• Energy distributions of D(D,n)He$^3$ and T(D,n)He$^4$ fusion neutrons for a variety of suprathermal distributions of fuel nuclei have been calculated using two different algorithms.

• Verification of the obtained results has been successfully performed by four methods.

• The results may be used in the framework of the research and development activities towards a demonstration fusion neutron source DEMO-FNS and for the interpretation of diagnostic data in neutron spectrometry.