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REQUIREMENTS FOR ENGINEERING APPROVAL OF METALLIC RAW MATERIAL SUPPLIERS

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1. SCOPE

1.1 GENERAL

This document contains engineering requirements for the production of metallic raw materials for use on Boeing Commercial Airplane products. These requirements apply to:

a. Non-United States suppliers of primary raw material such as ingot and intermediate wrought products that will be used to produce products in accordance with the specifications listed in TABLE I.

b. Non-United States suppliers of secondary raw material that alter primary raw material by thermomechanical processing to yield products in accordance with the specifications listed in TABLE I.

c. United States suppliers of titanium ingot that will be used to produce products in accordance with the specifications listed in TABLE I.

1.2 PURPOSE

This document provides for engineering approval of non-United States sources of primary and secondary metallic raw materials and United States suppliers of titanium ingot. Approval in accordance with this document shall be listed in D1-4426.

2. CLASSIFICATION

Classification of suppliers shall be in accordance with the code 600 categories listed in D1-4426 and include:

a. Ingot, by alloy (primary raw material suppliers)

b. The specifications listed in TABLE I (secondary raw material suppliers)

3. REFERENCES

The issue of the following references form a part of this specification to the extent herein indicated.

D1-4426	*Approved Process Sources*
D6-1276	*Control of Materials and Processes for Designated Parts and Components of Boeing Products*

MMPDS	*Metallic Materials Properties Development and Standardization*
AMS 2772	*Heat Treatment of Aluminum Alloy Raw Materials*

4. DEFINITIONS

Definitions used throughout the text are defined within this section.

Engineering Drawing	The collection of product definition data used to disclose, directly or by reference, through pictorial or textual presentations, or combinations of both, the physical and functional end product requirements and configuration of an item. The term may be used regardless of the actual medium or method used for its depiction. A drawing may be computer-aided, manually produced, digitally defined within a dataset and plotted, or digitally defined within a dataset and not plotted.
Heat	Material from the same melt batch processed at the same time. For continuous casting, a heat would consist of material cast during a single run from an unreplenished melt. For steel, the applicable heat is the vacuum arc remelt ingot or electroslag remelt ingot.
Lot	Material of the same mill form, alloy, temper, section and size, traceable to the same heat treatment furnace load(s) or, if heat treated in a continuous furnace, charged consecutively during an 8-hour period. For all alloys except aluminum alloys, a lot shall also·be comprised of the same heat.
Quench Delay Time	For air furnaces, the time interval between when the furnace door starts to open and the immersion of the last corner of the load. For salt baths, the interval begins when the first corner of the load emerges from the salt surface and ends with the immersion of the last corner of the load. For bottom-quench downdraft air furnaces, the start of the interval may begin when the parts begin to emerge from the work zone or when the work zone temperature drops 10 F below the minimum solution temperature, whichever comes first.

T_{90}	Statistically based lower tolerance bound for a mechanical property such that at least 90 percent of the population is expected to exceed T_{90} with 95 percent confidence
T_{99}	Statistically based lower tolerance bound for a mechanical property such that at least 99 percent of the population is expected to exceed T_{99} with 95 percent confidence.

5. REQUIREMENTS

Unless otherwise amended by Boeing Research & Technology, the following are required prior to approval.

5.1 REQUEST FOR APPROVAL

Requests for approval shall be submitted through the Supplier Management Division of Boeing Commercial Airplane. The request shall include the alloy, product form, specification, size range, and a preliminary data package for each alloy for which approval is sought.

In some cases data from a similar alloy may be considered.

5.2 PRELIMINARY DATA PACKAGE

5.2.1 PRELIMINARY DATA PACKAGE: PRIMARY RAW MATERIAL SUPPLIERS

The preliminary data package shall include:

a. Sources of elemental raw materials and/or procurement criteria (for example, internal specification).

b. A history of production of the alloy and form including the current production level in tons for each year.

c. Description of the production practice with particular attention to the items of Section 5.4.

d. Chemistry data from the most recent five consecutive heats of the alloy. Include the identity of each heat and the date of production.

5.2.2 PRELIMINARY DATA PACKAGE: SECONDARY RAW MATERIAL SUPPLIERS

The preliminary data package shall include:

a. Sources of the primary raw materials that will be used.

b. If these sources are non-United States sources and not listed in D1-4426 then submit the data of Section 5.2.1 for these sources.

c. A history of production of the alloy and form as well as the particular specification for which approval is sought.

d. A summary of production practices with particular attention to Section 5.4 and the requirements of the specification for which approval is sought.

e. Mechanical data from at least three consecutive lots (preferably the most recent) made to the specification for which approval is being sought or data from lots of the same alloy, but made to other specifications. A minimum of 18 tensile tests in each grain direction in each thickness range is required. If only one thickness range is being qualified, a minimum of 30 tensile tests in each grain direction is required. An analysis and probability plotting in accordance with APPENDIX A is required. Include the identity of each lot and the approximate date of production, date of testing, or date of certification. Include the identity of each heat for each lot (not applicable for aluminum alloys). Include lots that were rejected, retested, reworked, or scrapped during the period and a brief explanation or corrective action taken (the data from such lots should not be included in the analyses and plotting in accordance with APPENDIX A). Aluminum suppliers shall include electrical conductivity data or a statement why electrical conductivity data are not available (for example, not required by the procurement specification).

f. One copy of at least three certifications corresponding to the aforementioned lots. Certifications in languages other than English shall be accompanied by translations or marked with the English translation on the certification copy.

g. A summary of approvals from other aerospace companies including the history of such approval and limitations.

5.3 DATA PACKAGE

Based on favorable review of the preliminary data package and authorization to proceed with the approval process, additional data may be requested. These data may include the following:

a. Data required by the applicable procurement specification to demonstrate compliance and/or to initiate qualification (when required).

b. Additional mechanical data to assess property reliability and support of Boeing design parameters. This data may be evaluated in accordance with APPENDIX A and/or by Boeing Stress Methods and Allowables.

c. Additional data and/or specimens as deemed necessary.

5.4 SUPPLEMENTAL CRITERIA

5.4.1 SUPPLIERS OF ALUMINUM: PRIMARY

a. Aluminum alloys shall be cast utilizing the following:

(1) Degassing of the melt shall be accomplished using chlorine gas, a chlorine-inert gas mixture, or an inert gas, introduced through an in-line degassing unit such as a Spinning Nozzle Inert Flotation (SNIF) or equivalent. Analytical capability for hydrogen or periodic hydrogen analyses by an independent laboratory is required; and documented controls of hydrogen content shall be in place and supportable by historical data.

(2) Filtration of the metal utilizing some type of filter unit, that is, ceramic foam filter or equivalent in conjunction with an in-line inert gas degassing system is required. Use of fiberglass cloth downstream of the filter unit is advisable. However, use of fiberglass cloth as the only means of filtration is not considered adequate. If chlorine gas is used for degassing, provisions shall be employed to preclude clogging and/or channeling of the filtration system.

b. Aluminum alloy ingots for wrought products shall be cast by the Direct Chill (DC) or continuous cast method.

c. The source shall show evidence that the Iron (Fe) and Silicon (Si) content of alloys 7075 and 2024 are typically below 0.30 (Fe) and 0.15 (Si) weight percent.

d. Sources of 7075 and 2024 shall show evidence that Zirconium (Zr) is below 0.05 percent.

e. The source shall demonstrate control of hydrogen below 0.14 cm^3/100 gram (maximum individual measurement) as measured by Alscan or equivalent.

5.4.2 SUPPLIERS OF ALUMINUM-SECONDARY

The following items apply to all suppliers of secondary aluminum forms, including forgings. Aluminum forging suppliers should also see Section 5.4.6.

a. The following information shall be submitted on immersion quench facilities.

(1) General description of the quench facility.

(2) Detailed description of quenchants used and quench agitation.

(3) Description of quenchant cooling system.

(4) Typical and minimum available quench delays.

(5) Detailed description of racking procedures (examples).

(6) Sufficient conductivity data to verify quench uniformity in accordance with AMS 2772.

b. For spray quench facilities, electrical conductivity data, produced according to the procedure outlined in AMS 2772, shall be submitted prior to approval.

c. Facilities used for quenching aluminum forgings shall be capable of meeting a 15 second quench delay. Facilities intending to solution treat forgings with sections less than 0.090 inch thick shall be capable of meeting a 10-second quench delay. If this quench delay cannot be met, the heat treatment shall be subcontracted to an approved source, which can and shall meet the required quench delay.

5.4.3 SUPPLIERS OF STEEL: PRIMARY

The source shall show evidence that the sulfur content is consistently held below 0.006 weight percent for Vacuum Arc Remelted (VAR) and Electro-slag Remelted (ESR) steel, and below 0.015 weight percent for air melted grades. Except for 15-5 PH steel, the phosphorous content of VAR steel shall be consistently less than 0.020 weight percent.

5.4.4 SUPPLIERS OF TITANIUM: PRIMARY

All suppliers, foreign and domestic that produce titanium ingots of alloys listed in TABLE I require Boeing approval. The following items are required and must be made available to obtain approval:

a. Process Control

(1) The melting source shall have internal controls for sponge and master alloy. The controls shall include requirements and inspection practices of the sponge and master alloy.

(2) Melting source shall have internal controls for the use of scrap. For non-hearth processes, the controls shall include X-ray inspection of chips/turnings, prohibition of welds, castings, as flame cut surfaces, embedded tool fragments and uninspectable surfaces.

(3) Melting source shall have internal control for the electrode fabrication.

(4) Melting source shall have controls of the voltage, amperage, and atmosphere used for melting including provision for hot top and melt interruption.

(5) Melting sources relying on the cold hearth process to remove high and low density inclusions shall have documented the ability of the process to remove inclusions using the controls in Section 5.4.4a(4). The melt rate used to demonstrate the defect removal capability shall not be exceeded during production.

b. Production

The melting source shall demonstrate the ability to control the elemental compositions of the alloying elements for the alloys approved. Control shall consist of demonstration of a true Cp of 1.0 or greater for each alloying element.

5.4.5 SUPPLIERS OF TITANIUM: SECONDARY

For titanium forging suppliers, see also Section 5.4.4.

a. The source shall have an established procedure for removal of alpha case and other surface contaminants.

b. The source shall show evidence that the hydrogen content of the finished product is held consistently below 75 parts per million (ppm) and that the oxygen content is consistently below 0.20 weight percent.

c. The source shall have an established microstructural standard for evaluation of their product.

5.4.6 FORGING SUPPLIERS: ALL ALLOYS

a. The forging source shall demonstrate (from forgings in production) that their forging techniques will produce acceptable material movement in the filling of the dies. This will normally involve the use of blocker cavities to assure proper metal preparation for the finish forging operations. Appropriate grain flow photographs taken after the final forge operation shall be submitted for review.

b. The forging source shall demonstrate the use of planning/shop travelers which fully define each forging operation, inspections, stock preheat temperatures and die temperatures.

c. The forging source of their independent heat treater shall demonstrate the use of planning shop travelers which fully define the parameters used for heat treatment.

d. Unless waived on the approval letter, forging plans and data from the first 10 Boeing part numbers for each alloy shall be submitted in accordance with APPENDIX D.

5.5 SURVEY REQUIREMENTS

On-site surveys by Boeing Research & Technology will be required. Assessment of the following items will be determined by the survey.

a. The source has the technical ability and assignment of responsibilities to assure consistent quality in the product.

b. The product size limitations that are dictated by the melting, hot-working, and heat-treating facilities.

c. The controls used by the source that will assure meeting the applicable specification, specific requirements of D042T601 and the design properties as specified in APPENDIX A.

d. The source has the experience in recognizing the methods for evaluating and correcting segregation problems or other metallurgical imperfections common to the alloy system it is producing.

e. The source can demonstrate established methods for the evaluation of the cleanliness of the metal it is using.

f. The source shall show evidence that the techniques used to reduce the material from the ingot to the billet (or bar) stage, adequately work the material throughout the entire cross section.

6. APPROVAL

6.1 ATTAINMENT OF APPROVAL

Following acceptable evidence of compliance with the explicit requirements of this document (as may be amended by Boeing Research & Technology), a memo by Boeing Research & Technology will be issued to indicate Engineering approval. Listing in D1-4426 indicates full D042T601 approval for the source to produce the raw materials as designated therein.

6.2 RETENTION OF APPROVAL

Continued approval is contingent upon continued production in support of Boeing programs, and continued compliance with the requirements of D042T601, D1-4426, and the applicable procurement specifications, as well as any and all conditions which may appear on the approval memo. Periodic review of chemical and/or mechanical data relative to Boeing design parameters may be required.

6.3 REINSTATEMENT OF PREVIOUS APPROVAL

If a previous approval has not been retained, reinstatement of that approval may require a justification for re-approval and may require refulfillment of some or all of the requirements necessary for initial approval. Such determinations will be made on a case-by-case basis.

7. QUALITY CONTROL

7.1 SUPPLIER QUALITY CONTROL

The supplier shall have an established Quality system capable for assuring consistent product in accordance with procurement specification and this document.

7.2 PURCHASER QUALITY CONTROL

Not applicable to this document.

8. MATERIAL TEST METHODS

Material test methods shall be in accordance with the applicable procurement specifications. When submitting test data for approval in accordance with this document, any differences between the test methods used to obtain these data and the test methods required by the applicable procurement specification shall be noted and the reasons explained.

9. MATERIAL IDENTIFICATION

Material identification shall be in accordance with the applicable procurement specifications.

10. PACKAGING AND MARKING

Packaging and marking shall be in accordance with the applicable procurement specifications.

TABLE I. ALLOYS AND PRODUCT SPECIFICATIONS FOR WHICH APPROVAL IS REQUIRED

ALLOY FL 1	SHEET/ PLATE FL 4	EXTRUDED BAR/SHAPE FL 4	FORGING STOCK (FORGED BLOCK BAR, OR DIE FORGING) FL 4	TUBE FL 4
2014	----	----	BMS7-186	----
2024	AMS-QO-A-250/4 AMS-QO-A-250/5 BMS7-305	AMS-QO-A-200/3	AMS-QO-A-225/6	AMS-WW-T-700/3
2124	AMS 4101 AMS-QQ-A-250/29	---- ----	---- ----	---- ----
2219	BMS7-110 AMS-QQ-A-250/30	BMS7-118 AMS 4163 AMS 4162	AMS 4143 BMS7-186 AMS-QQ-A-367 AMS 4144	BMS7-121
7049	----	----	BMS7-214	----
7050	AMS 4050 AMS 4201	AMS 4340 AMS 4342	BMS7-214 AMS 4333 AMS 4107	---- ---- ----
7055	---- ----	AMS 4336 AMS 4324	---- ----	---- ----

ALLOY FL 1	SHEET/ PLATE FL 4	EXTRUDED BAR/SHAPE FL 4	FORGING STOCK (FORGED BLOCK BAR, OR DIE FORGING) FL 4	TUBE FL 4
7075	AMS-QQ-A-250/12 BMS7-302 AMS 4048 AMS 4049 AMS 4315 AMS 4316	 AMS-QQ-A-200/11 or AMS-QQ-A-200//15	BMS7-186 AMS-QO-A-225/9	AMS-WW-T-70017
7175	----	AMS 4344	BMS7-214	----
7178	AMS-QQ-A-250/14	AMS-QQ-A-200/13	----	----
300M	----	----	AMS 6419	AMS 6419
4330M	BMS7-34	BMS7-122 AMS 6411 BMS7-225 FL 2	BMS7-122 AMS 6411	BMS7-122 AMS 6411
4340	AMS 6359	----	AMS 6415 AMS 6409 AMS 6414	AMS 6415 AMS 6409 AMS 6414
4340M	----	----	BMS7-26, Type I BMS7-26, Type II, Bar	BMS7-26, Type I BMS7-26, Type II, Tube

ALLOY FL 1	SHEET/ PLATE FL 4	EXTRUDED BAR/SHAPE FL 4	FORGING STOCK (FORGED BLOCK BAR, OR DIE FORGING) FL 4	TUBE FL 4
9Ni-4Co-0.30C	----	----	BMS7-182 (Type II)	BMS7-182 (Type II)
15-5 PH	BMS7-240 AMS 5862	AMS 5659	AMS 5659	
17-7 PH	AMS 5528	----	----	----
PH 13-8Mo	----	AMS 5629 BMS7-332	AMS 5629 BMS7-332	----
Nickel Alloy 625	AMS 5599	----	AMS 5666	AMS 5581
Nickel Alloy 718	AMS 5596	----	AMS 5662	AMS 5589
Ti-6Al-4V	AMS 4911 AMS 4904	AMS 4935 AMS 4965 AMS 6930 AMS 4934	AMS 4928 BMS7-269	----
Ti-6Al-4V (ELI)	AMS 4905	----	----	----
Ti-6Al-6V-2Sn	----	----	AMS 4978 AMS 4979 AMS 4971	
Ti-3Al-2.5V	----	----	----	BMS7-234
Ti-6Al-2Sn-4Zr-2Mo	AMS 6945 AMS 4919	----	AMS 6931 AMS 4976	----
Ti-3Al-8V-6Cr-4Mo-4Zr FL 3	----	----	----	----

FL 1 Ingots and primary raw material used to produce material procured to the listed specifications shall be procured from United States sources or from suppliers approved to this document and listed in D1-4426. Approval of secondary raw material may constitute conditional approval of the supplier of the primary raw material (Section 5.2.2b.).

FL 2 BMS7-122 and BMS7-225: Approval for extrusions of 4330M is required only when both of these specifications are required by the Engineering Drawing.

FL 3 Ingot approval required for raw material used for BMS7-320, AMS 4957, and AMS 4958.

FL 4 AMS-QQ-A-XXX and QQ-A-XXX, or MIL-X-YYY and AMS-X-YYY approvals are equivalent.

APPENDIX A STATISTICAL ANALYSIS OF DATA

A.1 AVERAGE VALUE AND STANDARD DEVIATION

The average value ($\overline{x}$) and the standard deviation(s) shall be calculated for the material Key Characteristics noted below for the last 100 lots of material (or all the data if less than 100 lots).

$$\overline{x} = \frac{\sum x}{n} \qquad (1)$$

$$s = \left[\frac{\sum x^{2} - \frac{(\sum x)^{2}}{n}}{n-1} \right]^{1/2}$$

where:

x = the individual lot averages from the data package (TUS, TYS, or RA)

n = the number of lot averages (data points).

A.2 GRAPHICAL REPRESENTATION OF DATA

a. Cumulative Probability

The cumulative probability shall be calculated and plotted for points representing the complete range of values (percentiles for the lowest and the highest ranking points shall be calculated). The rank of each point selected for plotting is equal to the number of lower test points plus the plotted point. The cumulative probability, in percent, is equal to the rank times 100, divided by one more than the total number of test points:

$$P\ (in\ percent) = \frac{rank\ x\ 100}{n+1} \qquad (2)$$

The cumulative probability when plotted on arithmetic probability paper shall show a distribution in accordance with the following analysis.

(1) Calculate the values:

$$L = \overline{x} - 3s$$

$$L = \overline{x} + 3s$$

(2) Plot the L point value at 0.13 percentile and the H point value at 99.87 percentile.

(3) Draw a line between the L and H.

(4) Plot the cumulative probability determined above.

(5) Determine the acceptable scatter band by drawing lines offset from the L-H line by ± 0.01 H.

(6) The plotted data shall be within the scatter band drawn in APPENDIX A.2a.(5) between the 5 and 95 percentile values. Below the 5-percentile value, the data shall not exceed the upper scatter line.

b. Frequency Histogram

Mechanical data shall be presented as frequency histograms in order to determine whether the data can be approximated by a Normal distribution (that is, bell-shaped curve).

c. Time History

Mechanical data shall be plotted versus time in a scatter plot, to evaluate consistency of the given property over time. Time can be described as the production date of the material or the date of testing corresponding to each data record.

A.3 STATISTICAL CALCULATIONS

The T_{99} and T_{90} values shall be calculated by the equations:

$$T_{99} = \overline{x} - K_1 s \quad (3)$$

$$T_{90} = \overline{x} - K_2 s \quad (4)$$

The K values are listed in TABLE V. The calculated T_{99} and T_{90} values shall equal or exceed the T_{99} and T_{90} values listed in TABLE VI through TABLE XV, or the A-basis and B-basis allowables, respectively, as listed in the MMPDS Handbook, for the alloy and form tested.

If only the S-basis value is shown in the Metallic Material Properties Development and Standardization (MMPDS) Handbook, then the T_{99} value shall be calculated for comparison.

A.4 SAMPLE STATISTIC CALCULATION

The following example illustrates the calculation of statistics as required in Section 5.2.2. The following data in TABLE II represents 52 lots of 2.001 to 3.000 inch 7075-T73 die forging data taken in the longitudinal grain direction.

TABLE II. STATISTICAL SAMPLE DATA

Test Date	TUS (ksi)	TYS (ksi)	Elonga-tion (percent)	Test Date	TUS (ksi)	TYS (ksi)	Elonga-tion (percent)
15-MAR-2006	77.7	69.5	13.0	01-JUN-2006	75.0	65.4	14.0
18-MAR-2006	73.4	62.6	14.0	04-JUN-2006	77.2	68.4	15.0
21-MAR-2006	77.0	66.8	14.0	07-JUN-2006	77.4	65.6	15.5
24-MAR-2006	76.8	66.8	15.0	10-JUN-2006	76.4	67.2	14.0
27-MAR-2006	76.3	67.3	14.0	13-JUN-2006	76.6	65.4	15.0
30-MAR-2006	76.5	68.4	13.0	16-JUN-2006	77.3	67.4	13.0
02-APR-2006	76.2	66.4	14.0	19-JUN-2006	73.8	64.2	14.0
05-APR-2006	77.2	67.0	14.5	22-JUN-2006	74.2	65.2	14.0
08-APR-2006	77.0	67.6	14.0	25-JUN-2006	76.5	67.1	14.0
11-APR-2006	73.8	64.9	15.0	28-JUN-2006	75.4	68.4	8.5
14-APR-2006	76.4	66.6	15.0	01-JUL-2006	75.6	66.6	13.0
17-APR-2006	76.8	67.5	13.5	04-JUL-2006	74.6	64.5	15.0
20-APR-2006	76.0	67.0	15.0	07-JUL-2006	76.2	66.4	13.5
23-APR-2006	72.4	66.2	7.0	10-JUL-2006	73.4	63.6	15.0
26-APR-2006	75.0	64.2	15.5	13-JUL-2006	73.8	64.4	14.0
29-APR-2006	75.9	66.9	15.0	16-JUL-2006	73.9	65.5	15.5
02-MAY-2006	76.3	66.8	13.5	19-JUL-2006	75.6	66.5	14.5
05-MAY-2006	77.8	67.0	13.0	22-JUL-2006	73.0	64.0	14.0
08-MAY-2006	78.2	69.2	13.5	25-JUL-2006	74.7	65.2	14.0
11-MAY-2006	75.0	66.0	15.0	28-JUL-2006	76.2	66.0	15.5
14-MAY-2006	75.0	65.9	15.0	31-JUL-2006	75.4	66.0	14.0
17-MAY-2006	72.3	61.1	11.0	03-AUG-2006	76.8	66.8	15.0

Test Date	TUS (ksi)	TYS (ksi)	Elonga-tion (percent)	Test Date	TUS (ksi)	TYS (ksi)	Elonga-tion (percent)
20-MAY-2006	76.2	66.0	15.0	06-AUG-2006	77.0	66.4	15.0
23-MAY-2006	76.0	65.8	12.5	09-AUG-2006	75.0	64.8	14.5
26-MAY-2006	76.8	66.4	13.0	12-AUG-2006	75.4	66.8	15.0
29-MAY-2006	77.3	66.4	14.5	15-AUG-2006	76.2	66.0	13.5

From TABLE II data, the data summary in TABLE III is calculated.

TABLE III. STATISTICAL SAMPLE, DATA SUMMARY

	$\bar{x}$	s	L	H
TUS	75.71	1.42	71.44	79.97
TYS	66.10	1.54	61.51	70.74

The cumulative probability calculated by equation (2) is shown in TABLE IV.

TABLE IV. STATISTICAL SAMPLE, CUMULATIVE PROBABILITY

TUS VALUE (KSI)	RANK	PERCENTILE	TYS VALUE (KSI)	RANK	PERCENTILE
72.3	1	1.9	61.1	1	1.9
73.0	3	5.7	62.6	2	3.8
74.0	9	17.0	64.0	4	7.6
75.0	17	32.1	65.0	11	20.8
76.0	26	49.1	66.0	23	43.4
77.0	44	83.0	67.0	41	77.4
78.0	51	96.2	68.0	47	88.7
78.2	52	98.1	69.0	50	94.3
			69.5	52	98.1

As shown in FIGURE 1, plot of the data from TABLE II, the data for ultimate strength all fall within the scatter band. The data for yield strength deviate from the scatter band below 5 percent. The deviation is below the scatter and is therefore acceptable.

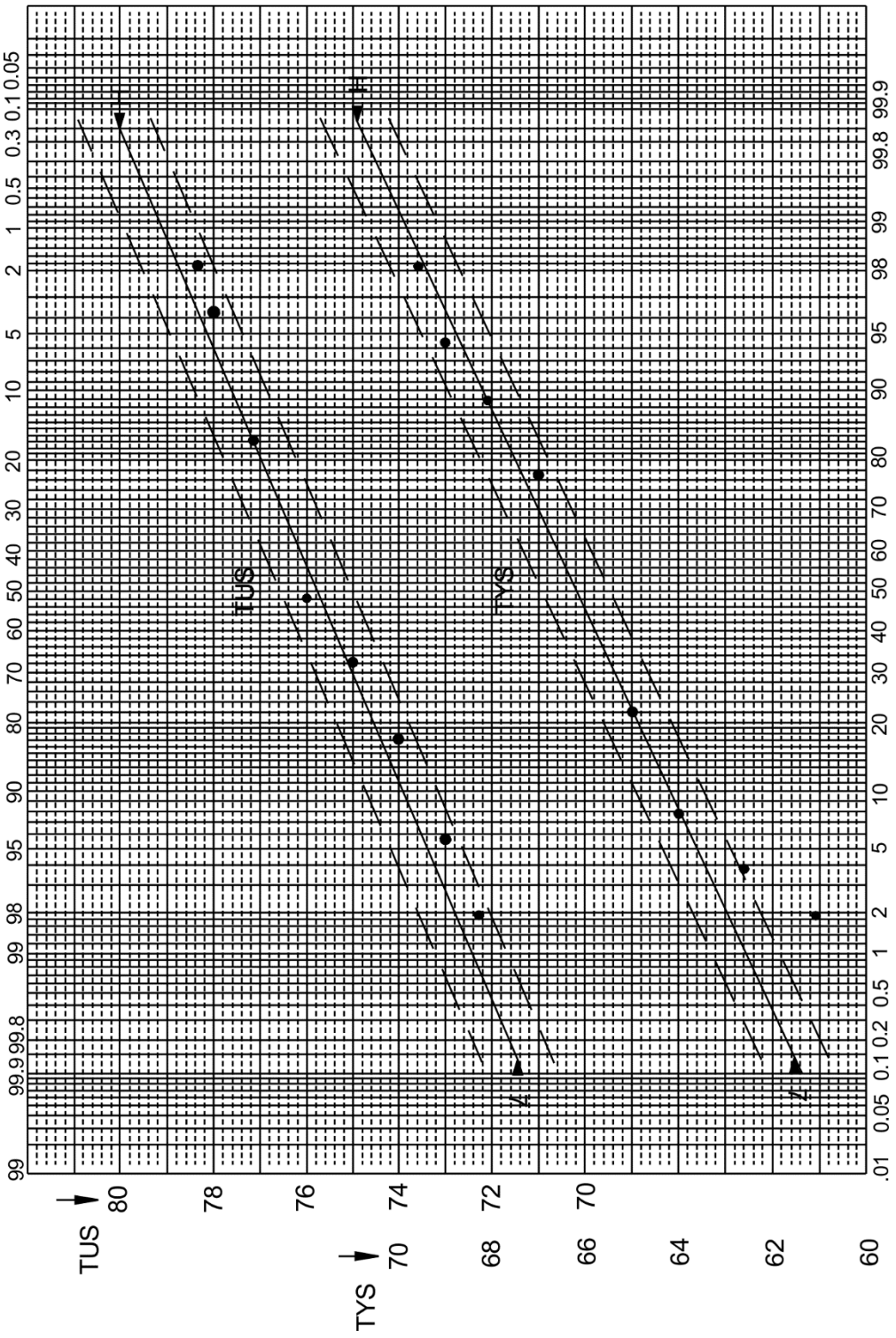

FIGURE 1 PLOT OF DATA CALCULATED FOR THE EXAMPLE

The data is plotted as histograms in FIGURE 2 and FIGURE 3 for TUS and TYS, respectively.

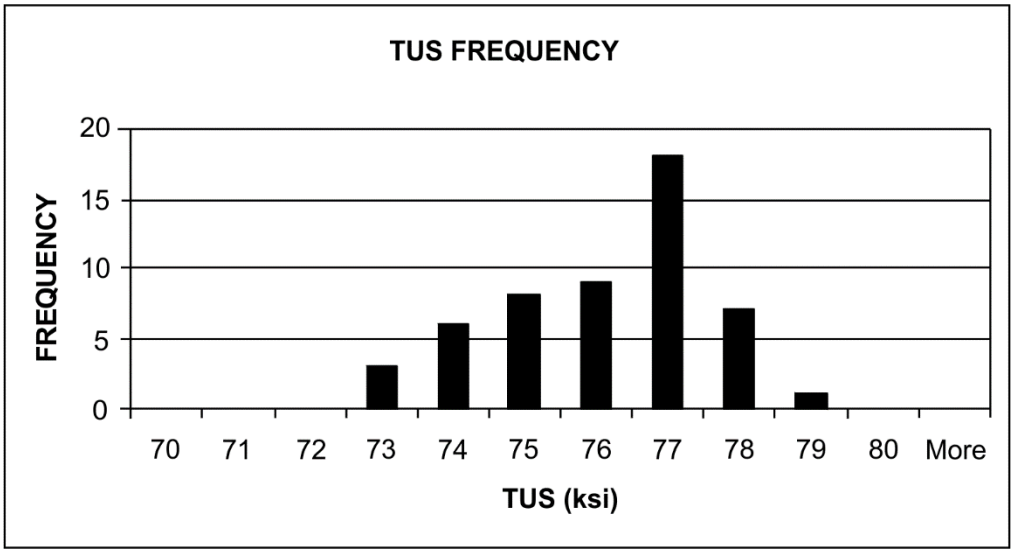

FIGURE 2 FREQUENCY HISTOGRAM FOR TUS

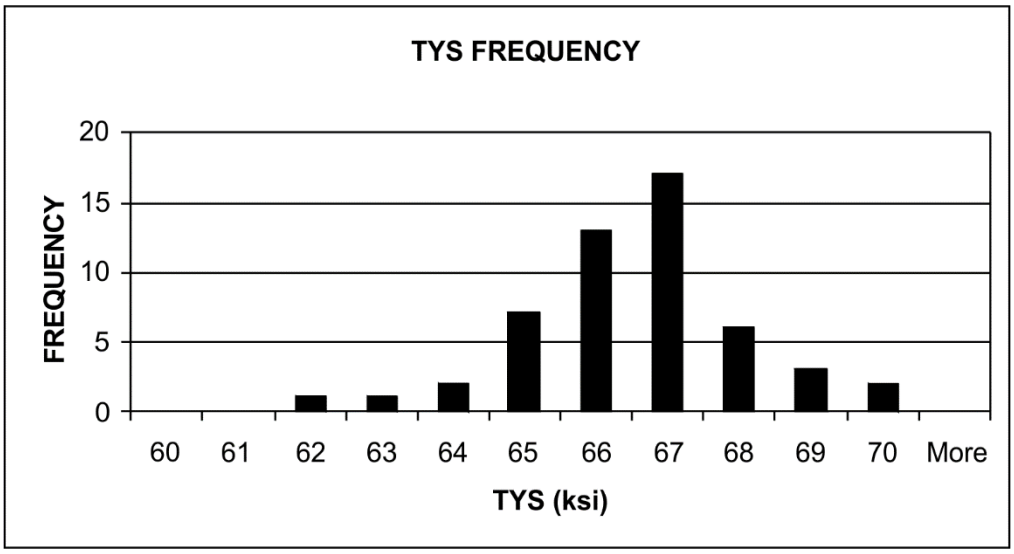

FIGURE 3 FREQUENCY HISTOGRAM FOR TYS

From the histograms, it appears that both the TUS and TYS data are somewhat negatively skewed.

The data is plotted versus time in FIGURE 4.

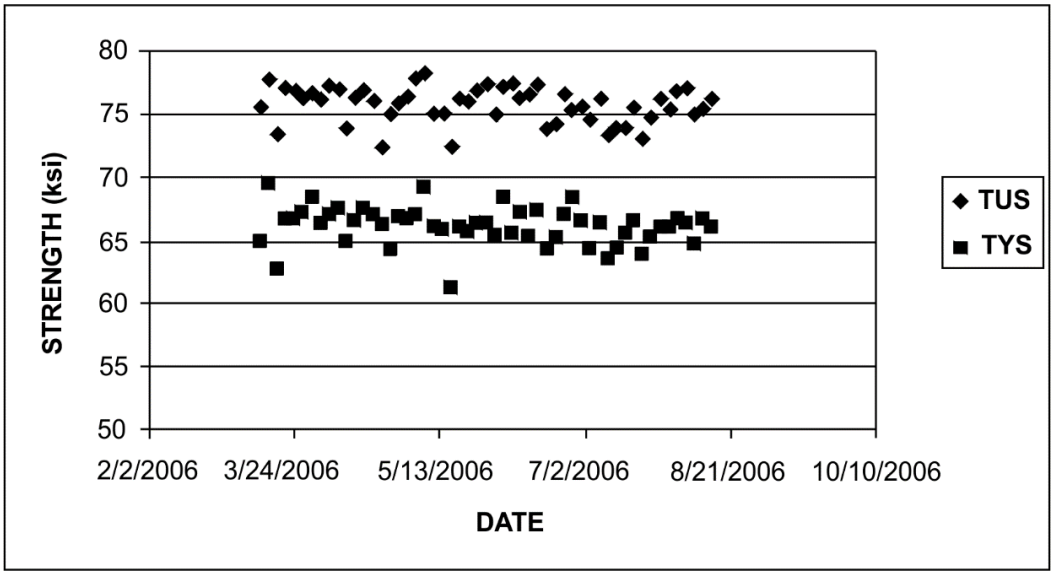

FIGURE 4 TUS AND TYS DATA VERSUS TIME

It appears that the data is consistent over time, with perhaps one or two low values.

Calculating T_{99} and T_{90}:

From APPENDIX B, TABLE V, K_1 and K_2 are found (for $n = 52$) to be:

$K_1 = 2.850$

$K_2 = 1.637$

The T_{99} values can then be calculated from equation (3):

$T_{99} = 75.71 - (2.850)(1.42) = 71.66\ ksi\ (TUS)$

$= 66.12 - (2.850)(1.54) = 61.74\ ksi\ (TYS)$

The T_{90} values can be calculated from equation (4):

$T_{90} = 75.71 - (1.637)(1.42) = 73.39\ ksi\ (TUS)$

$= 66.12 - (1.637)(1.54) = 63.60\ ksi\ (TYS)$

From the MMPDS Handbook, the required longitudinal A-basis (T_{99}) and B-basis (T_{90}) values for 7075-T73 forgings are:

For TUS, $T_{99} = 66$ ksi $T_{90} = 69$ ksi

For TYS, $T_{99} = 56$ ksi $T_{90} = 59$ ksi

Therefore, the material from this source would be considered acceptable.

APPENDIX B K FACTORS FOR CALCULATION OF T_{99} AND T_{90} VALUES

TABLE V. K FACTORS

n	K_1	K_2	n	K_1	K_2	n	K_1	K_2
18	3.370	1.974	46	2.890	1.664	74	2.751	1.572
19	3.331	1.949	47	2.883	1.659	75	2.748	1.570
20	3.295	1.926	48	2.876	1.654	76	2.745	1.568
21	3.263	1.905	49	2.869	1.650	77	2.742	1.565
22	3.233	1.886	50	2.862	1.646	78	2.739	1.563
23	3.206	1.869	51	2.856	1.641	79	2.736	1.561
24	3.181	1.853	52	2.850	1.637	80	2.733	1.559
25	3.158	1.838	53	2.844	1.633	81	2.730	1.557
26	3.136	1.824	54	2.838	1.630	82	2.727	1.556
27	3.116	1.811	55	2.833	1.626	83	2.724	1.554
28	3.098	1.799	56	2.827	1.622	84	2.721	1.552
29	3.080	1.788	57	2.822	1.619	85	2.719	1.550
30	3.064	1.777	58	2.817	1.615	86	2.716	1.548
31	3.048	1.767	59	2.812	1.612	87	2.714	1.547
32	3.034	1.758	60	2.807	1.609	88	2.711	1.545
33	3.020	1.749	61	2.802	1.606	89	2.709	1.543
34	3.007	1.740	62	2.798	1.603	90	2.706	1.542
35	2.995	1.732	63	2.793	1.600	91	2.704	1.540
36	2.983	1.725	64	2.789	1.597	92	2.701	1.538
37	2.972	1.717	65	2.785	1.594	93	2.699	1.537
38	2.961	1.710	66	2.781	1.591	94	2.697	1.535
39	2.951	1.704	67	2.777	1.589	95	2.695	1.534
40	2.941	1.697	68	2.773	1.586	96	2.692	1.532
41	2.932	1.691	69	2.769	1.584	97	2.690	1.531
42	2.923	1.685	70	2.769	1.581	98	2.688	1.530
43	2.914	1.680	71	2.762	1.579	99	2.686	1.528
44	2.906	1.674	72	2.758	1.576	100	2.684	1.527
45	2.898	1.669	73	2.755	1.574			

APPENDIX C SUPPLIER MINIMUM T_{99} AND T_{90} VALUES

The following TABLE VI through TABLE XV give the T_{99} and T_{90} values that are to be verified by the statistical analysis performed by a material supplier. Values for thicknesses and/or for alloys, or tempers not listed in the table will be provided by Boeing Research & Technology.

NOTE: For all TABLE VI through TABLE XV.

L = Longitudinal Grain Direction
T = Transverse Grain Direction
LT = Long Transverse Grain Direction
ST = Short Transverse Grain Direction

TABLE VI. MINIMUM T_{99} AND T_{90} VALUES FOR 2000 SERIES ALUMINUM ALLOYS

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
2014-T6	Bar or Forging	All	MMPDS Handbook values.							
2024-T3	Sheet, Bare	All	MMPDS Handbook values.							
	Sheet, Clad									
2024-T351	Plate	All	MMPDS Handbook values.							
2024-T3511	Extruded Bar and Shapes	All	MMPDS Handbook values.							
2024 All	Rolled Bar	All	MMPDS Handbook values.							
2024 All	Extruded Tube	All	MMPDS Handbook values.							
2024-T42	Drawn Tube	All	MMPDS Handbook values.							
2024-T3	Drawn Tube	All	MMPDS Handbook values.							
2124 All	Plate	All	MMPDS Handbook values.							
2219 All	All	All	MMPDS Handbook values.							
2219-T37	Plate	0.500-2.000	46	47	-	-	34	35	-	-
2219-T87	Plate	0.500-2.000	63	64	-	-	50	51	-	-
2219-T81	Plate	0.500-2.000	45	46	-	-	28	28	-	-
2219-T851	Plate	0.500-2.000	61	62	-	-	47	46	-	-
2219-T852	Forging	0.000-4.000	60	60	-	-	47	47	-	-
2219-T62	Extruded Bar and Shapes	0.000-0.249	52	50	-	-	32	29	-	-
2219-T62	Extruded Bar and Shapes	0.250-0.999	53	51	-	-	33	30	-	-
2219-T62	Extruded Bar and Shapes	1.000-2.999	54	52	-	-	34	31	-	-
2219-T31	Drawn Tube	All	45	42	-	-	26	23	-	-

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
2219-T81	Drawn Tube	All	60	57	-	-	42	38	-	-
2219-T62	Drawn Tube	All	54	51	-	-	36	32	-	-

TABLE VII. MINIMUM T_{99} AND T_{90} VALUES FOR 7075-T6X, T7X ALUMINUM SHEET AND MISCELLANEOUS FORMS

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
7075-T651	Rolled Bar	All	MMPDS Handbook values.							
7075-T7351	Rolled Drawn, Cold Finished Bar	All	MMPDS Handbook values.							
7075-T6511	Extruded Bar, Shapes and Tube	All	MMPDS Handbook values.							
7075-T73	Rolled Drawn Cold Finished Bar	All	MMPDS Handbook values.							
7075-T73511	Extruded Bar, Shapes and Tube	All	MMPDS Handbook values.							
7075-T6-, T62	Drawn Tube	All	MMPDS Handbook values.							
7075-T6	Sheet-Bare	All	MMPDS Handbook values.							
	Sheet-Clad	All	MMPDS Handbook values							

TABLE VIII. MINIMUM T_{99} AND T_{90} VALUES FOR 7075 ALUMINUM PLATE, HAND FORGINGS AND -T73 SHEET

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS			T_{90} TUS			T_{99} TYS			T_{90} TYS		
			L	LT	ST	L	LT	ST	L	LT	ST	L	LT	ST
			(KSI)											
7075-T651	Plate	All	MMPDS Handbook values.											
7075-T7351	Plate	All	MMPDS Handbook values.											
7075-T73	Hand Forgings	All	MMPDS Handbook values.											
7075-T73	Sheet-Bare and Clad	All	MMPDS Handbook values.											

TABLE IX. MINIMUM T_{99} AND T_{90} VALUES FOR 7075 ALUMINUM DIE FORGINGS AND 7175, ALL FORMS

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
7075-T73	Die Forgings	All	MMPDS Handbook values.							
7075-T7352	Die Forgings	All	MMPDS Handbook values.							
7175-All	Extrusions	All	MMPDS Handbook values when available, if not available, then minimum values of applicable specifications.							
7175-T74	Die Forgings	Under 2.000	73	71	75	74	62	61	65	64
		2.001 to 3.000	73	70	74	72	62	59	64	62
		3.001 to 4.000	72	69	74	71	61	57	63	60
		4.001 to 5.000	70	67	72	69	59	55	62	58
		5.001 to 6.000	68	65	70	67	58	53	60	56

TABLE X. MINIMUM T_{99} AND T_{90} VALUES FOR 7050 ALUMINUM, ALL FORMS

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS			T_{90} TUS			T_{99} TYS			T_{90} TYS		
			L	LT	ST	L	LT	ST	L	LT	ST	L	LT	ST
			(KSI)											
7050-All	All	All	MMPDS Handbook values.											
7050-T745X	BMS7-214 Forgings	All	BMS7-214 values.											

TABLE XI. MINIMUM T_{99} AND T_{90} VALUES FOR 7055 AND 7178 ALUMINUM, ALL FORMS

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
7055-T74511 7055-T76511	Extrusions	All	MMPDS Handbook values.							
7178-T651	Plate	0.250 to 0.499	83	84	85	86	75	73	77	75
		0.500 to 1.000	83	84	85	86	74	73	76	75
		1.001 to 1.500	83	84	85	86	73	73	75	75
		1.501 to 2.000	79	80	80	81	70	70	71	71
7178-T6511	Extrusions	0.250 to 0.499	87	82	90	85	78	71	81	75
		0.500 to 0.749	87	81	90	84	78	71	81	74
		0.750 to 1.499	87	79	90	82	78	69	81	71

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
		1.50 to 2.499	86	74	-	-	77	64	-	-
		2.500 to 2.999	82	66	-	-	71	53	-	-

TABLE XII. MINIMUM V1 AND V2 VALUES FOR TI-6AL-4V AND TI-10V-2FE-3AL AND TI-6AL-2SN-4ZR-2MO

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
Ti-6Al-4V Annealed	Sheet, Plate	All	MMPDS Handbook values.							
	Forgings AMS 4928	Under 2.000	MMPDS Handbook values.							
	Forgings	Under 6.001	MMPDS Handbook values.							
	Extrusions	All	MMPDS Handbook values.							
	Bar, Rolled or Forged	0.501 to 1.000 1.001 to 2.000 2.001 to 3.000	MMPDS Handbook values.							
Ti-6Al-4V (ELI)	Plate	All	MMPDS Handbook values.							
Ti-10V-2Fe-3Al Sol. TR. Aged	Forgings	Under 3.001	173	173	178	178	160	160	166	166
Ti-6Al-2Sn-4Zr-2Mo	Sheet	Under 0.187	135	135	143	143	125	125	136	134
	Bar, Rolled or Forged	Under 3.001	130	130	-	-	120	120	-	-
	Forgings	All	MMPDS Handbook values.							

TABLE XIII. MINIMUM T_{99} AND T_{90} VALUES FOR TI-6AL-6V-2SN AND TI-3AL-8V-6CR-4MO-4ZR

ALLOY/ TEMPER	FORM(S)	THICKNESS (INCHES)	T_{99} TUS			T_{90} TYS		
			L	LT	ST	L	LT	ST
			(KSI)					
Ti-6Al-6V-2Sn Sol. Tr. Aged	Rolled Bar, Forged Bar, Forgings	Under 1.001 2.001 to 2.000 2.001 to 3.000 3.001 to 4.000	MMPDS Handbook values.					
	All Except Above All	Under 1.501	MMPDS Handbook values.					

TABLE XIV. MINIMUM T_{99} AND T_{90} VALUES FOR NICKEL ALLOYS AND PH STAINLESS STEELS

ALLOY	FORM(S)	THICKNESS (INCHES)	T_{99} TUS		T_{90} TUS		T_{99} TYS		T_{90} TYS	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
Nickel Alloy 718	All	All	MMPDS Handbook values.							
Nickel Alloy 625	All	All	MMPDS Handbook values.							
15-5PH (H9000)	All	All	MMPDS Handbook values.							
17-7PH (TH1050)	Sheet	0.15-0.187	MMPDS Handbook values.							
PH13-8Mo (H1000)	All	All	MMPDS Handbook values.							

TABLE XV. MINIMUM T_{99} AND T_{90} VALUES FOR ALLOY STEELS

ALLOY FL 1	FORM(S)	THICKNESS (INCHES)	T_{99} TUS FL 2		T_{90} TUS FL 2		T_{99} TYS FL 2		T_{90} TYS FL 2	
			L	LT	L	LT	L	LT	L	LT
			(KSI)							
4330M (HT to 220-240 ksi)	All	All	220	220	-	-	186	186	-	-
4340 (HT to 180-200 ksi)	All	All	180	180	-	-	163	163	-	-
4340M	All	All	275	275	280	280	226	226	234	234
9Ni-4Co-0.3C	All	All	MMPDS Handbook values.							
300M	All	All	280	280	-	-	230	230	-	-
Aermet 100	All	All	MMPDS Handbook values.							

FL 1 Alloy steels require statistical verification of short transverse present reduction of area. Minimum values are:

4330M, 4340, and 9Ni-4Co-0.30C = 30 percent;

4340M = 25 percent.

300M = 25 percent

Aermet 100 = 45 percent

FL 2 Required Mechanical testing directions are determined by the applicable material specification.

APPENDIX D PRODUCTION REQUIREMENTS FOR FORGINGS

The following information on the first 10 Boeing forging part numbers of each alloy (10 different forging configurations) shall be submitted to the Boeing Research & Technology organization. Submission of data in accordance with D6-1276 fulfills this requirement for each applicable part number.

a. Forging Planning

(1) The planning shall fully define the forging operations to be used in the fabrication of the part (that is, starting stock, material form, preshape dimensions, blocking configurations, finish treatments, etcetera).

(2) The planning shall indicate the thermal cycles used during the forging operations and shall include the stock and die temperatures to be used.

b. Property Testing

(1) Complete documentation of the mechanical property tests shall be performed on a forging from the first lot. These tests shall include all requirements of the Engineering Drawing and procurement specification. Mechanical property tests shall be performed on material from the forging or from a prolongation of the forging, not from material specifically forged for testing purposes.

(2) The documentation shall include photographs of sections taken to verify the conformance of the grain flow to the part configuration.

Active Page Record

Page Numbers	Revision Level	Revision Type (Added, Deleted)
i through v	C	
1 through 13	C	
Appendix A-1 through Appendix A-8	C	
Appendix B-1	C	
Appendix C-1 through Appendix C-6	C	
Appendix D-1	C	
APR-1	C	
Rev Record-1 through Rev Record -3	C	

Page Numbers	Revision Level	Revision Type (Added, Deleted)

Revision Record

Revision Letter	**A**
Changes in This Revision	Title Change and Complete Revision

Authorization for Release

AUTHOR:	R.J. VOIT	G-8283	18-FEB-1980
	First Name MI Last Name	Org. Number	Date
APPROVAL:	C. S. Carter	G-8283	18-FEB-1980
	Supervisor	Org. Number	Date
APPROVAL:	R.V. Carter	G-8283	18-FEB-1980
	Engineering	Org. Number	Date
DOCUMENT RELEASE:			
		Org. Number	Date

Revision Record

Revision Letter	**B**
Changes in This Revision	Complete Revision to - (1) Clarify requirements for primary and secondary raw material suppliers. (2) Add provisions for additional alloys

Authorization for Release

AUTHOR:	J.D. Keenan	G-8283	11-NOV-1991
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DOCUMENT RELEASE:	D. Carlson	Release Clerk	14-NOV-1991
		Org. Number	Date

Revision Record

Revision Letter **C**

Changes in This Revision

Revision to:

1. Added new alloys, deleted several alloys
2. Update hydrogen detection technology
3. Update statistics
4. Change lot and heat size
5. Editorial corrections.
6. Reformatted appendixes and tables.
7. Change hydrogen level from 0.15 cc/100 grams to 0.14 cm^3/100 grams.

Authorization for Release

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