The Worker Exposure Failure Modes and Effects Analysis

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This paper presents a new approach to quantitative evaluation of worker risks from possible failures of co-located equipment in the complex environment of a magnetic or inertial confinement fusion experiment. For next-step experiments such as the International Thermonuclear Experimental Reactor (ITER) or the National Ignition Facility (NIF), the systems and equipment will be larger, handle more throughput or power, and will, in general, be more robust than past experiments. Despite the large size of these experiments, there is congestion as all the required systems and equipment share rooms so that they can be plumbed or connected to the tokamak or laser chamber. These systems and equipment are necessary to operate the machine, but the complicated equipment rooms and access pathways for piping runs or cable chases also pose a new, higher level of hazard for workers who will perform the necessary hands-on maintenance tasks.

Conventional safety assessment methods, such as the well-known Job Hazards Analysis (JHA) endorsed by the US Occupational Safety and Health Administration (OSHA), focus on the task at hand; these methods define the hazards inherent with the steps of that task and identify methods that can be used to mitigate those hazards. Presuming that conventional worker safety assessment methods will provide adequate protection for the task at hand, completing JHA or similar analyses will still leave the worker potentially vulnerable to hazards from co-located equipment and systems in these complex facilities. The new analysis approach, called the Worker Exposure Failure Modes and Effects Analysis (WE-FMEA) is a method to analyze the nearby equipment and the work environment for equipment failure and other inherent hazards, and then develop scenarios of workers' exposure to the hazards. The proven FMEA technique lends its structure to provide a systematic, thorough treatment to identify the potential hazards to the workers. Only the equipment failure modes that can threaten the workers with exposure to an energy source or a hazardous material are addressed in this analysis. Once identified, the exposure scenarios can be evaluated for the severity of the worker hazards and quantitative worker risk values can be calculated.

The US DOE Fusion Safety Standard directs that fusion facility workers shall be protected from routine industrial hazards to a level commensurate with that of comparable industrial facilities, and that the US OSHA regulations will be followed to provide worker safety. Therefore, data from comparable industrial activities that are similarly regulated can be used as a comparison point to the WE-FMEA findings. Each quantified worker risk scenario identified in the WE-FMEA can be compared to existing statistical data on worker injuries from a comparable industry; WE-FMEA scenarios that are shown to be unacceptably high risk can be analyzed in more detail to agree on the proper means to reduce or mitigate the hazard. In this paper, the WE-FMEA approach is described, its strengths and potential weaknesses are discussed, and a cooling system maintenance example is given. This new approach can support worker safety assessment in ITER, NIF, and other next-step experiments.

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