Exemption Request Form

Date of submission: 23DEC2020

1. Name and contact details

1) Name and contact details of applicant:

Company:	Ariston Thermo SpA	Tel: +39 33 557 89 557
Name:	Luigi Tischer	E-Mail: luigi.tischer@aristonthermo.com
Function:	R&D Senior Director	Address: Via della Vignolina 2 20864 Agrate Brianza (MB) Italy

2) Name and contact details of responsible person for this application (if different from above):

Company:	_____	Tel.:	_____
Name:	_____	E-Mail:	_____
Function:	_____	Address:	_____

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2. Reason for application:

Please indicate where relevant:

☐ Request for new exemption in:

☒Request for amendment of existing exemption in

☒Request for extension of existing exemption in

☐Request for deletion of existing exemption in:

☒Provision of information referring to an existing specific exemption in:

☒Annex III ☐Annex IV

No. of exemption in Annex III or IV where applicable:	9
Proposed or existing wording:	please see below
Duration where applicable:	5 years

☐ Other: _____

3. Summary of the exemption request / revocation request

Ariston Thermo SpA is applying for an amendment / change of the wording and the extension of “Exemption 9” in RoHS.

The current exemption covers only the use of ‘Hexavalent Chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0.75 % by weight in the cooling solution’.

Ariston Thermo SpA is currently applying for an Authorisation for the “use of sodium chromate as an anticorrosion agent of the carbon steel in sealed circuit of gas absorption appliances up to 0.70% by weight (as Cr-VI) in the refrigerant solution”.

Gas Absorption Heat Pumps (GAHP) and refrigerators use scientifically and technologically the same thermodynamic principles. More precisely, refrigerators and GAHP are:

- Identical from the operating principle
- Extremely similar from the operating conditions
- Identical from the metallurgy/corrosion/construction point of view

Therefore, Ariston Thermo SpA is requesting within this application to change the wording of the current exemption to additionally cover gas absorption heat pumps.
GAHP is the most promising thermally driven heat pump category. It is perceived as the technology to replace the conventional gas boiler technology in support of the energy transition and therefore it is instrumental to accelerate the energy transition toward hydrogen.

Therefore, in place of the current wording:

> *"Hexavalent chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0.75 % by weight in the cooling solution"*

The following wording is proposed:

> *“Hexavalent chromium as an anticorrosion agent of the carbon steel sealed circuit in gas absorption driven appliances up to 0.75 % by weight in the refrigerant solution”*

4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?

Name of applications or products:

Anticorrosion agent in gas absorption driven appliances

a. List of relevant categories: (mark more than one where applicable)

☒	1	☐	7
☐	2	☐	8
☐	3	☐	9
☐	4	☐	10
☐	5	☐	11
☐	6		

b. Please specify if application is in use in other categories to which the exemption request does not refer: _____

c. Please specify for equipment of category 8 and 9:

The requested exemption will be applied in

☐ monitoring and control instruments in industry

☐ in-vitro diagnostics

☐ other medical devices or other monitoring and control instruments than those in industry

2. Which of the six substances is in use in the application/product?

(Indicate more than one where applicable)

☐Pb ☐Cd ☐Hg ☒Cr-VI ☐PBB ☐PBDE

3. Function of the substance:

Chromium VI is used as anticorrosion agent in the refrigerant solution. The inhibitor function is proved and tested for GAHP.

In basic media Cr-VI oxidises iron on the steel surface and forms a protective layer which contains iron oxide and chromium (III) oxide. Cr-VI itself is reduced to Cr-III to build the protective layer.

$$9\ Fe + 8\ Na_2CrO_4 + 8\ H_2O \rightarrow 3\ Fe_3O_4 + 4\ Cr_2O_3 + 16\ Na\ OH$$

This passivating film builds a very effective protection of carbon steel against corrosive processes and possesses self-healing ability

4. Content of substance in homogeneous material (%weight):

A maximum amount of 0.7% (weight) Cr-VI in the homogenous refrigerant solution is introduced into the sealed system of the GAHP appliances. Before placing on the market the gas absorption heat pumps are fully tested (mandatory for compliance with Gas Appliance Regulation).

During testing significant amount of Cr-VI will be reduced to chromium oxide (Cr_2O_3) and adhere to the inner surface of the sealed circuit. Consequently, the concentration of Cr-VI in the homogenous material (refrigerant solution) will be significant lower than the introduced 0.7%, when placed on the market.

Further reduction of concentration is expected in the following operation of the appliance in application.

Currently measurements are planned to determine the exact trend of Cr-VI concentration after testing.

5. Amount of substance entering the EU market annually through application for which the exemption is requested: 1400 kg/year

Please supply information and calculations to support stated figure.

As the product is not yet placed on the market, exact numbers cannot be currently measured and stated. The amount mentioned in the Chemical Safety Report (CSR) of the application for Authorisation of 1400 kg/year can be considered as worst case assumption. This value reflects the maximum production capacity. One of the substitution strategies of Ariston Thermo SpA is to further reduce the concentrations/amount of Cr-VI in the refrigerant solution.

6. Name of material/component:

Cr-VI (in form of sodium chromate) is used in the refrigerant solution to protect the inside of the carbon steel sealed circuit against corrosion. The natural refrigerant solution (with zero GWP and zero ODP) consists of water and ammonia.
The sealed circuit is made of material compatible with ammonia and water. Currently the only commercially available material able to withstand this demanding environment (temperature, pressure, erosion by cavitation and chemical reactions) is steel, which mandatorily requires to use of a corrosion inhibitor.

7. Environmental Assessment:

LCA: ☒Yes
☐No

A life cycle analysis was performed in the report “Environmental Product Policy for Hydronic Central Heating Generators assessed 12 base cases including the GAHP. (VHK, 2012). In the report the main environmental impacts, including GHG and other air emissions (Nox, OGC, CO and PM) were

estimated in the life cycle analysis.

The complete report is available under:
https://www.vhk.nl/downloads/Reports/2012/VHK%20472%20Final%20Report%20IPTS%20study.pdf

A life cycle cost analysis was performed in 2019 by VHK for the European commission. This analysis reported that the GAHP technology ("gas/sorption HP") shows the lowest total life cycle cost for kWh of heat produced (Fig.26).

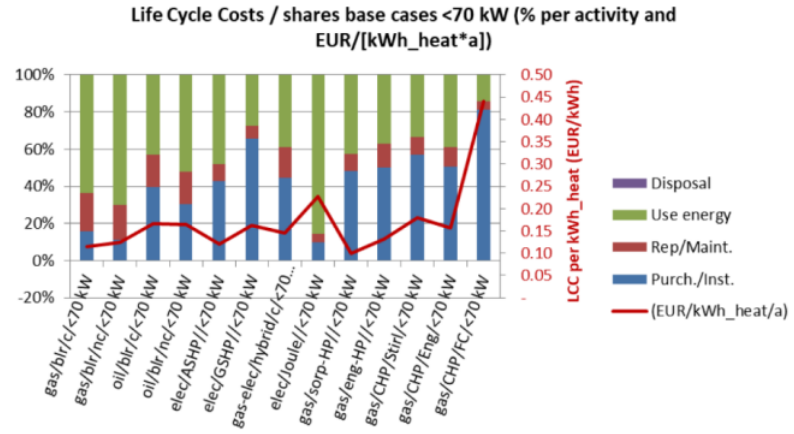

Figure 26. Shares of LCC per cost aspect and LCC per kWh-heat per year, < 70 kW

The complete report and analysis can be found under:
https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%205%20final%20report%20July%202019.pdf

In the Authorisation application a simplified LCA was performed. The key findings are presented below.

Manufacturing:
The raw materials for a gas absorption heat pump are comparable to the ones for a condensing boiler. The sealed circuit of the gas absorption heat pumps is made of carbon steel and the refrigerant solution consists of the natural refrigerant water and ammonia. Cr-VI is added as corrosion inhibitor. The ammonium-water solution is the most environmentally friendly refrigerant solution featuring a Global warming potential (GWP) of zero and an Ozone Depletion Potential (ODP) of zero. GAHP technology has no fluorinated gas (F-Gas) emissions and it is therefore exempt from the F-Gas Directive.
All raw materials for the refrigerant solution are bought from EU based suppliers. Currently the GAHP manufacturing imposes a 100% vertical integration at the manufacturing site, which is very atypical for the heating sector.

Use stage:
GAHP are low maintenance products with an expected lifetime of 24 years (VHK, 2019) without any refilling requirements of the refrigerant solution containing Cr-VI.
The technology meets the criteria for the EU Ecolabel and the Energy labeling A++ set by the European Commission (2013).

When the primary energy used by the GAHP is “natural gas”, then GAHP appliance shows currently the lowest CO_2 emission of all fuels (burning oil, fuel oil, and LPG). The CO_2 emissions of gas (0.184kgCO_2/kWh) are at the moment significantly lower compared to electricity based on information of the UK government (Treasury 2018).

Assumptions about emissions factors for different fuels

		2013	Future trajectory – 2030 status
Natural Gas	kgCO_2e/kWh	0.1841	Constant - As 2013
Burning Oil	kgCO_2e/kWh	0.2456	Constant - As 2013
Fuel Oil	kgCO_2e/kWh	0.2688	Constant - As 2013
LPG	kgCO_2e/kWh	0.2145	Constant - As 2013

Source: Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, Tables 1-20: supporting the toolkit and the guidance

ELECTRICITY	2013	2014	2015	2016	2017	2018	2019	2020	2021
Services kgCO_2e/kWh	0.508	0.483	0.437	0.346	0.313	0.295	0.272	0.233	0.220
Industrial kgCO_2e/kWh	0.498	0.474	0.429	0.339	0.307	0.289	0.266	0.229	0.216

ELECTRICITY	2022	2023	2024	2025	2026	2027	2028	2029	2030
Services kgCO_2e/kWh	0.231	0.202	0.198	0.181	0.159	0.168	0.149	0.128	0.110
Industrial kgCO_2e/kWh	0.227	0.198	0.195	0.177	0.156	0.165	0.146	0.126	0.108

Figure 1: Comparison of CO_2 emissions from different fuels and electricity

GAHP achieve a seasonal space heating efficiency on primary energy (on high temperature applications) in excess of 125% (measured on “radiator”, according to EN12309, expressed as GCV, and including auxiliary electrical consumption). For comparison condensing boiler technology will reach approx. ~ 90-95%.

This means that to cover the energy demand 25,000 kWh/household/year, a GAHP requires 20,000 kWh/household of gas per year. Taking into account the CO_2 emissions of gas (0.184kgCO_2/kWh), the use of GAHP results in 3,682 kgCO_2/household/year.
Compared to the condensing boiler technology the CO_2 emissions are around 30-35% lower.

When the primary energy source is a “green gas” (Bio-LPG, Bio-methane, Green Hydrogen) the resulting CO_2 emissions will be virtually zero.
The European energy transition will imply large use of green gases by 2050, which will imply a substantially higher operating costs for end users with traditional technologies (condensing boilers).
The high energy efficiency on primary energy of GAHP technology will contribute to lower the heating costs for end users resulting from using a more expensive energy vector (green gases).

End of life:
Dedicated dismantling infrastructure is in place. After end of service, the GAHP will be picked up by authorised installers and replaced by a new one. The sealed circuit containing refrigerant solution (NH_3 and the remaining portion of Cr-VI) will be emptied and collected by installers / workers with specific training. The refrigerant is disposed as hazardous waste according to national laws.

(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Cr-VI in form of sodium chromate is added to the refrigerant solution with the function to prevent corrosion of the carbon steel sealed circuit of the GAHP. The sealed circuit builds the functional part of the GAHP and refrigerant enables the thermodynamic circle (as shown in the figure below). Without a corrosion inhibitor, corrosion and thermal decomposition of ammonia can form non-condensable gases in the refrigerant solution which could result in a reduction of efficiency or even in a complete breakdown of the heat pump (Harald Moser et al. 2013).

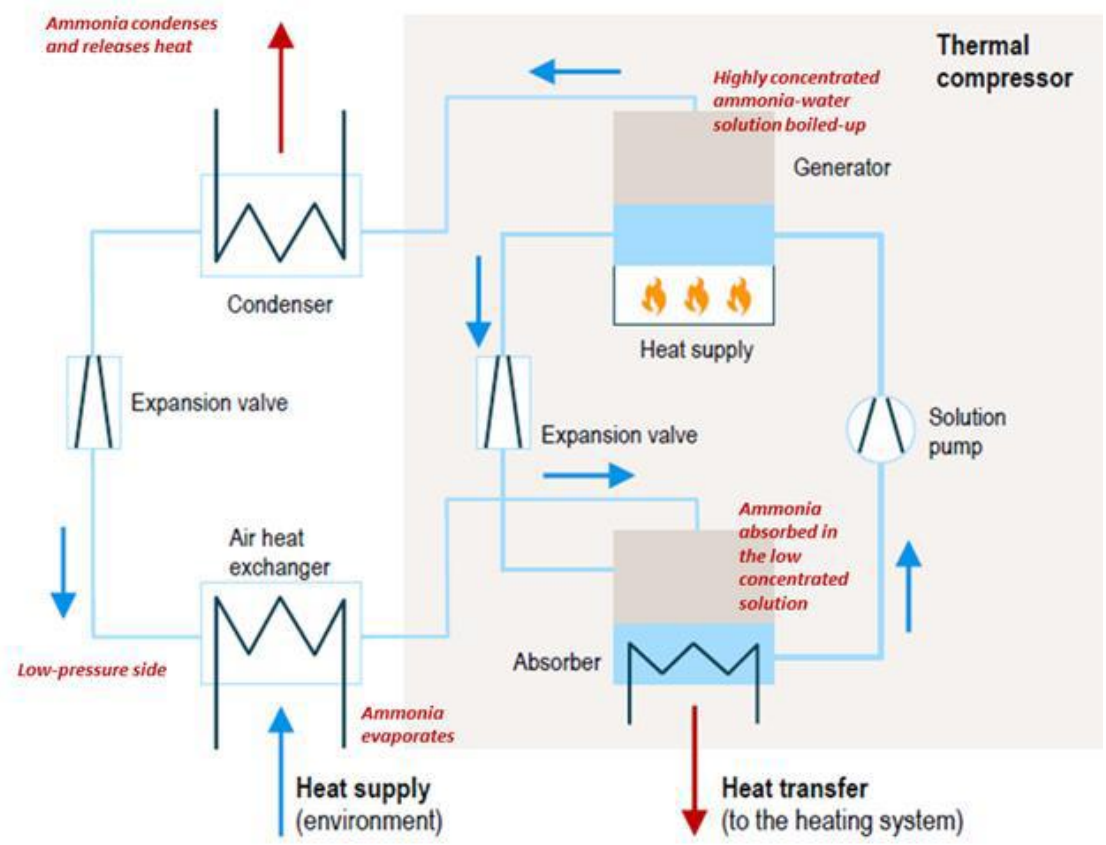

Figure 2: Thermodynamic cycle of a GAHP

(C) What are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?

The particular characteristics of Cr-VI is that in the basic media (water-ammonia) Cr-VI as corrosion inhibitor oxidizes iron on the steel surface and forms a protective layer which contains iron oxide and chromium (III) oxide. This passivating film builds a very effective protection of carbon steel against corrosion, which fulfills the requirements set by the GAHP technology (listed below). The GAHP is developed for residential buildings and the retrofit sector as replacement technology of the condensing boiler.

Benchmark	Requirements
Corrosion resistance	
– Under anaerobe conditions	– Process takes place in sealed circuit under anaerobe conditions
– In high NH_3 concentrations	– Concentrations up to 40% NH_3 in water – In boiling conditions up to 100% NH_3
– Protection in different aggregated state	– Change of aggregated phases from liquid to gaseous and back to liquid
– Protection at high pH values	– pH values >7
High operating temperature	– Process takes place in boiling conditions up to 200 °C
High operating pressure	– Pressure up to 26 bar
Long lifetime service	– Expected average service life of a boiler in EU is currently 24 years (VHK, 2019)
	– No service or refilling requirements
Prevention of gas formation	– Prevention of formation of H_2 gases – Prevention of building non-condensable gases

Figure 3: Benchmarks for substitutes

It is worth pointing out that “water ammonia absorption refrigerators” and “water ammonia heat pumps” are:

- Identical from the operating principle: both of them are thermodynamic machines operating according to the principle of the “heat pump” (in “refrigerators” the useful effect is the “cooling effect”, in heat pumps the useful effect is the “heating effect”; both of them are always simultaneously resulting from the heat pump principle that transfer heat from a “low temperature source” to a “high temperature source” reserving the natural low of heat from high to low temperatures).
- Extremely similar from the operating conditions (temperatures, pressure, refrigerant and sorbent). The heat pumps tend to operate with higher temperatures in the desorber/generator and for longer amount of time (number of hours of operation / year).
- Identical from the metallurgy / corrosion / construction point of view (carbon steel as pressurized vessel subject to possible corrosion by the boiling refrigerant solution).

Therefore, the characteristics and functions of Cr-VI in the GAHP application are consistent / overlapped to the function performed by Cr-VI in absorption refrigerators (with the only difference that in GAHP the operating environment is even more challenging for the higher temps and the operating hours of the equipment tend to be higher).

Therefore, the technical requirements for the corrosion inhibitor are substantially identical, only the “application focus” on a different benefit of the sorption appliances.

5. Information on Possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

1) Please indicate if a closed loop system exist for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

A closed loop system for heating, ventilation, and air conditioning (HVAC) systems for thermic comfort including gas absorption heat pumps exists. Refrigerant is considered as hazardous waste and disposed according to national laws and requirements by well-trained specialist installers / companies.

2) Please indicate where relevant:

☐Article is collected and sent without dismantling for recycling

☐Article is collected and completely refurbished for reuse

☒Article is collected and dismantled:

☐The following parts are refurbished for use as spare parts: _____

☒The following parts are subsequently recycled: _

The GAHP is picked up by authorized installers. The complete GAHP is dismantled and recycled. The refrigerant solution in the sealed circuit is

disposed as hazardous waste (ammonia content imposes proper handling of waste by professional and trained installers). The refrigerant solution, that might contain still a portion of the initially charged Cr-VI, is therefore properly handled since it belongs to a category of products where dismantling is imposed by law and also because the refrigerant (ammonia) implies proper handling (being a toxic substance). Installers and recyclers are trained in correct handling of the refrigerant solution.

☐ Article cannot be recycled and is therefore:

☐ Sent for energy return

☐ Landfilled

3) Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:

☐In articles which are refurbished

☒In articles which are recycled

After 24 years of service the amount of Cr-VI in the refrigerant solution is expected to be <<0.7%.
As the product is not yet on the market, exact values of concentration in Ariston GAHP cannot be stated.
In the initial request for Exemption #9, Dometic (Op. cit.) stated that around 90% of Cr-VI is reduced to Cr-III in the first two to three years of operating time.
Given that the working conditions of the inhibitor in an "absorption refrigerator" and in a "GAHP" are substantially identical, we expect that these trends of decay are applicable also for the inhibitor used inside a GAHP.
Therefore, in absence of any experimental results so far, we assume that at the end of lifetime of a GAHP more than 90% of Cr-VI in the refrigerant will be consumed.
Nevertheless, as already described in the request for Authorisation submitted to ECHA, AristonThermo will diligently work to explore all possible options to identify a replacement from Cr-VI. The initial step includes the assessment of the inhibitor with the specific AristonThermo sealed circuit (Stage 1 of replacement Roadmap: "Monitoring").
As part of such program, measurements of the Cr-VI content and its decay over time are being performed by AristonThermo product. Given the time horizon of this corrosion phenomenon, initial answers are not expected anytime soon.

☐In articles which are sent for energy return

☐In articles which are landfilled

6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

Alternative to "substance"
As anticipated, Ariston Thermo SpA performed an extensive research on possible alternatives and has come to the conclusion that currently no alternative exists, which could deal with the requirements set by the GAHP. Detailed information on the assessment of alternatives are presented in the application for Authorisation and in the answers submitted to RAC and SEAC during the opinion making process.
Ariston Thermo SpA is investing in testing programs to progressively decrease the concentration of Cr-VI in the refrigerant solution to the minimum possible concentration.

Alternative to "application"
The GAHP is considered as replacement technology for the condensing boiler. Electrical heat pumps cannot deliver the required high thermal lift. Information on the evaluation of the technologies are presented in more detail in the application for Authorisation.

(B) Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

As indicated above. Currently no substitute is available.

7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

Ariston Thermo SpA collaborates with European universities in monitoring and research new substitutes. Ariston Thermo Innovative Technologies (Aristonthermo R&D center for innovative / renewable technologies) has invested in creating an endurance test area to perform validation testing of future potential substitutes.

(B) Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

In the roadmap of substitution in the application for Authorisation five stages have been identified to establish a possible future substitute:

1. Monitoring/ Research
2. Identification
3. Validation

4. Product development
5. Market implementation

Overall, a period of around 20 years is expected from the detection of a possible alternative to the replacement of the corrosion inhibitor. Even with an already identified substitute the replacement is expected to take not less than 12-15 years. Corrosion / erosion in GAHPs is a very slow process. Effects of corrosion can materialise after 5 to 10 years without precognition.
Therefore, extensive real appliance testing under ALT (Accelerated Life Test) and / or HALT (High Accelerated Life Test) conditions are required. These tests are by far the longest and most expensive activities in establishing a possible substitute.

8. Justification according to Article 5(1)(a):

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

☒Authorisation

☒SVHC

☒Candidate list

☒Proposal inclusion Annex XIV

☒Annex XIV:

Application for authorisation was prepared by Ariston Thermo SpA. Commission decision pending.

☐Restriction

☐Annex XVII: Application is not affected by the restriction of Cr-VI (entry 47)

☐Registry of intrusions

☒Registration: Substance is registered by supplier

2) Provide REACH-relevant information received through the supply chain.
Name of document: _____

(B) Elimination/substitution:

1. Can the substance named under 4(A) be eliminated?

☐Yes. Consequences? _____

☒No. Justification:

GAHP appliance without Cr-VI as corrosion inhibitor will breakdown after a short period (months). More detailed information is available in the application for Authorisation.

2. Can the substance named under 4(A) be substituted?

☐Yes.

- ☐ Design changes:
- ☐ Other materials:
- ☐ Other substance:

☒No.

Justification:
Currently no substitute is available
The Inhibitor 7, mentioned in the initial request for Exemption #9 by Dometic as potential substitute, is not available to Ariston Thermo SpA.
As discussed previously, GAHP have even higher requirements on the corrosion inhibitor due to the higher boiling temperatures (>200°C) and increased numbers of operating hours than the sorption refrigerators.

3. Give details on the reliability of substitutes (technical data + information):___

   Not Applicable in absence of substitution substance

4. Describe environmental assessment of substance from 4(A) and possible substitutes with regard to

   1) Environmental impacts:
      The use of gas absorption heat pumps with Cr-VI as corrosion inhibitor is beneficially for the environment. Compared to other technologies (condensing boilers) available for the retro-fit sector, the GAHPs emit around 30-35% less CO_2. GAHPs are seen as a future solution in space and water heating of residential buildings. The natural refrigerant of water and Ammonia is the only refrigerant with a zero GWP and ODP. More details can be obtained from the application for Authorisation.
   2) Health impacts:
      Sodium chromate (Cr-VI) is a CMR substances and subject to Authorisation due to human health hazards. The detailed assessment of the health impacts was performed in the application for Authorisation. Due to the very minimum quantity used and the very high-automated production standards the impacts on human health has been reduced to extremely low levels. Detailed assessment is presented in the CSR of the application for Authorisation.
   3) Consumer safety impacts:
      Cr-VI is used in the hermetically sealed circuit as refrigerant solution. Any contact by consumer is not possible without destroying the appliance. Appliance will not need any charge to or maintenance of the sealed circuit for the entire life of the product

   Based on the outcome of the chemical safety assessment, Ariston Thermo SpA estimates the human health costs for the continued use to be 216€ - 362€. Compared to the benefits between 36,489,490€ (15%) and 50,232,841€ (4%).
   Overall, the benefits of the use of Cr-IV as corrosion inhibitor in GAHP outweigh by far the risk.

⇨ Do impacts of substitution outweigh benefits thereof?

Please provide third-party verified assessment on this:

Not Applicable in absence of substitution substance

(C) Availability of substitutes:

a) Describe supply sources for substitutes: _____
b) Have you encountered problems with the availability? Describe: _____
c) Do you consider the price of the substitute to be a problem for the availability?
   ☐ Yes ☐ No
d) What conditions need to be fulfilled to ensure the availability? _____

(D) Socio-economic impact of substitution:

⇨ What kind of economic effects do you consider related to substitution?

☐ Increase in direct production costs
☐ Increase in fixed costs
☐ Increase in overhead
☐ Possible social impacts within the EU
☐ Possible social impacts external to the EU
☐ Other: _____

⇨ Provide sufficient evidence (third-party verified) to support your statement: _____

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

European Commission support to GAHP technology development for residential applications:

- Heat4U program under the Seventh Framework Programme (FP7): https://cordis.europa.eu/project/id/285158/de

- i-GAP project, co-financed by the Regional Operational Programme of the European Regional Development Fund (ERDF ROP)

- Lombhe@t project, co-financed by the Regional Operational Programme of the European Regional Development Fund (ERDF ROP)

AristonThermo request for Authorisation to ECHA

- Authorisation application ID136-01: https://echa.europa.eu/de/applications-for-authorisation-previous-consultations/-/substance-rev/23315/del/50/col/synonymDynamicField_302/type/asc/pre/5/view

European Commission study (where environmental impact of GAHP technology is assessed)

- Ecodesign and Energy Labelling:
  VHK (2019). Task 4 – Technologies - Draft Final Report - Review study of Commission Regulation (EU) No. 813/2013 [Ecodesign] and Commission Delegated Regulation No. (EU) No. 811/2013 (Energy Label) - Prepared by VHK for the European Commission DG ENER C.3 - March 2019
  https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%204%20final%20report%20July%202019.pdf

European Commission study on Space and Water Heating Technology (where GAHP technology is included)

- Commission Regulation (EU) No. 813/2013 [Ecodesign] and Commission Delegated Regulation No. (EU) No. 811/2013 (Energy Label)

VHK (2019). Task 7 - Scenarios - Draft Final Report - Review study of Commission Regulation (EU) No. 813/2013 [Ecodesign] and Commission Delegated Regulation No. (EU) No. 811/2013 (Energy Label) - Prepared by VHK, Delft (NL), for the European Commission, DG ENER C.3 - March 2019, https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%207%20final%20report%20July%202019.pdf, checked on 15.12.2020

10. Information that should be regarded as proprietary

Please state clearly whether any of the above information should be regarded to as proprietary information. If so, please provide verifiable justification:

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11. References

Harald Moser; Gerald Zotter; Oleksandr Kotenko; René Rieberer (2013): The formation of non-condensable gases in ammonia/ water absorption heat pumps made of stainless steel - literature review and experimental investigation.

European Commission JRC (2013): Development of European Ecolabel Criteria for Water-based Heaters. TECHNICAL REPORT.

Treasury, H. M. (2018): The Green Book. CENTRAL GOVERNMENT GUIDANCE ON APPRAISAL AND EVALUATION

VHK (2012): Technical Background Study in Support of Environmental Product Policy for Hydronic Central Heating Generators covering task 1-5, Prepared by VHK for Institute for Prospective Technological Studies, 11 July 2012.Available online: https://www.vhk.nl/downloads/Reports/2012/VHK%20472%20Final%20Report%20IPTS%20study.pdf, checked on 15.12.2020

VHK (2019): Space and combination heaters, Review study Task 2 Market Analysis. Review study of Commission Regulation (EU) No. 813/2013 [Ecodesign] and Commission Delegated Regulation No. (EU) No. 811/2013 (Energy Label), Prepared by VHK, Delft (NL), in collaboration with BRG Building Solutions, London (UK) for the European Commission, Brussels (BE). Available online: https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%202%20final%20report%20July%202019.pdf, checked on 15.12.2020.