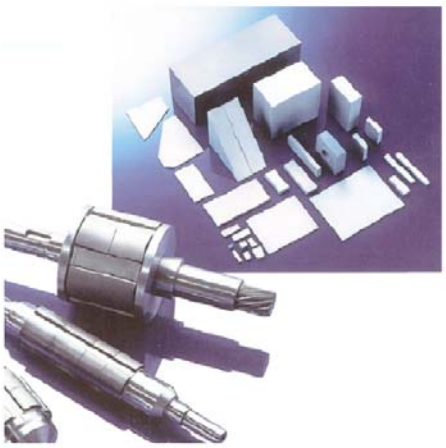
ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

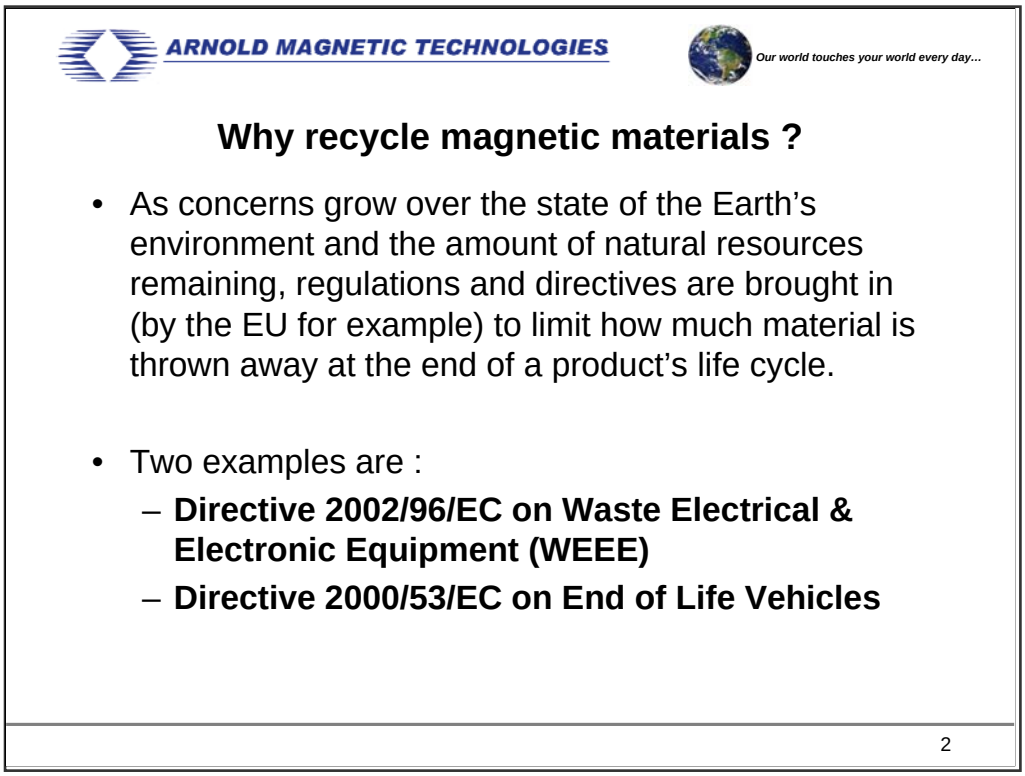
THE RECYCLING AND FUTURE SELECTION OF PERMANENT MAGNETS AND POWDER CORES



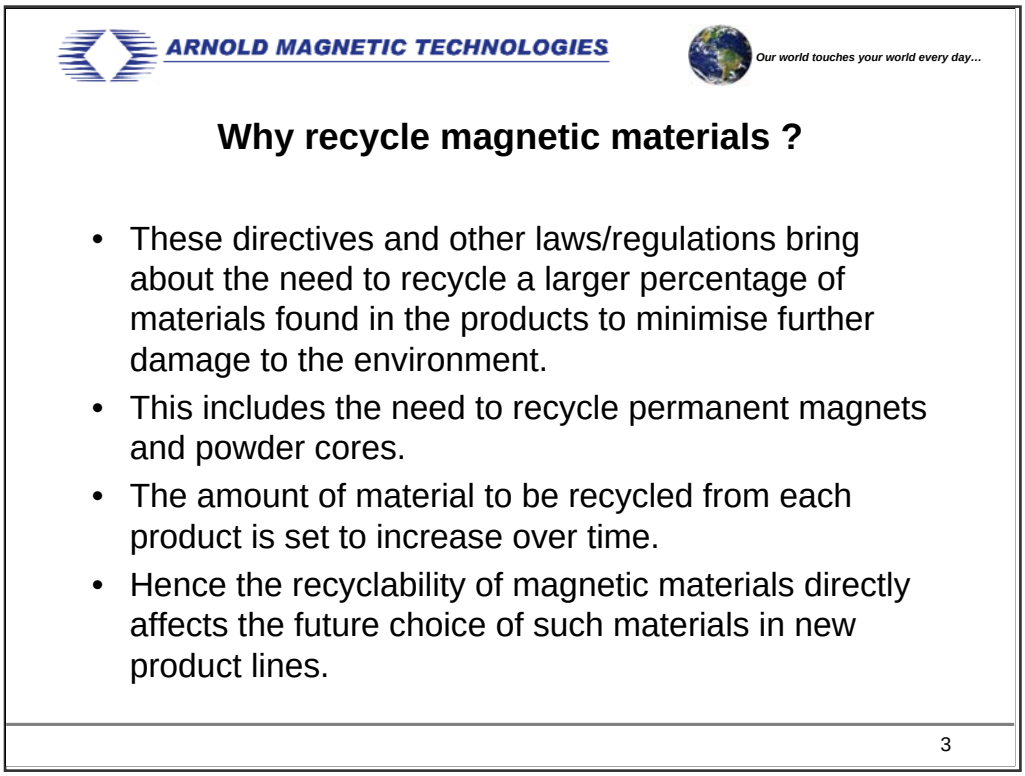
Presented by Dr Ewan Goodier
Applications Engineer
Swift Levick Magnets

1

- This presentation covers the following topics:
  - The need to recycle;
  - Aspects to consider when designing with magnets;
  - RoSH ;
  - WEEE;
  - The recycling of permanent magnets and powder cores; and
  - Magnet designs for the future.



- The natural resources on Earth are depleting.
- The amount of material being thrown away has increased over the last few decades - much of this material could be recycled/re-used.
- Countries are starting to implement laws that force companies and households to recycle more of their waste.
- In the European Union, this is in the form of Directives.



- The Directives, Regulations and Laws affect nearly all companies.
- The amount of materials to be recycled are set to increase over time.
- Permanent magnets and powder cores can be recycled. This will be discussed later.
- The ease and cost of recycling different materials will be factors for new products.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day...

Factors affecting Magnet Material Selection

The choice of magnet material for a given application is governed by standard factors such as :-

- Cost.
- Energy product of material.
- Maximum operating temperature.
- Stability of output with respect to operating temperature range.
- Stability of output with respect to other external demagnetising forces e.g. armature currents.
- Operating environment e.g. high humidity.

4

- The density of magnets and ultimately the total weight of magnets used is set to become an issue. For comparison purposes example densities of materials are as follows:-

  - SmCo 8.35-8.4 g/cm3
  - NdFeB 7.5 g/cm3
  - Alnico 7.3 g/cm3
  - Ferrite 4.8-4.9 g/cm3
  - FM-60 bonded ferrite 3.72 g/cm3
  - bonded SmCo 5.5 g/cm3
  - bonded NdFeB 5.1 g/cm3

ARNOLD MAGNETIC TECHNOLOGIES

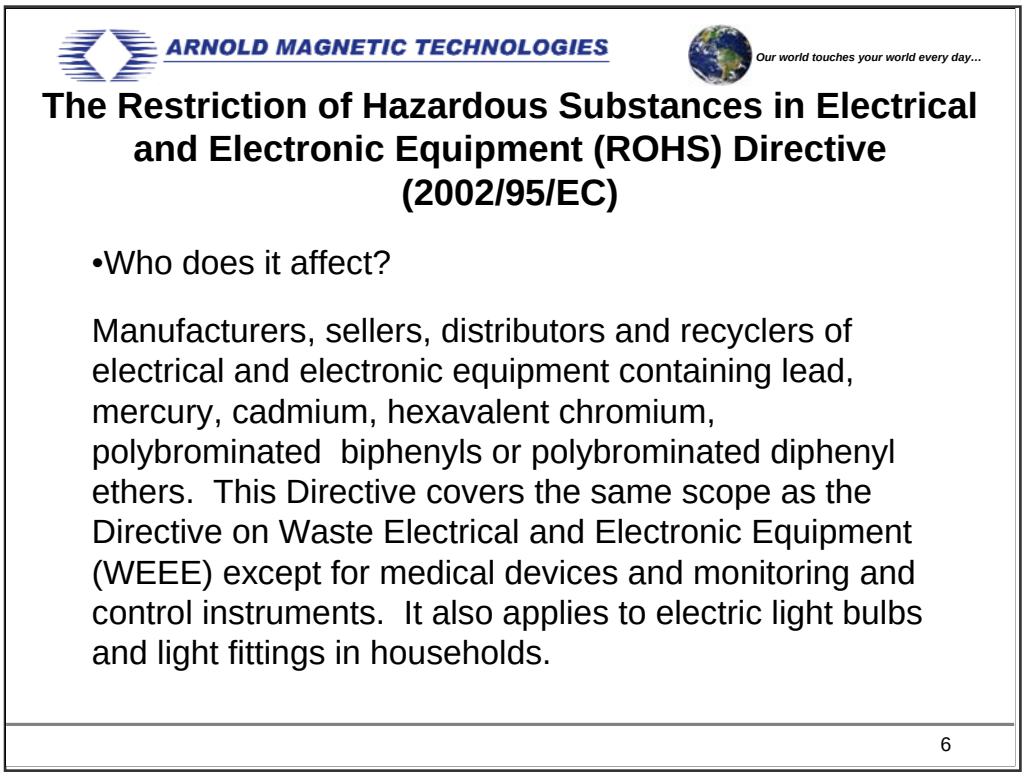
Our world touches your world every day…

Magnet Material Selection cont.

- ROHS and WEEE are now new factors in determining magnet material selection.
- The introduction of ROHS means that the actual constituents within magnetic materials is a factor in material selection for some companies.
- The introduction of WEEE affects how companies recycle components in their products so the recyclability of component materials is of increasing importance.
- So what exactly is ROHS and WEEE ?

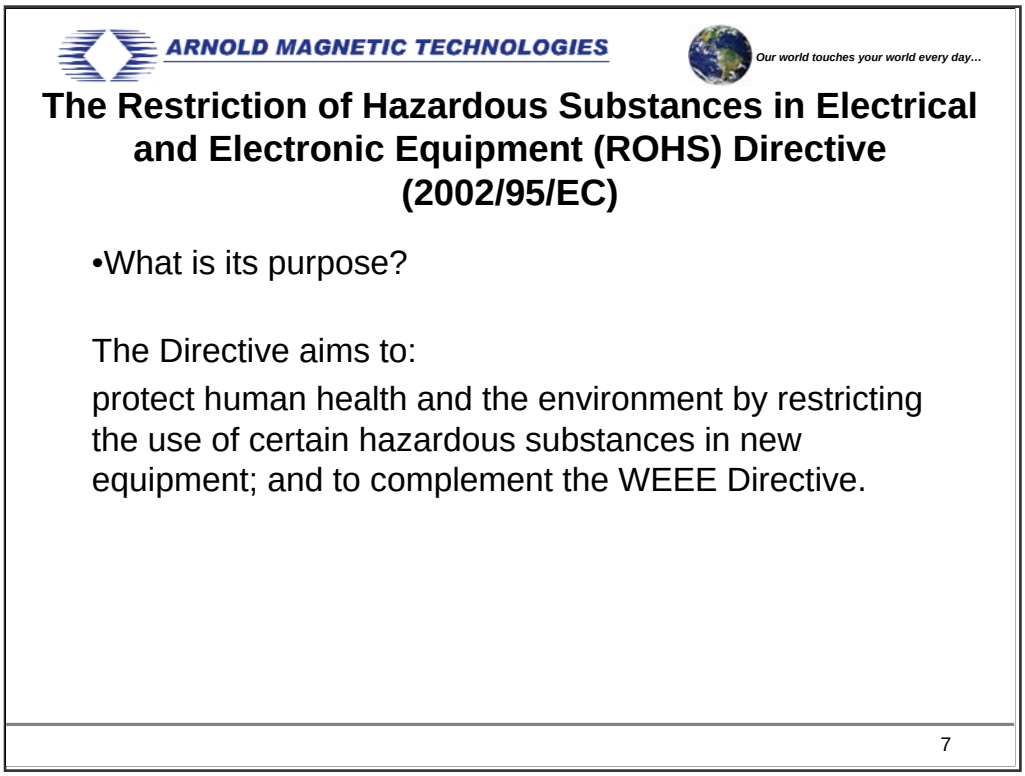
5

- ROHS and WEEE need to be taken into account for new and existing products.
- ROHS affects the selection of the material as it is related to the constituents of the materials themselves.
- WEEE relates to the recycling and re-use of materials in certain products.



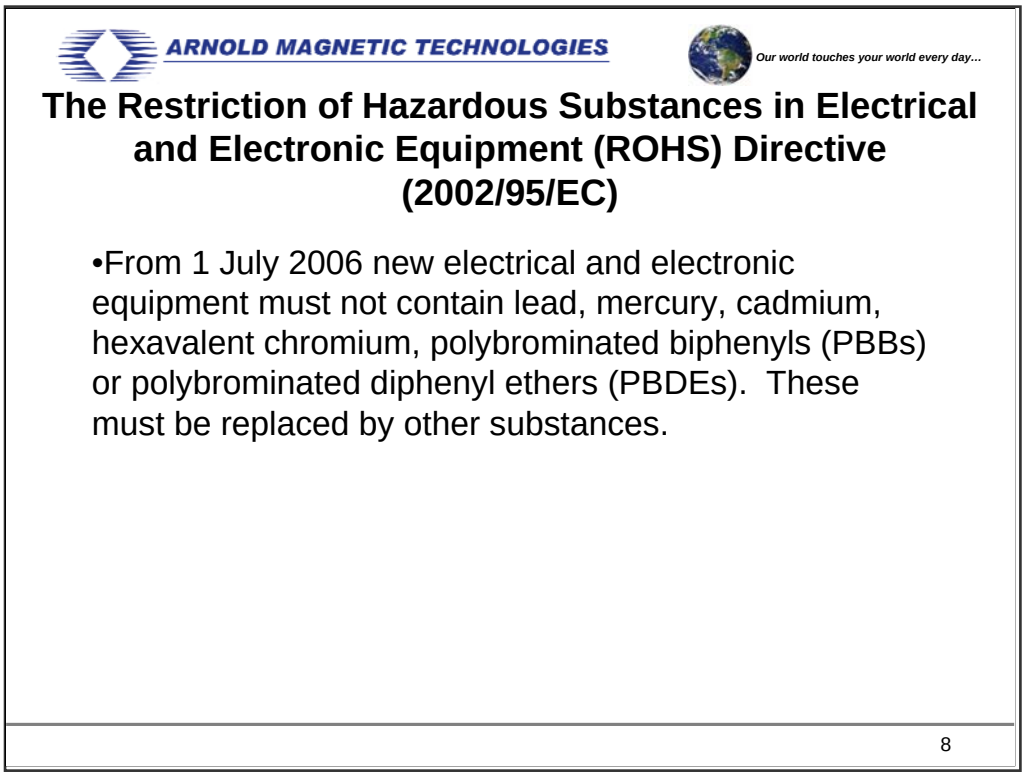
- The ROHS Directive states that certain chemicals are not to be used in Electrical and Electronic Equipment.

- ROHS and WEEE are linked to each other.



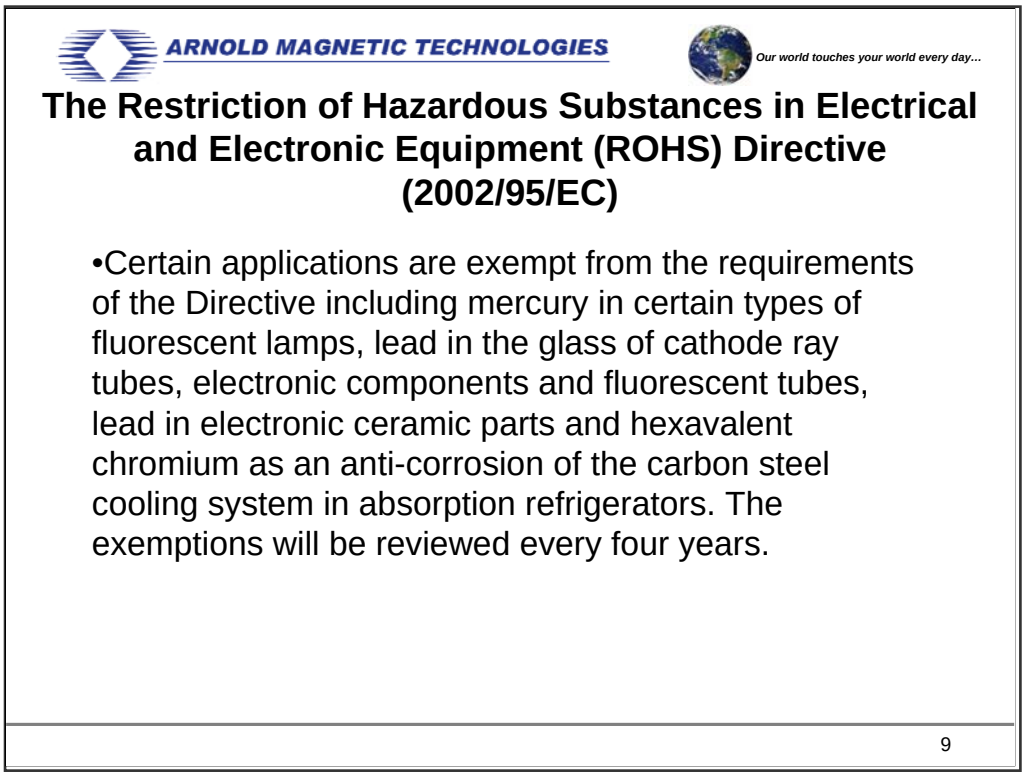
- ROHS complements the WEEE directive by restricting the use of certain substances that are regarded as hazardous.

- This only applies to new Electrical and Electronic equipment.



- The hazardous chemicals are:-
  - Lead
  - Mercury
  - Cadmium
  - Hexavalent Chromium
  - Polbrominated biphenyls (PBBs)
  - Polybrominated biphenyl ethers (PDBEs)

- Other substances must be used to replace the above.



- There are some exemptions.

- The exemptions are reviewed on a 4 yearly basis.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

The Restriction of Hazardous Substances in Electrical and Electronic Equipment (ROHS) Directive (2002/95/EC)

Swift Levick Magnets SmCo and Alnico do not contain any of following restricted substances :-

Lead

Cadmium

Mercury

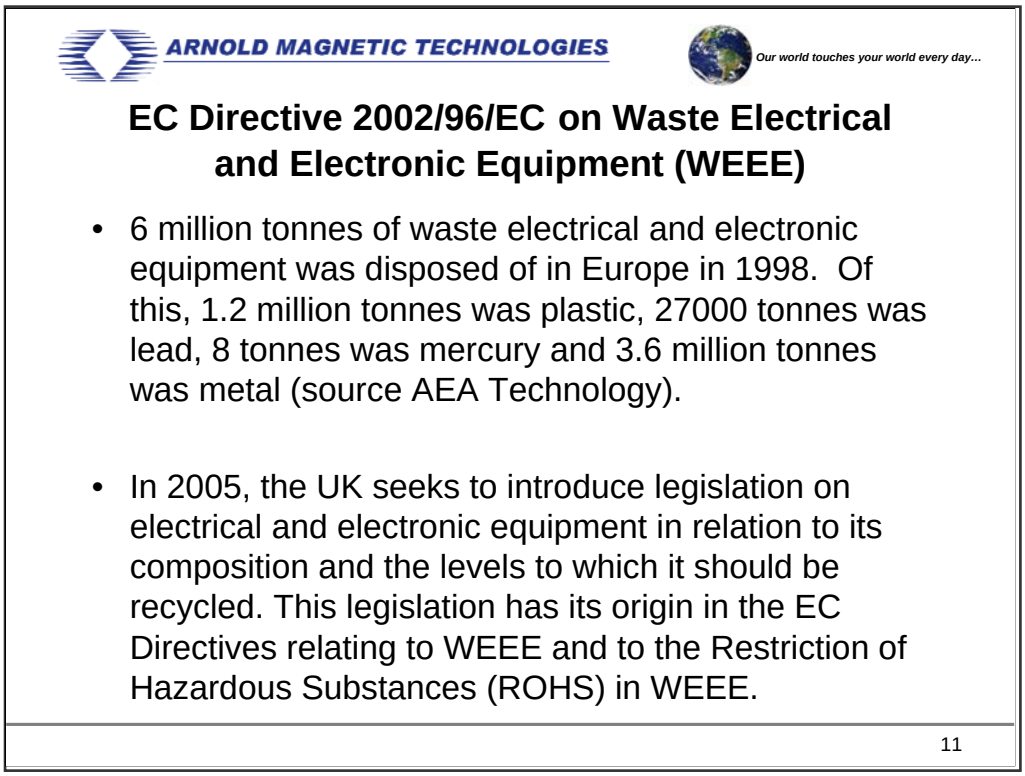
Hexavalent Chromium

Polybrominated Biphenyl (PBB's)

Polybrominated Diphenyl Ethers (PBDE's)

10

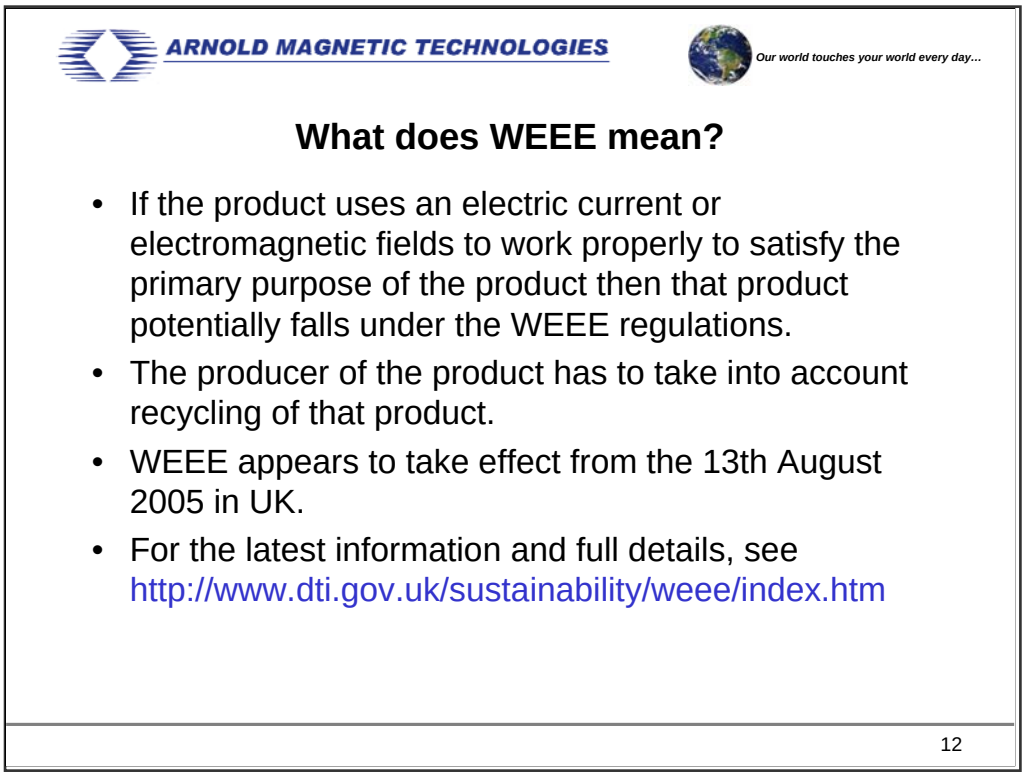
- The SmCo and Alnico produced by Swift Levick Magnets is ROHS compliant.



- The amount of waste electrical and electronic equipment disposed of each year is colossal.

- Because of this the WEEE Directive sets out to force the recycling of WEEE to reduce the amount of material dumped in waste sites.

- WEEE and ROHS are linked to each other.



- If an electric current or an electromagnetic field is required for a product to carry out its primary purpose, then that product may be affected by the WEEE Directive.

- The producers of affected products have responsibilities for the recycling/re-use of their products.

- The DTI website has much more information on WEEE.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

Examples

- A birthday card with an electronic circuit in it is not affected by WEEE as the circuit is not part of the primary purpose.
- The permanent magnet motor in a vacuum cleaner is needed in the primary purpose and so the whole vacuum cleaner is affected by the WEEE regulations. The vacuum cleaner producer will need to be able to recycle a percentage of its product.

13

- A birthday card does not need an electronic circuit to be a card so it is not affected by WEEE.

- A vacuum cleaner needs its motor to provide the suction of air to perform the cleaning product. It therefore is affected by WEEE.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day...

What happens?

Collect

Treat

Recover

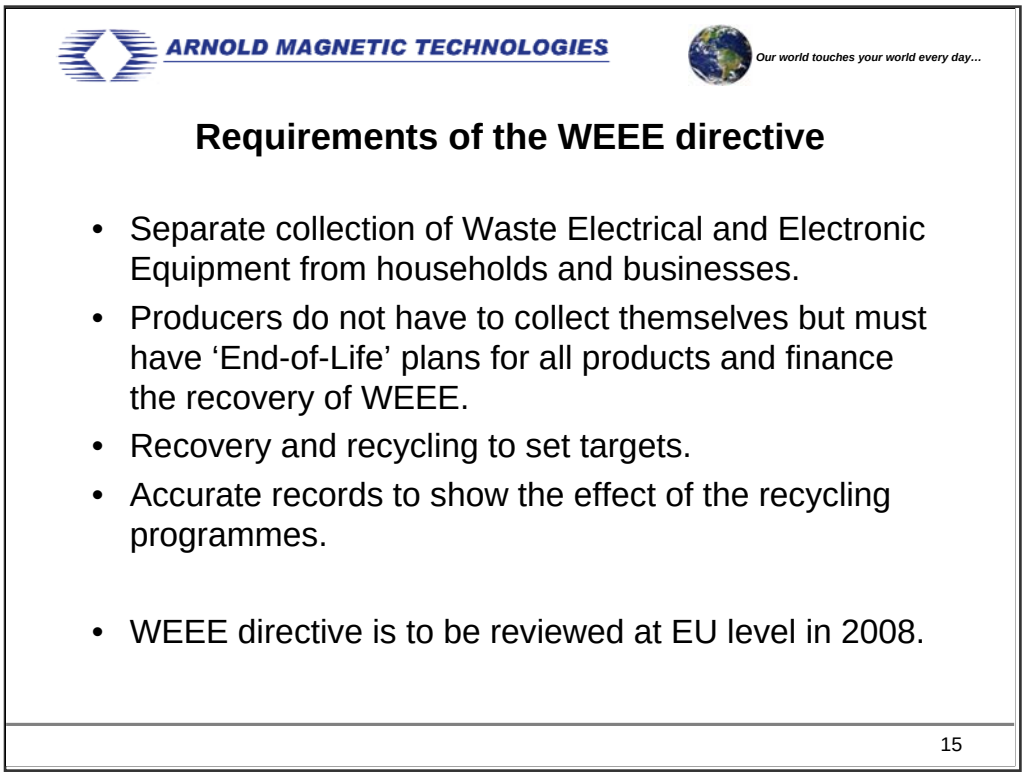
Recycle Reuse/Refurbish

14

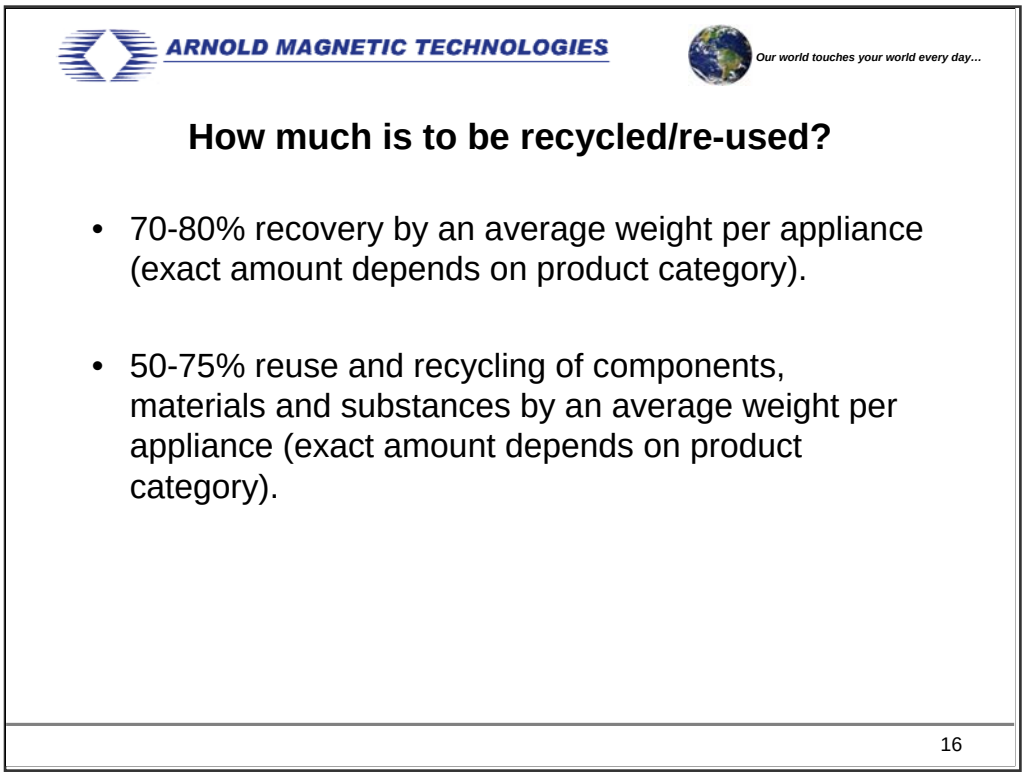
- The producers have to arrange for the collection of their product, the treatment of their product (e.g. to clean it, remove contaminants, etc), to recover parts and to then either recycle or re-use/refurbish.

- The Directive require that this all needs to be accounted for with correct documentation.

- The crossed out bin symbol is to be part of the labelling of new products that are to comply with the WEEE Directive.



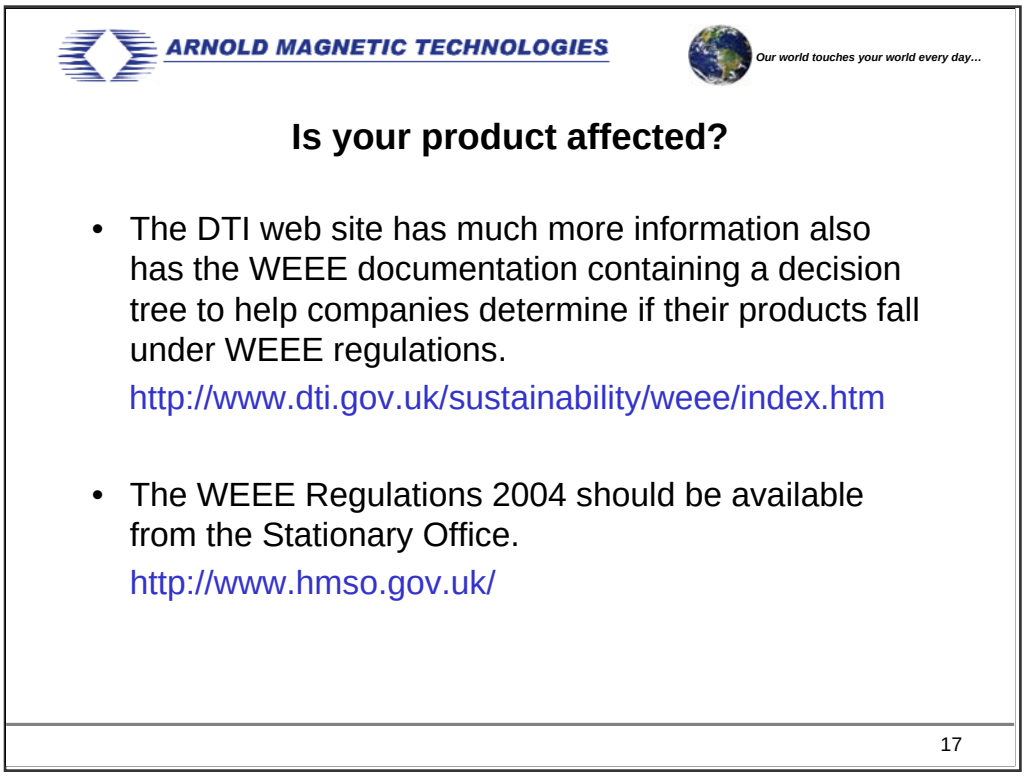
- The Directive gives strict instructions on how much product need to be recovered and recycled.
- Accurate records need to be kept by the producers.
- The producers must prove they have met their obligations.
- The WEEE directive is to be reviewed in 2008.



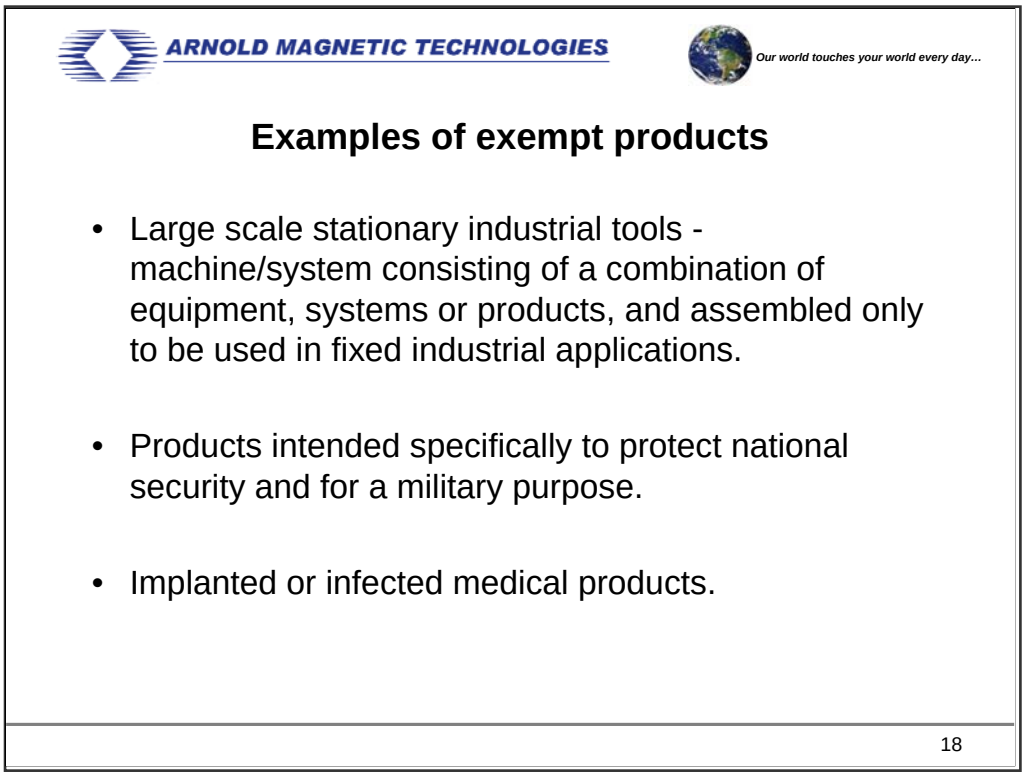
- The exact amount that has to be recovered and re-used/recycled depend on the product category.

- The DTI has more information on the categories and the amounts.

- If in doubt you should consult the DTI.



- The WEEE Directive is available from HMSO and general information and advice is available from the DTI.



- Some products are exempt:-
  - Some large scale stationary industrial tools;
  - Some military products; and
  - Some medical products.

ARNOLD MAGNETIC TECHNOLOGIES

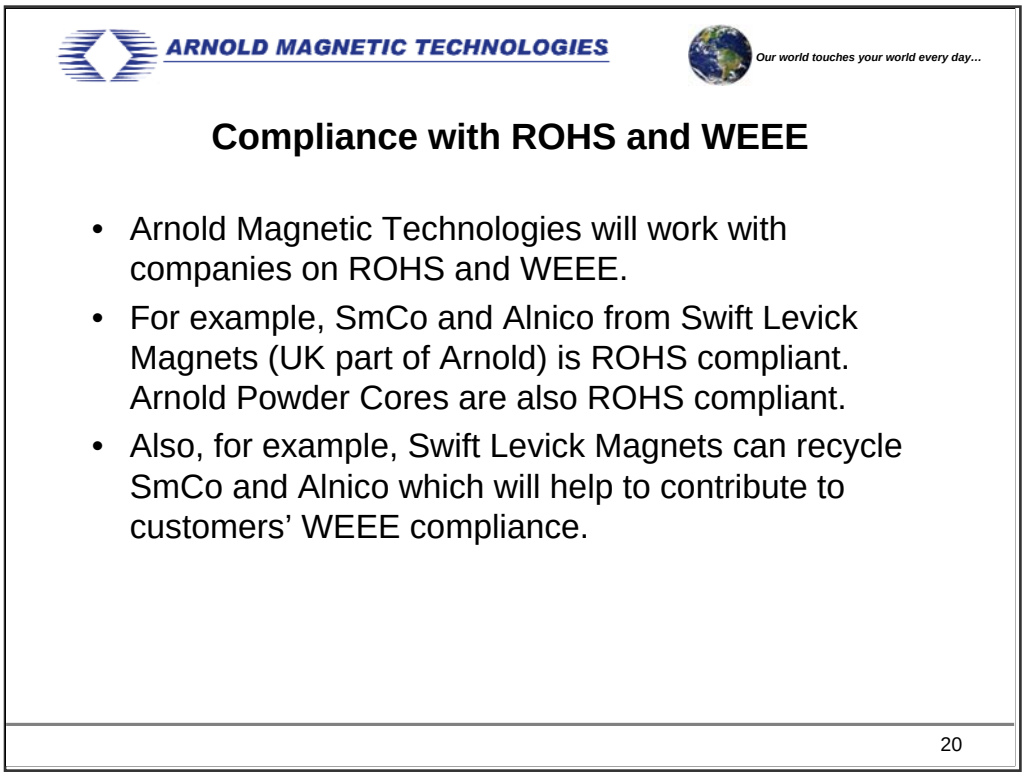
Our world touches your world every day...

Collection and Treatment of WEEE

- Swift Levick Magnets can recycle some permanent magnet materials and some of our assemblies.
- We do not collect, treat, recycle or re-use other materials.
- Because of the above, Swift Levick Magnets is not:-
  - registered as an Authorised Treatment Facility (ATF)
  - registered as a Designated Collection Facility (DCF)
- We have confirmed and clarified this situation with DEFRA (Department of Food, Environment and Rural Affairs http://www.defra.gov.uk/).

19

- What can Arnold offer?
- We cannot collect full products, even if our materials form part of the full product.
- We can only recycle certain permanent magnet materials and powder cores.



- Arnold will assist companies who are working on ROHS and WEEE compliance.

- We will review each situation individually.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day...

Recycling of SmCo magnets

- SmCo reprocessing involves re-melting the alloy, adjusting the alloy chemistry through a second melt then processing as a raw material.
- Variations in additives from one manufacturer to another may cause compositional or use limitations.
- It is prohibitively expensive to re-refine the material.
- When recycled material can be identified as made by one manufacturer, it may be reprocessed with economic benefit through reclaim of the high cost rare earths and cobalt content.

21

- The high costs of the rare earth elements and cobalt allow the recycling of SmCo to be potentially economically viable.

- SmCo produced by SLM is easier to recycle as we know the constituents of our own magnets.

- Unwanted additives (used by other producers) and excess glue may make recycling too costly.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

Recycling of SmCo magnets cont.

- SmCo produced by Swift Levick Magnets (SLM) can be re-used by SLM provided the level of contamination is not too high.
  - Glue on the magnet surfaces should not be a major issue if small amounts only are present.
  - Contamination may be caused by the environment of the application.
- SmCo produced by other manufacturers may be re-usable by SLM but it depends on the constitution of the material.
- We will look at any enquiry for the recycling of SmCo and will offer assistance where possible.

22

- The ability to recycle and its cost effectiveness depends on the amount to recycle and its quality.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day...

Recycling of Ferrite magnets

- Ferrite is an inexpensive raw material which must go through an expensive, energy consuming reprocessing to be usable as a starting material.
- Different additives are used by manufacturers which combined can poison the formulation.
- The end product, being "ceramic" in nature, is more suited for structural applications such as roadbed and crushed aggregate fill applications.
- It is our experience that ferrite is not bought back much by the actual producers of ferrite magnets.
- Arnold Magnetic Technologies cannot offer to recycle ferrite magnets as we do not produce these magnets.

23

- Ferrite magnets are inexpensive to produce.
- Ferrite magnets are expensive to reprocess.
- Additives can ‘poison’ the formulation.
- It is unlikely that ferrite can be recycled without a financial loss to the producer.
- It may not be WEEE ‘friendly’.

ARNOLD MAGNETIC TECHNOLOGIES

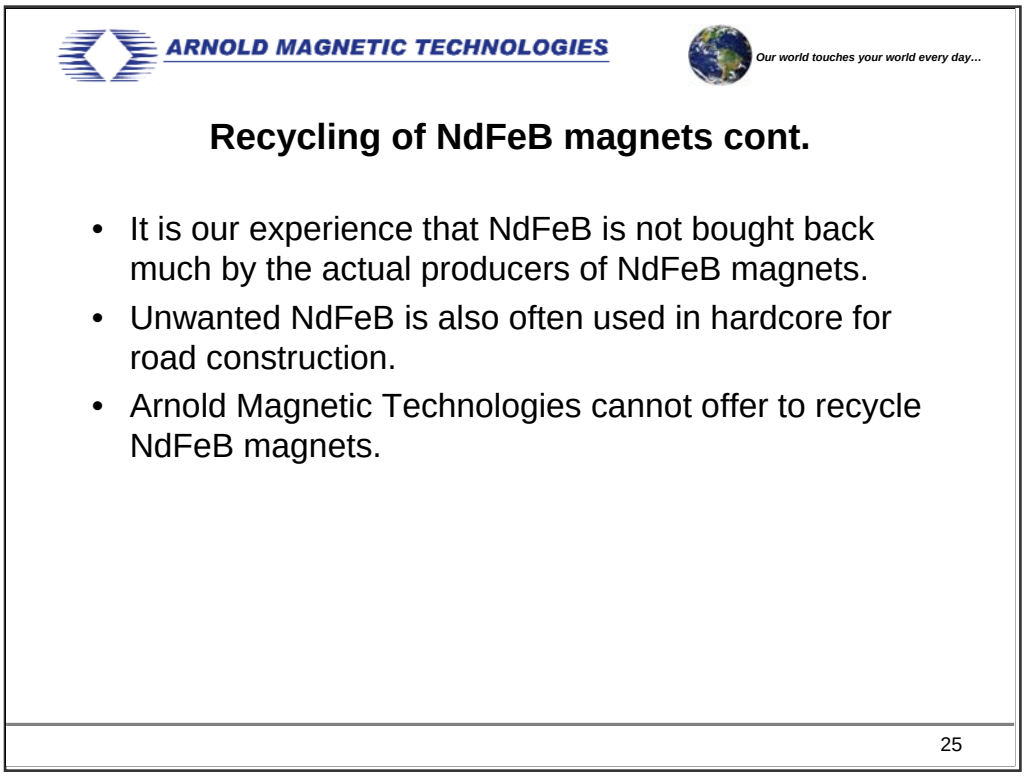
Our world touches your world every day...

Recycling of NdFeB magnets

- When the rare earth (especially NdFeB) magnet has degraded or shows signs of corrosion, it is likely that the material will not reprocess satisfactorily and will require refining to remove oxides and hydroxides.
- Re-melting contaminated NdFeB magnets provides for low yields and is often not economical.
- Most NdFeB magnets are Nickel plated.
- By having the plating, the magnets become more complex to recycle.

24

- Corrosion of NdFeB makes reprocessing more difficult.
- Plated magnets increase the complexity of reprocessing.
- Reprocessing yields are low.



- It is not always economical for the NdFeB producers to reprocess NdFeB.
- It is currently unlikely that the producers will take back NdFeB.
- NdFeB is thus potentially not so WEEE ‘friendly’.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day...

Recycling of Alnico magnets

- As in ferrite and rare earth magnets, each manufacturer has established compositions utilizing small amounts of additives to achieve specific magnetic and physical characteristics.
- The mixing of magnets from these manufacturers can result in an undesirable combination of additives.
- When magnet reclaim can be restricted to one manufacturer, it is possible to recycle the raw material with good success. As the pricing for nickel and cobalt cycle high, recycling becomes even more desirable.

26

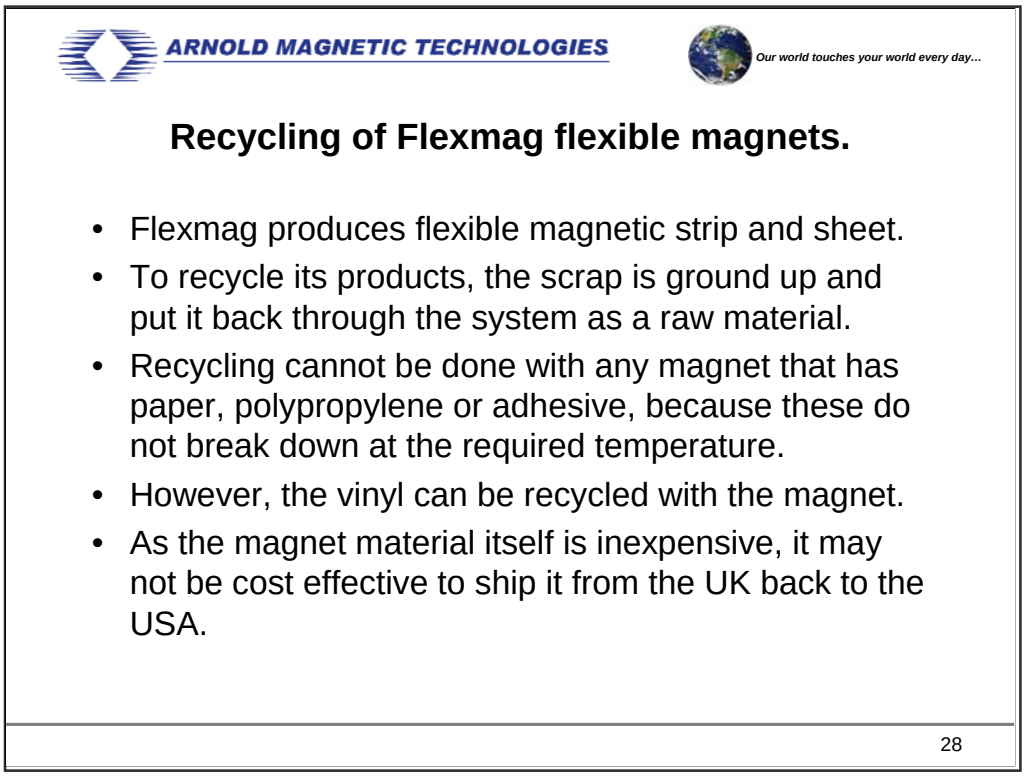
- Unknown additives make recycling of magnet materials more complicated, more expensive and hence less desirable.

- When the magnets are known to be from a single manufacturer, recycling is more practical, particularly if recycling your own product.

- When Ni and Co prices are high, recycling can be more desirable.

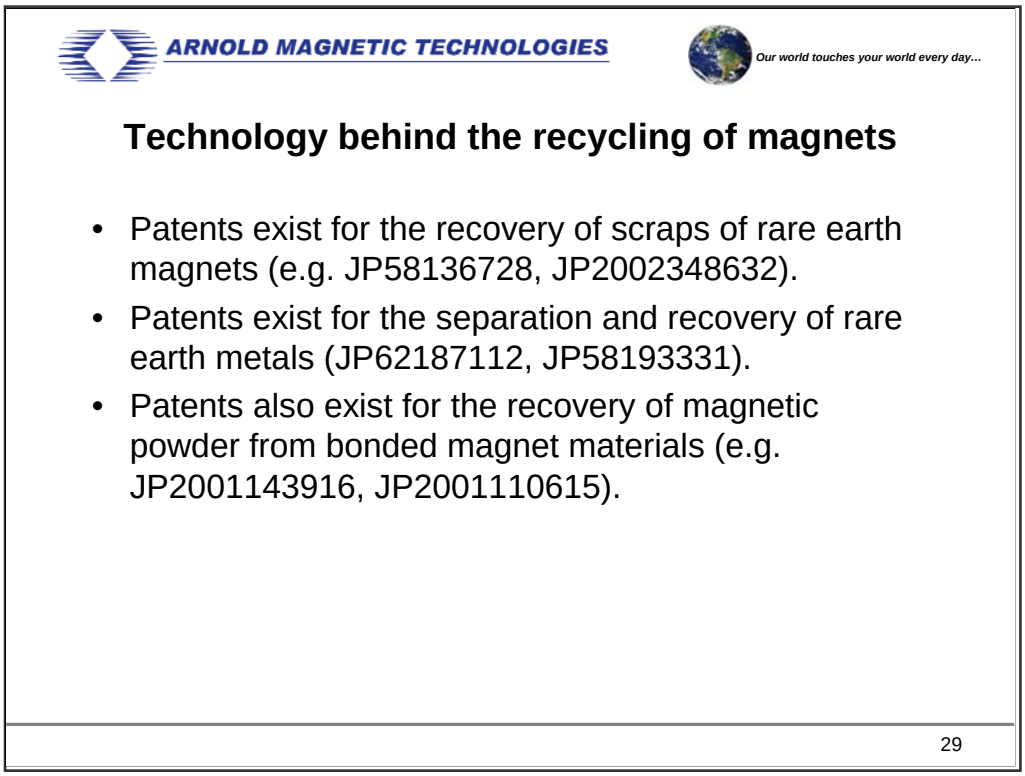
- Contaminants are undesirable.

- If the quality and volume offered is good then recycling is more economically viable.



- Flexible magnets such as flexible ferrites can be inexpensive to produce so the cost of shipping abroad to the original suppliers may make reprocessing uneconomical.

- The cost of exporting magnets to a producer will affect the recyclability of any magnet material.



- Many patents exist for the recycling of permanent magnets and for the recovery of elements from the magnets.

- The exact reprocessing and recovery processes will vary from producer to producer.

- Sometimes specialist companies are used to reclaim the materials on behalf of the producer.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

Recycling of POWDER CORES

- Arnold Magnetic Technologies produces powder cores in its China facility in Schenzhen:-
  - SuperMSS ™ (Sendust)
  - Molybdenum Permalloy Powder (MPP)
  - Hi-Flux ™
- The powder cores are ROHS 2000/95/EC compliant.
- We will offer to take back powder cores from the field provided the quality of the cores is good.

30

- Arnold also manufactures powder cores.

- Arnold powder cores can be taken back and reprocessed if the quality is acceptable.

ARNOLD MAGNETIC TECHNOLOGIES

Our world touches your world every day…

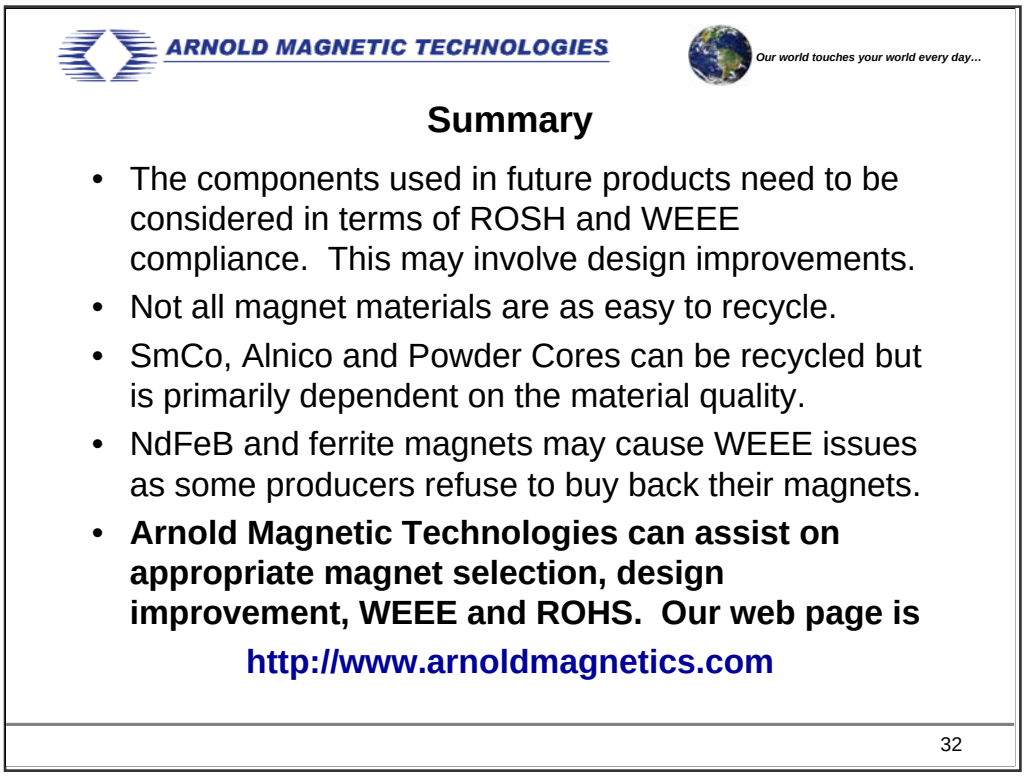
Designing for the future

- Future designs need to be such that the components are :-
  - free from banned chemicals.
  - made smaller (reduced weight and volume).
  - easier to reclaim.
  - easier to recycle.
  - easier to re-use / refurbish.
  - *longer lasting ?*
  - *able to comply with any stricter revisions to existing Directives or new Directives?*

Regulations/Directives are likely to get stricter with time.

31

- Are the products ROHS compliant?
- Are the products WEEE compliant?
- How much will it cost to have the products recovered and recycled/reused/refurbished?
- When the Directives are reviewed, what will happen? Will they get stricter? Will more products come under the Directives?



- New designs need to be considered in terms of ease of recycling and cost of recycling.
- Are the ferrite and NdFeB magnets a good choice longer term?
- Will magnet manufacturers realise they can help their customers?

- Arnold Magnetic Technologies can provide assistance on designs and on the taking back of some magnet materials for recycling.
- We can take those materials we know we can get recycled provided the quality is good and the volume is sufficient. We would look at each request individually. Our own products are the easier to recycle as we know their compositions.
- If in doubt please contact your nearest Arnold representative.