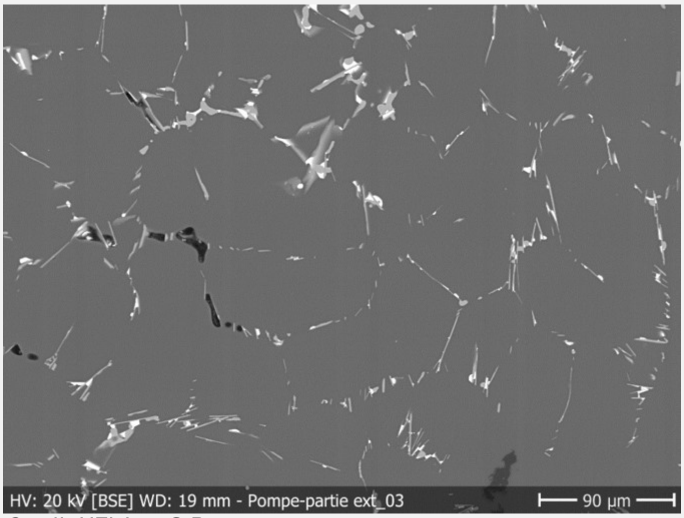
Credit HEI Arc, S.Ramseyer / Edit: He-Arc CR, E.Granget.

Fig. 8: Micrograph of the selected area (in red) of the sample shown on Fig. 7, unetched, dark field with location of Fig. 10,



Credit HEI Arc, S.Ramseyer / Edit: He-Arc CR, E.Granget.

Fig. 9: Micrograph similar to Fig. 8, unetched, bright field,



Credit HEI Arc, S.Ramseyer.

Fig. 10: SEM image (BSE mode) of the metal sample from Fig. 8 showing the microstructure of the fastening part. Black = pore, dark grey = main phase, light grey = interdendritic phase and white = Sn precipitate,

Microstructure	Dentritic structure with pores and inclusions
First metal element	Al
Other metal elements	Si, Fe, Cu, Sn

Complementary information

The body of the pump is casted in Al-Si alloy and the inner parts (turbine and other mechanical shafts) are made out of bronze, brass and steel.

Corrosion layers

The SEM image of Fig. 11 clearly shows a network of cracks throughout CM1 and CPs. These cracks are not marking any clear separation between strata, but seem to affect all corrosion layers. The main Al phase is preferentially oxidized, while the interdendritic phase seems to be preserved in the corrosion products (Figs. 11 to 13). Na and K but no Fe are detected in the corrosion layers CM1 and CPs (Fig. 14). This surface is in contact with the coolant (glycol + additives, usually mixed 1/1 in water), which sometimes contain Na or K-based corrosion inhibitors. A cluster of CaCO3 was identified on the very surface of the sample (Fig. 15). CaCO3 can sometimes precipitate if the water used to mix the coolant is hard.

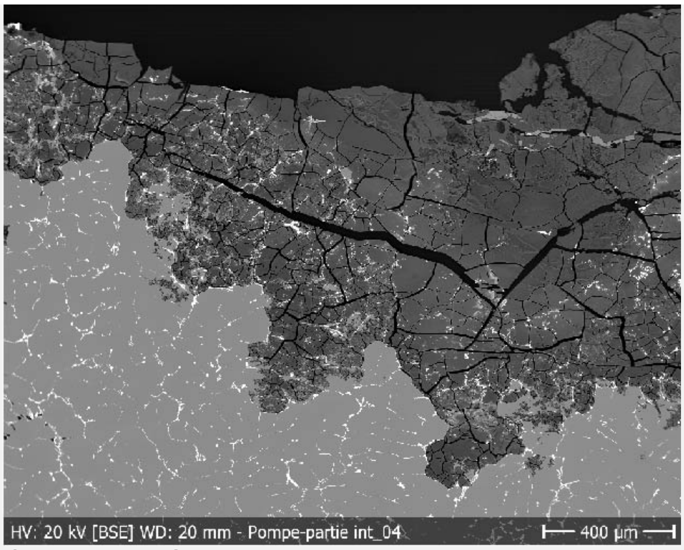


Fig. 11: SEM image (BSE mode) of the selected area (in blue) of the sample shown on Fig. 7, showing the remaining metal on the bottom and CM1 /CPs on top,

Credit HEI Arc, S.Ramseyer.

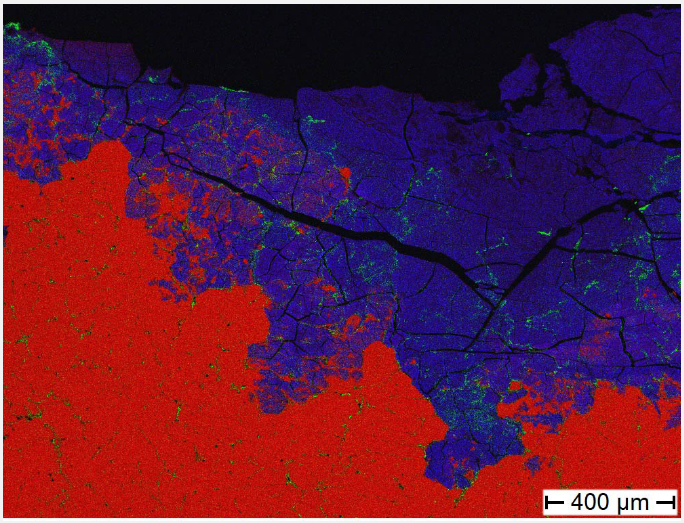


Fig. 12: Al (red), O (blue) and Cu (green) distribution of the area of Fig. 11. Method of analysis: SEM-EDS. Lab. of Electronic Microscopy and Microanalysis, Néode, HEI Arc,

Credit HEI Arc, S.Ramseyer.

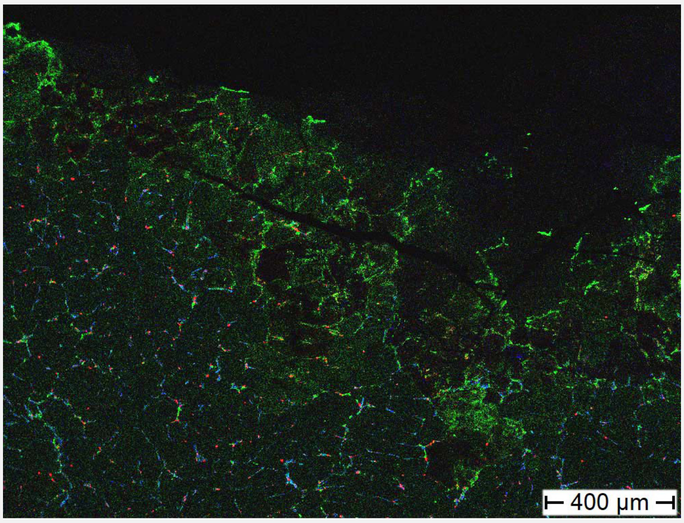
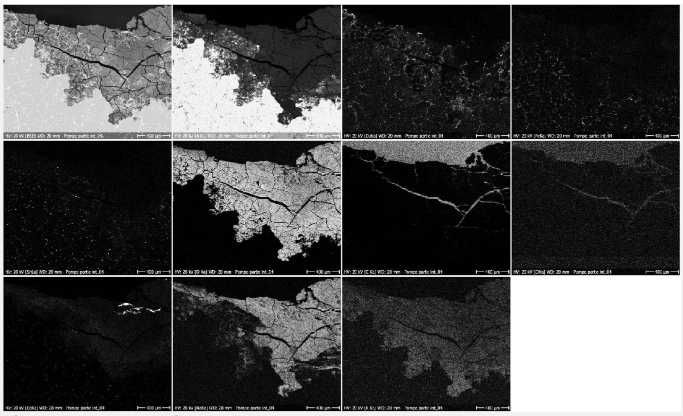


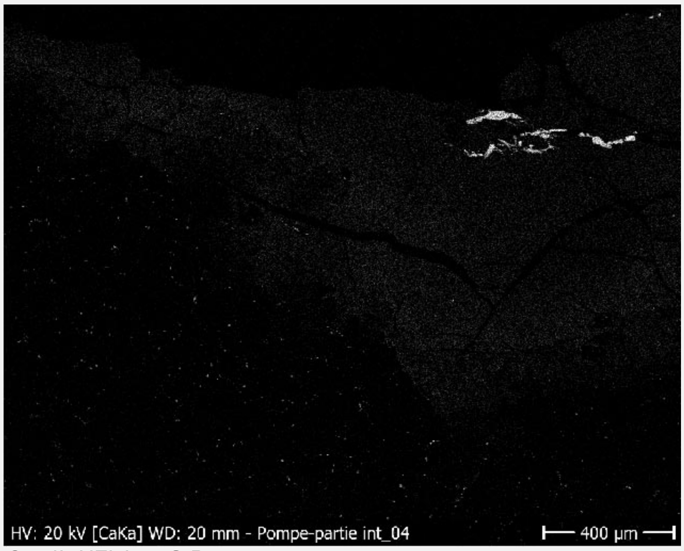
Fig. 13: Sn (red), Fe (blue) and Cu (green) distribution of the area of Fig. 11. Method of analysis: SEM-EDS. Lab. of Electronic Microscopy and Microanalysis, Néode, HEI Arc,

Credit HEI Arc, S.Ramseyer.



Credit HEI Arc, S.Ramseyer.

Fig. 14: SEM image and elemental chemical distribution of the area of Fig. 11. Method of analysis: SEM-EDS. Lab. of Electronic Microscopy and Microanalysis, Néode, HEI Arc,



Credit HEI Arc, S.Ramseyer.

Fig. 15: Ca distribution of the area of Fig. 11. Method of analysis: SEM-EDS. Lab. of Electronic Microscopy and Microanalysis, Néode, HEI Arc,

Corrosion form	Multiform
Corrosion type	None

Complementary information

None.

MiCorr stratigraphy(ies) – CS

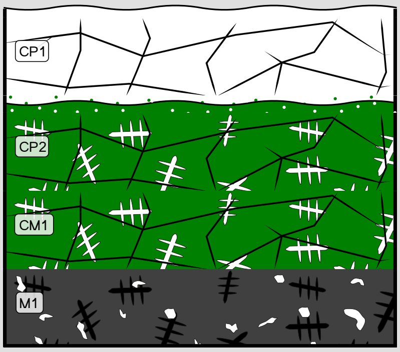
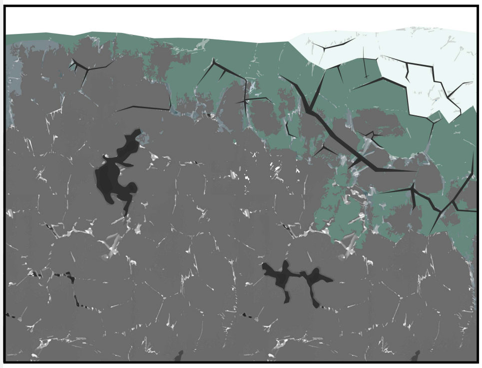


Fig. 16: Stratigraphic representation of the sample taken from the fastening part of the Hispano water pump in cross-section (dark field) using the MiCorr application. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation. This representation can be compared to Fig. 9, Credit HE-Arc CR, E.Granget.

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

The schematic representation of corrosion layers of Fig. 6 integrating additional information based on the analyses carried out is given in Fig. 17.



Credit He-Arc CR, E.Granget.

Fig. 17: Improved stratigraphic representation of the corrosion structure of the exit pipe of the disassembled Hispano water pump,

Conclusion

The heavily corroded exit pipe of the fastening part of this Hispano-suiza water pump is made out of an Al-Cu cast alloy with traces of Sn, Fe and Si(?). The corrosion is through the dendritic microstructure: the main phase (Al) is preferentially oxidized, while the interdendritic phase (Fe, Sn, Cu) and Sn precipitates are preserved in the corrosion products. This component of the engine being in contact with the coolant might explain the presence of Na, K and Ca in the corrosion layers.

References

References on object and sample

References object

1. Poulain, P. and J-M. (1995) Voitures de collection : Restauration Mécanique Editions Techniques pour l'Automobile et l'Industrie (ETAI), Paris.
2. Granget, E. (2020) La corrosion des alliages d'aluminium des circuits de refroidissement à eau de véhicules en contexte patrimonial : Utilisation d'outils open-access dans l'établissement d'un diagnostic des altérations d'un corpus de véhicules conservés au Musée National de l'Automobile de Mulhouse (Collection Schlumpf), Rapport interne MNAM.

References sample

3. Granget, E. (2020) La corrosion des alliages d'aluminium des circuits de refroidissement à eau de véhicules en contexte patrimonial : Utilisation d'outils open-access dans l'établissement d'un diagnostic des altérations d'un corpus de véhicules conservés au Musée National de l'Automobile de Mulhouse (Collection Schlumpf), Rapport interne MNAM.

References on analytic methods and interpretation

4. Vargel, C. (2004) Corrosion of Aluminium, Elsevier.
5. Degrigny C. and Schröter J. (2019) Aluminium Alloys in Swiss Public Collections: Identification and Development of Diagnostic Tools to Assess Their Condition, in METAL 2019, proceedings of the ICOM-CC Metal WG interim meeting, eds. C. Chemello, L. Brambilla, E. Joseph, Neuchâtel (Switzerland), 408-415.