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Adaption to Scientific and Technical Progress under Directive 2002/95/EC

Results previous evaluation

Exemption 30 under Directive 2002/95/EC

"Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more"

(Excerpt from Öko-Institut report 2006)

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6.31 Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers - JBL (request set 4 No. 13)

6.31.1 Description of requested exemption

The applicant uses a multi-coil transducer design that allows transducers to be as little as 1/3 the weight and smaller in size than conventional transducers. This design, according to the applicant, thus offers significant performance advantages over his competitors. The dual coil allows the use of an extremely efficient and light motor magnet, because the magnetic return path is utilised by the second coil. For example, an 18 inch woofer of conventional design (2242 H) weighs 35 lbs (15.9 kg), but its dual coil equivalent (2258 H) weighs only 10,5 lbs (4.8 kg) . Many auxiliary mounting, cabinet, packaging, and rigging parts can be reduced in size and weight because the woofer is so light, which results in a less expensive speaker system. Light weight is particularly important in portable or tour sound applications. There are other advantages, including reduced cost, size, and distortion.

The applicant has been granted multiple patents related to this multiple coil technology. He has been producing transducers of this type for over a decade and most of his products are now dependent upon this design.

The applicant's specific design requires a non-RoHS-compliant solder, which contains cadmium. The exemption would apply to cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers.

There are two general types of transducers which require the cadmium solder:

1) transducers where multiple voice coil windings are soldered together on the voice coil and
2) transducers where the voice coil windings are soldered to lead outs on the voice coil.

On cone transducers, the solder joints are used to interconnect the voice coil windings so the current flows in the correct direction in the windings. This makes both windings pull together to move the speaker cone. On compression drivers, the solder joints connect the moving voice coil winding to a fatigue resistant lead out for electrical connection to the driving signal. These applications have in common solder joints directly on the hot vibrating voice coil and are subjected to extreme temperatures of up to 250 °C and vibration.

The only solder known to work in this application contains 70-75% cadmium. From reference books, cadmium solder alloys have a solidus temperature of 265 °C. The voice coils in question are provided by an independent supplier outside the USA who considers the exact alloy to be proprietary information. The supplier has only revealed that the solder contains 73% cadmium.

The transducers had been redesigned in order to reduce the amount of cadmium. Before the redesign, the typical dual coil required 4 solder joints between the voice coil windings and interconnecting copper strips.

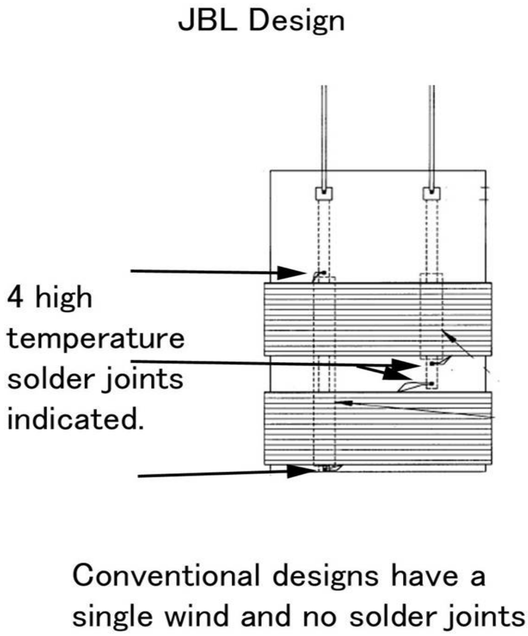

Figure 8: JBL voice coil design

The quantity of solder averaged 0.56 grams per transducer. 73% or 0.409 grams of the solder were cadmium. The average transducer weight is 4.5 kg. The typical speaker system weight is 18 kg per transducer. A typical end sales product therefore contains .0023% cadmium. Estimating 75,000 transducers annually, around 31 kg of cadmium were used. The redesign reduces the solder joints in question from four to two and thus saves around 50 % of the cadmium. The actual amount of cadmium involved in this application at JBL thus is around 16 kg per year.

The applicant says that to his knowledge he is the only manufacturer using this kind of technology with cadmium alloys in the voice coils. Assuming that the applicant is right, the exemption would allow the use of 16 kg of cadmium worldwide.

6.31.2 Summary of justification for the exemption

Applicant's criteria for justification

The applicant says that his dual coil design reduces the distortion.

The next figure shows a distortion measurement diagram of a conventional and multi-coil loudspeaker in comparison.

JBL 2226H single coil vs, 2265H Dual coil

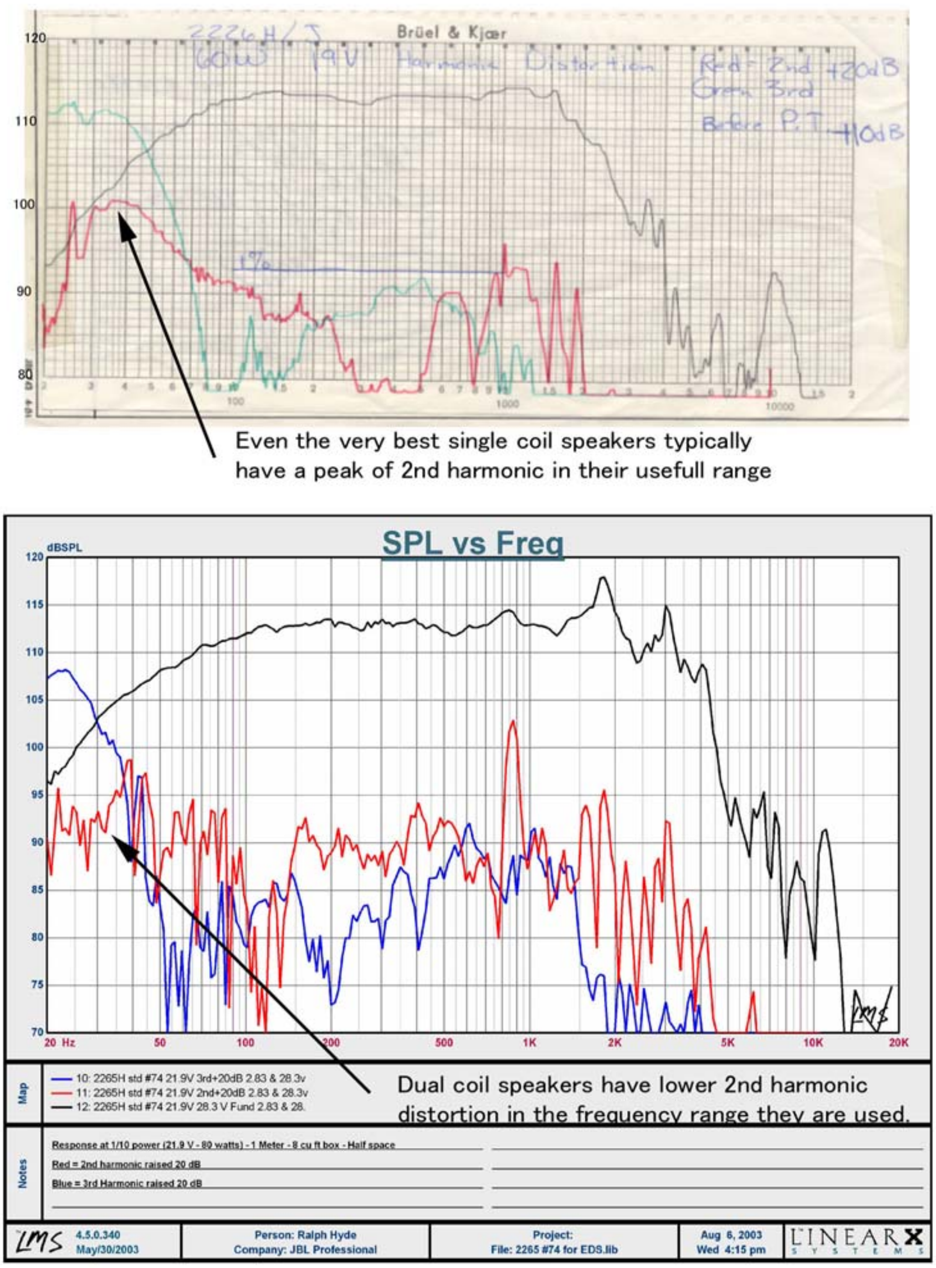

Figure 9: Single vs. dual coil loudspeaker comparison of distortion

The black lines are the frequency response. An ideal frequency response is flat and level from 20 Hz to 20 kHz, but a real response curve for a woofer has the characteristics seen here. These 15 inch Pro woofers are used from about 30 Hz to 300 Hz - and rarely higher. All the curves outside this frequency range can be ignored. Note that the output level around 100 -300 Hz is the same for the 2 speakers (113 dB) as it must be for a valid comparison.

Distortion is an unwanted and unpleasant noise generated in the transducer itself. Distortion consists primarily of harmonics. If a speaker is sent a pure tone of, for example, 100 Hz it would ideally only reproduce that tone, but in a real transducer it will also generate a small amount of 2nd harmonic at 200 Hz, 3rd harmonic at 300 Hz, and on up. JBL designs for minimum 2nd and 3rd harmonic distortion because minimising them will generally minimise all the harmonic distortions.

In the above figures, the blue line is the third harmonic and it can be ignored since it is not part of this discussion. The red lines are the distortion comparison. On the single coil speaker (upper curve), the 2nd harmonic averages about 100 dB between 30 and 45 Hz. On the dual coil speaker (lower curve) the second harmonic averages about 93 dB in the same frequency range. This 7 dB lower distortion is significant and it is due to the dual coil design of the 2265.

The mulit-coil motor for the applicant's loudspeakers is inherently symmetrical, and the resulting magnetic coupling to the voice coil is likewise symmetrical even as the coil is moving in the magnetic gap. This symmetrical motor design results in very low even order (2nd, 4th, etc) harmonic distortion. For single coil motor designs, it requires additional measures to approximate the symmetry which is inherent in the applicant's dual coil design.

The typical dual coil design required four, now two solder joints after the redesign, between the voice coil windings and interconnecting copper strips. The solder joints are directly on the moving voice coil and are subjected to extreme temperature and vibration. The only solder known to work in this application contains 70-75% cadmium.

Integral in the multi-coil transducer design are separate windings on a single coil form, but the windings must circulate electrical current in opposing directions. The only practical way the applicant knows to accomplish this is to solder the windings to interconnection strips on the voice coil itself in close proximity to the windings. JBL Pro has been unable to find a substitute solder due to the difficult nature of these solder connections:

- Most of the applicant's applications use aluminium windings, and aluminum is very difficult to solder. Only a very limited number of alloys are suitable.
- The solder connection must withstand operation approaching 300 degrees C, which is well over the melting point of most solders.

- The solder connections must function at full temperature on the moving voice coil with accelerations in thousands of Gs.

There are several tin/zinc alloys recommended for aluminum, but with a solidus temperature of only 200 C they are not applicable to the applicants speakers. The applicant tried one of these alloys, which confirmed that it does not work. It quickly melted and failed upon power testing. He also tried 95Zn/5Al with 382 C melting point, but it dissolved the very thin voice coil wire instantly while soldering. The applicant says that he tried the high lead, RoHS exempt solder as well, which is NOT recommended for aluminium. The high electromotive potential difference between lead and aluminum is expected to cause galvanic corrosion. The applicant considers it a stopgap fix only. In the testing, these coils are showing promise, but their reliability is questionable. The evaluation will only be complete after a full year of field usage confirms the reliability of the new voice coils. Transducers made with high lead RoHS exempt solder contain no cadmium. However, the applicant is afraid the exemption for high lead solder might expire. In the case that the lead-tin solder would prove to be a viable substitute, the amount of lead used at JBL for this application would be around 19 kg of lead replacing 16 kg of cadmium.

According to the applicant, there is a very remote possibility that other alloys might work and he intends to continue looking for a substitute. However, he says that there is no chance he will have an approved substitute by July 1, 2006.

A design change from aluminum to other voice coil materials like copper is not possible. The voice coil windings are required in the great majority of JBL Professional transducer applications to provide sufficient speaker efficiency to be competitive. Aluminum coil windings have conductivity to weight ratio two times that of copper. This is essential to achieve the high sound pressure levels required in professional use. With copper coils, the sensitivity and ultimate output level of the speaker suffers. Aluminium wire transducers yield aproximately 1,5 dB greater maximum output than copper coil drivers of the same basic design. Only limited applications, such as low sensitivity sub woofers, are competitive with a copper coil.

The use of copper clad aluminium coil wires in order to solve the contact problem, which only cadmium containing solders can solve sufficiently, is not a viable option. According to the applicant, copper clad aluminum wire is brittle and it breaks under the extreme usage these speakers must handle. This causes an unacceptable reliability problem. Even if copper or copper clad aluminum wire were to be used, a high temperature solder is still required. The only acceptable solder the applicant knows of for copper is the high temperature, high lead (>85%) solder, which is exempted from the RoHS Directive (entry 7 of the Annex).

The elimination of cadmium by a complete redesign of the transducers may be possible eventually, but not by July 1, 2006. The high temperature of up to 250 °C limits the number of possible solder alternatives. The applicant continues to work on design changes to the coils to eliminate high temperature solder joints or move them to lower temperature locations. Assuming that a potential alternative design or a substitute solder would be possible, it would require extensive qualification testing in many different transducer models. In order to discover infrequent failure levels as per the applicant's quality standards, very large quantities of transducers (hundreds to thousands) will have to be power tested. This test is destructive to the transducer and the applicant will have to bear the considerable cost of these expensive professional transducers. Even the most thorough test cycle will not give the same assurance of reliability in the field that the applicant has currently from its years of field experience with the existing solder. With the knowledge that any exemption will be temporary, the applicant says that he will continue investigating substitute solders and fundamental redesign of the voice coils to eliminate the need for cadmium.

The applicant says that he has more than a decade of transducer and system designs which would require redesign, test, and qualification. If an acceptable alternative design is found, minimum qualification cycles are months in length and at best he could only support a few simultaneously. A best case changeover by complete transducer redesign would be measured in years instead of weeks.

Reverting to a conventional design would eliminate the great majority of the applicant's products. The products would have to be redesigned to be heavier, less competitive, conventional designs. The applicant says that this would waste 10 years of design and development and destroy his competitive advantage. The applicant has a substantial business in professional and commercial speaker systems in Europe and China. An inability to sell in these markets would be devastating to the company.

Critical review of data and information (given by applicant or other parties)

The applicant uses a specific multi-coil technology for transducers offering technical advantages: high performance at less speaker volume and only around 1/3 of the weight compared to speakers produced with other technologies. The technical function itself – the function of a professional high-powered loudspeaker with sound pressure levels of more than 100 dB (A) – can be realised in compliance with the RoHS Directive, in opposition to the applicant's transducer technology. The mulit-coil motor for the applicant's loudspeakers is inherently symmetrical, and reduces the distortion, as the applicant showed with the provided distortion measurement diagram.

The PLASA (Professional Lighting and Sound Association) confirms that currently the applicant's technology cannot be produced in line with the RoHS Directive (stakeholder document "PLASA Harman.JBL response.pdf").

It must be acknowledged that the applicant has reduced the amount of cadmium to 50 % of the original need, and that he has been testing alternative solder alloys. The applicant only started his efforts in 2005, which is 2 years after the RoHS Directive had been enacted. So far, he has not yet found a possibility to produce his technology in line with the RoHS Directive. Once the applicant would have found an alternative product design offering similar advantages, it would take years, the applicant says, to implement this design in all products. Although the consultants do not have clear insight into the redesign processes and cycles, this argument is at least typical for a manufacturer of professional equipment with long product redesign cycles and limited redesign capacities.

The applicant himself did not put forward any environmental reasons to justify his exemption request. The reduced product weight and material use and a possibly lower energy consumption, could be environmentally advantageous and could have supported a recommendation to grant the exemption.

Based on article 5 (1) (b), the consultants can only recommend to grant the exemption if the applicant's technology itself – high performance at low volume and weight – is considered as the proper function, not just the function of a professional high-powered loudspeaker – generating sound in good quality and at sound pressure levels of 100 dB and more. While in the first case, the applicant currently does not have a technologically practicable and RoHS compliant solution, in the latter case the function can be provided in line with the requirements of the RoHS Directive.

The applicant says that the weight and volume are in particular important in portable or tour sound applications, additional to other advantages like distortion. The applicant did not prove that his technology is superior in terms of distortion. Nevertheless, the argument is plausible that weight and volume are crucial criteria for mobile use. The applicant says that he does not know of any other voice coil/motor technology that delivers equivalent performance at such low weight. Other manufacturers do not make high performance transducers with such a light weight, according to the applicant. The Professional Lighting and Sound Association (PLASA) supports this exemption request (PLASA Harman.JBL response.pdf). PLASA says that the applicant's patented multi-coil technology cannot be produced in line with the requirements of the RoHS Directive. The stakeholder therefore was asked to confirm that the JBL multi-coil technology currently is the only way to manufacture professional loudspeakers with such low volume and weight at high sound performance and reduced distortion. At the time when this review process was closed, there was no answer from PLASA. Other stakeholder comments were not available.

Within their mandate to review the exemption requests based on the applicants' and stakeholders' information, the consultants thus have to rely on the manufacturers information, which is plausible and complete, as the consultant had requested it. They must assume that low weight and volume and high performance loudspeakers currently can only be produced with the applicant's patented multi-coil technology implying the use of cadmium.

The consultants do not know whether a further investigation, e. g. at other manufacturers, would have yielded different results. Time contraints limited further assessments.

The RoHS Directive already contains an exemption for the use of lead in high melting temperature type solders (i.e. lead-tin solder alloys containing more than 85 % lead) in entry 7 of the Directive's Annex. The applicant is therefore testing whether the use of such a lead-tin-type solder could be a viable option, but does not yet have a final result.

The consultants additionally doubt that the substitiution of 16 kg of cadmium by 19 kg of lead, which would result from the the use of lead-tin solders with more than 85 % of lead, environmentally is a good strategy, the more as it is not clear whether the toxic potential and related risk would actually be lower.

The applicant could be more advanced with his research for a RoHS compliant solution, assuming that there is a reasonable one, if he had started his efforts not just less than one year before the RoHS deadline 1 July 2006. On the other hand, it should be acknowledged that the applicant has changed the transducer design reducing his use of cadmium from around 31 to 16 kg per year.

Taking into consideration all the facts, the consultants recommend granting the exemption with the following wording:

Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more until 30 June 2010.

The limitation to 2010 is recommended because the applicant has started his efforts only in 2005, although the RoHS Directive had been enacted in 2003 already, as explained above. The applicant thus should be encouraged to boost his research for RoHS compliant alternatives, and he still should have enough time to find a reasonable and environmentally sound solution, which is in line with the requirements and the objectives of the RoHS Directive.

6.31.3 Final recommendation

The consultants recommend granting the exemption with the following wording:

Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more until 30 June 2010.

The applicant's transducer technology offers advantages – less product weight and volume at high performance - which currently cannot be substituted using a RoHS compliant technology, as to the consultant's knowledge, which they could obtain within their mandate and the available time. Currently, the applicant does not have a RoHS compliant solution for his technology, but he changed the design of his product and thus reduced the use of cadmium from around 31 to around 16 kg. The time limit of 2010 is recommended as the applicant started his efforts to be RoHS compliant late in 2005 only and thus could be more advanced with his research for a RoHS compliant solution.

6.32 Lead in thermal cutoffs for special applications – Asco (request Set 4 No. 14)

6.32.1 Requested exemption

The company ASCO Valve has requested an exemption for the use of lead[19] in a fusible element itself being part of a thermal cutoff. As such this request overlaps with request nr. 12 set 3 ("8. Cadmium and its compounds in electrical contacts except for applications of one-shot operation function such as thermal links and cadmium plating except for the applications banned under Directive 91/338/EEC amending Directive 76/769/EEC relating to the restriction on the marketing and use of certain dangerous substances and preparations."). However, request nr. 12 set 3 related to the use of cadmium and not to lead as it is the case here. Furthermore, the applicant has specified his exemption request for applications where normal operating temperature exceeds 140°C and reliable, predictable operation for a minimum of 30.000 hours is required.

The function of lead has not been specified by the applicant but is assumed to be ensuring the desired melting temperature of the fuse. The applicant is not the manufacturer of the thermal cutoff but of solenoid valves for use in hazardous locations. A UL standard[20] requires the involved solenoid coil to have a minimum life of 30.000 hours and the necessity to have a means of limiting the surface temperature to defined safe values when subjected to fault conditions. The applicant states that a thermal cutoff with a lead-based fusible element provides this required functionality (the body temperature of the installed thermal cutoff exceeds 140°C when the solenoid valve is operated within normal limits (not further specified by the applicant).

[19] The initial wording included the possibility of the presence of cadmium, mercury and/or hexavalent chromium. However, in the course of the evaluation procedure, the applicant provided a new wording only referring to lead.

[20] UL1002: Standard for Electrically Operated Valves for Use in Hazardous (Classified) Locations.