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Federal Aviation Administration

Advisory Circular

Subject: PARTS AND MATERIALS SUBSTITUTION FOR VINTAGE AIRPLANES

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FOREWORD

This AC provides guidance for substantiating parts or materials substitutions to maintain the safety of old or out of production general aviation (GA) airplanes. This AC also provides guidance about the data required to gain Federal Aviation Administration (FAA) approval for making these substitutions. This AC does not include specific approvals for installations. It provides guidelines to follow when collecting information needed for an FAA approval.

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1. PURPOSE

a. This AC provides guidance for substantiating parts or materials substitutions to maintain the safety of old or out of production general aviation (GA) airplanes. This AC also provides guidance about the data required to gain Federal Aviation Administration (FAA) approval for making these substitutions. You may use the data in this AC as "approved" data for substantiating parts or materials substitutions to vintage aircraft. The appendices include examples of parts substitutions and guidance on recording minor alterations through logbook entries. These guidelines will help owners avoid having to obtain a field approval for like substitutions on subsequent airplanes.

b. This AC does not include specific approvals for installations. It provides guidelines to follow when collecting information needed for an FAA approval. Based on the work done, the Aviation Safety Inspector (ASI) makes the final determination for any approvals. The guidelines in this AC promote consistency and reduce the time required to accomplish safety-enhancing upgrades. This AC is a living document and sections may be added to the Appendices as additional data is gathered.

c. This AC is not mandatory or regulatory in nature and does not constitute a regulation. If a repair manual exists, that information takes precedence over the information in this AC. If you use the guidance in this AC, you must follow the guidance in its entirety.

2. CANCELLATION

This AC does not cancel any previously issued AC.

3. APPLICABILITY

a. This AC applies to small airplanes type certificated (TC) before January 1, 1980 that have a maximum certificated weight of 12,500 pounds or less. Follow-on TC models of the same airplane, or a derivative thereof, which may be assigned a later TC date, also meet this criteria.

b. The guidance in this AC also assists in increasing the confidence and knowledge of the ASI, mechanics with inspection authorization (IA), the owner, and the management designated airworthiness representative (DAR) in expediting field approvals through the flight standards district offices (FSDO) and the aircraft certification offices (ACO). This data is equally applicable for use as substantiating data in support of a Supplemental Type Certificate (STC) project.

4. RELATED REGULATIONS AND DOCUMENTS

You may obtain copies of current editions of the following FAA publications free from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785. You may also obtain Advisory Circulars and FAA Orders at http://www.airweb.faa.gov/rgl.

a. AC 20-62, Eligibility, Quality, and Identification of Aeronautical Replacements Parts;

b. AC 23-21, Airworthiness Compliance Checklists used to Substantiate Major Alterations for Small Airplanes;

c. AC 43.9-1 Instructions for Completion of FAA Form 337, Major Repair and Alteration (Airframe, Powerplant, Propeller, or Appliance);

d. AC 43-18, Fabrication of Aircraft Parts by Maintenance Personnel;

e. FAA Order 8110.37, Designated Engineering Representative (DER) Handbook;

f. FAA Order 8110.42, Parts Manufacturer Approved Procedures; and

g. The following parts and sections of the Title 14 of the Code of Federal Regulations (CFR):

(1) Part 21, Certification Procedures for Products and Parts;

(a) Section 21.21, Issue of Type Certificate: Normal, Utility, Acrobatic Commuter, and Transport Category Aircraft; Manned Free Balloons; Special Classes of Aircraft, Aircraft Engines; Propellers;

(b) Section 21.29, Issue of Type Certificate: Import Products;

(c) Section 21.303, Replacement and Modification Parts; and

(d) Section 21.502, Approval of Materials, Parts, and Appliances.

(2) Part 43, Maintenance, Preventive Maintenance, Rebuilding, and Alteration; and

(3) Part 145, Repair Stations.

5. BACKGROUND

Today, vintage airplanes need safety enhancing upgrades and modifications to maintain the continued airworthiness of the aircraft. These same vintage airplanes often have little of the required data needed to get FAA approval of such modifications. This lack of data makes it difficult for owners to substantiate modifications they may want to do.

a. Many vintage airplanes no longer have factory support for replacement parts. An approved duplicate replacement part or the data describing the original part (form, fit, and function) are difficult to find or no longer exist. Often, owners and mechanics replace parts by substituting parts from other sources. Examples of substituted parts include circuit breakers, solenoids, batteries, alternator belts, wheels, and brakes. Occasionally, a supplemental type certificate (STC) may exist for an installation, such as wheels and brakes, but often does not.

b. Many materials or material product forms used to manufacture or maintain the original parts on today’s vintage airplanes are no longer available or practical for reproduction to the original design data. To manufacture the needed parts requires materials or material product

forms substitutions, such as replacing a cast part with a machined part or substituting a material rarely used today with an equal to or improved material. Additionally, some of the materials used today for hoses and fabrics, are better than those used when the vintage airplanes were originally built.

c. Confusion exists about what makes a "correct" replacement part. Usually little or no documentation regarding the replacement part's suitability for installation on a specific airplane model exists. This lack of information makes it difficult to approve many substitutions.

d. Sometimes, the owner must substitute a part that has no prior FAA approval. In these instances, a consistent and straightforward approach for approving substitute parts benefits both the owners and FAA. This approach makes the approval decision for the FAA easier. This approach helps the owner replace old parts with newer and usually better parts through a process acceptable to the FAA.

e. Consider certain factors when determining whether one part is a suitable substitution for another.

(1) What is the function of the original part?

(2) Are there current industry standards for the part?

f. The most important aspect to consider when substituting parts is whether the failure of the part would prevent continued safe flight and landing. Often, there is a safety benefit when original parts are replaced. However, if the failure of the part would prevent continued safe flight and landing, then more data is required for approval. Industry standards such as Society of Automotive Engineers (SAE), American Society for Testing and Materials (ASTM), and National Aerospace Standards (NAS), are valuable resources to help provide data to justify approval.

6. SCOPE

a. This AC intends to make suitable replacement parts selection easier and expedite the field approval process when needed. It addresses the pertinent scenarios of this issue, such as equivalent parts, part number substitutions, modifications via substitution, etc. We included examples of "do's and don'ts."

b. The appendices to this AC contain examples of information generally needed for a specific part installation approval. Appendix 1 contains the data to substantiate specific part substitution and provides data needed for approval on any vintage airplane. Appendix 2 contains the data to substantiate specific material substitution and provides data needed for approval on any vintage airplane. We will revise these two appendices as we approve more parts or material substitutions.

c. This AC explains the roles of FAA ASIs and engineers. For instance, ASIs should not make material substitution decisions for issues involving design function, loads, stresses, material properties, chemical composition, heat treatment, etc. Only qualified engineers or DERs should document and make these determinations. ASIs should not approve material substitutions unless provided with supporting documentation acceptable to the FAA allowing a

particular material substitution. The supporting documentation should be from a source qualified to properly evaluate the material substitution. The latest version of AC 20-62 provides guidance for replacement parts and materials for aircraft with standard airworthiness certificates. If deviations from AC 20-62 are identified as important to vintage airplane substitutions, then thorough coordination within the FAA and with related policy and orders will be needed. The latest version of Order 8110.37 also provides guidance on the approval of major alterations.

7. LIMITS ON SUBSTITUTION

a. Class of powered aircraft or glider/sailplane must meet all of the following criteria:

(1) Type Certificated before January 1, 1980. Follow-on TC models of the same airplane, or a derivative thereof, which may be assigned a later TC date, also meet this criteria;

(2) Fixed wing;

(3) Reciprocating engine(s) (not applicable to gliders/sailplanes);

(4) Unpressurized; and

(5) Certificated weight of 12,500 pounds or less.

b. Aircraft must meet the certification basis below, and substitution cannot cause perceptible change to the certification basis for that particular aircraft:

(1) "Group 2 Memo" and Approved Type Certificate (ATC) airplanes (both as approved by the Department of Commerce), and approvals issued per Civil Air Regulations (CAR) 3 and Aeronautics Bulletin 7; or

(2) TC approvals issued under Title 14 CFR Part 23 where the airplane was certificated before January 1, 1980, meet the criteria in paragraph 7(a).

c. This AC limits discussion to the following conditions as they relate to function:

(1) You may use the substitute part/material on secondary structures. Examples of these would include fuselage formers and stringers (typically on steel tube fabric covered aircraft), side windows, material on fabric covered airplanes, and wheel bearings. These substitutions may be a minor repair or alteration, and as such can be documented by logbook entry. See also section 13 "DOCUMENTING SUBSTITUTION" of this AC.

(2) You may substitute parts where a direct substitute for a part/material can be found under manufacturer part number, military specification, or other recognized standard, such as the SAE.

(3) When a direct substitution is not available, you may establish the replacement part/material as at least equal to the original part/material per standards such as military specifications and SAE (for example, the substitution of 4130 steel for milder steel). In these cases, substitutions should be consistent with information already available in manufacturing manuals (Civil Aeronautic Manual (CAM) 18, AC 43-13, etc.).

(4) You may use previously approved (per STC or field approval) part/material substitutions on like-type aircraft. If the part/material is installed with previously approved parts or material, parts manufacturer approval (PMA), technical standard order (TSO), AN, NAS etc., and if it is completed in a similar manner consistent with a previous field approval or STC, you may use those approvals as the basis for approval on your airplane. However, if you want to use a previous field approval or STC as the basis for approval on your airplane, you must have all the previous field approval or STC data, including any instructions for continued airworthiness.

8. DEFINITIONS

a. Major Repair

Title 14 CFR part 1, § 1.1 General definitions, defines a *Major repair* as one of the following:

(1) A repair that, if improperly done, might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness; or

(2) A repair that is not done according to accepted practices or cannot be done by elementary operations.

You should also review Title 14 CFR part 43, Appendix A, for expanded definitions and examples of *Major Repairs* to *airframes*, *powerplants*, *propellers* and *appliances*.

b. Major Alteration

Title 14 CFR part 1, §1.1 General definitions, defines a *Major alteration* as an alteration not listed in the aircraft, aircraft engine, or propeller specifications and meets one of the following conditions:

(1) The alteration might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness; or

(2) The alteration is not done according to accepted practices or cannot be done by elementary operations.

You should also review Title 14 CFR part 43, Appendix A, for expanded definitions and examples of *Major Alterations* to *airframes*, *powerplants*, *propellers* and *appliances*.

c. Standard Part

A standard part (reference Title 14 CFR part 21, §21.303 as it relates to this AC's guidance) is a part manufactured in complete compliance with an established industry or U.S. government specification. The part must completely comply with an established industry or U.S. government specification by either of the two following methods. The part must include design, manufacturing, test and acceptance criteria, and uniform identification requirements or the Administrator must find that the part demonstrates conformity based solely on meeting

performance criteria. The specification must include all information necessary to produce and conform the part.

(1) What should I consider before replacing a standard part?

(a) The substitute, replacement standard part must have properties and performance at least equal to those of the original standard part in all applications and service environments. The replacement parts must adhere to the design, manufacturing, test and acceptance criteria, and uniform identification requirements established by an industry or U.S. government specification. Before replacing any standard part, review the following considerations:

1. Does replacing the original standard part with the replacement part affect the interchangeability of the part for future repairs?

2. Does the part replacement affect the fit of the part or cause the part to interfere with mating parts?

3. Will the safety of the aircraft be compromised by replacement of the standard part?

4. Does the part replacement have a detrimental effect on the overall product quality?

5. Is the part dissimilar to other installations (original equipment, approved by field approval, approved by DER, etc.)?

6. Does the replacement part require special installation procedures, special inspections, or different operating instructions from the original standard part?

Note: If you answer yes, to any of these questions, you may not be able to make the substitutions as outlined in this AC.

(b) Replacement standard parts must be as structurally sound as the original configuration. Any doubt regarding the acceptability of the standard part affecting any of the above items should be eliminated by compliance to Title 14 CFR part 21, § 21.303. The replacement standard part must have no significant bearing on the effective use or operation of its intended application and must not adversely affect the performance, durability, weight, interchangeability, maintainability, reliability, or operation of the airplane.

d. TSO

A TSO is a written specification published by the FAA as a minimum performance standard for specified materials, parts, and appliances used on aircraft. It may specify input and output parameters, operating parameters, and other minimum specifications that apply to an article. The FAA publishes TSOs to set uniform, minimum standards for articles installed in aircraft.

e. Technical Standard Order Authorization (TSOA)

A TSOA authorizes a manufacturer to produce a material, part, or appliance to a TSO standard. Receiving a TSO authorization approves both design and production of the TSO standard. A TSOA does not authorize the installation of a TSO part in a certificated airplane. The standard procedures for the installation or modification of an airplane must be followed (i.e., STC, field approval, etc.).

9. PARTS MANUFACTURE APPROVAL (PMA) PROCEDURES

a. FAA Order 8110.42, states that discrete electrical and electronic components that conform to their applicable performance criteria are standard parts. Forward to AIR-100 (Aircraft Certification Service Engineering Division, Washington, DC) for disposition any requests to declare a part a standard part based on conforming to a performance-only specification.

b. Following Title 14 CFR part 21, § 21.303, persons producing replacement or modification parts for sale to install on a type-certificated product must obtain a PMA. You may obtain a PMA for replacement parts in lieu of the original approved TSOA part, provided that installation eligibility of that product can be shown. When an applicant's design meets the provision of Title 14 CFR part 21, § 21.303, it would normally not be considered a major design change. Any modifications to a TSO article should follow the latest version of Order 8150.1.

c. A part that would constitute a major design change to the TSOA article cannot be produced under PMA and would require a new TSOA.

d. No person may produce a modification or replacement part to sell for installation on a type-certificated product unless they have obtained a PMA.

e. A PMA is not required for the following:

(1) Parts produced under a type or production certificate;

(2) Parts produced by an owner or operator for maintaining or altering his own product;

(3) Parts produced under an FAA TSO; or

(4) Standard parts (such as bolts and nuts) conforming to established industry or U.S. specifications.

10. OBTAINING A PMA

The description of this process is beyond the scope of this AC. The latest version of FAA Order 8110.42, Parts Manufacturer Approval Procedures, discusses this topic in depth.

11. SPECIAL CONSIDERATIONS

In evaluating applications for approval to produce parts for sale to install on older TC products, FAA personnel should consider potential problems. For example, type design information may be difficult to obtain, the product may no longer be in production, or the TC holder may no longer exist or may no longer be producing parts. In these cases, the applicant must still submit sufficient information to determine whether the applicant's design meets the applicable airworthiness standards and whether the applicant will produce parts that conform to the approved parts design.

12. REPAIR STATIONS AND PMAs

a. You may refer to AC 43-18, Fabrication of Aircraft Parts by Maintenance Personnel.

b. To summarize the uniform procedures, a repair station that manufactures replacement or modification parts may be given three options:

(1) A PMA may be issued if the repair station applies for a PMA and meets the provisions of 14 CFR Part 21, § 21.303.

(2) The replacement or modification parts may be produced under the provisions of 14 CFR Parts 43 and 145 when:

(a) The repair station modifies aircraft per an STC based on drawings and specifications adequate to produce duplicates;

(b) The repair station is appropriately rated for the aircraft involved; and

(c) The repair station procedures manual provides controls, which may be similar to those in 14 CFR Part 21, § 21.303 (h) to cover the manufacturing operations.

c. The options in the paragraphs 19b(2) and (3) apply only when the parts manufactured by the repair station are installed on the aircraft at the repair station or the parts are installed at other locations under the repair station's direct authority.

13. DOCUMENTING SUBSTITUTION

a. You may document substitution of parts or materials classified as minor (repair/alteration) by a logbook entry containing the information listed in 14 CFR Part 43, § 43.9(a), Maintenance Record Entries.

b. Part and Material substitutions classified as a major repair or major alteration will require an FAA Form 337, Major Repairs and Alterations, in addition to a logbook entry containing information listed in 14 CFR Part 43, § 43.9(a). Detailed instructions for using FAA Form 337 are contained in AC 43.9-1, Instructions for Completion of FAA Form 337, Major Repair and Alteration (Airframe, Powerplant, Propeller, or Appliance), current edition.

APPENDIX 1
PART SUBSTITUTIONS

1. DRIVE BELTS

Alternator or Generator Belts: For airplanes where the manufacturer no longer sells the original alternator or generator belt, you may use a belt made by the same belt manufacturer if the original part number is known. If the original part number is not known or the belt is no longer available, you may use a belt manufactured to a known specification such as SAE J636 and the belt properly fits the application. Pay special attention to fit of the belt to the pulley and proper tension of the belt. We highly recommend the use of technical information from similar aircraft.

The SAE J636 specification covers standard dimensions, tolerances, and methods of measurement of V-belts and pulleys for automotive V-belt drives. The V-belts that Piper supplies for the PA28-140 conform to this specification.

Approval: This is a minor alteration and you may document it by a logbook entry. The logbook entry must reference the original (if available) and replacement belts' specification and manufacturer's identification.

2. BATTERIES

If one type of series 35 battery (i.e. a Gill 35) is approved as original equipment or a PMA part, and another type of series 35 battery (i.e. a Concord 35) is PMA approved for some airplane models but not your model airplane, you may install the alternate type of series 35 battery, and document the installation with only a logbook entry. This applies to all series 35 batteries. This philosophy also applies to other series, such as series 25 batteries. However, this part substitution is permissible only as long as the batteries are the same weight, within plus or minus one pound, and have such similar physical characteristics as to enable the use of the same securing or attaching devices, mechanisms, or containers.

Approval: This is a minor alteration and you may document it by a logbook entry. The logbook entry must reference the original and replacement manufacturer's identification or the performance specifications of the original and replacement battery.

3. BEARINGS

Bearing catalogs from general bearing supply houses state in their introductions that the bearings listed in their catalog meet ANSI specifications or exclusions. They also give cross-references. Usually, they list bearings for aviation applications. You must use the appropriate part from the cross reference matrix.

Approval: This is a minor alteration and you may document it by a logbook entry. The logbook entry must reference the manufacturer's identification and industry specification for the original and replacement bearing.

4. TRANSPARENCIES - Non-pressurized airplane window panels other than windshields and canopies

For flat window panels, you may use the following substitutions:

You may substitute any commercial grade acrylic sheet (commonly known as Plexiglas) with an identical thickness polycarbonate sheet (commonly known as Dupont Lexan), of equivalent tint (transmissivity), that meets specification SAE-AMS-P-83310 (formerly MIL-P-83310).

You may substitute any commercial grade polycarbonate sheet with an identical thickness acrylic sheet, of equivalent tint (transmissivity), that meets specification MIL-PRF-8184 Type I or Type II, Class 2. Type I is suitable for "as cast" and for "stretching" applications, while Type II is suitable only for "as cast" sheets. Class 2 calls for the desirable improved moisture absorption resistance.

Using material that meets the above specifications ensures consistency of the mechanical properties, resistance to crazing, and resistance to UV exposure, etc.

> **Note 1:** If you substitute "Dupont Lexan" for "Plexiglas" or vice-versa, there may be different maintenance issues such as type of cleaners, polishing techniques, etc. Manufacturing techniques (cutting, drilling, or forming) will also differ according to the material chosen. You should follow the specific manufacturer's recommendations for maintenance.

Approval: This is a minor alteration and you may document it by a logbook entry. The logbook entry must reference the manufacturer's identification and industry specification for the original and replacement transparency.

5. TUBING

This part substitution does not apply to structural tubing, or systems with working pressures greater than 3,000 PSI.

Identify installed tube and specification number if possible.

Metal tubes, particularly aluminum and stainless steel, will generally have an ASTM specification or material identification number printed on the outer surface.

Reference the specification or material number to determine physical characteristics of tube (copper, aluminum, stainless steel). Measure inside and outside diameters and determine the wall thickness.

Determine the operational pressure or vacuum of the system the tube is installed in. For example, if using the tube in a landing gear retraction system, refer to the aircraft maintenance manual and/or the pump manufacturer's data to determine the maximum oil pressure specified for operation.

If no identification marks are found, use a tube meeting or exceeding a U.S. material specification, such as ASTM or MIL, for the material being replaced. For replacement of unmarked tubes, you must research the specifications of the replacement tube to make sure it has the same I.D. and that the rating meets or exceeds the maximum rating for the amount of vacuum and or pressure the system will place on the tube.

You may replace copper and/or brass tubing with aluminum tubing in the "O" or fully annealed condition if the tubing has the same I.D. and has the appropriate pressure service rating for the system the tube is installed in.

> **Note 2:** The "O" condition is important because applications that need to allow for vibration loads and manual bending of the lines often use copper and brass tubing.

Approval: This is a minor alteration and you may document it by a logbook entry. The logbook entry must reference the material specification, I.D. and wall thickness of the replacement tubing and the manufacturer's identification (if a standard part). Also reference the original tubing identification number if known. If the original tubing information is not known, then list the minimum/maximum operating environment specifications (material, fluid, service pressure, temperature, I.D., wall thickness, etc.).

APPENDIX 2
MATERIAL SUBSTITUTIONS

1. AMERICAN IRON AND STEEL INSTITUTE (AISI) 1020 OR 1025 CARBON STEEL

Metallurgical Considerations in the Substitution of AISI 4130 for AISI 1020 or 1025:

a. Assumptions and limitations.

(1) We limit this appendix to non-heat treated structures. Post weld heat treatments such as a quench and temper operation significantly improve the average strength of a structural member. In heat treatment of structures, section size and alloy content dramatically alter heat treat response; therefore, you should not use material substitutions of heat-treated components without appropriate metallurgical engineering analysis. The altered heat treat response will impact the static strength as well as the fatigue strength of the component. Examples of older aircraft with heat treated components include: Landing gear struts in the Luscombe 8 series and Stinson 108 series engine mounts.

(2) For material substitution related to fatigue life, we assume that the structure is ferrous (steel). Aluminum or titanium structures are out of scope as they have different material responses. We limit our conclusions to AISI 1020/1025 and AISI 4130 types of steel alloys.

(3) We also assume that the structure is designed for and operated in stress ranges below the base material yield strength (elastic region). The static strength of the weldment base material influences the fatigue strength of the weldment as the maximum stress in the fatigue cycle approaches the static strength of the base material. In this case, a higher strength base material will increase the “low cycle” fatigue strength of the weldment. The base material type in the elastic region does not affect S-N curves for welds. In the elastic-plastic region, the S-N curves for the different weld classifications will vary depending on the yield strength of the base material. Any repetitive stresses above the yield strength will be affected by the material’s alloy content. For this reason, you should consider only infinite life components. Any components designed with limited lives by the manufacturer should not have material substitutions without metallurgical engineering analysis.

(4) Even with tight controls in the manufacturing process of tubing, no one knows the thermal history of the structure. The welding operation results in various portions of the structure having an infinite potential for heating and cooling and the resultant strengths. Since the weld operation uses hot liquid metal in the weld pool and other areas on the part or structure are cold, we have a variety of starting microstructures. The cooling rate is a function of the welder’s skill and practices, location, type of repair, etc. Because of this unknown, we assume that somewhere in the loaded structure the strength of the material is a very low value, which is taken into account by the original designer when selecting the tubing size and wall thickness.

(5) External factors affecting fatigue of components are well documented. We only present a cursory review to illustrate the relative importance of other factors governing the fatigue strength:

(a) Notch sensitivity of the joint can have stress concentration from 1 to 4 times the nominal applied loads.

(b) In a similar vein to notch sensitivity is surface finish of the part. A 25% reduction in fatigue life is associated with rough vs. smooth surfaces.

(c) Corrosion can cause a reduction in the fatigue strength in the range of 25–35 percent. Thus weldments in areas subject to corrosion should have additional precautions.

Normal variation in these factors controls the structural load carrying capability and fatigue life, rather than the difference in minimum strength of the base material as a function of alloy content.

b. Certification Considerations in the Substitution of AISI 4130 for AISI 1020 or 1025:

You may substitute AISI (or other industry standard) 4130 low alloy steel in place of original AISI (or other industry standard) 1020 and 1025 plain carbon (non-sulfurized) steel. This applies only to annealed or normalized materials. Neither the original AISI 1020/1025, nor the replacement material AISI 4130 should be heat treated (high strength).

For pre-1945 airplane designs, the original material carbon content may not be known. You may use AISI 4130 material in place of the original equipment manufacturer's (OEM) material. AISI 1020 and 1025 are low carbon steels containing 0.20 percent and 0.25 percent carbon (nominal) respectively. AISI 4130 has a medium carbon content of 0.30 percent (nominal) with chromium and molybdenum as principal alloying elements.

For many years the alloy AISI 4130 has been substituted for AISI 1020 and 1025, and it is used extensively for new designs. AISI 4130 is more readily available, and has more desirable material properties than AISI 1020 and 1025-carbon steel. Typical parts originally manufactured from AISI 1020 or 1025 include (but are not limited to) fuselage, wing, empennage, engine mounts, landing gear supports, including associated gussets, doublers, etc.

For airplanes certificated before 14 CFR Part 23 Amendment 23-7 (August 13, 1969), the regulations did not require fatigue analysis (ref. 14 CFR Part 23, § 23.572). So, we do not require a new fatigue strength analysis when making this material substitution for these aircraft. For airplanes certificated after this date, you should determine whether a new fatigue strength analysis is necessary, by examining the Type Certificate Data Sheet (TCDS) for the certification basis of the airplane, or by contacting your local Aircraft Certification Office (ACO).

Sometimes, a damage tolerance analysis may exist as well, and you may have to re-analyze the part using the new material. The need for a new fatigue or damage tolerance analysis will depend on the part being replaced and whether any of the following exists for the current part:

(1) Stated life limit.

(2) Required inspection program by;

(a) Airworthiness Directive (AD)

(b) Instructions for Continued Airworthiness (ICA)

(c) OEM Maintenance or Operations Manual

If an AD covers the part, you must obtain an Alternate Means of Compliance (AMOC), in addition to any other approvals (i.e. Form 337 field approval, Supplemental Type Certificate (STC), etc.). If the part has an existing life limit, you must determine the new life limit using the substitute material. If the part is under any other existing inspections, you must evaluate the basis for the inspection and determine what type of analysis you must do and determine the new inspections required, if any. The new analysis and inspections (if any) are required as part of the material substitution. The guidance in this AC solely addresses the material substitution. The suitability of the material substitution to a particular part must be evaluated on a case-by-case basis. This AC does not circumvent the approval process for alterations to an existing aircraft. A field approval, coordinated field approval, STC, etc., may still be required, depending on the repair/alteration.

c. Design Considerations in the Substitution of AISI 4130 for AISI 1020 or 1025:

The part fabricated from the substitute material should have the same gauge or wall thickness as the original approved part. AISI 4130 (in general) has higher tensile ultimate strength, yield strength, and fatigue strength than plain low carbon steel AISI 1020 and 1025. However, the fracture toughness of 4130 may be lower than that of plain low carbon steel, so you must investigate the damage tolerance on any part that has an existing inspection requirement. In addition, the elongation property of AISI 4130 is usually lower than that of AISI 1020 or 1025. Therefore, evaluate any formed part to determine if the bend radius of the original part can be duplicated without cracking when using the new material. If a larger bend radius must be used to avoid cracking, the functionality of the part may be affected and fastener loads may increase if the fastener line is relocated to clear the larger radius. You must evaluate these alterations as part of the material substitution.

For welded structures, the quality of the weld is an important safety consideration regardless of the steel type. You should refer to and follow conventional welding practices specified for AISI 4130 material when substituting this material. Welding AISI 4130 requires specific pre-heat, interpass heat, post heat, and low hydrogen content welding rods. Disregard for these precautions may result in welds with unpredictable fatigue and ultimate strength due to hydrogen embrittlement.

You may want to take advantage of the increased tensile strength and fatigue properties of AISI 4130, by decreasing the material gauge, and thereby lowering the cost and weight. However, this will also decrease the stiffness and compression strength, and may have an overall affect (depending on the location and extent of the gauge reduction) on the aeroelastic properties of the airframe. A change to the aeroelastic properties will require a re-evaluation of the flutter characteristics of the aircraft as a minimum. Therefore, any change to the material gauge (along with the substitution) is beyond the scope of this AC. You should be aware that a complete reinvestigation of compliance, perhaps even a new type certificate could be required if you attempt this type of change.

Summary: The primary concern is allowing the substitution of SAE 4130 alloys in structures that originally were designed and fabricated from SAE 1020 grades. Thin walled tubing is more readily available in 4130 than in the lower alloy for the sizes typically needed.

(1) Heat treated components are not to be considered for material substitutions.

(2) Matching tubing diameter and wall thickness, when following repair or replacement procedures, are the only concerns when substituting 4130 alloys for 1020 in structural repairs.

(3) Surface finish, corrosion, geometry (stress concentrations), and base material strength are the prime determinates of fatigue strength in structures.

(4) Base material strength cannot be predicted in field-fabricated structures; therefore, design must accommodate all potential scenarios.

(5) The tensile strength of 4130 is marginally higher than 1020 in the conditions normally found in welded structures. As a result, the static and fatigue strength may increase by a minimal amount.

Conclusion: For structural tube on applicable airplanes, we permit the substitution of AISI 4130 steel (normalized) for either AISI 1020 or 1025 steel tube. We do not permit the substitution of AISI 1020 or 1025 steel for 4130. All work should be performed in accordance with the aircraft manufacturer's manuals or AC43.13-1B, if these manuals do not exist.

Approval: This material substitution on secondary structure is a minor repair or alteration and should be documented by logbook entry. However, if the material is substituted on primary structure then it is a major repair or alteration, and, as such, you must comply with various requirements in the Federal Aviation Regulations in order to obtain approval. You may use the data in this AC as approved data for the material substitution in those instances.