WEEE & RoHS
The Real Life Experience

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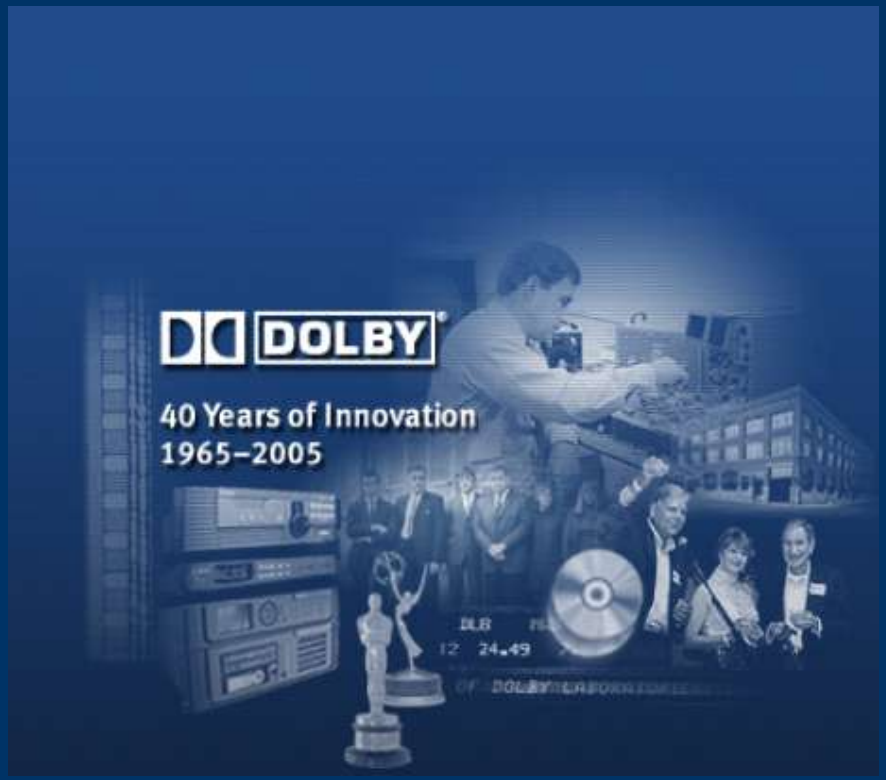
We don’t know all the answers!

- We don’t even know all the questions!
- But some of our ideas to deal with RoHS and WEEE might help you
- This presentation will cover:
  - Who are Dolby, what do we do and how do we do it?
  - RoHS and WEEE Directives – a brief reminder
  - What do the Directives mean to Dolby’s operations?
  - The Pain of Part Numbers
  - Converting existing product designs to be RoHS compliant
  - Selecting PCB laminates and finishes
  - Creating new soldering processes suitable for lead-free
  - Don’t forget metalwork and hardware!
  - Reliability tests
  - Managing the changeover to RoHS
  - Your next headache…

Dolby Laboratories, Inc.
Who are we?



- Established in London in 1965, entirely privately owned by our American founder, Dr. Ray Dolby, for 40 years until the company made an IPO on the New York Stock Exchange in February 2005 (DLB:NYSE)
- Head Offices are in San Francisco, USA, and European headquarters in Wiltshire, England - with similarly equipped manufacturing facilities in both these locations.
  - •We also have industry liaison offices in London, New York, Los Angeles, Hong Kong, Shanghai, Beijing, and Tokyo

Dolby Laboratories, Inc.
What do we do?

- We create technologies that intensify and enhance the entertainment experience, developing systems and manufacturing the professional equipment to implement these technologies in the motion picture, broadcasting, computer-gaming and music recording industries.

- We also license these technologies for use in the consumer electronics industry
  - Current figures show more than 2 billion licensed products sold worldwide.


Dolby Laboratories, Inc.
Professional Product Examples

Model CP650 Cinema Processor

Introduced 2000

Made in US & UK

DSP100 Digital Cinema System Show Player

Made in UK only

DSS100 Digital Cinema System Show Store

Made in USA only

Digital Cinema System introduced in 2005

Dolby Laboratories, Inc.
Manufacturing Process Equipment – UK

- SMT Assembly
  - Dek Horizon Printer with 2Di vision
  - Assembleon MG-1 multifunctional placer with auto-tray stacker (ATS)
  - Assembleon Topaz fast placer
  - Assembleon Emerald fine-pitch placer with large component sequencer (LCS)
  - Heller 1707EXL reflow oven
- Through-hole assembly
  - Universal Instruments axial, radial and DIP insertion
  - Blakell LS9000C/LS920C semi-auto guide insertion

Dolby Laboratories, Inc.
Manufacturing Process Equipment – UK

- Soldering
  - Blundell CMS400FS wave solder (Sn63Pb37 only)
  - Blundell CMS400LF wave solder (Lead-Free only)
  - Vitronics 6748 MySelective selective soldering (accommodates both Sn63Pb37 and lead-free)
- Test
  - Teradyne Z1890VP(Prism-Z) in-circuit tester
  - Scorpion Flying Probe fixtureless in-circuit tester
  - Audio Precision and Textronix-GPIB custom functional ATE systems

http://www.dolby.com/about/who_we_are/manufacturing.html

The RoHS Directive – a brief reminder

- European Union Directive 2002/95/EC "on the restriction of the use of certain hazardous substances in electrical and electronic equipment."
- A "single market" Directive which must be applied in full in all Member States' national legislation
- Member States shall ensure that, from ***1st July 2006***, new electrical and electronic equipment **placed on the market for the first time** does not contain more than permitted levels of lead, cadmium, mercury, hexavalent chromium, both PBDE and PBB flame retardants,…

The WEEE Directive – a brief reminder

- European Union Directive 2002/96/EC “on waste electrical and electronic equipment”
- Due to be fully enforced as of 13th August 2005, and targets met by 31st December 2006… but still no UK legislation in place.
- Not a “single market” Directive – describes minimum objectives only
- Requires producers of EEE to be responsible for end of life costs of their products = “The Polluter Pays!”
- Requires producers to adopt approaches that improve sustainable design and re-cycling, and encourage re-use at the end of the product’s life.
- Producers may undertake responsibilities themselves or by membership of an authorised “Compliance Scheme”
- Different rules for domestic WEEE and business WEEE
- Applies not just to new products, there is also collective responsibility for all equipment covered by the Directive already on the market = “Historical WEEE.”

WEEE & RoHS Directives….
Some Important Definitions

From the European Commission's "Blue Book"

"Guide to the implementation of directives based on the New Approach and the Global Approach"

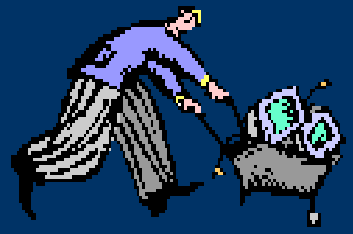
- ***"Put on the market"***
  - the initial action of a "***producer"*** to "***make a product available"*** for the first time on the Community market, transferred from the stage of manufacture, with a view to distribution or use in the Community.
    - *This refers to each individual product X serial no N+1, not to a brand new product Y serial no 1*
    - *All product destined for EU use in stock on July 1st 2006 and thereafter MUST comply unless imported into the EU prior to the deadline*
- ***"Making available"***
  - Can be for payment, loan, hire, or free of charge
- ***"Producer"***
  - A UK factory is a ***"producer"*** only in respect of products placed on the market for UK customers and any imported from outside EU for UK/EU sales.
    - *Once products transfer to EU distributors, they become the* ***"producer"*** *of these in their own country.*

WEEE - what does this mean to Dolby?

- UK operation must register as a *"**Producer**"* of WEEE and carry out required reporting duties for affected product sold to UK customers only
- US operation does not sell direct to EU end-users, all product is imported and sold via the UK office, so is not a "producer"
- WEEE responsibility for affected product sold into other EU markets lies with our appointed distributors and agents who we export to in these territories – who are the local "producer"
- After 13th August 2005, all product for the UK/EU must carry the underlined WEEE symbol, or …carry the plain WEEE symbol and be marked also to indicate the date it was *"**placed on the market**"*

http://www.dolby.com/about/who_we_are/manufacturing_environment.html

WEEE – what have we done so far?



- Chose to be a member of an appropriate compliance scheme looking after business “B2B” WEEE
- Where appropriate, negotiated passing on responsibility for WEEE end-of-life disposal costs with our B2B customers in the EU as part of sales contract for any equipment purchased by them, as the Directive allows
- Began adding symbol and reference text to sales documents as reminder to affected customers
- Began marking products with the WEEE-lie bin symbol in 2005
- Weighed examples of all finished products and stored this information in a database, cross-referred to UK market sales records so that we are able to provide reporting details of all obligated EEE put on the market as of August 2005
- Keep all non-obligated and internally generated WEEE separate from normal waste and use local recycler-WEEE treatment facility to collect and dispose.

RoHS - what does this mean to Dolby?

- All product built in the UK (except spares and upgrades) which first leaves our UK finished goods stocks for EU destinations (and thus "**placed on the market for the first time**") after July 2006 **must** comply with RoHS
- All US made product (except spares and upgrades) which leaves US finished goods stocks for the first time destined for the UK after July 2006, to later support any potential UK or EU customers, **must** comply with RoHS.
- Any US made product which has passed through UK customs destined for UK finished goods prior to July 2006 need not comply and may be sold after the deadline since passing though UK customs qualifies as being **"placed on the market"** prior to the deadline.

http://www.dolby.com/about/who_we_are/manufacturing_environment.html

RoHS/WEEE Compliance Project Team

- Multi-site
  - UK and US
- Multi-department
  - Manufacturing, Engineering, Quality, Marketing, and Senior Management
- Multi-disciplinary
  - Electronic design engineers, mechanical design engineers, PCB designers, component engineers, manufacturing process engineers, production engineers, quality engineers, product marketing staff, production schedulers, production supervisory staff etc.
- Team meets via video conference each week to discuss project progress
- Lead at Vice-President level with senior management steering committee
- Corporate Goal since 2003

Lessons Of War - Part 1: The Naming of Parts by Henry Miller

Today we have naming of parts. Yesterday,
We had daily cleaning. And tomorrow morning,
We shall have what to do after firing. But today,
Today we have naming of parts. Japonica
Glistens like coral in all of the neighbouring gardens,
And today we have naming of parts.

This is the lower sling swivel. And this
Is the upper sling swivel, whose use you will see,
When you are given your slings. And this is the piling swivel,
Which in your case you have not got. The branches
Hold in the gardens their silent, eloquent gestures,
Which in our case we have not got.

This is the safety-catch, which is always released
With an easy flick of the thumb. And please do not let me
See anyone using his finger. You can do it quite easy
If you have any strength in your thumb. The blossoms
Are fragile and motionless, never letting anyone see
Any of them using their finger.

And this you can see is the bolt. The purpose of this
Is to open the breech, as you see. We can slide it
Rapidly backwards and forwards: we call this
Easing the spring. And rapidly backwards and forwards
The early bees are assaulting and fumbling the flowers:
They call it easing the Spring.

They call it easing the Spring: it is perfectly easy
If you have any strength in your thumb: like the bolt,
And the breech, and the cocking-piece, and the point of balance,
Which in our case we have not got; and the almond-blossom
Silent in all of the gardens and the bees going backwards and forwards,
For today we have naming of parts.

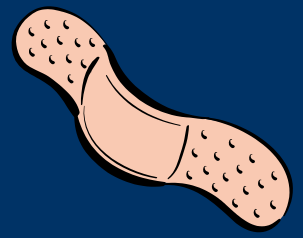
The Pain of Part Numbers

- No standard global approach for Manufacturers Part Numbers (MPNs)
- 3 scenarios that can trip you up:

  - Some MPNs not changing for RoHS – changeover to RoHS compliant version by date or lotcode only as their supply chain is flushed.
  - Even if MPNs do change to distinguish between existing parts and new RoHS part, sometimes the manufacturer slips in a design/feature change which means the part is no longer 100% functional compatibility and breaks your design.
  - MPN changes to add simple suffix for RoHS version, but after their supply chain flushes, the suffix is removed from the MPN.

The Pain of Part Numbers – Dolby's solution

- Our current internal part numbering scheme using Dolby Part Numbers or DPNs
- DPN=ABxyz
  - AB = component class code, xyz = class part number
- Create new RoHS converted DPN=AB0xyz0
  - AB0 = expanded component class code
  - xyz = class part number
  - 0 = RoHS (maybe =1 for next similar problem?!)



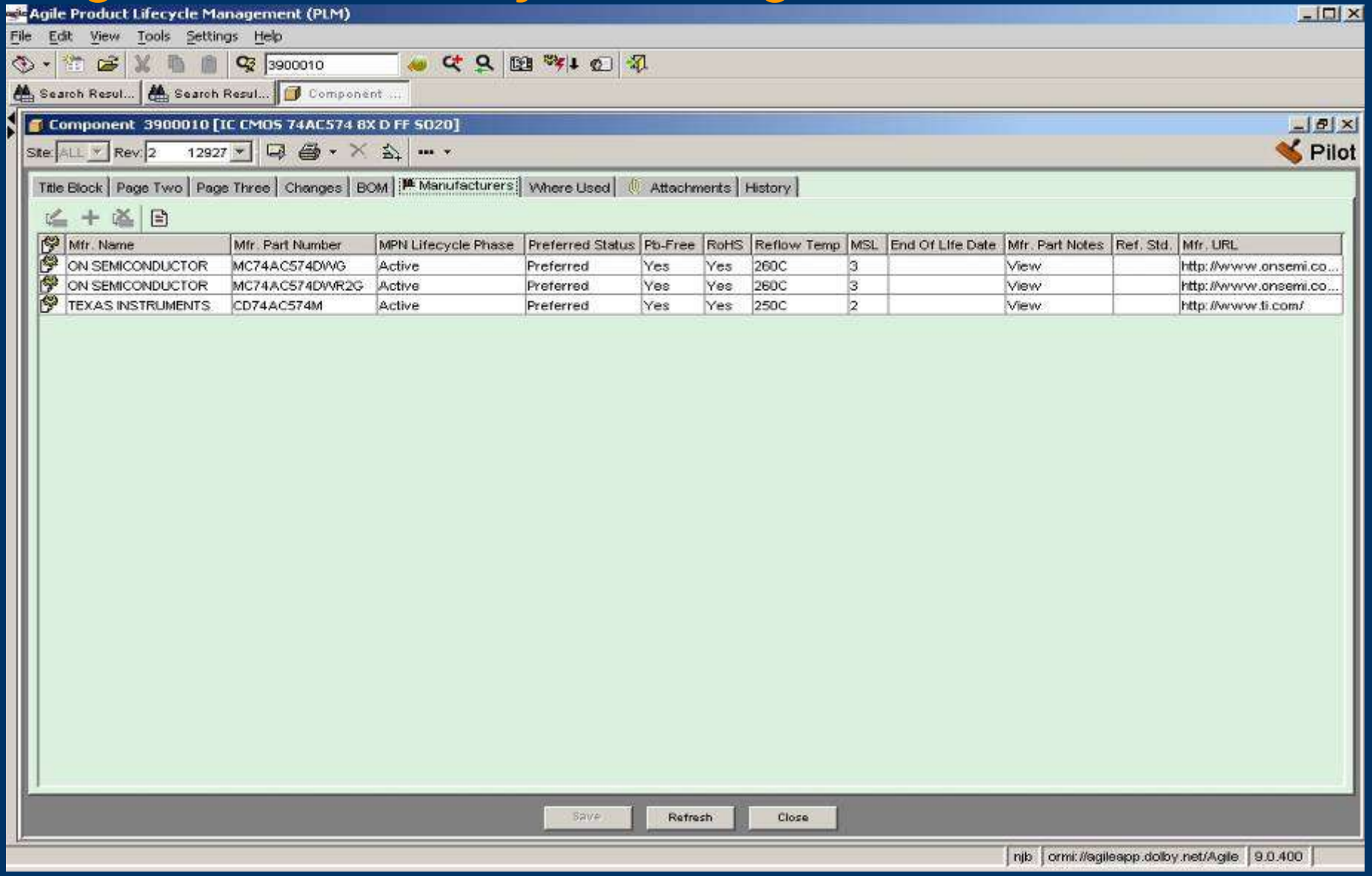
- For example:
  - 16288 = 10K0 1% 1206 resistor (non-RoHS or unconfirmed RoHS)
  - 1602880 = 10K0 1% 1206 resistor (RoHS confirmed)

  - 60095 = M3 x 8 panhead pozi screw (non-RoHS or unconfirmed RoHS)
  - 6000950 = M3 x 8 panhead pozi screw (RoHS confirmed)

Qualifying new RoHS compliant part sources

- Selected initially by engineering department from datasheet specifications as suitable for purpose
- For each DPN, try to qualify suitable MPN sources – multiple sources wherever possible to suit both UK and US purchasing supply chains
- Require written evidence of RoHS compliance from supplier or manufacturer
- For applicable SMT MPNs, record the MSL rating and check and record the maximum Pb-free reflow temperature per IPC/JEDEC standard J-STD-020C
- Prefer also written evidence of any exemptions claimed by manufacturer

Agile Product Lifecycle Management Database



Converting Dolby Product Designs for RoHS

- Rank and prioritise list of all products that require immediate conversion
- Phase out some mature low volume product which is not economic to convert
- Examine exemptions to see if some products fall outside scope – record decision and reasoning for any claimed exemptions
- Convert or, where necessary, redesign product by priority ranking, assembly-by-assembly.
- RoHS redesign must not allow for feature creep (keep Marketing out of design reviews!) – as a first pass a RoHS redesign must merely replicate existing design with modifications only permissible for new DFM concerns for Pb-free only.
- Continue to build non-compliant product in US factory for non-EU sales to reduce risk

Selecting PCB materials

- Decided to use higher performance laminates for new RoHS PCBs and move away from FR4 at least initially.
- Defined preferred spec and offer suitable qualified examples for supplier to choose from eg Isola FR408, Polyclad PCL-FR-370HR – but suppliers are free to offer alternates with similar properties which may also be suitable.
- RoHS designs use yellow silkscreen legend instead of white
- ENIG remains finish of choice for SMT PCBs, but trials for mixed technology and through-hole only PCBs have indicated that Immersion Ag is also a good choice and has some benefits for wave soldering process
- Peelable resist needs new formulations – some suitable ones now trialled OK from Peters and Electra

SMT Reflow Process

- Original 4-zone oven was capable for Pb-free but process window was narrow. Test vehicle PCBs suggested a new reflow oven was desirable with more zones. However, our choices were limited by floor space.
- Though we bought a Solderstar profiler, I used a free mathematical model from ECD to check performance “fit” of current oven and possible replacements against possible Pb and Pb-F pastes and required throughput for line beat rate.

  http://www.ecd.com/emfg/instruments/mole/profileplanner1.asp
- Ran performance tests and selected a 7-zone oven from Heller. Installed August 2004 in both UK and US factories. Original test vehicle checks repeated and confirm improvement in performance over old oven.
- Paste determined early on to be SAC. Mostly using SAC387 in UK and SAC305 in US, however tests and other studies show no significant differences in cost, performance or reliability. Thus happy to take either as supply dictates – which now seems to favour SAC305.
- Modified stencil aperture designs after several iterations – we found our standard stencil aperture reductions used for SnPb paste do not work well

Previous Dolby UK reflow process model - SAC

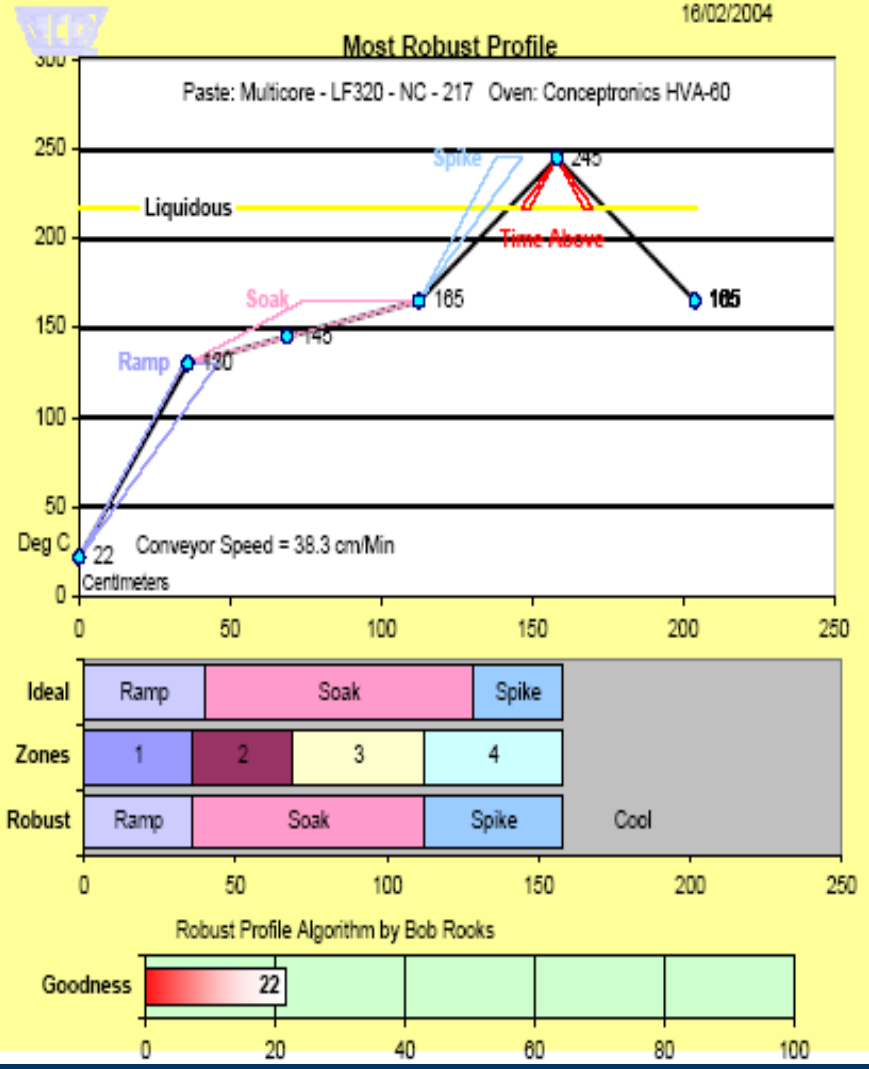
Select Paste
Multicore - LF320 - NC - 217

Select Oven
Conceptronics HVA-60

16/02/2004

Ideal Profile Data

	Ideal	Units	Nominal	User Set	Ideal	Units	Robust
Ramp	Slope	(Deg/Sec)	2.0		2.0	(Deg/Sec)	1.9
	Begin T	(Deg C)	22				
	End T	(Deg C)	130				
	Time				54.0	(Seconds)	56.5
Soak	Slope				0.3	(Deg/Sec)	0.3
	Begin T	(Deg C)	130	130			
	End T	(Deg C)	165				
	Time	(Seconds)	120		120.0	(Seconds)	120.0
Spike	Slope	(Deg/Sec)	2.0		2.0	(Deg/Sec)	1.1
	Begin T	(Deg C)	165	165			
	Peak T	(Deg C)	245				
	Time				40.0	(Seconds)	71.8
Liquidous	Peak T	(Deg C)	245				
	Liquidous	(Deg C)	217				
	Slope	(Deg/Sec)	2.0		2.0	(Deg/Sec)	1.1
	Time Above	(Seconds)	28		28.0	(Seconds)	50.2
Conveyor	Length	(cm)	158.3				
	Speed	(cm/Min)	44.4		44.4	(cm/Min)	38.3
	Speed	(In/Min)	17.5				



Please email comments and feedback to:
profileplanner@ecd.com

www.ecd.com

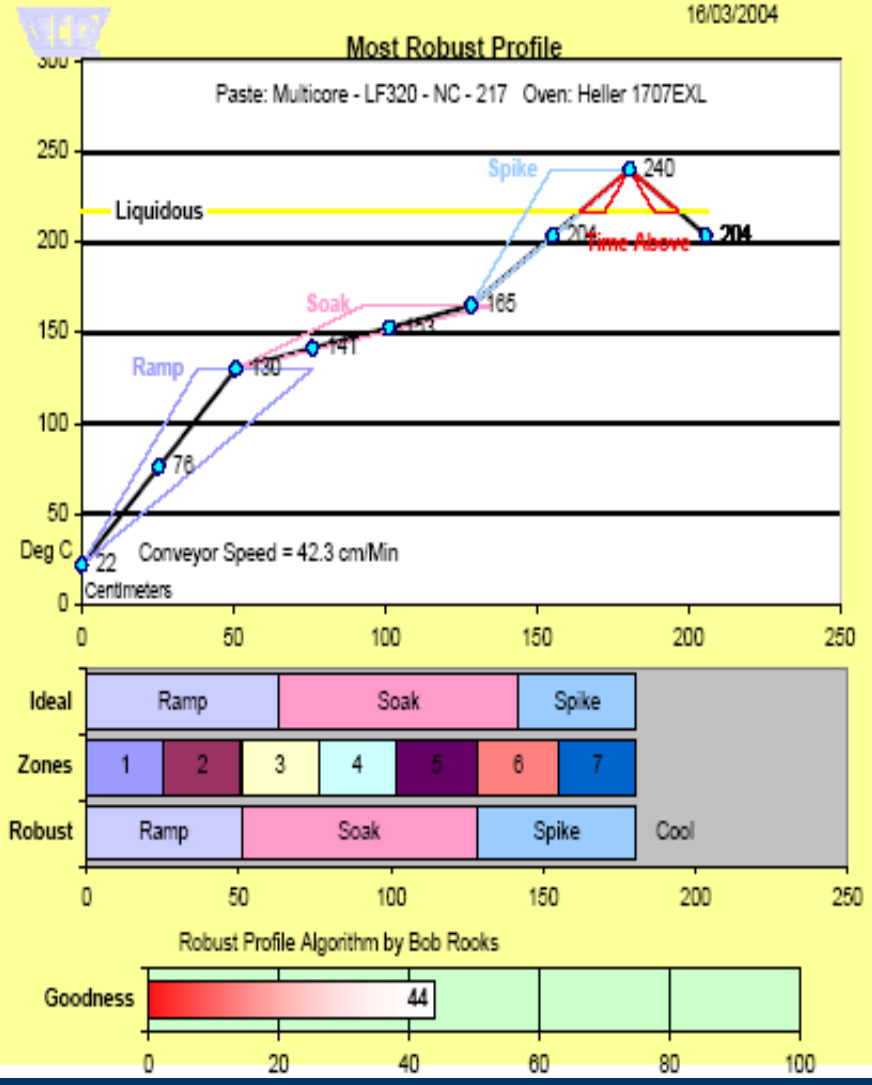
Predicted new Dolby UK reflow process – SAC

Select Paste
Multicore - LF320 - NC - 217

Select Oven
Heller 1707EXL

Ideal Profile Data

	Ideal	Units	Nominal	User Set	Ideal	Units	Robust
Ramp	Slope	(Deg/Sec)	1.5		1.5	(Deg/Sec)	1.5
	Begin T	(Deg C)	22				
	End T	(Deg C)	130				
	Time				72.0	(Seconds)	72.0
Soak	Slope				0.4	(Deg/Sec)	0.3
	Begin T	(Deg C)	130	130			
	End T	(Deg C)	165				
	Time	(Seconds)	90		90.0	(Seconds)	110.0
Spike	Slope	(Deg/Sec)	1.7		1.7	(Deg/Sec)	1.0
	Begin T	(Deg C)	165	165			
	Peak T	(Deg C)	240				
	Time				44.1	(Seconds)	74.0
Liquidous	Peak T	(Deg C)	240				
	Liquidous	(Deg C)	217				
	Slope	(Deg/Sec)	1.7		1.7	(Deg/Sec)	1.0
	Time Above	(Seconds)	27		27.1	(Seconds)	45.4
Conveyor	Length	(cm)	180.6				
	Speed	(cm/Min)	52.6		52.6	(cm/Min)	42.3
	Speed	(In/Min)	20.7				



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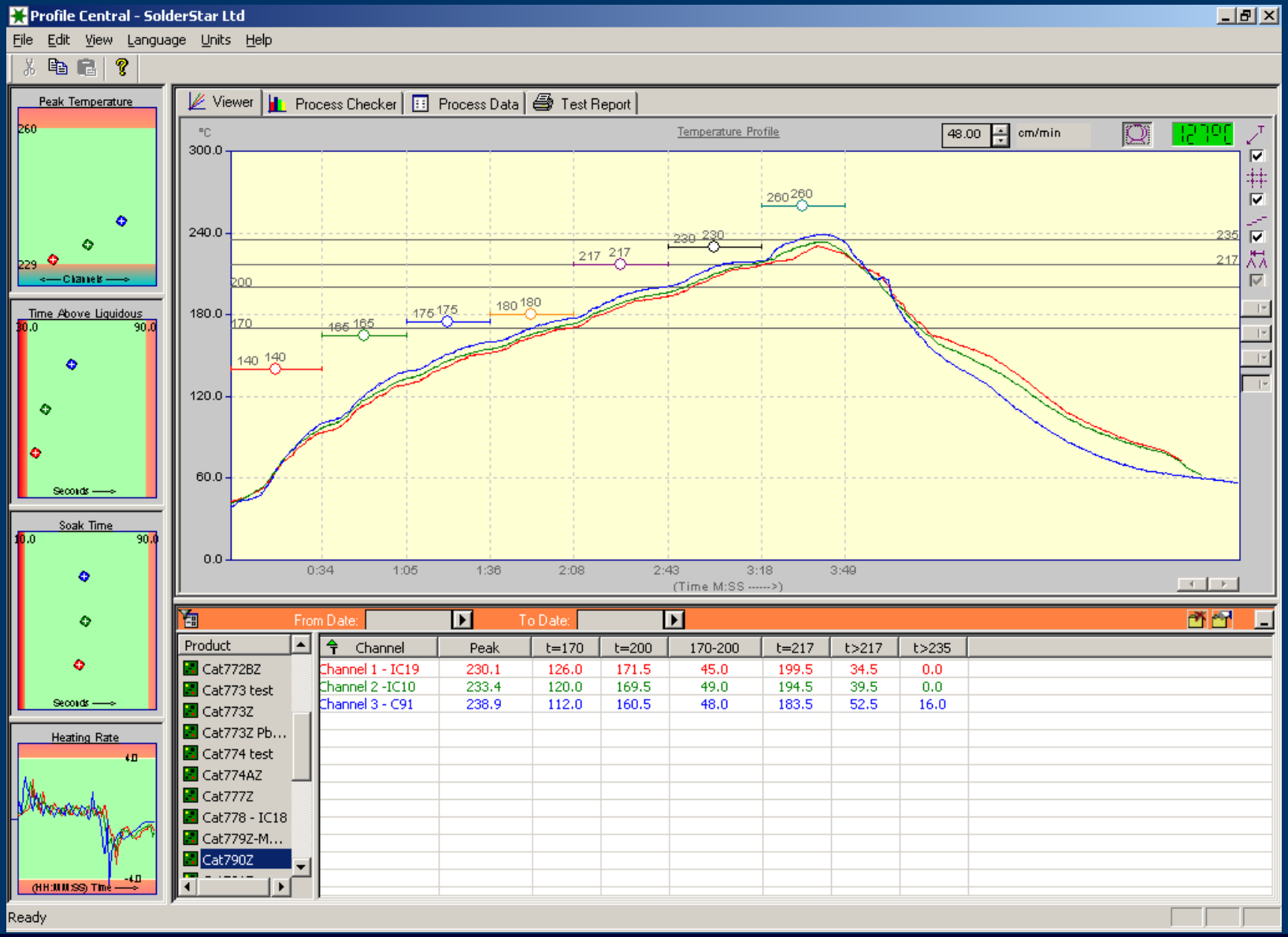
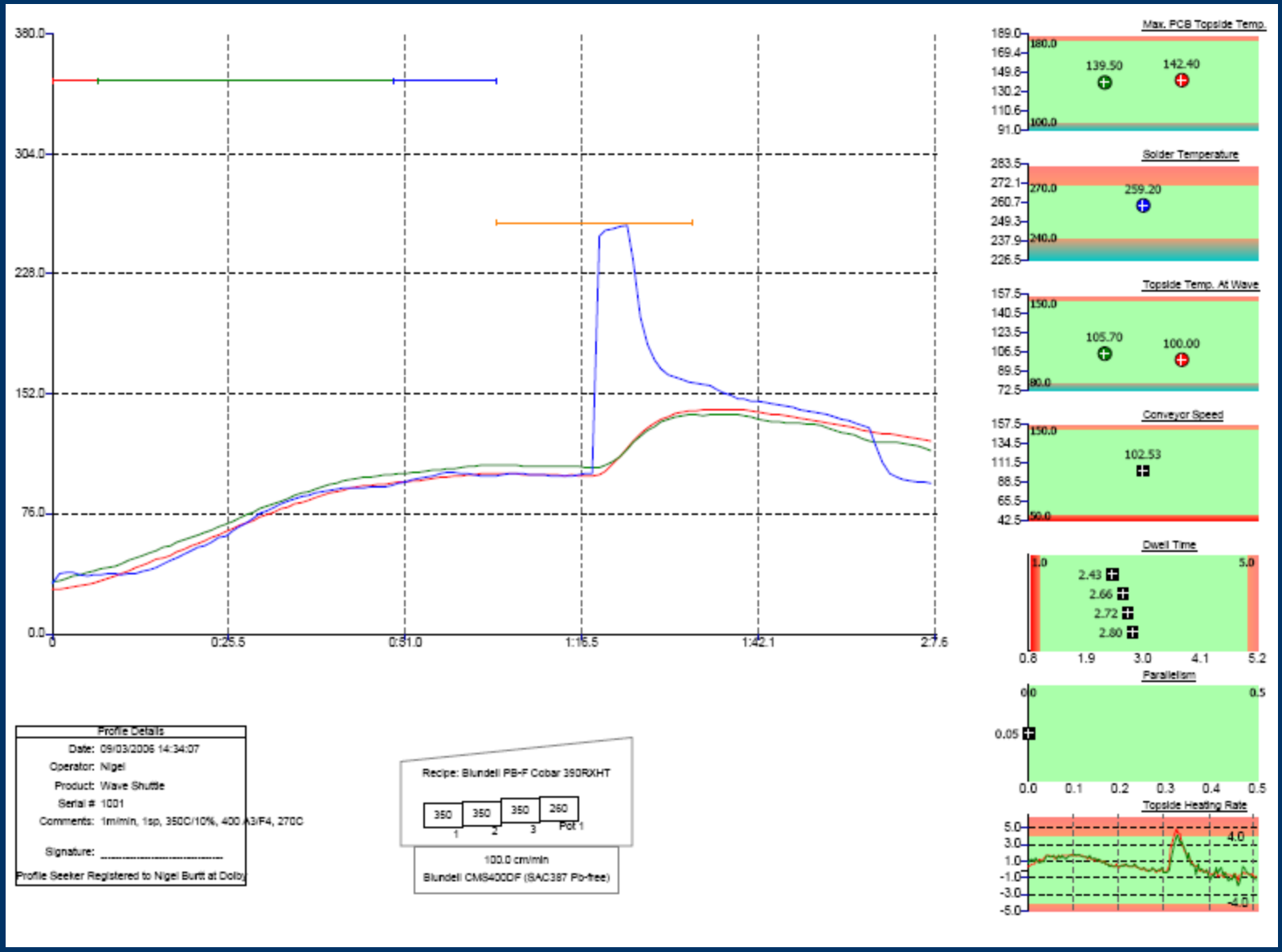
Actual Dolby UK reflow process example – SAC



Wave solder process

- Built several PTH boards stuffed with single Pb-F resistor value and through hole electrolytic caps. Used as test vehicles on possible choices for new wave solder machine – again choice limited by available floor space. New Blundell CMS400LF machine installed May 2005
- SAC alloy chosen as this had best data available regarding solder joint reliability. Other relevant studies such as JGPP still in progress and we could not wait for results – possibly SnCu+Ni and SnCu+Ag alloys may prove perfectly acceptable in future.
- SAC387 alloy chosen because closest match to eutectic. Same reason we use SnPB 63/37 and not 60/40
- No-clean fluxes, both VOC-free and IPA based trialled and both giving good results. VOC maybe better but solvent entrapment by fixtures is a major problem
- Wave solder pallet fixture material needs uprating. Have used different coloured material or coating with green Teflon to differentiate from Pb products still in progress. Pallets have a greater tendency to deform in contact with wave, so additional stiffeners found necessary.

Dolby UK wave solder process – SAC387



Selective solder process

- Long period of study of available machines suitable for both UK and US factory operations. Vitronics machine selected in USA first and trialled successfully there.
- UK machine installed in July 2004. Configured as new with 2 separate pots and solder fountains, one each for SnPb and Pb-free.
- Process introduction with SnPb only until June 2005 when we began running Pb-free products for the first time.
- Same VOC free flux used for both processes
- SAC387 used for Pb-free, for the same reasons as on wave solder

Rework

- Separate benches and tools segregated from normal production
- Current desoldering guns found unacceptable, solder tends to solidify at end of heater tube and block nozzle very quickly. New tools under consideration.
- Standard Metcal 600^0F tip needs to go to 700^0F range
- Soldering iron tips oxidise very quickly, return to best practice of cleaning tips (not using very wet sponge!) and re-tinning after each and every joint - which must be adhered to.
- Current Metcal BGA3500 rework system does seem capable, however new equipment under consideration (to get sufficient heat and maintain acceptable delta-T between top and bottom of all devices being reworked.)
- All solder wires more difficult to work with than SnPb – operator training needed. SAC305 selected

Don’t forget about your metalwork and hardware!

- Not just PCB assemblies, but plastic mouldings, fabricated sheet metal, paints, fasteners, cable, adhesives etc
- Lead used a plasticizer in wire insulation – are your mains leads compliant?
- Educate metalwork suppliers to understand RoHS requirements!
- Cr VI used in passivate on standard nuts and bolts – RoHS compliant versions are becoming available but not always within acceptable timeframe so we have moved many fasteners to stainless steel at least temporarily
- Salt spray test new RoHS products to check for any detrimental effect of new metal surface finishes etc.

Reliability

- Very early in project we identified an area of risk as BGAs. Mixed alloy joints tested using Practical components BGA test vehicle PCB made in both UK and US factories– confirmed risk in paste/ball mixture with BGAs. Also helped identify that current 4/5 zone reflow oven gave narrow process window for Pb-free paste
- To check process implementation Both factories built trial samples of an existing product with Pb-free BOM and Pb-free paste, and engineering tested reliability against control batch of current Pb product built at each factory - No major issues found.
- Designed custom test vehicle PCB with some help from Topline – Pb and Pb-F versions built at both factories using new reflow ovens (and In UK new wave solder process.) Assemblies tested at third party lab and currently undergoing test data analyis – no obvious problems found so far
- Participated in NPL studio project on Pb/Pb-F mixed solder joint project. Now a partner in follow up laminate reliability project

Production Changeover to RoHS compliant product

- Internally each product and sub-assembly has an additional character added to its name as a process variant only: e.g. Product ABC becomes Product ABCZ, with backplane ABCZ-BP, front panel ABCZ-FP, motherboard ABCZ-MB etc etc. Sales catalogue and marketing information still refers only to original product name ABC, so “Z” version is a phantom name mostly transparent to the user.
- Prototype each converted PCB sub-assembly and get engineering test and approval – sometimes using Pb parts under concession if BOM incomplete, then commence larger pilot build as fully RoHS BOM is possible
- Once pilot builds are tested and approved in engineering, phase in to normal production, to build and sell hybrid product containing both existing Pb sub-assys and new RoHS sub-assys. Gets some early market feedback if problems with reliability occur
- Gradually RoHS sub-assys become the majority of product hybrid build and non-RoHS build sub-assys phase out as we have supply chains drive RoHS BOM up and Pb BOM down. Eventually fully RoHS design available for sale
- US factory lagging approx 1 year behind on main product serving non-EU customers only, as a disaster fallback plan!

Next Headache…? The EUP Directive

- European Union Directive 2002/32/EC “establishing a framework for the setting of ecodesign requirements for energy-using products…”
- Formally adopted by the EU and put into force 11th August 2005
- Requirements of the EUP Directive are to be transposed into member state law by 11th August 2007 – so now less than 2 years away!

http://europa.eu.int/comm/enterprise/eco_design/

Are you doing what you need to?
All our jobs in “UK plc” depend on getting this right!