10.2.3 Turbine Rotor Integrity

Turbine rotor integrity is provided by the integrated combination of material selection, rotor design, fracture toughness requirements, tests, and preservice and inservice inspection. This combination results in a low probability of a condition that would cause a rotor failure.

The COL applicant shall identify the turbine vendor and model. Also, the COL applicant is to provide a description of how the turbine missile probability analysis conforms with Subsection 10.2.3.6 to ensure that requirements for protection against turbine missiles (e.g., applicable material properties, method of calculating the fracture toughness properties per SRP, Section 10.2.3, Acceptance Criteria, preservice inspections) will be met (COL 10.2(3)).

The as-built turbine material properties, turbine rotor and blade designs, pre-service inspection and testing results and in-service testing and inspection requirements shall be verified by ITAAC to meet the requirements defined in the turbine missile probability analysis.

10.2.3.1 Material Selection

Turbine rotor forgings are made from vacuum treated or remelted Ni-Cr-Mo-V alloy steel components using processes that minimize flaw occurrence, provide reasonable assurance of uniform strength, and provide adequate fracture toughness. Undesirable elements, such as sulfur and phosphorus, are controlled to the lowest practicable concentrations consistent with good feedstock selection and melting practice, and consistent with obtaining adequate initial and long-life fracture toughness for the environment in which the parts operate. The turbine rotor material conforms with the chemical property limits of ASTM A470 (Reference 3). The chemical composition of manufacturer's material for the rotor steel has lower or equal limitations than indicated in the ASTM standard for phosphorous, sulphur, and antimony as described in Table 10.2.3-1. The rotor forgings are heat treated and tested prior to the final machining process.

including use of shrunk on disks.

Turbine designs utilize rotors produced from large integral forgings or from multiple wrought components. Acceptable material properties will be consistent with component size and fabrication method. Material testing has shown that fracture appearance transition temperature (FATT) increases (and Charpy V-notch energy decreases) from the shall be shown acceptable in a turbine missile probability analysis performed by the COL applicant using as built material properties. Use of properties (as appropriate for the type of rotor and location of the sample) that are less fracture resistant than specified in SRP 10.2.3 shall be specifically identified and justified.

outer surface to the deep-seated region of a forging as a result of variation (slowing from outside to center) in the cooling rate during the quenching process. The cooling rate variation causes the FATT (and Charpy V-notch energy) to vary rapidly with depth near the surface of the forging and then more gradually at deeper forging locations. Since actual levels of the 50 percent FATT and Charpy V-notch energy vary depending upon the size of the part, and the location within the part, etc., these variations are taken into account in accepting specific forgings for use.

For a design using a shrunk on disk,

and welded

The 50 percent FATT, as obtained from Charpy tests performed in accordance with American Society of Testing Methods (ASTM) A-370 (Reference 4), is no higher than -18ºC (0ºF) for low-pressure turbine wheel (disc) forgings, and the Charpy V-notch energy at the minimum operating temperature is at least 8.3 kg-m (60 ft-lbf) in the tangential direction. If used, the larger size of integral rotors limits the achievable properties at the rotor body center bore. The 50 percent FATT, as obtained from Charpy tests performed in accordance with ASTM A-370, ~~is no higher than -1.1ºC (30ºF) and the Charpy V-notch energy at the minimum operating temperature is at least 6.22 kg-m (45 ft-lbf).~~ A minimum of three Charpy V-notch specimens are tested in accordance with specification ASTM A-370.

10.2.3.2 Fracture Toughness

The proper toughness of the turbine rotor is obtained through the use of selected materials as described in Subsection 10.2.3.1. High reliability and availability, efficiency, and safety are satisfied by keeping the balance between the strength and toughness of the turbine rotor.

The fracture toughness K_{IC} for actual rotor product is determined using a value of deep-seated FATT based on the measured FATT values from the center bore or trepan specimens from the rotor forging, and a correlation factor obtained from the past manufactured rotor material test data, and generated statistically lower bound of the data.

As part of the turbine missile probability analysis, the COL applicant is to identify which of the methods for determining fracture toughness properties of those allowed in SRP Section 10.2.3 acceptance criteria is used.