
Notes sur le guide FIDES

1 Présentation

« FIDES » est un guide de calcul pour l'estimation de la fiabilité des équipements électroniques qui prend en compte :

- la fiabilité des composants (technologie)
- l'environnement d'utilisation de l'équipement
- la qualité des processus tout au long du cycle de vie de l'équipements.

Elle est valable pour tous les types d'équipements, sachant que la partie processus de production a été optimisée pour les domaines de l'aérospatiale et de l'armement. La fiabilité des logiciels n'est pas prise en compte.

Le « FIDES group » est composé d'industriels français (AIRBUS, Eurocopter, GIAT, MBDA, Thales, DGA).

Le but du guide était de définir une nouvelle méthode de prévision de la fiabilité des systèmes électroniques prenant en compte les nouvelles technologies, ce qui n'était pas le cas des méthodes déjà existantes (MIL-HDBK-217 par exemple). Le guide FIDES a été publié par l'UTE sous la référence UTE C 80 811.

Il a été publié en 2004. Il a été mis à jour en 2009, principalement dans sa partie « audit processus », pour y inclure un guide d'application de la méthode.

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2 Fiabilité dans le guide FIDES

La fiabilité est exprimée en FIT dans la FIDES. 1 FIT = 1 défaillance par milliard d'heures (1.10^9 heures). C'est un taux d'erreur, désigné par abus de langage dans le reste du document par « fiabilité ».

La fiabilité d'un système est la somme de la fiabilité de ses composants :

$$\lambda_{\text{équipement}} = \sum_{\text{composants}} \lambda_{\text{composant}}$$

La fiabilité d'un composant est sa fiabilité physique $\lambda_{\text{physique}}$, pondérée par 2 facteurs qui sont calculés en fonction de l'utilisation du composant (sa fonction dans le système) et de la qualité des processus intervenant dans le cycle de vie du système :

$$\lambda = \lambda_{\text{physique}} \Pi_{\text{part-manufacturing}} \Pi_{\text{process}}$$

Le guide décrit certains composants électroniques, partagés en plusieurs familles, les formules statistiques utilisées plus bas ayant été adaptées aux modes de défaillances de chacune des familles :

- Composants électroniques
- PCB et connecteurs
- Cartes câblées (fonctions génériques comme un récepteur RS232 etc. dont on ne connaît pas la composition exacte). Cette famille est utilisée lors des études préliminaires du produit.
- Sous-ensembles (écrans LCD et CRT, disques durs)

3 Fiabilité physique

La fiabilité physique du composant est la somme pondérée des fiabilités respectives du composant lors de toutes les phases de fonctionnement (ou non fonctionnement) différentes de l'équipement ou cycles (la pondération est la durée de chaque phase par rapport à une année – dans les cas courants). Des exemples sont fournis dans le guide.

Les phases de fonctionnement de l'équipement doivent être clairement décrites (durée, températures atteintes, vibrations, exposition aux éléments chimiques...)

$$\text{Fiabilité physique du composant : } \lambda_{\text{physique}} = \sum_i^{\text{Phases}} \left(\frac{\text{duree}_{\text{phase } i}}{8760} * \lambda_{\text{phase } i} \right)$$

Fiabilité physique du composant pour une phase donnée :

$$\lambda_{\text{phase } i} = \left[\sum_{\text{Contributions physiques}} \lambda_0 \Pi_{\text{acceleration}} \right] \Pi_{\text{induced } i}$$

Π_{induced} représente les stress/surcharges accidentelles aux conditions d'utilisation prévues :

$$\Pi_{\text{induit } i} = (\Pi_{\text{placement}} \Pi_{\text{application } i} \Pi_{\text{durcissement}})^{0,511} \ln(C_{\text{sensibilité}})$$

λ_0 représente le taux de défaillance de base du composant.

$\Pi_{\text{acceleration}}$ est calculé différemment suivant la famille du composant, à partir des paramètres de la phase de fonctionnement considérée, et des paramètres de fonctionnement du composant dans ces phases. Les formules sont données dans des tables du guide FIDES.

La valeur de Π_{induit} varie entre 1 et 100 (pire cas, rare).

- $\Pi_{\text{application}_i}$: à calculer à partir d'une table pour chaque cycle, représente l'environnement dans lequel l'équipement est utilisé (transport du produit, qualification des utilisateurs, intempéries...)
- $\Pi_{\text{durcissement}}$: calculé à partir d'une table/questionnaire, ce facteur représente la prise en compte dans la conception des stress subits par le composant. Sa valeur par défaut (absence de calcul) est de 1,7.
- $\Pi_{\text{placement}}$: ce facteur représente la fonction que réalise le composant au sein de l'équipement (en particulier un rôle d'interface), calculé à partir d'une table qui dépend de la famille du composant.
- $C_{\text{sensibilité}}$: c'est un coefficient de sensibilité dépendant de la technologie utilisée (composants du commerce). Ce coefficient est tablé dans le guide pour chaque famille.

3.1 Phases de fonctionnement ou non-fonctionnement

Les phases peuvent être décrites par des valeurs les décrivant précisément, ou de valeurs minimum-maximum dans le cas de cycles répétitifs de température (par exemple).

Les phases de fonctionnement sont décrites par les paramètres ci-dessous.

- Durée annuelle
- Cycles :
 - ΔT
 - Nombre de cycles
 - Durée
 - Température maximum
- Pollution saline (faible, élevée)
- Pollution industrielle (négligeable, zone urbaine, zone industrielle)
- Aire d'utilisation (habitée, non-habitée, moteur)
- Niveau de protection (herméticité ou pas)
- Paramètres spécifiques à chaque composant pendant la phase (température de jonction, tension....)

Nota : Certaines valeurs sont « discrètes » car difficiles à évaluer (les niveaux de pollution par exemple). Chacune des valeurs vaut alors un certain nombre de points dans les formules de calcul.

4 $\Pi_{\text{part-manufacturing}}$

Ce paramètre est défini pour une référence de pièce/composant donnée (quelque soit l'équipement). Il représente le facteur de risque lié à la fabrication du composant. Sa valeur est comprise entre 0,5 et 2.

Nota : Le taux de panne de base du composant est donc multiplié d'un facteur de 0,5 à 2.

Les composants sont considérés comme étant des composants du commerce, ce qui est la pratique habituelle de nos jours. Il faut donc en théorie auditer/questionner tous les fournisseurs ainsi que procéder à l'analyse des qualifications et tests réalisés sur les composants.

Si ce n'est pas le cas la valeur par défaut est de 1,6 pour les composants passifs et 1,7 pour les composants actifs.

La formule de calcul est :

$$\Pi_{\text{part manufacturing}} = e^{\delta_1(1 - \text{PartGrade}) - \alpha_1}$$

dans laquelle

$$\text{PartGrade} = \frac{(AQ_{\text{fabricant}} + AQ_{\text{composant}} + AF_{\text{composant}}) * \epsilon}{36}$$

Les valeurs des paramètres sont donnés dans des tableaux pour chaque famille de composant :

δ_1 et α_1 sont des coefficients fixes

$AQ_{\text{fabricant}}$: niveau de certification du fabricant du composant (type ISO9001...)

$AQ_{\text{composant}}$: niveau de test et qualification du composant

$AF_{\text{composant}}$: Assurance fiabilité, niveau sévérité de la qualification du composant

ϵ : notation du fournisseur du composant par l'acheteur (fournisseur audité récemment, ou connu de longue date)

5 Π_{process}

Π_{process} représente la qualité des processus rentrant dans le cycle de vie de l'équipement (développement, fabrication, support produit...). S'il n'a pas été estimé, la valeur par défaut est de 4, sur une échelle de 1 (très bon) à 8.

Nota : la fiabilité physique du composant est directement multipliée par cette valeur de 1 à 8... le taux de panne calculé varie donc d'un facteur 1 à 8 en fonction de la qualité des processus de son cycle de vie.

$$\Pi_{\text{process}} = e^{\delta_2(1 - \text{ProcessGrade})}$$

ProcessGrade représente le degré de réussite de l'audit, entre 0 et 1 (bon), voir ci-dessous.

Π_{process} peut-être considéré comme défini pour un équipement donné, bien que beaucoup de questions s'adressent à l'organisation générale de l'organisme audité. L'audit s'inspire de l'ISO9001:2000, une grande partie des réponses doit pouvoir être déterminé quelque soit le produit, en fonction de la conformité supposée à l'ISO9001 :2000.

Dix-huit processus intervenant dans le cycle de vie du produit ont été définis pour l'audit (du développement aux ressources humaines en passant par la fabrication, la logistique et le support produit). Ils ont été groupés en 6 phases, chacune ayant son questionnaire et une pondération.

Le questionnaire et ses guides représentent 43% du guide FIDES, parties IV.4 et V).

Les 192 questions sont notées de 0 à 3, puis chacune pondérée par un facteur d'importance relative à la phase considérée.

On calcule ensuite la somme des points pour chaque phase. Chaque total est ensuite pondéré par l'importance relative de chaque phase dans le cycle de vie du produit.

Cette importance relative de chaque phase est évaluée en comparant le nombre de points maximum pouvant être obtenu pour chacune d'elles. C'est la « calibration ».

La performance globale *ProcessGrade* est le nombre de points obtenus sur l'ensemble des phases sur le nombre de points maximum qu'il est possible d'obtenir.

$$\text{ProcessGrade} = \frac{\sum_{\text{phases}} \text{PointsPhase}}{\text{MaxPointsProcess}}$$

MaxPointsProcess est calculé à partir du nombre de points maximum qu'il est possible d'obtenir à une phase, et avec la pondération de cette phase dans le cycle de vie du produit.

5.1 Pour aller plus loin

La norme ne fixe que la méthode de calcul de Π_{process} . Les utilisateurs sont libres d'adapter le questionnaire, le poids relatif des réponses etc. en fonction de leurs besoins (c'est alors que la « calibration » s'avère très utile). Cela sera principalement le cas si un retour sur expérience a permis de quantifier l'effet de tel ou tel point de process particulier sur le système sur le taux de panne.

6 Conclusion, éléments d'entrée à l'étude de fiabilité

Les données à apporter par celui qui réalise l'étude de fiabilité sont relativement simples, au pire relèvent de la conception (élévation de la température d'un composant par exemple), mais existent en quantité (une quinzaine de paramètres par cycle de fonctionnement par exemple, sans compter les cas particuliers de certains composants).

Beaucoup de valeurs utilisées dans les formules de calcul sont données par la norme dans des tables, par rapport à des informations d'entrées simples et compréhensibles.

La procédure à suivre peut être la suivante :

1. Définir la liste des éléments de l'équipement, leur type et leur quantité et redondances de fonctions
2. Définir les paramètres de chaque phase de fonctionnement de l'équipement
3. Définir les paramètres de chaque composant, par phase de fonctionnement ($\Pi_{\text{placement}}$, $\Pi_{\text{ruggedizing}}$, $\Pi_{\text{sensitivity}}$, paramètres liés au composant)
4. Calcul des $\lambda_{\text{physical}}$ par cycle, puis de leur somme
5. Evaluation de $\Pi_{\text{partmanufacturing}}$ pour chaque part-number
6. Evaluation de Π_{process} pour l'équipement
7. Calcul de $\lambda_{\text{physical}}$ pour chaque composant, et de leur somme pour la fiabilité de l'équipement

L'évaluation de $\Pi_{\text{partmanufacturing}}$ et de Π_{process} peuvent être un travail en amont de l'étude de fiabilité (ou un suivi continu, par base de donnée pour $\Pi_{\text{partmanufacturing}}$ et audit pour Π_{process}).

7 Références / Liens

Guide FIDES 2009

Wikipedia

http://fr.wikipedia.org/wiki/Fides_%28fiabilit%C3%A9%29

Site des utilisateurs de FIDES <http://www,fides-reliability.org/>

8 Mise à jour

2010-10-14 : Modifications mineures, Guide FIDES 2009

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