Exemption Request Form

Date of submission:

1. Name and contact details

1) Name and contact details of applicant:

Company: FEI Company
Tel.: +31 40 23 56165
Name: Casper Kruijer
E-Mail: casper.kruijer@fei.com
Function: RoHS Program Manager
Address: Achtseweg Noord 5, Eindhoven

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

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

2. Reason for application:

Please indicate where relevant:

- Request for new exemption in: Annex IV
- 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:
- Proposed or existing wording: The suggested title of this requested exemption is; "Lead and hexavalent chromium in reused spare parts, recovered from industrial monitoring and control instruments placed on the global market before 22 July 2017 and used in category 9 equipment placed on the market before July 22 2024, provided that use and reuse takes place in auditable closed-loop business-to-business return systems, and that the reuse of parts is notified to the consumer.
- This includes the maximum 7 years expiry period.
- Duration where applicable: **Minimum 7 years**
- Other:

3. Summary of the exemption request / revocation request

Manufacturers of electron microscopes regularly reuse parts that are removed from used equipment and these parts are refurbished and then used to repair other microscopes. Currently, these parts contain leaded solders and a few contain hexavalent chromium (CrVI). These can be used as spare parts in equipment that will be placed on the market before 22 July 2017 but without an exemption, could not be reused in equipment that will be placed on the market after this date. As lead-free versions will not be available until a short time before July 2017, FEI and other microscope manufacturers will in consequence build up a stock of refurbished used parts that contain lead-based solders The number of parts containing lead that will be needed will gradually decline, without an exemption, as the number of post-2017 microscopes placed on the market increase and old microscopes are replaced. There are no technical reasons why parts made with leaded solders cannot be used after 2017, but without an exemption, many will have to be disposed of as waste and replaced by new parts that comply with the RoHS substance restrictions. Reuse of parts within a closed loop system by FEI will have a significantly smaller environmental impact than from the creation of waste and replacement by new parts and so this exemption is requested because the alternative (reuse of parts) has a less negative impact on the environment as is demonstrated by a comparative life cycle assessment.

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: Lead in solders is used to make electrical connections on printed circuit boards (PCB), to connectors and inside components. These PCBs and other component parts are removed from used and defective electron microscopes, they are then refurbished and then reused to repair other electron microscopes. The types of parts that are reused by FEI include the following examples:

- Many types of printed circuit boards
- High voltage power supply units
- Microscope stages
- Microscope column parts
- Vacuum pumps and other vacuum components
- Camera heads
- Laser assemblies
- Detectors

Due to the need for high precision and stability, all electron microscope parts need to be very reliable and robust and as a result have very long useful lifetimes and so each part could in principal be reused several times.

At end of life, the preferred option in the hierarchy is the reuse of parts which is preferable to recycling with materials recovery. This is because this creates less waste and consumes less raw materials and energy. This is clearly encouraged by the EU WEEE directive (recital 20) and is also encouraged by the RoHS recast in Article 4.5 although the dates in this Article are appropriate only for types of equipment that were in scope of the original RoHS directive 2002/95/EC and are not suitable for industrial monitoring and control instruments that enter scope July 22 2017.

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

1	7	
2	8	
3	9	**YES**
4	10	
5	11	
6		

b. Please specify if application is in use in other categories to which the exemption request does not refer: Re-use of non-compliant parts is permitted by RoHS Article 4.5 (until 2016) and the Oko Institut has recommended that the European Commission grants a very similar exemption for parts of medical devices in category 8, although with more suitable later dates.

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

The requested exemption will be applied in

- monitoring and control instruments in industry YES
- in-vitro diagnostics
- other medical devices or other monitoring and control instruments than those in industry YES – (other monitoring and control instruments include some simpler models of electron microscopes that are used by students at universities and research facilities)

2. Which of the six substances is in use in the application/product?
(Indicate more than one where applicable)

Pb, CrVI

3. Function of the substance:
Lead – used in solders for printed circuit boards, to make connections to connectors and in some types of components. Hexavalent Chromium could be used as passivation layer to prevent corrosion of steel parts (sheet metal parts).

4. Content of substance in homogeneous material (% weight): ~37% Lead in Solder, estimated less than 10% CrVI in the passivation layers.

5. Amount of substance entering the EU market annually through application for which the exemption is requested: The following estimates are for FEI's products only. FEI estimates that it has a market share in the EU of >50%. 44 kg per year global (1/3rd is for EU sales so is 14.7 kg), but this is already in use before the compliance deadline.
Used parts are collected from FEI equipment in use world-wide and most is shipped to its EU warehouse for refurbishment and then reuse globally. Segregation of parts from EU equipment from parts from non-EU equipment is impractical as parts used in the EU and outside the EU are identical and are refurbished using the same processes. Although some parts collected from non-EU equipment are reused as parts in EU equipment, an equal quantity of parts collected from EU equipment will be reused as parts in non-EU equipment and so there will be no overall increase in the amounts of lead or CrVI placed on the EU market.

PCBs: The quantity of lead that will be present in reused PCBs is estimated to be:
One solder joint has about 0.02 grams of solder. On average we assume 1000 joints per board (PCB), leading to 20 grams of solder per board.
Database analysis shows FEI has about 5500 boards in Service Stocks being used yearly, we calculate about 100 kg of solder in total and about 40% of this would be lead (eutectic solder is 37% Lead). The amount of lead in PCBs that are reused globally per year is estimated at 44kg. If this continues for a 5 year period after July 2017, the amount of lead is 220kg but this is not new lead entering the EU market.

Column and stage components are primarily steel and aluminium but also include a small number (up to 200 bonds per device) of electrical connections which are made with leaded solder. This will be 6.4 kg lead per year globally (so 2.1kg Pb in the EU)

CRVI: The quantity of hexavalent chromium present in reused parts is calculated as follows: Typically 10 pieces of sheet steel with CrVI passivation coatings used in reused parts per year in the EU. Passivation coating typical thickness is up to 500nm (typical maximum thickness for yellow passivate[1]) and density is 5g/cm^3. Average sheet area = 20 x 50cm - two sides so 2 x 10 x 20 x 50 = 100,000cm^2. Mass of coating is calculated from: 0.00005 cm (thickness) x 100,000 (area) x 5.0 (density) = 5 grams[2]. As the CrVI content is expected to be less than 10%[3], the quantity of CrVI in reused parts per year is 0.5 grams (this is a worst case estimate as coatings are probably <500nm thickness).

Please supply information and calculations to support stated figure.

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[1] "Chromiting, chromium(VI)-free Passivating Basecoat for Deltacoll on Zinc and Zinc Alloys, P. Hulser, 1999.
[2] Japanese standard JIS H8625 assumes this value.
[3] CrVI concentrations are typically up to ~30% of total Cr in coatings but these also contain other oxides and additives so an estimate of 10% CrVI has been made.

6. Name of material/component: Lead in Solder and Hexavalent Chromium for passivation layers preventing corrosion of sheet metal parts. Passivation coatings are complex mixtures of oxides and their exact composition is usually uncertain.

7. Environmental Assessment:

LCA: Yes – see ERA Technology Report 2013-0291

No

(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?

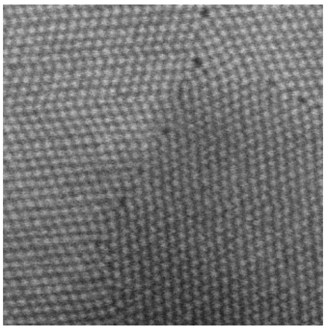
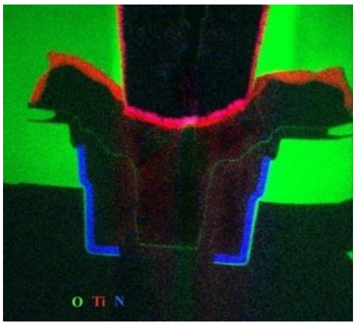
Scanning electron microscopes (SEM) and transmission electron microscopes (TEM) are instruments that are used for research and development and for investigating defects and failures. They are used to obtain images of items and materials which can have good depth of field, three-dimensional and can be very high magnification. They are also capable of obtaining chemical composition information and TEM can also provide crystal structure information of materials.

Small Dual Beam (SDB) and Large Dual Beam (LDB) equipment consist of an electron beam as well as a Focussed Ion Beam (FIB). The latter can be used for material manipulation like adding or removing atoms from a surface.



Picture 1: SEM/SDB, TEM and LDB equipment

Objects are most commonly examined by visible light as the human eye is sensitive to these wavelengths range. There are however two limitations of visible light which are the maximum magnification and the depth of field at high magnification. Objects and features that have a size that is similar to, and smaller than the wavelength of light are invisible and so cannot be seen with visible light microscopes. As magnification increases, focusing becomes more critical and so the images are clear only within a very small distance range (the depth of field) and they appear to be two dimensional. Magnification of 1000 times is about the maximum that is achievable with visible light microscopes, which is good enough to see human blood cells of ~ 1 micron diameter, whereas imaging of micro-organisms such as viruses and bacteria and features on modern integrated circuits, etc. need much higher magnification. These limitations are overcome by replacing visible light by a beam of electrons which have extremely short wavelengths and so much higher magnification is possible. Features as small as one tenth of a nanometer, which is the size of individual atoms can be seen with TEM.

Picture 2: TEM image of an atom structure (l) and SEM image of a wafer cross section (r)

SEM obtains images of surfaces by detection and analysis of reflected electrons or X-rays emitted from the surfaces being examined from which visible images are generated, either with phosphor screens or are electronically generated. Very thin specimens are needed for TEM as the electron beam needs to pass through the sample before being focussed onto the detector. TEM can be used to view real images from the beam that passes through the specimen or diffraction patterns from crystals in the sample, which give composition information.

Modern SEM and TEM are very complex instruments consisting of many complex precision engineered parts as well as the control electronics. Complex electrical circuits are used to generate and control the high energy electron beam, to accurately control the position of the specimen mounted on a "stage" and the electronic optics that control and focus the electron beam. Usually, the interior must have a high vacuum as air scatters and blocks the electron beam. The image can be created electronically using the characteristics properties of the detected electrons or X-rays, such as their energy and intensity. Standard images are black and white and represent the intensity from each location on the surface of the object but false colour images can be created using special software which is based on the energy or wavelength of the detected electrons or X-rays. A special type of SEM is used for examination of specimens that would be damaged by high vacuum which are the "Environmental SEM" in which the sample can be in air or in a low vacuum but the electron gun and most of the electron pathway are at high vacuum.

Component parts of electron microscopes include a very wide variety of printed circuit boards, some of which are very complex. The interior of the microscope is at high vacuum and so thick steel parts are used to withstand the pressure. "Column" parts and also parts attached to the vacuum chamber such as the stage, cameras, detectors, etc. all need to withstand the vacuum pressure and so are very heavy. For example, one type of column weighs 100kg. Samples are examined on special stages that move using electric motors in three axes and these form part of the vacuum chamber and so also have thick metal sections and one of the largest 300mm stages weighs 200kg. Other parts that are reused that also need to withstand the high vacuum are special cameras, electron beam accelerators, detectors and wafer handlers (for examination of silicon wafers), which typically weigh up to 100kg each. Also reusable are special high voltage power supplies that power the electron gun and vacuum pumps which can weigh up to 100kg.

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

SEM and TEM both use many complex printed circuit boards. Currently, these are made using lead-based solders as lead-free versions will not be mandatory in professional SEM and TEM until 22 July 2017, although simpler easier to use SEM that may be used by University students would need to comply by 2014. The SEM and TEM manufactured by FEI are the most advanced in the world and due to their complexity and the level of skill needed by operators, are designed to be used exclusively by professionals. FEI is carrying out research to build PCBs with lead-free solders but this is expected to take several more years due to the specific design requirements of advanced SEM and TEM PCBs. These circuits must be extremely stable and not affected by environmental conditions such as temperature or electromagnetic interference and the signals generated to control electron optics must not drift over time. Achieving the level of electrical stability required is very challenging and so FEI expect to have lead-free PCBs for all of its products only a short time before the 2017 deadline. At this time, FEI will have in stock a large number of PCBs and other electron microscope parts that will have been refurbished and can be used in future years but which will contain lead-based solders.

Electron microscopes are long lived products and so steel parts need to be protected from corrosion. In the past, coatings containing hexavalent chromium were used, but hexavalent chromium-free coatings are now used by FEI. Some older parts with hexavalent chromium coatings will continue to be reused as spare parts in future years.

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 return system already exists and is in operation for FEI's electron microscopes and their component parts. The electron microscopes are highly complex instruments that must be repaired and maintained by highly trained and qualified engineers who are approved by FEI. When an electron microscope is repaired and a part needs to be replaced, the engineer will return the used parts to FEI and will use refurbished parts from FEI to replace the parts that they remove. In this way, FEI can ensure that their parts are under their control from manufacture to end of life in a closed loop. They are able manage the entire product cycle so that uncontrolled use or disposal of FEI's parts will not occur. FEI take-back used parts from customers world-wide, then repair and refurbish if necessary or alternatively organise environmentally safe disposal by professional recyclers if the parts cannot be reused.

As FEI's electron microscopes are very complex, maintenance and repairs by unqualified personnel is highly unlikely and so FEI are able to ensure that there is a closed loop system for a very high percentage of parts of their products.

2) Please indicate where relevant:

- Article is collected and sent without dismantling for recycling
- Article is collected and completely refurbished for reuse YES
- Article is collected and dismantled:
    - The following parts are refurbished for use as spare parts: See below
    - The following parts are subsequently recycled:
- Article cannot be recycled and is therefore:
    - Sent for energy return
    - Landfilled

Parts from electron microscopes and TEMs are removed for two reasons; i) as they are faulty or ii) at end of life. It is often possible after removal to repair and refurbish these parts so that they can be reused, mainly as spare parts in other electron microscopes and TEM some of which will be placed on the EU market after 22 July 2017 and so need to comply with RoHS. It is also possible to reuse refurbished parts and components in new equipment.

A typical sequence of events involving reuse of parts is as follows:

- New FEI microscopes are constructed with new parts. These are sold world-wide.
- After a period in use, a part of a microscope becomes faulty.
- Faulty parts are removed from equipment world-wide and replaced with new or refurbished parts taken from FEI's stock. Repairs are carried out on-site as quickly as possible so that the user / operator of the microscope can re-start working as soon as possible. Minimising "down-time" is essential as this will delay R&D, manufacturing or health monitoring.
- The removed defective parts are returned to FEI where they are repaired and placed in FEI's stock for future use. Each refurbished part will probably not be used in the same microscope that it was originally installed and reuse is most likely to occur if it can be used as a spare part in any electron microscope (sometimes several times), including those placed on the market after 22 July 2017. A part originally removed from a microscope located outside the EU so which has not been placed on the EU market, may be refurbished then reused in a microscope located in the EU.

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

- In articles which are refurbished – Global market: 44kg of lead per year from PCBs (+ 6.4kg in other parts) and up to ca. 0.5 grams CrVI. EU market is one third of these values.
- In articles which are recycled
- In articles which are sent for energy return
- In articles which are landfilled – none – no new Pb or CrVI will be used in new equipment placed on the EU market after the category 9 compliance deadline

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

There are two alternative scenarios (these options are quantified in answer to Q8B.3):

- **With exemption**: Parts removed from electron microscopes will be refurbished and then reused to repair other electron microscopes including those placed on the market after 22 July 2017
- **Without exemption**: Parts that contain RoHS substances cannot be reused in electron microscope placed on the market from 22 July 2017 and so as the number of pre-2017 SEM and TEM in use gradually decline, so an increasing number of parts cannot be used and so will become waste. The number of pre-2017 parts will be stable until this date, so an increasing proportion will become waste earlier than if an exemption was in force and these will have to be replaced by new "compliant" parts. Construction of new replacement parts will consume energy and raw materials. Since most of the parts are very heavy in weight (>100kg for columns and stages), shipping of these spare parts to other global warehouses should be avoided due to high shipping costs and transport GHG emissions and the risk of mixing old and new items.

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

Substitute parts must be equally reliable to those currently in use and FEI are currently developing equipment which will be made with lead-free solders and expects to be able to produce equipment with these solders before July 2017. This exemption, however, is being requested on the basis of the criteria that having the exemption will have a less negative impact on the environment than without the exemption.

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.

Lead: PCBs and other parts made with lead-free solders are being developed and will be used as soon as these have been shown to be reliable. However, a significant number of used PCBs and components that were made with lead-base solder will be collected from used equipment which after refurbishment, can continue to be used and this will have a smaller environmental impact than if they become waste and had to be replaced.

CrVI: Parts having coatings containing CrVI are no longer produced by FEI and all new parts do not contain CrVI. However a small number of older parts that will be reused in the future will contain CrVI.

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

Not applicable

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 **No**
- SVHC **No**
- Candidate list **No**
- Proposal inclusion Annex XIV **No**
- Annex XIV **No**
- Restriction **No**
- Annex XVII **No**
- Registry of intentions **No**
- Registration **Not applicable**

2) Provide REACH-relevant information received through the supply chain.

(B) Elimination/substitution:

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

- Yes. Consequences?
- No. Justification: -

Yes, please see answers to previous questions

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

Yes.

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

No.

Justification: **Yes, please see answers to previous questions**

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

Yes, please see answers to previous questions

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to

1) Environmental impacts: **YES, explained below:**
2) Health impacts: **See below**
3) Consumer safety impacts: **None**

- Do impacts of substitution outweigh benefits thereof? **Yes,**

There are two options:

1. Reuse parts containing lead and CrVI with exemption
2. Without exemption, discard parts that contain lead solder and CrVI and replace by new parts

There is a larger negative environmental impact for option 2 than for option 1 as shown below:

Reuse of printed circuit boards made with lead solder (PCBs):

PCBs used in electron microscopes have already been produced and should have very long lifetimes, in excess of 25 years. More PCBs will be made with lead until lead-free versions are developed prior to the 2017 deadline and so by the time when industrial category 9 equipment enters the scope of RoHS, there will be a large number of these PCBs in use and in store ready for reuse and these could continue to be used for at least 25 years.

- With an exemption, these can be removed from used equipment, refurbished then reused. Refurbishment involves very little energy or raw materials and almost no waste is generated.

- Without the exemption, these PCBs would become waste and have to be replaced by new PCBs with the corresponding consumption of raw materials and energy for fabrication.
    - Quantity of waste – 5500 PCBs p.a. are refurbished and reused annually on global scale (and 1500 PCBs in the EU). Their total mass is about 550 kg.
    - Energy consumed making replacements, Average reflow ovens consume about 100,000 kWh per year and typically produce about 50 PCBs per hour. If these operate 1,920 hours per year (5 days / week, 8 hours / day and 48 weeks per year), then production of 5500 replacement PCBs will consume 5.7MWh/year. Energy will also be consumed to manufacture the replacement materials (solder, laminate, components) but it is impossible to calculate the total amount with any precision. The US EPA has calculated that the energy consumed mining, refining and processing of the metals used for soldering PCBs with SAC solder paste will consume 1,863MJ/kg of solder, so 110kg of SAC solder will consume 20.5GJ (57MWh)[4].
    - Mass of raw materials as replacements (PCB=550kg, solder=110kg (mostly tin), components= 550 tonnes)

Reuse of stages and columns made with lead solders:
Columns and stages consist of large pieces of steel and aluminium but relatively small amounts of electrical components including soldered connectors. If these are removed from an electron microscope, they can be refurbished and reused in other microscopes of the same design. Without an exemption, used parts that contain lead-based solder bonds cannot be refurbished and re-used in the EU in post July 2017 microscopes so these will become waste and have to be replaced by new parts. As they consist mainly of steel and aluminium, they will have a scrap metal value and so will be recycled by melting, followed by fabrication into other parts. Replacement columns and stages need to be fabricated from steel and aluminium. In a typical year, components containing the following masses of these metals could be reused in electron microscopes:

- Steel 580 tonnes
- Aluminium 10 tonnes

There are various published values for the energy required for the production of steel and aluminium. This is due to the variations in the energy efficiency of production plant across the world and also because there is a big difference between primary metal manufacture and scrap reuse energy consumption. . Typical published values for primary metals manufacture are 30MJ/kg (steel) and 155MJ/kg (aluminium) respectively[5] and based on these values, the additional energy consumption from not being able to reuse these columns and stages would be 7850GJ per year (2.2 GWh / year). Some amount of waste would also be created as the connectors and cables could not be reused. Refinery chemicals will also be consumed (for both primary and secondary processes) and produce the associated process emissions. Best available technology guidance published for the industrial emissions directive (IED BREF guides) include the energy consumption of the best EU processes which are:

Metal	Primary energy consumption	Secondary metal production
Steel	17 – 23 MJ/tonne (average = 21MJ/tonne)	3.5 – 4.5 MJ/tonne (about 40% of EU consumption)
Aluminium	137 – 158 MJ/tonne	Depends on feedstock, can be up to 20% of primary

In practice, if steel or aluminium need to be used to manufacture replacement electron microscope components, the proportion of primary and secondary metals that will be used will be the same as the EU's overall consumption. Secondary only could not be used without

[4] http://www.epa.gov/dfe/pubs/solder/lca/lca-summ2.pdf (see table 4.1 and SAC density from table 2.1)
[5] http://www.agentschapnl.nl/sites/default/files/GER-waarden_oktober_2012.xls

reducing its availability for other products which would then need to be made with more primary metal.

Reuse of steel panels with CrVI coatings

The impact of reuse of these is relatively small as less than ten panels are likely to be reused each year. However, the composition of coatings on older panels is usually unknown and so many more panels would not be used without this exemption as the surface coating composition is not known and chemical analysis could cause damage. Therefore many more than 10 per year would be discarded and have to be replaced by replacement steel panels. This would require more energy for steel recycling and new panel fabrication but also some energy consumption and emissions for passivation coating; these would not be necessary if these panels could be reused.

There will be different environmental impacts from printed circuit boards, stages, columns and other parts during their life cycle depending on whether this exemption is granted. The differences are shown below.

Life cycle phase	1. With exemption	2. Without exemption
Production of materials and manufacture of parts	Parts already produced so there will be a much smaller impact as new parts will be needed only to replace those that cannot be refurbished	New materials would have to be produced and parts constructed to replace all unusable parts. The environmental impact is quantified below
Use phase	There is no evidence that lead in solders or CrVI coatings poses a risk to users of electron microscopes. Lead and CrVI are not volatile so there are no gaseous emissions. All lead solder is internal and users and service engineers will not normally touch solder. There is no evidence that infrequent skin contact with CrVI passivation coatings is harmful	New parts will be similar in design and must have the same function, although lead-free solders will be used in new parts
End of life	Parts are re-used at least once, some several times, but all will eventually be recycled, but this is delayed by reuse of parts	Parts made with lead solders will become waste sooner if they cannot be reused. Recycling of large metal parts will have significant energy consumption to recycle metals.

Risk from continued use of lead in solders of reused parts within closed-loop.
Once lead is in solder bonds within equipment it poses no risk during the use phase as there are no hazardous emissions. Users and service engineers would not normally touch solder bonds, in fact this is strongly discouraged as electrostatic damage may occur. However, brief skin contact with lead does not pose a risk as no lead will be transferred into the human body from solder in the form of solder bonds attached to equipment. Lead solder is no friable or dusty and its air formed oxide is very resilient so transfer of lead compounds to the skin is not

likely to occur and there is no evidence that users of electrical equipment are at risk from lead in solders. In a closed-loop return, refurbishment and reuse system, only FEI approved engineers will handle these parts. Removal from used equipment and re-installation will involve either no physical contact or only very infrequent contact with solder bonds. However, as described above, transfer of lead compounds to workers is not likely due to the nature of solder alloys. Refurbishment may require some soldering processes. This will involve melting solder, removal of components ort connections and re-attaching new components and connections with fresh solder. The soldering process involves melting the lead-based solder at about 200 - 250˚C with a suitable flux. At this temperature, no lead compounds are emitted as any oxide that is formed is a solid at this temperature, so not volatile and is trapped within the flux. Fumes will be observed but these are only from the flux. These can be hazardous so fume extraction is used where soldering processes are carried out to prevent workers inhaling these fumes. Similar fumes are also produced when soldering with lead-free solders (i.e. to make replacement parts) so reuse of parts reduces the quantity of flux fumes that are produced. By ensuring that parts are reused within a closed-loop system, no parts containing lead will be sent to recyclers who carry out uncontrolled dangerous recycling processes.

Risk from continued use of CrVI coatings on reused parts within closed-loop.
Passivation coatings on steel parts are relatively stable and resilient so that material does not flake off and there is no transfer of CrVI to human skin when handled. There is no published evidence that frequent handling by workers of parts with CrVI passivation coatings is harmful. One reason for using these coatings is their resilience in that they do not rub off or create dust. Therefore workers who handle these parts will not be exposed to a risk from the very small amounts of CrVI within the coatings.

Risk from early recycling of parts without this exemption
Without this exemption, PCBs with lead solder that are removed could not be refurbished and so will become waste. Currently, a small proportion of WEEE generated in the EU is exported illegally to countries where unsafe recycling occurs and lead poses a risk where this occurs, although there is no evidence that electron microscope PCBs are illegally exported. Therefore extending the life of these PCBs from electron microscopes will delay the time when illegal export might occur. This delay should be beneficial as the EU is making efforts to end illegal exports and the governments of destination countries should also act to prevent these dangerous practices. Other parts that contain lead solders such as column parts are not recycled in the same way due to their valuable metal content. These tend to be recycled by melting but without removal and recycling of the small number of electrical components and the solder bonds. The lead is therefore vaporised by the melting process but in well controlled EU processes that are regulated by the Industrial Emissions Directive, this lead should be recovered and disposed of safely. However some metal parts may be exported to countries where lead emissions could occur due to the lack of local regulation. So as with lead in PCBs, delaying end of life of these parts will allow governments more time to tighten up on enforcement of their waste shipping legislation, so that when these parts eventually reach end of life, there will be less risk of unsafe recycling processes being carried out.

Recycling steel with passivation coatings does not pose a risk as during melting, the steel reacts with CrVI to form CrIII.

Quantitative comparison of environmental impacts for two options:
The waste created and energy consumed for the two options; i) with exemption and ii) without exemption are quantified below for the years until 2027.

Future year quantities of waste				Compliance deadline										
	2014	2015	2016	**2017**	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
With exemption														
PCBs available for reuse	5500	5500	5500	**5500**	5500	5500	5500	5500	5500	5500	5500	5500	5500	5500
Stages / columns, etc available for reuse	4238	4238	4238	**4238**	4238	4238	4238	4238	4238	4238	4238	4238	4238	4238
Mass of PCB waste [kg]	550	550	550	550	550	550	550	550	550	550	550	550	550	550
Mass of stage / column waste [tonnes]	580	580	580	580	580	580	580	580	580	580	580	580	580	580
Without exemption														
PCBs available for reuse	5500	5500	5500	**2644**	0	825	2090	2915	3520	3905	4235	4455	4620	4785
Stages / columns, etc available for reuse	4238	4238	4238	**2119**	0	636	1610	2246	2712	3009	3263	3433	3560	3687
Number of new replacement PCBs	0	0	0	**2856**	**5500**	**4675**	**3410**	**2585**	**1980**	**1595**	**1265**	**1045**	**880**	**715**
Number of replacement stages, columns, etc	0	0	0	**2119**	**4238**	**3602**	**2628**	**1992**	**1526**	**1229**	**975**	**805**	**678**	**551**
Mass of PCB waste	0	0	0	**285.6**	**550.0**	**467.5**	**341.0**	**258.5**	**198.0**	**159.5**	**126.5**	**104.5**	**88.0**	**71.5**
Mass of additional waste stage / column waste (tonnes)	0	0	0	**278**	550	467.5	341	258.5	198	159.5	126.5	104.5	88	71.5
Energy consumption for replacement parts (GJ)	0	0	0	30,766	61,070	51,998	35,257	22,905	15,246	21,282	12,741	8,047	15,776	14,506
Accumulated additional energy consumed (GJ)	0	0	0	30,766	91,836	143,834	179,091	201,995	217,241	238,523	251,263	259,310	275,086	289,591

Please provide third-party verified assessment on this: **See ERA's accompanying assessment**

(C) Availability of substitutes: See separate request dossier

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? **No**
d) What conditions need to be fulfilled to ensure the availability?

This is not applicable, see answer to Q7B.4

(D) Socio-economic impact of substitution: Not having this exemption could detrimentally affect electron microscope manufacturers based in the EU if they have to dispose of many millions of euros worth of parts whereas their non-EU competitors who sell mainly to customers outside the EU do not need to do this. EU microscope manufacturers will be at a competitive disadvantage and job losses could occur. There are about 5 EU-based electron microscope manufacturers and 7 that are located in the USA and Asia. Two thirds of electron microscopes are sold outside of the EU and so some non-EU manufacturers could focus on non-EU markets and so may not need to dispose of non-compliant parts. This is not however the main justification for this exemption request.

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

Increase in direct production costs - Cost of provision of new replacement parts
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:

None

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: