Extreme operating temperatures, greater than 1100°C, within the turbine section of jet engines require sophisticated methods of material protection. Thermal barrier coatings (TBCs) achieve this through a ceramic coating applied to the underlying substrate material (nickel-based superalloy). Electron-beam physical vapor deposition (EB-PVD) is the industry standard coatings used on jet engines. Plasma-spray physical vapor deposition (PS-PVD), an emerging deposition technique, is capable of non-line-of-sight deposition, which allows coating of more complex geometries and multiple parts simultaneously. Tailoring the microstructure of PS-PVD coatings to be similar to that of EB-PVD coatings allows the benefits of strain tolerance to be obtained while improving coating deposition times. This work investigates the strain through depth of uncycled and cycled samples using these coating techniques with synchrotron X-ray diffraction (XRD) over the lifetime. In the TGO, room temperature XRD measurements indicated samples of both deposition methods showed similar in-plane compressive stresses after 300 and 600 thermal cycles. In-situ XRD measurements indicated similar high-temperature in-plane and out-of-plane stress in the TGO and no spallation after 600 thermal cycles for both coatings. Additionally, in this work, stress through depth of the YSZ top coat was investigated in both PS-PVD and EB-PVD samples during their lifetime. The measurements were made during a one-hour thermal cycle via in-situ XRD. Tensile in-plane residual stresses were found in uncycled PS-PVD samples, similar to APS coatings. After thermal cycling PS-PVD stress through depth showed general similarities to EB-PVD coatings. However, PS-PVD samples showed in most cases, higher compressive residual in-plane stress at the YSZ/TGO interface. These results provide valuable insight for optimizing the PS-PVD processing parameters to obtain strain compliance similar to that of EB-PVD.