



AEROSPACE INFORMATION REPORT

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AS36100 Background and Development Record

RATIONALE

AIR36108 has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE

1.1 Purpose

- 1.1.1 This Aerospace Information Report (AIR) provides a record of the development by SAE AGE-2A Air Cargo Sub-Committee of Aerospace Standard AS36100, *Air Cargo Unit Load Devices — Performance Requirements and Test Parameters*, published 2005-02, and its revision A published 2006-04, intended as a technical reference for airworthiness approval of air cargo unit load devices (pallets, nets and containers) to be loaded with either baggage or freight on board civil transport aircraft, and to partly supersede previously used NAS 3610, *Cargo unit load devices - Specification for* — [Revision 10, 1990, referenced in TSO C90(c)].
- 1.1.2 AS36100 was developed over a 5 year period (1999-2004) by a Panel of SAE AGE-2A designated as “NAS 3610 Oversight Panel” (OSP), based on a worldwide industry consensus that NAS 3610, used since 1969 as technical reference for TSO C90(c), had become largely obsolescent, not properly understood by many of its users, and still contained errors while document sponsor AIA stated they were not going to update or revise this document. This consensus was initially reached at the International Standardization Organization (ISO) TC20/SC9 Air Cargo Sub-Committee meeting Nr 29 (1998, Memphis TN), which hence agreed to prepare a corrigendum (published 2001) to ISO 8097 (based on NAS 3610), and to entrust SAE AGE-2A, on behalf of the industry, with identification of the needs for a replacement document. AGE-2A thus created in 1999 the OSP, which undertook a systematic review of the air cargo industry's actual requirements and the step by step development and discussion of AS 36100.

AS36100 Revision A (published 2006-04) was subsequently developed in 2005 by AGE-2A in order to obviate the first edition's identified shortcomings prior to expected TSO C90(d) publication.

- 1.1.3 The scope of the OSP work, thus the present AIR, also included other documents - some of which existed, some of which were subsequently developed - associated with AS36100 or supplementing it, covering such other areas as continued airworthiness requirements, design and testing methods, unit load devices design specifications and accessories, and rules for their proper operation/utilization and operating staff training. A list of the identified areas is provided under 1.1 of AS36100. See 2.1.2 hereafter for other associated documents concerned.

1.2 Field of Application

- 1.2.1 The present AIR is intended to provide future users of AS36100, including Airworthiness Authorities, unit load devices designers, purchasers and operators as well as civil transport aircraft and aircraft cargo systems or ULD designers within the industry, with the background and rationales of the requirements and parameters retained therein, in order to achieve full understanding of the technical justifications for these requirements.
- 1.2.2 In the same way, it is intended to provide AGE-2A members with means to re-examine provisions of AS36100 for any future revisions resulting from operational experience or the evolutions of industry needs, while keeping track of the originally retained rationales.
- 1.2.3 It is intended such revisions will be evaluated by the AGE-2A permanent Airworthiness Panel established to continuously monitor AS36100 and the associated documents, and the rationales for these revisions documented and recorded at that time.

2. REFERENCES

2.1 Reference Documents

The following publications form a part of this document to the extent specified herein or in AS36100. When referring to them, the latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of publication of AS36100A (2006-04) or its latest revision. Nothing in these documents, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS33601	Track and Stud Fitting for Cargo Transport Aircraft, Standard Dimensions for
AS36100A	Air Cargo Unit Load Devices - Performance Requirements and Testing Parameters
AS36101	Air Cargo Unit Load Devices - Load Distribution Model
AS36102	Air Cargo Unit Load Devices - Test Methods
ARP36103	Air Cargo Unit Load Devices - Center of Gravity Control Methods
ARP36104	Air Cargo Pallets and Nets Compatibility
AIR36105	Air Cargo Unit Load Devices - Reference Standards [Bibliography]
AIR36106	Air Cargo Unit Load Devices - Use of Airworthiness Reference Documents

NOTE: Where no revision number is indicated, check the latest published revision number on the SAE web site. Numerous other unit load device related SAE documents may also be concerned: see AIR36105.

2.1.2 U.S. Government Publications

Available from U.S. Government Printing Office, Mail Stop SSOP, Washington DC 20402-9325, www.gpoaccess.gov/ecfr and the FAA website www.airweb.faa.gov/rql.

Title 14 CFR (FAR) Part 21 - Certification Procedures for Products and Parts, Subpart O - Technical Standard Order Authorizations

FAA Technical Standard Order (TSO) C90, Cargo Pallets, Nets and Containers

Title 14 CFR (FAR) Part 25 - Airworthiness Standards: Transport Category Airplanes

2.1.3 European Union Publications

Available from European Aviation Safety Agency (EASA), Otto Platz 1, Köln Deutz, Postfach 101253, D-50452 Cologne, Germany, www.easa.eu.int.

EASA CS-ETSO, Certification Specifications for European Technical Standard Orders

European Technical Standard Order (ETSO) C90, Cargo Pallets, Nets and Containers

EASA CS-25, Certification Specifications for Large Aeroplanes

2.1.4 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS 3610 Cargo unit load devices - Specification for - [Revision 10, 1990, referenced by TSO C90(c)]

2.1.5 International Standards

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org, or International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org, or any of the national Standards Institutes worldwide, Members of ISO.

ISO 7166	Aircraft - Rail and stud configuration
ISO 8097	Aircraft - Minimum airworthiness requirements and test conditions for certified air cargo unit load devices [4 th edition, 2001, referenced by ETSO C90(c)]
ISO 9788	Air cargo equipment - Cast component of double-stud fitting assembly with a load capacity of 22 250 N (5000 lbf) for aircraft cargo restraint
ISO 11242	Aircraft - Pressure equalization requirements for cargo containers
ISO 21100	Air cargo unit load devices - Performance requirements and test parameters [ETSO C90(d) pending]

2.1.6 IATA Publications

IATA standard specifications concerning air cargo unit load devices were taken into consideration, and are published in the IATA Unit Load Devices Technical Manual (UTM), available from International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z1M1, Canada, or its web site at www.iata.org.

2.2 Terms and Definitions

For the purposes of the present AIR and listed documents, the following terms and definitions apply unless otherwise defined in the document:

CIVIL TRANSPORT AIRCRAFT: An aircraft, type certificated under 14CFR Part 25 or EASA CS-25, operated for civil commercial transport of passengers or freight, and capable of carrying air cargo unit load devices for baggage or freight.

CONTAINER (AIR CARGO -): A rigid structure which interfaces directly with the aircraft cargo handling and restraint system and alone performs all the functions of a unit load device.

INSTALLATION: The fact of installing a unit load device for flight into an aircraft's cargo compartment and restraint system.

NET (AIR CARGO PALLET -): A webbing or rope net for restraining load onto an air cargo pallet.

PALLET (AIR CARGO -): A unit load device consisting of a flat platform with flat undersurface of standard dimensions, on which goods are assembled and secured by a net before being loaded as a unit onto the aircraft, and which interfaces directly with the aircraft handling and restraint system.

RESTRAINT SYSTEM: Equipment for supporting and restraining unit load devices in an aircraft against the ground/flight loads. It usually consists of such items as rollers, side guides and locks for securing unit load devices to the aircraft structure. It does not include unit load devices, barrier nets and tie-down straps.

TYPE 1 ULD: A unit load device designed for use in an approved aircraft restraint system that conforms to all flight and ground cargo restraint and occupant protection requirements of Title 14 CFR Part 25, including the 9.0g forward ultimate inertia force of § 25.561 (b)(3)(ii).

TYPE 2 ULD: A unit load device designed for use in an approved aircraft cargo compartment and restraint system that conforms to the flight and ground cargo restraint and occupant protection requirements of Title 14 CFR Part 25, except for the 9.0g forward ultimate inertia force of § 25.561 (b)(3)(ii), which is complied with either by supplementary installation of a barrier net or bulkhead, or by specifying an approved placement of the ULD in the aircraft.

UNIT LOAD DEVICE (ULD): Device for grouping, transferring and restraining cargo for transit. It may consist of a pallet with a net or it may be a container.

UTILIZATION: All actions pertaining to operational use of a unit load device, including inspection, build-up, securing, ground transport, loading, and installation aboard aircraft.

3. AS36100A BACKGROUND INFORMATION

The information hereafter is provided in order to identify the background and rationale for each item concerned in AS36100A (2006-04). It is given in the sequence and numbering system of that document to indicate the source or decision process for each item.

An **[X-X]** index cross-refers for each item to the appropriate technical discussion documents, reproduced in Appendixes to this AIR, where the same **[X-X]** index can be found. Appendixes are numbered from 1 through 14, indicating successive development sequences. Attachments used at each sequence are designated as e.g. 1A, 1B, 1C, for sequence 1, etc., and the second index figure indicates the relevant location in the Attachment.

3.1 General requirements part [AS36100A Sections 1 to 6]

Framed numbering refers to the relevant paragraphs of AS36100A, in that document's sequence.

General It was agreed AS36100 was to retain, inasmuch as possible, NAS 3610 wording verbatim in order to facilitate TSO compatibility. AS36100 nevertheless adds to NAS 3610 certain requirements where justified by experience.

Title was agreed as "*Performance and test parameters*", not "*Specification*" as NAS 3610's, because both documents only cover these, not complete ULD specification criteria.

1. No "9g" (type 1) ULD type was retained for AS36100, the ULD types of which are based on the established or foreseen 21st century air cargo market **[1A-01] [4A-01] [6D-01]**. Also see **[8B-01] [9B-01]** for cargo compartments classification.

1.1 For all other aspects not included in AS36100, see bibliography (industry standards, not regulatory approved) in AIR36105 **[6F-01]**.

1.2 The 2nd sentence was agreed to clarify and avoid interpretation ambiguities in the former NAS 3610, which was often misconstrued by users for an aircraft systems design standard while it exclusively addresses ULD approval criteria **[6A-02]**. Also see **[3.3]** for more detailed clarification of ULD testing restraint conditions vs aircraft actual restraint cases.

The 3rd and 4th sentences were agreed to clarify the respective fields of application of AS36100 and maintained NAS 3610. ULD types not covered in AS36100, including all "9g"(type 1) ULDs, will still have to be approved in reference to NAS 3610.

NOTE: Cargo covers, except where a net is incorporated, are defined only from the fire protection perspective in 14CFR Part 25 Appendix F Part I (a)(2)(iv), and not deemed to be part of a unit load device except where they are permanently attached to a net. If a net is permanently attached, the performance and testing requirements applicable to the net as shown in AS36100, plus 14CFR Part 25 Appendix F requirements, are applicable to the net/cover assembly. If no net is permanently attached, see applicable industry guidelines in ARP5486.

2.1.1 For AS33601 (former MS 33601B) applicability and its equivalence with ISO 7166, see **[6C-01]**. By convention, in order to reduce updating requirements, the current document revision letters are not provided and are to be checked on the SAE web site prior to reference.

2.1.2 The Panel agreed that only U.S. Government (CFR) regulatory references would be included in AS36100. Foreign (European, Japanese) applicable references are listed in the equivalent International Standard ISO 21100.

3.1 Types 1 and 2 definitions wording is based on 14CFR 25.561 : for decision background on deleting type 1 "9g" units from AS36100, see **[1A-01] [4A-01] [6D-01] [8B-01] [9B-01]**.

3.2 The selection of ULD sizes retained in AS 36100 was based on established or foreseen air cargo market needs **[1A-01] [4A-01]**. Sizes not previously included in NAS 3610 are :

- sizes N and S : "half-size" units increasingly used by express cargo operators.

NOTE: size S is 88x61.5" nominal. Where 88x62.5" units are used, it was agreed they could and should be approved as a TSO deviation under base size S parameters (see **[UC S1]** hereafter).

- sizes P and Q : used on B767 aircraft as non-certified containers only (see AS1677). Boeing perceives a potential need for certified (airworthiness approved) containers of the same base size **[1A-01] [4A-01]**.

As to dimensions, it was agreed **[7A-01]** all dimensions and loads be given in metric units first with inch-pound units between brackets, as per SAE TSB-003 rules **[7B-03] [7E-01]**.

3.3 The last paragraph was added to clarify and avoid interpretation ambiguities in the former NAS 3610, which was often misconstrued by users for an aircraft systems design standard while it exclusively addresses ULD approval criteria. ULD restraint configurations shown in AS36100 Section 8 are for standardized ULD testing only. Aircraft cargo systems may be quite different, as dictated by aircraft design constraints and applicable aircraft local load factors. It is up to the airframer to determine (on the basis of the ULD's maximum capability determined in accordance with the AS) the criteria (maximum gross mass, maximum allowable C.G. deviation, others) to be met at any ULD position on the aircraft, and publish them in the airworthiness Authority approved Weight and Balance Manual, sole source for limitations to be applied by the operators **[6A-02] [10B-01]**. Also see general statement in **[1.2]**.

NOTE: "airframer", in the context of AS36100 and the present, designates the entity responsible for preparing and publishing the approved Weight and Balance Manual for the aircraft, which may be either:

- the Original Equipment Manufacturer holding the aircraft's Type Certificate (TC), or
- a Supplemental Type Certificate (STC) holder.

In either case, the Weight and Balance Manual defines the airworthiness Authority approved methods and parameters of installation of unit load devices on board the aircraft type or sub-type concerned.

3.5 The AS36100 ULD configuration codes were assigned in order to differentiate from former NAS 3610 ULD configurations where a difference exists. The same codes were used where ULD geometrical configuration, ultimate load criteria and test restraint conditions are identical. Thus configuration codes are non ambiguous and determine the maximum allowable capabilities for the so marked ULD, whether approved under AS 36100 or former NAS 3610. See **7.2**. **[4A-01]** .

4.4 For AS33601 (former MS 33601B) track and stud applicability and its equivalence with ISO 7166, see **[6C-01] [6C-02]**. ISO 9788 defines a modified geometry double stud fitting that is capable of higher 22,250 N (5,000 lb) omnidirectional ultimate load when installed in an AS33601 (ISO 7166) aluminium alloy track. Though this ultimate load level is not normally required for double stud fittings used in ULD (nets) construction, using ISO 9788 double stud fittings remains allowable per excess as an alternate to AS33601 fittings.

4.5 The marking requirements are reproduced without change from TSO C90(c) wording **[8B-04]** . No MGW marking is included (to result from aircraft W&B Manual). **[8B-05]**, **[6.2]**.

4.7 The fire protection requirements applicable to ULD materials are specified in accordance with 14CFR Part 25 Appendix F, implying its latest published amendment, to be checked at the time of ULD approval. The applicable one currently is Amdt. 25-111, effective 2003-09-02.

4.8 The rapid decompression requirements are defined in NAS 3610 (TSO C90(c)) only as a general objective to be met. ISO 11242 provides detailed guidelines as to parameters to be met and the various allowable methods, particularly including :

- normal flight pressure balancing and emergency (rapid decompression) parameters,
- minimum venting area requirements in either case in relation with container internal volume,
- possibilities of using container door seal areas as part of the required minimum venting area.

4.9 Unspecified tolerances were determined in accordance with the metric usage for metric dimensions, and NAS 3610 for dimensions in inches. See **[7B-03]** **[7E-01]** for conversion details. It is essential to note that, where tolerances are otherwise noted in the configuration or restraint drawings, these supersede the general unspecified ones in this paragraph. Particularly, all ULD bases dimensions have a (+ 0 / - x) tolerance, not a ($\pm$ x) tolerance interval, in order to avoid the risk of jamming in aircraft restraint systems.

NOTE: Since AS36100 is intended as a ULD type approval reference document, the tolerances stated, whether unspecified or specified, are intended to apply to new units being tested. Tolerances for in-service units are not necessarily identical, where the approved Weight and Balance Manual for a given airplane type differently allows. However, the specified ULD bases dimensions tolerance intervals were determined taking into account industry experience to provide reasonable allowances for in-service wear, assuming the new unit was delivered at or close to the maximum allowable dimension.

4.10.1 Section 7 ULD configuration drawings all note where certain ultimate loads are to be considered as acting simultaneously (i.e., horizontal load in combination with a specified down load). These load combinations are identical to those in NAS 3610 for the same ULD sizes, based on the Oversight Panel agreed principle not to introduce a technical change from former approval criteria unless specifically required by available evidence or experience.

4.10.2 The general tolerances specified in **4.9** apply to all Section 8 restraint conditions figures where applicable tolerances are not otherwise explicitly defined.

4.10.3.1 Revision A added the two last sentences :

"For substantiating a net, any net tensioning devices shall be engaged" (moved from restraint conditions sheets, as their applicability to nets was withdrawn based on the following), and

"A pallet needs not be used for testing, provided that all net fittings are at the locations specified in the unit load device configuration" : this resulted from discussion and resolution of the one ballot disapproval at Revision A's first AGE-2A ballot, leading to withdraw applicability of (base) restraint conditions to nets testing. **[13F-01]** **[14B-02]** **[14C-01]**

4.10.3.2 See **4.4** **[6C-01]** **[6C-02]** for identity of AS33601 (former MS 33601B) and ISO 7166 track and stud, and clarification of ISO 9788 double stud fitting's different geometry and capability.

4.10.3.3 Note that specified 8,900 N (2,000 lb) and 17,800 N (4,000 lb) omni-directional ratings are minimum ultimate strength requirements, supported by experience with aluminium alloy track and steel stud meeting AS33601 / ISO 7166, respectively in the single stud and double stud cases. This does not preclude using higher performance items, e.g. ISO 9788 double stud fittings with a 22,250 N (5,000 lb) demonstrated ultimate capability **[6C-02]**.

4.10.3.4 , **4.10.3.5** :See **4.10.3.3** .

4.10.4 For background on minimum base area load capability (not required in NAS 3610), see **[3A-01]** **[3A-02]**. Note minimum 10 kPa (209 lb/ft²) requirement applies to sizes A, B, K, L, M, N, P, Q and S. Sizes G and R have a minimum requirement of 20 kPa (418 lb/ft²) **[6A-01]**.

For background on minimum ULD base edge vertical EI value (not required in NAS 3610), see [7B-01], [7C-01], [10B-02], [10D-01].

Base edge profiles rounding or chamfer (not required in NAS 3610) was agreed to be a requirement for aircraft cargo loading system protection. See [8B-02], [9B-02].

4.11 For discussion of references for environment and particularly U.V. degradation protection requirements, see [8A-01]. Currently available references are ISO TR 8647 and AIR 1490C. However, they do need updating, and an ISO TC20/SC9 research project is underway to develop a standardized U.V. degradation testing method with calibrated and reproducible results. While this is not yet available, it was determined current documents, which provide only guidelines, should be left out of AS36100. Reference to a standardized testing method is intended to be added once available. See [7B-02] [8A-01].

5.1 "Tests and / or analysis" as per NAS 3610 (TSO C90c). Numeric simulation added due to modern technologies development, with a definition including validation requirements added under 2.2. See [4B-01].

5.3 Dynamic testing was discussed but deemed both more realistic vs in-flight conditions and more difficult to achieve in a reproducible manner, thus static testing was kept as per NAS 3610 (TSO C90(c)). For background on ultimate load application duration, it was agreed to require the 3 seconds minimum duration defined in 14CFR 25.305 (b).

5.4 For an industry agreed definition of "discharging its contents", see AS36102, *ULD Test Methods*, which provides full details not included in AS36100. The agreed standard definition of "contents" for this purpose is a 600 x 400 x 250 mm (24 x 16 x 10 in) box [8B-06] [8B-08] [10B-05] [10C-01].

The second sentence's "*shall be based on yield stress values for the materials concerned*" of the original AS36100, as published 2005-02, had been questioned [11B-03] [11E-01], due to:

- yield strength being in principle more related to limit loads as defined in 14CFR 25.301, while the AS, same as NAS 3610, is based on ultimate loads (including factor of safety) more related to breaking strength,
- some aluminium alloys used not yielding like ductile steel, but going steadily to failure. Also, other materials (e.g. composites) increasingly used do not have a yield point at all.

On these bases, it was decided to delete this wording from AS36100 Revision A.

6.1 For definition of aircraft cargo compartments the specified type 2 ULDs are exclusively intended for, see 1 and 3.1. [8B-01]

6.2 Maximum gross weights (MGW) for the relevant unit load devices are not provided in AS 36100, as they were not provided either in NAS 3610 since its Rev.3 [referenced by TSO C90(a)]. The document specifies, and approval guarantees, only ultimate load capacities in defined restraint conditions, which airframers will use in order to determine the MGW allowable on any given aircraft position based on the certified local load factors applicable at that position (see aircraft Weight and Balance Manual).

6.3 Maximum allowable ULD contours are not shown, as in NAS 3610, because irrelevant to the ULD's performance and testing while other parameters are met. The dotted line contours illustrated (no dimensions) on NAS 3610 configuration drawings K and L were thus deleted (other contours today exist). It does not follow that adherence to stringent maximum contour limits is optional: a maximum container contour shall be determined in relation with the inner envelope of the individual aircraft cargo compartment(s) it is intended to be loaded into, following the rules and minimum clearances defined in AS1825 (ISO 10046). [6A-03]

6.4 Continuous pallet edge track was decided to be allowable all around all pallets unless specifically excluded, in order to conform with long established industry usage. Configurations excluded for technical reasons are UC K4 and L6 long sides (risk of base disengagement under upward load, should a net be attached in the central part of the long sides. See these UCs).

3.2 ULD configurations (UC) part [AS36100A Section 7]

7.2 ULD configuration codes (see **3.5** and NOTE to Table 1) were assigned in order not to be ambiguous vs NAS 3610 configuration codes, i.e. the same code is used only where the same ultimate loads, C.G. eccentricities and testing restraint condition exist **[4A-01] [9B-03]**.

On this same basis, ULD configuration code M2 of the original AS36100 was changed to M4 in revision A, in order to reflect testing restraint conditions different from NAS 3610 2M2, which had previously been overlooked. New ULD configurations A8, B8 and M5 were added to Table 1 at revision A, as agreed in order to provide the possibility of separate lower deck approval **[14C-03]**.

UCs layout In order to reduce the complexity of using previous NAS 3610, it was decided to combine into a single sheet (designated ULD configuration, UC) the minimum geometrical and dimensional requirements together with the ultimate loads and C.G. eccentricity requirements (former NAS 3610 load conditions, LC), and identification of the applicable testing restraint condition (RC).

General The following additional details not previously in NAS 3610 are applicable to all AS36100A ULD configurations:

- minimum base area load requirement of 10 kPa (209 lb/ft²), except for sizes G and R (high stiffness "heavy duty" base) 20 kPa (418 lb/ft²), consistent with aircraft floors capabilities **[3A-02] [6A-01]**.

- C.G. height for containers and nets limited to 55% (+10% deviation) of ULD's maximum overall contour height, in order to avoid having e.g. to test at 48 in (+ 25% deviation) C.G. height a 63 in or less high lower deck dedicated container or net **[9B-08] [10A-04]**. Also see operational control methods for ULD C.G. height in ARP36103.

- base edge thickness (not specified in NAS 3610 except sizes K and L, or only indirectly as 32mm (1.25in) maximum through restraint Figures) had been specified in the original AS36100 as 19.6mm (0.77in) minimum / 25.4mm (1.00in) maximum, same as NAS 3610 UCs 2K2 / 2L2. Based on ULD manufacturers input, AGE-2A and the Airworthiness Panel then agreed to remove from Revision A the minimum value, irrelevant as regards airworthiness, and keep only the maximum value to specify the interface with restraints, for all sizes except UCs G and R (thick base), where the design minimum of 12.7mm (0.50in) was kept as in NAS 3610 **[13G-02] [14B-01] [14C-02] [14D-01]**.

- minimum container base periphery recess height (unspecified in NAS 3610 except sizes K and L) specified as 63.5mm (2.50in) for all sizes, not 53.8mm (2.12in) as in NAS 3610 UC 2K2 / 2L2, due to documented reports of interference of such containers when deformed with the top of aircraft side restraints. Increasing this dimension was deemed an airworthiness issue in the interest of enhanced flight safety **[8B-07] [9B-04] [10A-01]**.

NOTE: 63.5mm (2.50in) of course remains a minimum value defined for airworthiness purposes, and many industry design standards currently specify a higher recess on containers for operational reasons.

- continuous AS33601 track all around, which is common practice in the industry, optional on all pallets, except UC K4 and L6 where conditions of restraint without vertical restraint on the long sides of the base dictate precise net fittings locations in order to guarantee airworthiness. This results in some instances in the necessity to adjust net fitting locations to an integer number of inches. The minimum distance between base edge and track centreline, not specified in NAS 3610, was deemed a potential airworthiness issue due to reports of interference with aircraft restraints, hence specified at 41mm (1.62in) as per IATA SS 50/1 and industry practice.

UC A7 Initially based on NAS 3610 UC 2A6 (2A1 for nets, with 18 double stud fittings only), with ultimate load condition (LC) 18 under restraint condition (RC) 7 described by Fig. 8.

NAS 3610 LC 18's C.G. eccentricities of $\pm 14.4\%$ / $\pm 21.4\%$ were found to be both excessive and impossible to reach in practice (loading simulations), hence never used by the airlines. It was therefore agreed to specify only $\pm 10.0\%$, thus making the UC's loads in effect identical to NAS 3610 LC 32 (added at Revision 7 of NAS 3610 in 1983 [referenced in TSO C90(b)] but which was applicable to size M only, though in the same RC) **[3A-01] [13E-01]**.

It was then agreed to identify the worst testing case under those conditions in order to define the corresponding testing restraint condition (RC A), aiming at defining a single (hence bi-directional) worst testing case. This was found **[5A-01]** to be NAS 3610 RC 11-12 (Fig. 13, with 635mm / 25in restraints spacing instead of 511mm / 20.125in in RC 7, Fig.8) but with NAS 3610 LC 32 ultimate loads instead of lower LC 14's. This resulted in RC A, intended as a single worst case restraint configuration, being defined with 3 restraints on the small sides (per NAS 3610 RC 7, Fig. 8) and 5 equally spaced restraints on the long sides (per NAS 3610 RC 11-12, Fig. 13). This RC was approved in AS 36100's 9th draft, subsequently approved by AGE-2A ballot **[5A-01]**.

However, it was then found that another testing case, intended for lower deck, had been overlooked **[5A-01]**, i.e. NAS 3610 LC 8 (about 60% of the ultimate loads of LC18/32) under RC 9, Fig. 9, with only 4 restraints on the long sides and a central 1270mm (50 in) unrestrained span. Due to this gap, the upward bending moment in the central part of the ULD is in this case higher than with 5 restraints, even with the higher LC 18/32 ultimate load **[11G-01]**.

After considering various options, it was agreed **[11A-01]** **[11G-02]** that RC A would be changed to only 4 restraints on the long sides with a central 1270mm (50 in) unrestrained gap, same as NAS 3610 RC9 / Fig. 9, while keeping the ultimate loads of UC A7 unchanged (i.e. same as NAS 3610 LC 18/32) : this combined the two separate worst testing cases into a desired single testing arrangement, thus was effectively a worst testing case.

A poll of participating ULD manufacturers **[11B-01]** had indicated there was no evidence of a substantial ULD weight increase to result from such more stringent testing. Accordingly, the so revised RC A was approved in AS36100's 11th and last draft, then approved at ballot. UC A7 as originally published (2005-02) was therefore based on this RC A testing arrangement.

REVISION A CHANGES:

Subsequent reconsideration constituted the one factor deemed important enough to justify preparing a Revision A to the document. See **[12A-01]** for rationales : AGE-2A recognized that cumulating the 4 latches lower deck restraint condition with higher main deck ultimate loads resulted in difficulties for aircraft Weight and Balance Manual preparation, and did uselessly increase containers weight. As to possible solutions considered, see Attachments **13A** to **13G** and **14A**. It was decided **[13D-01]** that Revision A would include two separate testing restraint configurations A1 with 5 latches on the long sides ("main deck" case) and A2 with 4 ("lower deck" case), with the corresponding testing ultimate loads in accordance with NAS 3610. The first draft was balloted on this basis. When addressing the ballot results, AGE-2A decided that the two sets of ultimate loads used should be editorially renumbered as new separate UCs (A7 and A8) in order to allow, as an additional benefit, distinct approval of lower deck or main deck dedicated containers **[14A-01]** **[14A-02]** **[14B-03]**.

Revision A's UC7 therefore is identical to the original AS36100's, except that, in referring to the A1 restraint configuration, it requires a test set-up with 5 latches (as in AS36100's 9th draft) on the long sides, rather than 4. It defines the requirements for main deck ULDs.

UC A8 was therefore introduced into Revision A as the additional step to provide the approval requirements for lower deck dedicated units. It uses identical geometry, ultimate load conditions from NAS 3610 LC 8 **[13A-01]**, and requires testing restraint condition A2 with 4 latches on the long sides (former RC A in the original AS36100, equivalent to NAS 3610 RC 9).

NOTES:

- it is believed most or all containers will be approved under either UC A7 or UC A8 of AS36100A, depending on their contour. Lower deck containers approved under UC A8 will be weight limited when carried on aircraft main deck, but this is already the case under NAS 3610 (TSO C90c) approval, and found not commercially penalizing due to their lower volume.
- on the contrary, most or all pallets approved under AS36100A will have to be tested twice (though it can be on the same test appliance) and receive dual approval in order to be acceptable without weight limitations on both lower deck and main deck. This constitutes the main identified inconvenience.
- nets, being tested independently from the pallet's restraint configuration (see [4.10.3.1](#) above), are not RC dependent. Approval under UC A7 will cover net use on both lower deck and main deck, while UC A8 will cover only lower deck use with reduced loads as per NAS 3610 LC9.
- all of the above equally applies to new dual configurations B7/B8 and M4/M5 introduced in Revision A.

UC B7 Based on NAS 3610 UC 2B5 (with 18 double stud fittings as in 2B6 instead of single stud in 2B5, due to increased durability at lesser cost), with ultimate load condition (LC) 16 under restraint condition (RC) 7 described by Fig. 8 **[9A-01]**.

NAS 3610 LC 16's C.G. eccentricities of $\pm 14.4\%$ / $\pm 21.4\%$ were found to be both excessive and impossible to reach in practice (loading simulations), hence never used by the airlines. It was therefore agreed to specify only $\pm 10.0\%$ **[3A-01] [13E-01] [14A-01]**.

The originally published (2005-02) corresponding testing restraint condition was RC A as ultimately decided (see detailed background in [UC A7](#) above). However, Revision A resulted in changing it to RC A1 with 5 latches on the long sides, and introduced in addition new configuration B8. See Revision A changes under [UC A7](#) and [UC A8](#), entirely applicable.

UC B8 was therefore introduced into Revision A as the additional step to provide the approval requirements for lower deck dedicated units. It uses identical geometry, ultimate load conditions from NAS 3610 LC 7 / 8 **[13A-01]**, and requires testing restraint condition A2 with 4 latches on the long sides (former RC A in the original AS 36100, equivalent to NAS 3610 RC 9).

UC G1 Identical to NAS 3610 UC 2G1, with ultimate load condition (LC) 19 under restraint condition (RC) 24 described by Fig. 31. UC designation code kept, since identical to NAS 3610.

Optional continuous track added as currently practiced on most pallets : NAS 3610 fittings spacing adjusted (9.32in to 8.00in, 15.43in to 16.00in, 17.02in to 17.00in) accordingly, since spacing has to be an integer number of inches **[9B-07] [10A-03]**. Minimum distance between base edge and track centreline was specified at 47mm (1.85in), higher than the 41mm (1.62in) retained for other UCs (see [General](#) above) in order to ensure compatibility with side restraints **[9B-06] [10A-02]**.

Edge details not affecting airworthiness or performance also adjusted to reflect current practice : edge thickness 12.7mm (0.50in) nominal changed to 12.7mm (0.50in) minimum / 25.4mm (1.00in) maximum, same as NAS 3610 UC 2R1, in order to minimize wear and ensure compatibility with aircraft vertical restraints **[7B-04] [8B-03] [7A-02]**.

Minimum pallet thickness, previously unspecified by NAS 3610, added as 50.8mm (2.00in) **[7A-02]**, consistent with industry practice, side latching requirements, and minimum area load requirement of 20 kPa (418 lb/ft²).

UC K4 Based on NAS 3610 UC 2K2 (containers) / 2K3 (pallets and nets), with the following changes (in addition to those applicable to all UCs) :

Combination of 2K2 / 2K3 into a single UC applicable to containers, pallets, nets (reminder : container contours are not defined either in NAS 3610 or AS36100, since not directly pertaining to airworthiness requirements: see **6.3**).

Ultimate load condition in accordance with NAS 3610 LC 30 applicable to UC 2K2 / 2K3, but with increased side loads identical to fore and aft ones. This is due to more recent aircraft types presenting at certain locations higher side loads than had been assumed in former NAS 3610, thus possibly resulting in lower allowable MGW at such positions **[7B-06] [8A-02]**. It also meets the agreed target of a single, omni-directional, testing condition (see RC K). UC code hence changed to K4 in order to differentiate from 2K2 / 2K3 and reflect the different side loads condition.

C.G. height limitation to 55% of maximum contour height (see **General** above) maintained for containers, but not for nets, due to the geometric possibility of a nominally 45in high full contour net to IATA code NKH also being used in a 63in high half-width contour to code NKE, where maximum C.G. height of 34in applies **[9B-09] [10A-04]**.

Deletion of UC 2K2 local restraint slots, with previously optional, though universally used, continuous recess all around container base periphery becoming standard.

Minimum container base periphery recess height specified as 63.5mm (2.50in), not 53.8mm (2.12in) as in NAS 3610 UC 2K2, due to documented reports of interference of such containers when deformed with the top of aircraft side restraints (see **General** above). Increasing this dimension was deemed an airworthiness issue in the interest of enhanced flight safety **[8B-07] [9B-04] [10A-01]**.

UC L5 Based on NAS 3610 UC 2L2 (containers) / 2L3 (pallets and nets), with the following changes (in addition to those applicable to all UCs) :

Combination of 2L2 / 2L3 into a single UC applicable to containers, pallets, nets (reminder : container contours are not defined either in NAS 3610 or AS36100, since not directly pertaining to airworthiness requirements: see **6.3**).

Ultimate load condition in accordance with NAS 3610 LC 31 applicable to UC 2L2 / 2L3, but with increased side loads identical to fore and aft ones. This is due to more recent aircraft types presenting at certain locations higher side loads than had been assumed in former NAS 3610, thus possibly resulting in lower allowable MGW at such positions **[7B-06] [8A-02]**. It also meets the agreed target of a single, omni-directional, testing condition (see RC L). UC code hence changed to L5 in order to differentiate from 2L2 / 2L3 and reflect the different side loads condition.

C.G. height limitation to 55% of maximum contour height (see **General** above) not kept for either containers or nets, all known ULDs of L size having a 63 to 64in maximum contour height, where maximum C.G. height of 34in applies **[9B-09] [10A-04]**.

Deletion of UC 2L2 local restraint slots, with previously optional, though universally used, continuous recess all around container base periphery becoming standard.

Minimum container base periphery recess height specified as 63.5mm (2.50in), not 53.8mm (2.12in) as in NAS 3610 UC 2L2, due to documented reports of interference of such containers when deformed with the top of aircraft side restraints (see **General** above). Increasing this dimension was deemed an airworthiness issue in the interest of enhanced flight safety **[8B-07] [9B-04] [10A-01]**.

UC L6 Based on NAS 3610 UC 2L4 (pallets and nets), with the following changes (in addition to those applicable to all UCs) :

Ultimate load condition in accordance with NAS 3610 LC 31 applicable to UC 2L4, but with increased side loads identical to fore and aft ones. This is due to more recent aircraft types presenting at certain locations higher side loads than had been assumed in former NAS 3610, thus possibly resulting in lower allowable MGW at such positions **[8A-02]**. It also meets the agreed target of a single, omni-directional, testing condition (see RC L). UC code hence changed to L6 in order to differentiate from 2L4 and reflect the different side loads condition.

C.G. height limitation to 55% of maximum contour height (see **General** above) not kept for nets, since all known nets of L size have a 63-64in maximum contour height, where maximum C.G. height of 34in applies **[9B-09] [10A-04]**.

NOTE: NAS 3610 UC 2L4 (pallets and nets) was kept as a separate UC L6, due to its inherently different configuration and testing parameters. It was found impossible to combine all NAS 3610 UCs into a single one, because actually different ULD types are in service. Reminder : in order to withstand tests without vertical restraints on the fore and aft sides, the 2L3/L5 pallet must be of a very stiff and thick construction, whereas the 2L4/L6 one can remain thin and light while meeting the tests through specified load limited net attachments on the long (fore and aft) sides with no pallet edge vertical restraint.

UC M4 Based on NAS 3610 UC 2M2 (pallets and nets)/2M3 (containers and pallets), with the following changes (in addition to those applicable to all UCs) :

Combination of 2M2 / 2M3 into a single UC applicable to containers, pallets, nets (reminder : container contours are not defined either in NAS 3610 or AS36100, since not directly pertaining to airworthiness requirements: see **[6.3]**).

Ultimate load condition in accordance with NAS 3610 LC 32 applicable to UC 2M2, with the same $\pm 10\%$ C.G. eccentricities. Since ULD configuration, ultimate loads and C.G. eccentricities are identical to NAS 3610 2M2, designation M2 had been kept for the original AS36100's UC.

NOTE: However, subsequent changes in AS36100 testing restraint configuration RC A made it substantially different from that of NAS 3610 (restraint condition (RC) 7 described by Fig. 8). Therefore, performance criteria are not entirely identical, which justified changing the UC designation to M4 (vs M2 in the original AS 36100), in order to differentiate from NAS 3610 UC 2M2.

The originally published (2005-02) corresponding testing restraint condition was RC A as ultimately decided (see detailed background in **UC A7** above). However, Revision A resulted in changing it to RC A1 with 5 latches on the long sides, and introduced in addition new configuration M5. See Revision A changes under **UC A7** and **UC A8** , entirely applicable.

UC M5 was therefore introduced into Revision A as the additional step to provide the approval requirements for lower deck dedicated units. It uses identical geometry, ultimate load conditions from NAS 3610 LC 9, and requires testing restraint condition A2 with 4 latches on the long sides (former RC A in the original AS36100, equivalent to NAS 3610 RC 9).

UC N1 New ULD size and configuration, not previously in NAS 3610, agreed **[6B-01] [7A-03] [7B-09]** to be needed by the air cargo market, particularly express cargo airlines. A significant number of STC approved units were built, principally for use on B767, while the unit can be carried on the lower deck of most other wide-body aircraft and the main deck of some. TSO approval will allow unlimited carriage where appropriate aircraft restraint systems exist.

Since the unit is half an M size, the ultimate load condition and testing restraint condition (RC N) defined are half those of UC M2, using a 14 fittings net layout **[7B-05]** instead of 18.

UC P1 New ULD size and configuration (containers only), previously in service only as a non-certified (LD2) container (AS 1677, ISO 4118), principally on B767s. Boeing determined there would be identifiable advantages for certain airlines to order certified rather than non-certified units, which further seem likely to be required on future transport aircraft types.

The ULD configuration, ultimate load condition and testing restraint configuration (RC P) were proposed by Boeing **[7B-10]**, consistent with the B767 Weight and Balance Manual, and agreed but with increased side loads, identical to fore and aft ones **[7B-06] [8A-02]**, for the same reasons as other dedicated lower deck sizes (see UCs K, L, Q).

C.G. height limitation to 55% of maximum contour height (see **General** above) not kept, for UC P applies only to 64in high lower deck containers where 34in maximum C.G. height applies.

UC Q1 New ULD size and configuration (containers only), previously in service only as a non-certified (LD4-LD8) container (AS 1677, ISO 4118), principally on B767s. Boeing determined there would be identifiable advantages for certain airlines to order certified rather than non-certified units, which further seem likely to be required on future transport aircraft types.

The ULD configuration, ultimate load condition and testing restraint configuration (RC P) were proposed by Boeing **[7B-10]**, consistent with the B767 Weight and Balance Manual, and agreed but with increased side loads, identical to fore and aft ones **[7B-06] [8A-02]**, for the same reasons as other dedicated lower deck sizes (see UCs K, L, P).

C.G. height limitation to 55% of maximum contour height (see **General** above) not kept, for UC Q applies only to 64in high lower deck containers where 34in maximum C.G. height applies.

UC R1 Identical to NAS 3610 UC 2R1, with ultimate load condition (LC) 19 under restraint conditions (RC) 24, 27 or 28 described by Fig. 31 (lengthwise, side-locked), 36 and 37 (cross-wise, end-locked). UC designation code kept, since identical to NAS 3610.

NOTE: AS36100 RC G is identical to NAS 3610 RC 24 (Fig. 31). NAS 3610 RC 27/28 (Fig. 36/37) were combined into a single RC R, but it was agreed this does not significantly differ from either Fig.36 or Fig.37 in terms of testing performance, so that the testing restraint conditions remain in fact the same. With all other requirements identical, the same UC designator can thus be kept.

Optional continuous track added as currently practiced on most pallets : NAS 3610 fittings spacing adjusted (9.37in to 8.00in or 10.00in, 15.43in and 16.11in to 16.00in) accordingly, since spacing has to be an integer number of inches **[9B-07] [10A-03]**. The minimum distance between base edge and track centreline was specified at 47mm (1.85in), higher than the 41mm (1.62in) retained for other UCs (see **General** above) in order to ensure compatibility with side restraints **[9B-06] [10A-02]**.

Minimum pallet thickness, previously unspecified by NAS 3610, added as 50.8mm (2.00in) **[7A-02]**, consistent with industry practice, side latching requirements and minimum area load requirement of 20 kPa (418 lb/ft²).

UC S1 New ULD size and configuration, not previously in NAS 3610, agreed **[6B-01] [7A-03] [7B-09]** to be needed by the air cargo market, particularly express cargo airlines. A significant number of STC approved units of this or very similar size were built, while the unit can physically be carried on the lower deck of all wide-body aircraft and the main deck of some. TSO approval will allow unlimited carriage where appropriate aircraft restraint systems exist.

Since the unit is half an A size, the ultimate load condition and testing restraint condition (RC N) defined are half those of UC A7, using a 14 fittings net layout **[7B-05]** instead of 18.

NOTE: Discussion took place between the "half-size" S1 as defined (88x61.5in nominal base size) and the "demi" size also used by certain airlines for containers (88x62.5in nominal base size). S1 size was retained because it is readily compatible with standard existing aircraft restraint systems, while the "demi" size requires special, thinner, centre restraint hardware which is not readily available on all aircraft, denying the free interchange of the unit size between aircraft of different types and different airlines which is the very purpose of TSO approval. It was agreed any "demi" (88x62.5in nominal base size) containers could, as is common practice, be TSO approved under a UC S1 deviation, providing their identification code clearly identifies the difference in base size in order to avoid inappropriate loading on aircraft.

3.3 Testing restraint conditions (RC) part [AS36100A Section 8]

8.1 For definition of the testing worst case retained, see **[5A-01]**. In addition, all restraint conditions were determined based on a 25.00 in restraints spacing, vs 20.125in in most NAS 3610 Figures. See **[7A-04]** and **General** hereafter.

8.2 Table 2 : only 8 restraint configurations were found to be necessary for the 12 ULD sizes, due to RC A being common to UC A, B and M and RC N common to UC N and S.

Revision A added a 9th restraint configuration by splitting RC A into RC A1 and A2 : see "Revision A changes" under **UC A7** above.

It was agreed to specify lower, main and upper deck applicability (not specified in NAS 3610) in order to facilitate users understanding, based on possibilities of known existing aircraft, except RC G (lengthwise, side-locked) was also agreed as a geometrically possible upper deck case based on provided Airbus A380F information **[10B-03]**.

RCs layout In order to reduce the complexity of using previous NAS 3610, it was decided to combine into a single sheet (designated restraint condition, RC) the general geometrical and dimensional requirements together with the restraint details (shown as separate Figures in NAS 3610) and identification of the applicable ultimate loads and C.G. eccentricity requirements (former NAS 3610 load conditions, LC).

General A general decision, applicable to all RCs with the exception of RC G (side locks spacing), was to standardize the variety of restraint spacings in NAS 3610 to 635mm (25.00in), which was confirmed to be acceptable on existing ULDs based on test results, and compatible with new aircraft such as the A380 which do not anymore use a 20-21 fuselage frames spacing.

It was also agreed to consider all RCs, except for dedicated lower deck sizes and RC G, omni-directional instead of lengthwise only (already implicit in NAS 3610 with side loads identical to fore and aft in the cases concerned).

Variation of dimensions and shapes of restraint details in NAS 3610 restraint figures is considerable, seemingly modelled after actual aircraft systems many of which do not exist anymore. Since testing experience indicates no measurable difference as to test results and a single omni-directional test set-up was intended, it was also agreed to standardize all restraint details on a width of 25.4mm (1.0in), except for dedicated lower deck sizes and RC G side locks which are designed to take a major 90° horizontal load **[7B-12]**.

The clearances between restraints were similarly standardized at 10.2 mm (0.4 in) **[7B-07]** **[7F-01]** **[8A-04]** all around , except for dedicated lower deck sizes where they were increased to 5.1mm (0.2 in) from NAS 3610's 2.5 mm (0.10 in) **[11A-02]** **[11B-02]** **[11C-01]**.

Applicable tolerances : see **4.9** where not explicitly specified in RC **[7B-03]** **[7E-01]**.

REVISION A CHANGES:

The original AS36100 (published 2005-02) listed nets on restraint condition sheets, implying they were to be tested attached to a pallet restrained as specified. This was found unnecessary, since nets must be tested with all their fittings at the locations specified in the unit load device configuration, but test results do not depend on the pallet edge's own behaviour. Accordingly, references to nets were removed from all RC sheets, and explanatory sentences were added to **4.10.3.1**. See **[13F-01]** **[14B-02]** **[14C-01]** for detailed discussion.

RC A1 Intended to reflect typical main deck restraint cases, was initially based on NAS 3610 RC 11-12 (Fig.13) but under LC 18 for UC A and M, successively modified (also see **UC A7** in 3.2 above) as follows :

- deletion of $\pm 14.4\%$ / $\pm 21.4\%$ C.G. eccentricities, i.e. referring to NAS 3610 LC 32 (same ultimate loads but $\pm 10\%$ C.G. eccentricity) rather than LC 18 **[3A-01]** **[13E-01]** **[14A-01]**.
- change based on conducted worst testing case analysis **[5A-01]**, retaining NAS 3610 RC 11-12 (Fig.13, with 635mm / 25.00in restraints spacing) on the long sides, while retaining RC7 / Fig.8's three restraints on the short sides **[7G-01]** **[8A-03]** **[8B-09]**. The restraint condition achieved was therefore a 16 restraints one, 3 on each short side, 5 equally spaced on each long side, effectively a worst case for the NAS 3610 RC 7 / LC 32 maximum load main deck case, approved by AGE-2A ballot in AS 36100 9th draft **[5A-01]**.
- it was subsequently identified that another testing case, intended for lower deck, had been overlooked in **[5A-01]**, i.e. NAS 3610 LC 8 (with lower ultimate loads, about 60% of LC18/32's) under RC 9, Fig. 9, with only 4 restraints on the long sides and a central 1270mm (50 in) unrestrained span. Due to this gap, the upward bending moment in the central part of the ULD is in this case higher than with 5 restraints, even with the higher LC 18/32 ultimate load. See **[11G-01]**.
- after considering various possible options to resolve this difficulty, it was agreed **[11A-01]** **[11G-02]** that RC A would be changed to only 4 restraints on the long sides with a central 1270mm (50 in) unrestrained span, same as NAS 3610 RC9 / Fig. 9, while keeping the ultimate loads of UC A7 unchanged (i.e. same as NAS 3610 LC 18/32) : this combined the two separate worst testing cases (one main deck, one lower deck) into a desired single testing condition, thus was effectively a worst testing case.
- a poll of participating ULD manufacturers **[11B-01]** indicated there was no evidence of a substantial ULD weight increase to be expected to result from such significantly more stringent testing. Accordingly, the so revised RC A was approved in AS36100's 11th and last draft, then approved by AGE-2A and AGE-2 ballot. RC A as published is therefore this condition with 14 restraints only.

Additional discussion had also considered the broad variety of restraint clearances shown in NAS 3610 restraint conditions, and agreed to retain an omni-directional 10.2mm (0.40in) clearance all around the testing configuration **[7F-01]** **[8A-04]** and **General** above.

REVISION A CHANGES:

Subsequent reconsideration constituted the one factor deemed important enough to justify preparing a Revision A to the document. See **[12A-01]** for rationales : AGE-2A recognized that cumulating the 4 latches lower deck restraint condition with higher main deck ultimate loads resulted in difficulties for aircraft Weight and Balance Manual preparation, and did uselessly increase containers weight, contrary to what had first been assessed. As to possible solutions considered, see Attachments **13A** to **13F** and **14A**. It was decided **[13D-01]** that Revision A would include two separate testing restraint conditions, A1 with 5 latches on the long sides ("main deck" case) and A2 with 4 ("lower deck" case), with the corresponding testing ultimate loads in accordance with NAS 3610.

Revision A's RC A1 therefore is identical to the original AS36100's 9th draft, with 5 latches on the long sides, rather than 4. It defines the requirements for main deck ULDs.

RC A2 was therefore introduced into Revision A as the additional step to provide the approval requirements for lower deck dedicated units, with 4 latches on the long sides and a 50 in central gap (former RC A in the original AS36100 (published 2005-02), equivalent to NAS 3610 RC 9). It defines the requirements for lower deck dedicated ULDs.

RC G Identical to NAS 3610 RC 24 (Fig.31-32) under LC 19 for UC G and R, without change.

Editorial clarification agreed : added legend (not shown in NAS 3610) to the figure in order to clarify 511.2mm (20.125 in) spacing applies to vertical restraints, while side locks are spaced 1022.4mm (40.250 in) from each other **[7B-13]**.

RC K Based on NAS 3610 RC 25 (Fig.33-35) under LC 30 modified with increased side loads as per AS 36100 UC K4, with the following changes :

- side restraints spacing increased to 635mm (25.00in) as for all RCs **[7A-04]**. Note the word "*continuous*" means side restraints are assumed to be in a continuous 635 mm (25.00 in) layout all along aircraft system's side rails, resulting in the possibility of either 2 or 3 side restraints being located anywhere along the ULD's short side. The worst case retained for testing occurs as shown in RC K drawing, i.e. when only 2 side restraints are available.

- discussion of restraint clearances (only lateral shown in NAS 36100) resulted in retaining an omni-directional 5.1mm (0.20in) clearance all around the testing configuration, identical to that shown for lateral clearances in NAS 3610 Fig.34 for size L. The 2.5 mm (0.10 in) shown in NAS 3610 Fig. 33 for size K were agreed to be too tight for realistic aircraft systems and conducive to jamming **[11C-01]**.

- in reference to NAS 3610 RC 25 (Fig. 33) showing seven containers in line, the question arose whether this had effectively been used in any testing **[7A-05]**. Participating ULD manufacturers had no record or knowledge of such simultaneous testing of seven units ever taking place, implying all or most size K units in service were TSO approved without having been so tested. However, Boeing aircraft still restrain ULDs of size K by lines up to seven units. After discussion, it was agreed **[7B-08] [8A-05]** to add note **⌘** requiring an evenly distributed horizontal force equal to 6 times the forward load to be applied alongside the pallet or container base edge to simulate a stack of 7 units. In accordance with **[5.1]** and **[5.3]**, this may be achieved either by physical means, or by analysis, or by numeric simulation.

Editorial clarification was agreed **[9A-02]** to add a note specifying the vertical rollers shown on the restraint details (as on NAS 3610 Fig. 35) may be omitted for testing, providing the clearance remains identical to that specified.

RC L Based on NAS 3610 RC 26 (Fig.34-35) under LC 31 modified with increased side loads as per AS36100 UC L5/L6, with the following changes :

- side restraints spacing increased to 635mm (25.00in) as for all RCs **[7A-04]**. Note the word "*continuous*" means side restraints are assumed to be in a continuous 635 mm (25.00 in) layout all along aircraft system's side rails, resulting in the possibility of either 2 or 3 side restraints being located anywhere along the ULD's short side. The worst case retained for testing occurs as shown in RC L, i.e. when only 2 side restraints are available.

- discussion of restraint clearances (only lateral shown in NAS 3610) resulted in retaining the NAS 3610 Fig.34 5.1mm (0.20in) clearance, which was confirmed to be that existing on aircraft, but making it omni-directional all around the testing configuration **[11C-01]**.

- in reference to NAS 3610 RC 26 (Fig.34) showing seven containers in line, the question arose whether this had effectively been used in any testing **[7A-05]**. Participating ULD manufacturers had no record or knowledge of such simultaneous testing of seven units ever taking place, implying all or most size L units in service were TSO approved without having been so tested. However, Boeing aircraft still restrain ULDs of size L by lines up to seven units. After discussion, it was agreed **[7B-08] [8A-05]** to add note **⌘** requiring an evenly distributed horizontal force equal to 6 times the forward load to be applied alongside the pallet or container base edge to simulate a stack of 7 units. In accordance with **[5.1]** and **[5.3]**, this may be achieved either by physical means, or by analysis, or by numeric simulation.

Editorial clarification was agreed **[9A-02]** to add a note specifying the vertical rollers shown on the restraint details (as on NAS 3610 Fig. 35) may be omitted for testing, providing the clearance remains identical to that specified.

RC N New restraint configuration for sizes N and S, not shown in NAS 3610. The restraint configuration was proposed in the AS 36100 4th draft **[6B-01]** and agreed, on the basis of NAS 3610 RC 16 (Fig.15-16-19) for 2E1 units (88x53in), closest to new sizes N and S.

It thus provides for 3 restraints on the long sides **[8A-03]** and 635 mm (25.00in) restraints spacing, accordingly is in line with both RC A1 and A2 (since the 5th central latch is inoperative for half-size units) as retained for double size units, respectively A and M sizes.

Additional discussion also considered the broad variety of restraint clearances shown in NAS 3610 restraint conditions, and agreed to retain an omni-directional 10.2 mm (0.4 in) clearance all around the testing configuration, same as RC A1 / A2 **[7B-07]** **[7F-01]** **[8A-04]**.

RC P

RC Q New restraint configurations for formerly non-certified only sizes P and Q, not shown in NAS 3610. The restraint layouts were proposed by Boeing **[7B-10]** and agreed. All decisions taken as regards lower deck **RC K** and **RC L** (see above) were also applied to RC P and Q.

RC R Applies to size R units for carriage across aircraft, in addition to RC G applicable when they are to be carried lengthwise. Based on NAS 3610 RC 27 (Fig.36) under LC 32, agreed by the Panel with the following changes **[7B-11]** :

NOTE: NAS 3610 also contains RC 28 (Fig.37), equally applicable to 2R1 units restraint across aircraft. However, Fig.36 is essentially identical to Fig.37, with 4 restraints less (2 in the centre part of each long side). Accordingly, it was agreed Fig.36 constitutes the worst testing case and could be retained as a single RC. In addition, this area is where NAS 3610 Rev.10 contains a series of never corrected printed errors, which prohibit a comprehensive definition of the restraint arrangements. It was thus even more necessary to completely define a worst testing case restraint condition.

- fore and aft restraints spacing adjusted to 635 mm (25.00 in) instead of 629 mm (24.75 in), in order to standardize testing appliances on spacing retained for other sizes **[10A-05]**.

- side restraints spacing also adjusted to 635mm (25.00in) instead of 511 mm (20.125 in) **[8B-10]**, also in order to standardize testing appliances on the spacing retained for other sizes.

Additional discussion also considered the broad variety of restraint clearances shown in NAS 3610 restraint conditions, and agreed to retain an omni-directional 10.2 mm (0.4 in) clearance all around the testing configuration, same as RC A **[7F-01]** **[8A-04]**.

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APPENDIX 1

Attachment 1A page 1

PROPOSALS TO SAE AGE-2A NAS 3610 OVERSIGHT PANEL

“ALL NEW” NAS 3610 REVISION A GENERAL OBJECTIVES

■ CREATE A USER FRIENDLY DOCUMENT :

- (a) simpler to read and use (self-explanatory)
- (b) recognizable relationship to the purposes (to be detailed) of the different users :
 - airworthiness authorities (validation)
 - airframe and cargo systems designers
 - ULD manufacturers
 - ULD operators (actual air cargo practices)
- (c) provide typical, not mandatory, guidelines for application / equivalences

■ MAINTAIN REGULATORY CONSISTENCY :

- (a) single TSO endorsement regardless of technical reference document (old or new)
- (b) keep unchanged main regulatorily meaningful general statements
- (c) do not increase regulatory burden unless proven necessary for safety

■ ADAPT TO MODERN AIR CARGO NEEDS :

- (a) delete obsolete ULD sizes and restraint configurations
- (b) introduce needed sizes for baggage / general cargo / express and mail purposes
- (c) leave maximum design freedom for future aircraft types / cargo system variants
- (d) define a set of additional, non TSO, industry standards as to operating rules guidelines ensuring the TSO's requirements will be met in field practice

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PROPOSALS TO SAE AGE-2A NAS 3610 OVERSIGHT PANEL

ULD BASE SIZES TO BE COVERED / DELETED IN "ALL NEW" REVISION A :

Code	Size	Being used	IATA code	9g type	Not for new designs ?	Comments
A	88 x 125	Yes	Yes	Yes		Delete 9g ? Evaluate variety of configurations.
B	88 x 108	Yes	Yes	Yes		Delete 9g (except 463L ?) ? Evaluate configurations variety.
C	88 x 118	TBD	NO	Yes	X	L100 pallet ? Is it still in use ? Enquiry with operators required.
D	88 x 54	TBD	NO	Only	X	Delete ? DC9 : obsolete ? Bae146QT use ? Enquiry required.
E	88 x 53	Yes	Yes	Yes	X	Delete 9g ? Remains necessary on DC9s ?
F	96 x 117 ¾	NO	Yes	No	X	Can be dropped altogether.
G	96 x 238 ½	Yes	Yes	No		
H	96 x 359 ¼	NO	Yes	No	X	Can be dropped except for specific (STC) applications ?
J	96 x 480	Indir.	Yes	No	X	Status of a dual 20ft unit ?
K	60.4 x 61.5	Yes	Yes	No		
L	60.4 x 125	Yes	Yes	No		Evaluate variety of NAS 3610 configurations.
M	96 x 125	Yes	Yes	No		
R	96 x 196	Yes	Yes	No		

Sizes proposed to be added (subject to operators / IATA UTP concurrence) :

S?	88 x 61.5	Yes	TBD	No	Demi size used by express cargo / mail operators.
T?	96 x 61.5	Yes	TBD	No	Demi size similarly used, plus B767 potential capability.

[1A-01]

PROPOSALS TO SAE AGE-2A NAS 3610 OVERSIGHT PANEL

REVISION 10 ULD CONFIGURATIONS TO BE KEPT / DELETED IN "ALL NEW" REVISION A

R.10 sheet	Conf. code	ULD type	Net attach	Proposal	R.10 sheet	Conf. code	ULD type	Net attach	Proposal	R.10 sheet	Conf. code	ULD type	Net attach	Proposal
13	1A1	NP	16D	delete	33	2B6	NP	18 d	delete	51	2L3	CNP	14s	open
14	1A2	NP	mix	delete	34	1C1	CNP	mix	delete	52	2L4	NP	20s	KEEP
15	1A3	P	mix	delete	35	1C2	CNP	mix	delete	53	2M1	CNP	28s	delete
16	2A1	NP	18d	KEEP	36	2C1	CNP	18D	delete	54	2M2	NP	18d	KEEP
17	2A2	CNP	28s	delete	37	2C2	NP	18s	delete?	55	2M3	C P	cont	KEEP?
18	2A3	NP	22d	delete	38	1D1	NP	14st	delete	56	2R1	CNP	36d	KEEP
19	2A4	P	cont	KEEP?	39	1E1	NP	22d	delete					
20	2A5	CNP	mix	delete	40	1E2	NP	14D	delete					
21	2A6	CNP	28s	delete	41	1E3	NP	mix	delete					
22	1B1	NP	14D	delete	42	2E1	NP	22d	delete?					
23	1B2	NP	mix	delete	43	2E2	NP	18s	KEEP?					
24	1B3	P	mix	delete	44	2F1	CNP	26d	delete					
25	1B4	CNP	mix	delete	45	2G1	CNP	40d	KEEP					
26	1B5	NP	20st	delete	46	2H1	CNP	54d	delete					
27	1B6	NP	463L	KEEP?	47	2J1	CNP	70d	delete?					
28	2B1	NP	32s	delete	48	2K1	C		delete?					
29	2B2	NP	18s	KEEP?	48	2K2	C		KEEP					
30	2B3	C P	cont	KEEP?	49	2K3	NP	12s	KEEP					
31	2B4	CNP	18D	delete	50	2L1	C		delete?					
32	2B5	NP	18s	delete	50	2L2	C		KEEP					

= 10/12 sheets instead of 43 ?

EXPLANATION OF CODES USED :

Apparent duplicates (loads) underlined
s,d,t = single, double, triple stud fitting;
Cont = continuous ("seat") track
D = D rings

[1A-002]

Attachment 1A page 3

PROPOSALS TO SAE AGE-2A NAS 3610 OVERSIGHT PANEL
AVERAGE ULD DENSITIES AND MAXIMUM GROSS WEIGHTS

The former (original NAS3610) tables I through XIV showing ULD maximum gross weights were deleted, together with any mention of MGW, at Revision 5 dated 15 Nov.1975, endorsed by the TSO C90(a) revision dated 21 Dec 1978. Since, table II shows only ultimate load criteria, from which MGWs can be derived on any aircraft type or ULD position based on ultimate load factors certified for this type or position. See historical analysis.

This major change was retained, in due concurrence with the FAA, because ULD MGW per se was becoming meaningless in view of an increasing variety of aircraft types where they could be loaded, and relevant ultimate load factors. This situation still exists, and has even expanded since with newer aircraft types as well as experience of certain ULDs certification and use at MGWs in excess of the originally rated value - at certain positions of certain aircraft.

Reverting 25 years later to a published MGW value for each ULD configuration would create havoc in terms of regulatory consistency with ULD types already certified under NAS 3610 Revisions 5 through 10 - TSO C90 (a) through (c), but also constitute a useless constraint on the design and potential of future aircraft, some of which could exhibit ultimate load factors lower than today's types.

Airframe designers may need to know more than what is presently available in NAS 3610 as to the load footprint of a given ULD type. This could hopefully be derived from generally accepted figures of maximum area load and running load, applied to the unit MGW resulting from their aircraft's own (design or testing, as appropriate) ultimate load factors. A difficulty seems to be, there tends to be a broadening range of area loads and running loads, including some freighter aircraft (e.g. AN124) largely used today. Also, no assumptions can usually be made as regards ULD base stiffness (shoring effectiveness), except as specified by IATA (minimum level for purely practical reasons) or, implicitly, for those ULD restraint configurations not including vertical restraint all around.

✚ Maintain MGWs out of Revision A as per current revision 10 and TSO C90(c)

BASE THICKNESS / STIFFNESS

Base thickness, or more accurately stiffness / load spreading capability, of the ULDs is not currently specified in NAS 3610. See previous view, average densities and maximum gross weights : except where implicitly specified by either restraint devices geometry (sizes F through J) or restraint configuration (e.g. 2L3), "heavy duty" (high inertia) bases are not covered, and remain an optional design feature not deemed to be part of airworthiness certification requirements.

In practice, therefore, base thickness / stiffness appears as a customer requirement : it is of the same nature as load shoring requirements, handled by the operator. Note no minimum stiffness value that could be stated would, anyway, cover all possible concentrated loads shoring requirements ! In this context, operators may (and some do) elect, usually on a limited number of units, to specify a high inertia base in order to save on additional shoring time and materials. This essentially is the "heavy duty" base : a built-in supply of shoring capability (up to a limited extent anyway : it may itself need to be complemented).

The actual certification question seems to be the download case : assuming the stated ultimate load (translated into MGW for a given aircraft and position) and CG offset limits are met, is it possible to significantly exceed aircraft maximum floor (area and running) loads ? The answer obviously depends on the, quite variable, value of these loads. It may also be pointed out that, on smaller base sizes (the larger ones, from G to J, are in fact bound to be high inertia), the size of the "most loaded quarter" resulting from maximum CG offset hardly ever spans more than 2 floor beams in the aircraft, so that the question of what is the intermediate load distribution onto the floor may look somewhat academic as to its influence on the aircraft's structure : it essentially affects potential damage to rollers and tracks, but airline experience demonstrates this is in any event to be catered for by adequate shoring, of which ULD base stiffness is only one component.

✚ Maintain base stiffness out of Rev. A as per current revision 10 and TSO C90(c)

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PROPOSALS TO SAE AGE-2A NAS 3610 OVERSIGHT PANEL

ULD VARIANTS

ULD variants, currently not specified in NAS 3610, may include “heavy duty” bases (see previous view), but also a variety of items :

- hanging loads (i.e. specific load paths),
- two-tier or slanted automobile transport devices,
- dedicated aircraft engine transport units,
- fluids tank containers,
- etc . . .

The rationale for analyzing such specific circumstances seems the same as with base stiffness : a potential load distribution problem, principally in the download certification case, within the specified ultimate load and CG offset criteria. The same logic should prevail.

- + Recommend to keep Revision A and any TSO C90 revision to general purpose ULDs certification requirements
- + NAS 3610 and the TSO should include all that is necessary to guarantee safety within the aircraft's certified flight envelope, and solely that.

In fact, apart from its layout complexity, NAS 3610, as endorsed by the TSO, was wisely written as deliberately limited to features pertaining to airworthiness certification, and only these. This scope should not be changed, as it defines the regulatory requirements.

It is well understood, because of this NAS 3610 does not resolve all problems for everyone, e.g. in particular airframe or cargo system design parameters. But, where it may need to be complemented, this should be achieved by (may be more comprehensive than today's) industry specifications, without a regulatory character through a TSO status : such issues as shoring rules (including base stiffness), tie-down, and floor rules for designing and testing ULDs compliance should be handled in (a set of ?) such specifications.

ULD LOAD MODELS : THE PRACTICAL (CARRIER) SIDE

It is recognized NAS 3610 as it currently stands leaves an open interpretation problem as to how should the allowable CG deviation be translated into load distribution. The FAA B727 AD 98-26-18 essentially assesses it in the upload certification case, which appears correct. In the download case, see comments above as to ULD base stiffness.

It is therefore reasonable to pursue the objective of a single, industry and Authority agreed, “ULD load model” method to allow consistency of interpretations. For the reasons outlined above, it might be more suitable to publish it, once agreed, in an industry agreed specification (in complement to NAS 3610) rather than NAS 3610 and the TSO themselves, but this is obviously up to the FAA. There is, however, a risk of a largely academic discussion in a theoretical approach, as illustrated by an airline's practical view :

Most theoretical models need to assume load continuity : in practice, if load distribution is continuous; this is precisely when there is either a homogeneous commodity, or some random mix (baggage, small parcels, etc..) close to it, so there is no risk whatsoever of a major CG deviation !! Those cases where, in actual practice, airlines do meet a potential CG limits problem are :

- either CG deviation (easy to compute) resulting from asymmetrical ULD contour with an homogeneous load,

Attachment 1A page 5

or a single asymmetrical or overhanging large item (e.g., machinery, etc...): its CG location is at least roughly determined, and care is taken to locate it in a reasonably appropriate manner vs the pallet's geometric center, or, if impossible, perform adequate additional tie-down directly onto the aircraft's structure in order to keep the restraint system within limits.

or when, because they came in at different times or they cannot be stacked together, two commodities of very different densities (e.g. flowers and mechanical parts) have to be loaded onto the same pallet. Standard airline procedures in this case require the load be located in a symmetrical arrangement in order to avoid a significant CG offset.

None of these practical cases fits anywhere near the potential theoretical models under discussion! Therefore, these models or algorithms largely have an arbitrary character, unrelated to reality - which does not imply they are meaningless, because choosing one will at least allow consistent designs, testing and comparisons. (See more detailed discussion in separate paper submitted)

APPENDIX 2

Attachment 2A

ULD LOAD DISTRIBUTION MODEL - C.G. ECCENTRICITY " TRADE-OFF " (preliminary)

References:(a) previous papers
(b) attachment to Vancouver fall 1998 AGE-2A meeting report
(c) FAA AD 98-26-18

The purpose of the present is to express a few preliminary comments regarding the methodology, or principles / postulates implicit in it. If the panel wants to have any kind of "scientific" handling of the issue, we should first be quite sure the underlying assumptions are correct and the method appropriate.

1. REAL LIFE SITUATION

What is basically missing in the approach till now is consideration of the practical situations encountered in commercial air cargo. This is where airframers are short of actual data, and only the experience gathered over the years by a large variety of multi-purpose (not only specialized, e.g. express cargo) operators can shed some light.

The basic attempt assumes some sort of continuity in the load distribution (hence investigates possible mathematical models to represent this supposedly continuous "density" variation over the base). This does not ever exist in real life cargo, and can be severely misleading. In real life situations, cargo can consist of :

1.1 - either a large quantity of boxes or crates of the same contents and weights : there is no load distribution variety, at least as long as their larger dimension is only a fraction of the pallet's, or the stack is centred on it,

1.2 - or a random mix of boxes, bags, etc.. of different contents and weights but still with relatively small dimensions. Typical cases are baggage (a good part of "cargo", at least for LD3s...), mail, parcel mail, express cargo, and many though not all cases of "general cargo". As long as their dimensions are small in relation with the pallet's, again, load distribution will be randomized and there is no practical possibility of any significant CG variation (noticeable exception : where the container contour itself creates a CG shift, e.g. LD3 and the like. But this is easy to compute and account for). Both these cases could be assimilated to a more or less continuous load distribution, but they are precisely the cases when there will in practice never be any significant CG variation, or none at all. This tends to defeat the very concept of continuity, at least as a possible representation of reality (see 3 hereafter for other possible purpose).

1.3 - or large items (say, typically, more than half the pallet or base size), which may themselves have :

1.3.1 - either a centred CG : in this case, the worst one, what counts is where the piece is located on the pallet, and what else is loaded next to it,

1.3.2 - or an offset CG per their own contents (or a result of an unavoidable geometric overhang), e.g. with machinery. But in this case the logical thing to do, and it is usually done if staff is properly trained, is to locate the piece's CG towards the ULD base centre. This results in alleviating the CG deviation, so that this case is in fact less critical. Noticeable exception : when overhangs out of the pallet's plan-view limit the possible offset. This occurs on main deck, not ever lower deck.

1.4 - or, a rather common case with the airlines, when for some reason two commodities with very different densities (e.g. flowers and mechanical parts) have to be loaded onto the same ULD. This is a case which can easily result in extreme CG locations. But it is so well known it is part of the most basis and systematic air cargo warehouse training : staff is made aware, and instructed to distribute such loads, when they cannot be stacked over each other with the lightest on the top - which would be ideal, in a symmetrical manner over the ULD base so as to keep an approximately centred overall CG. One can see how important is operator's staff training in coping with the situations encountered.

The point is, these latter cases can result in significant ULD CG deviation, but they cannot be assimilated to any kind of model using a continuous "density" variation, at least again as an attempt of representing reality. So, in any kind of real life situation, a continuous variation model cannot ever be useful in describing, even in a simplified approach, real load distribution on bases or pallets with a significantly offset CG.

The following general preliminary conclusions, based on experience, are therefore proposed :

1.5 - a typology of potential load cases, such as the above but more precise and thought out, should be part of the premises in any study, in order to define the real life environment expected,

1.6 - an assessment of actual load distributions on ULD bases cannot be made unless some prior hypotheses are laid down as to the training and procedures used by palletization (or baggage room) staff to fill up the ULD space in presence of different types of cargo, and the finished ULD load check by a supervisor to give it an OK for loading into the aircraft. Such defined assumptions are necessary for any realistic approach. Particularly see reference (c) page 2001, SeaTac FedEx facility evaluation,

1.7 - there is a major difference in practice between containers, used for baggage (practically homogeneous density) or even for cargo (they tend to be filled up with homogeneous commodities, or at least none of the last categories defined above, because of the physical difficulty in fork-lifting very large pieces into a closed volume) and pallets : pallets are, in practice, the overwhelming majority of ULDs presenting a significant load CG offset. Even farther, lower deck pallets in practice (except very special cases such as automobiles, split engine carriage, etc..) have very little CG problems. Main deck ones are much more exposed to it due to the nature and individual volume of cargo carried.

NOTE: as to whether this should or not be taken into account in the study, the following should be considered :

- a given pallet can be carried indifferently lower deck or main deck, and therefore ULD certification must be based on the most critical case i.e. main deck (while the aircraft lower deck system, itself, may not need to address major CG deviations not encountered in practice ?). The only ULDs that are specifically lower deck and never carried on a main deck are the contoured ones (LD3 and the like) : since they also are containers, it would be conceivable to limit their CG variation if this brought any value; but they must anyway meet the CG deviation their own contour systematically creates.
- even though the typology would clearly be of the kind above, there are no means to prevent some quite seldom exceptions to it (e.g. a very big and heavy steel cable drum into a container, etc..), and therefore ULD certification, based on safety and a very high probability objective (European Authorities tend to use 10^{-7} per flight, the FAA in reference (c) implies a "lifetime gust" at about 10^{-5} per flight hour), cannot refer to only what is considered "commonplace" or "typical" in the air cargo business. This implies that containers should probably be certified to the same criteria as pallets, contrary to factual evidence.

2. STATISTICS

The above contains the very reasons why the "statistical approach" suggested in reference (d) 2 is inappropriate :

2.1 - it can only be interpreted as an attempt to bring analysis closer to actual situations. But we just saw that, where a statistical evaluation (of package sizes and weights) would have some meaning, there would normally never be in practice any case of even being close to CG limits. And conversely, where CG limits might be reached, no random distribution of a large number of similar pieces could be taken into account, thus defeating the notion of statistical analysis.

2.2 - in fact, the major methodology bias is, statistical analysis can validly be applied exclusively to objects presenting some characteristic of a mass phenomenon, and some unknown but actual commonality resulting in a statistical distribution curve. In the air cargo case, this does not exist : there are several different types of cargo businesses (here again, a typology might be useful to clarify), e.g. baggage, mail, express cargo, general cargo, perishables, industrial shipments, oversize cargo, etc.. which have nothing in common and therefore cannot validly be subjected to a joint statistical analysis. This is true in general - at the industry's scale - but even truer if one considers any individual carrier (because many tend to specialize on certain markets) and more so if one considers an individual route (markets nature varies according to route and sometimes season), not to mention an individual flight (the one significant level in terms of safety, but deeply dependent on the day's type of cargo mix which may considerably differ from yesterday's).

2.3 - Taken at the industry's scale worldwide, there is no available data to support the notion that, from express cargo (in itself probably a reasonable candidate for statistical analysis if isolated) to oversize through a broad and unpredictable variety of intermediate sizes and natures of general cargo, there could be something as a valid common statistical distribution (Gauss or comparable, at least any kind of continuous distribution). Same as load distribution continuity over a pallet surface is a total illusion (see 1), a continuous statistical distribution of all kinds of cargo presented for shipment and subsequently palletized is likely another large illusion.

2.4 - last but not least, as already observed, if a statistical method was providing some closer relationship to reality, flight safety hence ULD certification could not be based exclusively on such parameters because there is no guarantee of how much and how often the "observed statistical distribution" taken into account will be deviated from, and the target is really a very high probability of never reaching the critical condition.

NOTE: agreedly, the probability could in principle, if accepted by the FAA/JAA, be defined as simultaneous occurrence of once-in-a-lifetime gusts and extreme CG deviation conditions on at least one ULD of the flight : by multiplying very low occurrence probabilities, we would obtain such extremely low simultaneous occurrence likelihood that discussions on the validity of sampling or statistical analysis could be many orders of magnitude afar. But this does not seem to be at least the FAA's thinking, as illustrated by reference (c) : they seem to consider the (very low) peak gust probability, and state the ULDs (as actually loaded on the flight, which is not only theory) shall withstand it (i.e. 100%, not statistically). This might be a subject for debate with them should an opportunity arise (out of the specific context of the B727 AD).

3. ALGORITHM

It would seem, from the above, hopeless to try establishing a set of methods or models to represent in a semi-realistic manner the actual load distribution situations which can be met in air cargo. It is only half so : yes, it is hopeless and futile if one tries to reproduce or approach "reality". But probably no, if the target is only establishing an industry agreed algorithm to handle definition, computation and ultimately testing of certified ULDs (as to testing, it should not be a systematic and mandatory requirement, but be left to the airworthiness authority's judgement).

The point is, the TSO, through NAS 3610, defines CG limits which the ULDs must be capable to safely handle in a given restraint configuration, but does not provide a defined method to analyse the consequences of these CG shifts onto the ULD itself (e.g. a net's straps) or onto the airplane's system and structure. Consequently, there are various ways to analyse this, which defeats standardization and may historically have allowed a manufacturer with a complacent local Authority representative to use his own favourable interpretation while his competitors could or would not (and his customers accepted it or not).

It is therefore believed it would be a service to both flight safety (through uniformization and elimination of adventurous ad hoc interpretations) and the industry (through more level competition rules) to define an industry agreed algorithm to link CG deviations with ULD design and airplane structural analysis (floor area loads, loads per latch, missing restraints, etc..). "Industry" means everyone i.e. airlines, airframers, ULD manufacturers, the FAA and the JAA. This is the consensus we need to achieve. It will be all the more difficult if the methodology and the target are not very clearly defined prior to discussion. And the conclusion is, such an algorithm is necessary but can only be arbitrary : it cannot bear any significant relationship (through modelling, statistics, etc...) with the actual situations met in air cargo. Compliance, in actual operation, will keep being ensured by airline training and supervision, including an "OK to fly" check by qualified independent personnel after ULD completion (this process itself could also very well be required and even controlled by the airworthiness authority, but within the operating rules, Part 121 or JAR-OPS, not Part 25 : SAE, ISO, NAS 3610 do not need to be involved).

The notion of an "arbitrary" algorithm may look shocking. However, many more basic parameters of airworthiness regulations, e.g. the 1,5 FAR 25.308 safety factor, or the ludicrous and much argued about "9g" crash case, etc.. are just as arbitrary - justified however by decades of experience and the advent of no recorded negative consequences. There is value in even arbitrary rules as long as they are the same for all and bear some reasonable - not identical - relevancy to the technical reality : obviously, It is not proposed to get a random set of rules out of a hat : we know enough of it, thanks to accumulated experience and theoretical research, to choose reasonably adequate ones.

4. FAA

The reference (c) B727 AD provides the first written and responsible statement on this subject known from the FAA in 25 years of activity. Therefore it is a precious move towards what should be done, and an indication of what may or may not be acceptable to the regulatory agencies.

According to the developments under "Fore and aft centre of gravity shifts" and "FAA's methodology", pages 2000 through 2002 of reference (c) :

4.1 - the FAA used in this case a "trapezoidal" method (previously referred to as "linear" in working papers). It has the advantage of being relatively simple and impose a minimum number of arbitrary parameters : in fact, only one, the algorithm itself. For a given total weight and a given CG shift, there is only one load distribution possibility.

NOTE: it seems the FAA used this method in a linear mode, without integrating from "dx" to the whole width, which would result in a "saddle curve" (part of a paraboloid?). Can this be confirmed? It makes it so much easier, and also meets the principles developed above, i.e. arbitrary, but simple and reasonably relevant to the problem, while other more sophisticated calculation methods, such as integration, may provide only an illusion of accuracy because anyway they are not directly describing any actual situation...

4.2 - FedEx in their alternate studies used a "box" (fictitious boxes, not real ones) or "rectangular" or "step" model. The first major point is, the FAA concedes that this method is also acceptable, and even a bit more conservative by 14% (with side-locks. But this is the only case one wishes to consider : NAS 3610 provides for side vertical restraint, and many fail to understand why a freighter main deck could have been certified without them at the onset !). This illustrates the fact that, for the FAA as well, a variety of methods (called algorithms above) may be acceptable, regardless of the fact that they unavoidably provide somewhat different results...

NOTE: one draw-back of the "box" method is, it is just as arbitrary as the "trapezoidal" one but necessitates more parameters, e.g. number and location of steps, which is more unnecessary arbitrary input.

4.3 - the second major point is, the FAA states in writing that the maximum 14% difference between both (arbitrary) methods "does not significantly affect analysis" (their words), one reason being that the side locks are distributed along the cabin in increments of 20" and not 89", hence their actual locations vary, and another being "the manner in which loads are actually distributed among all locks", which also varies (reasons : effect of container / pallet variable stiffness, different reaction of a net, effect of airplane floor deflection, etc... all which have nothing to do with CG shift). In other words, NAS 3610 provides only typical restraint configurations, the exact actual configurations will vary from an airplane type to another and even from one position to another on a given airplane type. The result is the actual load distribution on the locks and the airplane structure will vary, depending on exact detail configuration, by quite more than 14%, hence it is illusory to discuss the differences of such an order of magnitude between possible arbitrary algorithms while many other built-in factors have more influence.

The interim conclusion is, at this stage, we should better keep on the track the FAA is providing us, that is try to standardize one arbitrary but industry agreed algorithm to calculate the effects of ULD CG offset on the airplane in a gust situation, and choose the simplest (arithmetically but also necessitating least arbitrary parameters to be set) that would be acceptable to the regulatory authorities. From the above, this would point at the "trapezoidal" method more than any other one. Yet, for international application, it would remain to be checked whether the JAA would concur with the FAA on it : there are past records of disagreement between agencies on similar issues.

5. OTHER ISSUES

Rather than exclusively concentrating on the (agreedly important) CG offset issue, AGE-2A should identify other areas where similar industry agreed algorithms are also missing to calculate either ULD design or ULD operational rules. As examples :

- application of airplane running load : over the ULD length, or between two frames, or any distance, taking into account any unoccupied floor space or not, etc...
- application of maximum area load : the same questions more or less arise,

both being essential to determine any ULD stiffness and load shoring requirements, with the airframers presently providing surprisingly little material such as examples or interpretative statements for the user, and also undefined in NAS 3610 which does not at any point consider the roller system or the mode of transmission of the download to the structure.

- agreed rules as to computation / simulation of net stretching and the resulting load distribution on the pallet edge,
- probably quite a few others, not yet identified though we should.

Whether all such items should be introduced into NAS 3610 “all new” revision “A” itself is another story: It is strongly believed, for regulatory reasons, NAS 3610 as the reference document for the TSO, i.e. the official airworthiness regulation, should include everything that is deemed essential for safety, but solely this. Any additional interpretative material should be established in agreement with the FAA and JAA, but published somewhere else, e.g. an ad hoc industry agreed specification (see for instance the JAA system of regulations / Acceptable Means of Compliance / Interpretative Explanatory Material : though maybe a little too formal for the items we have in mind here, it illustrates the usefulness of a graded response at several levels). This is another discussion the Oversight Panel needs to have, but preferably once the list of items considered has been determined...

APPENDIX 3

Attachment 3A

ULD LOAD DISTRIBUTION MODEL- CG ECCENTRICITY " TRADE-OFF "

References: (a) "ULD load models preliminary general comments" paper (Spring 1999 AGE-2A), 5 p.
(b) "New document"<NAS 3610> Rev.A16.0, undated (Fall 1999 AGE-2A), ULD load models.
(c) AGE-2A Presentation to ATA ULD CG Control TF Seattle meeting, Jan.24, 1999 (50 p.)

In view of the reference (c) detailed computational approach and the recent discussions within the ATA (B727 P-F) ULD CG Control TF and with the FAA as to AMOC, the problem discussed seems to have now matured, or been sufficiently analyzed, to the extent tentative conclusions can be proposed. This is what is attempted hereafter, avoiding too theoretical / mathematical developments.

1. LOAD DISTRIBUTION MODEL NECESSITY / PURPOSES :

It was generally agreed a standardized "load model" is one of the missing items in the present NAS 3610 puzzle, but not fully clarified why and for what practical/regulatory purpose(s) such a model is necessary.

The reference (a) comments, discussed in the Fort Worth meeting, propose the following conclusions :

- an industry standard load model is required because essentially of two purposes within the scope :
 1. standardizing the assumptions required for ULD testing (the sole primary purpose of NAS 3610 and TSO C90, to be remembered), and, as evidenced by ATA discussions and others :
 2. providing standard means, acceptable to airworthiness Authorities, to develop operating rules on the use of ULDs, consistent with this testing. The readily available example is the need for CG eccentricity trade-off at ULD weights lower than certified MGW. There are potentially others (e.g. : determination of damage allowances for pallet nets ?).

NOTE: a standardized load model, once agreed and knowing it is the basis demonstrated by certified ULDs testing, can and probably will also be used for other purposes, most prominently as background for aircraft structure and cargo systems design. But this purpose should not be mixed with the others, since it does not properly belong to NAS 3610 and TSO C90's scope.

■ no single load distribution model, however sophisticated, can realistically simulate the actual field situation, if only because this (nature and mix of cargo) considerably varies within the industry between different types of commercial operations while the ULDs used are often the same, and the airworthiness Authorities need a single set of rules applicable to all. Even in the relatively simpler case of express cargo operators where such notions as random distributions can be considered (untrue in the general cargo business), discussions have evidenced developing a model representative of reality is nearly hopeless.

■ the conclusion is, any model selected will necessarily have a somewhat arbitrary character (even though, obviously, it also has to be mathematically tested to make sure it does not produce results contradictory with reality). This may look shocking to some. Yet, many more important basic airworthiness assumptions or criteria already are arbitrary, because there was no other way, and they serve their purpose : e.g., the famous "9g" crash condition. In other words, the scheme (model, algorithm) selected would have value for the industry, including the Authorities that would have to approve it, by the sheer fact of being standard, not because of a supposed capability to simulate actual ULD loading.

■ since it will have to be arbitrary, the best for any purposes is that the selected model in the future document to supersede NAS 3610 be as simple as possible (i.e., consistent with testing requirements and field reality), and necessitates the minimum number of parameters (ideally, none) to be arbitrarily fixed (Occam's razor).

2. WHICH MODEL ?

Examining the various models discussed and the results of mathematical evaluations performed :

- the alleged “FAA model”, a possible candidate if CG eccentricity's effects are separately analyzed in each direction, seems inappropriate if one wants to consider the worst case, i.e. simultaneous maximum CG offset in both directions : it is in this case non continuous, making it difficult to establish a test setup.
- the “multi-linear” and “stair step” (with 1 ft² steps or similar) models appear somewhat uselessly complicated (e.g., introducing additional, non needed, arbitrary parameters),
- the “planar” model allows reaching at most only $\pm 6.6\%$ deviation,
- the “6 steps” model appears the most realistic of all, because of the values reached and because it corresponds to a frequent real situation in the air cargo business (6 industrial wooden pallets onto an aircraft pallet) that is easily repeatable for testing purposes and can also if needed be checked on the field.

Yet, all these models were demonstrated to suffer from one basic inconvenience : they address only the CG location issue, and they ignore other design constraints applicable to the ULD with effect onto the aircraft : particularly, in all of them it is impossible to reach $\pm 10\%$ CG deviation without exceeding the maximum area load for the ULD and aircraft. This clearly points at their being not totally adequate.

NOTE: maximum area load is not currently stated in NAS 3610. It is in aircraft Weight and Balance Manuals. The implicit assumption here is that it should be one of the ULD design parameters to be stated in the new document to supersede NAS 3610 (consequence : unusual aircraft types with an extremely high maximum area load, e.g. AN124, would still be limited to common area load parameters when using NAS 3610 certified ULDs. This makes sense from an engineering standpoint).

On this basis, it is recommended the Panel retain (subject to acceptance from airframe manufacturers and the FAA) the simplest available model, which is the only one to also be consistent with maximum running load and maximum area load requirements : the “ 80% ” model (for a $\pm 10\%$ CG deviation case). It easily lends itself to repeatable testing arrangements, can be readily understood by anyone, is visually verifiable in field situations, and requires the addition of no arbitrary parameters such as steps size, etc... **[3A-01]**

3. CG OFFSET TRADE-OFF :

A good test of the practicality of the proposed “ 80% ” model is, how it can accommodate the requirement to provide a standard method to assess allowable CG deviation trade-off at ULD weights lower than MGW.

Reference (c), 5.2.1 page 39, provides the computation results for such CG deviation trade-off with the various models studied. The attached sheet reproduces them, together with the results of two conceivable simple methods to compute CG deviation trade-off in the “ 80% ” model :

A. Maintaining constant the moment from the ULD base's geometric center, or

B. Maintaining constant the area load on the most loaded part of the ULD base.

It is straightforward from either method to determine a maximum allowable CG deviation, as follows :

% of MGW	100	90	80	70	60	50	40	30	20	10	0
CG offset $\pm$											
Method A	10%	11.1%	12.5%	14.3%	16.7%	20%	25%	33.3%	50%	>50%	
Method B	10%	14%	18%	22%	26%	30%	34%	38%	42%	46%	50% (linear)

It can be seen method A provides seemingly acceptable values for the higher weights, but a maximum CG offset should be observed for the lower weights, e.g. something like 33%, since the figures become meaningless and unusable below approximately 30% of MGW.

Neglecting the ULD's stiffness (safe : any ULD base stiffness will contribute in more even load distribution), method B has the advantage of physically ensuring no part of the ULD base or the cargo systems will be more loaded than in the design case (MGW and $\pm 10\%$ CG). It also is easy to compute or check for field applications where required, and offers no meaningless segment at low weights.

The comparison of both methods with computation results for the other models considered appears on the attached sheet. Method A, useless for the lower weights unless a straight limit is set, appears extremely conservative for the higher weights. Method B is less conservative at the higher weights, but its nature still guarantees the ULD base or aircraft cargo systems and structure will not be loaded over their design parameters. It also has the advantage of providing by the same token the reverse trade-off, i.e. the possibility (subject to airframe manufacturer allowance in the W&B Manual or otherwise) of increased MGW under reduced CG offset (or none) conditions.

Overall, linear method B appears both acceptable and optimum for all users.

4. CONCLUSIONS :

For the reasons outlined above, it is recommended that the Panel retains for inclusion into the future document to supersede NAS 3610 :

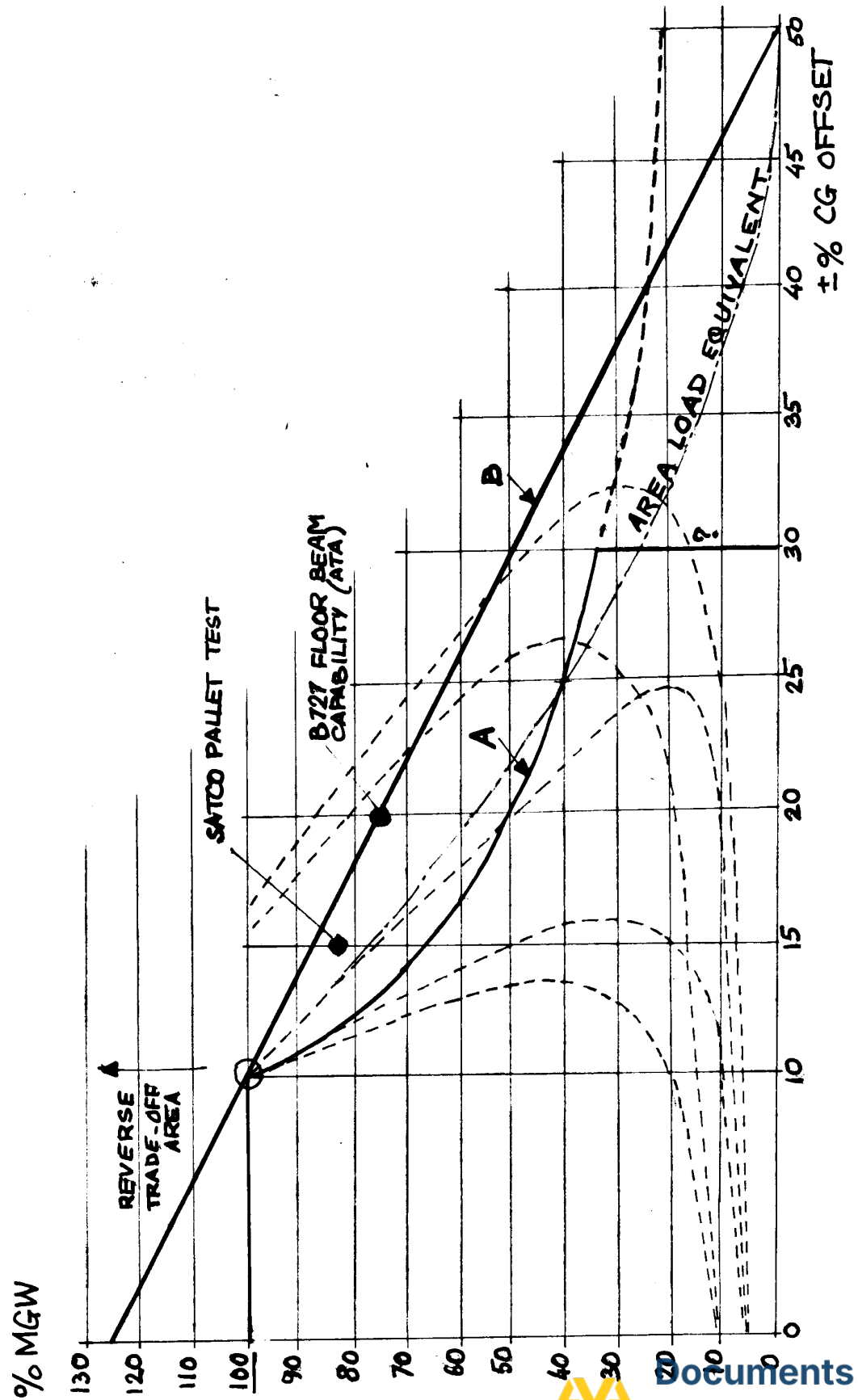
(a) mandatory maximum area load parameters (likely different for the "thin" type bases per AS 1491 and the "stiff" type ones, to be loaded on main deck only) per AS 1130, **[3A-02]**

(b) recognition of the simple " 80% " load model, the only one fully consistent with **(a)**, as standard means to determine ULD testing requirements and operational interpretations consistent therewith, **[3A-01]**

(c) the linear method for assessing allowable trade-off of ULD weight vs CG offset.

Computed CG offset vs GW trade-off curves

See reference (c) 5.2.1, page 39



APPENDIX 4

Attachment 4A

[4A-01]

ULD CONFIGURATIONS RETAINED AT OSP 1 meeting (one horizontal box is one new configuration)

ULD size	ULD configuration	Load cond.	NAS 3610 Restraint conditions	NAS 3610 Figures (details)		Comments
				Across a/c	Lengthwise	
A	net : 2A1 pal/cont : 2A4	14 or : 17	11-12-13-14 or : 2 - 7	13 (15,16,17) or: 1 (2,4)	14 (15,16,17) or: 8 (10,11)	(1)
B	pal/net : 1B6	25	3	5 (2,3)		HCU-6E ? (2)
B	pal/cont : 2B3 net : 2B6	6 or : 7	11-12-13-14 or : 5 - 7 - 9	13 (15,16,17) or: 9 (10,11) or : 5 (2,4)	14 (15,16,17) or: 8 (10,11 or 12)	(1)
G	pal/net/con: 2G1	19	24		31 (32)	
K	cont : 2K2 pal/net : 2K3	30	25	33 (35)		
L	cont : 2L2 pal/net : 2L3	31	26	34 (35)		
L	pal/net : 2L4	31	26	34 (35)		
M	net : 2M2 pal/cont : 2M3	9 or : 14 or : 18 - 32	9 or : 11 - 12 or : 7	9 (10,11) or : 13 (15,16,17)	8 (10,11)	(1)
N	pal/net/con: 2N1	parameters to be defined				new size prop.
R	pal/net/con: 2R1	19	24 - 27 - 28	36 or 37 (10,32)	31 (32)	(1)
S	pal/net/con: 2S1	parameters to be defined				new size prop.

- (1) selection of load and restraint condition(s) is to be proposed, based on worst testing case analysis.
 (2) Figure 3's, side restraint without vertical lips, applicability to be reviewed (military transport aircraft?)

ULD CONFIGURATIONS TO BE INVESTIGATED (for potential certified B767 unit sizes)

P	cont : 2P1 ?	discussion is required as to usefulness of certified LD2/LD4 size units and determination of the corresponding load and restraint conditions. Boeing only possible source ?	new size prop.
Q	cont : 2Q1 ?		new size prop.
Q	pal/net : 2Q2 ?		new size prop.

Attachment 4B

AS36100 1st DRAFT SUMMARY

The attached draft (5 pages) is a first proposal to meet the “reference documents” work package defined at the San Diego meeting. It consists in an attempt at producing the general cover pages for the future AS36100, (previously "NAS 3610 Rev.A") including scope, references, and general requirements. Explanatory comments are:

- basically, it consists in a redraft, where and only where deemed necessary, of the present wording of NAS 3610 (the changes from it are underlined for clarity). The reasons are :

(a) this might facilitate FAA and (through ISO endorsement) JAA recognition as the new TSO / ETSO reference,

(b) transition difficulties would increase should NAS 3610 and AS36100 have significant differences in general requirements wording, that could affect the design of ULDs,

(c) when reviewing in detail the wording of the former NAS 3610, it appears carefully worded and in most cases quite pertinent to define ULD general requirements in a minimum number of words.

- Previously submitted general “NAS 36101” general document proposal could, as agreed, become the introductory and explanatory commentary. The main changes proposed on the basis of Oversight Panel discussions are :

- Purpose and Field of application added to fit the standard SAE Technical Reports style, resulting in slight clauses renumbering.

- First list of potential “satellite” or related documents in 1.1, Purpose. Whether or not they should be quoted in the References section is to be discussed with FAA representatives, since the goal is, contrary to AS36100 itself, avoiding future updates of these documents to be subject to regulatory approval (“Incorporation by reference” ?).

- Proposal to refer to ISO 7166 and (for double stud fittings) ISO 9788 in replacement of MS 33601B (where does this military standard currently stand ? It is not shown on the list of SAE conversions).

- Proposal to introduce metric units (first, with imperial units between brackets) as is current SAE TSB 003 rule (and U.S. legal rule ? to be confirmed).

- List of ULD sizes to be covered reflects Oversight Panel discussions, thus includes B767 sizes P and Q currently only non certified (is this necessary, particularly as they can hardly be applicable to pallets or nets ?).

- The ULD base tolerances, ultimate load requirements (CG deviations simultaneity ?), and, preferably through a “satellite” document to be elaborated, test methods may require further Panel discussion and orientations.

- Numeric simulation was added as agreed to the acceptable methods of demonstrating test requirements. **[4B-01]**

- The wording and cross-referencing will clearly be affected by the final form of the tables and integrated ULD configuration sheets being developed under separate work packages. We need an agreed list of these sheets prior to finalizing anything as a draft.

Alternate approaches could include :

- either an entirely new document rather than an update of the current NAS 3610 wording. This would have both merits and potential drawbacks.

- having a non-normative “bibliography” annex that could potentially list all the “satellite” or complementary documents listed under 1, Scope, but also all generally agreed industry ULD design specifications ?

APPENDIX 5

Attachment 5A

AS36100 RESTRAINT CONFIGURATIONS

Proposed analysis of testing worst case for sizes A, B, and M

Applicable NAS 3610 Rev.10 (TSO C90c) restraint conditions (RC)

Restraint condition (RC)	1	2	5	7	9	11	12	13	14	19	20
Applicable to ULD config. 2A1 to 2A6 2B1 to 2B6 2M1 to 2M3	X (2A5 only)	X	X	X X X	X X X	X X X	X X X	X X	X X	X (2B4 only)	X (2B4 only)
Restraint Figure	1	1	5	8	9	13	13	14	14	22	23
Fore and aft details Fig.	2	2	2	10	10	16	16	16	16	25	26
Side restraint details Fig.	3	4	4	11	11	15	17	15	17	25	26
ULD across aircraft	X	X	X		X	X	X			X	X
ULD lengthwise in aircraft				X				X	X		
Restraint spacing (sides)	20.00"	20.00"	20.00"	20.13"	20.00"	25.00"	25.00"	22.00" 25.00"	22.00" 25.00"	20.00"	20.00"
Restraint spacing (ends)	20.75" 24.75"	20.75" 24.75"	20.75" 24.75"	24.75"	20.75" 49.50"	25.00"	25.00"	25.00"	25.00"	20.00"	20.00" 26.25"
Vertical restraint all round		X	X	X	X	X	X	X	X		X
No vertical restr. on sides	X									X	
Total number of restraints	18	18	16	18	16	18	18	18	18	18	18
with vertical restraint	10	18	16	18	16	18	18	18	18	10	18
without vertical restraint	8									8	

OBJECTIVES

- Define worst testing case for the ULD, not the aircraft restraint system, which can - and generally will - be different :
⇒ Proposed section 8 title to avoid ambiguity : " Testing restraint conditions ", rather than "Aircraft ...".
- Provide means for airframe design offices to extrapolate behavior of so tested ULD in a different restraint system :
⇒ Define / specify minimum base edge profile EI value ?
- Ensure consistency - though not necessarily identity - with NAS 3610 restraint condition(s) for same load condition.
- Minimize testing cost and complexity of testing, while still providing for worst ultimate load case :
⇒ Aim for isotropic restraint condition, consistent with isotropic horizontal ultimate loads stated in section 7 ?

PROPOSED CRITERIA FOR SELECTION OF ULD TESTING WORST CASE

- Preferably, single testing restraint condition for all 3 sizes, or at least for sizes A and M (same ultimate loads)
- Testing to be based on maximum ultimate loads and CG deviations stated in section 7, ULD configurations.
- Eliminate cases without vertical restraint on the sides (not applicable : RC 1 - 2A5, and RC 19 - 2B4).
- The critical testing cases are therefore assumed to be either of :
 - ⇒ Upward testing under maximum horizontal CG offset,
 - ⇒ Horizontal testing under maximum CG height.
- Cater for worse possible pallet net fittings mislocation (continuous seat track standard).

PROPOSED DEFINITION OF ULD TESTING WORST CASE

[5A-01]

- The one worst testing case in existing NAS 3610 restraint conditions is RC 9 (Fig.9), due to 49.50" latches spacing on fore and aft sides. However, it can hardly be retained, because :
 - ⇒ Not isotropic as per objectives, would require an altogether different lengthwise testing condition,
 - ⇒ Highly irregular spacing might result in all ULDs requiring significantly higher base edge EI,
 - ⇒ It is applicable only for ultimate loads and CG height significantly lower than those required per section 7 :
 - 2A1 - 2A6 : LC 8 = 12,500 lb fore and aft, 9,000 lb sides, 22,500 lb up, maximum CG height 36.0",
 - 2M1 - 2M3 : LC 9 = 13,500 lb fore and aft, 9,720 lb sides, 25,200 lb up, maximum CG height 36.0",corresponding only to a rather low MGW lower deck utilization.
- The next testing worst case is RC 11 or 12 (Fig.13) : it encompasses all the other ones except RC 9. It is applicable according to NAS 3610 (TSO C90c) to the following load conditions (LC) :
 - 2A1 - 2A6 : LC 14 = 18,750 lb fore and aft, 18,750 lb sides, 37,500 lb up, maximum CG height 36.0",
 - 2M1 - 2M3 : LC 14 as well,closer from target but still corresponding to a relatively low MGW and maximum CG height.
- The ultimate load conditions and maximum CG height retained for sizes A and M in AS36100 section 7 are :
NAS 3610 Load Condition 18 or 32 = 22,500 lb fore, aft and sides, 38,000 lb up, maximum CG height 48.0" (equivalent to 15,000 lb MGW under 1.5 g horizontal and 2.53 g upward),
which according to NAS 3610 (TSO C90c) corresponds to Restraint Condition 7 (Fig.8, lengthwise). But RC 7 is significantly less critical, restraint wise, than RC 11/12 (20.13" vertical restraint spacing, instead of 25.0", on sides).
- Accordingly, the proposal to define a testing worst case condition is simultaneously using Load Condition 32 (the ultimate loads specified in AS36100 proposed ULD configurations A1 and M1) with Restraint Condition 11/12 (Fig. 13), also using the worst possible pallet net fitting locations. This will effectively create a worst case condition, by either providing a more critical restraint condition for a given set of ultimate loads, or increasing the loads for the selected restraint condition.

[5A-01]

NOTE : this would, in principle, create a more severe testing condition for a "new" (AS36100 certified) 2A1 or 2M1 ULD than for previous (NAS 3610 certified) 2A6, 2M1, 2M2 or 2M3 ones. It is felt this should be no cause for inconsistency, inasmuch as ULDs of the present generation are assumed to be capable of withstanding such enhanced testing criteria (25.00" spacing between latches instead of 20.13" on the long sides and 24.75" on the short sides). This, however, is to be confirmed by ULD manufacturers.

- One advantage of the proposed selection is isotropy, that is the possibility of using a single restraint configuration (i.e. test fixture) to test the ULD in all directions (see objectives).