1 Scope

1.1 Philosophy of FITNET FFS Approach

The approach described in this procedure is suitable for the assessment of metallic structures and components with and without welds containing, or postulated to contain, flaws. The failure mechanisms considered are fracture, fatigue, creep and corrosion, together with combinations of these failure modes. In order to facilitate a unified assessment route through the FITNET FFS procedure, information is grouped under seven main Sections:

(I) Information required for assessment (Inputs): Section 5

(II) Assessment modules (Fracture, Fatigue, Creep, Corrosion): Sections 6, 7, 8 and 9

(III) Assessment and reporting of results (Output): Section 10

(IV) Alternative and specific assessments for fracture: Section 11

(V) Additional information for fracture Assessment: Section 12

(VI) Case studies: Section 13

(VII) Tutorials: Section 14

The volume I of the FITNET FFS Procedure contains first 12 Sections. The volume II contains case studies and tutorials. The third volume puts together the Annexes. The philosophy of the approach in each of four assessment modules (Fracture, Fatigue, Creep and Corrosion Modules) is differently structured.

Fracture Module: The quality of input data is reflected in the sophistication and accuracy of the resulting analysis. A series of levels is available, each of increasing complexity and each being less conservative than the next lower level; consequently 'penalties' and 'rewards' accrue from the use of poor and high quality data respectively. This procedural structure means that an unacceptable result at any level can become acceptable at a higher one. The user need only perform the work necessary to reach an acceptable level and need not invest in unnecessarily complicated tests or analysis.

Due to the hierarchical structure of data and assessment levels, the path selection through the procedure is made based on the relative levels of contribution of brittle fracture and plastic collapse towards the overall failure. Qualitative and quantitative guidance is provided for guiding the user in the direction that will yield most benefit in terms of data improvement. The basis for this is the location of the initial analysis point in terms of brittle fracture and plastic collapse. This can be assessed by either the Failure Assessment Diagram (FAD) or the Crack Driving Force curve (CDF). The methods can be applied to determine the acceptability of a given set of conditions, determine the value of a critical parameter, assess the safety margins against failure or determine the probability of failure. Fig.1.1 shows the general decision steps and possible outcome.

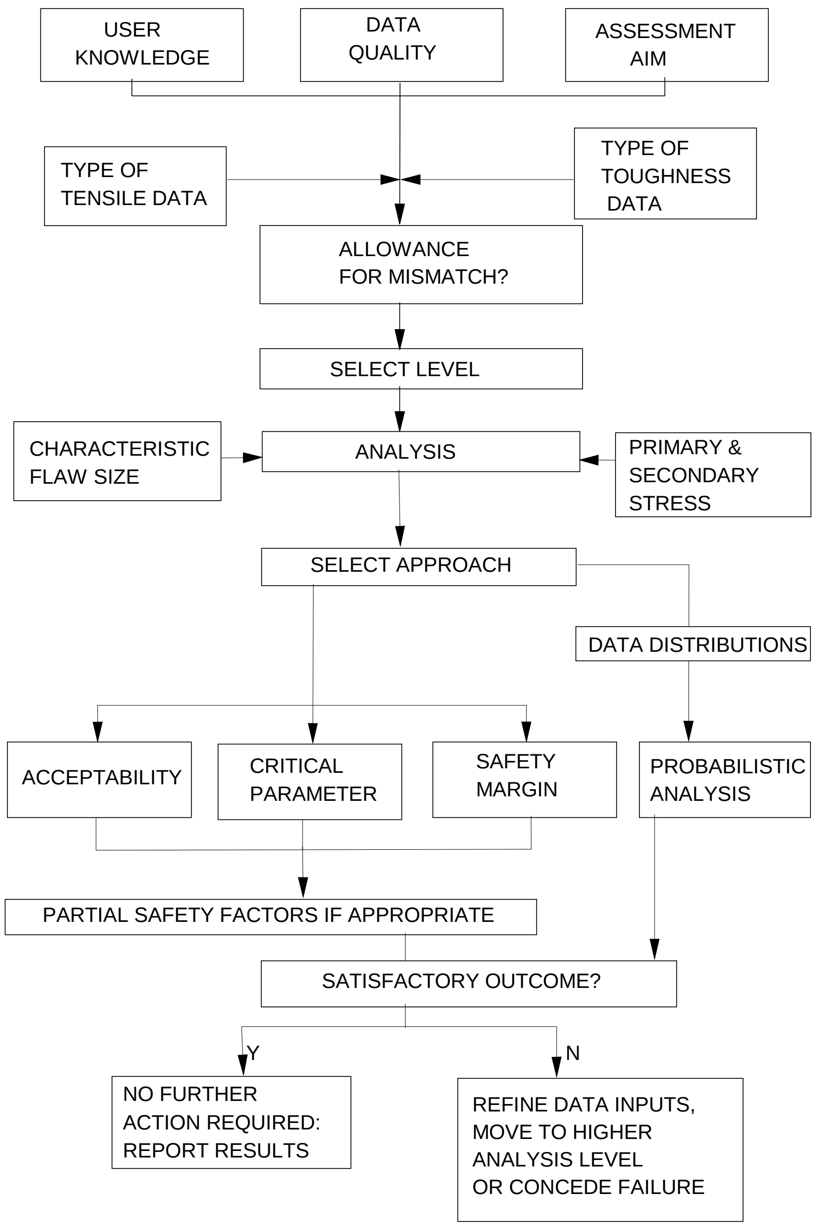

Figure 1.1 - Generalised Flowchart of Decision Steps and Types of Outcome for Fracture Module

Fatigue Module: In the FITNET FFS fatigue analysis there is a principal need to determine whether the analysis is intended to determine the cyclic life to fatigue crack initiation for a specified load history at a critical location or to evaluate the propagation of a reported or postulated flaw up to a critical size to produce fracture or local collapse. Obviously, both aspects may need to be considered in cases for which the location of the reported flaw does not coincide with that of highest loading. This Module provides five assessment routes for evaluating the effects of cyclic loads on the service life of the defect-free component or component with postulated or real defects. The FITNET FFS Fatigue Damage Assessment Routes are: Route 1) Nominal Stress, Route 2) Structural Stress or Notch Stress, Route 3) Strain-Based Fatigue Life Curves, Route 4) Fatigue Crack Propagation, Route 5) Non-Planar Flaw Assessment.

Covered by the above five assessment routes, two basic application scenarios are foreseen in the Fatigue Module:

a) A design detail or feature of a component is to be assessed with respect to potential fatigue failure from that feature, rather than from any identifiable flaw. The analysis is then based on the accumulation of fatigue damage at a critical location on the component (fatigue damage analysis). In this case, the basic approach is to determine the fluctuating stress range at the location under study and relate the analysis to the appropriate fatigue life curves. Three different routes are proposed (Routes 1, 2 and 3), depending on the available information about loading and flaw information, fatigue regime, and application specification (i.e., welded or non welded component).

b) An actual or postulated flaw is to be assessed with respect to potential growth to a critical size under fatigue loading. In general, such flaws would be considered to be planar (crack-like) regardless of their actual type. In this case the analysis is focused on determination of the cyclic growth of the flaw (Route 4). However, a supplementary, less conservative route is included specifically for assessing volumetric non-planar flaws (Route 5).

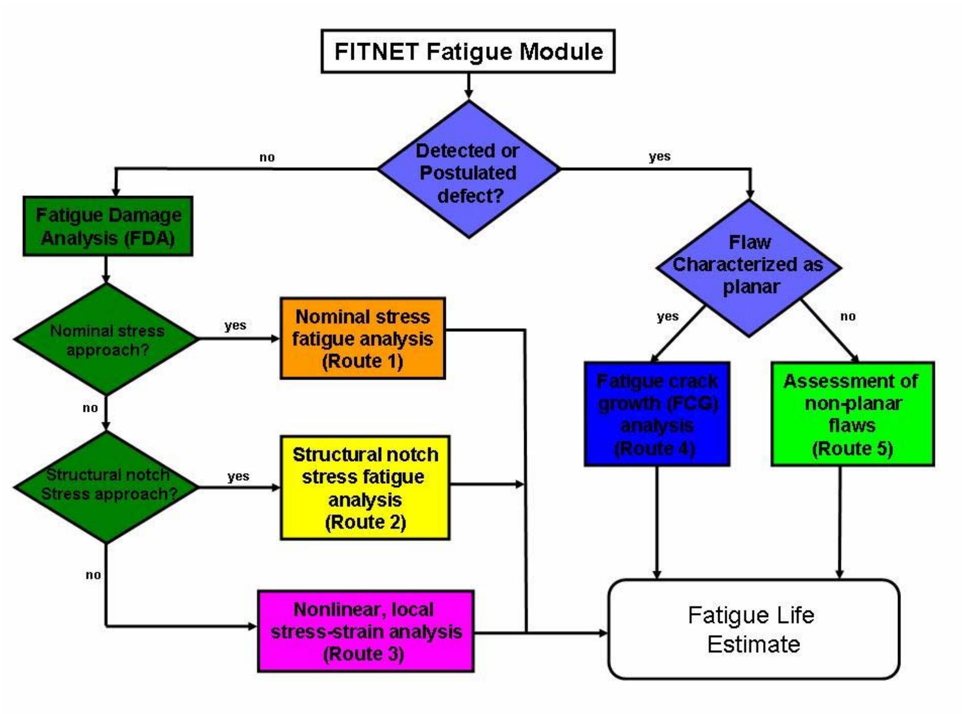

Figure 1.2 – Generalised Flowchart of Assessment Routes for Fatigue Module

Creep Module:

The creep module specifies methods for assessing defects in structures operating at high temperatures and subject to creep-fatigue loading conditions. Creep is a time-dependent phenomenon. Therefore, the creep module evaluates the times associated with three significant events. First, the initiation time is the time prior to which no significant crack growth occurs. Secondly, the time associated with creep-fatigue crack growth or the crack growth in a specified time is calculated. Finally, the time for creep rupture damage to spread throughout the ligament ahead of a flaw must be evaluated. This last time can be life-limiting even if no significant crack growth occurs in service.

Creep crack growth in Section 8 is generally based on reference stress methods for calculating the steady state creep parameter, C*. These methods are similar in basis to those used in the fracture module. Indeed, the creep module includes an alternative time-dependent failure assessment diagram, which reduces to the failure assessment diagram approach in the fracture module when creep strains are negligible. The creep module also includes other alternative approaches and guidance for some specific applications

Corrosion Module:

The corrosion module provides guidelines on the appropriate steps to take when an environmental assisted, either by stress corrosion or corrosion fatigue, crack as well as local thin area (LTA) has been detected in service and an assessment of the implications for structural integrity has to be done. Such an evaluation should be made in the context of the perceived consequences of failure using appropriate risk-based management methodologies. Since this is plant/component specific it is beyond the scope of this section. Hence, this Module deals primarily with the Fitness-for-Service assessments of damage types due to environmental assisted cracking (EAC) - covering stress corrosion cracking and corrosion fatigue – and Local Thinned Area (LTA).

1.2 Limits of Validity

The methods described in this procedure were derived by reviewing and collating existing information and utilising the results of recently completed EU-Projects in the field of FFS. The materials to which the procedure can be applied cover the full range of metallic materials. Emphasis throughout has been given to strength mis-matched welds and to a certain extent to the advanced welded structures of steels and aluminium.

The procedure is applicable to combinations of the following failure modes.

Fracture

Fatigue

Creep and other high temperature failure modes

Corrosion (Environmentally assisted cracking, local thin areas)

Crack arrest

Mixed-mode loading etc.

The failure mode of Buckling is not covered by this procedure.