On emergency cooling system inoperable. alternatively, water

On March 11th 2011 at 2: 46 PM an earthquakewith a magnitude of 9. 0 struck off of the eastern coastal area of Tohoku, Japan(TEPCO, 2012). Subsequently a massive tsunami ensued, which reached heights ofup to thirty meters (Kushida, 2012; Baba, 2013) and in its wake left areasdevastated with a total of 20.

500 people dead or missing (Ohnishi, 2012) and aseverely damaged infrastructure (Funabashi & Kitazawa, 2012; Figueroa, 2013). In particular, the Fukushima Prefecture received the heaviest blow where multiplenuclear power plants were hit. Although most were inoperative due to maintenance, the Fukushima Daiichi nuclear power station had three active units (Kushida, 2012). The earthquake caused an automatic shutdown of all units, however theexternal power lines were also severed (TEPCO, 2012). Despite the successfulreactor shutdown, the cooling pumps required on-site power to function. As aback-up emergency diesel generators were present, unfortunately the tsunamibreached the defences of the power station and carried away fuel tanks (Anzaiet al.

, 2011), thus, rendering the emergency cooling system inoperable. Alternatively, water injection was applied, consequently the combination of steam and corefuel led to the generation of hydrogen (TEPCO, 2012). Over the next three days, the three reactors experienced core meltdowns and hydrogen explosions whichdestroyed the structure of the buildings and caused the release of radioactivematerial into the environment (Funabashi & Kitazawa, 2012; Anzai et al., 2011).

AnalysisUpon taking acloser look at the Fukushima nuclear disaster, it becomes evident thatultimately a sequence of systemic failures played a crucial role in thedeterioration of the Daiichi plant (Kushida, 2012). Therefore, a systemapproach rather than a person approach is deemed more appropriate in dissectingthe situation, in which no root cause is assumed and errors are consequences ofcomplex and systemic factors (Reason, 2000). In addition, by applying the Swisscheese model of system accidents a set of latent conditions is revealed(Reason, 2000), such as the roughly six meters tall defensive walls, which wereeasily bypassed by the fifteen meters tall tsunami, and the refusal torefurbish the plant in 2006 (Hollnagel & Fujita, 2013). Said designdeficiencies fall under latent conditions that create long-lasting weaknesses(Reason, 2000), and taking into account that the Daiichi power plant had beendesigned in the 1960s it is not unreasonable to assume that the buildings whichencompass the nuclear reactors had degraded over the years (Kushida, 2012).

Threegeneral systemic factors can be identified, namely the inability to considerstructural and functional liability (Hollnagel & Fujita, 2013), a laggedresponse from an organizational perspective (Pfotenhauer et al., 2012), andpoor risk communication which led to less informed decisions (Figueroa, 2013). To begin with, in the initial design assessment of theDaiichi power station the anticipation of major earthquakes was made, howeverthe initial appraisal cannot be completed because new information can becomeavailable (Hollnagel & Fujita, 2013). For example, in 2004 another nuclear power plant was hit by an earthquake that exceeded itsdesign basis as some geological faults had been overlooked in the initial review. Similarly, the 2011 Tohoku earthquake exceeded Daiichi’s design basis, eventhough the probability of large earthquakes was known before the actual disaster(Hollnagel & Fujita, 2013). Furthermore, the structures of the buildingswere essentially forty years old and couldn’t cope with the earthquake (Kushida, 2012).

In addition, the retaining walls standing at approximately 5. 7 meterstall were based on the assessment method of the Japan Society of Civil Engineers dating from2002 (TEPCO, 2012). In hindsight, the walls should have been higher to withstanda fifteen meters tall tsunami, however in 2006 recommendations forrefurbishment of the plant were turned down. Since the recommendations werebased on a historical study of a much larger tsunami in the ninth century, theevidence was not accepted by specialists (Hollnagel & Fujita, 2013).

Regardless, strategies to respond to unexpected severe situations areas critical as stronger defences (Pfotenhauer et al., 2012). The total loss ofpower rendered the cooling systems useless and emergency batteries took over(TEPCO, 2012), however they merely lasted for eight hours (Ohnishi, 2012).

As aresult, TEPCO had to resort to the use of electricity trucks, though thetsunami had caused a gridlock and only few could make it (Hollnagel &Fujita, 2013). Concurrently, the government tried flying electricity trucks tothe power plant, but the load was too heavy, indicating that preparations fortransport of such proportions had not been thoroughly investigated (Hollnagel& Fujita, 2013). Moreover, communication between TEPCO headquarters and plantpersonnel was limited as there were no adequate back-up transmitters, and thechairman was absent until twenty hours after the events, thus further slowingdown the response (Kushida, 2012). Finally, risk communication failed to help people make moreinformed decisions, as risks were initially denied.

At 4: 54 PM Prime Minister Kanstated that the Daiichi station was under control, while earlier, the plantmanager had declared a nuclear emergency in progress (Figueroa, 2013). Inaddition, the residents had never drilled for evacuation, and the ‘ venting’ ofthe plant took many hours since the execution of the procedures was unknown tothe personnel. By that point the situation had already exacerbated (Figueroa, 2013). Conclusion and recommendations for the future In conclusion, thedisaster was triggered by the earthquake and the tsunami, but essentially wascaused by TEPCO design deficiencies (Baba, 2013). In light of the Swiss cheesemodel, it was first the weakened building structures that allowed for damagefrom the earthquake, then the inadequate retaining walls that were bypassed bythe tsunami and finally the emergency cooling systems that failed to preventhydrogen explosions.

Given that other nuclear plants like Daini successfullyavoided damage to the reactors because of available electricity (TEPCO, 2012), perhaps the most important hindrances to post-measures were lagged operationrelated response and poor communication (Hollnagel & Fujita, 2013). For thefuture it is strongly recommended that organisations like TEPCO invest intodeveloping response strategies that prepare for beyond-design-parameter events(Kushida, 2012). Furthermore, policies should leave room for discussion of standardand disaster operations, including questioning outdated narratives (Pfotenhaueret al., 2012). Lastly, organisations should strive for transparency in riskcommunication and inclusion of citizens to enhance decision-making in diresituations, and to assure successful evacuation procedures (Baba, 2013).