Presentation to: SSTC

Shelf Life and Solderability Ageing

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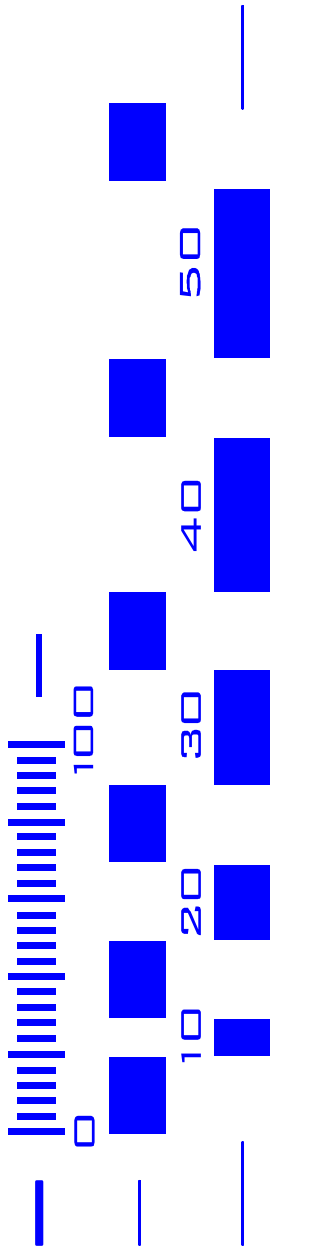

What are the issues with component storage

- Ideally we like to store components indefinitely
- Why is this not possible
- What are the degradation mechanisms
- How do you optimise storage lifetime

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Loss of solderability

- All components have an ability to be wet by solder
- This deteriorates with time
- This occurs due to ageing of the surface coating that is provided to protect the substrate.

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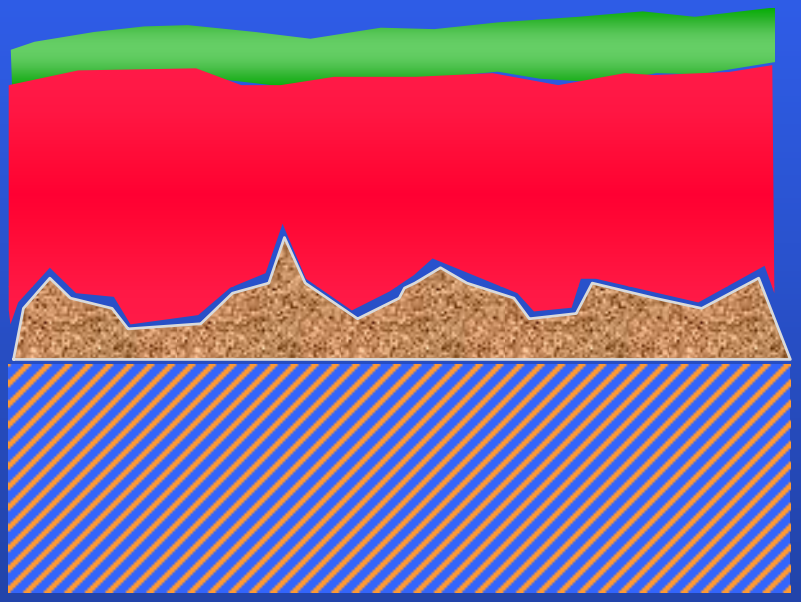
Solderability Degradation

Tin / Lead Coating



Oxide [SnO_2, ($PbCO_3$)]

Fusible coating [SnPb] (~10µm)

Intermetallic [Cu_6Sn_5 / Cu_3Sn]

Substrate [Cu]

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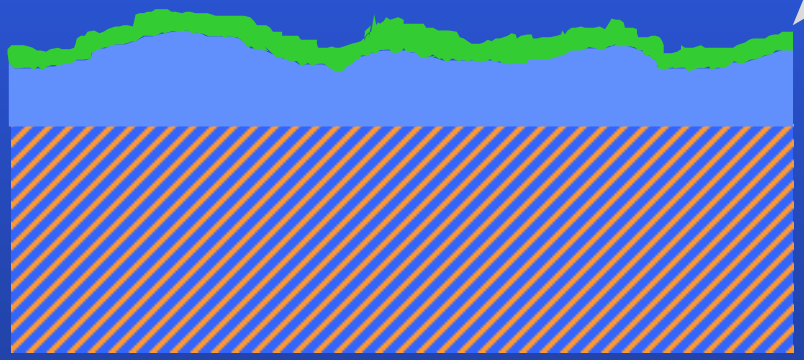
Solderability Degradation

Noble Metal / Nickel Coatings



Palladium or Gold (~0.1µm)

Nickel (~2µm)

Substrate [Cu]

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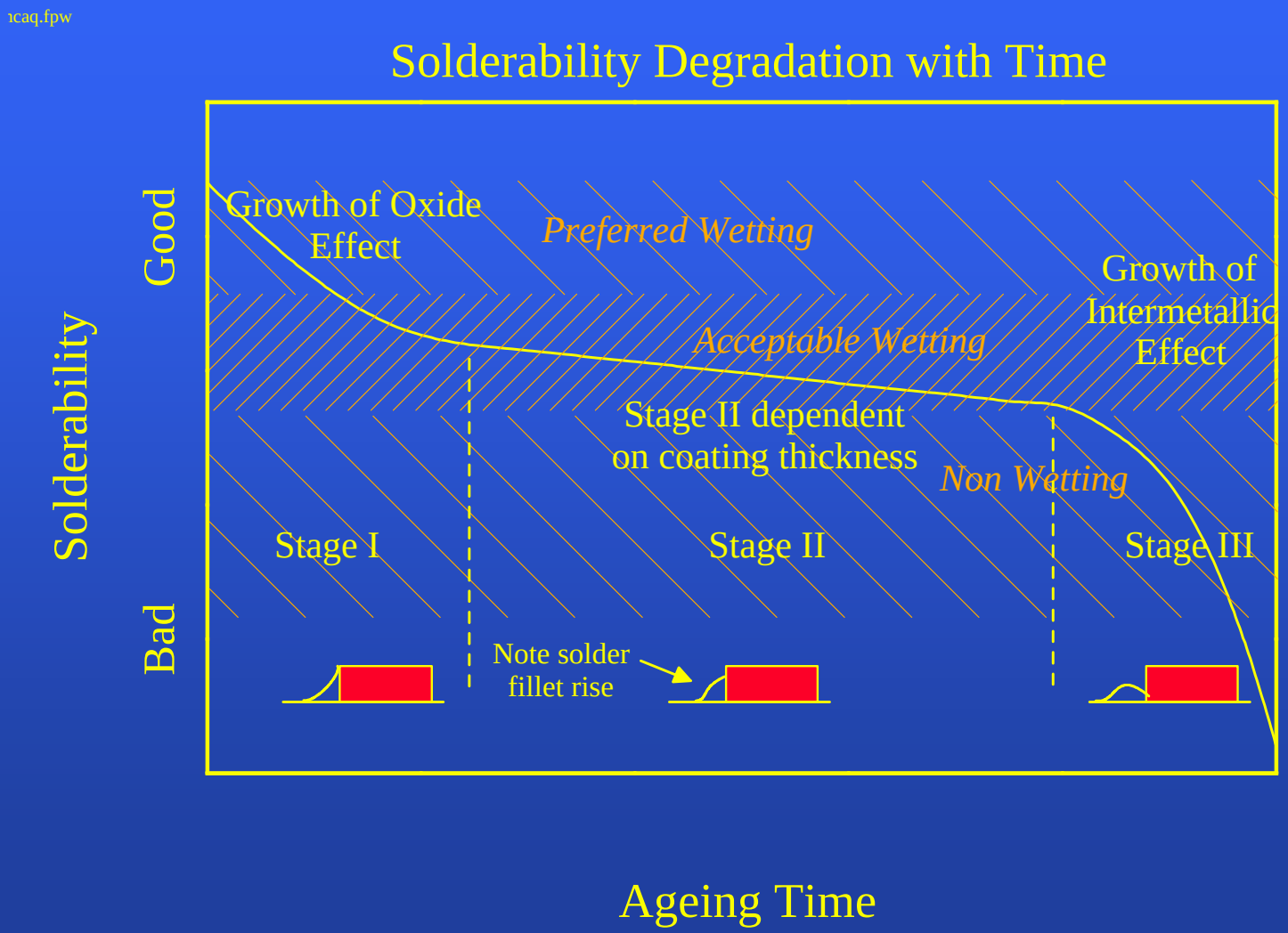
Overview for Sn based coatings



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Identifying the optimum storage environment

- Clearly fundamental changes in solder coatings are inevitable
  - intermetallic and oxide growth
- Air born contamination and humidity are the factors impacting on storage conditions
- There are a number of storage packaging styles available
- We investigate a number of these with a range of components

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Packaging & Components

- Air
- Plastic Bag
- Plastic Bag with O_2 arrest paper
- Plastic Bag with Desiccant
- Moisture Barrier Bag
- Moisture Barrier Bag with N_2
- Moisture Barrier Bag with Desiccant

- SM Resistors
- SM Capacitors
- Minimelfs
- SOT
- SOIC
- PLCC
- QFP

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Storage Environments

- Factory
  - Temperature
    - 8°C diurnal fluctuation
    - winter mean 15°C, summer mean 24 °C
    - min 10 °C, max 30 °C
  - Humidity
    - 20% diurnal fluctuation
    - winter mean 50%, summer mean 60%
    - min 40%, max 90%

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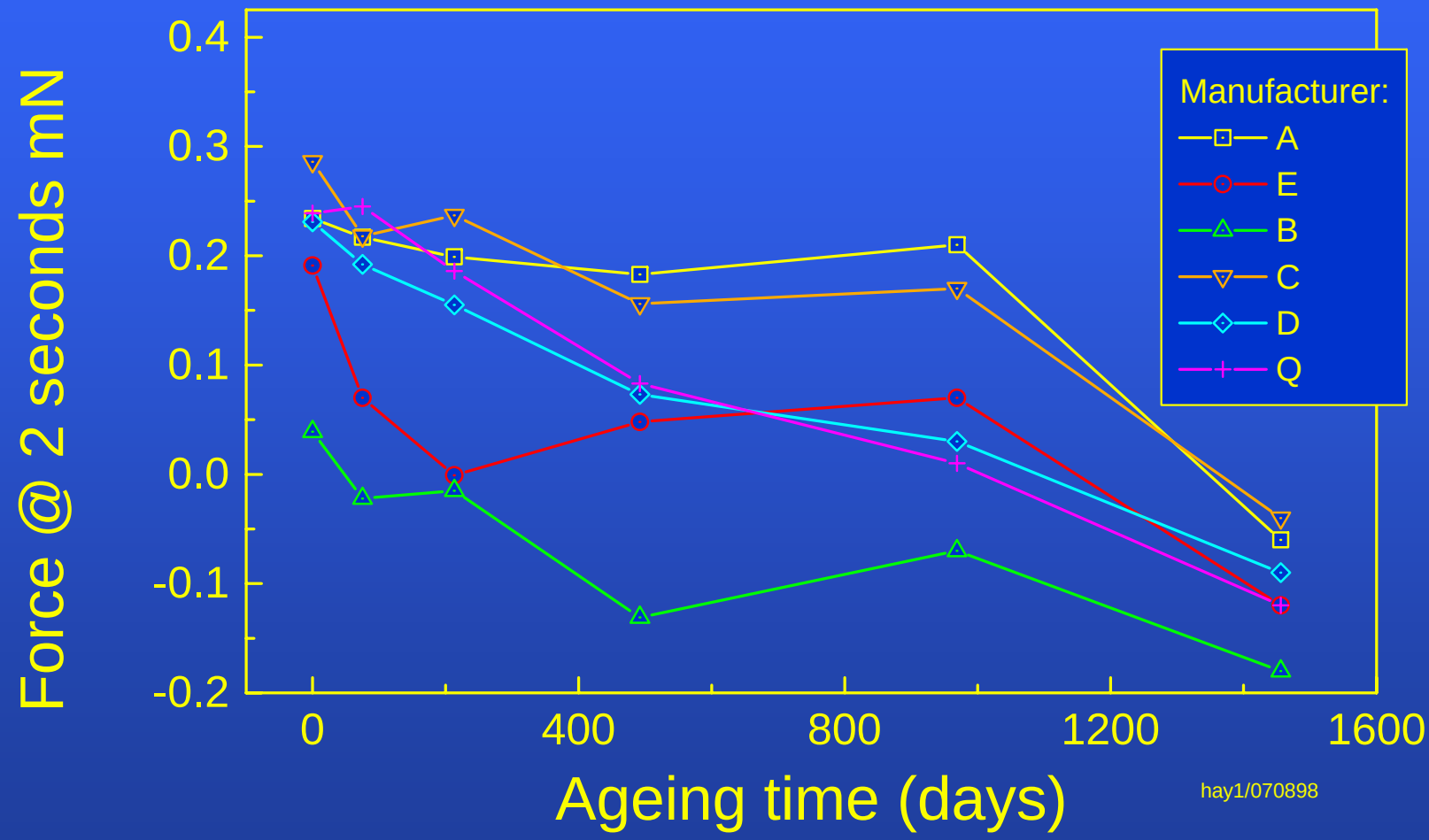
Resisitors: naturally aged under factory conditions, stored in air



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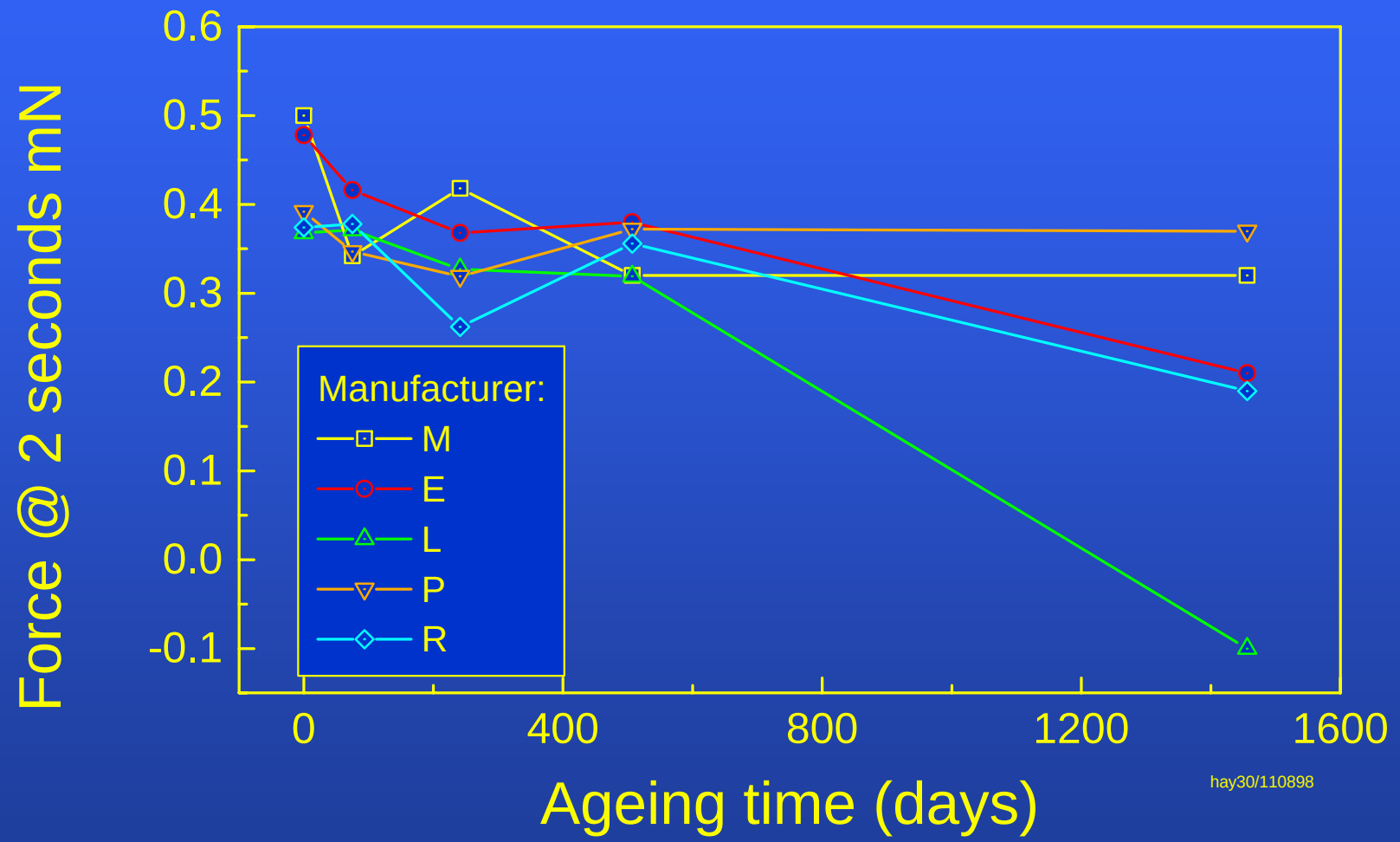
SOICs: naturally aged under factory conditions, stored in plastic bags with desiccant



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Data Averaging

- There are 49 graphs, such as the previous two.
- The objective is to form an overview of the merits of the specific packaging styles.
- The component ageing for each component style is similar in each packaging environment.
- As a first cut compare the solderability after 4 years for each averaged component group in the specific packaging environment.

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Resistors: aged under factory conditions

Solderability after 4 years

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SOICs: aged under factory conditions

Solderability after 4 years

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Ageing Factor (λ)

- To display the results from each component on a common axis we use the following formula.

  F_S Initial force at 2 seconds

  F_F Force at 2 seconds after 4 years storage

  n The number of manufacturers of each component style

$$\lambda = \frac{\sum \frac{F_S - F_F}{F_S + 0.2}}{n} \times 100 \ (\%)$$

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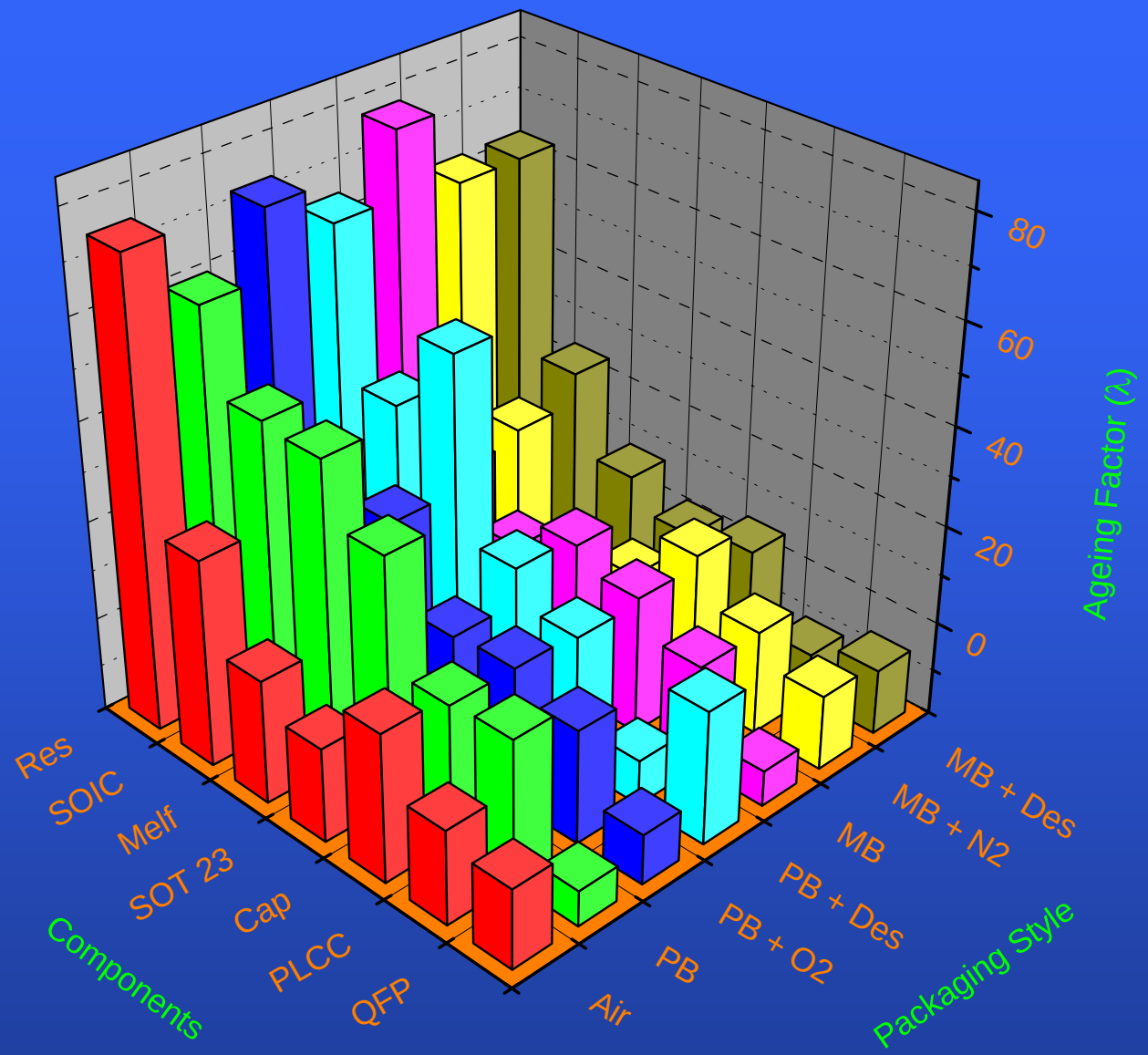
Ageing Factor (λ)
0
20
40
60
80
Components
Res
SOIC
Melf
SOT 23
Cap
PLCC
QFP
Packaging Style
Air
PB
PB + O2
PB + Des
MB
MB + N2
MB + Des

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Component Ageing

- The results show that the component type dominates the ageing, and that the packaging style is of secondary importance
- To reveal the impact of the various storage packaging styles the Ageing Factors are averaged for each component style in the different storage packaging.
- The difference from this average, normalises the Ageing Factor for the various components.
- This is plotted to show the effect of storage packaging styles

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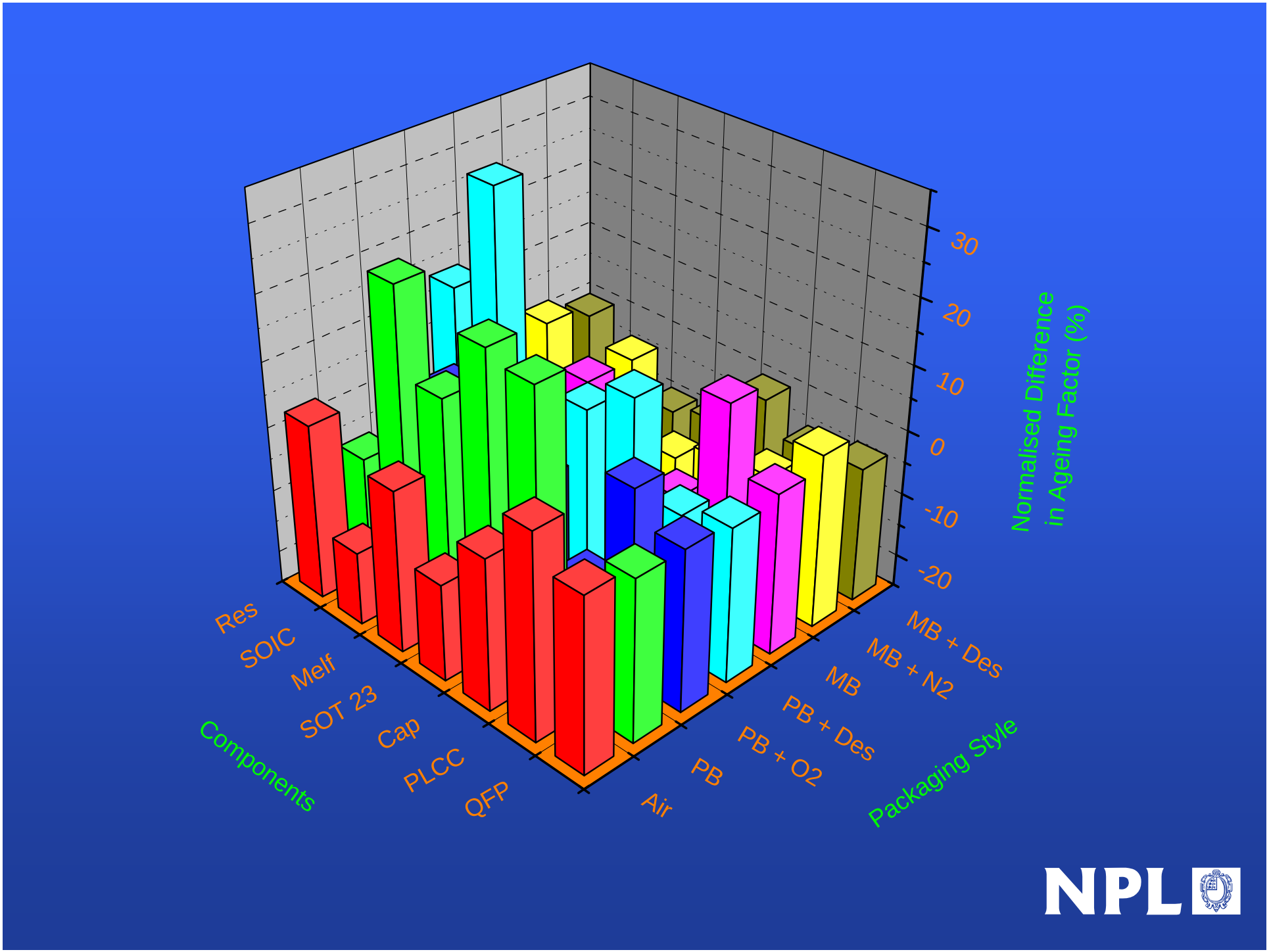
Normalised Difference
in Ageing Factor (%)
30
20
10
0
-10
-20
Res
SOIC
Melf
SOT 23
Cap
PLCC
QFP
Components
Air
PB
PB + O2
PB + Des
MB
MB + N2
MB + Des
Packaging Style

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Packaging Styles

- We can investigate the effect of each packaging style by averaging across the different component styles for each packaging style.

- Define this number as the Storage Quality (α)

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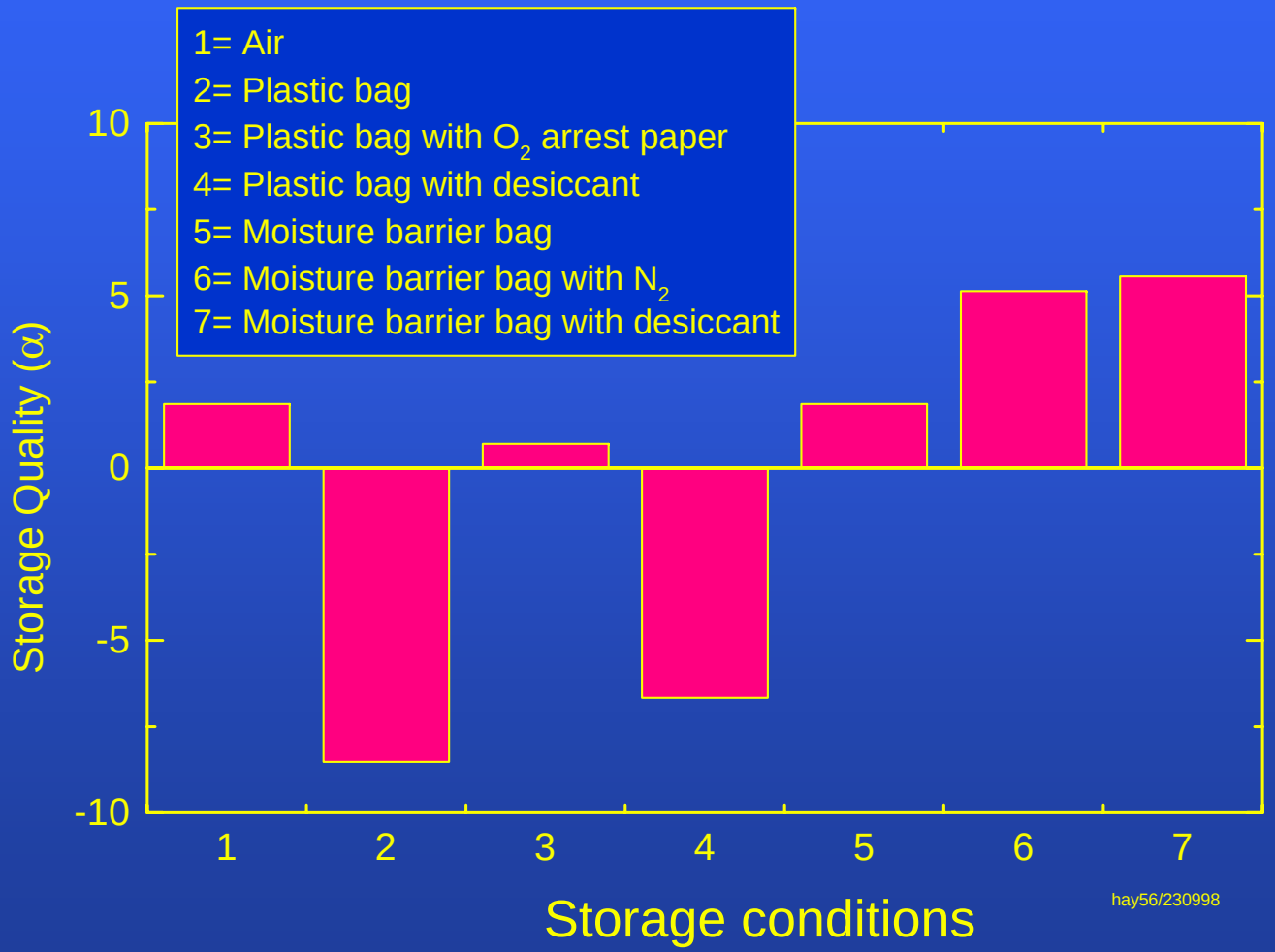
Storage Quality



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Summary of Component Ageing

- Clearly the packaging style is generally not of crucial importance as can be seen by the results of storing components in air.
- However, storing in plastic bags did have a deleterious effect on some components. These were ordinary polyethylene bags. We can suspect the plasticizers and any free halide ions being leached from the bags.
- Moisture barrier bag performance was marginally superior.
- Oxidation arrest paper proved effective at preventing the harmful effect of the plastic bags.

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Component oxidation

- Why should the storage packaging style have only a minimal affect on solderability.
- Storage in any containment bag will only influence the oxidation rate.
- For these components, of which the majority were tin lead, the impact of oxidation is shown in the next figure.

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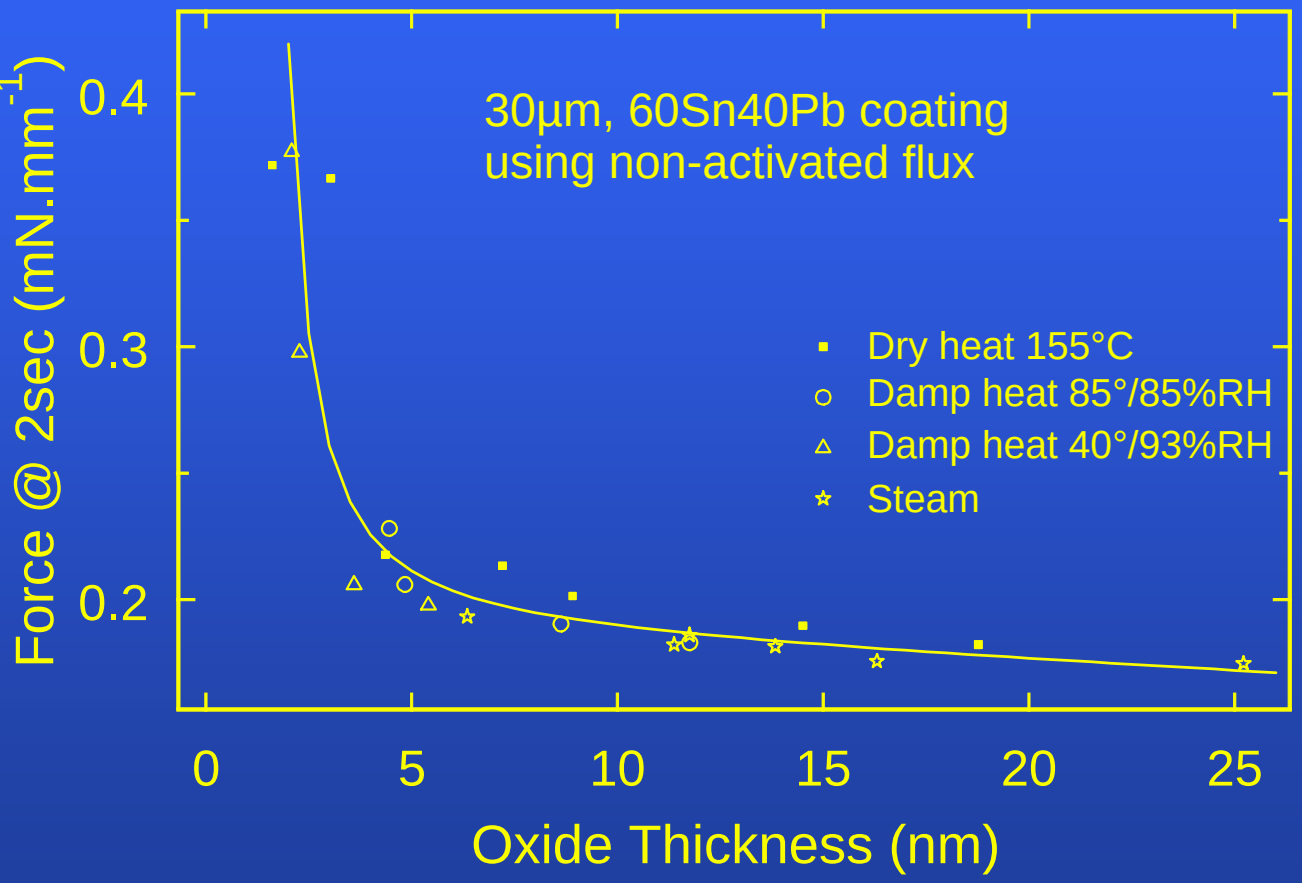
Solderability as a function of the oxide thickness



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Impact of oxidation on Solderability

- There is a significant impact on solderability as the first 5nm of oxide forms. This first 5nm of oxide will form very quickly during natural ageing.
- Subsequent ageing as the oxide thickens does not significantly influence the solderability.
- Hence any variation in oxidation rate between the storage environments will have a minimal effect.

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Natural Storage of Boards

- A range of board finishes were supplied to NPL during 1996 for a project to look at the durability of OSP finishes to multiple reflow soldering. (Report CMMT (A) 41)
- As part of this project some boards were put into the same natural ageing regime of temperature and humidity as the components.
- The boards were rapped in blue tissue paper and placed in an open plastic bag
- These boards have been aged over 30 month period.
- Solderability has been measured in an identical way using the wetting balance with the solder globule.
- The results are plotted using the Ageing Factor defined earlier, with F_F equating to the force at 2 seconds after 30 months.

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Non OSP Finishes

Supplier	Trade Name	Coating
Atotech	Aurotech	Nickel Gold
Enthone OMI	Sel-Rex SMT	
Lea Ronal	Ronamerse	
Lektrachem	Omikron	Electroless tin
MFS	APT884	
Shipley Europe	Tinposit	
Atotech	Pallatect	Palladium
Lea Ronal	Pallamerse SMT	
Alpha Fry	Alpha Level	Silver

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OSP Finishes

Company	Trade Name	Company Type	Finish Type
MecEurope	MecSeal	Supplier	Benzimidazole
GSPK	MecSeal	PCB Manufacturer	Benzimidazole
Enthone OMI	Entek Plus	Supplier	Substituted Benzimidazole
Prestwick	Glicoat E3	PCB Manufacturer	Alkylbenzimidazole
Signum Circuits	Entek Plus	PCB Manufacturer	Substituted Benzimidazole
	Glicoat SMD F1		Alkylbenzimidazole
	Copper guard 117		Unknown
Exacta Circuits	Glicoat SMD F1	PCB Manufacturer	Alkylbenzimidazole
Lea Ronal	Ronacoat	Supplier	Imidazole
Atotech	Shercoat	Supplier	Benzimidazole
Philips Printed Circuits	M-Coat+	PCB Manufacturer	Substituted Benzimidazole
Shipley Europe	Protecto	Supplier	Imidazole

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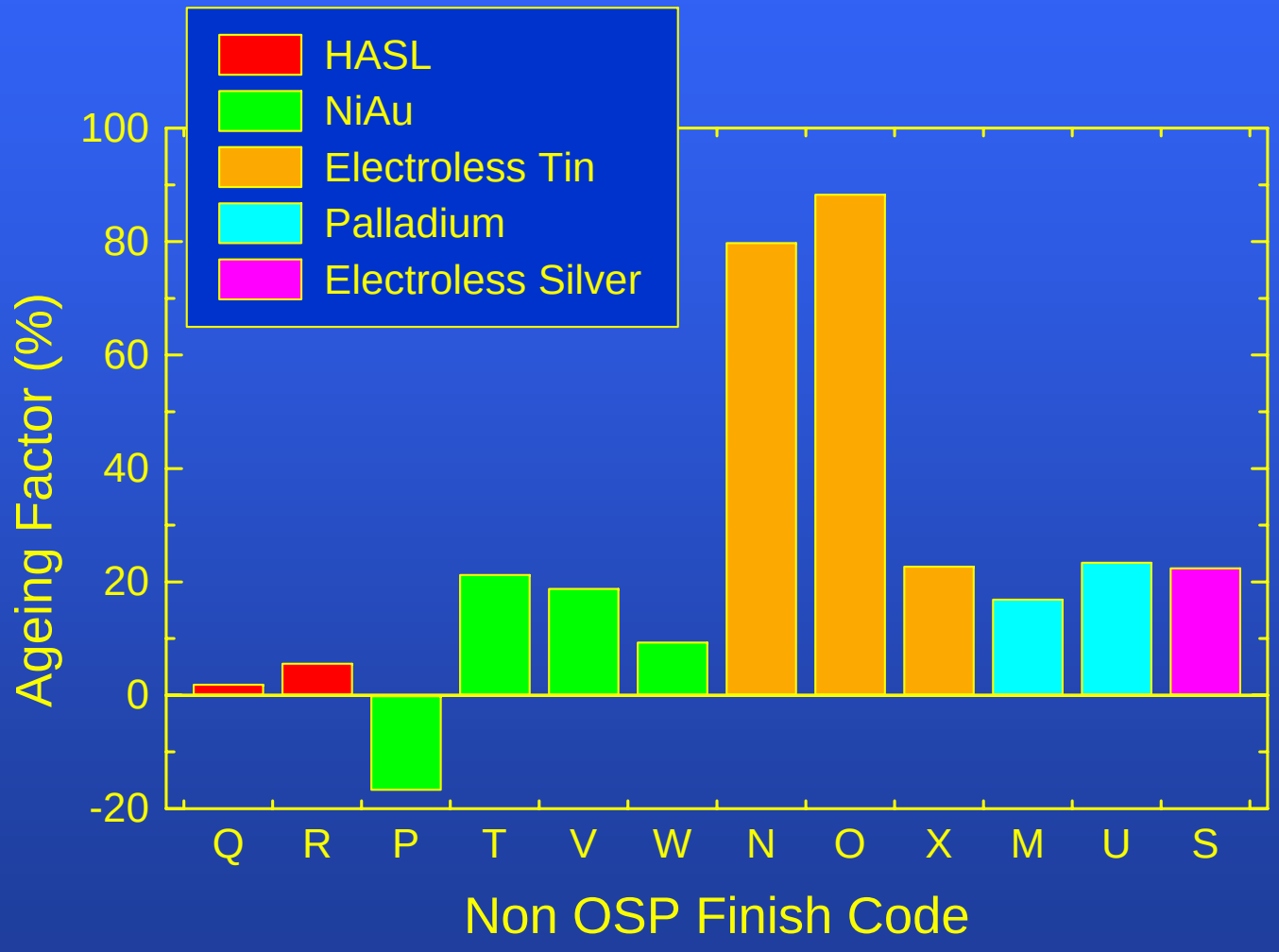
Ageing Factor for Non OSP Finishes



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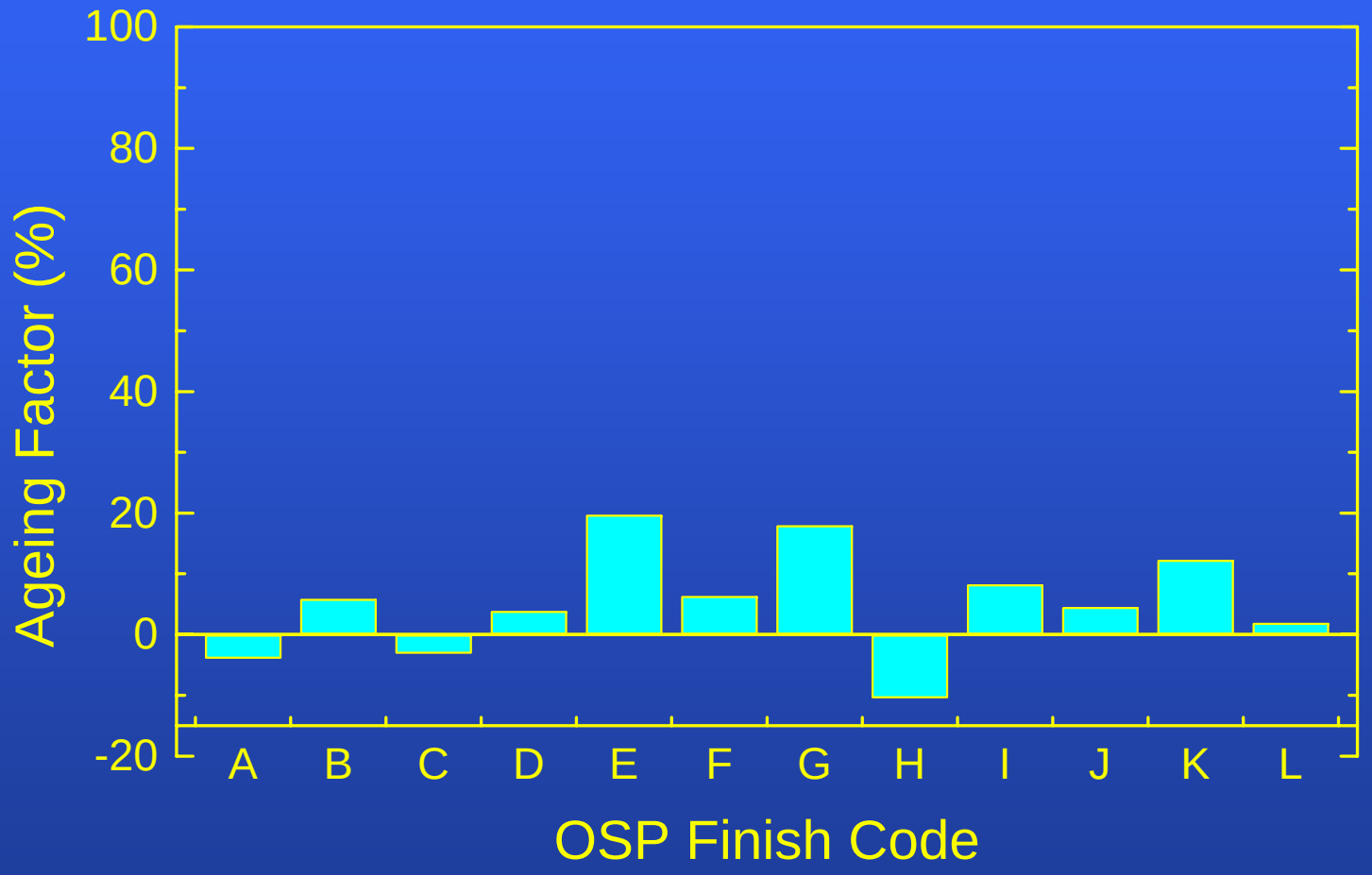
Ageing Factor for OSP Finishes



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Summary of Board Ageing

- Clearly the majority of boards remain solderable over the 30 month period.
- The tin finished boards underwent the greatest solderability loss.
- The OSP finishes all aged very well, with only marginal loss of solderability.
- The gold and the palladium finished boards loss of solderability was comparable indicating that porosity of these layers is key.

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Conclusions

- Resistors aged far more than other components, SOIC and Melfs were next and SOTs and Caps after that.
- Some components did not age significantly, eg QFP, PLCC
- For some components packaging style was irrelevant
  - Packaging in air was as good as the others
  - Since, additional oxidation during storage has little or no impact on solderability.
- Packaging in plastic bags had a serious deleterious impact on some components. Suspect plasticizer and any halides.
  - For SOTs there was a significant loss in solderability. The ageing factor changed from 0 to 30% from air to plastic bags.
- Board finishes proved generally robust. OSP as a family of coatings were robust.

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Storage Recommendations

- Clearly plastic bags represent an unacceptable risk.
- If no harmful contamination comes into contact with the components, storage in air, wrapped in aluminium foil, is an exceptable alternative.
- ***The optimum approach is to use moisture barrier bags.*** This confers added robustness to inadvertent exposure to deleterious agents.
- Desiccant is useless in sealed bags, ineffectual.
- ***Oxidation arrest paper has a very beneficial effect,*** ameliorating the harmful influence of the plastic bags. It will have a similar effect in other contaminating environments.

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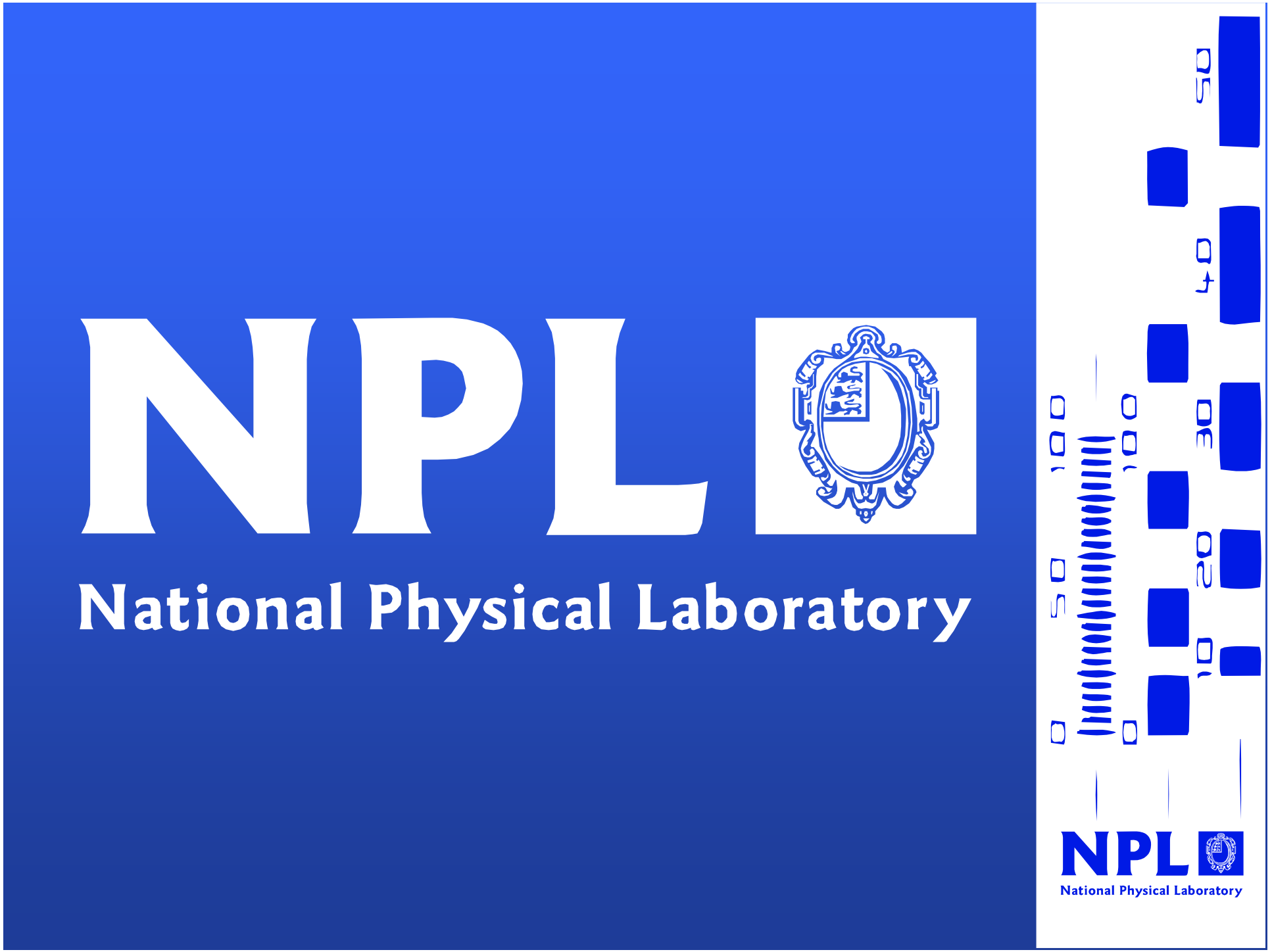
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