AEROSPACE RECOMMENDED PRACTICE	**ARP813™**	**REV. D**
	Issued 1966-12 Reaffirmed 2019-02 Revised 2024-07 Superseding ARP813C	

(R) Maintainability Recommendations for Aircraft Wheel and Hydraulically Actuated Brake Design

RATIONALE

This revision will incorporate current/best design practices to enhance wheel/brake maintainability.

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) recommends the maintainability features that should be considered in the design of aircraft wheels and brakes. The effect on other factors, such as cost, weight, reliability, and compatibility with other systems, should be weighed before incorporation of any of these maintainability features into the design.

1.1 Purpose

The purpose of this ARP is to identify design features for aircraft wheels and hydraulically actuated brakes that would enhance their maintainability.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR4403 Selection, Testing, Lubrication, and Sealing of Single Row Tapered Roller Bearings for Aerospace Wheel Applications

AIR4830 Aircraft Tire Pressure Monitoring Systems

AIR5490 Carbon Brake Contamination and Oxidation

AIR5567 Test Method for Catalytic Carbon Brake Disk Oxidation

ARP1322 Overpressurization Release Devices

ARP6137 Tire Pressure Monitoring Systems (TPMS) for Aircraft

AS707 Thermal Sensitive Inflation Pressure Release Devices for Tubeless Aircraft Wheels

AS6817 Valve, Inflation, Aircraft Wheel

2.2 Other Publications

2.2.1 Tire and Rim Association (TRA) Publications

Available from The Tire and Rim Association, 4000 Embassy Parkway, Suite 390, Akron, OH 44333, Tel: 330-666-8121, www.us-tra.org.

Aircraft Year Book

2.2.2 European Union (EU) Council Regulations

Available from http://data.europa.eu/eli/reg/2007/1354/oj.

1907/2006 Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

3. RECOMMENDED DESIGN FEATURES

3.1 General

3.1.1 Corrosion-resistant aircraft standard materials and hardware should be used wherever possible.

3.1.2 Positive fastener retention requirements (safety wire/cable, threadlocker, safety wire bosses, drilled bolts, etc.) should be considered during the design process.

3.1.3 Structural fastener torque values, such as wheel tie bolts and brake assembly bolts, should be permanently marked on the assembly unless specifically required otherwise. It should be noted that permanent torque value markings reduce risk as long as torque requirements are never modified during the service life of the assembly. Non-structural fastener torque values should be documented in the maintenance manual only and not permanently marked on the assembly.

3.1.4 Thread inserts should be provided in tapped holes or adequate material should be provided to accommodate inserts/slimserts for repair.

3.1.5 Assemblies should be designed to prevent improper substitution/assembly of parts.

3.1.6 Assemblies should be designed to enable maintenance/overhaul with commercially available tools except as noted herein. The maintenance manual should include manufacturing drawings of all special tools.

3.1.7 As an anticorrosion measure, provision should be made for adequate drainage of installed assemblies so that fluids will not be trapped or held in pockets. Adequate material should be provided to permit rework of areas that commonly encounter corrosion. The design should include provisions to inhibit galvanic corrosion.

3.1.8 Metallic coatings applied to surfaces normally exposed to elevated temperatures should be governed by the following preferred limits (see Table 1). These limits are for the coatings themselves and not for substrates that may be governed by other factors, such as tempering temperature.

NOTE: Cadmium and chrome surface coatings should not be used. If possible, use low hydrogen embrittlement (LHE) zinc-nickel for corrosion protection in place of cadmium and high-velocity oxygen fuel (HVOF) wear coatings in place of chrome. Refer to EU Council Regulation 1907/2006 for EU-specific guidance.

Table 1 - Preferred Limits

Metallic Coatings	°C	°F
Aluminum	496	925
Zinc	260	500
Cadmium	232	450
Tin	204	400
Chrome*	427/871	800/1600
Nickel	538	1000
Silver	649	1200
Low Hydrogen Embrittlement (LHE) Zinc Nickel (ZnNi)	482	900
Phosphate (Zinc Based)	93	200
Phosphate (Iron Based)	204	400
Phosphate (Magnesium Based)	288	550

*Lower temperature for designs with wear requirements.

3.1.9 Seal materials should be selected for compatibility with the operational environment (e.g., lubricating compounds, greases, hydraulic fluids, deicers, etc.).

3.2 Wheels

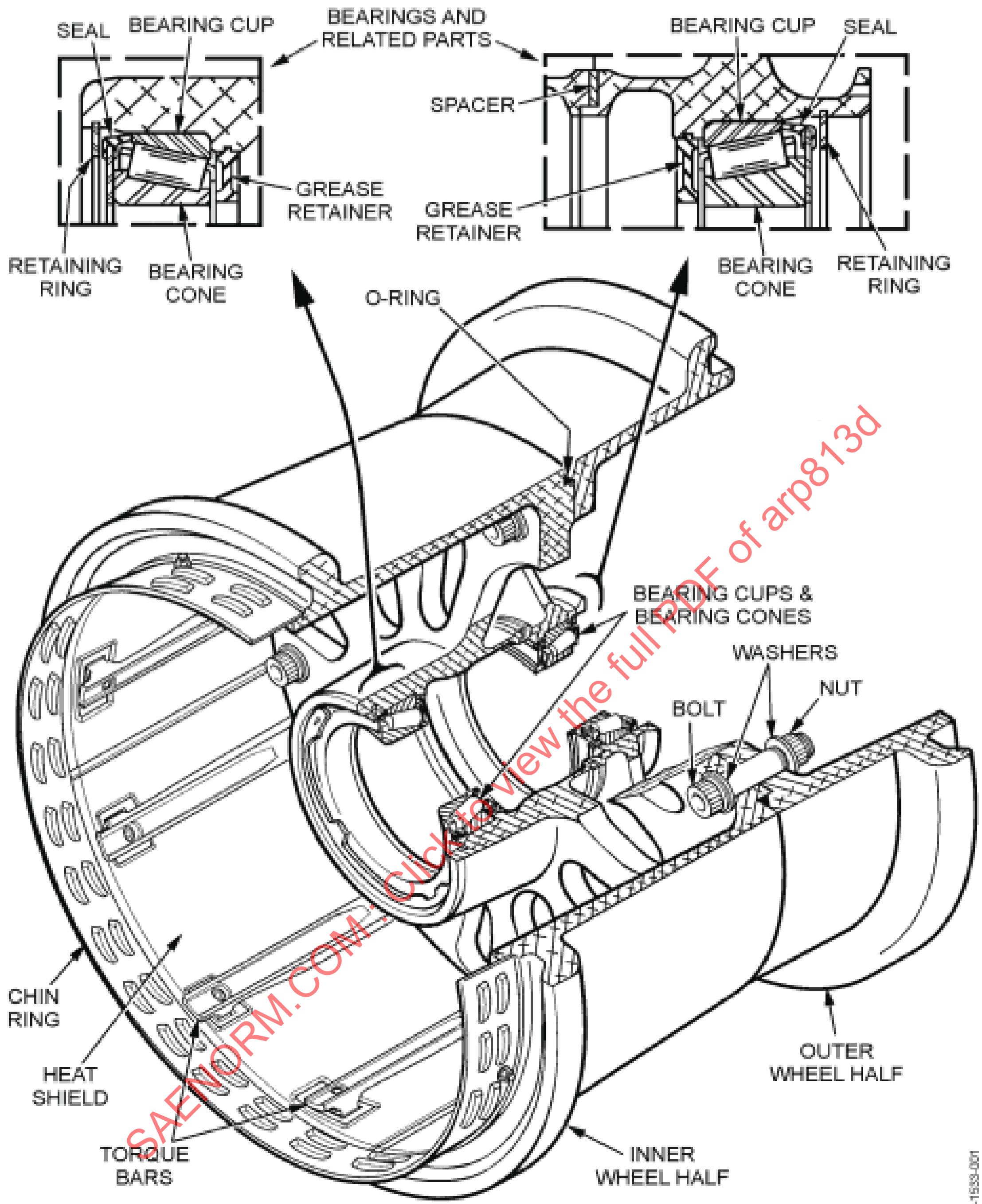

Figure 1 - Aircraft bolted wheel nomenclature

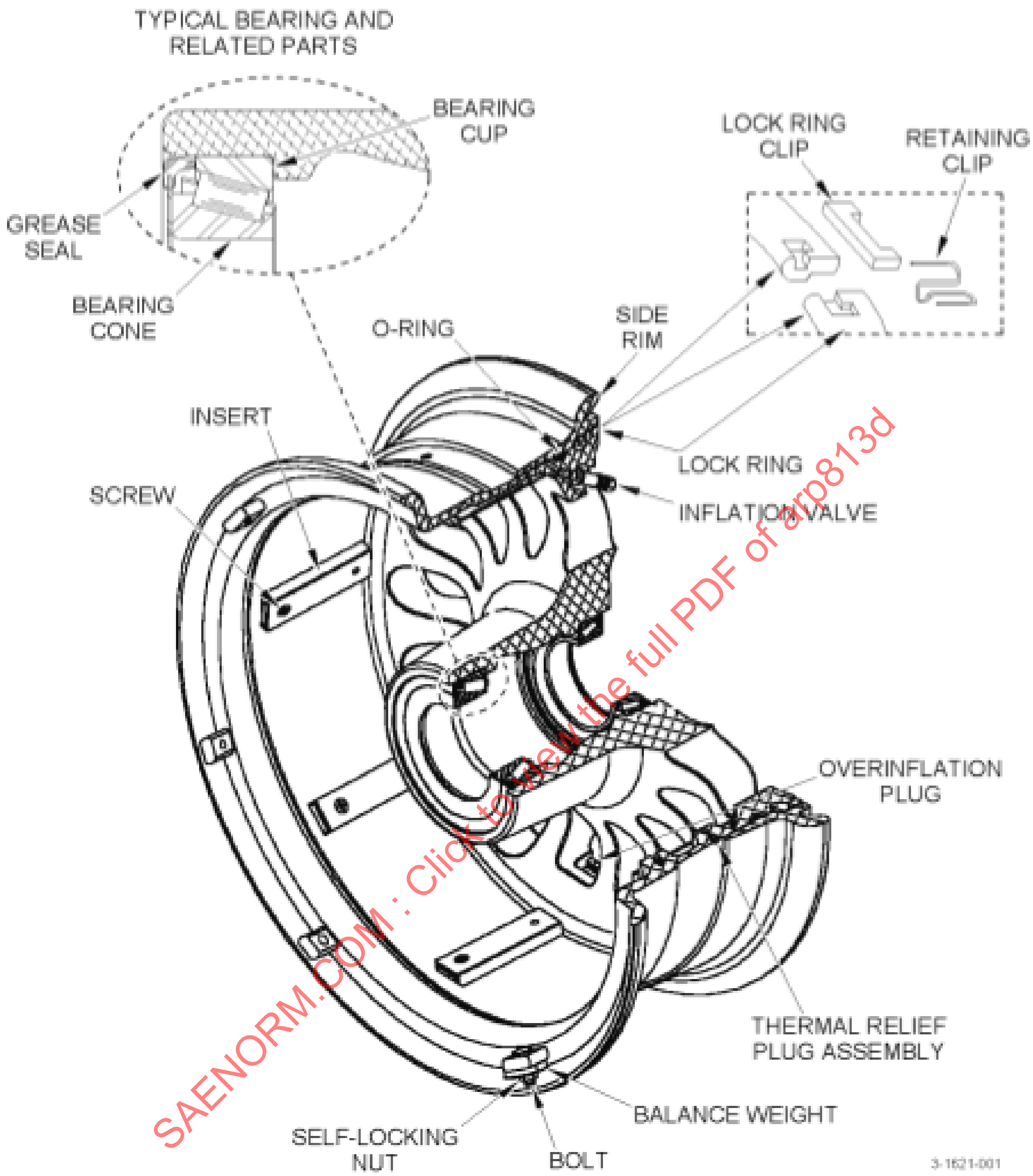

Figure 2 - Aircraft lock-ring wheel nomenclature

3.2.1 Wheels should be designed without heat shields, if possible, to minimize part count and to eliminate durability/maintenance problems. It is desirable that heat shields, if used, and not of the continuous type, should be readily removable without the removal of brake rotor drive keys so wheel inspection procedures are not prevented or hindered. Heat shield design should prevent destructive abrasion between the shield and basic wheel material up to tire rated speed by supporting the sides of the heat shield in slots in the drive keys/bars or equivalent retainer attached to the drive keys/bars. The use of rubber/phenolic insulators to prevent shield-to-wheel contact should be avoided. Heat shields should be designed to preclude damage, material cracking/breakout, excessive wear, or looseness in attachment areas. The wheel heat shields should also be designed to minimize direct contamination of brake friction components by deicing and cleaning fluids. Heat shields should be processed to eliminate sharp edges and surfaces that could injure maintenance personnel. Heat shields should not protrude beyond the wheel contour (drive keys/bars). It is desirable that heat shields be non-hygroscopic (i.e., does not readily absorb or retain moisture). If hygroscopic materials are used in the heat shield design, testing should be accomplished to show that a saturated heat shield will not expand and cause damage or interference with itself and/or adjoining components within the full range of temperatures experienced in operation. If multilayer heat shields are used, they should have drains that tolerate heat shield immersion and not contain absorbent materials capable of retaining cleaning solvents.

3.2.2 The wheel bearing grease seal rubbing surfaces should rotate with the wheel, have provision to prevent rotation within the wheel hub, be readily replaceable, and have adequate abrasion resistance to prolong service life of the sealing surface. The grease seal retaining ring should have a circular cross section that energizes the grease seal, improves the sealing interface, and has geometric features to facilitate easy removal. The design should provide for ease of replacement and/or repair of the rubbing surface(s). The design should prevent grease extrusion and foreign matter intrusion.

3.2.3 Grease seals should be elastomeric (reinforced) or polymeric and be provided on the outboard side of the inboard and outboard wheel bearings. Wheel grease retainers/dams, which are an integral part of the forging/casting, should be avoided. If metallic grease retainers/dams are used, they should be of sufficient strength to be used as a bearing surface in removing bearing cups. Grease retainers/dams that are elastomeric should be suitably secured/reinforced so they are not dislodged during wheel installation.

3.2.4 The wheel and/or brake should be designed so that the wheel assembly rotor drive keys/bars cannot be improperly aligned with the brake assembly rotors during wheel installation. If a device is mounted on the wheel to prevent improper alignment of the wheel with the brake rotors, the device should be readily replaceable, sturdy, and positively fastened.

3.2.5 Possible fretting between wheel halves at mating surfaces, such as the inner and outer registers, tie bolt boss areas, lock-ring groove, and demountable flange interfaces (lock-ring retained wheels), should be minimized by the use of adequate bearing area, tie bolts of sufficient number, size and preload, and judicious selection of spacer materials. For lock-ring retained wheels, any rotation of the demountable flange or lock-ring should not cause premature removal of the wheel from service or damage to the mating surfaces. Lock-ring retained wheels should be designed with a suitable retaining device (i.e., snap ring or stop) to keep the demountable flange from proceeding too far inboard and becoming lodged during tire demounting.

3.2.6 Consideration should be given to maintenance inspection procedures during the selection of wheel processes, finishes, and coatings used to protect the wheel from corrosion. Paint finishes, if used, should promote easy cleaning and should be a color that de-emphasizes the need or inclination to accomplish on-aircraft cleaning.

3.2.7 Inboard and outboard wheel halves (or wheel base and demountable flange) should be clearly identified by part and serial number and be readable when the wheel is installed on the aircraft. Impression stamping, etching, or embossing should be located only in noncritical areas. Raised pads are preferred. As permitted by envelope, adequate space should be provided to mark tire changes or inspection events for the life of the wheel. In addition, mounting provisions should be provided on both wheel halves (or wheel base and demountable flange) for the attachment of 2D bar-code plates or direct marked 2D bar codes, which are visible from the outside of the assembled wheel.

3.2.8 Whenever possible, balance weights should be avoided for braked wheels. Instead, balance requirements should be specified and met solely by wheel manufacturing. Reusable balance weight attachment provisions, if required for statically balancing the wheel half assemblies, should be considered. For nose wheels, spin balancing is recommended over static (bubble) balancing. Modern wheel/tire assemblies are effectively balanced when placed into operation. Given that normal tire wear will always introduce some degree of uncontrolled imbalance in the assembly, the addition or adjustment of wheel balance weights solely for the purpose of in-service wheel balancing is typically considered unnecessary and should be avoided where possible.

3.2.9 Materials used for the impregnation of cast wheels should be resistant to paint stripping solutions and hydraulic fluids.

3.2.10 Aircraft-quality wheel bearings of a standard size should be used whenever practical. When selecting aircraft wheel bearings, consideration should be given to designs that prevent installation of otherwise matching parts with different load ratings, especially for different wheels (nose and main) used on the same aircraft. Consideration should be given to selecting sizes (i.e., adequate radial and axial load capacities) and configurations (re-greasable versus sealed) that satisfy anticipated operating conditions. Differences in bearing components, materials, finishes, and/or geometric tolerances can adversely affect bearing fatigue performance. Changes in bearing geometry can have pronounced effects on bearing performance. Given that cones are not paired with cups at any point in the distribution chain, changes affecting interface features and unapproved intermix of bearing parts of different manufacturers are definitely not recommended (refer to AIR4403).

3.2.11 Bearing cups should only be removed for cause due to the potential for collateral damage associated with the removal process. When economically feasible, sufficient material should be provided in the structure of the wheel to allow for the rework and installation of cup bushings (0.060 inch [1.52 mm] minimum wall thickness) or oversize bearing cups. Adequate material should be provided in the wheel rim (flange) to allow rework/removal of reasonable in-service damage. Adequate material should be allowed in the bead seat and tubewell area to compensate for some allowable corrosion and fretting damage. Recommended tolerances on nominal wheel diameters are specified within the Aircraft Year Book.

3.2.12 Sealing features of split and lock-ring retained flange tubeless wheels should be designed for protection from handling damage.

3.2.13 Aircraft standard hardware should be used wherever possible unless aircraft standard hardware will not accommodate design requirements and unique aircraft-quality hardware must be used.

3.2.14 Thermal sensitive pressure release devices (fuse plugs) (refer to AS707) should be located so that they are accessible for removal only after the tire is removed from the wheel assembly. Fuse plug design should be capable of operation in a fuse plug boss that has been oversized for corrosion removal without requiring an oversize fuse plug. Threaded fuse plugs should be avoided.

3.2.15 Provision should be made for removal of all parts from the basic wheel halves, such as inserts, bearing cups and bushings, to accommodate necessary overhaul operations without damage to the wheel areas around these parts.

3.2.16 Adequate space should be provided around the bolt heads and nuts to accommodate standard socket wrenches without damaging the finish of adjacent structure due to contact. Adequate material should be provided to allow for corrosion and mechanical damage removal around bolt holes and hole faces and for the installation of repair bushings if economically feasible. An even number of tie bolts should be considered to allow interface with the most commonly used twin spindle torquing machines.

3.2.17 The wheel should be designed so it can be maintained with commercially available tools, especially tire bead breakers.

3.2.18 The wheel should be of the divided type retained by tie bolt or lock-ring retention to permit tire mounting/dismounting with relative ease. When economically feasible, lock-ring retained demountable flange wheels should be considered over tie bolt retained wheels in order to reduce part count and minimize nondestructive inspection requirements/risks.

3.2.19 Large bore inflation valves are desirable (refer to AS6817). The inflation valve should be located in an accessible location for tire servicing, and adequate clearance for valve extension should be provided to permit the use of standard inflation servicing chucks. Location of the tubeless valve should be such as to permit valve removal without wheel disassembly. Space should be provided for possible installation of a tire pressure gauge/fill valve assembly. Over-inflation protection should be considered, and the specified overinflation device should have a unique sized inlet from the inflation valve inlet or another unique feature to prevent incorrect installation. Overinflation devices should meet the requirements of ARP1322. Provisions for preventing inflation valve and/or overinflation protection device loosening should be provided. Inflation valves, pressure gauges, overinflation devices, etc. (protruding items) should be mounted so they are recessed in the bowl of the wheel half and thus protected from damage during handling of the wheel. Ancillary items should be physically spaced around the wheel circumference to satisfy wheel balance requirements.

3.2.20 The wheel and its components should be designed to prevent the improper assembly of parts. Double countersunk washers should be utilized to prevent improper installation.

3.2.21 Wheel Rotor Drives

3.2.21.1 If wheel drive inserts (drive keys or drive caps) are used, they should be of proper hardness and/or wear-resistant coated (tungsten carbide cobalt [WC-Co] or equivalent) to minimize impact damage and should be easy to remove. Consideration should be given to manufacturing tolerances that preclude mechanical damage/wear to the wheel or the inserts during assembly and subsequent service. Blind holes should be avoided when attaching drive inserts (keys/caps) to the wheel structure.

3.2.21.2 Wheel drive bars (commonly referred to as beam keys or torque bars) are preferred over drive keys/caps (envelope permitting). Drive keys/caps typically have more critical interfaces (in terms of total surface area) and are therefore more challenging to maintain and repair. Drive bars should be attached to the wheel by aircraft standard fasteners on one end, and the other end should interface with the wheel via a through hole, thus providing for a replaceable repair bushing (with oversize capability). All drive designs should be wear-resistant coated (WC-Co or equivalent) and suited for high temperatures.

3.2.22 Provisions should be considered for the installation of a tire pressure indicator and/or a tire pressure monitoring system (TPMS) sensor (refer to AIR4830 and ARP6137). If an indicator is provisioned, it should be visible after wheel installation and should have sufficient accuracy to indicate whether the tire pressure is within safe operating limits.

3.2.23 The disassembly warning information (i.e., WARNING DEFLATE TIRE BEFORE DISASSEMBLY) presented on the wheel should be easily visible regardless of the orientation of the wheel.

3.2.24 Consideration should be given to defining a wheel configuration that does not expose its critical features and components (drive bosses, drive keys, drive key fasteners, heat shield tabs/fasteners, etc.) to abrasion/deformation when the wheel is laying on a flat surface. Furthermore, in order to minimize the potential for physical damage to the wheel and its components during handling as a wheel-tire assembly, consideration should be given to specifying a wheel envelope that does not extend beyond the inflated tire envelope. Inboard and outboard wheel halves should be designed to consider machined surfaces in critical areas that can accommodate (automated) ultrasonic/eddy current nondestructive inspection (NDI).

3.2.25 Wheel hubcap attachment should allow for easy removal/installation during wheel/tire change. V-band clamps are a preferred design over threaded fastener attachment.

3.2.26 The wheel, grease seals, and wheel bearings should be designed in such a way that the wheel bearings and grease seals will remain with the wheel assembly upon installation and removal from the aircraft. This will prevent possible bearing and seal contamination.

3.2.27 Synthetic hydrocarbon/lithium complex (non-hygroscopic) wheel bearing grease is preferred over petroleum/clay hygroscopic wheel bearing grease.

3.2.28 Seals used in the wheel design should be compatible with fluids listed in the maintenance manuals.