JETQC

JETQC-001

Issue 8, 30 September 2016

JETQC Titanium Alloy Defect Reporting System

Content

1. Scope

This document states the guidelines to be used by titanium producers for reporting the defects they find in semi-finished products, and the feedback they get from OEMs.

2. Principles

Each titanium producer shall report all defects found in rotor grade/premium quality titanium alloy product, as listed in Appendix 1. This data is confidentially provided to JETQC contacts.

3. Definitions

JETQC **J**et **E**ngine **T**itanium **Q**uality **C**ommittee, formed under the auspices of the FAA (**F**ederal **A**viation **A**dministration), with membership currently including all the US and European Aircraft Engine Producers, for the purpose of rapid dissemination of titanium alloy melt related defect issues and data.

Type I (Also commonly called **Hard alpha** or **HID** – high interstitial defect – or **LDI** – low-density inclusion)

An interstitially stabilized alpha phase region (inclusion) of substantially higher hardness than the surrounding material. It arises from very high local nitrogen, oxygen, or carbon concentrations which increase the beta transus and produce the high hardness, brittle, alpha phase.

Type II (Also commonly called **HAD** - high aluminum defect)

An aluminum-rich alpha stabilized segregation region containing an abnormally large amount of aluminum, which may extend across a large number of beta grains. It contains an inordinate volume fraction of primary alpha, but has a micro hardness only slightly higher than the adjacent matrix. If the defect contains an interstitial content higher than the base alloy in addition to the high Al (such as a contaminated crown fall-in), it is to be classed as a Type I.

HDI (High Density Inclusion) A region (inclusion) with a high concentration of refractory elements (usually tungsten, molybdenum, tantalum, or niobium) having a higher density and a significantly higher melting point than the matrix.

Clean voids Voids appearing in the microstructure without microstructure evidence of other Type I inclusions or Type II segregation.

Other defects Any other foreign contaminant (i.e. beta flecks do not need to be reported)

Semi-finished product Bar, billet, plate as delivered by a material producer to a forging or a machining plant.

Original JETQC Melter An organization that melts titanium and has contributed data to the JETQC organization. Original JETQC Melters are listed in Appendix 7a.

New JETQC Melter An organization that melts titanium and has met the requirements of section 5.4. New JETQC Melters are listed in Appendix 7b.

Pending New JETQC melter An organization that melts titanium, has been approved by a minimum of two JETQC OEMs and has started the qualification process of section 5.4. Pending New JETQC Melters are listed in Appendix 7c.

New Melter An organization that melts titanium, is supplying to a single JETQC OEM, and has not started the qualification process of section 5.4.

Summary of different categories of Melters

		Appendix
Original JETQC Melter	the melters that have historically contributed to JETQC	7a
New JETQC Melter	Qualified per the JETQC 001 criteria	7b
Pending New JETQC Melter	are supplying to 2 JETQC OEMs and have started the qualification process per JETQC 001	7c
New Melter	are supplying to a single JETQC OEM and have not started the qualification process	n/a

Original JETQC OEM A manufacturer of commercial turbine engines and/or manufacturer of critical rotating components that has Regulatory Body approval of a lifing system, and has contributed to the JETQC organization. Original JETQC OEMs are listed in Appendix 5a.

New JETQC OEM A manufacturer of commercial turbine engines and/or manufacturer of critical rotating components that has Regulatory Body approval of a lifing system, has contributed to the JETQC organization, and has met the requirements of section 5.5. New JETQC OEMs are listed in Appendix 5b.

Pending New JETQC OEM A manufacturer of commercial turbine engines and/or manufacturer of critical rotating components that has Regulatory Body approval of a lifing system, has contributed to the JETQC organization, and is working to meet the requirements of section 5.5. Pending New JETQC OEMs are listed in Appendix 5c.

Summary of different categories of OEMs

Original JETQC OEM	the OEMs that have historically contributed to JETQC	5a
New JETQC OEM	Qualified per the JETQC 001 criteria	5b
Pending New JETQC OEM	have started the qualification process per JETQC 001	5c

Regulatory Body A Body that has authority from their government to grant approval for a lifing system for design and manufacture of critical rotating components. In the context of this document, these Bodies are limited to FAA (Federal Aviation Administration), TCCA (Transport Canada Civil Aviation), and/or EASA (European Aviation Safety Agency)

4. Requirements

4.1. What to report

Titanium producers are requested to report the defects found at any stage in the manufacture of rotor grade/premium quality titanium alloy semi-finished products, even if final product is diverted to lower level applications. Titanium producers include companies that melt, convert and inspect semi-finished products, and companies that convert and inspect semi-finished products.

Each report covers the **products inspected during the stated quarter**.

The **list of** relevant **specifications** is given in Appendix 1.

Defects to be considered are as follows:

- Type I
- Type II
- HDI
- Clean voids
- Others

It is recommended that titanium producers retain defect-containing samples indefinitely, if the defect has not been consumed during analysis process.

4.2. How to report

Summarizing tables

For each type of product (either billet or bar/plate), the relevant table (IA or IB) in Appendix 2 must be filled out. Information to give is as follows:

- **Alloy**: Alloy specified by OEM Material Specification (and class). See OEM Alloy/Specification List in Appendix 1 for appropriate alloy/melt type combinations; the recognized alloys are shown in Tables IA and IB. All Rotor Grade or Premium Quality alloy ingot/ billet material produced and inspected to the specifications are to be reported.
- **Type of melt**: Double VAR (Vacuum Arc Remelt), Triple VAR, HM (Hearth Melt, either EBM or PAM or small PAM) + VAR, and Scull + VAR. The 2XVAR(-) infers a process that may have exceptions to a full Rotor Grade or Premium Quality process.
- **Number of heats inspected:** Number of heats inspected to material specification in the stated quarter. Note that heats in process, but not inspected, are not reported.
- **Weight of heats inspected (lbs)**: This column is necessary to facilitate compilation of the data from all sources. Ingot weights are to be given in lbs, rather than tons, to avoid the confusion on the two definitions for tons. **Important note**: weight to be reported corresponds to **ingot weight** but not to final product weight.
- **Number of defects by type**: Enter the number of defects found for each type. In respect to segregation (e.g. type II), only finds exceeding specification limits are to be reported.
- **Frequency:**

  Percentage of heats with defects: This entry, along with the entries for the prior seven columns, shall include both delivered Rotor Grade/ Premium Quality heats and downgraded heats produced to the same requirements.

  Defects per ton (2000 lbs) ingot: This entry should be separated by defect type if more than one type is being reported.

Notes:

1. When heats produced meet multiple OEM specification requirements, the data may be combined in the Tables.
2. For a New Melter supplying rotor grade/premium quality titanium alloy product to an Original or New JETQC OEM, that New Melter shall provide the requested data to the Original or New JETQC OEM, who will then report the data to JETQC on an annual basis. This data will be incorporated into the overall industry data that will be provided as feedback to the industry per Section 5.2. If a New Melter initiates a qualification program to supply rotor grade/premium quality titanium alloy product to a second Original or New JETQC OEM, that qualification data shall be provided to the second Original or New JETQC OEM, who will then report the data to JETQC on an annual basis. Once a New Melter becomes a Pending New JETQC Melter data shall be reported according to Note 3 below.
3. For a JETQC melter (Original, New or Pending New) qualified and supplying rotor grade/ premium quality titanium alloy product to multiple Original and/or New JETQC OEMs, that JETQC melter shall combine and provide the requested data to JETQC on a quarterly basis according to Section 4.1 & 4.2. This data will be incorporated into the overall industry data that will be provided as feedback to the industry per Section 5.2.
4. **All categories of melters** shall only report the following data to **Pending New JETQC OEMs**:
    - The volume of material melted during the quarter to the Pending New JETQC OEMs specifications (Appendix 1)
    - Any JETQC reportable defects found during the inspection of material produced to the pending New JETQC OEMs specifications.
    - The melter shall include a statement to confirm that the data reported to the pending New JETQC OEM was included in the quarterly report submitted to JETQC.

Characterization report

For each individual defect, a report must be completed according to the relevant form in Appendix 3 (Table II). Some information to be reported needs the following clarifications:

- Location: Identify defect position in % from the bottom and from the rim of ingot;
- Defect size: transverse section two-dimension (max, min) measurement of core plus diffusion zone based on microstructural differences;
- Void/crack size: transverse section two-dimension (max, min) measurement of observed void/crack size from defect.

Notes:

1. In case of similar defects, attributed to the same root cause (e.g. clean voids), only a selection of those defects might be characterized. **This alleviation is not applicable to hard alphas**, unless agreed with the melter's OEM customer.
2. For Type II defects, presence of interstitial elements needs to be checked, to confirm this is not a Type I defect.
3. For any **hard alpha inclusion** or **high density inclusion**, Table II shall include **the most probable source(s)** and the confidence rating.
4. The most probable source(s) shall be described using standard

nomenclature. The relevant Original JETQC OEM shall ensure that the appropriate standard nomenclature is used. If the relevant OEM is a Pending or New JETQC OEM, that OEM shall contact the JETQC Chair for guidance with the root cause standard nomenclature.

5. The confidence is described in terms of the following scale:
   1 - remote possibility source,
   2 - possible source,
   3 - probable source, and
   4 - known source.

   The potential source(s) and confidence(s) description will be agreed upon by the melter and the OEM that was to receive the heat. In the case where a melter and OEM disagree on the proposed source(s), multiple sources may be listed.
6. When a supplier submits a **characterization report** for a given quarter, it is permissible to provide a **preliminary** characterization report titled as follows: **Table II - Billet/Bar/Plate Sonic/Macro etch Defect Characterization Preliminary Report**, providing the supplier provides a **final characterization report** entitled: **Table II - Billet/Bar/Plate Sonic/Macro etch Defect Characterization Final Report** with their next quarterly JETQC submittal. In the event that an **error** is identified in a supplier's characterization report, the supplier shall update the original report in the following manner: **Table II - Billet/Bar/Plate Sonic/Macro etch Defect Characterization Updated Report**.

In addition, and per FAA Advisory Circular 33.15-1 request, a **3D characterization** of unacceptable indications shall be conducted. This characterization is only requested for Type I inclusions. It must be performed per relevant OEM time requirements or within 6 months, whichever comes first.

This characterization, as appropriate and as a minimum, shall provide the following information:

a) Defect type,
b) 3D defect size,
c) 3D void/crack size if any,
d) Defect orientation to ultrasonic inspection direction
e) Micro hardness,
f) Scanning Electron Microscope (SEM) evaluation: nature of constituents, fractography of void/crack,
g) Microprobe analysis: chemical composition of defect, nature of inclusions,
h) Photomicrographs of the defect in two perpendicular directions.

The length of Type I defect on bar/plate product can be assessed via macro or sonic inspection. The **recommended procedure** for 3D inclusion characterization is outlined in Appendix 4. Figure 1 in Appendix 4 includes a sketch of a longitudinal section of an inclusion to illustrate some definitions (core, diffusion zone, maximum length, etc.).

4.3. When and to whom to send the report

Each quarterly report must be sent to **JETQC contacts listed** in Appendix 5a and 5b, **within thirty days of the end of the quarter**.

5. JETQC obligations

5.1. Confidentiality

All the data submitted to any JETQC member has to be considered as **confidential**. It should be noted that the FAA has requested JETQC provide a high-level summary of JETQC's defect statistics. The most recent paper presented by JETQC was in the 2007 11th World Titanium Conference in Japan (Ti-2007, Science and Technology, 2007, pp 151-154).

5.2. Composite ingot map

Once a year, **feedback** is provided to the Original and New JETQC melters (listed in Appendices 5a and 5b), allowing them to determine where they rank compared to the rest of the industry. Feedback is only provided to those melters who have actively produced rotor grade/premium quality titanium semi-finished products to JETQC member companies in the preceding year.

This feedback is the « **Composite Ingot Maps** », which combines, for each type of defect and product form, the number of these defects and their location (with respect to the ingot weight – in % distance from the bottom – on the ordinate and distance from the rim – 100 % equal to center of ingot – on the abscissa). The accuracy of the plotted position for each defect is based on the defect characterization reports submitted by the producers. Separate **Composite Ingot Maps** will be generated for defects in billet and bar/plate. If a melter has only produced bar/plate in a given year, then only bar/plate feedback will be provided to that melter. If a melter has produced billet or both billet and bar/plate in a given year, then bar/plate and billet feedback will be provided to that melter.

Feedback will not be provided to converters.

An example of feedback is shown in Appendix 6.

The **Composite Ingot Map provides** no indication of melt source or melt process. For Type I and HDI defects, the feedback to the melters will also include a brief description of the potential defect source(s) and the confidence(s) associated with the proposed source(s).

Number of ingots, total weight and percentage of billet and bar/plate production is also indicated.

Responsibility for establishing and distributing the bar/plate and billet Composite Ingot Maps for a given year is determined during the yearly JETQC meeting.

This information is provided **only to (i) Original JETQC melters (Appendix 7a), (ii) New JETQC melters (Appendix 7b)**, **(iii) Original JETQC OEMs (Appendix 5a), (iv) New JETQC OEMs (Appendix 5b), and (v) FAA.**

This annual feedback will be accompanied with the latest version of **JETQC-001** if an update has occurred.

Any update of **JETQC-001** will also be sent to the converters, listed in Appendix 8.

5.3. Defect found on parts

It is the responsibility of the OEM to prepare a report on any **defect** found in a **forging** or a **finished part**.

The form in Appendix 9 (Table III) shall be used. Some information to be reported needs the following clarifications:

- Defect size: at least two-dimension (max, min) measurement of core plus diffusion zone based on microstructural differences;

- Void/crack size: at least two-dimension (max, min) measurement of observed void/crack size from defect.

For any hard alpha inclusion or high density inclusion, Table III shall include the most probable source(s) and the confidence rating.

In addition, and per FAA Advisory Circular 33.15-1 request, a **3D characterization** of defects shall be conducted, according to the same requirements as those given in Section 4.2 for defects found on semi-finished products.

The report is **shared** with Original and New **JETQC OEM contacts (Appendices 5a and 5b)**, **within 30 days of the end of the quarter**. In addition, details are presented during the yearly meeting.

The information is also **forwarded to the relevant melt source,** but is not included in the melt source quarterly report. It is included in the relevant Composite Ingot Map, as shown in Appendix 6, where it is identified by the melt year.

5.4. JETQC Criteria for New Melter Membership

For a Pending New JETQC Melter to become a New JETQC Melter, these criteria must be met:

- Manufacture and supply a particular product form (bar/plate or billet to one or more specifications listed in Appendix 1) to two or more Original JETQC OEMs (Appendix 5a) and/or New JETQC OEMs (Appendix 5b), and
- Manufacture, supply and report annually more than 100,000 lbs of a particular product form (bar/plate or billet to a specification listed in Appendix 1) for three consecutive years, and
- Manufacture, supply and report more than a total of 2,000,000 lbs of a particular product form (bar/plate or billet to a specification listed in Appendix 1).

The JETQC Committee shall agree at the annual meeting the start date for the annual 100,000 lbs. and total of 2,000,000 lbs. for a Pending New JETQC Melter. This start date shall be communicated to the melter and Appendix 7c updated. Once the Pending New JETQC Melter meets the above criteria for a particular product form (e.g. Bar/plate) that Pending New JETQC Melter shall become a New JETQC Melter, receive the industry composite ingot map for **bar/plate**, and Appendix 7b and 7c updated. In order for a Pending New JETQC Melter to receive industry composite ingot maps for both bar/plate and billet, that melter must meet the above requirements for both bar/plate and billet.

5.5. JETQC Criteria for New OEM Membership

A Pending New JETQC OEM may become a New JETQC OEM when they have met the following criteria for a period of 5 consecutive years:

1. Obtain Regulatory Body approval for a lifing system for design and manufacture of critical rotating components. This requires the use of rotor grade/premium quality material from Original JETQC Melters and/or New JETQC Melters.

2. Support JETQC meetings and provide / share necessary data and resources in support of industry data collection efforts.

3. Contribute a significant level of new relevant rotor grade Ti experience and information that JETQC does not possess currently, and that could be used to support on-going JETQC activities. To demonstrate this experience, the Pending New JETQC OEM shall:

- Provide historical rotor and relevant non-rotor Ti inclusion data in the format listed in Section 4.2

- Present detailed rotor grade Ti manufacturing oversight experience (raw materials, melting, conversion) related to Original and/or New JETQC melters as detailed below:
    - Present summary of manufacturing improvements made to improve material quality.
    - Present detailed rotor grade Ti supplier hazard review summaries (Ti sponge, master alloy and elementals).
    - Demonstrate effective supplier hazard review training materials and provide supplier employee feedback.
    - Provide details of the type of hazard review conducted and provide examples of specific questions asked during hazard reviews. Demonstrate the ability to identify potential inclusion sources.
    - Give details of specific methods and frequency of supplier oversight.
    - Continued reliance on external consultants to develop and update all of the above information is not acceptable (i.e. Pending New JETQC OEM needs to develop internal company expertise).
- If an inclusion is found, provide detailed rotor Ti inclusion root cause analyses including detailed chemical signature and implementation of corrective actions.
- Demonstrate Ti hard alpha inclusion chemical analysis techniques using known standards and any hard alpha inclusion found by melters (rotor and/or non-rotor grade material).

When the Pending New JETQC OEM meets the criteria outlined above, they may attend the annual JETQC meeting and receive:

- Quarterly JETQC reports
- JETQC meeting minutes / presentations
- Composite ingot maps
- New JETQC OEM/Melter training materials
- Inclusion chemistry analysis best practices document (when it becomes available)

5.6. Pending New JETQC OEM and New JETQC OEM Constraints

Pending New JETQC OEMs and New JETQC OEMs have the following constraints:

1. JETQC proprietary information may only be shared within OEM company on a need-to-know basis.
2. JETQC proprietary information may not be shared with any person or company that is not a member of JETQC; for example, JETQC proprietary information may not be shared with a consultant, or with a joint venture partner.
3. Access to historical databases or inclusion surveys will not be provided.

Mis en forme : Anglais (États-Unis)

6. Appendices

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Appendix Documents

Appendix 1
List of Rotor Grade/Premium Quality Titanium Alloy Specification Numbers

Alloy	Form Used	GEAE	PWA	Rolls Royce	SNECMA	Honeywell	Rolls Royce	Turbomeca	P&W-C	MTU	Williams	IHI *
Spec Prefix		C50TF-	PWA-	MSRR- RRMS-	DMD-	EMS- and M-	EMS-	CCT-LA-	CPW-	MTS-	CWIMS-	J-MSRR and J-ISAJT-
Ti-6-4	Billet-DM	12/35, Cl C/D	-	8638	-	-	-	-	41	1006T1	-	J-ISAJT-M316
	Billet-TM	12/35, Cl E/F	1215/1228	8636/36000	777-24	EMS54930	59501/59503	0111/0166/0365	41/551 781	1389T2	788	J-MSRR8636 J-ISAJT-M316
	Billet-HM+V	12, Cl H/I & 35, Cl G/H	1215/1228	8636/36000	777-42	EMS54930	59501/59503	-	814	-	-	J-ISAJT-M316
	Billet Sc+V			8636, 36000								
	Bar-DM	22, Cl A / E	1228	8610/8657/ 8624	778-24	EMS54924, Gr 1/	-	-	41	1006T2/3 1359-1	-	J-MSRR8610 J-ISAJT-M316
	Bar-TM	22, Cl-C / F	1228	8610	778-24	EMS54924, Gr 2/ M3403	59501/59503	0111/0166/0365	41	1359-1	-	J-MSRR8610 J-ISAJT-M316
	Bar-HM+V	22 Cl D/G	1228	-	778-24	-	59501/59503	-	-	-	-	J-ISAJT-M316
	Bar-SHM+V	-			778-24							
	Bar-Sc+V	22 Cl H/I	-	8610	778-49	-	-	-	-	-	-	-
	Bar-DM(-)*	-	-	-	-	EMS52325(DM,TM)	-	-	-	-	-	-
	Plate-DM	-	1232	8672/8689 36006/36007	782-25	-	-	-	-	-	-	-
	Plate-HM+V	-	1232	36006/36007	-	-	-	-	-	-	-	-
Ti-8-1-1	Billet-DM	-	1202	-	-	-	-	-	-	-	-	-

Alloy	Form Used	GEAE	PWA	Rolls Royce	SNECMA	Honeywell	Rolls Royce	Turbomeca	P&W-C	MTU	Williams	IHI *
	Billet-TM	-	-	-	-	-	-	-	-	-	-	-
	Billet-HM+V	-	1202	-	-	-	-	-	-	-	-	-
	Bar-DM	26, Cl B / E	1202	-	-	-	-	-	-	-	-	-
	Bar-TM	26, Cl C / F	-	-	-	-	-	-	-	-	-	-
	Bar-HM+V	26, Cl D / G	1202	-	-	-	-	-	-	-	-	-
Ti-17	Billet-TM	57, Cl B	-	-	717-24	-	-	-	-	-	-	-
	Billet-HM+V	57, Cl C	-	-	717-42	-	-	-	-	-	-	-
Ti-6246	Billet-DM	-	1216	-	-	-	-	-	-	-	-	-
	Billet-TM	125, Cl A	1216 1227	8684 36001	-	EMS54931/ M3404	-	0725	- 459 783	1436-2 1552-2	-	-
	Billet-HM+V	125, Cl A	-	-	-	-	-	-	-	1436-2 1552-2	-	-
	Billet Sc+V			8684, 36001								
Ti-6242	Billet-DM	39, Cl A	-	-	-	-	-	-	756	1007T1	-	-
	Billet-TM	39,Cl B/93,Cl A	1209/1214/ 1224/1225	36004	715-24	EMS54929 EMS54937	59502 59504	0323/0399	358 782	1279T2	789	-
	Billet-HM+V	39,Cl C/93,Cl B	1209/1214/ 1224/1225	36004	-	-	-	-	-	-	-	-
	Bar-DM	08, Cl A	1209/1214/ 1224/1225	8693	715-24	EMS54927, Gr 1	-	-	756	1007T2/3	-	-
	Bar-TM	08, Cl B / D	1209/1214/ 1224/1225	-	-	EMS54927, Gr 2	59502	0323/0399	358 782	1279T3/4	-	-
	Bar-HM+V	08, Cl C / E	1209/1214/	-	-	EMS54927, Gr 2	-	-	-	-	-	-

Alloy	Form Used	GEAE	PWA	Rolls Royce	SNECMA	Honeywell	Rolls Royce	Turbomeca	P&W-C	MTU	Williams	IHI *
			1224/1225									
	Bar-DM(-)*	-	-	-	711-24	-	-	-	-	-	-	-
TiMetal550	Billet-DM	-	-	8634	-	-	-	-	-	-	-	-
	Billet-TM	-	-	8663	-	-	-	-	-	-	-	-
	Bar-DM	113, Cl A / D	-	-	-	-	-	-	-	-	-	-
	Bar-TM	113, Cl B / E	-	-	-	-	-	-	-	-	-	-
	Bar-HM+V	113, Cl C / F	-	-	-	-	-	-	-	-	-	-
TiMetal679	Billet-DM	-	-	8613	-	-	-	-	-	-	-	-
	Billet-TM	-	-	-	-	-	-	-	-	-	-	-
	Bar-DM	-	-	8612	-	-	-	-	-	-	-	-
	Bar-TM	-	-	-	-	-	-	-	-	-	-	-
TiMetal685	Billet-DM	-	-	-	-	-	-	-	-	-	-	-
	Billet-TM	-	-	8665	712-24	-	-	O202	-	1284T2	-	-
	Bar-DM	-	-	8611	712-24	-	-	-	-	-	-	-
	Bar-TM	-	-	-	-	-	-	O202	-	-	-	-
TiMetal829	Billet-DM	-	-	-	-	-	-	-	-	-	-	-
	Billet-TM	-	-	8647	-	-	-	-	-	-	-	-
	Bar-DM	-	-	8648/8660	-	-	-	-	-	-	-	-
	Bar-TM	-	-	-	-	-	-	-	-	-	-	-
TiMetal834	Billet-DM	-	-	-	-	-	-	-	-	-	-	-
	Billet-TM	-	-	8679	9003-24	-	59538	-	534/784	1267T2	-	-
	Bar-DM	-	-	-	9003-24	-	-	-	-	1267T3/4	-	-
	Bar-TM	-	-	-	-	-	59538	-	-	-	-	-

Alloy	Form Used	GEAE	PWA	Rolls Royce	SNECMA	Honeywell	Rolls Royce	Turbomeca	P&W-C	MTU	Williams	IHI *
Ti 10-2-3	Billet-DM	-	-	-	-	-	-	-	-	-	-	-
	Billet-TM	-	-	-	-	-	-	764	-	-	-	-
	Bar-DM	-	-	-	-	-	-	-	-	-	-	-
	Bar-TM	-	-	-	-	-	-	-	-	-	-	-

***IHI is currently a Pending New JETQC OEM**

With:
D.M: Double VAR Melt
DM(-)* : DM with some exceptions to premium requirement
TM : Triple VAR Melt
HM+V : Hearth Melt plus VAR
SHM+V : Short Hearth Melt plus VAR
Sc+V : Scull melt plus VAR

Appendix 2
Table IA and IB - Quarterly Report Summarizing Forms

Example Form

Table IA. JET ENGINE TITANIUM QUALITY COMMITTEE QUARTERLY BILLET SONIC/MACRO ETCH REPORT.
SUPPLIER NAME: _____

___Quarter 20___

Alloy	Type of Melt	Number of Heats Inspected	Weight of Heats Insp. (lbs)	No. of Defects by Type					Frequency	
				Type I	Type II	HDI	Clean Voids	Other	% of Heats with Defects	Defects per Ton (2000 lb) Ingot
Ti-6-4	2XVAR									
	3XVAR									
	HM+VAR									
	Sc+V									
Ti-8-1-1	2XVAR									
	3XVAR									
	HM+VAR									
Ti-17	3XVAR									
	HM+VAR									
Ti-6246	2XVAR									
	3XVAR									
	HM+VAR									
	Sc+V									
Ti-6242	2XVAR									
	3XVAR									
	HM+VAR									
TiMetal550 (Ti-442)	2XVAR									
	3XVAR									
TiMetal679	2XVAR									
	3XVAR									
TiMetal685	2XVAR									
	3XVAR									
TiMetal829	2XVAR									
	3XVAR									
TiMetal834	2XVAR									
	3XVAR									
Ti 10-2-3	2XVAR									
	3XVAR									

Example Form

Table IB. JET ENGINE TITANIUM QUALITY COMMITTEE QUARTERLY BAR/PLATE SONIC/MACROETCH REPORT.
SUPPLIER NAME: _____

_____Quarter 20___

Alloy	Type of Melt	Number of Heats Inspected	Weight of Heats Insp. (lbs)	No. of Defects by Type					Frequency	
				Type I	Type II	HDI	Clean Voids	Other	% of Heats with Defects	Defects per Ton (2000 lb) Ingot
Ti-6-4	2XVAR(-)									
	2XVAR									
	3XVAR									
	SHM+VAR									
	HM+VAR									
	Sc+VAR									
Ti-8-1-1	2XVAR									
	3XVAR									
	HM+VAR									
Ti-17	3XVAR									
	HM+VAR									
Ti-6246	2XVAR									
	3XVAR									
	HM+VAR									
Ti-6242	2XVAR(-)									
	2XVAR									
	3XVAR									
	HM+VAR									
TiMetal550 (Ti-442)	2XVAR									
	3XVAR									
	HM+VAR									
TiMetal679	2XVAR									
	3XVAR									
TiMetal685	2XVAR									
	3XVAR									
TiMetal829	2XVAR									
	3XVAR									
TiMetal834	2XVAR									
	3XVAR									
Ti 10-2-3	2XVAR									
	3XVAR									

Appendix 3
Table II - Billet/Bar/Plate Sonic/Macro etch Defect Characterization Report

Table II. Titanium Billet and Bar/plate Sonic/Macro etch Defect Characterization Report - Preliminary / Final / Updated*

* delete as appropriate

Melt Source	**Heat #**	**Alloy**	**Melt Date**	**Melt Type**	**Heat Formulation**	**Ingot Diameter**
Billet Source						
Billet/Bar Size	**Location**			**% FBH**		**# of Defects**
	% from Ingot Bottom	**% from Rim**		(See appendix for additional ultrasonic data)		
Defect Type	**Defect Size (transverse/ longitudinal)**	**Void/Crack Size**		**Composition of the Defect**		**Hardness**
Photomicrographs			**Probable Cause/Source of Defect**			

Rating

1 = Remotely Possible Hard Alpha Source
2 = Possible Hard Alpha Source
3 = Probable Hard Alpha Source
4 = Known Hard Alpha Source

Table II – Ultrasonic inspection data

UT Response Limits		**Inspection Results - UT Data**		**UT Calibration Information**				**Transducer and UT Set-up Information**					
Detection Threshold (% FSH)	Maximum Noise Level Allowed (% FSH)	Material Noise Level (% FSH)	Indication Peak Amplitude (% FSH)	Reflector Type (FBH?)	Reflector Size	Amplitude of Calibration Reflector (% FSH)	DAC Used (Yes or No)	Frequency	Diameter (or major axes, if elliptical)	Focal Length(s)	Mode of Inspection (longitu-dinal, or shear)	Focusing Condition	Beam Diameter In Billet Known?
What does the spec call out for the Alarm Threshold?	If there is a max limit on billet noise what is it?	What was the measured noise level in the billet	On evaluation what was the measured peak amplitude?	What type of calibration reflector is required (FBH or SDH)?	What size calibration reflector is required?	To what level should the signal from the calibration reflector be placed?	Distance Amplitude Correction (Yes or No)?	What frequency is the transducer being driven at?	What is the diameter(s) of the transducer?	What is the focal length(s) of the transducer?	Longitudinal or transverse inspection mode?	Water Path or Location of focal point with respect to billet surface	Do you know the beam diameter as a function of depth?

Appendix 4
Recommended Procedure for 3D Inclusion Characterization

Step 1: Characterize the ultrasonic indication in the product:

- Angulation
- Two different frequencies
- Exact location (marking)

Step 2: Cut a sample (approximately 40 X 40 mm) out of the product containing the indication (mark each face to maintain orientation).

Step 3: NDT Inspection.

Step 4: Relocate indication ultrasonically and remark (to maintain orientation).

Step 5: Cut a cube whose side is approximately 25 mm (1 inch). If necessary, relocate the indication ultrasonically.

Step 6: Consider performing 3D Computer Aided Tomography (CAT) scanning or other NDT technique to assist in determination of the 3D shape and size of the defect.

Step 7: Metallurgical characterization

7-1 Approach:

- Approach the defect by the face of the cube perpendicular to face exhibiting the maximum ultrasonic response.
- Precut at 2 mm from identified position

7-2 Macrographic examination:

- Any segregation
- Orientation of grain structure

7-3 Micrographic examination:

- Polish in steps from 50 to 500 microns
- Determine defect type, 3D defect size, 3D void/crack size, and micro hardness.
- Take photomicrographs of the defect at its maximum dimensions in two perpendicular directions.
- Consider performing 3D CAT scanning or other NDT technique to assist in determination of the 3D shape and size of the defect.

7-4 Microprobe analysis (in case of inclusion):

- Chemical composition of the defect.

7-5 Scanning Electron Microscope (SEM) examination (if necessary):

- Nature of constituents
- Fractography of void/crack

Note: this procedure is based on AC 33.15-1 dated 09/22/1998

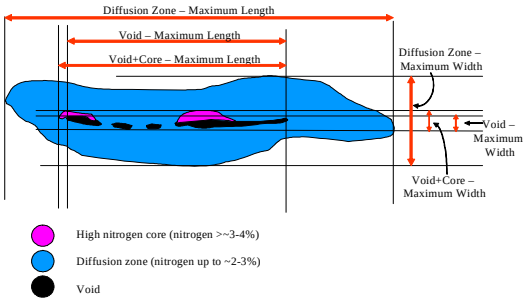

Figure 1. Definition of boundaries of Void, Core and Diffusion Zone

Appendix 5a
Original JETQC OEM Quarterly Report Mailing List

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Appendix 5b
New JETQC OEM Quarterly Report Mailing List

Currently no OEMs on this list.

Appendix 5c
Pending New JETQC OEM Mailing List

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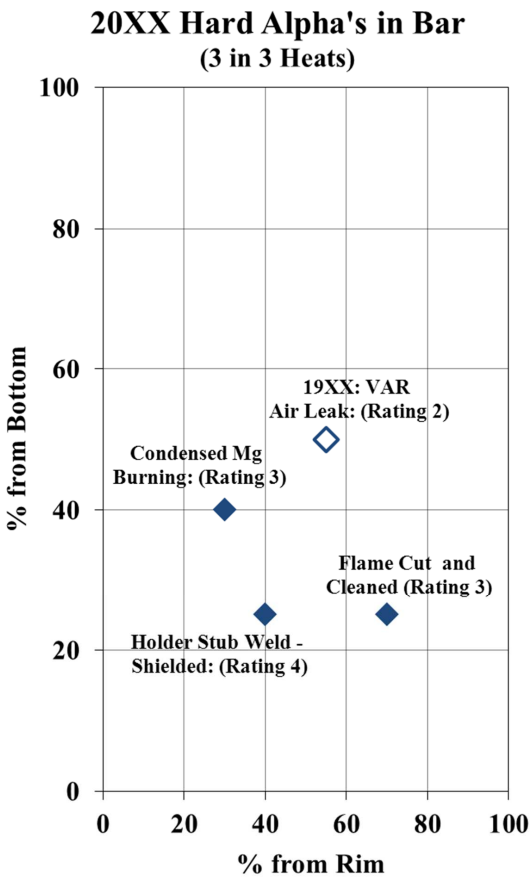
Nishitama-gun,
Tokyo
190-1297 Japan
mitsuhiro_takekawa@ihi.co.jp

Appendix 6
Example of Composite Ingot Map



Note: Three solid diamond inclusions found in material produced during 20XX. Open diamond inclusion identified by 19XX would be a component find for material produced in 19XX.

Appendix 7a
Original JETQC Melter Mailing List

Glenn Morgan

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Juan Sauceda

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Appendix 7b
New JETQC Melter Mailing List

Currently no suppliers on this list.

Appendix 7c
Pending New JETQC Melter Mailing List

Pending for bar/plate:

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JAPAN
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Pending for billet: Currently no suppliers on this list.

Appendix 8
Converter Mailing List

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Nicholas Cecchini

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Appendix 9
Table III - Forging/Part Sonic/Macro etch Report

Table III. Titanium Forging/Part Sonic/Macro etch Defect Characterization Report

Melt Source	**Heat #**	**Alloy**	**Melt Date**	**Melt Type**	**Heat Formulation**	**Ingot Diameter**
Billet Source						
Billet/Bar/plate Size	**Location**			**% FBH**		**# of Defects**
	% from Ingot Bottom	**% from Rim**				
Defect Type	**Defect Size** (transverse/ longitudinal)	**Void/Crack Size**		**Composition of the Defect**		**Hardness**
Photomicrographs			**Probable Cause/Source of Defect**			

Rating

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